APPENDIX G
EVALUATION OF HUMAN HEALTH EFFECTS OF OVERLAND TRANSPORTATION

G.1 INTRODUCTION

Overland transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose an additional risk due to the unique nature of the material itself. To permit a complete appraisal of the environmental impacts of the proposed action and alternatives, the human health risks associated with the overland transportation of spent nuclear fuel are assessed.

This appendix provides an overview of the approach used to assess the human health risks that may result from overland transportation. The topics in this appendix include the scope of the assessment, packaging and determination of potential transportation routes, analytical methods used for the risk assessment (e.g., computer models), and important assessment assumptions. It also presents the results of the assessment. In addition, to aid in the understanding and interpretation of the results, specific areas of uncertainty are described with an emphasis on how the uncertainties may affect comparisons of the alternatives.

The risk assessment results are presented in this appendix in terms of "per-shipment" risk factors, as well as for the total risks for a given alternative. Per-shipment risk factors provide an estimate of the risk from a single shipment. The total risks for a given alternative are found by multiplying the expected number of shipments by the appropriate per-shipment risk factors.

G.2 SCOPE OF ASSESSMENT

The scope of the overland transportation human health risk assessment, including the alternatives and options, transportation activities, potential radiological and nonradiological impacts, and transportation modes considered, is described below. Additional details of the assessment are provided in the remaining sections of the appendix.

Proposed Action and Alternatives

The transportation risk assessment conducted for this environmental impact statement (EIS) estimates the human health risks associated with the transportation of sodium-bonded spent nuclear fuel for the 6 alternatives. There are 6 different shipping arrangements for 8 fuel types that cover the 6 alternatives evaluated. Consistent with the scope of the overland transportation human health risks, this evaluation focuses on using onsite and offsite public highways.

Transportation-Related Activities

The transportation risk assessment is limited to estimating the human health risks incurred during overland transportation for each alternative. The risks to workers or to the public during loading, unloading, and handling prior to or after shipment are not included in the overland transportation assessment, but are addressed in Appendix F of this EIS. The transportation risk assessment does not address possible impacts from increased transportation levels on local traffic flow, noise levels, or infrastructure.

Radiological Impacts

For each alternative, radiological risks (i.e., those risks that result from the radioactive nature of the spent nuclear fuel) are assessed for both incident-free (i.e., normal) and accident transportation conditions. The radiological risk associated with incident-free transportation conditions would result from the potential exposure of people to external radiation in the vicinity of a loaded shipment. The radiological risk from transportation accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people.

All radiological impacts are calculated in terms of committed dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (see 10 CFR 20), which is the sum of the effective dose equivalent from external radiation exposure and the 50-year committed effective dose equivalent from internal radiation exposure. Radiation doses are presented in units of roentgen equivalent man (rem) for individuals and person-rem for collective populations. The impacts are further expressed as health risks in terms of latent cancer fatalities and cancer incidence in exposed populations using the dose-to-risk conversion factors established by the National Council on Radiation Protection and Measurement (NCRP 1993).

Nonradiological Impacts

In addition to the radiological risks posed by overland transportation activities, vehicle-related risks are also assessed for nonradiological causes (i.e., causes related to the transport vehicles and not the radioactive cargo) for the same transportation routes. The nonradiological transportation risks, which would be incurred for similar shipments of any commodity, are assessed for both incident-free and accident conditions. The nonradiological risks during incident-free transportation conditions would be caused by potential exposure to increased vehicle exhaust emissions. The nonradiological accident risk refers to the potential occurrence of transportation accidents that directly result in fatalities unrelated to the shipment of cargo. State-specific transportation fatality rates are used in the assessment. Nonradiological risks are presented in terms of estimated fatalities.

Transportation Modes

All shipments are assumed to take place by truck transportation modes.

Receptors

Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered are truck crew members involved in the actual overland transportation. The general public includes all persons who could be exposed to a shipment while it is moving or stopped during transit. Potential risks are estimated for the collective populations of exposed people and for the hypothetical maximally exposed individual. For incident-free operation, the maximally exposed individual would be an individual stuck in traffic next to the shipment for 30 minutes. For accident conditions, the maximally exposed individual would be an individual located 33 meters (105 feet) directly downwind from the accident. The collective population risk is a measure of the radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing various alternatives.

G.3 PACKAGING AND REPRESENTATIVE SHIPMENT CONFIGURATIONS

Regulations that govern the transportation of radioactive materials are designed to protect the public from the potential loss or dispersal of radioactive materials, as well as from routine radiation doses during transit. The primary regulatory approach to promote safety is the specification of standards for the packaging of radioactive materials. Because packaging represents the primary barrier between the radioactive material being transported and radiation exposure to the public and the environment, packaging requirements are an important consideration for transportation risk assessment. Regulatory packaging requirements are discussed briefly below and in Chapter 4. The representative packaging and shipment configurations assumed for this EIS also are described below.

G.3.1 Packaging Overview

Although several Federal and state organizations are involved in the regulation of radioactive waste transportation, primary regulatory responsibility resides with the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission (NRC). All transportation activities must take place in accordance with the applicable regulations of these agencies as specified in 49 CFR 172 and 173 and 10 CFR 71.

Transportation packaging for small quantities of radioactive materials must be designed, constructed, and maintained to contain and shield their contents during normal transport conditions. For large quantities and for more highly radioactive material, such as high-level radioactive waste or spent nuclear fuel, they must contain and shield their contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Another packaging option, “Strong, Tight,” is still available for some domestic shipments.

Excepted packages are limited to transporting materials with extremely low-levels of radioactivity. Industrial packages are used to transport materials that, because of their low concentration of radioactive materials, present a limited hazard to the public and the environment. Type A packages are designed to protect and retain their contents under normal transport conditions and must maintain sufficient shielding to limit radiation exposure to handling personnel. These packages are used to transport radioactive materials with higher concentrations or amounts of radioactivity than Excepted, or Industrial packages. Strong, Tight packages are used in the United States for shipment of certain materials with low-levels of radioactivity, such as natural uranium and rubble from the decommissioning of nuclear reactors. Type B packages are used to transport material with the highest radioactivity levels, are designed to protect and retain their contents under transportation accident conditions, and are described in more detail in the following sections.

G.3.2 Regulations Applicable to Type B Casks

Regulations for the transport of radioactive materials in the United States are issued by the U.S. Department of Transportation and are codified in 49 CFR 173. The regulation authority for radioactive materials transport is jointly shared by the U.S. Department of Transportation and the NRC. As outlined in a 1979 Memorandum of Understanding with the NRC, the U.S. Department of Transportation specifically regulates the carriers of spent nuclear fuel and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The U.S. Department of Transportation also regulates the labeling, classification, and marking of all spent nuclear fuel packages. The NRC regulates the packaging and transport of spent nuclear fuel for its licensees, which include commercial shippers of spent nuclear fuel. In addition, NRC sets the standards for packages containing fissile materials and spent nuclear fuel.

DOE policy requires compliance with applicable Federal regulations regarding domestic shipments of spent nuclear fuel. Accordingly, DOE has adopted the requirements of 10 CFR 71, “Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions,” and 49 CFR 173, “Shippers--General Requirements for Shipping and Packaging.” DOE Headquarters can issue a certificate of compliance for a package to be used only by DOE and its contractors.

G.3.2.1 Cask Design Regulations

Spent nuclear fuel is transported in robust "Type B" transportation casks that are certified for transporting radioactive materials. Casks designed and certified for spent nuclear fuel transportation within the United States must meet the applicable requirements of NRC for design, fabrication, operation, and maintenance as contained in 10 CFR 71.

Cask design and fabrication can only be done by approved vendors with established quality assurance programs (10 CFR 71.101). Cask and component suppliers or vendors are required to obtain and maintain documents that prove the materials, processes, tests, instrumentation, measurements, final dimensions, and cask operating characteristics meet the design-basis established in the Safety Analysis Report for Packaging (described in the next section) for the cask and that the cask will function as designed.

