PAGE TOC FIGURES TABLES PAGE

APPENDIX D Naval Spent Nuclear Fuel Management Part B

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laborartory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume 1
Appendix D
Part B
Naval Spent Nuclear Fuel Management
April 1995
U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

ATTACHMENT A - TRANSPORTATION OF NAVAL SPENT NUCLEAR FUEL

TABLE OF CONTENTS

LIST OF FIGURES

Figure No.	Title	
A-1	Transportation origins for naval spent nuclear fuel	A-3
A-2	Transportation origins and destinations for test speciman shipments	
A-3	M-130 shipping container mounted on railcar	A-15
A-4	M-140 shipping container mounted on railcar	A-1
A-5	M-160 shipping container mounted on railcar	A
A-6	NFS-100 cask mounted on truck	
A-7	Peach Bottom cask mounted on truck	
A-8	Large Cell cask	
A-9	NR/ATR cask mounted on truck	
A-10	WAPD-40 shipping container	A
A-11	NRBK-41 shipping container	

LIST OF TABLES

Table No. Title

ATTACHMENT A

TRANSPORTATION OF
NAVAL SPENT NUCLEAR FUEL

A.1 PURPOSE AND SCOPE

This attachment provides an evaluation of the radiological and non-radiologic with the transportation of naval spent nuclear fuel and test specimens that origina commercial shipyards, prototypes, and related Department of Energy laboratories. T all past shipments through May 1995 and shipments planned in the 40-year period frc the end of 2035. This attachment evaluates the radiological risks associated with described in Section 3.

A.2 BACKGROUND

The transportation of naval spent nuclear fuel and test specimens covered in into the following four categories:

- Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes
- Transfers of Naval Spent Nuclear Fuel to Storage Following Examination
- Transfers of Naval Test Specimen Assemblies Between the Examination Facili Reactor Area
- Shipments of Naval Test Specimens to Examination and Testing Facilities.

Each category is described in more detail below.

A.2.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and

Prototypes

Since 1956, spent nuclear fuel has been removed from Navy nuclear-powered shi as a routine part of their operational cycle. The spent nuclear fuel has been tran Core Facility (ECF) for examination and evaluation. ECF is part of the Naval React within the Idaho National Engineering Laboratory (INEL). The examinations of the s irradiated test specimens have provided and will continue to provide engineering da designs used in technology development for naval nuclear reactors.

In the past, shipments have originated from two prototype sites, nine shipyar Shippingport Atomic Power Station (SAPS), located in Shippingport, Pennsylvania. T locations are the Kenneth A. Kesselring Site (KSO), located in West Milton, New Yor Site Operation (WSO), located in Windsor, Connecticut. The nine shipyard locations Shipbuilding (NNS), located in Newport News, Virginia; the Norfolk Naval Shipyard (Portsmouth, Virginia; the Pearl Harbor Naval Shipyard (PHNS), located in Pearl Hark Portsmouth Naval Shipyard (PNS), located in Kittery, Maine; the Puget Sound Naval S located in Bremerton, Washington; the Charleston Naval Shipyard (CNS), located in C Carolina; the Mare Island Naval Shipyard (MINS), located in Vallejo, California; th Division of General Dynamics (EB), located in Groton, Connecticut, and Ingalls Shir located in Pascagoula, Mississippi. Figure A-1 provides a map of the United States transportation origins for naval spent nuclear fuel. No future shipments from the Ingalls Shipbuilding, and Shippingport Atomic Power Station facilities are planned. Naval Shipyard, Charleston Naval Shipyard, and Windsor Site Operations facilities a

The naval spent nuclear fuel has been shipped in M-130, M-140, M-160, and S2W containers. Only the M-130, M-140, and M-160 shipping containers will be used in t description of the shipping containers to be used for naval spent nuclear fuel shir prototype sites is provided in Section A.4.1.

Figure A-1. Transportation origins for naval spent nuclear fuel. The naval spent spurs to the sites are not available. Therefore, the shipping containers are trans transporter to a nearby commercial rail line where the containers are then transpor Harbor Naval Shipyard, the containers are transported by ship to the Puget Sound Na the containers are then transported to ECF by rail. Since 1956, 599 containers of

have been shipped to ECF. An additional 16 containers of spent nuclear fuel were s Shippingport Atomic Power Station to Hanford and 4 from ECF to Hanford); however, t covered by the DOE historic shipment calculations in Appendix I, Volume 1 of this E Statement. Table A-1 provides a list of these shipments made by year and originati

A.2.2 Transfers of Naval Spent Nuclear Fuel to Storage Following

Examination

In the past, following examinations at ECF, the spent nuclear fuel has been p transferred to the Idaho Chemical Processing Plant (ICPP), also located on the INEL description of the operations performed in the Expended Core Facility is provided i spent nuclear fuel is currently being held at ICPP until permanent disposition becc

Since 1956, approximately 5400 transfers of naval spent nuclear fuel have bee ICPP in shipping casks transported by truck dedicated to performing only such shipm For alternatives involving continued transfers to storage, the transfers would be m Peach Bottom, and Large Cell casks, in exclusive-use trucks. A detailed descriptic used for naval spent nuclear fuel transfers to storage is provided in Section A.4.2

A.2.3 Transfers of Naval Test Specimen Assemblies Between the

Examination Facility and the Test Reactor Area

In addition to naval spent nuclear fuel from ships and prototypes, irradiatec assemblies (fuel and non-fuel) have also been transported to ECF for examination. are constructed of plant materials, reactor structural materials, and fuels used in

Table A-1. Number of past naval spent nuclear fuel containers shipped to ECF by or

Year	Origin EB	SAPS	KSO	MINS	PHNS	PSNS	NNS	PNS	CNS	WS
1957	1									
1958			1							
1959	1							1		
1960										
1961	1	2	2							
1962	5			1	1					
1963		3		1	1					
1964	2	1	2							
1965	2	1		2			33	1	2	
1966	4	2		1	1			1		1
1967	2		1			2	8	3	3	
1968	2			4		4	2	3	2	
1969	8		2	3	1	2	4		2	
1970	4			7		2	32	2	2	
1971	4			2		8	4	2		
1972	2			4		2	2		4	
1973	2	1	1	2	1	6	4	2	2	
1974	2	1		6		6	2	3		
1975	2		1	4	1	4	2		2	1
1976	4		3	7			2	4	2	
1977				4	1	2	2	2	2	
1978		2		3	1	4	4		2	
1979				1		2			2	
1980				2		6	4	1	1	

Table A-1 (Cont).

Year	Origin EB	SAPS	KSO	MINS	PHNS	PSNS	NNS	PNS	CNS	WS
1981					1		4		3	
1982					1		6		3	
1983		3		2		6	4		2	1
1984		7			1	6	4	2		
1985						2	2	2	2	
1986				2	1	4	4	2	2	
1987				1		4		2	6	
1988				4	1	5		3	4	

1989				4	1	7		2	4	
1990			3	4		10	4	4	3	
1991				4	2	4		1	7	
1992			3	3	2	7			4	
1993					2	8	12			
1994 (1)			2	4		1	5		4	
1995 (1)				2		1				
TOTAL	48	23	21	84	20	115	150	43	72	3

EB = Electric Boat Division of General Dynamics
SAPS = Shippingport Atomic Power Station
KSO = Kenneth A. Kesselring Site Operations
MINS = Mare Island Naval Shipyard
PHNS = Pearl Harbor Naval Shipyard
PSNS = Puget Sound Naval Shipyard
NNS = Newport News Shipbuilding
PNS = Portsmouth Naval Shipyard
CNS = Charleston Naval Shipyard
WSO = Windsor Site Operations
NOR = Norfolk Naval Shipyard
INGL = Ingalls Shipbuilding
(1) Shipments in these years cover those authorized by the court injunction.

plants are tested and qualified to characterize their performance for the lifetime qualification program is to perform various irradiation tests of the materials for certification. Along with those tests are pre- and post-examinations that provide subsequent analysis of the material in question. This work is considered a fundame design and safe operation of naval reactor plants. Therefore, the transfers of tes the examination facility and shipments of the test specimens to the test facilities transportation evaluation. The test specimens have been assembled into test specim irradiated at the Test Reactor Area (TRA) on the INEL. The irradiated test specime returned to ECF for disassembly and examination.

Since 1956, approximately 3600 transfers of naval test specimen assemblies ha between ECF and TRA in shipping casks transported by exclusive-use truck. For alte future transfers of this type, the transfers would be made in the NR-1, ATR-2, NR-3 casks. A detailed description of the shipping casks used to transfer irradiated te provided in Section A.4.3.

A.2.4 Shipments of Naval Irradiated Test Specimens to Examination

and Testing Facilities

Following disassembly and examination of the test specimen assemblies at ECF, are shipped to off-site facilities for further testing or examination. These tests generally very specialized and ECF does not have the capability to perform them or in a timely manner due to other examination priorities. Specimens are also shippeć examination or further irradiation at TRA.

Test specimen shipments have been shipped to or from several laboratories anć They are the Bettis Atomic Power Laboratory (Bettis), located in West Mifflin, Penn Atomic Power Laboratory (KAPL), located in Niskayuna, New York; the Oak Ridge Natic (ORNL), located in Oak Ridge, Tennessee; the Argonne National Laboratory (ANL)-East Argonne, Illinois; the Battelle Memorial Institute, located in Columbus, Ohio; the Laboratories, located in Chalk River, Ontario, Canada (1 shipment only); the Hanfor Richland, Washington; and the ANL-West, Central Facilities Area (CFA), TRA, and ICP located on the INEL. Based on current schedules, Bettis and KAPL will be the only origins for future shipments. Figure A-2 provides a map of the United States transportation origins and destinations for the test specimen shipments.

Since 1956, approximately 850 shipments of naval test specimens have been mać and on- and off-site testing and examination facilities, in shipping containers tra truck. The shipments have been made in NRBK-41, -42, -43, and -44 shipping contain 39 and -40 shipping containers. For alternatives involving future shipments of thi would be made in the NRBK-41 and WAPD-40 shipping containers. A detailed descripti shipping containers used to ship irradiated test specimens between off-site facilit facility is provided in Section A.4.4.

A.3 ALTERNATIVES TO BE EVALUATED

A detailed description of the alternatives is provided in Section 3. The spe the four types of naval shipments (described in Section A.2) are described below fc

A.3.1 Alternative 1 - No Action

Under this alternative, after implementation, there would be no further shipm nuclear fuel from the shipyards and prototypes. The Expended Core Facility would b spent nuclear fuel would be stored at a facility at the site where it was removed c with the exception of naval spent nuclear fuel removed at Newport News Shipbuilding shipyard, which would be transported to Norfolk Naval Shipyard for storage. All na currently at ECF would be transferred to ICPP prior to the start of the 40-year per the fuel saved for future examinations, referred to as reference specimens. The re the naval spent nuclear fuel which originated at the prototype sites at NRF would b ICPP sometime during the 40-year period. The TRA facility would perform any work a assembly, disassembly, and routine examination of the test train assemblies; theref be required. Specimens shipped off-site would remain at the destination following A-2 summarizes the shipments for the No Action alternative.

Figure A-2. Transportation origins and destinations for test specimen shipment

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	None
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Spec Prototype Only
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	None
Shipments of Irradiated Test Specimens Between Off-Site Facilities and ECF	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.2 Alternative 2 - Decentralization

As described in Section 3.4, this alternative also involves storage of the na near the point of origin. An evaluation of each of the three subalternatives defin performed. The impact of the transportation related to each subalternative is brie

A.3.2.1 Alternative 2a - Store Naval Spent Nuclear Fuel at or Close to Locations Where Removed Without

Examination. From the standpoint of transportation, this subalternative is equival alternative.

A.3.2.2 Alternative 2b - Examine a Limited Amount of Naval Fuel in the Puget Sound Naval Shipyard Water

Pit Facility and Store All Naval Fuel at Navy Facilities. For this alternative, th Facility at NRF would be shut down and only high priority spent nuclear fuel would Puget Sound Naval Shipyard for examination. For the naval spent nuclear fuel, appr of the total spent nuclear fuel for the 40-year period would be shipped. Following would remain at Puget Sound Naval Shipyard. As in the No Action alternative, only specimens would remain at ECF after June 1995. Ten percent of the reference specim transferred from ECF to Puget Sound Naval Shipyard. The remainder of the reference naval spent nuclear fuel which originated at the prototype sites at NRF would be tr TRA facility would perform any work associated with the assembly, disassembly, and of the test specimen assemblies; therefore, no transfers would be required. Shipme off-site facilities for specialized examinations would continue. Test specimens sh

remain at the destination following examination. Table A-3 summarizes the shipment

Table A-3. Summary of shipments for the Decentralization - Limited Inspection alte

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to Puget Sound	Approximately of spent fuel
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Spec Prototype Only
Transfers of Naval Test Specimen Assemblies Between Puget Sound and TRA	None
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from TRA	Yes
- Shipments back to TRA	None

A.3.2.3 Alternative 2c - Examine All Naval Spent Nuclear Fuel at the INEL and Return to Navy Facilities

for Storage. For this alternative, all naval spent nuclear fuel would be shipped t has been in the past. Only non-destructive examinations would be performed. The s would be returned in the same condition as originally shipped. Following examinati returned to the originating shipyard or prototype site for storage in the same type exception that naval spent nuclear fuel which originated at Newport News Shipbuildi to Norfolk Naval Shipyard for storage. New equipment would have to be designed anc the spent nuclear fuel which returns to the shipyard. As in the No Action alternat specimens would remain at ECF after June 1995. The naval spent nuclear fuel which prototype sites at NRF (A1W and S5G) would be transferred to ICPP. Transfers of th specimen assemblies would continue, along with the shipments of test specimens from testing or examination facilities. Specimens shipped off-site would remain at the examination. Table A-4 summarizes the planned shipments for this alternative.

Table A-4. Summary of shipments for the Decentralization - Full Examination altern

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	To Norfolk frc
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	NRF Prototypes
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.3 Alternative 3 - 1992/1993 Planning Basis

This alternative plans on making the same types of shipments described in Sec attachment. The only difference is that some of the historical origins of naval sp destinations for the test specimen shipments will not be used. Table A-5 summarize shipments for this alternative.

Table A-5. Summary of shipments for the 1992/1993 Planning Basis alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	No
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Yes
Transfers of Naval Test Specimen Assemblies Between ECF and ATR	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	Yes

A.3.4 Alternative 4 - Regionalization

As described in Section 3.4, this alternative would distribute existing and n between various sites either on the basis of the fuel type or on the basis of divid eastern and western parts of the United States. An evaluation of each of the optic described in Section 3.4 was performed. The impact of the transportation related t alternative is briefly described below.

A.3.4.1 Alternative 4a - Regionalization Using Storage at Three Sites. From the standpoint of

transportation of naval spent nuclear fuel and test specimens, this alternative is Planning Basis alternative.

A.3.4.2 Alternative 4b - Regionalization Using Storage at Two Sites. This alternative would utilize an

existing DOE site in the eastern part of the United States and another existing DOE of the country for storage of spent nuclear fuel. From the standpoint of transport nuclear fuel and test specimens, this alternative is equivalent to the Centralizati DOE sites because the Navy would operate a facility for examining naval spent nucle the DOE sites and the naval spent nuclear fuel would be stored at the same site whe

A.3.5 Alternative 5 - Centralization

This alternative considers consolidating all naval spent nuclear fuel and tes INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site INEL is identical to the 1992/1993 Planning Basis alternative. For the other centr and number of shipments would be identical to the 1992/1993 Planning Basis alternat difference being the destination. The naval spent nuclear fuel will be shipped to examination and subsequently transferred to a storage facility at the centralizatic equivalent to ICPP. Naval spent nuclear fuel shipments from Newport News Shipbuilc Naval Shipyard would not be necessary. As in the No Action alternative, only refer remain at ECF after June 1995. All reference specimens would be shipped to the cen naval spent nuclear fuel which originated in the prototype sites at NRF would also centralization site. The test specimen assembly shipments would be shipped between alternate site. The test specimen shipments would originate at the centralization would ultimately return to that site for storage.

A.4 GENERAL DESCRIPTIONS

The following general information is common to all of the alternatives evalua

A.4.1 Spent Nuclear Fuel Shipping Containers

For naval spent nuclear fuel, the M-130, M-140, and M-160 shipping containers all alternatives. The shipping containers are primarily transported by railcars us part of general-use freight trains. Section A.2.1 describes the special circumstan containers are transported by ship or heavy-lift transporter. A brief description follows.

A.4.1.1 M-130 Shipping Container. The M-130 shipping container is a large, lead-lined, steel-shelled

shipping container that is transported in the vertical position on a depressed cent The major components of the M-130 shipping container include the shielded container dust cover. Module holders are installed inside the container to hold the irradiat and can be modified to accept different sized fuel modules. The container is shipp exception of a small amount of residual water. Cooling fins on the outside of the

dissipate the heat generated by the spent nuclear fuel.
Figure A-3. M-130 shipping container mounted on railcar. The M-130 shipping conta configuration. The container is approximately 13 feet tall and 7 feet in diameter. bottom cylindrical lead shell that is covered both on the inside and the outside wi steel. The lead on the cylindrical sides is about 10 inches thick and is a minimum the bottom. In the standard configuration, the closure head at the top of the cont constructed of 5.25 inches of lead and 7 inches of steel.

A.4.1.2 M-140 Shipping Container. The M-140 shipping container is a large, stainless steel shipping

container that is transported in the vertical position on a specially designed well The major components of the M-140 shipping container include the shielded container protective dome. Module holders are installed inside the container to hold the irr place and can be modified to accept different sized fuel modules. The container is exception of a small amount of residual water. Cooling fins on the outside of the dissipate the heat generated by the fuel.

The M-140 shipping container weighs approximately 375,000 pounds in the loade The container is approximately 16 feet tall with a maximum diameter of 10.5 feet. made from stainless steel forgings with 14-inch thick walls and a 12-inch thick bot and protective dome have a total thickness of 17.5 inches of stainless steel.

A.4.1.3 M-160 Shipping Container. The M-160 shipping container is a large, lead-lined, steel-shelled

shipping container that is transported in a horizontal position on a support struct flat bed railcar (Figure A-5). The major components of the M-160 shipping containe container, closure head, and dust cover. Module holders are installed inside the c irradiated fuel modules in place. The container is shipped dry with the exception residual water. Cooling fins on the outside of the container are designed to dissi the fuel.
Figure A-4. M-140 shipping container mounted on railcar. Figure A-5. M-160 ship The container is approximately 16.5 feet long and 6.5 feet in diameter. The contai concentric bottom closed steel cylinders with a 9.4-inch annulus between the cylind lead. The outer shell is made from 1.5-inch thick steel, and the inner shell is ma The bottom plate is approximately 7 inches thick, and the closure head is approxima

A.4.1.4 Government Escorts for Spent Nuclear Fuel. Commercial railroads, exclusive-use heavy-lift

transporters, or exclusive-use ships are used to transport the naval spent nuclear and shipyards. The specific routes used to transport the spent nuclear fuel are se shipping companies. All naval spent nuclear fuel shipments are accompanied by gove escorts perform the duties necessary to ensure the safe, expeditious transportation nuclear fuel.

The government escorts receive specialized training in shipment safety proced controls, security, and emergency response. Routine shipment escort procedures inv authorization and shipping documentation, pre-shipment inspections, tracking shipme schedules, enroute inspections, shipment observation and surveillance, and periodic checks. The government escorts have been trained to use and are equipped with the monitoring equipment to verify the shipping container integrity.

A large amount of the government escorts' training involves emergency respons involves emergency procedures for notification of technical and safeguards support government escorts are equipped to immediately notify emergency assistance personne assess the containment status of the shipping container, and communicate this infor support personnel. Depending on the situation, the technical and support personnel emergency control centers that are prepared to provide the government escorts with to quickly and safely bring an emergency situation under control. All railroads, w shipments, also have specific emergency response procedures to safely expedite recc that are involved in a rail line accident. Continually manned railroad operation c capability to contact personnel from a combination of resources which provide appro manpower at the accident scene.

A.4.2 Spent Nuclear Fuel Shipping Casks for Transfers to Storage

Following Examination

For naval spent nuclear fuel being transferred from the examination facility ICPP), the Nuclear Fuel Services Model 100 cask (NFS-100), Peach Bottom cask, and t will be used for all alternatives. These shipping containers are transported by ex description of each cask follows.

A.4.2.1 NFS-100 Cask. The NFS-100 cask is a large, lead-lined, steel-shelled shipping cask that is

transported in the horizontal position on a skid assembly attached to a tandem axle The major components of the NFS-100 cask include the shielded cask and closure heac insert is installed inside the cask to hold the irradiated fuel modules in place. with the exception of a small amount of residual water. The cask is enclosed on th during shipment.

The NFS-100 cask weighs approximately 110,000 pounds in the loaded configurat approximately 10.5 feet tall and 7 feet in diameter. The cask is a closed bottom c 0.375-inch thick steel inner shell and a 2-inch thick outer shell. The lead on the 8.75 inches thick and the lead on the bottom is 8.8 inches thick. The closure heac constructed of 9.75 inches of lead and 2 inches of steel.

A.4.2.2 Peach Bottom Cask. The Peach Bottom cask is a large, lead-lined, steel-shelled shipping cask that

is transported in the horizontal position on a skid assembly attached to a tandem a The major components of the Peach Bottom cask include the shielded cask and closure holding insert is installed inside the cask to hold the irradiated fuel modules in dry with the exception of a small amount of residual water. The cask is enclosed c cover during shipment.

Figure A-6. NFS-100 cask mounted on truck. Figure A-7. Peach Bottom cask moun cask is approximately 16 feet tall and 3.5 feet in diameter. The cask is a steppec 0.25-inch thick steel inner shell and a 1.75-inch thick steel outer shell. The lea ranges from 5.25 to 6.25 inches thick. The closure heads on each end of the cask a and are constructed of 8.5 inches of steel.

A.4.2.3 Large Cell Cask. The Large Cell cask, currently being designed for larger fuel types, will be a

large, stainless steel shipping cask that is transported in the vertical position c (Figure A-8). The major components of the Large Cell cask will include a shielded shipping cask, and external impact limiters. Fuel-holding inserts will be installe the irradiated fuel modules in place. The cask will be shipped dry with the except residual water. Cooling fins on the outside of the shipping cask are designed to c generated by the fuel.

The Large Cell cask will weigh approximately 220,000 pounds in the loaded con shielded cask will be approximately 14 feet tall and 7 feet in diameter. The shiel closed bottom cylinder made from stainless steel forgings with 13.5-inch thick wall bottom. The closure head will be a 14-inch thick stainless steel forging. The shi assembled to the shipping cask during transport. The shipping cask will be a 2-inc bottom cylinder with fins extending to a total diameter of 93.6 inches. The extern assemblies, located on both ends of the cask, will be constructed of encased bi-dir honeycomb and are approximately 10 feet in diameter. The total Large Cell cask hei approximately 17 feet.

A.4.2.4 Shipment Controls. All spent nuclear fuel transfers to a storage facility at the same site as the

examination facility will be accompanied by escorts. The escorts are personnel whc perform the duties necessary to ensure the safe transportation of the spent nuclear vehicles located in front of and behind the truck carrying the shipping cask.

The escorts receive specialized training in shipment safety procedures, radic security, and emergency response. The escort vehicles are equipped with distinctiv the escorts are capable of radio contact with each other, the driver of the transpc emergency coordinating personnel.

Figure A-8. Large Cell cask. A large amount of the escorts' training involves em

emergency procedures for notification of site technical and safeguards support pers equipped to immediately notify emergency assistance personnel, immediately assess t of the shipping cask, and communicate this information to emergency support personn the situation, the technical and support personnel may activate various emergency c equipped with the equipment and manpower to provide the escorts with the necessary and safely bring an emergency situation under control.

Additional administrative controls are imposed on the transfers to further mi example, the transfers are not allowed to travel during heavy traffic periods such convoy travels at reduced speeds. The route itself also enhances safety, since the and the highest possible drop distance in the event of an accident is approximately the location where the highway crosses a river bed.

A.4.3 Naval Test Specimen Assembly Casks for Transfers Between

TRA and the Examination Facility

For naval test specimen assemblies being transferred on-site between TRA and facility, the NR-1, ATR-2, NR-3, NR-4, and Test Train casks will be used. These ca exclusive-use truck. For off-site shipments to the examination facility at the cen Test Train cask will be used. A brief description of each cask follows.

A.4.3.1 NR and ATR Casks. The NR and ATR casks are large, lead-lined, steel-shelled casks that are

transported approximately 10y off horizontal in a cradle assembly attached to a tan A-9). The major components of the casks include the shielded body, mast, and bottc

The shielded bodies of the casks are all approximately 32 inches in diameter. thickness ranges from 0.5 inch to 1.0 inch. The thickness of the inner steel shell for each cask. The lead ranges from approximately 10 inches to 11 inches for the v height of the shielded body ranges from approximately 6 feet to 12 feet. The mast formed of reinforced aluminum and serves to support the structural end of the

Figure A-9. NR/ATR cask mounted on truck. specimen assemblies which require very cask. The bottom closure/shield is constructed of 1.0 to 1.75 inches of steel and

The NR and ATR casks range in weight from approximately 19,000 to 48,000 poun overall cask height ranges from approximately 20 to 30 feet.

A.4.3.2 Test Train Casks. A new test specimen container would be required to transport irradiated test

specimen assemblies between TRA and the examination facility located at the sites c Centralization alternative. A new cask is currently being designed to replace the transport the test specimen assemblies between ECF and TRA, which are approaching t design lifetime. The basic concept for this new cask is a thick-walled, stainless steel closures on each end. Energy absorbers will be attached to the cask to preve specimens. The current estimated size of this cask is 34 feet long by 5 feet in di approximately 40 tons. This cask would be shipped by exclusive-use truck.

A.4.3.3 Shipment Controls. All spent nuclear fuel transfers to an examination facility at the same site as

the irradiation facility will be accompanied by two escorts. The escorts are persc trained to perform the duties necessary to ensure the safe transportation of the sp escorts are in vehicles located in front of and behind the truck carrying the shipp

The escorts receive specialized training in shipment safety procedures, radic security, and emergency response. A large amount of the escorts' training involves This training involves emergency procedures for notification of site technical and personnel. The escorts are equipped to immediately notify emergency assistance per assess the containment status of the shipping cask, and communicate this informatic support personnel. Depending on the situation, the technical and support personnel emergency control centers that are equipped with the equipment and manpower to prov the necessary support to quickly and safely bring an emergency situation under cont vehicles are equipped with distinctive warning flashers, and the escorts are capabl each other, the driver of the transport vehicle, and emergency coordinating personn

Additional administrative controls are imposed on the shipments to further mi example, the transfers are not allowed to travel during heavy traffic periods such

convoy travels at reduced speeds. The route itself also enhances safety, since the
and the maximum possible drop in the event of an accident is from the bed of the tr
For the Centralization alternative, the casks would be shipped off-site. In
certified for over-the-road transportation in accordance with the Nuclear Regulator
regulations would be used for shipments of the test trains. No escorts or addition
would be used.

A.4.4 Test Specimen Shipping Containers

For test specimens, the WAPD-40 and NRBK-41 shipping containers would be usec
the specimens between ECF and the off-site laboratories and test facilities for all
shipping containers are transported by an enclosed truck using a commercial carrier
each container follows.

A.4.4.1 WAPD-40 Shipping Container. The WAPD-40 shipping container (Figure A-10) is a cylindrical,

lead-shielded, steel-clad container that is shipped in a horizontal position. The
inch thick, and the outer steel shell is 0.5-inch thick with 9.875 inches of lead s
container is approximately 13 feet long and 2 feet in diameter. Steel clad, lead-s
onto each end, and 0.5-inch thick plates are bolted over the end plugs. The specim
special sealed inner containers prior to placement into the WAPD-40 shipping contai
the container and skid assembly is approximately 28,000 pounds. The container and
mounted into a special holddown cradle on the truck. This holddown cradle weighs a
pounds.

A.4.4.2 NRBK-41 Shipping Container. The NRBK-41 shipping container (Figure A-11) is a cylindrical,

lead-shielded, steel-clad container that is shipped in the vertical position. The
thick, and the outer steel shell is 0.5-inch thick with 10 inches of lead shielding
has a 1-inch thick steel plate welded to the bottom with a second 1-inch thick stee
plate with a 0.125-inch deep recess to provide a thermal break for the
Figure A-10. WAPD-40 shipping container. Figure A-11. NRBK-41 shipping contain
provides a 0.125-inch air gap between the outer shell and the thermal shield. The
approximately 4 feet tall and 2.25 feet in diameter. The container is bolted to a
I-beam skid that is used to distribute the container load. The specimens are place
inner container prior to placement into the NRBK-41 shipping container. The weight
container is approximately 9,000 pounds.

A.4.5 Shipping Container Design Requirements

The M-130, M-140, M-160, NRBK-41, and WAPD-40 shipping containers have been c
and built to meet the regulations specified in Title 49, Code of Federal Regulation
entitled " Shippers - General Requirements for Shipments and Packagings" (CFR 1991)
naval spent nuclear fuel and test specimens are further regulated by Title 10, Code
Part 71 (10CFR71), entitled "Packaging of Radioactive Material for Transportation a
Radioactive Material Under Certain Conditions" (CFR 1993). These regulations requi
container to meet specific criteria under normal transport and accident conditions.
must be evaluated under free drop, puncture, heat, cold, pressure, water spray, and
conditions and a series of severe hypothetical accident conditions with the results
criteria provided in 10CFR71.

The M-130, M-140, M-160, WAPD-40, and NRBK-41 shipping containers have underg
rigorous engineering evaluations to assure compliance with 49CFR173 and 10CFR71 req
addition, actual scale model or mock-up tests have been performed to verify selecte
evaluations. This compliance has been certified by the U. S. Department of Energy
Regulatory Commission. The new Test Train and Large Cell casks will also be design
with the requirements of 49CFR173 and 10CFR71 and will undergo the same rigorous en
evaluations and testing.

The safety analyses for the NFS-100, Peach Bottom, NR, and ATR casks demonstr
with the requirements specified by the Department of Energy (DOE) in DOE Order 5480
"Safety Requirements for the Packaging and Transportation of Hazardous Materials, H
Substances, and Hazardous Wastes" (DOE 1985) and supplemented by DOE Idaho Operatic

Order ID 5480.3, entitled "Hazardous Materials Packaging and Transportation Safety (DOE 1991). These requirements are similar to the requirements of 10CFR71 with the being that a worst credible accident can be defined based on site-specific informat

The NFS-100, Peach Bottom, NR, and ATR casks have undergone rigorous engineer evaluations to assure compliance with the DOE requirements. In addition, actual sc tests have been performed to verify selected engineering evaluations. The shipping requirements of DOE 5480.3 and DOE ID 5480.3 and this compliance is demonstrated by the Idaho Operations Office of the Department of Energy.

A.5 TECHNICAL APPROACH - GENERAL

Several computer codes were used to assess the radiological risks associated transportation of naval spent nuclear fuel and test specimens. Specifically, the R model, developed by Sandia National Laboratories (Neuhauser and Kanipe 1992), was u the general population and transportation crew (occupational) radiological risks as transportation of radioactive materials. This computer code was used extensively i accident risk assessments. In some cases, other methods were more appropriate than computer code for naval spent nuclear fuel. In these cases, other calculational mc specifically identified.

The RISKIND computer code, developed by Argonne National Laboratory (Yuan et specifically analyzes radiological consequences and health risks to individuals frc with transportation. For incident-free evaluations, RISKIND uses a generic truck c adjustments for different sized casks which is not appropriate for naval spent nucl specimen casks; therefore, this code was not used. RISKIND (a version which accept isotopes) was found to be the best code for calculation of the maximum individual a consequences for the accident scenario and was used for that purpose.

Several other computer codes were used to provide input for the RADTRAN 4 and computer codes. The codes include INTERLINE, HIGHWAY, SPAN4, and ORIGEN2. A descr each computer code and how the code was used is provided below.

The INTERLINE computer code, developed by Oak Ridge National Laboratory (John 1993a), was used to evaluate the rail routes used for the spent nuclear fuel shipme

The HIGHWAY computer code, also developed by Oak Ridge National Laboratory (J 1993b), was used to evaluate the truck routes used for the test specimen shipments.

The SPAN4 computer code (Wallace 1972) was used to perform gamma exposure rat calculations for the various shipping containers to assess the effect of increased on exposure. SPAN4 is a point kernel code where appropriate exponential kernels ar source distribution. SPAN4 was developed by the Bettis Atomic Power Laboratory spe spent nuclear fuel.

The ORIGEN2 is a computer code, developed by Oak Ridge National Laboratory (C that is used to simulate radiation and decay of materials that are irradiated in a ORIGEN2 computer code is widely accepted in the public domain and was used to indep the fission product inventory for naval fuel developed using the standard Bettis At method. In addition, the standard Bettis Atomic Power Laboratory method has been u Analysis Reports for Packaging, reviewed and accepted by the Nuclear Regulatory Con

The radiological risks associated with the transportation of spent nuclear fu specimens have been assessed for the general population, transportation workers (oc hypothetical maximum exposed individuals under incident-free and accident condition presented in Section A.3. The maximum consequences for an accident are also provid alternative. The radiation exposure to the government escorts for shipments was cc in nature and was included with the transportation worker results.

The radiological impacts are first expressed as the calculated total exposure population, occupational workers, and the maximum exposed individuals. The calcula are then used to estimate the hypothetical health effects, expressed in terms of es The health risk conversion factors used in this evaluation are taken from the Inter Radiological Protection (ICRP Publication 60) which specifies 0.0005 fatal cancer c bers of the public, 0.0004 fatal cancer cases per person-rem for workers (ICRP 1991 estimated health detriment, the calculated exposure would be multiplied by the conv health detriments per person-rem for members of the public, and 0.00056 health detr

The numerical estimates of cancer deaths and other health detriments presente the practice of linear extrapolation from the nominal risk estimate for lifetime tc rad. Other methods of extrapolation to the low-dose region could yield higher or l estimates of cancer deaths. Studies of human populations exposed at low doses are demonstrate the actual level of risk. There is scientific uncertainty about cancer

below the range of epidemiologic observation, and the possibility of no risk cannot 1992). In this appendix, the doses have been provided in all cases to allow indepe any relation between exposure and health effects.

Non-radiological risks related to the transportation of naval spent nuclear f The non-radiological risks are associated with vehicle exhaust emission for inciden fatalities resulting from transportation accidents. The non-radiological risks ass return empty containers to the origin are also included. Risk factors for vehicle state-level accident fatality rates were obtained from "Non-Radiological Impacts of Radioactive Material" (Rao et al. 1982), "Transportation Impacts of the Commercial Management Program" (Cashwell et al. 1986), and "Longitudinal Review of State-Level Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994), respectiv

The shipments of radioactive waste at shipyards are not addressed. The expos incident-free transportation would be small and would be the same for all alternati affect the decision-making process. The consequences of an accident would also be compared to the accidents analyzed for spent nuclear fuel.

For the ocean-going portion of the shipments of naval spent nuclear fuel from prototypes, there would be no exposure to the general population. The basis for th ship's hull provides a considerable amount of additional shielding and that there w the general population close enough to the ship to receive appreciable exposure dur The consequences of an accident during the ocean-going portion have also not been e forces on the container during an accident aboard the ship would not be large enoug the container or fuel inside it since the ship itself would sustain the direct impa the fact that the impact forces to the container would be less than the regulatory release would occur.

A.5.1 Technical Approach for the Assessment of

Incident-free Transportation

For incident-free transportation of naval spent nuclear fuel, the RADTRAN 4 c used to calculate the radiologi-
cal exposure for the general population and a portion of the occupational exposure.

Included in the RADTRAN 4 computer code incident-free risk calculations for t models describing (1) exposures to persons (e.g., residents) adjacent to the transp exposures), (2) exposures to persons (e.g., passengers on passing trains or vehicle route (on-link doses), (3) exposures to persons at stops (e.g., residents or rail a involved with the shipment), and (4) exposures to transportation crew members (occu exposures calculated for the first three groups were added together to estimate the exposure estimates for rail and truck transport; the exposure calculated for the fc occupational exposure to the rail crew exposures during inspections and truck crew inspections. Table A-6 summarizes the calculational methods used for each group fc naval spent nuclear fuel and test specimens.

As shown in Table A-6, simple calculations were performed to account for situ RADTRAN 4 computer code was not the best calculational model with respect to the tr naval spent nuclear fuel. The information used in the simple calculations was base information. The results obtained using these simple calculations are expected to than any exposures which might actually occur.

The maximum possible radiological exposure to an individual for the routine t spent nuclear fuel and test specimens off-site was estimated for transportation wor of the general population. For rail shipments, the three general population scenar worker who might be working at a distance of 10 meters (32.8 feet) from the shippin hours, (2) a resident who might live 30 meters (98.4 feet) from the rail line

Table A-6. Calculational methods used to obtain exposures for population groups of

Shipment Type	Origin	Destination(a) a)	Mode	General Population	
				Off-Link and On-Link	S

Spent Nuclear Fuel to ECF or Equivalent	Kesselring Site	Ballston Spa	Truck	(1)	(
	Shipyard/Rail Siding	Various	Rail	(1)	(
	Windsor Site	Griffen Siding	Truck	(1)	(
	Pearl Harbor	Puget Sound	Ship	N/A	N
Spent Nuclear Fuel to Storage	ECF or Equivalent	Various	Truck	(1)	(
Test Specimen Assemblies	TRA	Various	Truck	(1)	(
Test Specimens	ECF or Equivalent	Bettis/ KAPL, etc.	Truck	(1)	(

Calculational Methods:
(1) RADTRAN 4 calculations.
(2) RADTRAN 4 rail calculations for inspection exposure and simple calculations b transportation data supplied by the government escorts for rail transit expos
(3) Simple calculation model based on truck transportation data supplied by site
(4) Simple calculation model based on ship transportation data supplied by Pearl
(5) Exposures based on historical TLD readings.
(6) Simple calculation model based on scenarios provided in RISKIND.
(a) The methods provided in this table apply to the destination for all the alter

where the shipping container was being transported, and (3) a resident who could be (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours and crew members from the rail, heavy-lift transporter, and ship were evaluated for workers (occupational). Based on records of past escorted rail shipments, the gove the same individual for as many as two-thirds of the shipments in a 5-year period. postulated to be the same individuals for all shipments in the 40-year period.

For off-site truck shipments, the three scenarios for the general population might be caught in traffic and located 1 meter (3 feet) away from the surface of th one-half hour, (2) a resident who might be living 30 meters (98.4 feet) from the hi the shipping container, and (3) a service station worker who might be working at a (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum expo radiological exposures were accumulated over the 40-year period. However, for the individual who might be caught in traffic next to a truck transporting spent nuclea exposures were only calculated for one event since it was considered unlikely that would be caught in traffic next to all containers for all shipments. For truck shi maximum exposed individual is the driver. For each of the categories of truck ship Sections A.4.2 through A.4.4, the calculations used a single individual as the driv in the past. For shipments in the 40-year period being evaluated, a single person calculations as the driver for all shipments of each category.

The hypothetical maximum exposed individual scenarios for the general populat above were not applicable for on-site shipments of naval spent nuclear fuel and tes reasons. The first is that there are no members of the general population in the v shipments. The second reason is that an obstruction, if encountered, would be safe direction of the escorts. Two alternate scenarios were developed. They were: (1) disabled vehicle along the transport route, located 10 meters (32.8 feet) from the employee trailing the slow-moving transport vehicle for the entire trip. These sce be single-event occurrences.

As noted in Table A-6, simple methods were also used to calculate radiologica radiological exposures to personnel at a fixed distance from the shipping container was used.

Exposures to personnel at a fixed distance from the container:
= N x NBA x T x SF x K x TI / D2

where:
N = number of people

NBA = factor to account for exposure decrease at increased distance from th (attenuation/buildup). (Refer to Neuhauser and Kanipe 1993.)
T = time
SF = shielding factor
K = transport index to exposure rate conversion factor
TI = transport index (see Section A.7.1.1.2)
D = distance from the centerline.

For the radiological exposures associated with the ship transport of spent nu Pearl Harbor Naval Shipyard to the Puget Sound Naval Shipyard, the following genera used:

Exposures to personnel aboard ship during transport:

= N x NBA x T x SF x K x TI x (1/(X1 + X2)2 + 1/X22)

where:

X1 = distance between the centerlines of the two shipping containers
X2 = distance between centerline of the nearest shipping container and the individual

Exposures to personnel aboard ship during inspections:

= (N x T x TI) + (N x NBA x T x K x SF x TI / (X1 - R - 1)2)

where:

R = effective radius to account for the exposure from the second shipping c

Table A-7 provides an estimate of the number of people included in the analys this number, the basic equation used was:

(Distance Traveled) x (Exposure Path Width) x (Density of People).

In each alternative, there are many shipments from several different origin/d combinations. Since the route would be the same for each shipment from the same or combination, the people along the route would also not change, therefore, the dista trip for each origin/destination combination. The exposure path width is 1.6 kilom with the RADTRAN 4 computer code methodology for incident-free calculations. The p was calculated by summing the product of the fraction of travel times the density i (rural, suburban, and urban). The fraction of travel and density were obtained frc INTERLINE. The total number of people was then calculated by summing the results c origin/destination combinations for each alternative.

Table A-7. Estimated number of people included in incident-free transportation ana

Alternative	Number of Peop
No Action	890,000
Decentralization - No Examination	890,000
Decentralization - Limited Examination	9,240,000
Decentralization - Full Examination	6,820,000
1992/1993 Planning Basis	7,290,000
Regionalization or Centralization at INEL	7,290,000
Regionalization or Centralization at Hanford	8,370,000
Regionalization or Centralization at Savannah River	6,950,000
Regionalization or Centralization at Oak Ridge	5,660,000
Regionalization or Centralization at Nevada Test Site	8,320,000

A.5.2 Technical Approach for Transportation Accidents

The RADTRAN 4 computer code was used to calculate the radiological risk to th population and transportation (occupational) crew under accident conditions. The R code evaluates six pathways for radiation exposures resulting from an accident. Th are:

- Direct Radiation Exposure from the Damaged Container
- Inhalation Exposure from the Plume of Radioactive Material Released from t Container
- Direct Radiation Exposure from Immersion in the Plume of Radioactive Mater from the Damaged Container
- Direct Radiation Exposure from Ground Deposition of the Radioactive Materi from the Damaged Container

- Inhalation Exposure from Resuspension of the Radioactive Material Deposite Ground
- Ingestion Exposure from Food Products Grown on the Soil Contaminated by Gr Deposition of Radioactive Material Released from the Damaged Container.

For each pathway, a specific formula is used to determine an estimate of the expressed in exposure, from that particular pathway with the total radiation exposu the exposure for each pathway. The total accident radiation exposure accounts for accident occurring and the probability of an accident of a particular severity. It consequences are included in the risk assessment, regardless of the probability. T the population exposure from all pathways is:

DR = -c,r (Nc x Lr,c x Pr x -i,j,k (Pj x RFj x Di,j,k))

where: DR = population exposure from the accident
Nc = number of naval spent nuclear fuel modules shipped of fuel type c
Lr,c = shipment distance for fuel type c shipped through state r
Pr = frequency of traffic accidents
Pj = probability of occurrence of accident severity category j
RFj = fraction of curies released from shipping container by severity categ
Di,j,k = radiation exposure resulting from accident severity category j throu population density zone k.

The accident risk evaluation was performed using neutral and stable atmospher (Pasquill Stability Classes D and F, respectively). The neutral atmospheric condit estimate of the risk. Stable atmospheric conditions resulted in values approximate conditions, ignoring the lower probability of occurrence.

In addition to the estimation of the radiological risk of an accident describ of the consequences of an accident of the highest severity was performed. The cons radiological exposure, are calculated for the maximum exposed individual and the ge Exposures to the general population were calculated for each of the three populatic suburban, and urban). The maximum exposed individual was placed in the population in the highest exposure.

The RISKIND computer code, modified by its authors to accept the fission proc unique to naval spent nuclear fuel, was used to calculate the maximum consequences. evaluated by RISKIND are identical to those used in the RADTRAN 4 computer code for evaluation.

The maximum consequence evaluation presents the consequences for design basis defined as those accidents which have a probability of greater than 1 x 10y6 per y basis accidents, defined as those which have a probability of 1 x 10y6 to 1 x 10y7 probability of less than 1 x 10y7 were not analyzed in the maximum consequence eval

To determine the overall probabilities, the probability of an accident, the p quences, fraction of travel in each population area, and probability of the meteorc be determined.

The probability of the accident was calculated by multiplying the accident ra times the distance traveled in each state times the number of shipments. The resul combination of origin and destination for the alternative.

As described later in Section A.7, a study performed by Lawrence Livermore Na ry
entitled "Shipping Container Response to Severe Highway and Railway Accident Condit 1987) grouped accidents into categories by strain and container mid-wall temperatur probabilities of accidents of each category. Section A.7 also describes the conseq each accident category for the naval spent nuclear fuel and test specimen shipments were summed for the categories which have the same consequences.

The fraction of travel in each population area (rural, suburban, and urban) w INTERLINE and HIGHWAY for each origin/destination combination. Each alternative cc shipments from various origin/destination combinations; therefore, an overall fract overall fraction, by alternative, was calculated by multiplying each origin/destina INTERLINE and HIGHWAY) by the number of shipments from that particular origin/desti combination, summing the results and dividing by the total number of shipments.

To calculate the probability of the meteorological conditions, Pasquill Class be equivalent to 50% meteorology; that is, 50% of the time, conditions are expected 50% of the time, conditions are expected to be less severe. Pasquill Class F was c equivalent to 95% meteorology; that is, 5% of the time, it is more severe, and 95%

severe. Since the difference in 50% (1 chance in 2) and 95% (1 chance in 20) is a probability of encountering Pasquill Class F was concluded to be a factor of 10 les Analyses performed by the National Oceanic and Atmospheric Administration (Doty et that this assumption is reasonable.

The overall probability of the consequence of an accident for each population calculated by multiplying the accident probability times the consequence probabilit distance traveled. Starting with the highest consequences, the probabilities were 1 x 10y6 per year criterion for the design basis accidents and 1 x 10y7 per year cr design basis accidents. If the probability was greater than 10 times the criterion most severe Pasquill Class F results were presented. If not, and the probability w criterion (1 x 10y6 or 1 x 10y7), Pasquill Class D was presented. If the probabili the probabilities having the next most severe consequences were compared to the sam step was repeated until all consequences were evaluated. As a minimum, the consequ release of 1% of the corrosion products (Pasquill Class D) were presented.

Careful attention was paid to ensure that the probabilities were not calculat categories that the resulting probabilities were less than the criterion and result present less severe consequences. When the highest consequence accident did not me probability of the next highest accident was determined by summing both the acciden evaluated and the probability of the higher consequence accidents previously shown less than the criterion. This same technique was applied to the fraction of travel equivalent to highest consequence, suburban fraction is next highest, etc.) as demc example.

Probability of the accident of Consequence A	-	1.17 x 10y7
Fraction of distance traveled in rural area	-	0.85
Fraction of distance traveled in suburban area	-	0.11
Fraction of distance traveled in urban area	-	0.04

The urban fraction was multiplied by the probability, and the resultant proba Consequence A in an urban area was 4.68 x 10y9. The consequences of this accident evaluated. For the suburban area, the suburban and urban fractions were added and probability (1.75 x 10y8). Again, the consequences of this accident would not be e probability is less than 1 x 10y7. Likewise, for the rural area, the rural, suburb added and multiplied by the probability. Using this technique, the probabilities w probability was 1.17 x 10y7, which is greater than the 1 x 10y7 criterion and the C would be presented. If the fractions were used at face value, however, the probabi Consequence A would have been 4.68 x 10y9 in an urban area, 1.29 x 10y8 in a suburb in a rural area. When individually compared to the 1 x 10y7 criterion, this accide presented for any area.

Accident results are presented for both the maximum exposed individual and th population. These results include members of the transportation crew.

A.6 ROUTING ANALYSIS

In order to assess the radiological risks associated with transportation, it determine route characteristics based on the origin and destination of each shipmen

For naval spent nuclear fuel shipments, the origin is the prototype or shipya naval spent nuclear fuel is removed from a prototype or shipboard reactor. The des Savannah River Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, or Puge Shipyard, depending on the alternative. For each origin and destination pair, the been generated and analyzed using the INTERLINE computer code (Johnson 1993a). For originating from Pearl Harbor Naval Shipyard, the containers travel by ship to Puge Shipyard, where they are transferred to rail for shipment to the destination follow naval spent nuclear fuel shipments originating from Puget Sound Naval Shipyard. Th time by ocean was based on historical data on the time in transit, independent of t heavy-lift transporter shipments from the Kesselring and Windsor prototype sites tc the actual street routes and shipment duration times based on previous shipments we

INTERLINE is an interactive computer program designed to simulate routing usi system. The INTERLINE code used is the latest available from Oak Ridge National La contains the 1990 census data. The INTERLINE data base consists of networks repres competing rail companies in the U.S. The routes used for the transportation evalua INTERLINE model which simulates the selection procedure that railroad companies wou shipments of spent nuclear fuel. The code is updated periodically to reflect curre has been benchmarked against reported mileages and observations. INTERLINE also pr weighted population densities for rural, suburban, and urban populations for each s

all states along the shipment route and the percentage of mileage traveled in each distance traveled, weighted population density, and percentage of distance in each input variables in the RADTRAN 4 code.

For the off-site transportation of the test specimen assemblies and test spec made by exclusive-use truck which includes no other freight. The destinations are Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, Puget Sound Naval Ship Power Laboratory, and Knolls Atomic Power Laboratory for the various alternatives. destination pair, the potential truck routes have been generated and analyzed using HIGHWAY.

HIGHWAY is an interactive computer code designed to simulate routing using th system. The HIGHWAY code used for this report is the latest available from Oak Rid Laboratory. The code is updated periodically as new roads are added. HIGHWAY prov between the origin and destination, the weighted population densities along the rou of distance traveled in each population density, all input variables for the RADTRA

For the on-site transportation, HIGHWAY only has two of the sites on the INEL origin/destination pair was run using HIGHWAY to determine the population densities travel in each population density. The actual distance between sites on the INEL w

A.7 INPUT PARAMETERS

The major input parameters and models used to evaluate the radiological risks five alternatives described in Section A.3 are provided in this section. Standard code values, as well as actual data gathered from historical naval spent nuclear fu shipments, were used as the basis for the input parameters. For those situations w available, the actual data were used in place of the standard RADTRAN 4 computer cc the best estimate of the radiological risks associated with each alternative.

A.7.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and

Prototypes

A.7.1.1 Incident-free Transportation of Spent Nuclear Fuel from Shipyards and Prototypes. This

section provides the input parameters used to determine the radiological impacts as routine, incident-free (i.e., no accident) transportation of spent nuclear fuel for

A.7.1.1.1 Planned Shipments. The list of planned shipments of naval spent nuclear fuel by origin

is provided in Table A-8.

Table A-8. Planned shipments of naval spent nuclear fuel from shipyards and protot

Alternative	Generating Site East Coast	West Coast	NRF	TOTAL
No Action, Decentralization - No Exam	204	0	0	204
Decentralization - Limited Exam	53	0	1	54
	181	0	0	181
	234	0	1	235
Decentralization - Full Exam	314	261	0	575
	314	261	0	575
	628	522	0	1150
1992/1993 Planning Basis, Regionalization at INEL and Centralization at INEL	314	261	0	575
All other Regionalization and Centralization Alternatives	314	261	3	578

A.7.1.1.2 Transport Index. Historical information from prior shipments was used to estimate the

expected external radiation exposure rates for future shipments. This information measured radiation levels and the recorded Transport Indexes (TIs) from past shipme this analysis is the sum of the maximum neutron and gamma radiation measured at 1 m the surface of the cask. The TIs that were used ranged from 0.1 to 1.8.

A.7.1.1.3 Transportation Distances and Population Densities. Section A.6 provided a

description of the general methodology used for determining transportation distance densities along the transportation routes. Historical data were obtained on the di shipments from the shipyards and prototype sites to ECF. These data were averaged compared to the value calculated by INTERLINE. The actual data were approximately the distance predicted by INTERLINE on average. In order to provide the best estin based on the distance traveled, the INTERLINE distances were increased by 11% for t Planning Basis alternative. One of the primary reasons the actual distances travel longer than the INTERLINE prediction was the escort responsibility to avoid potenti or security problems. The shipments to the alternative sites will also be escorted increased travel distance is expected. The 11% increase in distance traveled was a alternatives. This technique allowed for comparison of the alternatives on an equa of distance traveled in each population density calculated by INTERLINE were applie increased by 11%.

A.7.1.1.4 Train Speed. The RADTRAN 4 computer code provides standard values for train

speeds that are dependent on the population density. For rural areas, the standard per hour (40 miles per hour (mph)). For suburban areas, the standard value is 40.2 mph), and for urban areas, the standard value is 24.1 kilometers per hour (15 mph). nuclear fuel shipments are required to be transported at speeds not to exceed 56.3 mph). Government escort logs from historical spent nuclear fuel shipments support per hour (15 mph). This 24.1 kilometers per hour (15 mph) train speed estimate was five alternatives.

A.7.1.1.5 Train Stop Time. The RADTRAN 4 computer code provides standard values for train

stop times that are either dependent or independent of the distances traveled. For transported by rail, the government escorts are responsible for ensuring that the s most efficient and safe manner. The government escort logs for historical spent nu were reviewed, and actual stop times were determined to be much shorter than the st computer code values. The recorded stop times were divided by the actual distance historical data over the last 3 years and an average of 0.02 hour per kilometer (0. calculated. This value was used to evaluate all five alternatives since the rail t nuclear fuel will always be accompanied by government escorts and all alternatives same locations.

A.7.1.1.6 Number of Train Crew Members. The standard RADTRAN 4 computer code value for the

number of train crew members is five. For all shipments to NRF, all rail companies Burlington Northern have two crew members during shipments, located in the locomoti Northern adds a third crew member in a caboose immediately behind the government es the RADTRAN 4 computer code, exposure to the crew members is not calculated since t crew members is large. In actuality, the distance to the Burlington Northern crew caboose is less than that used in the RADTRAN 4 computer code and therefore simple performed to determine the radiological exposure. In addition, naval spent nuclear shipped periodically by "special train." In the special train configuration, the t locomotive are one car from the railcar with the shipping container. Historically, approximately 42 percent of the time. The majority of shipments by "special" train railroad companies to meet railroad schedules. On occasion, the Navy requests "spe shipments with high-priority examination material. Simple calculations were also p the radiological exposure during these special shipments. For shipments to the sit was no experience with all railroad companies which would have to be used; however, expect the rail companies to change their standard practices. In these cases, ther

crewmen, both located in the engine area. Forty-two percent of the shipments woulc train to the alternate sites. When applicable, the third Burlington Northern crew accounted for.

A.7.1.1.7 Transport Index to Exposure Rate Conversion Factors. Container transport index to

exposure rate conversion factors for the M-130 and M-140 shipping containers were c standard equation in the RADTRAN 4 computer code. The results were compared to det analyses performed using SPAN4, and the RADTRAN 4 results were found to overestimat by a factor of two to three. Using the SPAN4 computer code results, the effective the containers used in the RADTRAN 4 calculations were adjusted to provide a conser realistic value of the transport index to exposure rate conversion factor. Due to construction and fuel shipped, the M-130 conversion factor was applicable to the M- are provided in Table A-9.

Table A-9. Transport index to exposure rate conversion factors for the M-130, M-14 shipping containers.

Container	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
M-130/M-160	2.50 (8.2 feet)	5.06
M-140	3.20 (10.5 feet)	6.76

A.7.1.1.8 Train Stop Shield Factors. For train stops, the standard RADTRAN 4 computer code

gamma and neutron radiation shield factors are both assigned as 0.1. This value in substantial railyard steel structures equivalent to approximately 4 inches of steel reduces gamma radiation by more than a factor of 10; however, the steel only reduce a factor of approximately 2. Therefore, a shield factor of 0.5 was conservatively radiation. In order to incorporate this shielding into the RADTRAN 4 computer code neutron radiation exposure calculations were performed. However, since RADTRAN 4 c separate shielding factors to be used for different types of radiation, the stop ti evaluations were increased by a factor of 5 to provide an equivalent increase in ne more realistic changes to the standard RADTRAN 4 computer code values were incorpor alternatives.

A.7.1.1.9 Radiation Exposure Decrease Due to Distance. The RADTRAN 4 computer code

provides standard values for determining the gamma and neutron radiation exposure c distance from the source. For gamma radiation, the RADTRAN 4 computer code uses th due to distance. The RADTRAN 4 computer code also specifically calculates the decr exposure at increased distances. The adequacy of the RADTRAN 4 radiation exposure evaluated. The gamma radiation decrease factor used by RADTRAN 4 was consistent wi predicted for naval fuel. The RADTRAN 4 prediction for neutron radiation slightly decrease in exposure at far distances for the shipping containers used for naval sh basic equation used by RADTRAN, a value of 2.0 x 10y10 was used for the RADTRAN 4 c lieu of 0. The value of 2 x 10y10 produces results which are slightly higher than agree with measurements of neutron exposure rates from naval spent nuclear fuel shi

A.7.1.1.10 Shipment Storage Time. As noted previously, the government escorts accompanying

the rail shipments of spent nuclear fuel are responsible for ensuring that the nava shipments are made in the most efficient and safe manner. Naval spent nuclear fuel being shipped; therefore, there was no intermediate shipment storage time associate alternatives. There is also no intermediate storage time during the heavy-lift tra prototype sites and the ocean shipments from Pearl Harbor Naval Shipyard.

A.7.1.1.11 Heavy-lift Transporter Transportation Crew. Information from records of naval

spent nuclear fuel shipments was reviewed to determine a realistic estimate of the involved, the amount of time required, and the distances between individuals and th The number of hours worked ranged from 1 to 10 and the distance from the container

91 meters (5 to 300 feet). For simplicity, weighted averages of the number of hour shipping container were calculated and are provided in Table A-10.

Table A-10. Summary of the number of people involved and distance from the contain heavy-lift transporter shipments to the rail siding at the prototype sites.

Prototype	Number of People	Number of Hours per Worker	Dista the S (mete
Windsor Site	37	5.08	25.0
Kesselring Site	36	5.11	32.3

This information was used to evaluate all five alternatives.

A.7.1.1.12 Time to Ship by Heavy-lift Transporter. Based on discussions with personnel at the

prototype facilities who have made shipments and a review of records, the average d lift transporter shipment from the prototype sites to the local rail siding is 2 hc

A.7.1.1.13 Number of Heavy-lift Transporter Inspections. The shipments are inspected prior to

leaving the prototype's site boundaries, and no additional inspections are performe lift transporter shipment. As a result, there are no inspections during the heavy- the evaluation of the five alternatives.

A.7.1.1.14 Heavy-lift Transporter Stop Time. Shipments of spent nuclear fuel from the two

prototype locations are first transported by heavy-lift transporter to the nearest from records of naval spent nuclear fuel shipments was reviewed to determine a real heavy-lift transporter stop times. For naval spent nuclear fuel heavy-lift transpc Windsor Site, a heavy-lift transporter stop time of 24 hours was used. For heavy- from the Kenneth A. Kesselring Site, a stop time of 10 hours was used. The heavy-l shipments from the prototypes to the rail sidings occur through suburban populatior lift transporter stop times were used to evaluate all five alternatives.

A.7.1.1.15 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4

computer code value was reviewed and determined to reflect the best estimate of cur practice:

- Number of Inspections of the Shipping Container and Railcar.

The following standard RADTRAN 4 computer code estimates of the populations t affected by the shipment of spent nuclear fuel were also used for the five alterna- tives:

- Number of People per Vehicle Sharing the Transport Route (On Link)
- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones
- Average Exposure Distance When Stopped
- Persons Exposed While Stopped
- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.1.1.16 Number of Ship Inspections. Shipments of spent nuclear fuel from Pearl Harbor

Naval Shipyard must first be transported by ship to the Puget Sound Naval Shipyard. values in the RADTRAN 4 computer code, the radiological exposures to the crew and g are negligible since the distances from these individuals to the shipping container the radiological exposure estimates are only expected to occur during inspections. monitoring results for past naval spent nuclear fuel shipments, this is not realist fuel, and a separate calculational model was developed to account for this potentia

The model uses the standard point source formula (see Section A.5.1) to calculate t ment escort exposures during transport by ship. The model took into account the sh index, transport time, distance between shipping containers, distance from the ship living quarters, distance from the shipping containers and the engine room, the num and government escorts, and the time required for inspections based on records from of spent nuclear fuel. After reviewing historical shipment records, it was determi sized ships have recently been used. The smallest one, Ship 1, was used once and i used in the future. Only the other two, Ships 2 and 3, would be used in the future Table A-11 below provides the information used to calculate the radiological exposu transporting naval spent nuclear fuel by ship. This model was used to evaluate all

Table A-11. Parameters used to calculate crew and escort exposure during ocean tra Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard.

Parameter	Ship 1	Ship
Transport Time, T, in days	11	8
Separation Between M-130s, X1, in feet	92	43
Nearest Distance to Living Quarters, X2, in feet	40	80
Nearest Distance to Engine Room, X3, in feet	20	80
Number of Crew Members, Nc	11	22
Number of Government Escorts (not part of crew size), Ne	2	2
Escort Inspection Time (per Escort), in hr/day	0.50 for histo 0.25 for futur	
Shielding Factor	(1/3) for gamm every 40-foot centerline	

A.7.1.2 Accident During Transportation of Spent Nuclear Fuel. This section provides the input

parameters used to calculate the radiological impacts for accidents during transpor fuel for evaluation of the five alternatives. The planned shipments, transportatic densities, and the percentages of travel in each population density described in Se used for the accident analyses. Unless otherwise described in this section, the st the RADTRAN 4 and RISKIND computer codes were used.

A.7.1.2.1 Accident Probability. The probability of a rail accident used for evaluation of all

alternatives was obtained from "Longitudinal Review of State-Level Accident Statist Interstate Freight" (Saricks and Kvitek 1994). The probabilities are provided both average. The state dependent probabilities were used for the accident risk assessm nuclear fuel shipments have traveled approximately 2 million kilometers (1.24 milli without an accident, which is consistent with the national average of 5.57 x 10y8 a

A.7.1.2.2 Accident Severity Categories and Probabilities. In the "Shipping Container

Response to Severe Highway and Railway Accident Conditions" (NUREG 1987), referred "Modal Study," Lawrence Livermore National Laboratory categorized the potential dam containers according to the magnitude of the thermal and mechanical forces that cou accident. The structural and thermal forces were categorized into 20 regions. Giv occurs, the probability that the accident would be in each region was calculated fc shipments. Table A-12 provides the probabilities for rail accidents by region.

Table A-12. Accident severity probabilities for rail shipments.

	R(4,1) 1.786 x 10y9	R(4,2) 3.290 x 10y13	R(4,3) 2.137 x 10y13	R(4,4) 1.644 x 10y1
S3 (30)	R(3,1) 5.545 x 10y4	R(3,2) 1.0217 x 10y7	R(3,3) 0.634 x 10y8	R(3,4) 5.162 x 10y8
S2 (2)	R(2,1) 2.7204 x 10y3	R(2,2) 5.011 x 10y7	R(2,3) 3.255 x 10y7	R(2,4) 2.531 x 10y7
S1 (0.2)	R(1,1) 0.993962	R(1,2) 1.2275 x 10y3	R(1,3) 7.9511 x 10y4	R(1,4) 6.140 x 10y4
				T4 (1050)

Thermal Response (lead mid-thickness temperature, yF)

A.7.1.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and

thermal analyses were performed for the shipping containers used for naval spent nu up to an equivalent strain of 30% and mid-wall temperature of 1050yF. For these ca nuclear fuel was not damaged. For the thermal and structural regions above 1050yF modal study defines the upper limits as unbounded. The naval spent nuclear fuel wa damaged and the fission products and corrosion products would be released in the qu Table A-13 for the risk analyses.

A.7.1.2.4 Release Fractions. The release fractions were derived based on the results presented

in the NRC modal study (NUREG 1987) and the results of the structural and thermal a above. Although the naval spent nuclear fuel is stronger, the release fractions fc (BWR), pressurized water reactor (PWR), and aluminum-clad fuel from the modal study the modal study, the release fraction in lower left region R(1,1) is zero for the r maximum consequence evaluation, 1% of the corrosion products might be released for region, R(1,1). Based on the results of the structural and thermal analyses up to mid-wall temperature, the naval spent nuclear fuel is not damaged; therefore, regic R(2,1), R(2,2), R(2,3), R(1,4), R(2,4), R(3,4), R(3,1), R(3,2) and R(3,3) do not re Ten percent of the corrosion products might be released. In the remaining regions, products might be available for release and released at the fractions specified bel 10% of the corrosion products. Table A-13 provides the release fractions used.

Table A-13. Cask release fractions used for the RADTRAN 4 risk analyses.

	Release Fractiona			
Cask Response Region	Inert Gas	Iodine	Cesium	Ruthenium
R(1,1)	0.0	0.0	0.0	0.0
R(1,2), R(1,3)	0.0	0.0	0.0	0.0
R(2,1), R(2,2), R(2,3)	0.0	0.0	0.0	0.0
R(1,4), R(2,4), R(3,4)	0.0	0.0	0.0	0.0
R(3,1), R(3,2), R(3,3)	0.0	0.0	0.0	0.0
R(1,5), R(2,5), R(3,5) R(4,5), R(4,1), R(4,2) R(4,3), R(4,4)	6.3 x 10y1	4.3 x 10y2	2.0 x 10y3	4.8 x 10y4

a The release fraction represents the fraction of the fuel inventory available for that would be released into the atmosphere following an accident of the given sev

A.7.1.2.5 Plume Release Height. For the accident risk assessment, a ground level release was

used. For the maximum consequence assessment, a plume release height of 10 meters used.

A.7.1.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the

accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the cc used.

A.7.1.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to

naval spent nuclear fuel in accordance with the methods described in Nuclear Regula Guide 1.109 (NUREG 1977).

A.7.1.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding

was accounted for as the plume passes for the calculation of the exposure to the ma location was determined using RISKIND based on the atmospheric stability and plume The maximum exposed individual could be a member of the rail crew or the general pc

A.7.1.2.9 RISKIND Population Density. The standard national average for each population

density from the RADTRAN 4 computer code was used for the RISKIND maximum consequen assessment (6 people per square kilometer for rural, 719 for suburban, and 3861 for

A.7.1.2.10 Radionuclide Inventory. The amount of radionuclides which would be released from

an average shipment are provided in Table A-14. The values factor in the damage fr Section A.7.1.2.3 and release fractions described in Section A.7.1.2.4. The radion 99 percent of the exposure in all pathways.

Table A-14. Radionuclides which would be released from an average shipment of nava nuclear fuel from a shipyard or prototype.

For Accidents which Release Both Fission and Corrosion Products		For Accidents which Release Corrosion Products
Nuclide	Activity (Ci)	Nuclide
Kr-85	9.85 x 102	Co-58
Cs-134	3.72 x 101	Mn-54
Cs-137	3.44 x 101	Fe-55
H-3	1.39 x 101	Co-60
Ru-106	9.02 x 10y1	Sr-90
Ce-144	4.89 x 10y1	Ni-63
Co-60	3.63 x 10y1	
Sr-90	3.41 x 10y1	
Pu-238	1.02 x 10y2	
Pu-241	3.43 x 10y3	
Cm-244	1.36 x 10y4	

A.7.2 Transfers of Naval Spent Nuclear Fuel to Storage Following

Examination

A.7.2.1 Incident-free Transportation of Naval Spent Nuclear Fuel to Storage. This section provides the

input parameters used to determine the radiological impacts associated with the rou no accident) transportation of naval spent nuclear fuel to storage for each of the

A.7.2.1.1 Planned Shipments. Table A-15 provides the number of planned transfers in each cask.

Table A-15. Planned transfers of naval spent nuclear fuel to storage.

	NFS-100	Peach Bottom	Large Cell
No Action,	0	0	15
Decentralization - No Exam,			
Decentralization - Limited Exam			
Decentralization - Full Exa0		0	14
1992/1993 Planning Basis,	196	64	468
All Regionalization Alternatives,			
All Centralization Alternatives			

A.7.2.1.2 Transport Index (TI). A TI of 0.3 was used for all NFS-100 cask transfers. This value

was determined from recorded measurements over the last 3 years for the same fuel t transferred in the future. The Peach Bottom and Large Cell casks have not previous planned transfers and therefore historic data were not available. Based on a compa values from conservative safety analyses to the actual measured TI's for similar ca of 1.0 was calculated for both the Peach Bottom and Large Cell casks.

A.7.2.1.3 Transportation Distances and Population Densities. Section A.6 provided a

description of the general methodology used for determining transportation distance densities along the transportation routes. The distance between ECF and ICPP is 9. From the HIGHWAY computer code, the transfer of naval spent nuclear fuel to storage area. As stated in Section A.3.5, the storage facility at the alternative sites wa Therefore, for the evaluation of the alternatives, the distance traveled and popula ICPP transfer were also used for the evaluation of the other alternatives.

A.7.2.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a

rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasc credible accident is less severe than the 10CFR71 hypothetical accident is that the by the on-site transportation procedures. An average speed of 24.1 kilometers per was used.

A.7.2.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck

stop times that are either dependent or independent of the distances traveled. The transfers of naval spent nuclear fuel to storage were reviewed, and it was determin times (10 minutes) were much shorter than the standard RADTRAN 4 computer code valu of 10 minutes was used to evaluate all five alternatives.

A.7.2.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to

distance described in Section A.7.1.1.9 was also applied to the truck transfers of storage.

A.7.2.1.7 Distance from Source to Crew. A distance of 6.1 meters (20 feet) was measured

between the shipping cask and the driver for the exclusive-use truck transfers of n shipments to storage. Two escorts, one located approximately 46 meters (150 feet) same distance behind the transport vehicle, are also present. These data were used analyses for all alternatives.

A.7.2.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure

rate conversion factors for the casks used for transfers of naval spent nuclear fue calculated using the standard equation in RADTRAN 4. The results were compared to analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate th Using the SPAN4 computer code results, the effective package dimensions of the cask RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic v index to exposure rate conversion factor. The values used are provided in Table A-

Table A-16. Transport index to exposure rate conversion factors for the NFS-100, P and Large Cell casks.