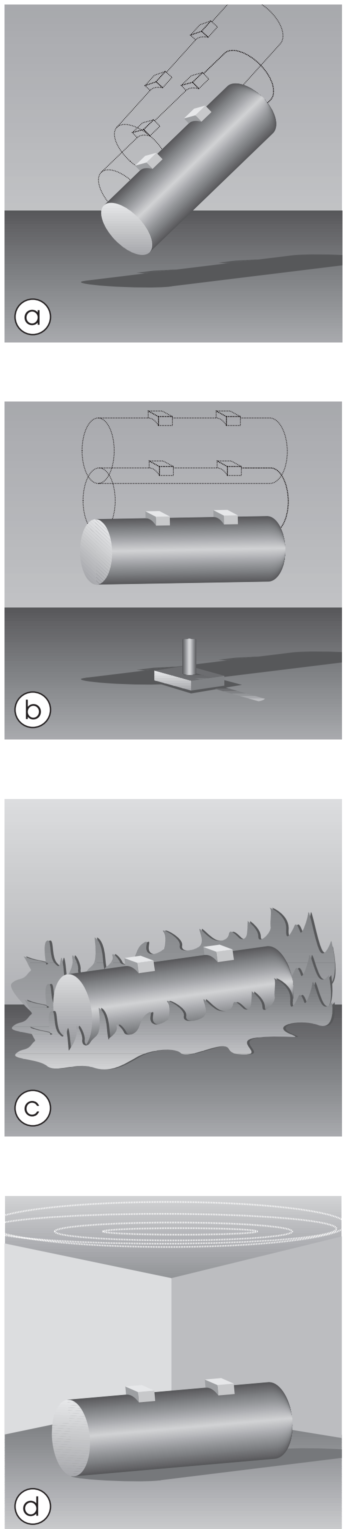
Regardless of where a transportation cask is designed, fabricated, or certified for use, it must meet certain minimum performance requirements (10 CFR 71.71–71.77). The primary function of a transportation cask is to provide containment and shielding. Regulations require that casks must be operated, inspected, and maintained to high standards to ensure their ability to contain their contents in the event of a transportation accident (10 CFR 71.87). There are no documented cases of a release of radioactive materials from spent nuclear fuel shipments, even though thousands of shipments have been made by road, rail, and water transport. Further, a number of obsolete casks have been tested under severe accident conditions to demonstrate their adherence to design criteria without failure.

Transportation casks are built out of heavy, durable structural materials such as stainless steel. These materials must ensure cask performance under a wide range of temperatures (10 CFR 71.43). In addition to the structural materials, shielding is provided to limit radiation levels at the surface and at prescribed distances from the surface of transportation casks (10 CFR 71.47). Shielding typically consists of dense material such as lead or depleted uranium. The assemblies are supported by internal structures, called baskets, that provide shock and vibration resistance and establish minimum spacing and heat transfer to maintain the temperature of the contents within the limits specified in the Safety Analysis Report for Packaging.

Finally, to limit impact forces and minimize damage to the structural components of a cask in the event of a transportation accident, impact-absorbing structures may be attached to the exterior of the cask. These are usually composed of balsa wood, foam, or aluminum honeycomb that is designed to readily deform upon impact to absorb impact energy. All of these components are designed to work together in order to satisfy the regulatory requirements for a cask to operate under normal conditions of transportation and maintain its integrity in an accident.

G.3.2.2 Design Certification

For certification, transportation casks must be shown by analysis and/or testing to withstand a series of hypothetical accident conditions. These conditions have been internationally accepted as simulating damage to transportation casks that could occur in most reasonably foreseeable accidents. The impact, fire, and water-immersion tests are considered in sequence to determine their cumulative effects on one package. These accident conditions are described in **Figure G–1**. The NRC issues regulations (10 CFR 71) governing the transportation of radioactive materials. In addition to the tests shown in Figure G–1, the regulations affecting Type B casks require that a transportation cask with activity greater than 10^6 curies (which is applicable to spent nuclear fuel) be designed and constructed so that its undamaged containment system would withstand an external water pressure of 2 megapascals (290 pounds per square inch), or immersion in 200 meters (656 feet) of water, for a period of not less than one hour without collapse, buckling, or allowing water to leak into the cask.



Standards for Type B Casks

For certification by the U.S. Nuclear Regulatory Commission, a cask must be shown by test or analysis to withstand a series of accident conditions without releasing its contents. These conditions have been internationally accepted as simulating damage to spent nuclear fuel casks that could occur in most severe credible accidents. The impact, fire, and water-immersion tests are considered in sequence to determine their cumulative effects on one package. An undamaged containment system is subjected to a deep water-immersion test. The details of the tests are as follows:

Impact

Free Drop (a) – The cask drops 9 meters (30 feet) onto a flat, horizontal, unyielding surface so that it strikes at its weakest point.

Puncture (b) – The cask drops 1 meter (40 inches) onto a 15.2-centimeter (6-inch) diameter steel bar at least 20.3 centimeters (8 inches) long; the bar strikes the cask at its most vulnerable spot.

Fire (c)

After the impact tests, the cask is totally engulfed in a 802 °C (1,475 °F) thermal environment for 30 minutes.

Water Immersion (d)

The cask is completely submerged under at least 1 meter (3 feet) of water for 8 hours. Additionally, undamaged containment systems (casks) are required to withstand more rigorous immersion tests.

Figure G–1 Standards for Transportation Casks

Under the Federal certification program, a Type B packaging design must be supported by a Safety Analysis Report for Packaging, which demonstrates that the design meets Federal packaging standards. The Safety Analysis Report for Packaging must include a description of the proposed packaging in sufficient detail to identify the packaging accurately and provide the basis for evaluating its design. The Safety Analysis Report for Packaging must provide the evaluation of the structural design, materials' properties, containment boundary, shielding capabilities, and criticality control, and present the operating procedures, acceptance testing, maintenance program, and the quality assurance program to be used for design and fabrication. Upon completion of a satisfactory review of the Safety Analysis Report for Packaging to verify compliance to the regulations, a Certificate of Compliance is issued.

G.3.2.3 Transportation Regulations

To ensure that the transportation cask is properly prepared for transportation, trained technicians perform numerous inspections and tests (10 CFR 71.87). These tests are designed to ensure that the cask components are properly assembled and meet leak-tightness, thermal, radiation, and contamination limits before shipping radioactive material. The tests and inspections are clearly identified in the Safety Analysis Report for Packaging and/or the Certificate of Compliance for each cask. Casks can only be operated by registered users who conduct operations in accordance with documented and approved quality assurance programs meeting the requirements of the regulatory authorities. Records must be maintained that document proper cask operations in accordance with the quality requirements of 10 CFR 71.91. Reports of defects or accidental mishandling must be submitted to NRC. DOE will be the Shipper-of-Record for the shipments that could be sent.

External radiation from a package must be below specified limits that minimize the exposure of handling personnel and the general public. For these types of shipments, the external radiation dose rate during normal transportation conditions must be maintained below the following limits of 49 CFR 173:

- 10 millirem per hour at any point 2 meters (6.6 feet) from the vertical planes projected by the outer lateral surfaces of the transport vehicle (referred to as the regulatory limit throughout this document), and
- 2 millirem per hour in any normally occupied position in the transport vehicle

Additional restrictions apply to package surface contamination levels, but these restrictions are not important for the transportation radiological risk assessment. Current contamination standards assure that workers and public receive doses much lower than those associated with radiation emitted from the casks. For risk assessment purposes, it is important to note that all packaging of a given type is designed to meet the same performance criteria. Therefore, two different Type B designs would be expected to perform similarly during incident-free and accident transportation conditions. The specific containers selected or designed, however, will determine the total number of shipments necessary to transport a given quantity material.