Cask	Effective Package Dimens (meters)	Transport Index to Exposure Rate Conversion Factor
NFS-100	3.8 (12.5 feet)	8.41
Peach Bottom	2.8 (9.2 feet)	5.76
Large Cell	3.2 (10.5 feet)	6.76

A.7.2.1.9 Storage. There is no intermediate storage time during transfers of naval spent nuclear

fuel to its destination.

A.7.2.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval spent

nuclear fuel to storage occurs during routine surveys at the destination entrance. from highway and general population and therefore no people were considered to be e short 10-minute stop. The escorts are not present during the surveys and the drive

the truck, 6.1 meters (20 feet) from the cask during the surveys. The people perfc badged and all exposure received during the surveys is included in the normal occur which is regularly monitored.

A.7.2.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470

vehicles per hour passing the transport vehicle. Travel on the transport path is r employees by a security checkpoint, the majority of INEL employees ride the INEL si the transfers are not made during high traffic times (i.e., shift changes when buse therefore, using the standard 470 vehicles per hour value would be extremely conser realistic estimate of 25 vehicles per hour was used.

A.7.2.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4

computer code value was reviewed and determined to reflect the best estimate of cur and was consistent with historical data from transfers of naval spent nuclear fuel

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be affected naval spent nuclear fuel to storage was used to evaluate the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.2.2 Accident During Transportation of Spent Nuclear Fuel to Storage. This section provides the

input parameters used to calculate the radiological impacts for accidents during tr nuclear fuel to storage for evaluation of the five alternatives. The planned trans distances, population densities, and the percentages of travel in each population d Section A.7.2.1 were also used for the accident analyses. Unless otherwise describ standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

A.7.2.2.1 Accident Probability. The probability of a truck accident used for evaluation of all

alternatives was obtained from "Longitudinal Review of State-Level Accident Statist Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state which naval spent nuclear fuel would be transferred to storage for the alternatives are Idaho, Washington, South Carolina, Tennessee, and Nevada. The corresponding ac travel on rural interstates in accidents per kilometer are 2.30 x 10y7 for Idaho, 1.83 x 10y7 for South Carolina, 1.48 x 10y7 for Tennessee, and 1.57 x 10y7 for Neva correspond to 3.70 x 10y7 (Idaho), 4.02 x 10y7 (Washington), 2.94 x 10y7 (South Car (Tennessee), and 2.53 x 10y7 (Nevada) accidents per mile.

A.7.2.2.2 Accident Severity Categories and Probabilities. In the modal study, Lawrence

Livermore National Laboratory categorized the potential damage to shipping containe magnitude of the thermal and mechanical forces that could result from an accident. thermal forces were categorized into 20 regions. Given that an accident occurs, th accident would be in each region was calculated for both rail and truck shipments. the probabilities for truck accidents by region.

Table A-17. Accident severity probabilities for truck shipments.

	R(4,1)	R(4,2)	R(4,3)	F
	1.532 x 10y7	3.926 x 10y14	1.495 x 10y 1	7
S3	R(3,1)	R(3,2)	R(3,3)	
(30)	1.7984 x 10y3	1.574 x 10y7	2.034 x 10y7	1.076
S2	R(2,1)	R(2,2)	R(2,3)	R(2,4
(2)	3.8192 x 10y3	2.330 x 10y7	3.008 x 10y7	1.592
S1	R(1,1)	R(1,2)	R(1,3)	R(1,4
(0.2)	0.994316	1.687 x 10y5	2.362 x 10y5	1.525
	T1 (500)	T2 (600)	T3 (650)	

Thermal Response (lead mid-thickness temperature, yF)

A.7.2.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and

thermal analyses have been performed for the casks used for shipments of naval spen storage. As described in Section A.4.5, these analyses are performed using a worst is defined based on the site specific terrain and administrative controls during th The probability of the worst credible accident is equal to that listed in region R(conditions in excess of the worst credible accident, the fission product and corros fractions described in the next section were used.

A.7.2.2.4 Cask Release Fractions. The cask release fractions were derived based on the results

presented in the NRC modal study (NUREG 1987). Although the naval spent nuclear fu release fractions for the BWR, PWR, and aluminum-clad fuel from the modal study wer modal study, the release fraction for lower left region R(1,1) is zero for the risk maximum consequence evaluation, 1% of the corrosion products were released for the R(1,1). The remaining regions used 10% of the fission products available for relea fractions specified below, and release of 10% of the corrosion products. Table A-1 fractions used. The release fractions in Table A-18 for the less severe conditions A-13 because supplementary structural and thermal analyses have not been performed discussed in this section.

Table A-18. Cask release fractions used for the RADTRAN 4 risk analyses.

	Release Fractiona			
Cask Response Region	Inert Gas	Iodine	Cesium	
R(1,1)	0.0	0.0	0.0	0.0
R(1,2), R(1,3)	9.9 x 10y3	7.5 x 10y5	6.0 x 10y6	8.1 x
R(2,1), R(2,2), R(2,3)	3.3 x 10y2	2.5 x 10y	4 2.0 x 10y5	2.7 x
R(1,4), R(2,4), R(3,4)	3.9 x 10y1	4.3 x 10y3	2.0 x 10y4	4.8 x
R(3,1), R(3,2), R(3,3)	3.3 x 10y1	2.5 x 10y3	2.0 x 10y4	2.7 x
R(1,5), R(2,5), R(3,5)	6.3 x 10y1	4.3 x 10y2	2.0 x 10y3	4.8 x
R(4,5), R(4,1), R(4,2)				
R(4,3), R(4,4)				

a The release fraction represents the fraction of the fuel inventory available for released into the atmosphere following an accident of the given severity.

A.7.2.2.5 Plume Release Height. For the accident risk assessment, a ground level release was

used. For the maximum consequence assessment, a plume release height of 10 meters used.

A.7.2.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the

accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the ca

A.7.2.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to

naval spent nuclear fuel in accordance with the methods described in Nuclear Regula Guide 1.109 (NUREG 1977).

A.7.2.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding

was accounted for as the plume passes for the calculation of the exposure to the ma location was determined using RISKIND based on the selected atmospheric stability a height. The maximum exposed individual could be a member of the track crew or the

A.7.2.2.9 RISKIND Population Density. From the HIGHWAY computer code, the population

density for the on-site shipment was determined to be one person per square kilomet square mile) in a rural area. For on-site transportation at INEL, the population d populated sector, from 1990 census data, is 55 people per square kilometer, with th people in the area 64.4 to 80 kilometers (40 to 50 miles) from the site. This popu the lower region of the suburban density range of 53.7 to 1284.7 people per square people per square mile) used in HIGHWAY and INTERLINE. The standard value of 6 (ru (suburban) people per square kilometer (15.5 and 1861 people per square mile, respe the evaluation of all alternatives.

A.7.2.2.10 Radionuclide Inventory. The transfers of naval spent nuclear fuel to storage contain

the same radionuclides as listed in Table A-14. On average, there is approximately activity of each radionuclide.

A.7.3 Transfers of Naval Test Specimen Assemblies Between the

Examination Facility and the Test Reactor Area

A.7.3.1 Incident-free Transportation of Naval Test Specimen Assemblies. This section provides the

input parameters used to determine the radiological impacts associated with the rou no accident) transportation of naval test specimen assemblies for each of the five

A.7.3.1.1 Planned Shipments. Table A-19 provides the number of planned transfers in each cask.

Table A-19. Planned transfers of naval test specimen assemblies.

	NR/ATR	Test Train
No Action, Decentralization - No Exam, Decentralization - Limited Exam	0	0
Decentralization - Full Exam 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL	38	922
All other Regionalization and Centralization Alternatives	0	960

A.7.3.1.2 Transport Index. A TI of 130.0 was used for all NR and ATR cask transfers. This

value was derived from historic measurements over the last several years. The new which are currently being designed, would have a TI of 1.0.

A.7.3.1.3 Transportation Distances and Population Densities. Section A.6 provided a

description of the general methodology used for determining transportation distance densities along the transportation routes. The distance between ECF and TRA is 8.0 From the HIGHWAY computer code, this on-site transfer of naval test specimen assemb rural area. For shipments from TRA to the centralization sites, the HIGHWAY comput calculate the distance traveled, the population densities, and the percent distance population density. As described in Section A.7.4.1.3, the HIGHWAY predicted dista shipments were increased by 3%.

A.7.3.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a

rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasc credible accident is less severe than the 10CFR71 hypothetical accident is that the limited. An average speed of 16.1 kilometers per hour (10 miles per hour) was usec

shipments. For off-site shipments to the centralization sites, the standard RADTRA values were used.

A.7.3.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck

stop times that are either dependent or independent of the distances traveled. The transfers of naval test specimen assemblies were reviewed, and it was determined th (one and one-half hours) was less than the standard RADTRAN 4 computer code values. alternative in which on-site transfers would continue, the one and one-half hour st the off-site shipments of test specimen assemblies to the centralization sites, a s kilometer (0.01 hour per mile) was used, consistent with the value used for other p outside the boundaries of DOE facilities (see Section A.7.4.1.4).

A.7.3.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to

distance described in Section A.7.1.1.9 was also applied to the truck transfers of

A.7.3.1.7 Distance from Source to Crew. A distance of 3.6 meters (12 feet) was measured

between the NR/ATR shipping cask and the driver for the exclusive-use truck transfe assemblies on-site. Two escorts, one located approximately 46 meters (150 feet) in distance behind the transport vehicle, are also present for on-site shipments.

For off-site shipments to the centralization sites, the standard RADTRAN 4 cc for the number of crew members was used (2). The value used for the distance from centerline of the cask for off-site shipments was 5.85 meters (20 feet), based on t the new Test Train cask.

A.7.3.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure

rate conversion factors for the casks used for test specimen assembly transfers wer standard equation used by RADTRAN 4. The results were compared to detailed compute performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposur SPAN4 computer code results, the effective package dimensions of the casks used in calculations were adjusted to provide a conservative yet more realistic value of th exposure rate conversion factor. The values used are provided in Table A-20.

Table A-20. Transport index to exposure rate conversion factors for the NR/ATR anc casks.

Cask	Effective Package Dimension (meters)	Transport Index to Exposur Rate Conversion Factor
NR/ATR	0.61 (2 feet)	1.70
Test Train	1.70 (5.6 feet)	3.42

A.7.3.1.9 Storage. There is no intermediate storage time during transfers of naval test specimen

assemblies.

A.7.3.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval test

specimen assemblies on-site occurs during routine surveys at the destination entran removed from highway and population and therefore no people were considered to be e one and one-half hour stop. The escorts are not present during the surveys and the approximately 46 meters (150 feet) from the source during the surveys. The people are badged and all exposure received during the survey is included in the normal oc which is regularly monitored. For off-site shipments, the standard RADTRAN 4 compu were used.

A.7.3.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470

vehicles per hour passing the transport vehicle. Travel on the on-site transport p

employees, the majority of INEL employees ride the INEL site buses to work, and the made during high traffic times (i.e., shift changes); therefore, using the standard value would excessively overestimate the number of persons involved. A more realis vehicles per hour was used for on-site shipments. For off-site shipments, the stan computer code values were used.

A.7.3.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4

computer code value was reviewed and determined to reflect the best estimate of cur and was consistent with recorded data from transfers of naval test specimen assembl

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be aff transfer of test specimen assemblies was used for evaluation of the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.3.2 Accident During Transportation of Naval Test Specimen Assemblies. This section provides the

input parameters used to calculate the radiological impacts for accidents during tr specimen assemblies for evaluation of the five alternatives. The planned transfers distances, population densities, and the percentages of travel in each population d Section A.7.3.1 were also used for the accident analyses. Unless otherwise describ standard values provided by the RADTRAN 4 and RISKIND computer codes were used. Al described in Section A.7.2.2 are applicable to these transfers with the exception c population density.

A.7.3.2.1 RISKIND Population Densities. For the Decentralization, 1992/1993 Planning Basis,

Regionalization at INEL, and Centralization at INEL alternatives, the test specimen would occur on the INEL site. For these transfers, the same conditions described i were used. For the other Regionalization and Centralization alternative risk asses densities from RADTRAN 4 were used.

A.7.3.2.2 Release Fractions. For the Decentralization, 1992/1993 Planning Basis, and

Regionalization at INEL, and Centralization at INEL alternatives, the test specimen would occur on the INEL site. For these transfers, the same conditions described i

A.7.2.2.4 were used. For the other Regionalization and Centralization alternatives, the conditions

described in Sections A.7.1.2.3 and A.7.1.2.4 were used.

A.7.3.2.3 Radionuclide Inventory. The radionuclides which would be released from an average

transfer are listed in Table A-21, along with the activity. The values factor in t release fractions described in Section A.7.3.2.2. The radionuclides listed result exposure in each pathway.

Table A-21. Radionuclides which would be released from an average transfer of test assemblies.

For Accidents which Release Both Fission and Corrosion Products		For Accidents which Release Corrosion Products
Nuclide	Activity (Ci)	Nuclide
I-131	1.30 x 103	Eu-156
H-3	3.51 x 102	Lu-177
I-132	3.10 x 102	Eu-152
Eu-156	3.75 x 101	Zr-95
Eu-152	1.41 x 101	Zn-65
Zr-95	1.09 x 101	Co-60
Zn-65	9.80 x 100	Ce-141
Co-60	7.68 x 100	Eu-154

Eu-154	6.15 x 100	Cs-136
Sc-46	3.25 x 100	Sc-46
Cs-137	1.78 x 100	I-131
Ru-106	3.36 x 10y1	Hf-181
Nb-95	2.64 x 10y1	
Pr-144	2.19 x 10y1	
Ce-144	2.19 x 10y1	

A.7.4 Shipments of Naval Irradiated Test Specimens to Examination

and Testing Facilities

A.7.4.1 Incident-free Transportation of Test Specimens. This section provides the input parameters

used to determine the radiological impacts associated with the routine, incident-fr transportation of test specimens for evaluation of the five alternatives.

A.7.4.1.1 Planned Shipments. Table A-22 provides the estimated number of shipments used in

the analysis.

Table A-22. Planned shipments of naval test specimens.

NRBK-41/WAPD-40

Alternative	Centralization ICPP	PSNS	Site
No Action	29	0	0
Decentralization - No Exam			
Decentralization - Limited Exam	26	3	0
Decentralization - Full Exam	0	0	0
1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL Alternatives	0	0	0
All other Regionalization and Centralization Alternatives	0	0	29

A.7.4.1.2 Transport Index. A TI of 0.1 was used for all NRBK-41 and WAPD-40 shipping

container shipments. These values were derived from recorded measurements over the

A.7.4.1.3 Transportation Distances and Population Densities. Section A.6 provided a

description of the general methodology used for determining transportation distance densities along the transportation routes. Historical data were obtained for shipm The distance traveled was averaged based on the point of origin and compared to the HIGHWAY. The actual distance traveled was approximately 3% higher on the average. provide the best estimate exposure, which is based on the distance traveled, the HI increased by 3% for all alternatives. This technique allowed for comparison of the basis. The percentages of distance traveled in each population density calculated to the distances which were increased by the 3%.

A.7.4.1.4 Truck Stop Time. The RADTRAN 4 computer code provides standard values for truck

stop times that are either dependent or independent of the distances traveled. The historical test specimen shipments were reviewed, and it was determined that the ac much shorter than the standard RADTRAN 4 computer code values. The recorded stop t divided by the actual distance traveled from historical data over the last three ye hour per kilometer (0.01 hour per mile) was calculated. This value was used to eva alternatives.

A.7.4.1.5 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to

distance described in Section A.7.1.1.9 was also applied to the truck shipments of

A.7.4.1.6 Transport Index to Exposure Rate Conversion Factors. Container transport index to

exposure rate conversion factors for the casks used for test specimen shipments wer standard equation used by RADTRAN 4. The results were compared to detailed compute performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposur SPAN4 computer code results, the effective package dimensions of the containers use 4 calculations were adjusted to provide a conservative yet more realistic value of exposure rate conversion factor. The values used are provided in Table A-23.

Table A-23. Transport index to exposure rate conversion factors for the NRBK-41 an shipping containers.

Container	Effective Package Dimens (meters)	Transport Index to Exposure Rate Conversion Factor
NRBK-41	0.74 (2.4 feet)	1.88
WAPD-40	3.2 (10.5 feet)	6.76

A.7.4.1.7 Storage. The test specimen shipping containers are not stored during shipment.

A.7.4.1.8 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4

computer code values were reviewed and were determined to reflect the best estimate practice and were consistent with historical data from shipments of naval test spec

- Truck Speed
- Distance from Source to Crew
- Number of Crewmen
- Minimum Number of Inspections.

The following standard RADTRAN 4 estimates of the populations that could be a shipment of test specimens were also used to evaluate the five alterna- tives:

- Persons Exposed While Stopped
- Average Exposure Distance While Stopped
- Number of People per Vehicle Sharing the Transport Route (On Link)
- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones
- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.4.2 Accident During Transportation of Test Specimens. This section provides the input parameters

used to calculate the radiological impacts for accidents during transportation of t the five alternatives. The planned shipments, transportation distances, population percentages of travel in each population density described in Section A.7.4.1 were accident analyses. Unless otherwise described in this section, the standard values RADTRAN 4 and RISKIND computer codes were used. All the conditions and variables d Section A.7.1.2 are applicable to these shipments with the exception of the Acciden

A.7.4.2.1 Accident Probability. The probability of a truck accident used for evaluation of all

alternatives was obtained from "Longitudinal Review of State-Level Accident Statist Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state which naval spent nuclear fuel would be shipped to storage for the alternatives des were obtained from HIGHWAY. The accident rate values are consistent with past test which have traveled approximately 2.4 million kilometers (1.5 million miles) withou

A.7.4.2.2 Test Specimen Integrity Following an Accident. Detailed structural and thermal

analyses were performed for the shipping containers used for naval test specimen sh equivalent strain of 30% and mid-wall temperature of 1050yF. For these cases, the was not damaged; therefore, only the activity on the outside of the inner container corrosion products, was released. For the thermal and structural regions above 105

modal study defines the upper limits as unbounded. For these cases, the sealed inn test specimens was postulated to be damaged and the fission products and corrosion released in the quantities described in Section A.7.1.2.4.

A.7.4.2.3 Radionuclide Inventory. The test specimen shipments contain the same radionuclides

as listed in Table A-21. On average, there is approximately 1.5 percent of the act

A.8 SUMMARY OF RESULTS

A.8.1 Historical - Incident Free

This section summarizes the results of the calculations for the radiological impacts of the incident-free transportation of naval spent nuclear fuel and test sp shows the radiological impact on the general population, transportation workers (oc maximum exposed individual, and the non-radiological impact on all persons. The ra the general population for all historical shipments is 1.95 person-rem, which stati 0.00098 cancer fatalities in the entire population over the 40-year period consider impact on transportation workers for all historical shipments is 16.6 person-rem, w corresponds to 0.0066 cancer fatalities. As can be seen from Table A-24, the radic general population is greatest for the highway transportation of test specimens. I impacts tend to be greater for highway transportation than for rail transportation population and transportation workers are closer to the shipping container in trans maximum exposed individual is a transportation worker, since the workers are closer a longer time than any member of the general population. The maximum exposed indiv is a driver for the trucks transferring test specimen assemblies between ECF and TF modeling approach that the same person drove every shipment for the entire period, total exposure of 7.5 rem over the approximate 40-year period, or about 0.19 rem pe occupationally exposed individuals. By comparison, the maximum exposed individual population received only 0.062 rem over the entire historical period, which is much to the maximum exposed individual transportation worker and corresponds to 0.0016 m year. It should be noted that the majority of the exposure to the transportation w exposed worker is already accounted for since most transportation workers are badge exposure is included with all other exposure they would receive on the job. The ra off-site truck drivers are the only transportation workers who are not badged. The calculated to be only approximately 30% of the total.

The estimated non-radiological fatalities due to vehicle emissions is 0.028 f period.

A.8.2 Incident Free

Table A-25 provides a summary of the annual exposures and risks from incident transportation of naval spent nuclear fuel and test specimens for all alternatives. by dividing the values in Table A-26 by the 40 years evaluated to obtain the averag

The annual radiological impact on the general population ranges from 0.0085 t The general population annual radiological risk ranges from 0.0000043 to 0.00015 fc

The radiological impact on the transportation crew (occupational) ranges from person-rem. The transportation crew annual radiological risk ranges from 0.000015 fatalities.

Table A-25. Summary of annual incident-free impacts during transportation of naval test specimens.

	General Population		Occupational		MEI-General Pc
	Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Collective Dose (person-rem /yr)	Estimated Cancer Fatalities (per year)	Dose (rem/yr)
No Action	0.0085	4.3 x	0.038	1.5 x	0.00

		10y6			10y5	8
Decentralization - No Exam	0.0085	4.3 x 10y6	0.038		1.5 x 10y5	0.0 8
Decentralization - Limited Exam	0.021	1.1 x 10y5	0.068		2.7 x 10y5	0.0
Decentralization - Full Exam	0.083	4.2 x 10y5	0.30		1.2 x 10y4	0.0
1992-1993 Planning Basis	0.053	2.7 x 10y5	0.18		7.2 x 10y5	0.0
Regionalization or Centralization at INEL	0.053	2.7 x 10y5	0.18		7.2 x 10y5	0.0
Regionalization or Centralization at Hanford	0.12	6.0 x 10y5	0.25		1.0 x 10y4	0.0
Regionalization or Centralization at Savannah River	0.30	1.5 x 10y4	0.38		1.5 x 10y4	0.0
Regionalization or Centralization at Oak Ridge	0.28	1.4 x 10y4	0.35		1.4 x 10y4	0.0
Regionalization or Centralization at Nevada Test Site	0.15	7.5 x 10y5	0.28		1.1 x 10y4	0.0

Table A-26. Summary of 40-year cumulative incident-free impacts during transportat nuclear fuel and test specimens.

	General Population		Occupational		MEI-General Population	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	E c F e
No Action	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2 1
Decentralization - No Exam	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2 1
Decentralization - Limited Exam	0.83	4.2 x 10y4	2.7	1.1 x 10y3	0.045	2 1
Decentralization - Full Exam	3.3	1.7 x 10y3	12	4.8 x 10y3	0.17	8 1
1992-1993 Planning Basis	2.1	1.1 x 10y3	7.3	2.9 x 10y3	0.086	4 1

Regionalization or Centralization at INEL	2.1	1.1 x 10y3	7.3	2.9 x 10y3	0.086	4 1
Regionalization or Centralization at Hanford	4.7	2.4 x 10y3	9.8	3.9 x 10y3	0.16	8 1
Regionalization or Centralization at Savannah River	12	6.0 x 10y3	15	6.0 x 10y3	0.16	8 1
Regionalization or Centralization at Oak Ridge	11	5.5 x 10y3	14	5.6 x 10y3	0.16	8 1
Regionalization or Centralization at Nevada Test Site	6.0	3.0 x 10y3	11	4.4 x 10y3	0.16	8 1

For all alternatives, the maximum exposed individual is a transportation work truck shipments. The annual radiological impact on the maximum exposed individual to 0.12 rem. These values were calculated based on the modeling approach that for of shipments described in Sections A.4.2 through A.4.4, the same person would drive maximum exposed individual annual radiological risk ranges from 0.0000035 to 0.0000 fatalities. The annual exposure to the maximum exposed individual of the general p 0.00098 to 0.0043 rem for the various alternatives. The estimated exposure and hea maximum exposed individual for the general population correspond to approximately a than those estimated for the transportation worker.

The annual non-radiological risk ranges from 0.00015 to 0.00093 fatalities.

The summary of exposures and risks from incident-free transportation of naval and test specimens for all alternatives are included in Table A-26 for the 40-year

The radiological impact on the general population ranges from 0.34 to 12 pers population radiological risk for the entire 40-year period ranges from 0.00017 to 0

The radiological impact on the transportation crew (occupational) ranges from rem. The transportation crew radiological risk for the entire 40-year period range for cancer fatalities.

For all alternatives, the maximum exposed individual is a transportation work truck shipments. The radiological impact on the maximum exposed individual ranges rem. These values were calculated based on using the same driver for all shipments categories of shipments described in Sections A.4.2 through A.4.4. The maximum exp radiological risk for the entire 40-year period, 1995 through 2035, ranges from 0.0 cancer fatalities. The exposure to the maximum exposed individual of the general p 0.039 to 0.17 rem for the various alternatives. The estimated exposure and health exposed individual for the general population correspond to approximately a factor estimated for the transportation worker.

The non-radiological risk ranges from 0.0059 to 0.037 fatalities for the enti

There are appreciable differences in exposure to the general population, tran the maximum exposed individual among the various alternatives. Part of these diffe varying number of shipments. For example, for the Decentralization - Full Examinat shipments of naval spent nuclear fuel are shipped to the INEL and then returned to prototypes, thereby doubling the number of shipments. However, the single most imp the differences among the alternatives is the shipment of test specimen assemblies. Decentralization - No Examination, and Decentralization - Limited Examination alter shipments; for the Decentralization - Full Examination, 1992/1993 Planning Basis, R INEL, and Centralization at INEL alternatives, the exposure is minimal since the sh INEL site. However, for the other Regionalization and Centralization alternatives, assemblies would be shipped off-site between the INEL and the alternative sites. W on the casks are low, the number of shipments and the distances involved increase t

on the transportation crew and the general population.

Tables A-27 and A-28 provide the 40-year cumulative incident-free results sep and off-site shipments. For all alternatives, the shipments of naval spent nuclear prototypes and shipments of naval irradiated test specimens are off-site. Likewise spent nuclear fuel to storage following examination are on-site for all alternative test specimen assemblies are off-site for the Regionalization and Centralization al Savannah River, Oak Ridge, and the Nevada Test Site, otherwise they would be on-sit

As described in Section 3.8 of the main body of this Appendix, all alternativ use of the existing Expended Core Facility at INEL would require a transition peric for examination and storage of naval spent nuclear fuel were developed. During the approximately 80 shipments from Navy sites to ECF would be needed. These shipments explicitly in the detailed analyses; however, the appropriate number of shipments n alternative during this period is explicitly included, so the range of environmenta shipments is bounded. For example, the estimated fatalities for the No Action, Dec Examination, and Decentralization - Limited Examination alternatives would actually the transition shipments were included. The estimated fatalities for the alternati continues to receive shipments would remain the same. For the Regionalization and alternatives at sites other than INEL, the estimated fatalities would

Table A-27. Summary of 40-year cumulative incident-free impacts of on-site transpc

	General Population		Occupational		MEI-General Population	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Es Ca Fa s
No Action	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8. 10
Decentralization - No Exam	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8. 10
Decentralization - Limited Exam	0.00010	5.0 x 10y8	0.0018	7.2 x 10y7	0.000017	8. 10
Decentralization - Full Exam	0.013	6.5 x 10y6	0.44	1.8 x 10y4	0.062	3. 10
1992-1993 Planning Basis	0.015	7.5 x 10y6	0.50	2.0 x 10y4	0.062	3. 10
Regionalization or Centralization at INEL	0.015	7.5 x 10y6	0.50	2.0 x 10y4	0.062	3. 10
Regionalization or Centralization at Hanford	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8. 10
Regionalization or Centralization at Savannah River	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8. 10
Regionalization or Centralization at Oak Ridge	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8. 10
Regionalization or Centralization at Nevada	0.0024	1.2 x 10y6	0.067	2.7 x 10y5	0.000017	8. 10

Test Site

Table A-28. Summary of 40-year cumulative incident-free impacts of off-site transp

	General Population		Occupational		MEI-General Population	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Es Ca Fa s
No Action	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2. 10
Decentralization - No Exam	0.34	1.7 x 10y4	1.5	6.0 x 10y4	0.039	2. 10
Decentralization - Limited Exam	0.83	4.2 x 10y4	2.7	1.1 x 10y3	0.045	2. 10
Decentralization - Full Exam	3.3	1.7 x 10y3	11	4.4 x 10y3	0.17	8. 10
1992-1993 Planning Basis	2.1	1.1 x 10y3	6.8	2.7 x 10y3	0.086	4. 10
Regionalization or Centralization at INEL	2.1	1.1 x 10y3	6.8	2.7 x 10y3	0.086	4. 10
Regionalization or Centralization at Hanford	4.7	2.4 x 10y3	9.7	3.9 x 10y3	0.16	8. 10
Regionalization or Centralization at Savannah River	12	6.0 x 10y3	15	6.0 x 10y3	0.16	8. 10
Regionalization or Centralization at Oak Ridge	11	5.5 x 10y3	14	5.6 x 10y3	0.16	8. 10
Regionalization or Centralization at Nevada Test Site	6.0	3.0 x 10y3	11	4.4 x 10y3	0.16	8. 10

also remain approximately the same since the number of shipments is approximately e between the east and west coast origins and therefore the total distance traveled i

A.8.3 Accident Risk

This section summarizes the results of the calculations for radiological and from accidents which could occur during shipments of naval spent nuclear fuel and t A-29 and A-30 provide the results of the accident risk assessment for each alternat provided for the general population in terms of exposure and estimated cancer fatal presented for 50% meteorological conditions, Pasquill Stability Class D. Table A-2 an annual basis and Table A-30 provides the total risks over the entire 40-year per

The annual radiological impact, from Table A-29, on the general population ra to 0.021 person-rem. These exposures equate to 0.00000011 to 0.000011 estimated ca non-radiological impacts, the estimated annual fatalities from traffic accidents ra

The cumulative radiological impact, from Table A-30, on the general populatic

0.0082 to 0.84 person-rem. These exposures equate to 0.0000041 to 0.00042 estimate
For non-radiological impacts, the estimated fatalities from traffic accidents range

There are appreciable differences in exposure to the general population, tran the maximum exposed individual among the various alternatives. Part of these diffe varying number of shipments. For example, for the Decentralization - Full Examinat shipments of naval spent nuclear fuel are shipped to the INEL and then returned to prototypes, thereby doubling the number of shipments. As in the incident-free asse test specimen assemblies is a large factor. For the No Action, Decentralization - Decentral-
ization - Limited Examination alternatives, there are no shipments; for the Decentr Examination, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization the exposure is minimal since the shipments remain

Table A-29. Summary of annual accident risk for transportation of naval spent nucl test specimens.

	General Population Collective Dose (person-rem/yr) Class D	Estimated Cancer Fatalities (per year) Class D	Estimated Traffic Fatalities (per year)
No Action	0.00021	1.1 x 10y7	1.2 x 10y3
Decentralization - No Exam	0.00021	1.1 x 10y7	1.2 x 10y3
Decentralization - Limit Exam	0.00043	2.2 x 10y7	1.6 x 10y3
Decentralization - Full	0.0028	1.4 x 10y6	2.2 x 10y2
1992/1993 Planning Basis	0.0020	1.0 x 10y6	1.3 x 10y2
Regionalization or Centralization at INEL	0.0020	1.0 x 10y6	1.3 x 10y2
Regionalization or Centralization at Hanford	0.0033	1.7 x 10y6	1.3 x 10y2
Regionalization or Centralization at Savannah River	0.0210	1.1 x 10y5	1.5 x 10y2
Regionalization or Centralization at Oak Ridge	0.015	7.5 x 10y6	1.4 x 10y2
Regionalization or Centralization at Nevada Test Site	0.0070	3.5 x 10y6	1.5 x 10y2

Table A-30. Summary of cumulative accident risk over the 40-year period for transp spent nuclear fuel and test specimens.

	General PopulatioEstimated Collective Dose (person-rem) Class D	Cancer Fatalities Class D	Estimated Traffic Fatalities
No Action	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - No Exam	0.0082	4.1 x 10y6	4.7 x 10y2
Decentralization - Limited Exam	0.017	8.5 x 10y6	6.5 x 10y2
Decentralization - Full Exam	0.11m	5.5 x 10y5	8.6 x 10y1
1992/1993 Planning Basis	0.079	4.0 x 10y5	5.1 x 10y1
Regionalization or Centralization at INEL	0.079	4.0 x 10y5	5.1 x 10y1
Regionalization or Centralization at Hanford	0.13	6.5 x 10y5	5.3 x 10y1
Regionalization or Centralization at Savannah River	0.84	4.2 x 10y4	6.0 x 10y1
Regionalization or	0.61	3.1 x 10y4	5.7 x 10y1

Centralization at Oak Ridge			
Regionalization or Centralization at Nevada Test Site	0.28	1.4 x 10y4	6.1 x 10y1

on the INEL site. However, for the other Regionalization and Centralization altern assemblies would be shipped off-site between the INEL and the alternate sites. Whi on the containers are low, the number of shipments and the distances involved incre impact on the transportation crew and the general population. In addition, the rou important factor. While differences in distance and population densities are impor the Regionalization at Savannah River and Centralization at Savannah River alternat due to the higher accident rates along the route taken and higher food transfer fac through farming states with much higher ingestion rates.

Table A-31 provides the 40-year cumulative risk, separated by on-site and off

As described in Section 3.8 of the main body of this Appendix, a transition p necessary which would require approximately 80 shipments from Navy sites to ECF. T not included explicitly in the detailed analyses; however, the appropriate number c by each alternative during this period is explicitly included, so the range of envi shipments is bounded. The addition of the transition shipments would increase the the No Action, Decentralization - No Examination, and Decentralization - Limited Ex alternatives. Since the accident risk is proportional to the distance traveled, th for these alternatives, which were the lowest of all alternatives. All other alter same. Therefore, incorporating the transition period would actually reduce the dif alternatives from the standpoint of transportation effects.

A.8.4 Accident Maximum Consequences

This section summarizes the results of the calculations of maximum consequenc which could occur during shipments of naval spent nuclear fuel and test specimens. provide the results of the maximum consequence assessment for each alternative. Th consequences are provided for the general population by population area (rural, sub the maximum exposed individual in terms of exposure. The members of the transporta the maximum exposed individual.

Table A-31. Summary of cumulative risk over the 40-year period for transportation fuel and test specimens (on-site/off-site).

	ON-SITE General Population Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities
No Action	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6
Decentralization - No Exam	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6
Decentralization - Limited Exam	1.3 x 10y6	6.5 x 10y10	6.8 x 10y6
Decentralization - Full Exam	4.1 x 10y5	2.1 x 10y8	3.2 x 10y4
1992-1993 Planning Basis	1.3 x 10y4	6.5 x 10y8	6.1 x 10y4
Regionalization or Centralization at INEL	1.3 x 10y4	6.5 x 10y8	6.1 x 10y4
Regionalization or Centralization at Hanford	8.7 x 10y5	4.4 x 10y8	2.1 x 10y4
Regionalization or Centralization at Savannah River	8.7 x 10y5	4.4 x 10y8	3.6 x 10y4
Regionalization or Centralization at Oak Ridge	8.7 x 10y5	4.4 x 10y8	2.3 x 10y4
Regionalization or Centralization at Nevada Test Site	8.7 x 10y5	4.4 x 10y8	1.6 x 10y4

Table A-32. Summary of maximum consequences (person-rem) of an accident (Design Ba

MAXIMUM CONSEQUENCES
DESIGN BASIS
(accident probability between 1 and 1 x 10y6)

	Maximum Exposed Individual (rem)	Rural (person-rem)	Suburban (person	
No Action	0.0034	0.51	4.3	
Decentralization - No Exam	0.0034	0.51	4.3	
Decentralization - Limited Exam	0.014	4.0	4.3	1
Decentralization - Full Exam	0.045	7.4	25	1
1992/1993 Planning Basis	0.045	7.4	25	
Regionalization or Centralization at INEL	0.045	7.4	25	
Regionalization or Centralization at Hanford	0.25	38	100	
Regionalization or Centralization at Savannah River	0.25	38	320	
Regionalization or Centralization at Oak Ridge	0.25	38	320	
Regionalization or Centralization at Nevada Test Site	0.25	38	320	

Table A-33. Summary of maximum consequences (person-rem) of an accident (Beyond Design Basis).