G.3.2.4 Communications

Proper communication assists in ensuring safe preparation and handling of transportation casks. Communication is provided by labels, markings, placarding, shipping papers, or other documents. Labels (49 CFR 172.403) applied to the cask document the contents and the amount of radiation emanating from the cask by giving the transport index. The transport index lists the ionizing radiation level (in millirem per hour) at a distance of 1 meter (3.3 feet) from the cask surface.

In addition to the label requirements, markings (49 CFR 173.471) should be placed on the exterior of the cask to show the proper shipping name and the consignor and consignee in case the cask is separated from its original shipping documents (49 CFR 172.203). Transportation casks are required to be permanently marked with the designation "Type B," the owner's (or fabricators') name and address, the Certificate of Compliance number, and the gross weight (10 CFR 71.83).

Placards (49 CFR 172.500) are applied to the transport vehicle or freight container holding the transportation cask. The placards indicate the radioactive nature of the contents. Spent nuclear fuel, which constitutes a highway route-controlled quantity or "HRCQ," must be placarded according to 49 CFR 172.507. Placards provide the first responders to a traffic or transportation accident with initial information about the nature of the contents.

Shipping papers for the spent nuclear fuel should contain the notation "HRCQ" and have entries identifying the following: the name of the shipper, emergency response telephone number, description of contents, and the shipper's certificate, as described in 49 CFR 172 Subpart C.

In addition, drivers of motor vehicles transporting radioactive material must have been trained in accordance with the requirements of 49 CFR 172.700. The training requirements include familiarization with the regulations, emergency response information, and the communication programs required by the Occupational Safety and Health Administration. Drivers are also required to have been trained on the procedures necessary for safe operation of the vehicle used to transport the spent nuclear fuel.

G.3.3 Packages Used in the Transportation of Spent Nuclear Fuel

Two Type B casks, a formerly certified type B cask, and an NRC-certified cask would provide primary transportation services for sodium-bonded fuel where public roads are involved. A commercially available cask will be certified and used for single shipments of miscellaneous sodium-bonded fuel from Tennessee and New Mexico. One other cask for onsite fuel transfers at ANL-W which does not use public roads will be employed. It is discussed below.

The TN-FSV is a certified Type B cask that would be used for intrasite transportation, and NAC-LWT would be used for the intersite transportation. The Peach Bottom (PB-1) is a formerly certified Type B cask that would be used for some of the intrasite transportation. The NRC-certified T-3 cask would be used for shipping the Fast Flux Test Facility Driver fuel from Washington to Idaho. The NRC-license is equivalent to the Type B certification described in the earlier sections.

The TN-FSV cask is a steel and lead shielded shipping cask originally designed for high temperature gas–cooled reactor fuel elements from the Fort St. Vrain reactor. The cask is a right circular cylinder, with a balsa and redwood impact limiter at each end. The cask body is made of two concentric shells of type 304 stainless steel, welded to a bottom plate and a top closure flange. The inner shell has an inside diameter of 46-centimeters (18 inches) and is 2.8 centimeters (1.1 inches) thick, and the cavity is 505 centimeters (199 inches) long. The outer shell has an outside diameter of approximately 76 centimeters (30 inches) and is 3.8 centimeters (1.5 inches) thick. The gross package weight, including the contents, is 21,319 kilograms (47,000 pounds). **Figure G–2** shows the TN-FSV.

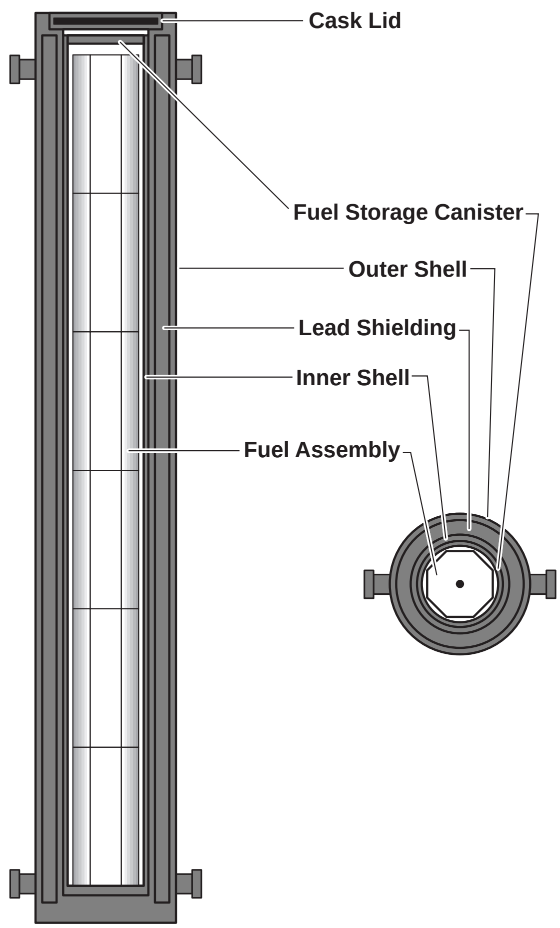


Figure G–2 TN-FSV Cask

The TN-FSV cask first received an NRC Certificate of Compliance in March 1993, and this certificate has been supplemented several times since that time. The current Certificate of Compliance would expire in May 1999, but it is likely that it would be renewed. The Certificate of Compliance would have to be supplemented for the materials that could be carried in this program. In addition to the size of the cavity, the limiting factors for this cask on the current Certificate of Compliance are a maximum of 360 watts of decay heat and a maximum total weight of contents of 2268 kilograms (5,000 pounds), including the fuel elements, fuel storage container and shield plug. (NRC 1998).

The NAC-LWT is a steel encased lead shielded shipping cask. The overall dimensions with impact limiters are 589 centimeters (232 inches) long by 165 centimeters (65 inches) in diameter. The cask body is approximately 508 centimeters (200 inches) in length and 112 centimeters (44 inches) in diameter. The cask cavity is approximately .41 cubic meters (14.5 cubic feet). The maximum weight of the package is 23,587 kilograms (52,000 pounds) and the maximum weight of the contents and basket is 1,814 kilograms (4,000 pounds). **Figure G–3** shows the NAC-LWT.

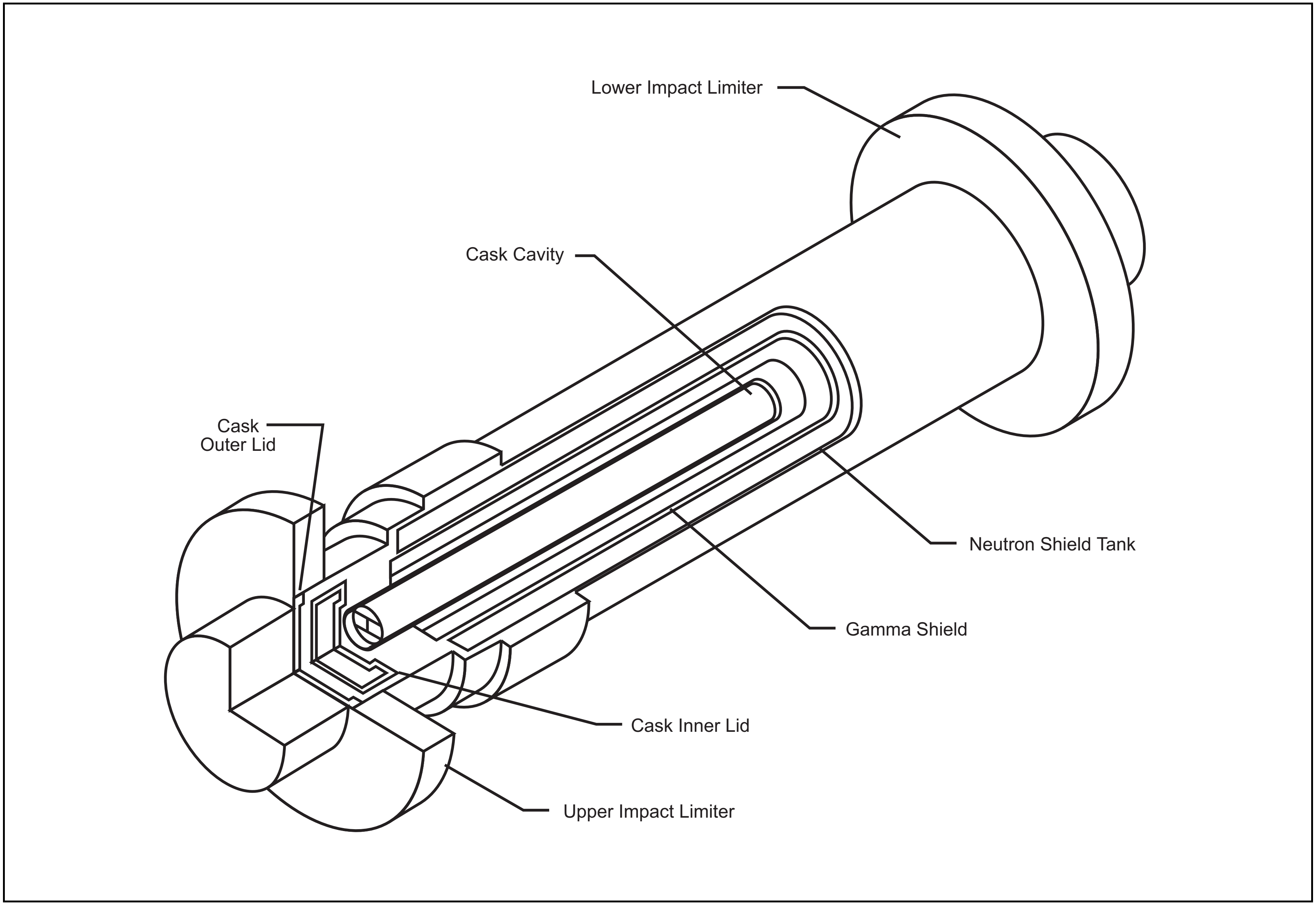


Figure G–3 Simplified Drawing of a NAC-LWT (Legal Weight Truck) Shipping Cask

The NAC-LWT first received an NRC Certificate of Compliance in March 1995, and this certificate has been supplemented several times. The current Certificate of Compliance would expire in February 2000, but it is likely that it would be renewed. The Certificate of Compliance would not need to be supplemented for the materials that could be carried in this program. The cask is designed to carry up to 42 reactor fuel assemblies. Besides the size of the cavity and weight, the limiting factor for this cask on the current Certificate of Compliance is a maximum of 210 watts of decay heat.

The intrasite transportation of Fermi-1 blanket material would use the formerly certified PB-1 cask. This cask was originally licensed for carrying Peach Bottom fuel, and was used to bring the Fermi-1 spent nuclear fuel to INTEC. The Certificate of Compliance for this cask has expired. Since the movement is a short distance on closed DOE-controlled roads, DOE procedures and NRC regulations do not require the use of a certified Type B cask. The use of formerly certified casks provides a margin of safety beyond that required by NRC regulations. The level of safety for intrasite shipments is carefully controlled by internal procedures, and the level of protection given by the PB-1 cask is approximately equivalent to that of a certified Type B cask. Since the roads are closed and site is uninhabited, there are no measurable impacts to the public.

The EBR-II driver and blanket material currently in storage at Argonne National Laboratory-West (ANL-W) is stored in HFEF-5 sealed canisters, another kind of cask. The canisters are single use, welded steel cans. DOE packs these cans in an unlicensed HFEF cask for onsite shipping. Fast Flux Test Facility driver material currently in storage at the Hanford Site would be shipped in the NRC-certified T-3 cask.

G.3.4 Ground Transportation Route Selection Process

According to DOE guidelines, spent nuclear fuel shipments must comply with both the NRC and U.S. Department of Transportation regulatory requirements. NRC regulations cover the packaging and transport of neptunium, spent nuclear fuel, whereas the U.S. Department of Transportation specifically regulates the carriers and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The highway routing of nuclear material is systematically determined according to U.S. Department of Transportation regulations 49 CFR 171–179 and 49 CFR 397 for commercial shipments. Specific routes cannot be publicly identified in advance for DOE's Transportation Safeguards Division's shipments because they are classified to protect national security interests.

The U.S. Department of Transportation routing regulations require that shipment of a highway route-controlled quantity of radioactive material be transported over a preferred highway network, including interstate highways, with preference toward interstate system bypasses and beltways around cities and state-designated preferred routes. A state or tribe may designate a preferred route to replace or supplement the interstate highway system in accordance with U.S. Department of Transportation guidelines (DOT 1992).

Carriers of highway route-controlled quantities are required to use the preferred network unless they are moving from their origin to the nearest interstate highway or from the interstate highway to their destination, they are making necessary repair or rest stops, or emergency conditions render the interstate highway unsafe or impassable. The primary criterion for selecting the preferred route for a shipment is travel time. Preferred routing takes into consideration accident rate, transit time, population density, activities, time of day, and day of the week.

The HIGHWAY computer code (Johnson et al. 1993) is used for selecting highway routes in the United States. The HIGHWAY database is a computerized road atlas that currently describes about 386,400 kilometers (240,000 miles) of roads. The Interstate System and all U.S. (US-designated) highways are completely described in the database. In addition, most of the principal state highways and many local and community roads are also identified. The code is updated periodically to reflect current road conditions and has been benchmarked against reported mileages and observations of commercial truck firms. Features in the

HIGHWAY code allow the user to select routes that conform to U.S. Department of Transportation regulations. Additionally, the HIGHWAY code contains data on the population densities along the routes. The distances and populations from the HIGHWAY code are part of the information used for the transportation impact analysis in this EIS.

G.4 METHODS FOR CALCULATING TRANSPORTATION RISKS

The overland transportation risk assessment method is summarized in **Figure G–4**. After the EIS alternatives were identified and the goals of the shipping campaign were understood, data was collected on material characteristics and accident parameters. Accident parameters were largely based on the NRC studies of transportation accidents undertaken for the Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0170 (NRC 1977) and the Modal Study, NUREG/CR-4829 (NRC 1987).

Representative routes that may be used for the shipments were selected for risk assessment purposes using the HIGHWAY code. They do not necessarily represent the actual routes that would be used to transport nuclear materials. Specific routes cannot be identified in advance because the routes cannot be finalized until they have been reviewed and approved by the NRC. The selection of the actual route would be responsive to environmental and other conditions that would be in effect or could be predicted at the time of shipment. Such conditions could include adverse weather conditions, road conditions, bridge closures, and local traffic problems. For security reasons, details about a route would not be publicized before the shipment.

The first analytic step in the ground transportation analysis was to determine the incident-free and accident risk factors on a per-shipment basis. Risk factors, as with any risk estimate, are the product of the probability of exposure and the magnitude of the exposure. Accident risk factors were calculated for radiological and nonradiological traffic accidents. The probabilities, which are much lower than one, and the magnitudes of exposure were multiplied, yielding very low risk numbers. Incident-free risk factors were calculated for crew and public exposure to radiation emanating from the shipping container (cask) and public exposure to the chemical toxicity of the transportation vehicle exhaust. The probability of incident-free exposure is unity (one).

For each alternative, risks were assessed for both incident-free transportation and accident conditions. For the incident-free assessment, risks are calculated for both collective populations of potentially exposed individuals and for maximally exposed individuals. The accident assessment consists of two components: (1) a probabilistic accident risk assessment that considers the probabilities and consequences of a range of possible transportation accident environments, including low-probability accidents that have high consequences and high-probability accidents that have low consequences, and (2) an accident consequence assessment that considers only the consequences of the most severe postulated transportation accidents.