MAXIMUM CONSEQUENCES
BEYOND DESIGN BASIS
(accident probability between 1 x 10y6 and 1 x 10y7)

	Maximum Exposed Individual		Rural		Su
	Estimated Dose (rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimate Collecti Dose (person
No Action	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25
Decentralization No Exam	0.014	7.0 x 10y6	4.0	2.0 x 10y3	
Decentralization Limited Exam	0.045	2.3 x 10y5	7.4	3.7 x 10y3	25
Decentralization Full Exam	1.8	9.0 x 10y4	2700	1.4	3300
1992/1993 Planning Basis	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at INEL	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Hanford	2.2	1.1 x 10y3	3300	1.7	41
Regionalization or Centralization at Savannah River	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Oak Ridge	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Nevada Test Site	2.2	1.1 x 10y3	3300	1.7	4100

For design basis accidents, the calculated exposure to the general population person-rem in a rural area to 560 person-rem in an urban area. The risk associatec ranges from 0.00026 to 0.28 cancer fatalities. The exposure to the maximum exposec from 0.0034 rem to 0.25 rem. The risk to the maximum individual ranges from 0.0000 cancer fatalities.

For beyond design basis accidents, the exposure to the general population ran rem in a rural area to 4100 person-rem in a suburban area (in this case, the probak the same consequence in the urban area was less than 1 x 10y7). The risk associate ranges from 0.002 to 2.1 cancer fatalities. The exposure to the maximum exposed in 0.014 rem to 2.2 rem. The risk to the maximum individual ranges from 0.000007 to 0 fatalities.

The shipments of naval spent nuclear fuel from shipyards and prototypes, tran nuclear fuel to storage, transfers of test specimen assemblies to the examination f test specimens to test facilities were evaluated for the maximum consequences of an the naval spent nuclear fuel shipments contain a higher amount of activity per shir where the test specimen shipment consequences are larger. The consequences are lar the higher number of shipments which increases the probabilities such that a more s evaluated.

Tables A-34 and A-35 provide the maximum consequences, separated by on-site a shipments, respectively.

As described in Section 3.8 of the main body of this Appendix, a transition p necessary which would require approximately 80 shipments from Navy sites to ECF. T not included explicitly in the detailed analyses; however, the appropriate number c by each alternative during this period is explicitly included, so the range of envi shipments is bounded. Since all alternatives ship the same basic fuel types, the m are determined by the probability of the accident which is a function of the distan in Section A.8.3, only the No Action, Decentralization - No Examination, and Decent Examination alternatives, which have the lowest estimated maximum consequences, wou distance traveled if the

Table A-34. Summary of maximum consequences of an on-site accident (Beyond Design

	MEI Collective Dose (person-rem)	Estimated Cancer Fatalities	Rural Collective Dose (person-rem)	Estimated Cancer Fatalities	Suburban Collective Dose (person-rem)
No Action	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4
Decentralization - No Exam	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4
Decentralization - Limited Exam	0.0013	6.5 x 10y7	0.37	1.9 x 10y4	2.4
Decentralization - Full Exam	0.51	2.6 x 10y4	200	1.0 x 10y1	100
1992-1993 Planning Basis	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at INEL	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Hanford	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Savannah River	2.2	1.1 x 10y3	3300	1.7	4100
Regionalization or Centralization at Oak Ridge	2.2	1.1 x 10y3	3300	1.7	4100
Regionalizatio	2.2	1.1 x 10y3	3300	1.7	4100

n or
Centralization
at
Nevada Test
Site

Table A-35. Summary of maximum consequences of an off-site accident

	MEI Collective Dose (person-rem)	Estimated Cancer Fatalities	Rural Collective Dose (person-rem)	Estimated Cancer Fatalities	Suburban Collective Dose (person-rem)
No Action	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25
Decentralization - No Exam	0.014	7.0 x 10y6	4.0	2.0 x 10y3	25
Decentralization - Limited Exam	0.045	2.3 x 10y5	7.4	3.7 x 10y3	25
Decentralization - Full Exam	1.8	9.0 x 10y4	2700	1.4	3300
1992-1993 Planning Basis	1.8	9.0 x 10y4	2700	1.4	79
Regionalization or Centralization at INEL	1.8	9.0 x 10y4	2700	1.4	79
Regionalization or Centralization at Hanford	1.8	9.0 x 10y4	2700	1.4	320
Regionalization or Centralization at Savannah River	1.8	9.0 x 10y4	2700	1.4	320
Regionalization or Centralization at Oak Ridge	1.8	9.0 x 10y4	2700	1.4	320
Regionalization or Centralization at Nevada Test Site	1.8	9.0 x 10y4	2700	1.4	320

transition shipments were included. Therefore, incorporating the transition perioc the difference between alternatives from the standpoint of transportation effects.

A.9 EFFECT ON ENVIRONMENTAL JUSTICE

The only method used to ship naval spent nuclear fuel to INEL in the past anc proposed for future shipments is by rail. The only exceptions to this are that nav Pearl Harbor Naval Shipyard is transported by ship from Hawaii to Puget Sound Naval shipping containers are transferred to railcars for the journey to INEL, and a heav to move the shipping containers from the Kesselring Site a few miles to the nearest shipment used for naval spent nuclear fuel tends to limit the exposure to members c during transportation. The shipments pass through urban, suburban, and rural areas by the railroads in accordance with applicable regulations and the requirements of

of the distance traveled in urban, suburban, and rural areas range from about 2.5% and 85% rural to approximately 4% urban, 35% suburban, and 61% rural, depending on considered.

As shown in the analyses in this Attachment, the impacts on human health or t resulting from routine transport of naval spent nuclear fuel and hypothetical trans be small for all of the alternatives considered. For example, it is unlikely that would occur as a result of the transportation of naval spent nuclear fuel under any accidents could occur at any location along the routes used, so it is not possible low-income composition of the populations along the routes. However, the fact that due to an accident for any of the alternatives considered would present no signific constitute a credible adverse impact on the population along the shipping routes ma that no adverse effects from accidents associated with the management of naval spen be expected for any specific segment of the population, minorities and low-income g

To place the impacts on environmental justice in perspective, the risk from r activities or hypothetical accidents associated with transportation of naval spent the alternatives considered would amount to less than one additional fatality per y population. For comparison, in 1990 there were approximately 40,000 traffic fatali States population and there were about 7,400 deaths caused by traffic accidents amc the U. S. Even if all of the additional cancer deaths associated with an accident considered for naval spent nuclear fuel management were assumed to occur only among that group would experience far less than one additional fatality per year. The sa drawn for low-income groups.

A.10 REFERENCES

Cashwell, J. W., K. S. Neuhauser, P. C. Reardon, G. W. McNair, 1986, Transportation the Commercial Radioactive Waste Management Program, SAND85-2715, TTC-0633, S National Laboratories, Albuquerque, New Mexico, April.

CFR (Code of Federal Regulations), 1991, Title 49 - Transportation, Parts 100 to 17 Federal Register National Archives and Records Administration, December 31.

CFR (Code of Federal Regulations), 1993, Title 10 - Energy, Parts 51 to 199; Office Register National Archives and Records Administration, January 1.

Croff, A. G., 1980, A User's Manual for the ORIGEN2 Computer Code, ORNL/TM-7175, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July.

CIRRPC (Committee on Interagency Radiation Research and Policy Coordination), 1992, Panel Report No. 9, Use of BEIR V and UNSCEAR 1988 in Radiation Risk Assessme Total Cancer Mortality Risk Estimates at Low Doses and Low Dose Rates for Low Radiation, Washington, D.C., December.

DOE (U.S. Department of Energy), 1985, DOE Order 5480.3, Safety Requirements for Pa and Transportation of Hazardous Materials, Hazardous Substances, and Hazardou 9.

DOE (U.S. Department of Energy Idaho Operations Office), 1991, Idaho Operations Off Order 5480.3, Hazardous Materials Packaging and Transportation Safety Require March 14.

Doty, S. R., B. L. Wallace, G. C. Holzworth, 1976, A Climatologic Analysis of Pasqu Categories Based on "STAR" Summaries, National Oceanic and Atmospheric Admini Environmental Data Service, National Climatic Center, Asheville, North Caroli

ICRP (International Commission on Radiological Protection), 1991, 1990 Recommendati International Commission on Radiological Protection, ICRP Publication 60, Ann Vol. 21, No. 1-3, Elmsford, New York: Pergamon Press.

Johnson, P. E., D. S. Joy, D. B. Clark, J. M. Jacobi, 1993a, INTERLINE 5.0, An Expa Railroad Routing Model: Program Description, Methodology, and Revised User's ORNL/TM-12090, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March.

Johnson, P. E., D. S. Joy, D. B. Clark, J. M. Jacobi, 1993b, HIGHWAY 3.1, An Enhanc Highway Routing Model: Program Description, Methodology, and Revised User's M ORNL/TM-12124, Oak Ridge National Laboratory, Oak Ridge, Tennessee, March.

Neuhauser, K. S. and F. L. Kanipe, 1992, RADTRAN 4 Users Guide, SAND89-2370, TTC-09 UC-722, Sandia National Laboratories, Albuquerque, New Mexico, January.

Neuhauser, K. S. and F. L. Kanipe, 1993, RADTRAN 4 Volume II: Technical Manual, SAND89-2370, Sandia National Laboratories, Albuquerque, New Mexico, August.

NUREG (U.S. Nuclear Regulatory Commission), 1977, Office of Standards Development, Guide 1.109, Calculation of Annual Doses to Man from Radiation Releases of Re for the Purpose of Evaluating Compliance with 10 CFR, Part 50, Appendix I, Re October.

NUREG (U.S. Nuclear Regulatory Commission), 1987, NUREG/CR-4829, Shipping Container Response to Severe Highway and Railway Accident Conditions, UCID-20733, prepa Lawrence Livermore National Laboratory for Division of Reactor System Safety, Nuclear Regulatory Research, Washington, D.C.

Rao, R. K., E. L. Wilmot, R. E. Luna, 1982, Non-Radiological Impacts of Transportin Material, SAND81-1703, TTC-0236, Sandia National Laboratories, Albuquerque, N February.

Saricks, C. and T. Kvitek, 1994, Longitudinal Review of State-Level Accident Statis of Interstate Freight, ANL/ESD/TM-68, Center for Transportation Research, Ene Division, Argonne National Laboratory, Argonne, Illinois, March.

Wallace, O. J., 1972, SPAN4 - A Point Kernel Computer Program for Shielding, WAPD-TM-809(L), Volumes I and II, Bettis Atomic Power Laboratory, Pittsburgh, October.

Yuan, Y. C., S. Y. Chen, D. J. LePoire, R. Rothman, 1993, RISKIND - A Computer Prog Calculating Radiological Consequences and Health Risks from Transportation of Fuel, Environmental Assessment and Information Sciences Division, Argonne Nat Laboratory, Argonne, Illinois, February.

ATTACHMENT B - DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL RECEIPT AND

HANDLING AT THE EXPENDED CORE FACILITY AT THE IDAHO NATIONAL ENGINEERING LABORATORY

TABLE OF CONTENTS

LIST OF FIGURES

ATTACHMENT B

DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL
RECEIPT AND HANDLING AT THE EXPENDED CORE
FACILITY AT THE
IDAHO NATIONAL ENGINEERING LABORATORY

B.1 GENERAL DESCRIPTION AND OPERATION OF FACILITIES

The Expended Core Facility (ECF) is located within the confines of the Naval Facility (NRF) at the Idaho National Engineering Laboratory (INEL). It is a large used to receive, examine, prepare for storage, and ship naval spent nuclear fuel an specimen assemblies. The information derived from the examinations performed at EC engineering data on nuclear reactor environments, material behavior, and design per data are used to develop new technology and to improve the cost-effectiveness of ex Naval spent nuclear fuel is prepared at ECF for storage and shipment to the Idaho C Processing Plant (ICPP). Some naval equipment contaminated by radioactive material the fleet is refurbished for reuse.

The building which houses ECF is a concrete block structure approximately 100 feet. This space provides offices and enclosed work areas, including an array of i reinforced concrete water pools which permit visual observation of naval spent nucl handling and inspection while shielding workers from radiation. Adjacent to the wa shielded cells used for operations which must be performed dry. Access to ECF for shipping of large containers is provided by large roll-up doors that allow railcar schematic view of ECF is shown in Figure B-1 and a photograph of the water pool are Figure B-2.

ECF has been specifically designed to provide the unique physical and adminis required by the Naval Nuclear Propulsion Program to ensure safe handling of irradia contaminated nuclear fuels and components with a high degree of worker safety and p Figure B-1. Schematic view of Expanded Core Facility. Figure B-2. Expanded Core a shielded cell with a connecting transfer canal. The facility has been modified a accomplish the expanding mission of the facility since then, including the addition water pools, several shielded cells, and other capabilities dictated by the nature

B.1.1 Water Pools

The purpose of the four interconnected water pools is to permit viewing and e radioactive reactor components and specimens while providing radiation shielding fc

Walls and stainless steel gates divide the water pools into smaller work are This partitioning makes it possible to drain a small portion of the total water poc facility equipment maintenance or repair is required. It also would permit isolati zone if a leak were to develop which, combined with transfer of the water from that facilities, would minimize the loss of water.

B.1.1.1 Water Pit No. 1. This pool is used for the removal of spent fuel from shipping contain-

ers, and for preparation of fuel and low-level waste for shipment to ICPP. It alsc non-fuel storage areas.

B.1.1.2 Water Pit No. 2. This water pool is used for handling irradiation test assemblies.

Various components are tested for their reaction to radiation. Test assemblies ret Advanced Test Reactor (ATR) at INEL are unloaded from the shipping cask and disasse Verification of test integrity and connection of electrical and mechanical monitori performed.

B.1.1.3 Water Pit No. 3. Radioactive components are separated by milling machines into smaller

units for examination in this water pool. Dimensional measuring equipment is used selected components. Fuel storage racks are also located in Water Pit No. 3.

Observation rooms are located along the northern wall of this water pool. Th below the level of the water surface and have viewing windows into the water pool. may be visually examined and remotely handled underwater for shielding purposes frc

B.1.1.4 Water Pit No. 4. Operations performed in this water pool include spent fuel removal

from transfer containers, temporary fuel storage in racks, fuel examination, and pr fuel shipments. Observation rooms are located along the northern wall of the water pool also contains the transfer canals that would link the water pools with the prc Project, which would prepare spent fuel for shipment in a dry, enclosed environment

B.1.1.5 Construction. All of the water pools are constructed of reinforced concrete in such a

manner that they are watertight. The water pool floors are designed to support ins and shielded shipping containers weighing up to 100 tons with a minimum base area c Water pool zone depths range from 20 feet to 45 feet. Water pool walls and floors thermo-setting plastic coating which is highly resistant to radiation damage, is ea and serves as an extra barrier to water leakage.

B.1.1.6 Water Treatment and Minimizing Radioactive Contamination. Radioactive contaminants which

have accumulated in the ECF water pools through the introduction of corrosion produ from irradiation test assemblies and the unloading of spent fuel are removed by var techniques. The design basis for the ECF water treatment system is to allow no dis radioactive material to the environment, maintain water clarity, and minimize the a

radioactive contaminants in the water.

The design goals are accomplished through the use of water purification modul surface skimming to remove film and floating material, and water recycling systems. purification modules prefilter the water to remove particles larger than 60 microns remove any dissolved solids in ion-exchange resin beds, and remove any organic or s material by absorption in an activated carbon bed. Spent resin, carbon, and filter disposed of as solid radioactive waste.

B.1.1.7 Water Management. The total volume of the ECF water pools (excluding the two new

transfer canals that are empty) is 3,000,000 gallons. A 1-inch difference in the w equivalent to approximately 9,300 gallons.

The water pools are maintained at a nearly constant level. Alarms are instal both high and low level conditions. The total water volume is accounted for monthl of water to the system is reported to a separate NRF site organization for an indep of water volume.

Water leaves the water pools via evaporation, temporary filling of shipping c decontamination of equipment, and transfers to retention basins. The water pool ev been calculated theoretically and confirmed by experiment. Water returns to the wa transfers from the retention basins and by draining shipping containers. Water rem system due to evaporation and equipment decontamination is replaced by adding demin

ECF has the capability of storing 235,000 gallons of water pool water in thre steel-reinforced, concrete storage basins. Two of the vaults each have a 40,000-ga the third has a 155,000-gallon capacity. These basins provide the capability to re pools and receive water pool water if draining a water pool zone is necessary.

B.1.2 Shielded Cells

There are 14 concrete shielded cells in the facility. These shielded cells a examination of smaller components, such as specimens which have been removed from i tests that have been exposed to a neutron flux in the ATR, and fuel and non-fuel cc water pools.

The shielded cells are constructed of concrete, with walls 3 feet thick to pr from radiation. Ventilation in the cell bank maintains negative pressure inside th the rest of the facility. This ensures that radiological contamination is containe

All work in the shielded cells is performed remotely by equipment controlled gallery, and is viewed through shielded lead glass windows. The windows are 3 feet provide the same shielding value as the concrete walls. The interior of the cells through wall periscopes that permit undistorted viewing of equipment and components

B.2 RECEIPT AND HANDLING OF NAVAL SPENT NUCLEAR FUEL

B.2.1 Receipt of Spent Fuel

Nuclear-powered ship assignments for refueling, defueling, and overhaul are c performed by the six nuclear-capable public shipyards (Mare Island, Puget Sound, Pe Portsmouth, Norfolk, and Charleston) and one nuclear-capable private shipyard (Newp 1993, the federal base closing commission included Mare Island and Charleston Naval among the bases to be closed in the near future. The spent fuel is removed from nu ships and loaded into shipping containers designed specifically for naval spent nuc fuel containers are loaded and sealed at the shipyard and shipped to ECF via railca Attachment A. A maximum of 48 containers can be staged on the rail siding at NRF c while awaiting transfer of the spent fuel to the water pools. ECF also receives sp prototype plants in a similar manner.

B.2.2 Handling of Spent Fuel

The shipping containers are brought into the ECF building at one of the two d and are prepared for defueling by removing the dust cover, leveling, and filling wi Appropriate containments to prevent release of radioactive material are installed a access plug is removed to allow access to the fuel modules.

The containers are unloaded at either the west end defueling station or the e station. Regardless of the defueling station used, the fuel modules are removed fr container one at a time using a fuel handling machine which draws the module out of into a shielded volume, and the entire machine is transferred to the water pools. then discharged into a receiving receptacle in the water pools. Photographs of the machines used are provided in Figures B-3 and B-4.

Every item containing nuclear fuel received at ECF has a unique serial number fuel is removed from its shipping container, two ECF fuel handlers independently re number and compare it to the shipping paperwork. After the serial number is confir

Figure B-3. M-140 container fuel handling machine. Figure B-4. M-130 containe

that the fuel is stored in the correct storage location. ECF has a computer-based system which maintains a record of the location and type of every piece of nuclear many grams of uranium are contained within the fuel. This system tracks every fuel during the time that the fuel is at ECF.

All naval fuel modules have metal structures which contain no fuel above and region to facilitate coolant flow and maintain proper support and spacing within th upper and lower non-fuel bearing structures must be removed to provide access to th sections to permit inspection of the module. Removal also reduces the storage spac required for the fuel by approximately 50 percent. The upper and lower non-fuel be removed during the preparation of fuel modules are evaluated using the waste classi established by federal regulations in 10CFR61 and DOE Order 5820.2. These non-fuel structures do not contain any fuel, or fission products from fuel, and therefore ca "spent nuclear fuel." They also do not contain transuranic elements or fission prc cannot be considered high-level waste or transuranic waste. Therefore, the amounts in the end boxes cause them to be classified as low-level waste. As indicated in S amount of low-level waste generated each year at the Expended Core Facility is 425 The radioactive isotopes which represent 99 percent of the activity in this materia follows:

ISOTOPE	HALF-LIFE (Years)	PRIMARY MODE OF DECAY
Fe-55	2.73	Electron Capture (x-ray)
Co-60	5.271	Beta and Gamma
Ni-59	76,000	Electron Capture
Ni-63	100	Beta

U.S. Nuclear Regulatory Commission 10CFR61 identifies three classes of low-le which are generally suitable for near-surface disposal, namely, Classes A, B, and C the requirements for near-surface disposal are shipped to the INEL Radioactive Wast Complex using a shielded cask. Wastes with concentrations greater than those speci for certain short- and long-lived isotopes were found to be not generally suitable disposal. These wastes are classified as Greater Than Class C Low-Level Radioactiv May 1989, the Nuclear Regulatory Commission promulgated a rule that requires dispos commercially generated low-level waste with concentrations of radioactivity greater deep geologic repository, unless disposal elsewhere is approved by the Nuclear Regu

Currently, a small amount (about 25 cubic meters) of greater than Class C low material removed from the ends of naval spent nuclear fuel modules over the years i the Naval Reactors Facility pending availability of a disposal facility licensed by Regulatory Commission. This material has been collected and held at the Expended C many years. This practice is expected to continue over the period of time covered mental Impact Statement.

After these upper and lower metal structures have been removed from a fuel mc fixture is installed to facilitate handling. Prepared fuel may then be inspected i be held for a time prior to inspection in storage racks in the water pool. In the temporarily stored while awaiting inspection, spacers are placed at the bottom of t the storage rack to maintain the position of the fuel module close to the top of th movement of the module easier.

Visual examinations of all modules are performed to verify that the fuel has expected. As discussed in Section 2.4.1, about 10 to 20 percent of the spent react selected for more detailed examination or destructive analysis in accordance with t

Naval Reactors fuel development program. The more extensive examinations performeć pools include measurements of key dimensions of the modules and collection of speci examined in the shielded cells. The specialized equipment used to perform examinat spent nuclear fuel are described in more detail in the section of this attachment ć Destructive analyses are performed at the Expended Core Facility or at other labora material subjected to such analysis must be removed from the spent fuel modules at Core Facility.

The last steps of spent fuel handling performed at ECF are staging the module and loading the module into the shipping cask used to transport spent fuel from ECF spent fuel may be temporarily stored in the racks in the ECF water pools until a ca available to transfer the material to ICPP.

B.2.3 Shipment of Fuel to the Idaho Chemical Processing Plant

A lead-filled, stainless steel shipping cask is used to transport naval and p modules from ECF to ICPP. The cask is removed from its transport truck and lowereć water pool until it rests on the floor of the pool. The closure head is removed, a in the cask to provide proper spacing of fuel and to maintain proper positioning du the modules. The modules are inserted into the cask, the closure head is rein-stalled, and the cask is
lifted from the water. The cask is drained, the exterior is decontaminated, and th onto the truck for shipment. The transport of the cask to ICPP is described in Att

B.2.4 Library of Naval Reactor Components

As the first modules of a given fuel design are received at the Expended Core examination, selected key operating components are retained in "library" storage in provide a source of reference. These older components are kept to ensure that ther representative item available to assist in diagnosis of problems which may occur in power plant in the fleet. The items chosen for this library are usually those that the longest so that they display the most pronounced effects of use. As the variou are replaced in fleet service by newer designs, fuel components related to the fuel are removed from library storage and shipped to ICPP.

B.3 HANDLING OF IRRADIATED TEST SPECIMENS

The irradiated materials program evaluates small specimens of materials for u reactor systems. The specimens are loaded in sample holders, and the holders are p assemblies at ECF. The assemblies are irradiated at ATR, and returned to ECF for ć The specimens are cleaned, examined, reloaded in a test assembly, and returned to t continued irradiation. A typical specimen undergoes several cycles of irradiation over several months or years. Examinations include nondestructive and destructive tests have historically included sectioning of specimens for mechanical testing anć Metallographic work was performed in the ECF hot cells in the past and is planned t on specimens in the future.

After completion of the final examination, specimens are shipped to ICPP for the INEL Radioactive Waste Management Complex for disposal. Other specimens are sh either the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania, or the Knc Power Laboratory near Schenectady, New York for more detailed examinations.

B.4 DESCRIPTION OF MAJOR ITEMS OF EQUIPMENT

The normal method for moving the fuel in the water pools to designated examin equipment areas is by use of one of five bridge cranes which move on rails located walls of the water pools. The fuel is handled remotely. All fuel movements are cc personnel, and accountability is maintained both by computer and by personnel using forms.

B.4.1 Water Pool Equipment

ECF has unique equipment in the water pools that has been designed for remote underwater to perform specific examinations on naval spent nuclear fuel and irradia Special consideration was given during equipment design to provide for remote repai ment of components. A description of the water pool spent nuclear fuel and irradia tion equipment is presented below.

B.4.1.1 Water Pool Band Saws. There are two underwater band saws in the ECF water pools.

These band saws are used to remove the non-fuel bearing structural material from th of fuel cells in preparation for inspection. The fuel region of the fuel cell rema cutting procedure.

B.4.1.2 Water Pool Milling Machines. Three milling machines in the water pools are used to

separate spent nuclear fuel components into smaller sections for examination in the The fuel region of the fuel cell remains intact during the machining. The mills ar spent fuel into pieces which can be handled in the shielded cells for examinations, radiation measurement, or for obtaining smaller specimens for metallurgical analysi measurement. The mill head of the largest milling machine can be remotely intercha saw attachment to convert the machine into a cutoff saw.

B.4.1.3 Universal Inspection Station. This equipment is used to obtain dimensional measure-

ments using specially designed probes that are inserted in the fuel module. This e position and rotate the probe in any orientation by a dedicated computer. This inf assess dimensional changes in the fuel module.

B.4.1.4 Vertical Inspection Gage. The vertical inspection gage is used for obtaining dimensional

measurements or to trace the contour of the external surfaces of fuel cell assembli This information can be used to provide a three-dimensional image of the fuel cell the end of fuel life to determine the effects of fuel element changes on the overal dimensions over fuel life and the effects of radiation on control rod dimensions ov

B.4.1.5 Video Visual Equipment. Underwater television cameras and lighting can be set up in

any zone in the water pools to obtain images of the external surfaces of the fuel c control rods. These visual inspections are used to search for anomalies such as ex wear on external surfaces. The bottom end of the fuel cell assemblies can also be blockage, corrosion, and wear.

B.4.1.6 Assembly and Disassembly Tables. These tables are used to assemble and disassemble

irradiated test assemblies that are inserted in the ATR. There are two identical a disassembly tables installed side by side in the water pools. Each is mounted on a used to rotate the table from a horizontal position for test assembly and disassemb position for loading and unloading the test assembly.

B.4.1.7 Headwork Station. The Headwork Station provides containment and shielding for the

mechanical connection and disconnection of components to and from the unirradiated assembly and disassembly of irradiations tests for the ATR. There are two indepenc stations; each consists of an elevator platform which raises the top unirradiated p above the water surface. A containment is positioned above the water surface to pr of contamination while the examination is performed above the water.

B.4.1.8 Fuel Storage Racks. Storage racks are required at ECF since, at times, fuel is received

into the facility faster than fuel can be prepared and shipped out of the facility. to store the small amount of naval spent nuclear fuel selected for retention as lib future reference and study. Ensuring that the racks are conservatively designed tc credible accident and continue to provide adequate nuclear separation are the major storage racks.

The basic configuration of a fuel storage rack is a rectangular structural ar ports. Each port has a square opening, but depth is variable. All storage ports i stainless steel. Stainless steel is used exclusively to resist corrosion during th racks. The storage ports are designed to withstand the weight of the heaviest fuel be placed in the port, and the frame assembly is designed to support the entire wei ports fully loaded with the heaviest fuel type.

All the fuel racks are designed to maintain their structural integrity during earthquake and to withstand the impact of a fuel module dropped onto the fuel racks fuel racks in the event of seismic activity has demonstrated that they will not col postulated earthquake. ECF also performed a full analysis of the strength of the p module were dropped over the fuel racks, including the kinetic energy which the drc module would impart to the rack. It was determined that all fuel racks at ECF were designed to withstand the energy of dropped fuel. The analysis also identified tha handled at ECF was heavy enough that the racks might be deformed if the equipment w Thus, operating rules and procedures prohibit the movement of large loads over the ensure that no accidental damage to the racks can occur.

Fuel storage racks were also designed to prevent arrangement of the modules i ly critical configuration. The fuel racks are designed so that each port separates contains from every other module by a distance great enough to prevent criticality limiting conditions possible. To assure that only one piece of fuel is placed in a ports are equipped with lids which can be locked and sealed. Finally, the frame as storage racks are covered with stainless steel sheeting to prevent fuel from inadve between fuel storage ports.

B.4.2 Water Pool to Shielded Cell Transfer Systems

Components that have been removed from spent nuclear fuel cells or test assem transferred into the shielded cells using one of the three available water pool to systems. The transfer systems use carts that are driven through underwater tunnels

B.4.3 Shielded Cell Examination Equipment

ECF has specialized equipment installed in the shielded cells which is design examinations on fuel elements and components removed from spent fuel cell assemblie specimens that have been irradiated in the ATR. A description of the major shielde follows.

B.4.3.1 Electronic Balances. These are commercially available electronic balances that have been

modified to operate remotely in the shielded cells. Components on these balances t deteriorate from exposure to radiation have been replaced using materials that are radiation damage. The equipment is interfaced with computer data acquisition syste operators in tracking and reducing the data. These balances are used primarily to changes that result from corrosion testing of materials in the ATR.

B.4.3.2 Descale Tanks. Corrosion removal is performed for test specimens that have been

irradiated in the ATR and structural components and fuel elements removed from spen modules. These tanks use heat, chemicals, and ultrasound to dislodge corrosion tha on the specimens or components. The corrosion removal aids in visual examination c specimens.

B.4.3.3 Bridgeport Milling Machine. This is a high-precision milling machine that has been

modified for remote operation in the ECF shielded cells. The mill is controlled by controller located in the shielded cell gallery. The Bridgeport mill is used for p non-fuel components removed from spent nuclear fuel cell assemblies.

B.4.3.4 Specimen Coordinate Automated Measuring Machine. The specimen coordinate

automated measuring machine is a fully automated unit specifically designed to perf dimensional measurements on irradiated test specimens and structural components rem nuclear fuel cells. The equipment is completely computer controlled and has an acc inch (50 microinches). The information obtained from this equipment is used to ass radiation on material growth and fuel burnup on swelling of specimens.

B.4.3.5 Fiducial Automated Measuring Machine. This machine is used to measure the distance

between scribe marks that are put on some types of specimens during fabrication. T rately measures the position of the scribe marks in relation to other fiducial mark These data are used to assess the effects of radiation on specimen growth and disto the effect of fuel depletion on fuel element swelling.

B.4.3.6 Gamma Scan System. This system measures gamma radiation emitted by fission

products to identify isotopes present in the fuel as a result of fuel depletion. T by a dedicated computer which positions the specimen, provides for data acquisition and provides an output of the isotopes detected by the system at each location alon specimen.

B.4.3.7 Alpha Box. The Alpha Box is a carbon steel containment inside the shielded cells. It

provides isolation within the shielded cells for fuel cutting to prevent the spread This is the only location in the facility where cutting through the fuel region of allowed.

B.5 FACILITY DESIGN AND INTEGRITY REQUIREMENTS

B.5.1 Flood

A flood at ECF due to overflow of any source of surface water within the INEL a low probability event. With the construction of the INEL flood control diversion the threat of a flood from overflowing of the Big Lost River, the primary source of the INEL, has become very small.

The maximum water elevation postulated at ECF would be caused by a hypothetic Maximum Flood resulting from failure of the Mackay Dam, located approximately 35 mi of the INEL. The hypothetical flood could result in a maximum water level approxim above the floor elevation of the ECF building. This flood is postulated to result over the top of the Mackay Dam and causing it to fail due to high water levels. Th unlikely. (Koslow and Van Haaften 1986)

Dam failure due to other causes, such as seismic activity, is more likely. A Mackay Dam survived the 1983 Borah Peak earthquake without damage, it was built wit design criteria. Additionally, it is not clear how resistant the dam structure is fault segment runs within 6 kilometers of the Mackay Dam.

Flooding of the ECF building is possible should the Mackay Dam fail. Floodin building would not create a nuclear criticality hazard. Flooding of the building c release of water containing low levels of radioactive contamination to the environm

equipment in flooded areas. Following the dam break, it would take over 16 hours f water to reach NRF. This is adequate time to complete emergency procedure preparat filling and placing sandbags, for the expected flood conditions.

B.5.2 Earthquake

The ECF building structure was built in accordance with the Uniform Building particular phase of construction. Water Pit No. 1, Water Pit No. 2, and Water Pit to "Zone 2" earthquake requirements which were judged to be appropriate under the U Survey classification of the area at the time of their construction. Water Pit No. transfer canals were built to the more restrictive "Zone 3" earthquake requirements time they were built.

A seismic assessment has been performed for the ECF using the actual characte existing facility. Based on this assessment, a design basis seismic event at ECF c ground acceleration of 0.24 g (Rizzo 1994). This peak ground acceleration is deriv that a moment magnitude 6.9 seismic event centered near Howe on the Lemhi fault wou rupture of approximately 34 kilometers along the Lemhi fault. The Howe epicenter i located closest to ECF, and 6.9 was the moment magnitude of the Borah Peak earthqua This approach for postulating the location of the seismic event is consistent with Regulatory Commission methodology used for commercial power plants. The beyond des seismic event was based on the entire 150 kilometers of the Lemhi fault rupturing. design basis earthquake might have a peak ground acceleration of 0.4 g at ECF.

B.5.3 Tornado

A tornado at ECF is a low probability event. The document "Technical Basis f Regional Tornado Criteria," WASH-1300, provides the technical basis for Nuclear Rea sion Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants." The W document identifies the probability of occurrence of a tornado at ECF to be 7.8 x 1 on historical records. Regulatory Guide 1.76 identifies the maximum wind speed app to be 240 mph. Data collected by Dr. T. Fugita of the University of Chicago perfor request of the DOE for the period between 1950 and 1976 indicate the probability of winds of that speed occurring at the INEL is about 1.3 x 10-9 per year. Based on a speed for tornado damage of 75 mph (refer to P. L. Doan, "Tornado Considerations fo Power Plant Structures," Nuclear Safety, Volume 11, No. 4) and a probability of 0.8 occurrence of tornado-induced wind speeds greater than or equal to 75 mph (WASH-130 the probability of a damaging tornado occurring at ECF is 7.8 x 10-5 per year x 0.8 year.

A tornado could not affect the fuel storage area in ECF in such a way that th rearranged into a critical configuration. The article by Doan cited above analyzes tornados for the general case of spent fuel in water pools and concludes "... massi to either tornado-induced wind forces or tornado-generated missiles cannot happen. however, that a couple of feet of water could be lost owing to the combination of w water entrainment, and pressure differentials. The spent fuel at the bottom of the however, remain completely covered.... By the same token, the radiation dose level surface would not increase by any meaningful amount."

B.5.4 Fires

The entire ECF facility is protected against fires by one of several types of A large, intense fire in fuel handling areas is a low probability event because of materials of construction in these areas, the amounts and kinds of material present protection system. Most of the spent fuel is under many feet of water, providing a against a fire which might involve fuel. Fires at other locations in the facility by the sprinkler system and by manual fire protection equipment (e.g., fire extingu hoses). An extensive fire involving the ECF building structure is highly unlikely constructed of non-combustible or fire-resistive material to the greatest extent po with applicable Atomic Energy Commission, Energy Resource and Development Administr DOE design criteria.