The RADTRAN 5 computer code (Neuhauser and Kanipe 1998) is used for incident-free and accident risk assessments to estimate the impacts on population. RADTRAN 5 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge. RADTRAN 5 was used to calculate the doses to the maximally exposed individuals.

The RADTRAN 5 population risk calculations include both the consequences and probabilities of potential exposure events. The RADTRAN 5 code consequence analyses include the cloud shine, ground shine, inhalation, and resuspension exposures. The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing the various alternatives.

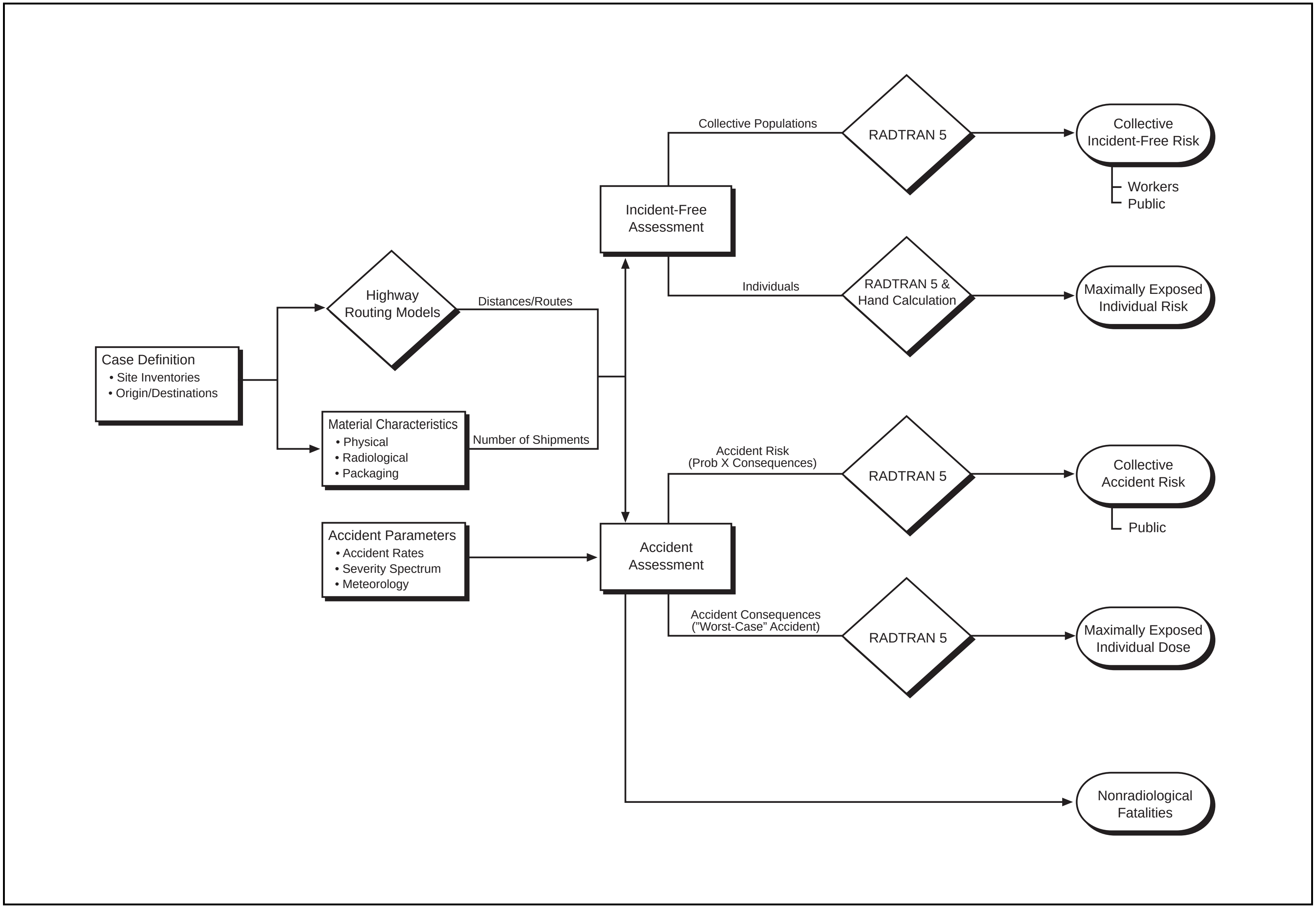


Figure G–4 Overland Transportation Risk Assessment

G.5 ALTERNATIVES, PARAMETERS, AND ASSUMPTIONS

G.5.1 Material Inventory and Shipping Campaigns

Table G–1 lists the fuels that could be shipped as a result of implementing an alternative to treat sodium-bonded spent nuclear fuel:

Table G–1 Transportation Summary for Sodium-Bonded Fuels

Fuel Type	*Applicable Alternatives*	*MTHM*	*Origin/ State*	*Destination/ State*	*Cask/Container Canister*	*Number of Shipments/ Type of Transport*
EBR-II Driver	All	1.1	ANL-W/ID	ANL-W/ID	HFEF-5	84/Onsite, intra-facility transfer
EBR-II Driver	1,2,3,4,5,6	2.0	INTEC/ID	ANL-W/ID	TN-FSV NAC-LWT	17 /Onsite With Roads Open 43/Onsite With Roads open
EBR-II Blanket	All	22.4	ANL-W/ID	ANL-W/ID	HFEF-5	165/Onsite, intra-facility transfer
Fast Flux Test Facility Driver	All	0.25	Hanford/ WA	ANL-W/ID	T-3	10/ Public Highways
Fermi-1 Blanket	All	34.2	INTEC/WA	ANL-W/ID	PB-1	14/Onsite with Road Closed
Miscellaneous	All	0.04	ORNL/TN SNL/NM	ANL-W/ID	Commercially Available Cask	1/Public Highways 1/Public Highways
Declad EBR-II Blanket	3,5	22.4	ANL-W/ID	SRS/SC	NAC-LWT	11/Public Highways
Declad Fermi-1 Blanket	3,5	34.2	ANL-W/ID	SRS/SC	NAC-LWT	18/Public Highways

MTHM = metric tons of heavy metal

The following shipment campaigns related to sodium-bonded spent nuclear fuel were analyzed by DOE in other NEPA documents and are not treated in detail here.

- Fast Flux Test Facility driver material is currently stored at the Hanford Site, and the transportation impacts are included in the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final EIS* (Programmatic Spent Nuclear Fuel EIS) (DOE 1995), and finalized in the Amendment to the Record of Decision (61 FR 9441).

- Miscellaneous spent nuclear fuel is currently stored at the Oak Ridge National Laboratory and at Sandia National Laboratory, and the transportation impacts are included in the Programmatic Spent Nuclear Fuel EIS (DOE 1995), and finalized in the Amendment to the Record of Decision (61 FR 9441).

The Programmatic Spent Nuclear Fuel EIS (DOE 1996) analyzed the transportation impacts in the same manner as this EIS. The representative routes were modeled using the HIGHWAY Code (Johnson, et. al. 1993), and the risks were quantified using an older version of the RADTRAN code. Since the Programmatic Spent Nuclear Fuel EIS assumed cask dose rates to be equal to the regulatory limit, and used representative fuel isotopics rather than actual sodium-bonded fuel isotopics, the published impact estimates were bounding.

All EBR-II blanket and some EBR-II driver fuel are currently stored at ANL-W and would be subject to a building-to-building movement for processing. Since the movement is a short distance, on closed DOE-controlled roads, DOE procedures and NRC regulations do not require the use of a certified Type B cask. DOE would use the HFEF-5 canister which is the sealed canister in which the spent nuclear fuel is currently stored. No incident-free risk analysis is necessary, because the public would receive no measurable exposure. Worker dose is included in the process and handling dose estimates because the same personnel would be moving the spent nuclear fuel. No accident analysis is necessary because potential accidents during movement are bounded in frequency and consequence by handling accidents. Once the cask is closed for the low-speed movement to the nearby building, the likelihood and consequence of any foreseeable accident are very small and not further quantified.