B.5.5 Loss of Water Pool Water

Loss of all water in a section of the water pool is extremely unlikely. Howe heavy object be dropped onto a water pool floor, a crack could develop. If this we cracked water pool area would be isolated and drained in a controlled manner to one basins before a substantial loss of water to the environment would occur. Even in severe damage to a water pool floor were to result in the loss of substantial amoun water, no nuclear criticality hazard would result and no melting of fuel would occu

B.6 CRITICALITY CONTROL

There has never been an inadvertent criticality at the Expended Core Facility result of strict application of the following principles.

A fundamental principle of nuclear safety is Criticality Control. When a mas reaches a condition at which its atoms are capable of undergoing a self-sustaining splitting (fissioning) into new elements, the result is called a criticality. Nucl energy in the form of radiation and heat. Controlled criticality within a shielded produces energy within a confined space without harm to personnel or the environmen water pools, the shielded cells, and the ECF building are designed to shield and cc radioactive contamination, an uncontrolled criticality (or nuclear excursion) withi able, and comprehensive measures are taken to prevent such an occurrence. Critical ECF could be described more accurately as "absolute criticality prevention." Condi identified, equipment or processes are designed, rules and procedures are formulate are trained to prevent occurrence of an accidental criticality.

Safety analyses are performed on all fuel types and system designs where all and unlikely accidents are considered. Conservatism is employed in establishing li and spent fuel is handled to the more restrictive as-built values. Then a "double applied to all fuel handling equipment and procedures. The double accident criteri must be handled and equipment designed so that acceptable margins to criticality ex limiting, unlikely, independent, and concurrent accidents. In this context, two e administrative procedure are considered to be a single accident, not two." As a re of this criterion to equipment and procedures at ECF, the amount of fuel which may any operation is typically restricted to one quarter of the minimum amount which cc criticality minus a safe margin to criticality.

All nuclear fuel operations must be performed in accordance with approved cri procedures. Nuclear safety analyses are carefully reviewed by the responsible mana independent nuclear safety committees. Naval Reactors must approve each analysis b Strict reviews and approvals are also applied to implementation of safety analyses in fuel handling procedures.

The successful criticality control program at ECF is also due to thorough tra sion of fuel handling personnel. Employees are educated concerning the principles associated hazards, and prevention. A system of checks to ensure that the rules an observed is employed. It includes detailed training documentation, qualification a a self-assessment (audit) program, and an array of accountability and nuclear safet

B.7 PROPOSED DRY CELL FACILITY

The Dry Cell Facility consists of a shielded, radiologically controlled area operated equipment. The facility is designed for a 40-year life, built of structur and would be integral with the existing ECF building.

The major element of the Dry Cell Facility is a large reinforced concrete shi interior dimensions of 22 feet wide by 84 feet long by 21 feet high, containing all necessary to inspect and disassemble fuel modules. The facility will have the capa and load one fuel module per shift in a shipping cask. Based on a two shift per da shifts per year), and a 25-percent maintenance downtime, the Dry Cell Facility year expected to be 375 modules. Shielded decontamination and repair cells will be atta shielded cell to allow remote decontamination and repair of equipment used throughc views of the Dry Cell Facility and the associated Cask Loading System are shown in B-6.

The dry cell design incorporates 4-foot thick, radiation shielding walls cons density and normal-density concrete. The shielding is designed to limit radiation occupied areas around the cell to 0.1 millirem per hour or less. At the INEL Site would be no measurable elevation above the naturally occurring background radiation cell design meets the latest seismic requirements and includes negative pressure ai radiological contamination control. Shielded lead glass windows and viewing aids a required at the workstations. Power, lighting, and a fire suppression system are a

The Dry Cell Facility is also designed to facilitate decontamination and decc the facility at some future date. This is achieved by including cell liner contami

fixed embedded piping, a minimum of cracks and crevices, smooth surfaces, and wall large enough to be radiologically surveyed to verify decontamination effectiveness.

B.8 REFERENCES

Koslow, K. N. and D. H. Van Haaften, 1986, Flood Routing Analysis for a Failure of EGG-EP-7184, EG&G Idaho, Inc., Idaho Falls, Idaho, June.

Rizzo (Paul C. Rizzo Associates), 1994, Natural Phenomena Hazards - Expended Core F Idaho National Engineering Laboratory, Monroeville, Pennsylvania, June.

ATTACHMENT C - COMPARISON OF STORAGE IN NEW WATER POOLS VERSUS DRY CONTAINER STORAGE

Figure B-5. Proposed ECF Dry Cell Facility. Figure B-6. ECF Dry Cell Facility Cask Loading System.

TABLE OF CONTENTS

ATTACHMENT C

COMPARISON OF STORAGE IN
NEW WATER POOLS VERSUS
DRY CONTAINER STORAGE

C.1 INTRODUCTION

This attachment discusses the advantages and disadvantages of water pools ver container storage should construction of additional interim storage be required. T considers the generic safety aspects of water pools and dry container storage basec performed by the Nuclear Regulatory Commission (NRC) and the Department of Energy (well as experience with naval spent nuclear fuel.

C.2 WATER POOLS

During the last four decades, the Expended Core Facility (ECF) at the Idaho N Engineering Laboratory (INEL) has demonstrated the safety and reliability of water control of the Naval Reactors Program. Water pools have historically been the meth interim storage and fuel handling because: (1) water has a high thermal capacity f heat from the fuel, (2) the transparency of water facilitates the inspection and mc (3) water is an excellent gamma and neutron shield, (4) water is easy to purify anc water provides a means to prevent release of radioactive material into the air.

The safety of spent fuel storage in a water pool can be considered in terms c criteria. They are: (1) the integrity of spent fuel under water pool storage conc structure and component safety of the facility, and (3) the potential risks of acci sabotage at the spent fuel facility.

The NRC conducted an extensive investigation into the storage of spent fuel a the findings in the Waste Confidence Decision (NUREG 1984). Based on the technical cited in that document, the NRC found that the Zircaloy cladding which encases spen resistant to failure under pool storage conditions and concluded that Zircaloy-clac satisfied the first generic criterion. This conclusion is consistent with the exte naval spent nuclear fuel. Naval fuel is Zircaloy clad and thus is highly resistant

water. In addition, a Navy fuel assembly has much higher mechanical integrity than since it is designed for military application and is capable of withstanding shock be encountered in battle conditions.

The NRC also conducted an extensive evaluation of the structural and componer water pools. The NRC found no reason why spent fuel storage pools would not be cap performing their cooling and storage functions for a number of years past the desig if the water pools are properly maintained; therefore, the second generic criterion This conclusion is consistent with the naval fuel experience of over 35 years of op

The risk of major accidents at spent fuel storage pools resulting in off-site remote because of the secure and stable character of the spent fuel in the storage and the absence of driving forces (i.e., high pressure or temperature) which might of radioactive material (NUREG 1984). The consequences of terrorist attacks on a s pool would be limited by the realities that the radioactive content of spent fuel i material encapsulated in high-integrity metal cladding and stored underwater in a r structure. Under these conditions, the radioactive content of spent fuel is relati dispersal to the environment (NUREG 1984).

These considerations led the NRC to conclude that storage pools can be design withstand accidents caused either by natural or man-made phenomena such that there impact to the environment. Therefore, the third generic criterion would be satisfi

The NRC concluded that all areas of safety and environmental concern (e.g., m systems and components, prevention of material degradation, protection against acci sabotage) have been addressed for water pools, and that spent fuel can be stored wi tal impact. This conclusion is supported by the Organization for Economic Co-Opera Development of the Nuclear Energy Agency (NEA 1993).

C.3 DRY CONTAINER STORAGE

Dry container storage technologies have been in use in the United Kingdom sin (MOCSG 1993). In the United States, demonstration projects have been underway sinc dry container storage, multiple barriers prevent gaseous as well as particulate fis Two separate barriers must fail before fission products can be released: (1) the fu (2) the outer secondary seal. In addition, dry storage systems provide metal or cc reduce the external radiation to acceptable limits.

The NRC concluded that dry container storage involves a simpler technology th represented by water storage systems. Water storage relies to a certain extent up such as pumps, renewable filters, and cooling systems to maintain safe storage. Fa chemistry must also be maintained to retard corrosion. Dry container storage uses circulation of an inert atmosphere in a sealed dry system so there is little opport (NUREG 1984).

The NRC also found that dry container storage of spent fuel in dry wells, vau metal casks is relatively invulnerable to sabotage and the forces of nature, becaus size of the sealed, protective enclosures, which may include 100-ton steel casks, l casks, and surface concrete silos (NUREG 1980).

The NRC concluded that for dry interim storage, all areas of safety and envir concern (e.g., maintenance of systems and components, prevention of material degrad against accidents and sabotage) have been addressed and shown to present no more pc adverse impact on the environment and the public health and safety than storage of pools. This conclusion is supported by the Organization for Economic Co-Operation ment of the Nuclear Energy Agency (NEA 1993).

As stated earlier, naval fuel uses Zircaloy cladding and has a much higher me integrity than commercial fuel since naval fuel is designed for military applicatic generic conclusions reached for commercial spent fuel are directly applicable to n

C.4 NON-RADIOLOGICAL CONSEQUENCES OF SPENT FUEL

STORAGE

The NRC concluded (NUREG 1984) that "there are no significant non-radiologica quences due to the extended storage of spent fuel which could adversely affect the construction of an interim spent fuel storage facility (i.e., the construction of a

water. In addition, a Navy fuel assembly has much higher mechanical integrity than since it is designed for military application and is capable of withstanding shock be encountered in battle conditions.

The NRC also conducted an extensive evaluation of the structural and componen water pools. The NRC found no reason why spent fuel storage pools would not be car performing their cooling and storage functions for a number of years past the desig if the water pools are properly maintained; therefore, the second generic criterion This conclusion is consistent with the naval fuel experience of over 35 years of or

The risk of major accidents at spent fuel storage pools resulting in off-site remote because of the secure and stable character of the spent fuel in the storage and the absence of driving forces (i.e., high pressure or temperature) which might of radioactive material (NUREG 1984). The consequences of terrorist attacks on a s pool would be limited by the realities that the radioactive content of spent fuel i material encapsulated in high-integrity metal cladding and stored underwater in a r structure. Under these conditions, the radioactive content of spent fuel is relati dispersal to the environment (NUREG 1984).

These considerations led the NRC to conclude that storage pools can be design withstand accidents caused either by natural or man-made phenomena such that there impact to the environment. Therefore, the third generic criterion would be satisfi

The NRC concluded that all areas of safety and environmental concern (e.g., m systems and components, prevention of material degradation, protection against acci sabotage) have been addressed for water pools, and that spent fuel can be stored wi tal impact. This conclusion is supported by the Organization for Economic Co-Opera Development of the Nuclear Energy Agency (NEA 1993).

C.3 DRY CONTAINER STORAGE

Dry container storage technologies have been in use in the United Kingdom sin (MOCSG 1993). In the United States, demonstration projects have been underway sinc dry container storage, multiple barriers prevent gaseous as well as particulate fis Two separate barriers must fail before fission products can be released: (1) the fu (2) the outer secondary seal. In addition, dry storage systems provide metal or cc reduce the external radiation to acceptable limits.

The NRC concluded that dry container storage involves a simpler technology th represented by water storage systems. Water storage relies to a certain extent up such as pumps, renewable filters, and cooling systems to maintain safe storage. Fa chemistry must also be maintained to retard corrosion. Dry container storage uses circulation of an inert atmosphere in a sealed dry system so there is little opport (NUREG 1984).

The NRC also found that dry container storage of spent fuel in dry wells, vau metal casks is relatively invulnerable to sabotage and the forces of nature, becaus size of the sealed, protective enclosures, which may include 100-ton steel casks, 1 casks, and surface concrete silos (NUREG 1980).

The NRC concluded that for dry interim storage, all areas of safety and envir concern (e.g., maintenance of systems and components, prevention of material degrac against accidents and sabotage) have been addressed and shown to present no more pc adverse impact on the environment and the public health and safety than storage of pools. This conclusion is supported by the Organization for Economic Co-Operation ment of the Nuclear Energy Agency (NEA 1993).

As stated earlier, naval fuel uses Zircaloy cladding and has a much higher me integrity than commercial fuel since naval fuel is designed for military applicatic generic conclusions reached for commercial spent fuel are directly applicable to n

C.4 NON-RADIOLOGICAL CONSEQUENCES OF SPENT FUEL

STORAGE

The NRC concluded (NUREG 1984) that "there are no significant non-radiologica quences due to the extended storage of spent fuel which could adversely affect the construction of an interim spent fuel storage facility (i.e., the construction of a

pad, a building, rail spur, etc.) would have little impact on the environment. The given off by spent fuel decreases with time as the fuel ages and decays radioactive of additional energy and water needed to maintain spent fuel storage is also small.

C.5 LAND UTILIZATION

With the use of water pool storage or dry container storage at an existing sh already devoted to industrial use is planned to be used for the spent fuel storage of land required for storage at specific shipyards is addressed in Attachment D.

C.6 COST

The use of alternate sites other than INEL would involve the construction of facilities. Both water pools and dry container storage could be used, with little therefore, the relative cost between these two options could be relevant. Conceptu have been prepared for each storage option at each location that is being evaluated comparisons are found in Attachments D and E.

C.7 SUMMARY

Based on the above discussion, both a new water pool and dry container storag suitable for the interim storage of spent naval fuel with no important radiological environmental impact. If a facility would be required to be used for the inspectic well as storage, then a water pool offers an advantage since water is an inexpensiv form of transparent shielding. If it were not necessary for a new facility to be u fuel, then the cost of the facility and the amount of land required could be factor option.

C.8 REFERENCES

MOCSG (The Midwestern Office of the Council of State Governments), 1993, Report on Storage of Spent Nuclear Fuel, DOE/CH/10402--22, April.

NEA (Nuclear Energy Agency), 1993, The Safety of the Nuclear Fuel Cycle, Organizati Economic Co-Operation and Development.

NUREG (U.S. Nuclear Regulatory Commission), 1980, Dry Storage of Spent Nuclear Fuel NUREG/CR-1223, April.

NUREG (U.S. Nuclear Regulatory Commission), 1984, "Waste Confidence Decision," Fede Register, Volume 49, No. 171, August 31.

ATTACHMENT D - DESCRIPTION OF STORAGE OF NAVAL SPENT NUCLEAR FUEL

AT SERVICING LOCATIONS (SHIPYARDS AND PROTOTYPES)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ATTACHMENT D

DESCRIPTION OF STORAGE OF NAVAL SPENT NUCLEAR FUEL AT SERVICING LOCATIONS (SHIPYARDS AND PROTOTYPES)

D.1 STORAGE OF NAVAL SPENT NUCLEAR FUEL IN CONTAINERS AT SHIPYARDS AND PROTOTYPES

D.1.1 Introduction

This attachment examines the alternative of storing naval spent nuclear fuel prototype sites where the fuel is removed from the reactor plant. Water pool stora storage containers, and dry storage in shipping containers are evaluated for each s prototype location. Under the No Action alternative, naval spent nuclear fuel woul shipping containers. For the other alternatives where naval spent nuclear fuel wou shipyard and prototype sites, the storage mode would be selected by the Record of D Attachment C has addressed the generic safety of water pool and dry storage and con methods would be suitable for the interim storage of naval spent nuclear fuel with environmental impact. This attachment addresses the design requirements, operation costs, and land requirements for the Puget Sound Naval Shipyard, Pearl Harbor Naval Norfolk Naval Shipyard, Portsmouth Naval Shipyard, and the Kesselring Site.

The interim storage facilities for naval spent nuclear fuel at shipyards and would be designed to comply with applicable requirements. The storage facilities w and maintained in compliance with Naval Reactors Program requirements for radiation workers and the public and the environment. Specifically, exposure to workers at t would be maintained as low as reasonably achievable and would be controlled to Nava Program radiation exposure standards. As with current naval practices, no measurab radiation levels at the site boundary would result from the storage of naval spent alternate site.

D.1.2 Shipping Containers

D.1.2.1 Container Design Features. Shipping containers and immobile dry storage containers

position the spent naval fuel modules within sealed structures designed to physical support, and remove residual heat from the fuel in an environment that prevents cor The massive size of the containers provides not only strength, but also shielding a radiation from the spent fuel within.

The shipping containers might be M-140 shipping containers with long-lived se storage of spent nuclear fuel for the duration of the period covered by this Enviro Statement (EIS). A description of the M-140 shipping container is provided in Atta container is already certified to meet the requirements of the U.S. Nuclear Regulat contained in 10CFR71, for the transportation of naval spent nuclear fuel. With ins lived seal, the M-140 container could be qualified for storage for 40 years. The s could either be positioned on railcars at the storage site or on concrete pads. Th designing the shipping container long-lived seal would commence with the Record of option were selected. The cost associated with the design and recertification of t would range from approximately $1 million to $5 million. The cost to manufacture e container would be about $5 million. Some uncertainties in estimated costs exist d detailed design for the shipping container long-lived seal is not yet available.

If the Record of Decision were to choose shipping containers, a more detailed would need to be performed to determine whether it is more appropriate to modify th shipping container design or whether a new container design should be used. Since designed as a shipping container, the modifications that would need to be made to c to accommodate interim storage might involve substantial new design work and recert shipping.

About 500 additional containers with holding capacity equivalent to the M-140 would need to be fabricated to cover the projected reactor servicing from 1995 thro alternative using the shipping containers were to be chosen, an expanded manufactur would need to be developed to meet the projected container requirements. With the manufacturing capabilities, 3 years are required to build an M-140 container and th is about 6 containers per year.

The shipping containers loaded during the period preceding the Record of Deci also need to be modified to meet the storage container design criteria. An evaluat performed to determine whether these modifications could be safely made with spent present in the containers. In the event that the spent nuclear fuel must be remove containers, the containers would be unloaded and the spent nuclear fuel would be tr modified shipping containers at a suitable facility under controls which would prot public, and the environment. The unloading of spent nuclear fuel from the original

containers and reloading into modified shipping containers would introduce addition fuel handling, transportation, and risks.

D.1.2.2 Operations. The process of loading spent nuclear fuel into shipping containers for storage

would be similar to that used for loading M-140 shipping containers. During reacto operations, spent nuclear fuel is normally loaded into M-140 shipping containers th water. The spent nuclear fuel is staged in this configuration for sufficient time produced by radioactive decay of fission products is adequately dissipated. When t removed from the M-140 container, the loaded M-140 can be shipped. After water is the shipping container, it would be transported to the storage site. The water is The transportation procedures would be essentially unchanged from current procedure containers would be moved to the interim storage site instead of being shipped to t Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for inspection. storage, the railcar would be positioned in the storage area. For cases where the stored on a concrete pad, the container would be off-loaded from the railcar or tru then secured to the pad (if securing would be required). In order to accomplish th capacity crane would be needed at each site, and the site would need to be prepared accommodate the mode of storage.

D.1.3 Immobile Dry Storage Containers

D.1.3.1 Container Design Features. There are currently no immobile dry storage containers

designed for interim storage of naval spent nuclear fuel. The container design wou that of containers which are presently certified by the Nuclear Regulatory Commissi spent nuclear fuel from commercial reactors. The design, approval, and constructio dry storage container would commence with the Record of Decision if this option wer effort could require up to 5 years to complete. The cost associated with the desig the immobile storage container would be about $2 million. The cost to construct ea storage container would be about $2 million. These estimates are based on costs of available containers with contingencies added to account for additional design feat required.

Two concepts for storing naval spent nuclear fuel in immobile dry storage con been developed in order to provide a baseline for assessing the impacts. Other dry approaches (such as dry storage vaults) exist and would be considered in more detai Decision were to choose the immobile dry container storage alternative. The first to as the minimum fuel loading concept) is based on the number of spent fuel assemb immobile dry storage container being about the same as that which is loaded into M- containers. This approach results in the need for about 500 immobile dry storage c second approach (referred to as the maximum fuel loading concept) maximizes the num assemblies that would be stored in the immobile dry storage containers. The number required for the second approach is about 300.

The minimum fuel loading concept results in a container with a comparatively less maintenance, and lower unit costs (~$1.9 million/container). Under the maximu concept, the container would need to be equipped with additional active cooling fea circulation to ensure that the heat produced by radioactive decay of fission produc removed. These additional cooling features would be needed for a period of several spent nuclear fuel is removed from the reactor vessel. For the minimum fuel loadin additional active cooling features such as recirculating water would not be require As with the shipping containers, an expanded vendor base would be necessary in orde the immobile dry storage containers at the rate they would be needed.

Figures D-1 and D-2 provide conceptual layouts of candidate immobile dry stor for naval spent nuclear fuel.

Figure D-1. Conceptual concrete immobile dry storage container for naval spent n

nuclear fuel would be approximately the same as the M-140 shipping container (i.e., 10 to 16 feet high and 8 to 10 feet wide). The fuel spacing within the container a itself would be designed to prevent any nuclear chain reaction, to ensure that deca dissipated, and to ensure that the spent fuel would be protected from hazards assoc phenomena or human activities for each storage site.

D.1.3.2 Operations. Operations commence following the defueling of the reactor, after fuel

modules are in a suitable holding container such as an M-130 or M-140 shipping cont immobile dry storage container would be positioned at the storage location. Transf module from the holding container to the dry storage container would be accomplishe module at a time using a shielded transfer container. All fuel transfers would be accordance with procedures which would have been written, reviewed, and approved by trained, qualified, and specifically authorized to perform such work. The transfer landed on the holding container, and a module would be withdrawn from the holding c module would be secured and the loaded transfer container closed, moved into positi storage container, and landed. The transfer container would be reopened and the mo seated in the immobile storage container. The transfer container would then be rem process would be repeated until the container is filled with spent fuel modules. T then be sealed.

Transfers of spent nuclear fuel to the immobile dry storage container would b accordance with Naval Reactors Program requirements for radiation protection. Radi containment devices would be used where necessary to prevent radioactivity from spr workplace and from becoming airborne. The transfer and storage containers would co shielding that minimizes radiation exposure to the workers during transfer and stor ensures that radiation levels at the site perimeter are indistinguishable from natu

D.1.4 Water Pool Storage

D.1.4.1 Water Pool Design Features. If the Record of Decision were to choose the alternative of

storing naval spent nuclear fuel in water pools, five water pools could be construc designated storage site. Each water pool facility would be designed, built, and op with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commiss requirements in 10CFR72 and associated Regulatory Guides. The siting, design, cons approval of a water pool storage facility would commence with the Record of Decisio 6 to 9 years to complete. The design and construction of each water pool facility with local construction standards for each site.

Water pools operate by holding spent fuel modules in a deep pool of water. T provides cooling for the spent fuel, a transparent medium for work activities, and radiation (see Attachment C). The structural materials of the fuel modules and nav well as temperature and chemistry control of the water, would result in the spent f resistant to corrosion. Corrosion-resistant racks below the water surface would be and position the fuel modules in place for handling and to prevent a critical mass water depth would be sufficient to provide shielding to protect workers and the env module movement and storage.

D.1.4.2 Operations. The naval spent nuclear fuel would be transferred to the water pool in a

suitable container, such as an M-130 or M-140 shipping container. The fuel modules transferred into the water pool using equipment and procedures that are similar to procedures used at ECF for unloading spent nuclear fuel from shipping containers. fuel modules would be individually lowered and secured in the storage racks located pool floor. The use of a water pool for storage of naval spent nuclear fuel would opportunity for limited visual inspection of the exterior of the fuel modules after the naval vessels. This opportunity would not exist to the same extent for the dry alternatives.

D.1.5 Design Basis Considerations for Storage Containers and Water

Pools

The design of both the shipping and immobile dry storage containers would be with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commiss requirements for independent spent fuel storage installations found in 10CFR72 and Regulatory Guides. Attachment F describes the exposures which would be expected du operational exposures and the exposures calculated for hypothetical accidents that interim storage of spent fuel at each shipyard and prototype location. The acciden used to establish the requirements for the design of the interim storage facilities

D.1.5.1 Design Basis Considerations for Storage Containers.

(1) Natural Phenomena. The fuel spacing within the container and the contain would be designed to prevent a nuclear criticality, to ensure that heat p radioactive decay of fission products is adequately dissipated, and to en container would safely survive hazards associated with natural phenomena or flooding for each storage site. The shipping containers and the immob containers would be designed to withstand the most severe design basis se expected for the storage sites. The seismic analysis would evaluate the external structures of the containers and the components associated with containers. The containers and associated components would be designed t environment during other natural phenomena such as tornado winds, tornado hurricanes, volcanic activity, design basis floods, and very large waves. of Decision involves the need for new facilities for the interim storage nuclear fuel, detailed site-specific seismic evaluations would be conduct and the results would be incorporated into the design of new facilities. of any new facilities for naval spent nuclear fuel management would meet standards for the interim storage of naval spent nuclear fuel. The desig construction of these facilities to seismic standards which take into con seismic character of the area would ensure that structures could withstan seismic event. The adequacy of the storage facility would be documented assessment report for each location.

(2) Man-made Hazards. The containers would be arranged to allow access for r inspections, maintenance, and emergencies. This includes sufficient acce pressure, temperature, and radiological monitoring as well as for fire fi and ambulances.

The containers would be designed to withstand a fire without losing fissio containment. Flammable liquids and gases as well as explosive materials w prohibited in the storage area with the exception of fuel in motor vehicle support operations. Combustible materials such as wood, paper, and plasti kept to a minimum in the spent nuclear fuel storage areas.

The fuel spacing within the container and the container itself would be de prevent nuclear criticality, to ensure that the heat produced by radioacti adequately dissipated, and to ensure that it would safely survive credible accidents for each storage site. Other man-made hazards such as truck acc airplane crashes, and objects dropped by cranes would also be addressed in assessment report.

D.1.5.2 Design Basis Considerations for Water Pools.

(1) Natural Phenomena. The spent nuclear fuel spacing within the water pool water pool itself and the building support structures would be designed t criticality, to ensure that heat produced by radioactive decay is adequat to ensure that it would protect the fuel from the hazards associated with natural phenomena for each storage site (i.e., seismic, tornados, missile tornado, hurricanes, volcanic activity, maximum expected floods, and very The water pools would be equipped with spent fuel storage racks for restr modules. The racks would be designed to safely survive the above hazards. Record of Decision involves the need for new facilities for the interim s spent nuclear fuel, detailed site-specific seismic evaluations would be c sites, and the results would be incorporated into the design of new facil construction of any new facilities for naval spent nuclear fuel managemen strict seismic standards for the interim storage of naval spent nuclear f and construction of these facilities to seismic standards which take into seismic character of the area would ensure that structures could withstan seismic event. The adequacy of the water pool facility would be document assessment report for each location.

(2) Man-made Hazards. The water pool facility would be designed to withstand without damage to the spent fuel within the water. Flammable liquids and as explosive materials would be prohibited in the vicinity of the storage exception of incidental quantities of flammable solvents necessary to sup Combustible materials such as wood, paper, and plastic would be kept to a

the water pool facility.
The fuel spacing within the water pool would be designed to prevent critic ensure that it would safely survive credible man-made accidents for each s Other man-made hazards such as truck accidents, airplane crashes, and cran accidents would also be addressed in the safety assessment report.

D.1.6 Shipyard and Prototype Locations

This section describes conceptual locations at the shipyard and prototype sit facilities could be located to service refuelings and defuelings of naval ships. T land requirements for each storage method at each location, the construction cost f and the associated operating cost.

D.1.6.1 Land Requirements. This section provides a summary of the land required for each of

the storage methods at each of the locations where refueling and defueling are plan through 2035.

These locations are the Portsmouth Naval Shipyard, the Puget Sound Naval Ship Pearl Harbor Naval Shipyard, the Norfolk Naval Shipyard, and the Kesselring Site. of these sites is provided in Figures D-3 through D-7, indicating a possible storag these facilities.

Figure D-3. Conceptual location of the interim storage site at Puget Sound Naval

at each of the locations where storage of naval spent nuclear fuel could be located that the number of containers and land required could be slightly less than identif result of actions taken during the transition period. As shown in Table D-1, stora containers on railcars would typically require dedication of the most land.

Table D-1. Square feet of land required for storage facility.

Location	Number of Immobile Dry Storage Containers(1)	Number of Shipping Containers	Immobile Dry Storage Containers(2) (ft2)	Shipping Containers on Concrete Pad(3) (ft2)	Shipping Container on Railca (ft2)
Portsmouth	27-51	61	10,000-19,000	18,000	72,000
Puget Sound	153-206	219	57,000-77,000	64,000	260,000
Pearl Harbor	21-30	42	8,000-11,000	12,000	50,000
Norfolk	132-219	247	49,000-82,000	72,000	293,000
Kesselring	5-6	6	1,900-2,000	1,700	7,100

(1) Range in required number of containers is due to options in conceptual design (
(2) The immobile dry storage arrangement uses the containers stored on a concrete p one container diameter separation between adjacent containers. Each row is sep accessway. Range in required land area is due to options in conceptual design.
(3) The shipping container arrangement uses the containers stored on a concrete pad between adjacent containers. Each row is separated by a 15-foot wide accessway
(4) The water pool facility consists of a building that contains adequate space to and facilities (approximately 17,000 ft2) and a water pool with adjacent work a accommodate the amount of spent nuclear fuel expected to be stored in the facil

D.1.6.2 Site Construction, Container, and Operating Costs. This section provides estimated

costs associated with each alternative for storing spent nuclear fuel at the shipya The major cost factors include facility construction or site preparation costs, con operating costs over the lifetime of the facility. Cost estimates are based on 199

Table D-2 provides a summary of the estimated construction costs for each sto each shipyard and prototype location. The construction costs for immobile and ship concrete pads and shipping containers on railcars include estimated costs for concr materials), rails (for railcars), or cranes for lifting and handling containers or (for concrete pad storage). The majority of the construction costs for concrete pa

Table D-2. Estimated site construction costs (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Construction and Installation of Water Pools
Portsmouth	11-12	10	2	96
Puget Sound	15-16	13	5	141
Pearl Harbor	10-11	9	1	95
Norfolk	14-17	14	6	135
Kesselring	10	8	1(1)	89
Total	60-66	54	15	556

(1)Estimate does not include costs associated with establishing railroad extension the storage site.

are associated with the need for a high-capacity crane. Water pool construction co estimates of costs for construction of the water pool, building structure, and asso equipment. The table shows that construction costs for a water pool facility excee alternatives, and that shipping containers on railcars involves the lowest construc the water pool facility construction costs represent a complete facility ready to h for interim storage. The construction costs in Table D-2 for the other storage mod completed site construction without the cost of the containers (see Table D-3) to h nuclear fuel.

Table D-3 provides a summary of the estimated costs to build shipping contain immobile dry storage containers through 2035. The table shows that the immobile dr containers are the least expensive containers, and that the cost to build shipping concrete pads is slightly lower than to rest on railcars. The difference in cost b shipping container options is due to the cost of a dedicated railcar during storage container costs in Table D-3 would be reduced by about 13 percent due to actions ta transition period (these actions are described in Section 3.8) to ship containers f ECF. Consequently, the total costs for shipping containers on concrete pads and sh on railcars considering the transition period would be about 2615 and 2760 million respectively.

Table D-3. Estimated container cost (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad(1)	Shipping Containers on Concrete Pad	Shipping Container Railcars(
Portsmouth	55-100	319	337
Puget Sound	314-406	1145	1209
Pearl Harbor	43-59	220	232
Norfolk	271-431	1292	1363
Kesselring	10-12	31	33
Total	693-1008	3007	3174

(1)Range in container costs due to options in conceptual designs (see Sections D.1. end of the range represents container costs for the maximum fuel loading option (wh containers).

(2)Includes the cost of an equal number of railcars and containers required for thi

Table D-4 provides the estimated costs to operate a naval spent nuclear fuel operating costs include estimates of cost for personnel to monitor the facility, ha fuel when it arrives at the facility, and maintain the facility. These estimates d associated with eventual preparation of spent fuel for shipment to a site for dispo preparation costs cannot be estimated at this time because the method for preparing not been defined. Table D-4 shows that the lowest operating costs are associated w containers on concrete pads and that water pool storage requires the highest operat

Table D-4. Estimated operating costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars(2)	Water Pool

Portsmouth	11	3	8	180
Puget Sound	23	4	24	206
Pearl Harbor	11	3	6	180
Norfolk	21	4	27	206
Kesselring	9	2	3	124
Total	75	16	68	896(1)

(1)For comparison, the estimated operating cost (personnel to monitor and handle fu for the ICPP Building 666 for the same period is 232 million dollars.
(2)Includes cost to replace or refurbish railcar after prolonged storage.

D.1.6.3 Total Construction and Operating Costs. Table D-5 is a compilation of the data

contained in Tables D-1 through D-4, and calculated based on the entire 40-year per Record of Decision (1995 through 2035). This table shows that the total costs asso of immobile dry storage containers are the lowest of all the storage options consid storage at Puget Sound and Norfolk where the largest amounts of spent fuel would be these cases, the total costs for using water pool storage are within the same range immobile dry container storage.

Table D-5. Total costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad(1)	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Water Pool
Portsmouth	77-123	332	347	276
Puget Sound	352-445	1162	1238	347
Pearl Harbor	64-81	232	239	275
Norfolk	306-469	1310	1396	341
Kesselring	29-31	41	37	213
Total Cost	828-1149	3077	3257	1452

(1)Range in total costs due to options in conceptual design (see Section D.1.3.1). with the maximum loading concept.

D.1.7 Time Required to Implement Each Storage Method

If the Record of Decision were to choose one of the alternatives involving st spent nuclear fuel at shipyards and prototype sites, some period of time would be r decision to fully implement the selected storage alternative. This section examine to implement each storage method.

D.1.7.1 Container Storage. Implementation of the alternatives involving use of immobile dry

storage containers and shipping containers could be viewed as a three-phase process would cover the time required to design the container or container modification, to the design, to approve the container, to establish contracts for container fabricat first container. During this phase, the shipyards and prototype sites where the co stored would also construct or modify the container storage location as appropriate chosen. For immobile dry storage containers, this phase would take about 5 years, required to design and accept the container design, 1 year is needed for approval o 2 years are required to build the container. For containers designed for both stor this process would take about 5 years, based on 1 year to design the modifications, the container, and 3 years to build the container.

The second phase would involve establishing funding. This will take approxim to complete. The third phase of the implementation period would involve fabricatio required containers. The estimate of the number of containers is based on the proj naval vessel refuelings and current estimates of the amount of spent nuclear fuel t into the containers. Although production rates for immobile dry storage containers containers are unknown, they can be approximated from existing production rates for containers. With current manufacturing capabilities, 3 years are required to build

container, and the manufacturing capacity is about six containers per year. This p would need to be accelerated to 18 to 24 containers per year by increasing the numb manufacturers and by making fabrication process improvements. If the production ra dry storage containers and shipping containers is the same as that of M-140 contain rates can be increased as noted above, the supply of immobile dry storage or shippi would meet the demand for these containers at some point after the first several ye transition period, when an insufficient number of containers would be available to fuel planned to be removed from U.S. Navy nuclear-powered vessels, some other means naval spent nuclear fuel would be needed. As described in Section 3.8 of this EIS, a transition period of 3 years of shipping followed by 3 years of allowing naval sp be stored in shipping containers at shipyards would provide the necessary storage s

D.1.7.2 Water Pool Storage. If 6 to 9 years would be required to design, approve, and construct

a water pool facility and this process would be initiated for each location within Record of Decision, water pools would be available for storage of naval spent nucle 10 years following the Record of Decision. During the transition period, when wate under construction at selected locations, some other means of spent nuclear fuel st needed, such as the method described in Section 3.8.

D.1.8 Summary

Table D-6 summarizes the major advantages and disadvantages of the spent nucl storage alternatives previously discussed in this attachment.

Table D-6. Comparison of naval spent nuclear fuel storage alternatives.

Storage Mode	Advantages	Disadvantages
1. Shipping Container		
A. Storage on Railcars	1. Least amount of container handling after arrival at storage location.	1. Railcars must be refurbished or replac after prolonged stora
	2. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site.	2. Requires the largest area of the storage o except for Kesselring
		3. Shipping containers a more expensive than immobile dry storage containers and water (water pools cost more when small fuel quantit are stored such as at Kesselring).
B. Storage on Concrete Pads	1. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site.	1. More container handli required compared to railcar storage optio containers will not n be removed from railc
	2. Concrete pads are less expensive than railcar storage if railcars must be replaced or refurbished.	2. Higher total cost tha immobile dry storage containers and water (*when large quantiti fuel are stored).

Table D-6 (Cont).

Storage Mode	Advantages	Disadvantages
2. Immobile Dry Storage Containers	1. Lowest total costs of all the storage options.	1. The maximum fuel load concept requires that containers be filled water for cooling pur for several years aft

		removal from the reac This requires additio maintenance and sligh increases risk of low contamination spillag during accidents. 2. Must remove spent fue from transfer contain load it into immobile container.
3. Water Pool Storage	1. Has a lower total cost than shipping containers, except for Pearl Harbor and Kesselring which have less containers. 2. Provides opportunity for conducting visual examinations.	1. Has the highest opera costs of all the stor options. 2. Must remove spent fue from transfer contain load into water pool.

D.2 INSPECT HIGH PRIORITY FUEL AT PUGET SOUND NAVAL

SHIPYARD

D.2.1 Introduction

This section of the attachment discusses the alternative of inspecting a limi spent nuclear fuel at Puget Sound Naval Shipyard (hereafter referred to as Puget So information on nuclear fuel performance for use in the development of advanced nucl The inspections would be performed at the shipyard's existing Water Pit Facility. of fuel inspected would be stored at Puget Sound following inspection, and all othe be stored in a facility at or near the refueling or defueling sites until the time storage becomes available.

D.2.2 Water Pit Facility Description

The Water Pit Facility is located at the west side of Dry Dock 5, within the Puget Sound. This zone consists of facilities involved in ship construction and re and conversions. The area is bounded by Decatur Avenue on the north, the waterfron the Naval Supply Center on the west, and the main gate on the east. The Water Pit approximately 411 meters (1350 feet) from the nearest shipyard public property boun D-8 illustrates the layout of the Water Pit Facility.

The Water Pit Facility was originally constructed to provide the shipyard wit to refuel nuclear-powered aircraft carriers, with the work for the first such refue expected to commence in approximately 2006. To date, the facility water pool has b refueling equipment demonstrations and testing.

Figure D-8. Puget Sound Naval Shipyard Water Pit Facility. The following key feat original aircraft-carrier refueling mission. Because of these design features, the considered suitable for limited naval spent fuel inspection operations.

1. A water pool for disassembly, assembly, and holding of fuel cells. The la water pool is described below.
2. A work area for unpackaging, inspection, and preparation of new fuel clust associated equipment
3. An area for loading of shipping containers
4. A general use work area to support miscellaneous refueling support operati

The Water Pit Facility is divided into two distinctive structures. The high radiologically controlled area containing the water pool and general work areas dis structure is designed to withstand the effects of design basis natural phenomena an

failures of adjoining or adjacent structures without damage to the water pool or co water pool. The high bay walls are constructed of concrete to a height of 3.7 mete ground level. The second structure is the Personnel Support Building which houses support areas. This structure is designed to meet the require-
ments of established naval facilities
standardized criteria for structural design.

The water pool measures 7.3 meters (24 feet) wide x 20.4 meters (67 feet) lon (36.5 feet) deep with a water depth of 10.5 meters (34.5 feet). It includes four w side of the pool at the east end to support refueling operations and a fuel holding of the pool. Three of the four work areas are a nominal 2.1 meters (7 feet) x 2.1 the fourth area is a nominal 2.6 meters (8.5 feet) x 2.1 meters (7 feet). The tran center of the pool is provided for all fuel and non-fuel movements. The water pool provisions for isolation gates for each work area, for the fuel holding area, and f isolation gate arrangement provides the capability to separate the various areas of required. The dry pit, measuring 7.3 meters (24 feet) wide x 4.9 meters (16 feet) (36.5 feet) deep, permits expansion of the water pool as needed.

D.2.3 Limited Inspection Operations

If future naval spent fuel examinations could not be accomplished at current capacity which was available would be used to best advantage. Only naval spent nuc identified as having the greatest scientific value would be selected for detailed e Generally, this is spent nuclear fuel which is the first of a kind design or which special interest.

Naval nuclear-powered ships would continue to be refueled and defueled at var across the country. Most of the spent fuel would be stored in a facility at or nea defueling sites until the time that permanent geologic storage becomes available. identified as high priority would be transported by railcar to Puget Sound in stand shipping containers. Following its receipt in the Water Pit Facility's railcar wor container would be prepared for fuel cell removal (dust cover removed, leveled, fil containment installed, access plug removed). The fuel cells would be removed from container, one at a time, and transferred to the water pool in a shielded transfer would be discharged into the pool and placed in the holding racks to await examinat completion of examination work, the spent fuel would be stored at Puget Sound as de Section D.1. Storage facilities would have to be designed and certified to accommo sections resulting from spent fuel examinations as well as intact modules.

The following major items of water pool equipment (or equivalent) are conside to support a high-priority naval spent nuclear fuel examination program. Also nece relatively small and portable cameras and light sources for visual inspections. Th support those spent fuel examinations currently performed in the ECF water pools at described in Section B.4.1 of Attachment B and summarized below.

EQUIPMENT ITEM	PURPOSE
Bandsaw/ Upender	Remove non-fuel structurals above & below fuel region to provide access for inspection and to rotate cells between vertical and horizontal orientations
Universal Inspection Station	Measure fuel cell dimensions
Vertical Inspection Gage	Trace contour of surfaces of fuel cell assemblies and control rods
Milling Machine	Section fuel cells into subassemblies, preassemblies, and elements for other examinations

Based on floor space requirements, the Water Pit Facility water pool and dry accommodate spent nuclear fuel examinations without removal of work area partition without removal of the aircraft carrier refueling equipment. As a result, Puget So longer have the capability to refuel nuclear-powered aircraft carriers. Expansion Facility to accommodate simultaneous refueling and examination operations is undesi proximity of other shipyard facilities.

Puget Sound does not have a shielded cell examination capability. Two option considered for implementing such a capability:

1. Transfer fuel sections from Puget Sound to a shielded cell facility at ano Reactors site such as the Knolls Atomic Power Laboratory near Schenectady, or the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania. This require additional shipments of spent fuel sections across the country. T would be transported in shipping casks which would have to be certified fo purpose.
2. Construct shielded cells at Puget Sound. These cells would necessarily be distance from the Water Pit Facility since sufficient space is not availab the facility or adjacent to it in the industrial zone of the shipyard. In of transferring items for examination between the water pool and the shiel would have to be implemented. Shielded cask movements via truck and cart via underground tunnel are two possible means of transfer. This option is because it involves construction of a new facility but does not provide di communication between the water pool and shielded cells.

Based on the above discussion, the alternative of examining a limited amount nuclear fuel would include a full range of water pool visual and dimensional inspec Sound Water Pit Facility and a full range of shielded cell examinations at another This alternative would therefore include all INEL-ECF capabilities as described in

B.4.3 of Attachment B.

D.2.4 Advantages and Disadvantages of this Alternative

Advantages

1. Portions of the naval spent nuclear fuel examination program could be move INEL-ECF without having to construct new facilities. A full range of wate inspections could be accomplished at Puget Sound. A full range of shielde examinations could be accomplished at another Naval Reactors site.

Disadvantages

1. The small size of the water pool complicates placement of inspection equip result, the equipment would be limited in nature and would require removal pool work area partition walls and removal of aircraft carrier refueling e result, Puget Sound would no longer have the capability to refuel nuclear- aircraft carriers.
2. Transferring items for examination between the water pool and shielded cel involve additional spent fuel shipments across the country and would requi certification of a container for this purpose.

D.2.5 Facility Support Systems

The systems which were intended to support the aircraft carrier refuelings wi the limited naval spent fuel inspection efforts. These include the water pool flui and ventilation systems, and the normal and emergency electrical power systems.

D.2.6 Radiation Sources

The primary sources of radiation in the Water Pit Facility would be the spent associated irradiated components which are handled during inspection operations. R from the fission products which reside in the fuel region of the depleted clusters the fuel cladding. The cladding around the fuel region would not be penetrated by cutting or sectioning operation in the Water Pit Facility. Irradiated non-fuel com sources of radiation, as are corrosion products which reside on all external surfac operations could cause some of the corrosion products to become detached from the s Therefore, in addition to direct radiation, contamination must be considered in the sources.

The water pool water is treated by the filtration and purification system to waterborne radioactivity as low as reasonably achievable, typically less than 1 x 1 Co-60/ml. This level of activity is below the concentration limit in 10CFR20, Atta for liquid effluents released to the general environment. The vessels and piping i then become potential radiation sources. The water must be considered a source eve radiation level will be very low. The waterborne radioactive material causes equip

to become radiation sources, the water pool floor to become contaminated, and a rad ring to form on the walls of the water pool at the water surface. Even considering sources contributing to the ambient radiation level in the water pool area, the con exercised will ensure that the overall source is minimal and the occupational expos as reasonably achievable.

There would normally be no airborne radioactivity generated by the handling o the water pool. However, very low levels of airborne activity (approximately 1 x 1 Co-60/ml) have been detected near the surfaces of other water pools. This level of the concentration limit in 10CFR20, Attachment B, Table 2 for airborne effluents re general environment. The presence of even low-level airborne contamination will ev the ventilation system ductwork and HEPA filters becoming sources of radiation. Th over a very long period of time and the radiation levels would be controlled to a v noted above, the controls which are exercised will ensure that the occupational exp low as reasonably achievable.

D.2.7 Radiological Protection Features

The facility is designed to protect workers and the general public from radio Controls are such that workers receive much less than the allowable limits for radi radioactivity. The ventilation system is designed to mitigate the consequences of of radionuclides within the Water Pit Facility building and to limit the atmospheri stack. The double-walled (reinforced concrete, stainless steel liner) water pool i leakage under design earthquake force loading conditions. The radioactive fluid sy zero liquid discharge to the environment during Water Pit Facility operations.

D.2.8 Estimated On-Site Dose Assessment

The occupational radiation exposure for workers performing limited spent fuel the Water Pit Facility is expected to be consistent with that of ECF workers perfor operations at INEL. As discussed in Section 5.2.12.1, radiation exposures to ECF w have averaged approximately 100 mrem per year. The person-rem per year for the Wat will vary with the manning level which is dependent on the spent fuel inspection ac the facility. However, the maximum manning level is anticipated not to exceed 60 p

D.2.9 Seismic Design

Structural loadings due to seismic activity were determined as follows. Buil response spectra for the horizontal and vertical directions were obtained from a th damping mass spring model of the high bay which included soil-structure interaction 0.35 g ground acceleration value resulting from the seismic design analysis. The h superstructure and substructure were analyzed using the floor response spectra in s element computer models. The superstructure model was subjected to structural load a 113.5-metric ton (125-ton) load lifted by the large overhead crane. The combined loads with the seismic loads were applied to the substructure model at the column b The substructure model was subjected to the design earthquake response spectra. Th repeated for other combinations of structural loads with wind or tornado loads. Me checked and designed for the maximum stress from any of the loading combinations. water pool is designed to contain the pool water under design earthquake force load

ATTACHMENT E - DESCRIPTION OF RECEIPT, HANDLING, AND EXAMINATION OF

NAVAL SPENT NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

TABLE OF CONTENTS

LIST OF FIGURES

ATTACHMENT E

DESCRIPTION OF RECEIPT, HANDLING, AND EXAMINATION OF NAVAL SPENT NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

E.1 DISCUSSION

This attachment describes the options for establishing new or modified facili essentially duplicate the capabilities of the existing Expended Core Facility (ECF) National Engineering Laboratory (INEL). Also discussed herein are the differences facility, which is described in detail in Attachment B.

The capabilities of the ECF at INEL include detailed examinations of spent nu naval reactors and test specimens from the Advanced Test Reactor (ATR) at the INEL Area. It would be possible to provide ECF capabilities at an alternate DOE facilit Site, Hanford Site, Oak Ridge Reservation, or Nevada Test Site) by constructing an facility. At Savannah River or Hanford, ECF capabilities could also be provided by existing facility. The preferred locations for siting an ECF at Savannah River, Ha and the Nevada Test Site are described in Sections 4.3.1, 4.4.1, 4.5.1, and 4.6.1, main advantage of new construction is that the facility can provide all capabilitie at the ECF at INEL without limitations. The new construction water pool and shield would be constructed in such a manner as to duplicate, as much as possible, the cap ECF at INEL. The existing ECF is highly capable, having been designed to accomplis required by the Naval Nuclear Propulsion Program. Key disadvantages of new constru however, are high cost and the time necessary to initiate and complete construction

Modification of an existing facility at Savannah River or Hanford which has a the features that are required in a functional ECF would enable reductions in cost full capability, depending on how many facility modifications are required. A disa is that some of the methods currently in use at the ECF at INEL may also require mo effectively and promptly utilize an existing facility, and such modifications may c capabilities of the examination facility. The existing facility that can be made a River Site is the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwel unused and available following acquisition from its present private corporate owner facility on the Hanford Site is the Fuels and Materials Examination Facility (FMEF) and available immediately. Sections E.2 and E.3 describe the modifications to exis current processes that would be needed to provide the complete range of ECF capabil Barnwell Plant and the FMEF. Section E.4 provides a discussion of how naval spent specimen examination work would proceed through the interim period as this work is transferred from the ECF at INEL to the ECF location at the alternate DOE facility.

Receipt and handling of naval spent fuel at the new ECF location at the alter would be similar to receipt and handling of spent fuel at the ECF at INEL as descri of Attachment B. Following all examinations at the new ECF, most of the spent fuel loaded in the water pool into shipping casks for transport to the long-term fuel st same DOE facility. The spent fuel would remain at this location until the time tha disposition is possible.

The new ECF would also duplicate the capabilities of the ECF at INEL with res assembly, disassembly, and examination of ATR irradiation test specimens.

E.2 USE OF THE BARNWELL PLANT AT SAVANNAH

RIVER

FOR ECF WORK

The Barnwell Plant is not owned by DOE but could be acquired and incorporated Savannah River Site property. It has a water pool complex with about 433 square me square feet) of surface area (see Figure E-1) that can be utilized with minor modif unloading of naval fuel transport casks in a manner virtually identical to that emp INEL. An overhead crane running the length of the water pool would have to be adde providing naval spent nuclear fuel and test specimen examination capabilities compa at INEL would entail an expansion of the Barnwell Plant water pool to at least two size. The design of the Barnwell Plant facility provides for such an expansion in while the existing water pool remains functional in a reduced capacity mode.

Figure E-1. Plan view of the Barnwell Plant Fuel Receiving and Storage Station.

Plant using a combination of the three remote maintenance cells and the eight sampl cells. Material would be transferred from the water pool to the remote maintenance conveyor. The crane equipment maintenance gallery and the upper level of the remot are connected by a shielded door; these cells are connected to the remote maintenan below by hatches (see Figure E-2). Additional work stations (viewing window and ma would have to be added to service these cells. The remote maintenance cells are co sample and analytical cells above via a waste chute which would have to be upgraded transfer capability between these cell areas. Methods would have to be developed f movement from one shielded cell elevation to another. The combined length of the E cells at INEL is less than 57.9 meters (190 feet). The combined length of the Barn maintenance cells and sample and analytical cells is greater than 67.1 meters (220 sufficient cell work space should be available. There are also five contact mainte available, although at present they have no workstations and are not connected to e other cell area, or to the water pool. An alternative to the Barnwell Plant water would be to use the contact maintenance cells for some of the operations presently ECF water pool at INEL. Varying amounts of existing equipment and piping in the Ba shielded cells would have to be removed and disposed.

Once modified, the Barnwell Plant would provide the full range of water pool cell examination capabilities. However, the arrangement of the cells in the fuel h make material movement within the facility more difficult than material movement at INEL. As a result, throughput in the Barnwell Plant could be adversely affected.

E.3 USE OF THE FUELS AND MATERIALS EXAMINATION FACILITY

AT HANFORD FOR ECF WORK

The FMEF on the DOE Hanford Site in Washington currently has a large shielded complex that is suitable for ECF-type shielded cell operations with several modific modifications primarily entail the logistics associated with installing the equipme transporting items for examination to and from this equipment.

Figure E-2. Elevation looking north in the Barnwell Plant fuel handling area.

At capabilities would be to establish a dry cell facility. The FMEF main process cell cell, and upper process cell were evaluated for such a facility (see Figure E-3). material would be transferred from shielded casks in the shipping and receiving cra decontamination cell via a ceiling port. At present, there are only small penetrat decontamination cell and main process cell; this would have to be upgraded to facil transfer. The combined surface area of the three cells is about 706 square meters compared to at least 866 square meters (9320 square feet) for the conceptual expand water pool discussed previously. This suggests that the full ECF water pool capabi provided in the dry cell facility. In addition, one or more of the process cells i inclusion in the shielded cell complex (see next paragraph). Removal of decay heat and irradiation test specimens in temporary dry storage would have to be evaluated. that duplication of ECF spent fuel and test specimen examination capabilities at FM construction of a new water pool at least two times the present size of the Barnwel The location of the pool and the means for transferring items between the pool and complex would have to be evaluated.

It is envisioned that the full ECF shielded cell capabilities could be provid

combination of the main process cell and the 14 process support cells. The main pr connected to the process support cells below by hatches (see Figure E-3). There ap sufficient workstations (viewing window and manipulator ports) servicing all cells. have to be developed for material movement from one shielded cell elevation to the combined length of the FMEF main process cell and process support cells is greater (250 feet), so that sufficient cell work space should be available. The decontamin process cell would be available in support of shielded cell operations. The FMEF s essentially empty.

Once modified, the FMEF would provide the full range of water pool and shield examination capabilities. However, the arrangement of the cells in the fuel handli separation of the water pool and shielded cells would make material movement within more difficult than material movement at the ECF at INEL. As a result, throughput could be adversely affected.

E.4 INTERIM OPERATIONAL PERIOD

Figure E-3. FMEF fuel handling area.

A transitional period will exist between the date that the Record of Decision date that the alternative selected can be fully implemented (unless the selected al ECF operations at INEL). This transition period would be approximately 6 years. I that all ECF work be completely transferred to an alternate DOE facility, then acti be taken to minimize the disruption in examination capability for naval spent nucle test specimens. This section discusses how this will be accomplished if the altern option is selected in the Record of Decision.

The Barnwell Plant would have to be acquired by the DOE from its present priv owners. It is estimated that less than $800 million in acquisition, modification, would complete the Barnwell Plant for ECF usage.

The FMEF at Hanford is already owned by the DOE but it appears to require a g amount of design effort to be a fully functional ECF since a large water pool would constructed and tied in to the shielded cell complex in order to initiate fuel rece that less than $800 million in modification and construction costs would complete t usage.

During the transitional period between the Record of Decision and full implem selected alternative, shipments of naval spent nuclear fuel to the ECF at INEL woul pending construction of storage and examination facilities at the new site. All na would then be transferred to the new site.

ATTACHMENT F - ANALYSIS OF NORMAL OPERATIONS AND ACCIDENT

CONDITIONS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

Figure No. Title

LIST OF TABLES

Table No. Title

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)
LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

TABLE OF CONTENTS (Cont)

LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)
LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)
LIST OF TABLES (Cont)

Table No. Title

TABLE OF CONTENTS (Cont)
LIST OF TABLES (Cont)

Table No. Title

ATTACHMENT F

ANALYSIS OF NORMAL OPERATIONS
AND ACCIDENT CONDITIONS

This attachment presents estimated environmental consequences, event probabil product of probability and consequence) for both normal operations and postulated a related to the storage and examination of naval spent nuclear fuel. Normal operati evaluated to estimate the potential for releases of both radioactive material and t results of these analyses are presented in terms of the health effects to facility predicted due to the release of radioactive materials and toxic chemicals into the environmental factors are also presented, based on the amount of land which could b postulated accidents.

Analysis results are presented for several different Department of Energy (DO shipyard locations which are being considered as alternative sites for future naval storage and examination. The DOE facilities evaluated include the Idaho National E (INEL), Savannah River Site, Hanford Site, Nevada Test Site, Oak Ridge Reservation to as Oak Ridge), and Kenneth A. Kesselring Site. Puget Sound Naval Shipyard, Pear Shipyard, Norfolk Naval Shipyard, and Portsmouth Naval Shipyard have also been eval spent nuclear fuel operations.

SUMMARY

Analyses of normal operations and design basis and beyond design basis hypoth were performed to estimate the potential consequences due to release of radioactive chemicals. The analysis results for radiological operations have been summarized b alternatives being considered in the Environmental Impact Statement.

Historical Accidents

The Naval Nuclear Propulsion Program has an outstanding nuclear safety record reactor-years of operation and more than 300 refuelings and defuelings of Naval rea been a nuclear reactor accident, criticality accident, transportation accident, or having a significant effect on the environment.

Summary of Naval Spent Nuclear Fuel (SNF) Alternatives

Alternative	Description of SNF Activity
No Action	SNF retained at shipyards and Kesselring. Dry storage in tainers only.
Decentralization No Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used.

Decentralization Limited Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used. Limited SNF shipments t Sound Naval Shipyard for examination.
Decentralization Full Examination	All SNF shipped to INEL-ECF for examination. All SNF returned to origin for storage in either dry containers or water pools
Planning Basis	SNF would be received, examined, and stored at INEL as in years. The proposed dry cell facility would be completed at ECF.
Regionalization or Centralization	SNF would be received, examined, and stored at either INEL Hanford, Savannah River, Nevada Test Site, or Oak Ridge.

Normal Operations

Table F-1 presents the estimated number of fatal cancers per year to the gene within a 50-mile radius of each facility due to radiological releases from normal o this table were calculated using the methods described in Section F.1.3. The numbe very low at all locations and for all alternatives.

The ISC2 computer code (EPA 1992b) was used to estimate the concentration of released during normal operations. The results show that for INEL, Hanford, Savann Test Site, the Barnwell Plant, and Oak Ridge, no ambient air quality standards woul therefore, no adverse effects are expected. Heating boilers and emergency diesel g at the Navy shipyard locations and thus selection of these alternate locations woul measurable increase in emissions.

Hypothetical Accident Evaluations

Several hypothetical accidents were analyzed at each facility for each of the results are summarized in Tables F-2 and F-3. The results in these tables were cal methods described in Section F.1.3. Both fatal cancers from the maximum foreseeabl location and the most severe risk from a facility accident at each location are pre the product of the consequences of an event multiplied by the probability of that e associated with the accidents analyzed have not been added together in order to avo impression that all risks have been calculated. The risks presented in this append range of accidents which might make a detectable contribution to overall risk and a would not be expected to result in increases in calculated risk. The facility acci highest risk is a drained water pool at INEL, Hanford, Puget Sound, Portsmouth, and Savannah River, Pearl Harbor, Norfolk, the Nevada Test Site, and Oak Ridge, an airp storage area or a dry cell facility results in the greatest risk. As was the case evaluation, the accident risk is very low at all locations and for all alternatives

Table F-4 presents a summary of the risk of fatal cancers by alternative for most severe facility accident for each alternative. Consistent with the detailed t shows that all alternatives and all locations associated with spent fuel examinatio

Tables F-5 through F-8 present a summary by alternative of the impacts from a nuclear fuel facility radiological accidents which were analyzed.

A shipping accident in Puget Sound, at a location in the shipping lane approx Seattle, was also analyzed using the methods described in this Attachment. This hy results in a fire onboard the ship which involves spent nuclear fuel shipping conta to the facility accidents analyzed at Puget Sound Naval Shipyard, this shipping acc lower risk of fatal cancers than the most severe facility accident at the shipyard.

The EPI computer code (Homann 1988) was used to estimate the concentration of released in the event of two postulated accident conditions. One postulated accide spill and fire at ECF and the alternate DOE sites and the other postulated accident fire at ECF, the alternate DOE sites, and the shipyard locations. The chemical

Table F-1. Number of fatal cancers per year from normal operations (fatalities per 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SI

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Regional Centrali INEL

INEL	0.00	0.00	0.00	8.50 x 10-7	8.50 x 1
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00
Puget Sound	1.20 x 10-6	1.20 x 10-6	6.62 x 10-5**	1.20 x 10-6	0.00
Pearl Harbor	9.30 x 10-9	9.30 x 10-9	9.30 x 10-9	9.30 x 10-9	0.00
Portsmouth	2.30 x 10-7	2.30 x 10-7	2.30 x 10-7	2.30 x 10-7	0.00
Norfolk	2.10 x 10-5	2.10 x 10-5	2.10 x 10-5	2.10 x 10-5	0.00
Kesselr-ing	4.10 x 10-12	4.10 x 10-12	4.10 x 10-12	4.10 x 10-12	0.00
Total	2.24 x 10-5	2.24 x 10-5	8.74 x 10-5	2.33 x 10-5	8.50 x 1
WATER POOL STORAGE AT ALL SITES*					
INEL	0.00	0.00	0.00	8.50 x 10-7	8.50 x 1
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00
Puget Sound	1.20 x 10-6	6.50 x 10-5	6.50 x 10-5	6.50 x 10-5	0.00
Pearl Harbor	9.30 x 10-9	7.00 x 10-5	7.00 x 10-5	7.00 x 10-5	0.00
Portsmouth	2.30 x 10-7	2.30 x 10-5	2.30 x 10-5	2.30 x 10-5	0.00
Norfolk	2.10 x 10-5	1.40 x 10-4	1.40 x 10-4	1.40 x 10-4	0.00
Kesselring	4.10 x 10-12	4.10 x 10-5	4.10 x 10-5	4.10 x 10-5	0.00
Total	2.24 x 10-5	3.39 x 10-4	3.39 x 10-4	3.40 x 10-4	8.50 x 1

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program site
**Includes dry storage and water pool examination under this alternative

Table F-2. Number of fatal cancers from a maximum foreseeable accident (fatalities accident over a 50-year period to general population within a 50-mile radius of si

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SI

	No Action	Decentral i-zation-No Examination	Decentral i-zation-Puget Sound Exam	Decentral i-zation-INEL Exam	Planning Basis/ Regional i-zation Centrali zation-INEL
INEL	0.00	0.00	0.00	1.70 x	1.70 x

				10-2	10-2
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00
Puget Sound	1.7 x 10-2	1.7 x 10-2	5.1 x 10-1**	1.7 x 10-2	0.00
Pearl Harbor	2.60 x 101	2.60 x 101	2.60 x 101	2.60 x 101	0.00
Portsmouth	9.00	9.00	9.00	9.00	0.00
Norfolk	1.6 x 101	1.6 x 101	1.6 x 101	1.6 x 101	0.00
Kesselring	7.50	7.50	7.50	7.50	0.00
Max	2.60 x 101	2.60 x 101	2.60 x 101	2.60 x 101	1.70 x 10-2
WATER POOL STORAGE AT ALL SITES*					
INEL	0.00	0.00	0.00	1.70 x 10-2	1.70 x 10-2
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00
Puget Sound	1.7 x 10-2	5.1 x 10-1	5.1 x 10-1	5.1 x 10-1	0.00
Pearl Harbor	2.60 x 101	1.10	1.10	1.10	0.00
Portsmouth	9.00	3.40 x 10-1	3.40 x 10-1	3.40 x 10-1	0.00
Norfolk	1.6 x 101	6.0 x 10-1	6.0 x 10-1	6.0 x 10-1	0.00
Kesselring	7.50	2.50 x 10-1	2.50 x 10-1	2.50 x 10-1	0.00
Max	2.60 x 101	1.10	1.10	1.10	1.70 x 10-2

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program site
**Includes dry storage and water pool examination under this alternative

Table F-3. Most severe risk from a facility accident (probability of fatalities pe accident to general population within a 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SI

	No Action	Decentrali-zation-No Examination	Decentrali-zation-Puget Sound Exam	Decentrali-zation-INEL Exam	Planning Basis/ Regionali-zatio Centralization-INEL
INEL	0.00	0.00	0.00	1.70 x 10-7	1.70 x 10-7
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00

Puget Sound	1.7 x 10-7	1.7 x 10-7	5.10 x 10-6**	1.7 x 10-7	0.00
Pearl Harbor	2.60 x 10-4	2.60 x 10-4	2.60 x 10-4	2.60 x 10-4	0.00
Portsmouth	9.00 x 10-7	9.00 x 10-7	9.00 x 10-7	9.00 x 10-7	0.00
Norfolk	1.6 x 10-5	1.6 x 10-5	1.6 x 10-5	1.6 x 10-5	0.00
Kesselring	7.50 x 10-7	7.50 x 10-7	7.50 x 10-7	7.50 x 10-7	0.00
Max	2.60 x 10-4	2.60 x 10-4	2.60 x 10-4	2.60 x 10-4	1.70 x 10-7
WATER POOL STORAGE AT ALL SITES*					
INEL	0.00	0.00	0.00	1.70 x 10-7	1.70 x 10-7
Hanford	0.00	0.00	0.00	0.00	0.00
Savannah River	0.00	0.00	0.00	0.00	0.00
Nevada Test Site	0.00	0.00	0.00	0.00	0.00
Oak Ridge	0.00	0.00	0.00	0.00	0.00
Puget Sound	1.7 x 10-7	5.1 x 10-6	5.1 x 10-6	5.1 x 10-6	0.00
Pearl Harbor	2.60 x 10-4	1.10 x 10-5	1.10 x 10-5	1.10 x 10-5	0.00
Portsmouth	9.00 x 10-7	3.40 x 10-6	3.40 x 10-6	3.40 x 10-6	0.00
Norfolk	1.6 x 10-5	6.0 x 10-6	6.0 x 10-6	6.0 x 10-6	0.00
Kesselring	7.50 x 10-7	2.50 x 10-6	2.50 x 10-6	2.50 x 10-6	0.00
Max	2.60 x 10-4	1.10 x 10-5	1.10 x 10-5	1.10 x 10-5	1.70 x 10-7

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program site
**Includes dry storage and water pool examination under this alternative

Table F-4. Risk of fatal cancers by alternative (probability of fatalities per yea accident to general population within a 50-mile radius of site).

	No Action	Decentrali- za- tion-No Exami- nation	Decentrali- z- ation- Puget Sound Exam	Decentrali- z- ation- INEL Exam	Planning Basis/ Regiona- liza- tion Centraliz a- tion- INEL	Re za io Ce za io Ha
Normal Opera- tions Risk Dry Storage At Navy Sites, Water Pool Storage At DOE Sites	2.24 x 10-5	2.24 x 10-5	8.74 x 10-5	2.33 x 10-5	8.50 x 10-7	4.
Normal Opera- tions Risk Wa- ter	2.24 x 10-5	3.39 x 10-4	3.39 x 10-4	3.40 x 10-4	8.50 x 10-7	4.

Pool Storage At All Sites						
Most Severe Risk From A Facility Accident Dry Storage At Naval Nuclear Propulsion Program Sites, Water Pool Storage At DOE Sites	2.60 x 10-4 (1)	2.60 x 10-4 (1)	2.60 x 10-4 (1)	2.60 x 10-4 (1)	1.70 x 10-7 (2)	4. (
Most Severe Risk From A Facility Accident Water Pool Storage At All Sites	2.60 x 10-4 (1)	1.10 x 10-5 (2)	1.10 x 10-5 (2)	1.10 x 10-5 (2)	1.70 x 10-7 (2)	4. (

(1) Accident initiator - Airplane crash
(2) Accident initiator - Drained water pool

Table F-5. Impacts from naval spent nuclear fuel facility radiological accidents f No Action alternative.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	5.6 x 10-2	3.9 x 10-2
Pearl Harbor	1.0 x 10-5	3.0 x 10-2	3.0 x 10-7	5.6 x 10-2	2.1 x 10-2
Norfolk	1.0 x 10-5	1.8 x 10-2	1.8 x 10-7	5.6 x 10-2	8.1 x 10-2
Portsmouth	1.0 x 10-5	1.0 x 10-2	1.0 x 10-7	5.6 x 10-2	4.2 x 10-2
Kesselring	1.0 x 10-5	7.4 x 10-3	7.4 x 10-8	5.6 x 10-2	8.1 x 10-3
Airplane Crash					
Pearl Harbor	1.0 x 10-5	26	2.6 x 10-4	92	19
Norfolk	1.0 x 10-6	16	1.6 x 10-5	92	72
Portsmouth	1.0 x 10-7	9.0	9.0 x 10-7	92	38
Kesselring	1.0 x 10-7	7.5	7.5 x 10-7	92	7.7

Table F-6. Impacts from naval spent nuclear fuel facility radiological accidents f Decentralization alternatives.

Accident	Probability	Consequences to Public	Risk to Public	Dose to W-	Dose to MOI

Description	(per year)	(fatalities per accident)	(fatalities)	ork- er (rem)	(rem)

WET STORAGE AND EXAMINATION ACCIDENTS

*Information applicable only for full examinations at INEL.

Drained Water Pool

*INEL	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	2.1	1.7 x 10-2
Puget Sound	1.0 x 10-5	5.1 x 10-1	5.1 x 10-6	2.1	1.4
Pearl Harbor	1.0 x 10-5	1.1	1.1 x 10-5	2.1	7.9 x 10-1
Norfolk	1.0 x 10-5	6.0 x 10-1	6.0 x 10-6	2.1	3.0
Portsmouth	1.0 x 10-5	3.4 x 10-1	3.4 x 10-6	2.1	1.6
Kesselring	1.0 x 10-5	2.5 x 10-1	2.5 x 10-6	2.1	2.9 x 10-1

Accidental Criticality

*INEL	1.0 x 10-5	6.4 x 10-3	6.4 x 10-8	8.0	9.2 x 10-3
Puget Sound	1.0 x 10-5	2.8 x 10-1	2.8 x 10-6	8.0	1.3
Pearl Harbor	1.0 x 10-5	6.0 x 10-1	6.0 x 10-6	8.0	6.7 x 10-1
Norfolk	1.0 x 10-5	3.5 x 10-1	3.5 x 10-6	8.0	2.7
Portsmouth	1.0 x 10-5	1.5 x 10-1	1.5 x 10-6	8.0	1.4
Kesselring	1.0 x 10-5	1.1 x 10-1	1.1 x 10-6	8.0	2.3 x 10-1

Mechanical Damage

*INEL	1.0 x 10-5	5.3 x 10-6	5.3 x 10-11	5.2 x 10-4	2.6 x 10-6
Puget Sound	1.0 x 10-5	7.2 x 10-5	7.2 x 10-10	5.2 x 10-4	1.7 x 10-4
Pearl Harbor	1.0 x 10-5	1.5 x 10-4	1.5 x 10-9	5.2 x 10-4	9.3 x 10-5
Norfolk	1.0 x 10-5	8.0 x 10-5	8.0 x 10-10	5.2 x 10-4	3.5 x 10-4
Portsmouth	1.0 x 10-5	5.6 x 10-5	5.6 x 10-10	5.2 x 10-4	1.9 x 10-4
Kesselring	1.0 x 10-5	6.0 x 10-5	6.0 x 10-10	5.2 x 10-4	3.6 x 10-5

Airplane Crash

Pearl Harbor	2.0 x 10-5	4.6 x 10-2	9.2 x 10-7	1.6 x 10-1	2.8 x 10-2
Norfolk	4.0 x 10-7	2.4 x 10-2	9.6 x 10-9	1.6 x 10-1	1.1 x 10-1
Kesselring	2.0 x 10-7	1.8 x 10-2	3.6 x 10-9	1.6 x 10-1	1.1 x 10-2

HEPA Filter Fire

*INEL	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	2.5 x 10-5
Puget Sound	5.0 x 10-4	6.4 x 10-4	3.2 x 10-7	2.4 x 10-3	1.6 x 10-3
Pearl Harbor	5.0 x 10-4	1.2 x 10-3	6.0 x 10-7	2.4 x 10-3	8.7 x 10-4
Norfolk	5.0 x 10-4	6.9 x 10-4	3.5 x 10-7	2.4 x 10-3	3.3 x 10-3

WET STORAGE AND EXAMINATION ACCIDENTS

*Information applicable only for full examinations at INEL.