Fermi-1 blanket fuel would be shipped from the INTEC to ANL-W in the formerly certified Type B cask, the PB-1 Cask. Since DOE would close the roads between INTEC and ANL-W using existing traffic gates, and there are no homes in the vicinity of the road within the INEEL site boundary, no quantitative analysis is necessary. No incident-free risk analysis is necessary, because the public would receive no measurable exposure. Worker dose is included in the process and handling dose estimates because the same personnel would be moving the spent nuclear fuel. Once the cask is closed for the movement on the INEEL site roads, the likelihood and consequence of any foreseeable accident are very small.

EBR-II driver fuel currently stored at INTEC would be shipped to ANL-W in a certified Type B cask, either TN-FSV or NAC-LWT. Since the cask would be certified, DOE would not close the roads between INTEC and ANL-W. However, since there are no homes in the vicinity of the road within the INEEL site boundary, limited quantitative analysis is necessary. No incident-free risk analysis for exposure to the public at stops or in their homes is necessary. Worker dose is analyzed for the transportation crew, and the dose to other vehicles using the road is estimated. No accident analysis is necessary, because potential accidents during movement are bounded in frequency and consequence, by the handling accidents. Once the cask is closed for the movement on the INEEL site roads, the likelihood and consequence of any foreseeable accident are very small and not further quantified.

G.5.2 Representative Routes

Representative overland truck routes were selected for the shipments from ANL-W to SRS. The routes were selected consistent with current routing practices and all applicable routing regulations and guidelines (DOT 1992). However, the routes were determined for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport spent nuclear fuel in the future. Specific routes cannot be identified in advance. The representative truck routes are shown in **Figure G–5**.

Route characteristics that are important to the radiological risk assessment include the total shipment distance and the population distribution along the route. The specific route selected determines both the total potentially exposed population and the expected frequency of transportation-related accidents. Route characteristics are summarized in **Table G–2**. The population densities along each route are derived from 1990 U.S. Bureau of Census data. Rural, suburban, and urban areas are characterized according to the following breakdown: rural population densities range from 0 to 54 persons per square kilometer (0 to 139 person per square mile); the suburban range is from 55 to 1,284 persons per square kilometer (140 to 3,326 persons per square mile); and the urban range includes all population densities greater than 1,284 persons per square kilometer (3,326 persons per square mile). The exposed population includes all persons living within 800 meters (0.5 mile) of each side of the road. The exposed population, for route characterization and incident-free dose calculation, includes all persons living within 800 meters (0.5 mile) of each side of the road.

Figure G–5 Representative Overland Truck Route

Table G–2 Potential Shipping Routes Evaluated for the Sodium Bonded Spent Nuclear Fuel EIS

From	To	Distance (km)	Percentages in Zones			Population Density in Zone ($1/km^2$)			Number of Affected Persons
			Rural	Suburban	Urban	Rural	Suburban	Urban	
Truck Routes									
ANL-W	SRS	3759.3	82.8	15.4	1.8	7.4	353	2173.3	599,000
INTEC	ANL-W	38.6	100	0	0	1.0	N/A	N/A	62

km = kilometers, N/A = not applicable
The shipment impact to SRS are all based on the distance and population exposed on a trip from ANL-W to SRS.

G.5.3 External Dose Rates

External dose rates are calculated for the spent nuclear fuel being shipped on public roads (SAIC 1999). For the EBR-II blanket fuel, the dose rate on contact with the cask is 0.6 millirem per hour and the dose rate at 2 meters (6 feet) from the cask is 0.1 millirem per hour. For the Fermi-1 blanket fuel, the dose rate on contact with the cask is 7.1×10^{-4} millirem per hour and the dose rate at 2 meters (6 feet) from the cask is 1.4×10^{-4} millirem per hour. For the EBR-II driver material shipped to ANL-W, the dose rate on contact with the cask is 0.59 millirem per hour and the dose rate at 2 meters (6 feet) from the cask is 0.12 millirem per hour.

G.5.4 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected cancer fatalities were: 0.0005 and 0.0004 fatal cancer cases per person-rem for members of the public and workers, respectively (NCRP 1993).

G.5.5 Accident Frequencies

For the calculation of accident risks, vehicle accident and fatality rates are taken from data provided in other reports (ANL 1994). Accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel in that same year. Therefore, the rate is a fractional value, with accident-involvement count as the numerator of the fraction and vehicular activity (total travel distance in truck-kilometers) as its denominator. Accident rates are generally determined for a multi-year period. For assessment purposes, the total number of expected accidents or fatalities is calculated by multiplying the total shipment distance for a specific case by the appropriate accident or fatality rate.

For truck transportation, the rates presented are specifically for heavy combination trucks involved in interstate commerce (ANL 1994). Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other. Heavy combination trucks are typically used for radioactive waste shipments. The truck accident rates are computed for each state based on statistics from 1986 to 1988 compiled by the U.S. Department of Transportation Office of Motor Carriers. Saricks and Kvitek (ANL 1994) present accident involvement and fatality counts; estimated kilometers of travel by state; and the corresponding average accident involvement, fatality, and injury rates for the three years investigated. A fatality caused by an accident is the death of a member of the public who is killed instantly or dies within 30 days due to the injuries sustained in the accident.

G.5.6 Container Accident Response Characteristics and Release Fractions

G.5.6.1 Development of Conditional Probabilities

NUREG-0170 (NRC 1977) originally was used to estimate the conditional probabilities associated with the accidents involving transportation of radioactive materials. The Modal Study, an initiative taken by the NRC (NRC 1987) to refine more precisely the analysis presented in NUREG-0170 (NRC 1977) for spent nuclear fuel shipping casks, was used to estimate the conditional probabilities of accidents.

Whereas the NUREG-0170 analysis was primarily performed using best engineering judgments and presumptions concerning cask response, the Modal Study relies on sophisticated structural and thermal engineering analysis and a probabilistic assessment of the conditions that could be experienced in severe transportation accidents. The Modal Study results are based on representative spent nuclear fuel casks assumed to have been designed, manufactured, operated, and maintained according to national codes and standards. Design parameters of the representative casks were chosen to meet the minimum test criteria specified in 10 CFR 71. The study is believed to provide realistic, yet conservative, results for radiological releases under transport accident conditions.

In the Modal Study, potential accident damage to a cask is categorized according to the magnitude of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity region associated with that range. The accident severity scheme is designed to take into account all potential foreseeable transportation accidents, including accidents with low probability but high consequences, and those with high probability but low consequences.

As discussed above, the accident consequence assessment only considers the potential impacts from the most severe transportation accidents. In terms of risk, the severity of an accident must be viewed in terms of potential radiological consequences, which are directly proportional to the fraction of the radioactive material within a cask that is released to the environment during the accident. Although regions span the entire range of mechanical and thermal accident loads, they are grouped into accident categories that can be characterized by a single set of release fractions and are, therefore, considered together in the accident consequence assessment. The accident category severity fraction is the sum of all conditional probabilities in that accident category.

G.5.6.2 Release Fraction Assumptions

The release fractions for were taken from the Programmatic Spent Nuclear Fuel EIS (DOE 1995), which was based on the above described Modal Study. Spent nuclear fuel could be shipped in two different forms: unaltered or declad. The construction and cladding of the spent nuclear fuel are assumed to be similar enough to aluminum-clad fuels analyzed in that EIS that the performance in an accident would be similar. The declad fuel would also exhibit similar performance, since the fuel is placed in a shipping can which is in turn placed inside the transportation cask.