Portsmouth	5.0 x 10-4	3.9 x 10-4	2.0 x 10-7	2.4 x 10-3	1.7 x 10-3
Kesselring	5.0 x 10-4	3.3 x 10-4	1.7 x 10-7	2.4 x 10-3	3.5 x 10-4

Minor Water Pool Leak

*INEL	1.0 x 10-1	1.3 x 10-8	1.3 x 10-9	N/A	2.5 x 10-9
Puget Sound	1.0 x 10-1	4.2 x 10-9	4.2 x 10-10	N/A	3.2 x 10-10
Pearl Harbor	1.0 x 10-1	4.6 x 10-10	4.6 x 10-11	N/A	1.3 x 10-10
Norfolk	1.0 x 10-1	1.8 x 10-9	1.8 x 10-10	N/A	2.7 x 10-10
Portsmouth	1.0 x 10-1	1.4 x 10-9	1.4 x 10-10	N/A	1.3 x 10-10
Kesselring	1.0 x 10-1	8.5 x 10-9	8.5 x 10-10	N/A	6.0 x 10-9

DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	5.6 x 10-2	3.9 x 10-2
Pearl Harbor	1.0 x 10-5	3.0 x 10-2	3.0 x 10-7	5.6 x 10-2	2.1 x 10-2
Norfolk	1.0 x 10-5	1.8 x 10-2	1.8 x 10-7	5.6 x 10-2	8.1 x 10-2
Portsmouth	1.0 x 10-5	1.0 x 10-2	1.0 x 10-7	5.6 x 10-2	4.2 x 10-2
Kesselring	1.0 x 10-5	7.4 x 10-3	7.4 x 10-8	5.6 x 10-2	8.1 x 10-3
Airplane Crash					
Pearl Harbor	1.0 x 10-5	26	2.6 x 10-4	92	19
Norfolk	1.0 x 10-6	16	1.6 x 10-5	92	72
Portsmouth	1.0 x 10-7	9.0	9.0 x 10-7	92	38
Kesselring	1.0 x 10-7	7.5	7.5 x 10-7	92	7.7
DRY CELL ACCIDENTS					
Mechanical Damage					
*INEL	1.0 x 10-4	3.5 x 10-4	3.5 x 10-8	1.0 x 10-1	2.2 x 10-4
Loss of Shielding					
*INEL	1.0 x 10-5	3.0 x 10-19	3.0 x 10-24	7.2 x 10-5	9.3 x 10-17

Table F-7. Impacts from naval spent nuclear fuel facility radiological accidents f Planning Basis, Centralization at INEL, and Regionalization at INEL alternatives.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
INEL	1.0 x 10-5	1.7 x 10-2	1.7 x 10-7	2.1	1.7 x 10-2
Accidental Criticality					
INEL	1.0 x 10-5	6.4 x 10-3	6.4 x 10-8	8.0	9.2 x 10-3
Mechanical Damage					
INEL	1.0 x 10-5	5.3 x 10-6	5.3 x 10-11	5.2 x 10-4	2.6 x 10-6
HEPA Filter Fire					
INEL	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	2.5 x 10-5
Minor Water Pool Leak					
INEL	1.0 x 10-1	1.3 x 10-8	1.3 x 10-9	N/A	2.5 x 10-9
DRY STORAGE ACCIDENTS					
Mechanical Damage					
INEL	1.0 x 10-5	4.9 x 10-4	4.9 x 10-9	5.6 x 10-2	4.6 x 10-4

DRY CELL ACCIDENTS					
Mechanical Damage					
INEL	1.0 x 10-4	3.5 x 10-4	3.5 x 10-8	1.0 x 10-1	2.2 x 10-4
Loss of Shielding					
INEL	1.0 x 10-5	3.0 x 10-19	3.0 x 10-24	7.2 x 10-5	9.3 x 10-17

Table F-8. Impacts from naval spent nuclear fuel facility radiological accidents f Regionalization or Centralization at other DOE sites alternatives.
Information applicable only to DOE site selected for Regionalization or Centralizat

Accident Description	Probability (per year)	Con- sequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to W- ork- er (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
Savannah Rive	1.0 x 10-5	1.1 x 10-1	1.1 x 10-6	2.1	1.6 x 10-2
Hanford	1.0 x 10-5	4.7 x 10-2	4.7 x 10-7	2.1	6.3 x 10-3
Nevada Test S	1.0 x 10-5	1.9 x 10-3	1.9 x 10-8	2.1	3.3 x 10-2
Oak Ridge	1.0 x 10-5	1.8 x 10-1	1.8 x 10-6	2.1	5.2
Accidental Criticality					
Savannah Rive	1.0 x 10-5	4.5 x 10-2	4.5 x 10-7	8.0	9.4 x 10-3
Hanford	1.0 x 10-5	1.6 x 10-2	1.6 x 10-7	8.0	2.8 x 10-3
Nevada Test S	1.0 x 10-5	7.0 x 10-4	7.0 x 10-9	8.0	2.0 x 10-2
Oak Ridge	1.0 x 10-5	8.8 x 10-2	8.8 x 10-7	8.0	4.7
Mechanical Damage					
Savannah Rive	1.0 x 10-5	2.0 x 10-5	2.0 x 10-10	5.2 x 10-4	2.2 x 10-6
Hanford	1.0 x 10-5	8.6 x 10-6	8.6 x 10-11	5.2 x 10-4	9.8 x 10-7
Nevada Test S	1.0 x 10-5	5.6 x 10-7	5.6 x 10-12	5.2 x 10-4	4.6 x 10-6
Oak Ridge	1.0 x 10-5	3.4 x 10-5	3.4 x 10-10	5.2 x 10-4	5.9 x 10-4
Airplane Crash					
Savannah Rive	2.0 x 10-6	6.1 x 10-3	1.2 x 10-8	1.6 x 10-1	6.4 x 10-4
Oak Ridge	1.0 x 10-6	1.0 x 10-2	1.0 x 10-8	1.6 x 10-1	1.8 x 10-1
Nevada Test S	4.0 x 10-7	1.7 x 10-4	6.8 x 10-11	1.6 x 10-1	1.3 x 10-3
HEPA Filter Fire					
Savannah Rive	5.0 x 10-4	1.3 x 10-4	6.5 x 10-8	2.4 x 10-3	2.1 x 10-5
Hanford	5.0 x 10-4	5.3 x 10-5	2.7 x 10-8	2.4 x 10-3	7.0 x 10-6
Nevada Test S	5.0 x 10-4	5.7 x 10-6	2.9 x 10-9	2.4 x 10-3	4.3 x 10-5
Oak Ridge	5.0 x 10-4	2.2 x 10-4	1.1 x 10-7	2.4 x 10-3	5.7 x 10-3
Minor Water Leak					
Savannah Rive	1.0 x 10-1	1.3 x 10-9	1.3 x 10-10	N/A	7.9 x 10-10
Hanford	1.0 x 10-1	1.7 x 10-10	1.7 x 10-11	N/A	9.9 x 10-12
Nevada Test S	1.0 x 10-1	1.4 x 10-9	1.4 x 10-10	N/A	2.5 x 10-9
Oak Ridge	1.0 x 10-1	3.9 x 10-9	3.9 x 10-10	N/A	1.5 x 10-9
DRY STORAGE ACCIDENTS					

Mechanical Damage

Savannah Rive	1.0 x 10-5	3.0 x 10-3	3.0 x 10-8	5.6 x 10-2	4.9 x 10-4
Hanford	1.0 x 10-5	1.3 x 10-3	1.3 x 10-8	5.6 x 10-2	1.7 x 10-4
Nevada Test S	1.0 x 10-5	5.3 x 10-5	5.3 x 10-10	5.6 x 10-2	8.8 x 10-4
Oak Ridge	1.0 x 10-5	5.1 x 10-3	5.1 x 10-8	5.6 x 10-2	1.4 x 10-1

Airplane Crash

Savannah Rive	3.0 x 10-7	2.8	8.4 x 10-7	92	4.7 x 10-1
Oak Ridge	3.0 x 10-7	4.7	1.4 x 10-6	92	120

DRY CELL ACCIDENTS

Mechanical Damage

Savannah Rive	1.0 x 10-4	1.4 x 10-3	1.4 x 10-7	1.0 x 10-1	2.4 x 10-4
Hanford	1.0 x 10-4	5.3 x 10-4	5.3 x 10-8	1.0 x 10-1	7.1 x 10-5
Nevada Test S	1.0 x 10-4	3.7 x 10-5	3.7 x 10-9	1.0 x 10-1	4.0 x 10-4
Oak Ridge	1.0 x 10-4	2.5 x 10-3	2.5 x 10-7	1.0 x 10-1	5.8 x 10-2

Loss of Shielding

Savannah Rive	1.0 x 10-5	3.0 x 10-16	3.0 x 10-21	7.2 x 10-5	6.7 x 10-15
Hanford	1.0 x 10-5	4.9 x 10-24	4.9 x 10-29	7.2 x 10-5	3.3 x 10-23
Nevada Test S	1.0 x 10-5	3.7 x 10-37	3.7 x 10-42	7.2 x 10-5	6.3 x 10-11
Oak Ridge	1.0 x 10-5	7.5 x 10-6	7.5 x 10-11	7.2 x 10-5	1.2 x 10-2

Airplane Crash

Savannah Rive	2.0 x 10-6	4.8	9.6 x 10-6	160	8.2 x 10-1
Oak Ridge	1.0 x 10-6	8.4	8.4 x 10-6	160	350
Nevada Test S	4.0 x 10-7	1.8 x 10-1	7.2 x 10-8	160	1.6

concentrations were then compared against Emergency Release Planning Guide (ERPG) l of evaluating their effects. ERPG values are specific for each substance and provi airborne concentration thresholds above which one can reasonably observe adverse ef an ERPG-1 level could result in a very mild effect whereas exposure to an ERPG-3 le life-threatening health effect. For the postulated accident involving a chemical s personnel (worker) could be exposed to concentrations of hydrochloric acid, phosgen sodium hydroxide above ERPG-3 levels which indicates a potential for long-term heal However, no member of the general public located off-site would be expected to be e above ERPG-3 except for Oak Ridge where sulfuric acid and sodium hydroxide concentr exceed ERPG-3. For the postulated accident involving a diesel fuel fire, on-site p exposed to concentrations of sulfur dioxide and oxides of nitrogen above ERPG-3 lev the general public located off-site would be expected to be exposed to levels above Oak Ridge where sulfur dioxide and oxides of nitrogen concentrations could exceed E shipyard location (Norfolk) where nitric oxide concentrations could exceed ERPG-3 u meteorological conditions. However, for both postulated accidents, the accident an evacuation of on-site or off-site personnel and it is expected that chemical exposu ERPG-3 levels because actions such as evacuation would be used to reduce the effect workers.

Fugitive Dust Analysis

The FDM computer code was used to estimate the fugitive dust concentrations t from the construction of a water pool facility at the alternate locations. It was of fugitive dust would not result in any adverse effects for any of the alternate l

Other Impacts

The radiological impact of accidents on the environs of a facility was determ the area that could be contaminated following such an event. Calculations using av conditions were performed for each accident scenario. These calculations determine contamination which causes only a small increase in background radiation from natur sources. For most facilities and most accidents, the contaminated area was confine the site. For a few cases, the casualty scenarios did result in contaminated land however, the total land contaminated for those scenarios (inside and outside the bo than 207 acres. The impact of this contamination would be temporary while the area remediation efforts completed.

F.1 RADIOLOGICAL ISSUES FROM NAVAL SPENT NUCLEAR FUEL

INSPECTIONS AND STORAGE

Naval spent nuclear fuel is currently examined and stored at the Naval Reacto Expended Core Facility (ECF) at the DOE Idaho National Engineering Laboratory (INEL INEL-ECF is a large laboratory facility used to receive, examine, and ship naval sp irradiated test specimen assemblies. Enclosed work areas at INEL-ECF include an ar reinforced concrete water pools which permit visual observation of naval spent nucl handling and inspection while shielding workers from radiation. Adjacent to the wa cells used for operations which must be performed dry. One of the water pools cont that will link the water pools with a proposed Dry Cell Project, which would provid preparation of spent fuel in a dry, enclosed environment.

The proposed Dry Cell Facility will consist of a shielded, radiologically con structural steel and concrete with remotely operated equipment necessary to examine

The Organization for Economic Co-operation and Development (OECD) of the Nucl Agency (NEA) reported that extensive safety analysis has shown that pool storage of a very safe option which can last for decades (NEA 1993). The external hazards, su aircraft crashes, are potential threats for these facilities (loss of coolant) but additional shielding can cope with these hazards. Dry storage has not yet generall very large scale but it is anticipated that long-term storage in adequate canisters against earthquakes and aircraft crashes.

Several technologies are being used currently for the storage of spent fuel a sites away from reactors. Both wet (pool) storage facilities and dry storage facil containers) are used on a commercial scale.

The safety of spent fuel storage has been extensively evaluated. The U.S. Nu Commission (NRC) reported in the "Waste Confidence Decision" of 1984 that there is assurance that spent fuel can be stored safely and without significant environmenta pools or in spent fuel storage installations (NUREG 1984). For both dry storage an stated its belief that current storage technologies are capable of providing safe s beyond the active lifetime of the reactor facility. The NRC also concluded that th accident or sabotage at a spent fuel storage facility with radiological consequence extremely remote.

Considerable experience has been gained in the transport of spent fuel elemen consequent safety-related development of suitable transportation casks. This exper possible to develop a concept for dry storage of spent fuel elements within transpo storage containers generally have not been the transportation casks themselves.

The concept of a cask which could be used for both transportation and storage in the United States in the framework of a policy of dry storage in Independent Spe Installations (CFR 1993). According to this policy, the reactor operators are enti elements, which have cooled in a pool for at least one year after discharge from th licensed containers under dry conditions for 20 years or more. A number of storage official approval for that purpose.

F.1.1 Normal Operations

Current practice for examination of naval spent nuclear fuel at ECF includes lower non-fuel bearing structures, visual examination, measurement of key dimension specimens, and loading into a shipping cask. Temporary storage of spent fuel at IN

since fuel is, at times, received into the facility faster than it can be examined facility. In addition, a small amount of spent fuel is selected for retention as l reference and examination. Routine releases to the atmosphere were evaluated at al measured releases from INEL-ECF. Each location was evaluated using releases equiva INEL-ECF. Each location's specific population and meteorology were then used to pr consequences.

F.1.1.1 Water Pool Storage. **Wet storage is a highly developed technique and it is the standard**

method used worldwide for storage of spent fuel. While in wet storage pools, tempe radiation fluxes are lower than in the reactor, so there is no intrinsic driving fo a major fraction of the radioactive materials contained in the stored spent fuel.

The Zircaloy cladding of naval spent nuclear fuel is an efficient barrier aga release during handling and storage of spent fuel. Given adequate control of water corrosion in water during the long-term storage conditions of fuel assemblies. At life, the fuel is covered with a tightly adhering oxide layer formed at high temper factor that inhibits further corrosion during storage.

Direct exposure to radiation of persons working in storage facilities can occ activities as handling of fuel casks and fuel assemblies, handling of contaminated maintenance work. Experience shows that, in common with other fuel cycle facilitie increased occupational exposure arises when any maintenance or unusual operations a increased exposures can, however, generally be minimized by good planning, adequate critical components, paying particular attention to the design of those items that contaminated from the point of view of repair and maintenance, and by the use of lo equipment decontamination procedures. Systems and components that are important in include:

- pool water cooling and makeup systems;
- filter equipment for purification of pool water;
- ventilation systems;
- equipment for temperature, water level, and leakage measurement in the f
- hoists and handling systems for fuel assemblies; and
- equipment for handling and storage of other wastes.

Shielding from radiation is normally assured by providing a minimum depth of fuel elements in storage to reduce the exposure rates. Fuel transfer mechanisms ha mechanical stops to prevent the inadvertent raising of fuel to the water surface. structure is needed in order to guarantee adequate containment of the pool water, b water resulting in a substantial reduction of the shielding layer is unlikely to in exposures to personnel above operational limits since adequate countermeasures can

Storage of naval spent nuclear fuel in water pools is an alternative being ev Navy shipyard locations discussed above. Source terms for all locations were based reported by INEL-ECF in the past. Exposures due to downwind dispersion, water rele radiation were calculated.

F.1.1.2 Dry Storage. **Many thousands of spent fuel assemblies of different types have been stored for**

periods of time ranging from a couple of years to over 30 years in more than 20 dif facilities. In general, the spent fuel behavior during storage has been excellent of dry storage on the integrity of the spent fuel have been detected (NEA 1993).

The dry storage of spent fuel is being used to a limited extent in several co States, fuel was stored in dry wells at the INEL. Dry wells were used for the stor fuel at the Nevada Test Site as part of a large dry storage demonstration program. Climax deep dry wells (600 meters below the surface in granite) in 1979. In 1983, underwent extensive non-destructive and destructive characterization. No problems changes were identified (NEA 1993).

Designs of metal casks for use in spent fuel storage have been in existence s The casks are generally equipped with a double-lid system to ensure safe containmen casks have been subjected to a variety of tests and demonstrations since the early and consolidated fuel.

The DOE sponsored the demonstration of the storage of fuel in metal casks at facility in 1984 and 1985. The DOE entered into a cooperative agreement with Virgi States' utility, to demonstrate the use of three types of metal casks. The Virgini Power Station has been licensed by the NRC for storage of spent fuel in metal casks

Results of demonstration activities have shown the following (NEA 1993):

- radiation and thermal levels resulting from metal cask storage have been
- no fuel failure has occurred during demonstration storage;
- no secondary wastes have arisen from the storage operation.

Storage of naval spent nuclear fuel in storage or shipping containers is an a evaluated at all locations. Since no airborne releases are expected from routine d the biological effects of direct radiation exposure to the on-site personnel and th

F.1.1.3 Dry Cell Operations. The handling of naval spent nuclear fuel for research and development

purposes in dry cells like the proposed Dry Cell Project was evaluated at selected health effects due to routine airborne releases and direct radiation exposure were

F.1.2 Screening/Selection of Accidents for Detailed Examination

Accidents were considered for inclusion in detailed analyses if they were exp substantially to risk (defined as the product of the probability of occurrence of t consequence of the accident). Accidents were categorized into three types as eithe Design Basis Accidents, or Beyond Design Basis Accidents. These categories are cha probability of occurrence as described further in Section F.1.3.7. Construction an included in these categories.

In selecting accidents to include in detailed analyses, several consideration Initiating events were reviewed including natural phenomena (earthquakes, volcanic hurricanes and other natural events) and human initiated events (human error, equip explosions, plane crashes, transportation accidents, and terrorism). Guiding princ such as: the radioactive materials involved must be available in a dispersible for mechanism available for release of such materials from the facility; and, there mus available for off-site dispersion of the released materials. The pathways whereby can be affected from the nuclear aspects of spent fuel operations are direct exposu inhalation of radioactive materials, or ingestion of radioactive materials. Recogn processes and pathways, accidents involving the following basic phenomena were iden

- loss of shielding of radioactive materials,
- release of radioactive products to the environment due to overheating of
- release of radioactive products to the environment due to mechanical sho inadvertent breaching of fuel cladding or containment,
- an unplanned criticality,
- transportation accidents.

After the basic phenomena were identified, other references were consulted to important accidents were considered. These included safety analysis reports, court environmental impact statements, and summary documents such as the "Final Generic E Impact Statement on Handling and Storage of Spent Light Water Reactor Power Reactor 1979a) and "The Safety of the Nuclear Fuel Cycle" (NEA 1993).

Examining the kinds of accidents which could result in release of radioactive environment or an increase in radiation levels shows that they can only occur if an severe conditions. Some types of accidents, such as procedure violations, spills o containing radioactive particles, or most other types of common human error, may oc than the more severe accidents analyzed. However, they do not involve enough radio radiation to result in a significant release to the environment or a meaningful inc Stated another way, the very low consequences associated with these events produce those for the accidents analyzed, even when combined with a higher probability of o Consequently, they have not been included in the results presented in this Environm Statement.

Acts of terrorism are expected to result in consequences which are bounded by accidents which were evaluated. Naval spent nuclear fuel is not considered to be a due to the bulk of the fuel and containers and due to the high radiation fields inv spent nuclear fuel. However, terrorist attacks on naval spent nuclear fuel during The massive structure of the shipping containers used for naval spent nuclear fuel target of a terrorist attack. No such attacks have occurred in the nearly 40 years have now travelled about 2 million kilometers. Thus, the probability of a terroris judged to be no more than the probability of a rail accident which is listed in Sec Attachment A to Appendix D of this Environmental Impact Statement. The consequence

attack are also judged to be no more severe than those listed for transportation ac
same conclusions reached for transportation accidents apply to the risk to the extr
containers from terrorist attack during a shipment. In addition, during shipment,
fuel containers are accompanied by escorts who remain in contact with headquarters.
emergency, state and federal resources would be quickly summoned to stabilize the s

For an act of war, sabotage, or terrorist attack, it is likely the risk would
for the airplane crash because it should be less probable that a force would exist
products into the atmosphere from a weapon as compared to the motive force of the f
case of an airplane crash. For example, attacks on containers using anti-tank weap
severe than the accidents analyzed because: (a) anti-tank weapons would cause a se
in the metal of a container, unlike that which is assumed from the airplane crash (
diameter engine rotor); (b) there is no explosive material inside the container, so
tank would if hit by such a weapon (in a tank attack, the tank shells inside the tu
would be no fire to disperse the radioactivity that is released when the container
aircraft crash where the jet fuel will burn creating such a fire. The rugged desig
thick walls of water pools, combined with the shock-absorbing nature of water with
the effects of other types of explosive charges. It is not credible that a terrori
criticality or meltdown of spent nuclear fuel; however, in Section F.1.4.2.1.2, the
hypothetical criticality accident are presented. The risks associated with an acci
than those associated with a drained water pool or an airplane crash into dry stora

The effect of a terrorist attack or an act of sabotage is expected to be cons
the limiting accident discussed at each facility under each alternative. For examp
accident involving naval spent nuclear fuel is described in this attachment to be a
shipping container at the Pearl Harbor Naval Shipyard. This accident would lead to
over the next 50 years in the population within 50 miles of the shipyard. Since th
is one chance in 100,000 per year, the risk would be 0.00026 latent fatal cancer fa
other words, about one chance in 4,000 of a single latent fatal cancer fatality ove
shared among the approximately 820,000 people residing within 50 miles of the shipy
expected to have over 2,000 cancer fatalities from all causes every year. For an a
terrorist attack, it is likely the risk would be lower than calculated because it s
force would exist to disperse radioactive products into the atmosphere from a weapo
motive force of the fire assumed in the case of an airplane crash.

Accidents initiated at nearby facilities, by other activities unrelated to sp
or storage, or during construction of an ECF or dry cell type of facility, would no
severe than the sequences of events described. This is because naval spent nuclear
examination or in storage under the conditions of the alternatives evaluated would
conditions or uninterrupted operator attention to prevent overheating, failure of c
shielding. Therefore, evacuation in response to an accident at some other facility
safety. This inherent safety, combined with the distance between naval spent nucle
any other activities which might suffer a catastrophic accident, means that the acc
document produce conditions at a naval spent nuclear fuel facility which would be m
for any hypothetical synergistic combination of events resulting from accidents at
facilities. Therefore, such analyses have not been included in this evaluation.

The existence of common cause accidents at a facility has been considered. I
spent nuclear fuel facility is located at a particular Navy site. However, it is p
na, like an earthquake, to produce more than one accident at some sites causing a s
release of radioactive material into the atmosphere or an increase in radiation lev
shielding. However, the probability of two or more accidents having maximum conseq
concurrently is less than the probability of the individual events. For example, i
the Naval Reactors Facility at INEL, a crane might fail causing damage to stored sp
might drain, and shielding for the Dry Cell might be damaged. The impacts for this
be estimated by summing the consequences. A combined total of 2.8 x 10-2 fatal can
Similarly, consequences from spent nuclear fuel facilities within a DOE site could
conservatively estimate site wide impacts. But again, the probability of a common
this number of consequences is lower than the probability of the individual acciden
of impact will vary between facilities due to separation distances.

Several accident scenarios were developed for the handling and storage of nav
fuel. All potential accidents were not evaluated, but cases which are considered t
other reasonable accidents were analyzed. Each of these accident scenarios was eva
locations using identical source terms. Like the evaluations for normal operations
meteorology data specific to each site were used to estimate site specific health e

F.1.2.1 Water Pool Storage. Six hypothetical accident scenarios were evaluated for naval spent

nuclear fuel stored in water pools. These hypothetical sequences of events include pool caused by an earthquake, an accidental criticality, mechanical damage due to o failure, an airplane crash into the water pool facility, a fire in a high efficienc filter, and minor water pool leakage. Radiation exposure to on-site individuals, a boundary, and the general population was estimated for airborne releases of radioac and direct radiation exposure.

F.1.2.2 Dry Storage. Two hypothetical accident scenarios were evaluated for naval spent nuclear fuel

stored in shipping containers. The first scenario postulates that a wind-driven mi casks, with mechanical damage causing a release of corrosion products into the envi hypothetical scenario is based on an airplane crash into the dry storage area. Onc exposure to on-site individuals, an individual at the site boundary, and the genera estimated for airborne releases, water releases, and direct radiation exposure.

F.1.2.3 Dry Cell Operations. Three hypothetical accidents were evaluated for naval spent nuclear fuel

handled in dry cells at several locations. These scenarios include cutting into th mechanical damage during examination work, partial loss of concrete shielding due t an airplane crash into the dry cell facility. Once again, radiation exposure to on individual at the site boundary, and the general population was estimated for airbo releases, and direct radiation exposure.

F.1.2.4 Shipboard Fire Involving Shipping Containers. Attachment A describes the historical

practice of shipping naval spent nuclear fuel from Pearl Harbor Naval Shipyard to P Shipyard by ship where the containers are then transported to ECF by rail. Since 1 shipments containing a total of 20 shipping containers. Even though there have not involving these shipments, hypothetical accidents were evaluated near the Pearl Har shipyards. The scenario involves a collision of the spent nuclear fuel ship with a in a fire. The radiation exposure to nearby individuals and the general population airborne and water releases.

F.1.3 Analysis Methods for Evaluation of Radiation Exposure

F.1.3.1 General. An evaluation of normal operations and hypothetical accidents at the existing and

proposed sites was performed to assess the possible radiation exposure to individua radioactive materials. The analyses are based on the same operations carried out a locations and the same accidents at any of the sites evaluated. With this approach compare the incremental effect of the proposed alternative actions or the different postulated accidents at the different sites. These locations include four naval sh Norfolk, Puget Sound, and Pearl Harbor), five Department of Energy facilities (INEL Hanford, Nevada Test Site, and Oak Ridge), and the Kesselring Site.

F.1.3.2 Exposures to be Calculated. Radiation exposure to the following different individuals and

the general population is calculated for normal operation of the spent fuel facilit conditions:

- Worker (Worker). An individual located 100 meters (330 feet) from the r material release point. (The impact of accidents on close-in workers is numerically but is discussed qualitatively for each accident in Section attachment.)

- Maximally exposed collocated worker (MCW). At DOE locations, a theoreti individual located at whichever is the greater of 0.4 mile from the faci or 75% of the distance to the nearest independent facility area. The MC evaluated if the site boundary is closer than the MCW location. Thus, at

locations and the Kesselring Site, the MCW is not specifically evaluated

- Maximally exposed off-site individual (MOI). A theoretical individual l site or shipyard boundary receiving the maximum exposure. At the Savann two separate MOI locations were evaluated depending upon whether the spe is constructed on the Savannah River Site or is located at the existing Fuel Plant (hereafter referred to as the Barnwell Plant) which is adjace River Site. At Hanford, two separate MOI locations were also evaluated whether a new facility is constructed in the 200 Area or modifications a Fuels and Materials Examination Facility (FMEF) which is located in the

- Nearest public access individual (NPA). At larger DOE sites, highways u public may cross the federal reservation which includes the facility whe nuclear fuel operations could be conducted. Consequently, these analyse evaluation of the exposure to a theoretical motorist who might be strand highway at the time of an accident. Based on experience from emergency emergency response teams would be able to evacuate such an individual wi so this was the exposure time used in the calculations. At naval shipya public access highways exist, but military personnel, civilian employees members, including some who reside on the base, may be located outside t industrial area boundary but inside the confines of the military base. might be at their homes, in buildings, or on the roadways of the base at accident or at any time throughout the year for the evaluation of normal base residents are used as the NPA individuals at these shipyards for an operations. In the event of a severe accident they would be evacuated w under military control of the base, so this time was used in accident ca value was calculated for the Kesselring Site and the Nevada Test Site be public roads which cross these sites, there are no residents, and there accesses.

- Maximally exposed individual at nearby communities is evaluated for acci

- General population within a 50-mile radius of the facility.

Exposure is calculated to result from direct radiation from the facility and contamination released to the air. Normal releases directly to the water pathway o which are located directly on bodies of water, and contamination of the water at al fallout of airborne contamination. The releases to the air might result in exposur pathways described as follows:

- External direct exposure from immersion in the airborne radioactive mate immersion)

- External direct exposure from radioactive material deposited on the grou surface)

- Internal exposure from inhalation of radioactive aerosols and suspended (inhalation)

- Internal exposure from ingestion of terrestrial food and animal products

- Exposure from contaminated water (water release).

The radiation exposure is calculated by the computer programs discussed in Se manner recommended by the International Commission on Radiological Protection (ICR 1979). Weighting factors are used for various body organs to calculate a "committe equivalent" (CEDE) from radiation inside the body due to inhalation or ingestion. equivalents (CDEs) are calculated for organs such as the lungs, stomach, small inte intestine, lower large intestine, bone surface red bone marrow, testes, ovaries, mu kidneys, liver etc. The CEDE value is the summation of the CDEs to the specific or relative risk to that organ compared to an equivalent whole-body exposure.

The programs also calculate an effective dose equivalent (EDE) for the extern pathways (immersion in the radioactive material, exposure to ground contamination) for the internal exposure pathways . The sum of the EDE from external pathways and pathways is called the "total effective dose equivalent" (TEDE) in this Environment

(EIS) and is also calculated by the programs. The TEDE reported in the results sec TEDE's from air, water, and direct radiation exposures.

The exposure from ingestion of terrestrial food and animal products is calcul However, it is expected that continued consumption of contaminated food products by suspended after a Protective Action Guideline is reached. In 1991, the Environment recommended protective action guidelines in the range of 1 to 5 rem whole-body expo consistent analysis basis, no reduction of exposure due to a Protective Action Guid in the analysis. This would result in a conservative approach which may slightly o effects within an exposed population, but allows for consistent comparisons between

Table F.1.3.2-1 identifies selected nearby communities for each site for whic exposures for a maximally exposed individual were calculated. In all cases, the MO than maximum exposure at any nearby community. Calculations were performed for the evaluate exposures for areas representative of the range of communities within 50 m analyzed. The selection of these communities was not intended to indicate that oth important. Other communities of interest in the vicinity of the sites in addition a number of communities in Maine and New Hampshire near the Portsmouth Naval Shipya Portsmouth, Durham, Eliot, Greenland, Kittery, New Castle, North Hampton, Ogunquit, Berwick.

Table F.1.3.2-1. Nearby communities for each site.

INEL	Howe, Atomic City, Arco, Blackfoot, Idaho Falls
Savannah River	Snelling, Barnwell, Jackson, Aiken, Allendale, August
Hanford	Othello, Richland, Prosser, Pasco, Yakima, Umatilla
Nevada Test Site	Beatty, Pahrump, Las Vegas
Oak Ridge	Oak Ridge, Harriman, Rockwood, Knoxville, Jefferson Ci
Puget Sound	Seattle, Tacoma, Olympia, Port Angeles
Pearl Harbor	Pearl City, Aiea, Pacific Palisades, Ewa Beach, Honolu
Norfolk	Newport News, Hampton, Suffolk, Virginia Beach, Willia
Portsmouth	Dover, Exeter, Hampton Beach, Sanford, Nashua, Lowell, C Boston
Kesselring	Ballston Spa, Saratoga Springs, Amsterdam, Schenectady

Table F.1.3.2-2 presents an example of the detailed exposure calculation resu performed. The table shows the possible exposure pathways and individuals analyzed

F.1.3.3 Evaluation of Health Effects. Health effects are calculated from the exposure results. The

risk factors used for calculations of health effects are taken from Publication 60 Commission on Radiological Protection (ICRP 1991). Table F.1.3.3-1 lists the appro the analysis of both the normal operations and the hypothetical accident scenarios.

Cancer fatalities were used to summarize and compare the results in this Envi Statement since this effect was viewed to be of the greatest interest to most peopl F.1.3.3-1, the number of total health effects (deaths, non-fatal cancers, genetic e on human health) may be easily obtained by multiplying the latent cancer fatalities which is the ratio of 7.3/5.0.

The numerical estimates of cancer deaths and other health detriments presente the practice of linear extrapolation from the nominal risk estimate for lifetime to rad. Other methods of extrapolation to the low-dose region could yield higher or l estimates of cancer deaths. Studies of human populations exposed at low doses are

Table F.1.3.2-2. Summary of exposure calculation results.