G.5.7 Nonradiological Risk (Vehicle Related)

Vehicle-related health risks resulting from incident-free transport may be associated with the generation of air pollutants by transport vehicles during shipment and are independent of the radioactive nature of the shipment. The health end-point assessed under incident-free transport conditions is the excess latent mortality due to inhalation of vehicle exhaust emissions. Risk factors for pollutant inhalation in terms of latent mortality have been generated (Neuhauser and Kanipe 1998). These risks are 1×10^{-7} mortality per kilometer (1.6×10^{-7} per mile) of truck travel in urban areas. The risk factors are based on regression analyses of the effects of sulfur dioxide and particulate releases from diesel exhaust on mortality rates. Excess latent mortalities are assumed to be equivalent to latent cancer fatalities. Vehicle-related risks from incident-free transportation are calculated for each case by multiplying the total distance traveled in urban areas by the appropriate risk factor. Similar data are not available for rural and suburban areas.

Risks are summed over the entire route and over all shipments for each case. This method has been used in several EISs to calculate risks from incident-free transport. Lack of information for rural and suburban areas is an obvious data gap, although the risk factor would presumably be lower than for urban areas because of lower total emissions from all sources and lower population densities in rural and suburban areas.

G.6 RISK ANALYSIS RESULTS

Per-shipment risk factors have been calculated for the collective populations of exposed persons and for the crew for all anticipated routes and shipment configurations. The radiological risks are presented in doses per shipment for each unique route, material, and container combination. The radiological dose per shipment factors for incident-free transportation are presented in **Table G–3** for the transportation routes analyzed for this EIS. As stated in Section G.5.1, the Programmatic Spent Nuclear Fuel EIS (DOE 1996) used very conservative assumptions to analyze the shipments from the Oak Ridge Reservation, Hanford Site, and Sandia National Laboratory. For these 12 shipments, the incident free public risk is 9.7×10^{-4} latent cancer fatalities from radiation and 8.1×10^{-6} latent cancer fatalities from exhaust emissions. The crew radiological risk is 3.1×10^{-4} latent cancer fatalities. The public risk from radiological accidents is 4.0×10^{-5} latent cancer fatalities and from nonradiological accidents is 1.2×10^{-3} fatalities.

Doses are calculated for the crew, off-link public (i.e., people living along the route), on-link public (i.e., pedestrians and drivers along the route), and public at rest and fueling stops (i.e., stopped cars, buses and trucks, workers, and other bystanders). For the onsite shipments from INTEC to ANL-W, the stop dose is set to zero, because a truck would not be expected to stop during a trip that takes less than an hour. The off-link dose is zero because no persons are residing within 800 meters (0.5 miles) of the road.

The radiological dose risk factors for transportation accidents are also presented in Table G–3. The accident risk factors are called “dose risk” because the values incorporate the spectrum of accident severity probabilities and associated consequences. The accident dose is very low because, although persons are residing in an 80 kilometers (50 miles) radius of the road, they are generally quite far from the road. Since RADTRAN 5 uses an assumption of homogeneous population from the road out to 80 kilometers (50 miles), it greatly overestimates the actual doses. However, the doses are clearly several factors of ten lower than the doses for the other transportation legs shown in Table G–3.

The nonradiological risk factors are presented in fatalities per shipment in **Table G–4**. Separate risk factors are provided for fatalities resulting from exhaust emissions (caused by hydrocarbon emissions known to be carcinogens) and transportation accidents (fatalities resulting from impact).

Table G–5 shows the risks of transportation for each alternative. The risks are calculated by multiplying the previously given per-shipment factors by the number of shipments over the duration of the program and, for the radiological doses, by the health risk conversion factors. The incident-free doses from the onsite shipments are very high, relative to the distance traveled, because the regulatory limit dose rate was used. As previously stated, the calculated dose rates for the packages being shipped to SRS are several factors of 10 lower than the regulatory limit.

Table G–3 Radiological Risk Factors for Single Shipments

From	To	Material & Package	Incident-Free Dose (Person-rem)					Accident Dose (Person-rem)
			Crew	Public				
				Off-link	On-link	Stops	Total	
ANL	SRS	EBR-II Blanket	1.07E-04	1.74E-04	9.02E-04	3.25E-07	1.08E-03	2.71E-7
ANL	SRS	Fermi-1 Blanket	1.34E-07	2.18E-07	1.13E-06	4.06E-10	1.35E-06	3.55E-9
INTEC	ANL-W	EBR-II Driver	1.10E-06	0.00E+00	8.10E-06	0.00E+00	8.10E-06	less than 1E-10

Table G–4 Nonradiological Risk Factors per Shipment

Nonradiological Risk Estimates (Fatalities/Shipment)			
From	To	Exhaust Emission	Accident
ANL-W	SRS	2.8E-5	7.0E-4
INTEC	ANL-W	0	8.2E-6

Table G–5 Risks of Transporting the Hazardous Materials[a]

Material Shipped	Alternative	Distance on Public Roads (kilometers)	Incident-Free			Accident	
			Radiological (person-rem)		Nonradiological		
			Crew	Public	Emission	Traffic	Radiological
None[b]	No Action	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EBR-II Driver Fuel	1	1,660	1.89E-08	1.74E-07	0.00E+00	8.21E-07	less than 1E-12
EBR-II Driver Fuel	2	1,660	1.89E-08	1.74E-07	0.00E+00	8.21E-07	less than 1E-12
EBR-II and Declad and Cleaned EBR-II and Fermi-1 Blanket Fuel	3	110,680	7.86E-07	6.09E-06	1.96E-04	2.11E-03	1.62E-09
EBR-II Driver Fuel	4	1,660	1.89E-08	1.74E-07	0.00E+00	8.21E-07	less than 1E-12
EBR-II Driver and Declad and Cleaned EBR-II and Fermi-1 Blanket Fuel	5	110,680	7.86E-07	6.09E-06	1.96E-04	2.11E-03	1.62E-09
EBR-II Driver Fuel	6	1,660	1.89E-08	1.74E-07	0.00E+00	8.21E-07	less than 1E-12

[a] All risks are expressed as number of latent cancer fatalities, except for the Accident-Traffic column, which lists number of accident fatalities.

[b] It is assumed that no material analyzed in this EIS would be shipped. If DOE would choose to move the EBR-II Driver material currently in storage at INTEC to ANL-W, the transportation impacts would be the same as those calculated for Alternatives 1, 2, 3, and 5.

The risks to various exposed individuals under incident-free transportation conditions have been estimated for hypothetical exposure scenarios. The estimated doses to workers and the public are presented in **Table G–6.**

Table G–6 Estimated Dose to Exposed Individuals During Incident-Free Transportation Conditions

Receptor		***Dose to Maximally Exposed Individual***	
		Idaho to SRS	***Intrasite***
Workers	Crew member (truck driver) [a]	1.5×10^{-6} rem	1.2×10^{-6} rem
	Inspector	2.9×10^{-5} rem per event	Not Applicable
Public	Resident	4.0×10^{-9} rem per event	Not Applicable
	Person in traffic congestion	1.1×10^{-4} rem per event	0.003 rem per event
	Person at service station	1.0×10^{-5} rem per event	Not Applicable

[a] Assumes that an individual driver takes every shipment.

All doses are presented on a per-event basis (person-rem per event) because it is not likely that the same person will be exposed to multiple events. The dose to the maximally exposed crew member is based on the same individual being responsible for driving every shipment for the duration of the campaign. Note that the potential exists for larger individual exposures if multiple exposure events occur. For example, the dose to a person stuck in traffic next to a shipment for 10 minutes is calculated to be 3 millirem. However, since the intersite shipments pass through urban areas, a 30-minute exposure time is considered. Using the estimated dose rates, the maximally exposed individual would receive 0.1 millirem. If the exposure duration were longer, the dose would rise proportionally. In addition, a person working at a truck service station could receive a significant dose if trucks were to use the same stops repeatedly. The dose to a person fueling a truck could be as much as 0.01 millirem per event.

The cumulative dose to a resident was calculated assuming all shipments passed his or her home. The cumulative doses assume that the resident is present for every shipment and is unshielded at a distance of 30 meters (about 66 feet) from the route. Therefore, the cumulative dose depends on the number of shipments passing a particular point and is independent of the actual route being considered. The maximum dose to this resident, if all the material were to be shipped via this route, would be less than 0.01 millirem.

The estimated dose to transportation crew members is presented for a commercial crew. No credit is taken for the shielding associated with the tractor or trailer.

The accident consequence assessment is intended to provide an estimate of the maximum potential impacts posed by the most severe potential transportation accidents involving a shipment. The maximum foreseeable (frequency greater than 1×10^{-7} per year) offsite transportation accident involves a shipment of EBR-II blanket fuel material under neutral (average) weather conditions. The accident has a probability of occurrence of about 1 every 10 million years and could result in 0.46 person-rem to the public. Additionally the accident could result in a dose of 1.9×10^{-3} rem to the hypothetical maximally exposed individual in the immediate vicinity of the accident. The probability of an accident occurring and the exposed populations are lower for the onsite shipment of EBR-II blanket fuel. The source term is lower for the offsite shipments of Fermi blanket fuel. This accident would fall into Category 5 of the Modal Study accident matrix (NRC 1987), and would occur in a suburban population zone. To incur this level of damage, the cask would have to collide with an immovable object at a speed of much greater than 88 kilometers per hour (55 miles per hour). The probability of an accident with a more energetic collision or a significant fire, which could lead to higher consequences, is lower.

G.7 CONCLUSIONS AND LONG-TERM IMPACTS OF TRANSPORTATION

G.7.1 Conclusions

It is unlikely that the transportation of radioactive materials will cause an additional fatality.

G.7.2 Long-Term Impacts of Transportation

The Programmatic Spent Nuclear Fuel EIS (DOE 1995) analyzed the cumulative impacts of all transportation of radioactive materials, including impacts from reasonably foreseeable actions that include transportation of radioactive material for a specific purpose and general radioactive materials transportation that is not related to a particular action. The total worker and general population collective doses are summarized in **Table G–7**. The table shows that the impacts of this program are quite small compared with overall transportation impacts. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities) for the period 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was due to the general transportation of radioactive material. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The total number of latent cancer fatalities estimated to result from radioactive materials transportation over the period between 1943 and 2035 was 290. Over this same period (93 years), approximately 28 million people would die from cancer, based on 300,000 cancer fatalities per year. It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010 percent of the total number of latent cancer fatalities.

Table G–7 Cumulative Transportation-Related Radiological Collective Doses and Latent Cancer Fatalities (1943 to 2035)

Category	*Collective Worker Dose (person-rem)*	*Collective General Population Dose (person-rem)*
Sodium-bonded Fuel Impacts (from Table G–4)	less than 1	less than 1
Other Nuclear Material Shipments		
Truck	11,000	50,000
Rail	820	1,700
General transportation (1943–2035)	310,000	270,000
Total collective dose	320,000	320,000
Total latent cancer fatalities	130	160

Source: DOE 1995.

G.8 UNCERTAINTY AND CONSERVATISM IN ESTIMATED IMPACTS

The sequence of analyses performed to generate the estimates of radiological risk for transportation includes: (1) determination of the inventory and characteristics, (2) estimation of shipment requirements, (3) determination of route characteristics, (4) calculation of radiation doses to exposed individuals (including estimating of environmental transport and uptake of radionuclides), and (5) estimation of health effects. Uncertainties are associated with each of these steps. Uncertainties exist in the way that the physical systems being analyzed are represented by the computational models; in the data required to exercise the models (due to measurement errors, sampling errors, natural variability, or unknowns simply caused by the future nature of the actions being analyzed); and in the calculations themselves (e.g., approximate algorithms used by the computers).

In principle, one can estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result; however, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions to be initiated at an unspecified time in the future. Instead, the risk analysis is designed to ensure, through uniform and judicious selection of scenarios, models, and input parameters, that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this design is accomplished by uniformly applying common input parameters and assumptions to each alternative. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives in a given measure of risk.

In the following sections, areas of uncertainty are discussed for the assessment steps enumerated above. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. The reality and conservatism of the assumption are addressed. Where practical, the parameters that most significantly affect the risk assessment results are identified.

G.8.1 Uncertainties in Material Inventory and Characterization

The inventories and the physical and radiological characteristics are important input parameters to the transportation risk assessment. The potential amount of transportation for any alternative is determined primarily by the projected dimensions of package contents, the strength of the radiation field, the heat that must be dissipated, and assumptions concerning shipment capacities. The physical and radiological characteristics are important in determining the material released during accidents and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

Uncertainties in the inventory and characterization will be reflected in the transportation risk results. If the inventory is overestimated (or underestimated), the resulting transportation risk estimates also will be overestimated (or underestimated) by roughly the same factor. However, the same inventory estimates are used to analyze the transportation impacts of each of the EIS alternatives. Therefore, for comparative purposes, the observed differences in transportation risks among the alternatives, as given in Table G-5, are believed to represent unbiased, reasonably accurate estimates from current information in terms of relative risk comparisons.

G.8.2 Uncertainties in Containers, Shipment Capacities, and Number of Shipments

The transportation required for each alternative is based in part on assumptions concerning the packaging characteristics and shipment capacities for commercial trucks and safe secure transports. Representative shipment capacities have been defined for assessment purposes based on probable future shipment capacities. In reality, the actual shipment capacities may differ from the predicted capacities such that the projected number of shipments and, consequently, the total transportation risk would change. However, although the predicted transportation risks would increase or decrease accordingly, the relative differences in risks among alternatives would remain about the same.

G.8.3 Uncertainties in Route Determination

Representative routes have been determined between all origin and destination sites considered in the EIS. The routes have been determined to be consistent with current guidelines, regulations, and practices, but may not be the actual routes that would be used in the future. In reality, the actual routes could differ from the representative ones concerning distances and total population along the routes. Moreover, since materials could be transported over an extended time starting at some time in the future, the highway infrastructures and the demographics along routes could change. These effects have not been accounted for in the transportation assessment; however, it is not anticipated that these changes would significantly affect relative comparisons of risk among the alternatives considered in the EIS. Specific routes cannot be identified in advance because the routes are classified to protect national security interests.

G.8.4 Uncertainties in the Calculation of Radiation Doses

The models used to calculate radiation doses from transportation activities introduce a further uncertainty in the risk assessment process. Estimating the accuracy or absolute uncertainty of the risk assessment results is generally difficult. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, or any computer code of this type, is the scarcity of data for certain input parameters.

Uncertainties associated with the computational models are reduced by using state-of-the-art computer codes that have undergone extensive review. Because many uncertainties are recognized but difficult to quantify, assumptions are made at each step of the risk assessment process intended to produce conservative results (i.e., overestimate the calculated dose and radiological risk). Because parameters and assumptions are applied to all alternatives, this model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, the results may not represent risks in an absolute sense.

Post accident mitigative actions are not considered for dispersal accidents. For severe accidents involving the release and dispersal of radioactive materials in the environment, no post accident mitigative actions, such as interdiction of crops or evacuation of the accident vicinity, have been considered in this risk assessment. In reality, mitigative actions would take place following an accident according to U.S. Environmental Protection Agency radiation protection guides for nuclear incidents (EPA 1991). The effects of mitigative actions on population accident doses are highly dependent upon the severity, location, and timing of the accident. For this risk assessment, ingestion doses are only calculated for accidents occurring in rural areas (the calculated ingestion doses, however, assume all food grown on contaminated ground is consumed and is not limited to the rural population). Examination of the severe accident consequence assessment results has shown that ingestion of contaminated foodstuffs contributes about 50 percent of the total population dose for rural accidents. Interdiction of foodstuffs would act to reduce, but not eliminate, this contribution.

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