Location	Inhalation	Air Immer-sion	Ground Surface	Ingestion	Total Airborne Release
	CEDE (rem)	EDE (rem)	EDE (rem)	EDE (rem)	EDE (rem)
Worker	5.4 x 10-1	6.5 x 10-4	7.9 x 10-1	N/A	1.3
MCW	4.8 x 10-4	8.6 x 10-7	3.4 x 10-4	N/A	8.2 x 10-4
NPA	1.4 x 10-4	3.2 x 10-7	5.2 x 10-5	N/A	1.9 x 10-4
MOI	6.1 x 10-4	1.2 x 10-6	7.8 x 10-4	3.1 x 10-4	1.7 x 10-3

Exposure to Maximally Exposed Individual at Nearby Communities (rem)					
Arco (30600m)	5.2 x 10-5	1.3 x 10-7	6.4 x 10-5	3.1 x 10-5	1.5 x 10-4
Howe (16100m)	9.8 x 10-5	1.8 x 10-7	1.2 x 10-4	5.6 x 10-5	2.7 x 10-4
Idaho Falls (72400m)	3.1 x 10-6	5.2 x 10-9	3.6 x 10-6	2.0 x 10-6	8.7 x 10-6
Blackfoot (68100m)	4.8 x 10-6	3.3 x 10-9	5.2 x 10-6	3.4 x 10-6	1.3 x 10-5
Atomic City (24200m)	2.9 x 10-5	1.0 x 10-7	3.6 x 10-5	1.6 x 10-5	8.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)					
Population of 115690	1.1 x 10-1	6.1 x 10-5	1.5 x 10-1	4.5 x 10-2	3.0 x 10-1

Table F.1.3.3-1. Risk estimators for health effects from ionizing radiation.

		Risk Factor (probability per rem)*	
Effect	Nuclide	Worker	General Population
Fatal cancer (all organs)	All	4.0 x 10-4	5.0 x 10-4
Weighted non-fatal can-cer**	All	8.0 x 10-5	1.0 x 10-4
Weighted genetic effects**	All	8.0 x 10-5	1.3 x 10-4
Weighted total effects**	All	5.6 x 10-4	7.3 x 10-4

* For high individual exposures (y20 rem), the above risk factors are multiplied by a factor of two.
General population exposures were not modified because the large drop in exposure with increasing distances results in average exposure rates well below 20 rem.

** In determining a means of assessing health effects from radiation exposure, the ICRP has developed a weighting method for non-fatal cancers and genetic effects to obtain a total weighted effect, or "health detriment".

inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). In this appendix, the doses have been provided in all cases to allow independent evaluation using any relation between exposure and health effects.

F.1.3.4 Population. Population distributions specific to each site were used for the evaluations. The

population distributions were obtained from 1990 United States Census data. The po was obtained in 16 compass directions and 5 equal radial distances from the likely spent nuclear fuel site to a 50-mile total distance.

F.1.3.5 Meteorology. For the navy shipyards, Savannah River, and Kesselring Sites, the

meteorological data used in the analyses were obtained from the SCRAM bulletin boar INEL, Hanford, Nevada Test Site, and Oak Ridge, site tower meteorological data were SCRAM bulletin board is operated by the Support Center for Regulatory Air Models wi Environmental Protection Agency, Office of Air Quality Planning and Standards. The meteorological data files are comprised of data acquired from the National Climatic SCRAM data for 4 or 5 years were used with programs from the bulletin board to deve data in the STability ARray (STAR) format which is a joint frequency distribution o intervals, 16 wind directions, and 6 stability categories. The STAR data were refo required by the GENII program, described below, for evaluation of normal operations

The STAR data were also used to calculate the 50% and 95% meteorological cond accident analyses. The 50% condition represents the average meteorological conditi defined as that for which more severe conditions with respect to accident consequen 50% of the time. The 95% condition represents the meteorological conditions which highest calculated exposures. This is defined as that condition which is not excee time or is the worst combination of weather stability class and wind speed. Each o evaluated for 16 wind directions.

For each location, the nearest available SCRAM data was used to represent the site being evaluated. Table F.1.3.5-1 shows the pertinent data for the meteorologi

Table F.1.3.5-1. Meteorological data applicability.

Site	Data From	Data Years
Portsmouth	Portland ME Airport	1985-1989
Norfolk	Norfolk VA Airport	1985-1989
Puget Sound	SEATAC Airport	1985-1989
Pearl Harbor	Honolulu Airport	1985-1989
INEL	NRF Tower	1987-1991
Kesselring	Albany NY Airport	1985-1989
Savannah River	Augusta GA Airport	1984-1987
Hanford	200 Area Tower	1983-1990
Nevada Test Site	Desert Rock Tower	1990
Oak Ridge	Y-12 West Tower	1990

F.1.3.6 Computer Programs. Five computer programs were used to evaluate the radiation exposures

to the specified individuals and general population.

F.1.3.6.1 GENII. The code used for the environmental and transport and exposure assessment

calculations for normal operations was GENII (Napier et al. 1988). This code was d Northwest Laboratory by Battelle Memorial Institute to incorporate the internal dos recommended by the International Commission on Radiological Protection in Publicati and Publication 30 (ICRP 1979) into environmental pathway analysis models in use at Laboratory.

Although GENII can be used to model both acute and chronic releases to the at chronic option was used in the normal operations evaluation reflecting long-term av released radioactive contaminants. For the chronic evaluations, the code also uses conditions averaged over each sector to reflect exposure to long-term average conce ingestion calculation used the modeling approach that exposed individuals within 50 consumed 30% of milk products and 10% of all products grown locally where the peopl

F.1.3.6.2 RSAC-5. The computer code RSAC-5 was developed by Westinghouse Idaho

Nuclear Co, Inc., for the DOE-ID Operations Office and is in the public domain (Wen calculates the consequences of the release of radionuclides to the atmosphere. It each fission product nuclide from a nuclear event to be input individually or to be the code. RSAC-5 calculates potential radiation exposures to maximally exposed ind population groups via inhalation, ingestion, exposure to radionuclides deposited on immer-
sion in airborne radioactive material, and radiation from a cloud of radioactive ma meteorological capabilities include Gaussian plume dispersion for Pascal-Gifford co release scenario modeling allows reduction of nuclides by chemical group or element and buildup during transport through operations, facilities, and the environment.

of filters or other cleanup systems. Population exposures are the product of the c
exposure and the number of people in the affected population.

F.1.3.6.3 ORIGEN. ORIGEN (Croff 1980) is a computer code system for calculating the

buildup and decay of radioactive materials (fission products, actinides, and activa
input was modeled to describe the naval nuclear fuel system and incorporates cross-
distinct to naval fuels.

F.1.3.6.4 SPAN. SPAN (Wallace 1972) is the computer code which was used to calculate the

direct radiation levels. Attenuation from air was included in the calculated radia
the unit person exposure per sector, SPAN was used to integrate the radiation level
radiation levels calculated at various distances were used as the source to represe
falloff in the sector, and a total radiation level for each sector was calculated.
radiation level for each sector was then divided by the sector volume, resulting in
exposure for any point within the sector.

F.1.3.6.5 WATER RELEASE. WATER RELEASE is an unpublished computer code used to

calculate exposures to humans arising from radionuclides which have been introduced
vicinity of the proposed spent nuclear fuel storage and examination facilities. Th
provides a brief description of the key points associated with obtaining these esti
which were considered to be introduced into the water at a site were postulated to
uniformly in the water in the immediate vicinity of the site during the time period
were introduced. There are two processes by which radionuclides might enter the wa
liquid discharge or via airborne discharge. For liquid discharges, a fraction of t
might enter the water accessed by humans each year by infiltrating the ground to th
traveling either to wells or surface water. For airborne discharges, some fraction
radionuclides might enter the water by deposition from the air. For both of these
radionuclides that might enter the water used by humans has been postulated to ente
immediately, except for NRF and the Nevada Test Site. For NRF and the Nevada Test
postulated that 20 years pass before the nuclides might enter the water accessed by
is based upon the fact that water must percolate into the ground and reach groundwa
contamination must travel with the water in the aquifer to a point where it can be
a well at Atomic City. An assessment of the infiltration rate of radionuclides ben
about 200 years are needed for them to pass into the aquifer (Smith 1994). Also, t
flows at a rate of 5 to 20 feet per day. Therefore, 20 years was used as the time
humans at INEL. Similarly, at the Nevada Test Site surface water is not present so
aquifers which are more than 600 feet deep. Hence, 20 years was also used at this

Once the radionuclides have been introduced into the water at a site, they we
transported to locations where they might affect man either directly as via immersi
indirectly as via ingestion of food. During this transport period, these radionucl
various mechanisms which may reduce their concentration in the water such as radioa
in larger volumes of water, removal by sedimentation, etc. The pathways considered
which radionuclides in the water at a site might reach man are immersion, exposure
boating and equipment exposure, and consumption of drinking water, fish, crustacea,
animals, vegetables and fruits, root crops, milk and eggs, and domesticated animals
when the radionuclides have left the water environment and are being transported th
man, they may be subjected to both concentration and removal mechanisms which will
their effect upon man. These mechanisms include concentration in the surface depos
pathways; decay during periods between harvesting a crop and its ingestion by man;
activity due to harvesting, handling, and cleaning of a foodstuff.

For each of the sites at which storage or examination of spent nuclear fuel i
estimates were made for the exposures which the total population affected by releas
receive and for the exposures which a maximally exposed individual may receive from
releases. The exposures to the population affected at a given site were obtained b
exposures received by an average individual in the vicinity of that site and multip
the number of people that are affected. The exposure to a maximally exposed indivi
maximum exposures and consumption rates which any individual at that site may exper
the probabilities associated with just one individual actually following all the ma
specific pathways which are applicable at a given site are dependent upon the site,

average or a maximum individual to each of the pathways is different for each of th exposures associated with the drinking water pathway are not considered for the shi radionuclides basically end up in salt water prior to their becoming available to m other hand, the radionuclides introduced at the DOE and prototype sites can enter t pathway after a delay period. An initial delay occurs while the radionuclides seep before entering the aquifer. The delay continues while the radionuclides travel th pathway and ultimately yield exposures to man. The total exposure to the populatio exposed individual at a given site is the resultant sum of the exposure commitments pathways applicable at that site.

F.1.3.7 Categorization of Accidents.

F.1.3.7.1 Abnormal Events. Abnormal Events are unplanned or improper events which result

in little or no consequence. Abnormal events include industrial accidents and acci operations such as skin contamination with radioactive materials, spills of radioac to direct radiation due to improper placement of shielding. The occurrence of thes been anticipated and mitigative procedures are in place which promptly detect and e and limit the effects of these events on individuals. As a result, there is little population from these events. Such events are considered to occur in the probabili year. The probability referred to here is the total probability of occurrence and event occurs (e.g., plane crash) times other probabilities required for the consequ included in this range, results are presented for both the 50% meteorological condi meteorology) and the 95% meteorological condition.

F.1.3.7.2 Design Basis Accident Range. Accidents which have a probability of occurrence

in the range of 10-3 to 10-6 per year are included in the range called the Design B terminology "design basis accident," which normally refers to facilities to be cons "evaluation" basis accident which applies to existing facilities. For accidents in are presented for both the 50% meteorological condition (average meteorology) and t cal condition. Risk calculations for accidents in this range utilize the consequen meteorological conditions.

F.1.3.7.3 Beyond Design Basis Accidents. This range includes accidents which are less

likely to occur than the design basis accidents but which may have very large or ca consequences. Accidents included in this range typically have a total probability range of 10-6 to 10-7 per year. Accidents which are less likely than 10-7 per year since it is expected they do not contribute in any substantial way to the risk. Fo accidents, consequences are presented for 50% and 95% meteorological conditions. R accidents in this range utilize the consequences associated with 95% meteorological

F.1.3.8 Evaluation of Impacted Area

The impacted area surrounding a facility following an accident was determined evaluated. The impacted area was defined as that area in which the plume deposited to such a degree that an individual standing on the boundary of the fallout area wo approximately 0.01 mrem/hr of exposure. If this individual spends 24 hours a day a person would receive about 88 mrem per year from the ground surface shine. This is 100 mrem/year limit of 10CFR20.

To best characterize the affected areas for each casualty, a typical 50% mete (Pasquill-Gifford Class D, wind speed 10 mph) and applied to each accident scenario results for ground surface dose were interpolated to determine the distance downwin dose had dropped to approximately 88 mrem per year based on 24 hours per day exposu class chosen, the plume remains within a singe 22.5-degree sector. The area affect determined as the entire sector contaminated to the calculated downwind distance. each facility accident analyzed and the contaminated footprint associated with the F.1.3.8-1. Footprint estimates for facility accidents.

	Footprint Length	Footprint Area*	Sites with Footprint Beyond Facility

Accident Scenario	(miles)	(acres)	Boundary
Drained Water Pool	0.29	11	Norfolk, Oak Ridge, Portsmouth
Criticality	0.25	8	Norfolk, Oak Ridge, Portsmouth
Wet Storage Mechani- cal Damage	<0.06	<0.5	none
Wet Storage Airplane Crash	<0.06	<0.5	none
Dry Storage Mechanical Damage	<0.06	<0.5	none
Dry Storage Airplane Crash	0.91	106	Pearl Harbor, Nor- folk, Oak Ridge, Portsmouth
Dry Cell Mechanical Damage	<0.06	<0.5	none
HEPA Filter Fire	<0.06	<0.5	none
Dry Cell Airplane Crash	1.27	207	Oak Ridge

*Based on contamination of a single sector.

Although the plume would be contained within a single sector, the direction o unknown. Therefore, each site was examined for impacts in all directions around th distance equal to the footprint length. Since the accidents do occur over a short acreage of the sector quoted is still an accurate indication of the total contamina the potential impacts for each site is contained in Tables F.1.3.8-2 through -11.

Table F.1.3.8-2. Secondary impacts of facility accidents at Puget Sound Naval Ship

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Puget Sound Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool 3. Criticality and all other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking andindustrial purposes is monitored and use may be temporari- ly suspended during cleanup operations. Some recreationalactivities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval at th could tempo conta durin accid Clean opera would store these full

Table F.1.3.8-3. Secondary impacts of facility accidents at Pearl Harbor Naval Shi

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Pearl Harbor Naval Shipyard	1. Dry Storage Plane Crash 2. All other radiological accidents	Plants and animals on the site and around the site will experi- ence no long term impacts.	The water used for drinking andindustrial purposes is monitored and use may be temporari- ly suspended during cleanup operations. Some recreationalactivities may also be temporarily suspended. No endur- ing impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other sup- port activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval sels at th could tempo conta ted durin accid Clean opera would store these full

Table F.1.3.8-4. Secondary impacts of facility accidents at Norfolk Naval Shipyard

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Norfolk Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool and Criticality	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking andindustrial purposes is monitored and use may be temporari- ly suspended during cleanup operations. Some	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during	Naval at th could tempo raril conta ted durin accid Clean opera would

	3. All other radiological accidents		recreational activities may also be temporarily suspended. No enduring impacts are expected.	cleanup operations. Some costs would also be incurred for the actual cleanup operation.	store these full

Table F.1.3.8-5. Secondary impacts of facility accidents at Portsmouth Naval Shipy

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Envi al Cont n
Portsmouth Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool 3. Criticality and all other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporari- ly suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would re- store these ships to full readiness.	1. A appr y 10 migh clea Cont n co exte 0.6 beyo clos est boun ary. 2. Cont tion occu the ship boun woul limi ed t appr mate 10 a 3.Co tion with ship boun Tabl F.1. the coul cont

nate

Table F.1.3.8-6. Secondary impacts of facility accidents at Oak Ridge Reservation.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Oak Ridge Reservation	1. Dry Cell Air Plane Crash 2. Dry Storage Plane Crash 3. Drained Water Pool and Criticality 4. All other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporari- ly suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impa

Table F.1.3.8-7. Secondary impacts of facility accidents at Savannah River Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Savannah River Site	All Radiological Accidents	Plants and animals on the site and around the	The water used for drinking and industrial purposes is monitored and use may be temporari- ly suspended	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other	No impa

		site will experience no long term impacts.	during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	

Table F.1.3.8-8. Secondary impacts of facility accidents at Nevada Test Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Nevada Test Site	All Radiological Accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporari-ly suspended during cleanup operations. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impa

Table F.1.3.8-9. Secondary impacts of facility accidents at Idaho National Enginee

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Idaho National Engineering Laboratory	All Radiological Accidents	Plants and animals on the site and around the site will	The water used for drinking and industrial purposes is monitored and use may be temporari-ly suspended during	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility	No impa

		experience no long term impacts.	cleanup operations. No enduring impacts are expected.	during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	

Table F.1.3.8-10. Secondary impacts of facility accidents at Hanford Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Hanford Site	All Radiological Accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking andindustrial purposes is monitored and use may be temporari-ly suspended during cleanup operations. Some recre-ational activi-ties may also be temporari-ly suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impa

Table F.1.3.8-11. Secondary impacts of facility accidents at Kenneth A. Kesselring

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	Natio Defen
Kenneth A. Kesselring Site	1. Dry Storage Plane Crash 2. Drained Water Pool and	Plants and animals on the site and around the site will experience	The water used for drinking andindustrial purposes is monitored and use may be temporari-ly suspended during cleanup operations.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during	No impa

all other radiological accidents	no long term impacts.	Some recre- ational activi- ties may also be temporari- ly suspended. No enduring impacts are expected.	cleanup operations. Some costs would also be incurred for the actual cleanup operation.

F.1.3.9 Emergency Preparedness and Mitigative Measures.

F.1.3.9.1 Emergency Preparedness Emergency plans are in effect at shipyards and

prototype sites to ensure that workers and the public would be properly protected i accident. In addition, emergency plans are in effect for accidents involving the t radioactive materials. These response plans include the activation of emergency re by the site and a site emergency control center, as well as activation of a command with Naval Reactors Headquarters and supporting laboratories. The long standing em program that exists within the Naval Nuclear Propulsion Program includes the abilit comprehensive and extensive emergency response resources of each naval site and pro coordination with appropriate civil authorities. In addition to the Naval Nuclear resources, extensive federal emergency response resources are available as needed t response.

Emergency response measures include provisions for immediate response to any shipyard or prototype site, identification of the accident conditions, and communic authorities providing radiological data and recommendations for any appropriate pro event of an accident involving radioactive or toxic materials, workers in the vicin promptly evacuate the immediate area. This evacuation can typically be accomplishe the accident and would reduce the hazard to workers.

Regularly scheduled exercises are conducted periodically at each site in orde ability to respond to accidents. These exercises include realistic tests of people communications involved in all aspects of the plans, and the plans are regularly re incorporate experience gained from the exercises. These exercises also periodicall the adequacy of interactions with local hospitals and emergency personnel and state

F.1.3.9.2 Mitigative Factors. For members of the general public residing at the site boundary

or beyond, no credit is taken for any preventive or mitigative actions that would l These individuals are calculated as being exposed to the entire contaminated plume from the accident site. Similarly no action is taken to prevent these people from day-to-day routine and ingestion of terrestrial food and animal products continue o discussed in Section F.1.3, action would be taken to prevent the public from exceed Guideline, if needed. No reduction of exposure due to these actions are accounted The public is assumed to spend approximately 30% of the day within their homes or o the exposure to ground surface radiation is therefore reduced appropriately on a ye

Individuals that reside or work on site, or those that may be traversing the be evacuated from the affected area within 2 hours. This is based on the availabil at all locations to oversee the removal of residents, collocated workers, and trave manner. Periodic training and evaluation of the security personnel is conducted to actions are taken during an actual casualty. Therefore, residents, collocated work be exposed to the entire contaminated plume as it travels downwind for a period not Similarly, the radiation shine from the deposited radioactive materials would be li No ingestion of contamination is calculated for these individuals.

Facility workers all undergo training to take quick, decisive action during a individuals quickly evacuate the area and move to previously defined "relocation" a Workers could be exposed to a full 5 minutes of the radioactive plume as they move centers. Once the immediate threat of the plume has moved off-site and downwind, t

instructed to walk to vehicles waiting to evacuate them from the site. An addition required to evacuate the workers from the contaminated area and therefore the worke 20 minutes of ground shine. No ingestion of contamination is calculated for these

The following summary provides the individual exposure times utilized in the presented in Section F.1.4.2.

Estimated Time an Individual Might be Exposed

	Worker (100 m)	Collocated Worker (MCW) and Nearest Public Access (NPA)	Individual at Nearest Site Boundary (MOI)
To Plume	5 min.	100% of release time up to 120 min.	100% of release time
To Fallout on Ground Surface	20 min.	120 min.	0.7 yr
To Food	N/A	N/A	1 yr

F.1.3.10 Perspective on Calculations of Cancer Fatalities and Risk

The topics of human health effects caused by radiation and the risks associat operations or postulated accidents associated with spent nuclear fuel management ar times throughout this Environmental Impact Statement. It is important to understan how they are used in order to understand the information presented in this document have some frame of reference or comparison for understanding how the risks compare life.

The method used to calculate the risk of any impact is fundamental to all of presented and follows standard accepted practices. The first step is to determine specific event will occur. For example, the probability that a routine task, such be performed sometime during a year of normal operations at a facility would be 1. action would certainly occur. The probability that an accident might occur is less because accidents occur only occasionally and some of the more severe accidents, su earthquake, might occur at any location only once in hundreds, thousands, or millio

Once the probability of an event has been determined, the next step is to pre quences of the event being considered might be. One important measure of consequen EIS is the number of human fatalities from cancer induced by radiation. This was c document deals with radioactive materials. The number of cancer fatalities that mi routine operation or any postulated accident can be calculated using a standard tec amount of radiation exposure that might occur from all conceivable pathways and the who might be affected (refer to Section F.1.3.3).

A couple of examples should serve to illustrate the calculation of risk. In of dying in a motor vehicle accident can be computed from the likelihood of an indi automobile accident and the consequences or number of fatalities per accident. The motor vehicle accidents during 1992 in the United States resulting in about 40,000 Thus, the probability of a person being in an automobile accident is 10,000,000 acc approximately 250,000,000 persons in the United States, or 0.04 per year. The numb accident, 0.004 (40,000 deaths divided by 10,000,000 accidents), is less than 1 sin not cause fatalities. Multiplying the probability of the accident (0.04 per year) accident (0.004 deaths per accident) by the number of years the person is exposed t considered to be an average lifetime) gives the risk for any individual being kille accident. From this calculation, the overall risk of someone dying in a motor vehi chance in 87 over their lifetime.

A second example illustrates the calculation of risk for another event which fuels, such as natural gas or coal, contain naturally occurring radioactive materia air during combustion. This radioactivity in the air finds its way into our bodies air we breathe. This radioactivity has been estimated to produce about 0.5 millire the average American each year (NCRP 1987). The probability of this happening is e these fuels are burned every day all over the country. The number of fatal cancers millirem per year is calculated by taking 0.5 millirem per year times the 72 years average lifetime times the 0.0005 fatal cancers estimated to be caused by each rem 72 years x 0.0005 fatal cancers per rem = 0.000018 fatal cancers per individual lif probability (1.0) times the consequences (0.000018 cancer fatalities) which equals 55,000 of death from this cause over a lifetime.

These risks and others from everyday life can be used to gain a perspective o with the alternatives in this EIS. As illustrated, the risk of death from cancer f released daily from combustion of fossil fuels is about 1 chance in 55,000 for the

further comparison, the naturally occurring radioactive materials in agricultural f 1 to 2 millirem per year to an average American's exposure to radiation (NCRP 1987) similar to the one in the preceding paragraph shows that the use of fertilizer to p United States results in a risk of death from cancer between 1 chance in 12,500 and Finally, the average American's risk of dying from cancer from all causes is 1 chan lifetime. These risks can be compared, for example, to the average individual risk 1 billion for a resident in the vicinity of the INEL developing a fatal cancer due tions at the Expended Core Facility (see the data in Section F.1.4.1).

A frame of reference for the risks from accidents associated with spent nucle alternatives can be developed in the same way. For an average resident in the vici individual risk of death from cancer caused by the water leaking from the Expended large earthquake would be approximately 1 chance in 9 billion. This individual ris dividing the risk value to the population within 50 miles (1.7 x 10-7 fatalities pe Table F-3) by the total population of 115,690 and multiplying by an average life sp risk can be compared to the risks of death from other accidental causes to gain a p the risk of death in a motor vehicle accident was calculated earlier to be about 1 the risk of death for the average American from fires is approximately 1 chance in accidental poisoning the risk is about 1 chance in 1000 (Crouch 1982).

F.1.4 Analysis Results

F.1.4.1 Normal Operations. The purpose of this analysis is to determine the hypothetical health

effects on workers and the public due to routine handling of naval spent nuclear fu from facilities involved in routine handling of naval spent nuclear fuel are small comparable DOE and commercial nuclear facilities. Records of routine releases due were used as source terms for all locations to estimate what effects these types of and the public. Site-specific meteorological and population data were used at each analyzed. For normal operations at the Naval Reactors Facility (NRF and Oak Ridge) nearest public access (NPA) individual is not estimated due to the short period of individual would spend on-site while driving on the public access road. At Hanford the Washington Public Power Supply System Plant, and at Savannah River at the U.S. Office. The NPA at shipyard locations is defined in Section F.1.3.2.

F.1.4.1.1 Water Pool Examination and Storage Source Terms. The evaluation of

normal water pool operations was performed using two different source terms. In on term was utilized which included both the incremental release of radioactive materi alternative spent nuclear fuel storage actions and the release from other ongoing N Identical source terms were used for the evaluation of radiation exposure due to th materials during normal operations of wet storage and spent fuel examinations. The release from the INEL-ECF was used to evaluate these operations. Since the INEL-EC extremely low, this upper limit approach is not unduly conservative for the wet sto expected to have a lower release. Table F.1.4.1.1-1 shows the 1991 INEL-ECF releas release rate at Kesselring and NRF (including both INEL-ECF and prototypes), and th representing Naval Reactors operations at naval shipyards. The release rate repres based on upper bound data from Navy operations contained in Naval Nuclear Propulsio Report NT-94-1 (NNPP 1994). With no current Naval Reactors facilities at Savannah Oak Ridge, or the Nevada Test Site, the current release for each of these sites is

Table F.1.4.1.1-1. Airborne releases from current Naval Reactors operations.

Location	Annual Releases (Ci/year)	
INEL-ECF	H-3 9.35 x 10-2	Y-90 5.5 x 10-6
	C-14 7.0 x 10-1	I-131 4.82 x 10-6
	Sr-90 5.5 x 10-6	Kr-85 3.0 x 10-1
NRF	H-3 9.35 x 10-2	Sr-90 2.45 x 10-5
	C-14 8.0 x 10-1	Y-90 2.45 x 10-5
	Ar-41 2.7 x 10-1	I-131 6.3 x 10-6
	Co-60 1.6 x 10-6	Cs-137 6.3 x 10-6
	Kr-85 3.0 x 10-1	
Kesselring	H-3 1.0 x 10-1	Kr-85 1.0 x 10-3
	C-14 4.0 x 10-1	I-131 5.0 x 10-4
	Ar-41 1.4	Cs-137 5.0 x 10-4

	Co-60 1.0 x 10-3	
Savannah River, Hanford,	none	
Nevada Test Site, Oak Ridge		
Portsmouth, Norfolk	H-3 1.0 x 10-3	Kr-87 5.0 x 10-2
Puget Sound,	C-14 1.0 x 10-1	Kr-88 2.0 x 10-2
Pearl Harbor	Ar-41 4.1 x 10-1	Xe131m 5.0 x 10-3
	Co-60 1.0 x 10-3	Xe133m 1.0 x 10-2
	Kr-83m 2.0 x 10-2	Xe-133 2.1 x 10-1
	Kr-85m 2.4 x 10-2	Xe-135 2.5 x 10-1
	Kr-85 1.0 x 10-3	

The evaluation of continuing Naval Reactors activities combined with the proposed a for naval spent nuclear fuel is based on the combined airborne release source terms F.1.4.1.1-2. This table presents a summation of the INEL-ECF source term and the c Reactors operations source terms from Table F.1.4.1.1-1 for each location. Beginni shutdown of the S5G prototype, the NRF releases will only result from the INEL-ECF, is shown in the table.

The other analysis utilized the same source term at all locations. The INEL- Table F.1.4.1.1-1 was used to compare the incremental health effects due to providi or examination facilities at each location.

Both analyses also considered the impact on health effects of direct radiatio pool facility and the deposition of radionuclides onto the ground and into water su Sections F.1.3.6.4 and F.1.3.6.5.

Table F.1.4.1.1-2. Airborne releases used in the analysis of water pool activities Naval Reactors operations.

Location	Annual Releases (Ci/year)	
NRF, Savannah River,	H-3 9.35 x 10-2	Y-90 5.5 x 10-6
Hanford, Nevada Test	C-14 7.0 x 10-1	I-131 4.82 x 10-6
Site, OakRidge	Sr-90 5.5 x 10-6	Kr-85 3.0 x 10-1
Kesselring	H-3 1.935 x 10-1	Sr-90 5.5 x 10-6
	C-14 1.1	Y-90 5.5 x 10-6
	Ar-41 1.4	I-131 5.0 x 10-4
	Kr-85 3.0 x 10-1	Cs-137 5.0 x 10-4
	Co-60 1.0 x 10-3	
Portsmouth, Norfolk	H-3 9.45 x 10-2	Kr-88 2.0 x 10-2
Puget Sound,	C-14 8.0 x 10-1	Sr-90 5.5 x 10-6
Pearl Harbor	Ar-41 4.1 x 10-1	Y-90 5.5 x 10-6
	Co-60 1.0 x 10-3	I-131 4.8 x 10-6
	Kr-83m 2.0 x 10-2	Xe131m 5.0 x 10-3
	Kr-85m 2.4 x 10-2	Xe133m 1.0 x 10-2
	Kr-85 3.0 x 10-1	Xe-133 2.1 x 10-1
	Kr-87 5.0 x 10-2	Xe-135 2.5 x 10-1

F.1.4.1.2 Dry Storage Source Terms. Another operation analyzed was the storage of naval

spent nuclear fuel in shipping containers or storage casks in a safe array at NRF, Kesselring locations. It is postulated that shielding and physical boundaries are with existing regulations to protect facility workers. There are expected to be no releases from the dry storage activity. The source will consist of an array of fil Supplementary shielding would be provided as needed to ensure that there would be n increase in radiation levels at the perimeter of the industrial area and that radia industrial area but outside the storage area would not require occupational radiati for workers. Each location analyzed would have a different number of storage casks received over time, shielding will be provided to limit radiation exposure rates as Distance falloff for radiation levels was determined using SPAN computer calculatio Section F.1.3.6.4.

F.1.4.1.3 Dry Cell Facility Source Terms. The normal airborne release source terms

utilized for the dry cell facility analyses are identical to the INEL-ECF releases expected that these values bound the actual releases from the proposed facility. A from the water pool analysis was utilized for the direct radiation calculations. T the proposed facility design, expected fuel examination capacity, and shielding cal

airborne releases, source terms for water deposition were identical to those utiliz analysis.

F.1.4.1.4 Water Pool Storage. This section presents tabulated radiation exposure results for

the wet storage option. The following summary provides an indication of the increm location due to the addition of an ECF-type facility.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage only
At All Sites

	INEL/N-RF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1 x 10-5	9.1 x 10-5	8.9 x 10-5	9.4 x 10-5	1.1 x
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	8.7 x 10-5	2.0 x
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	6.2 x 10-4	5.2 x
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.3 x 10-1	1.4 x
Number of Fatal Can-cers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	6.5 x 10-5	7.0 x

* MOI (Barnwell Plant)
** MOI (FMEF)

	Norfolk	Portsm-outh	Kesselring	Nevada Test Site	Oak R
Worker EDE (rem)	6.9 x 10-5	7.7 x 10-5	8.5 x 10-5	4.6 x 10-5	1.2 x
MOI EDE (rem)	1.1 x 10-4	4.4 x 10-5	6.8 x 10-6	3.4 x 10-7	1.0 x
NPA EDE (rem)	6.8 x 10-5	3.3 x 10-4	N/A	N/A	N/A
Total EDE (person-rem)	2.8 x 10-1	4.5 x 10-2	8.2 x 10-2	1.8 x 10-4	1.0 x
Number of Fatal Can-cers	1.4 x 10-4	2.3 x 10-5	4.1 x 10-5	9.0 x 10-8	5.0 x

Evaluations of environmental impacts at DOE sites are presented in Volume 1, C, and F. The radiological impacts at these sites are quite low in that fatal canc population within 50 miles from normal operations are well below 1.0. Further, imp shipyards and prototype sites are addressed in Appendix D and also are well below 1 addition of the above small values to those which already exist at a site result in quite small.

The following summary provides the exposure calculation results for water poo examination plus all ongoing Naval Reactors operations at each site.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage
plus all ongoing Naval Reactors operations
At all sites

	INEL/N-RF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1 x 10-5	9.1 x 10-5	8.9 x 10-5	1.2 x 10-4	1.4 x
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	1.0 x 10-4	2.3 x
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	7.2 x 10-4	5.8 x
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.5 x 10-1	1.7 x
Number of Fatal Can-cers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	7.6 x 10-5	8.5 x

* MOI (Barnwell Plant)

** MOI (FMEF)

	Norfolk	Portsm-outh	Kesselring	Nevada Test Site	Oak R
Worker EDE (rem)	8.4 x 10-5	9.7 x 10-5	1.4 x 10-4	4.6 x 10-5	1.2 x
MOI EDE (rem)	1.2 x 10-4	5.0 x 10-5	1.2 x 10-5	3.4 x 10-7	1.0 x
NPA EDE (rem)	7.4 x 10-5	3.5 x 10-4	N/A	N/A	N/A
Total EDE (person-rem)	3.4 x 10-1	5.5 x 10-2	1.4 x 10-1	1.8 x 10-4	1.0 x
Number of Fatal Can-cers	1.7 x 10-4	2.7 x 10-5	7.2 x 10-5	9.0 x 10-8	5.0 x

Tables F.1.4.1.4-1 through -10 present the detailed results of using the sour F.1.4.1-2 to determine the radiation exposures. These tables thus depict the resul examination operation is added to existing, current, continuing Naval Reactors oper and Navy shipyards.

Table F.1.4.1.4-1. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors oper At INEL

Loca-tion	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.1 x 10-5	2.8 x 10-8
MCW	4.2 x 10-8	1.7 x 10-11
MOI	2.5 x 10-7	1.3 x 10-10

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Can-cers
Popula-tion of 115,690	1.7 x 10-3	8.5 x 10-7

Table F.1.4.1.4-2. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors oper At Savannah River

Loca-tion	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.1 x 10-5	3.6 x 10-8
MCW	1.4 x 10-6	5.6 x 10-10
MOI (New ECF)*	4.8 x 10-7	2.4 x 10-10
MOI (Barnwell Plant)	3.8 x 10-6	1.9 x 10-9
NPA	2.1 x 10-8	1.1 x 10-11

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Can-cers
Popula-tion of 579,541	3.6 x 10-2	1.8 x 10-5

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah Rive
**MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nu

Table F.1.4.1.4-3. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors oper At Hanford

Loca-tion	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-5	3.6 x 10-8
MCW	1.6 x 10-6	6.4 x 10-10
MOI (New ECF)*	2.4 x 10-7	1.2 x 10-10

MOI (FMEF)**	4.4 x 10-7	2.2 x 10-10
NPA	1.3 x 10-8	6.5 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,860	8.0 x 10-3	4.0 x 10-6

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on t
**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materia Facility.

Table F.1.4.1.4-4. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operatio
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-4	4.8 x 10-8
MOI	1.0 x 10-4	5.1 x 10-8
NPA	7.2 x 10-4	3.6 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	1.5 x 10-1	7.6 x 10-5

Table F.1.4.1.4-5. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operatio
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.6 x 10-8
MOI	2.3 x 10-5	1.1 x 10-8
NPA	5.8 x 10-4	2.9 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	1.7 x 10-1	8.5 x 10-5

Table F.1.4.1.4-6. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operatio
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MOI	1.2 x 10-4	6.1 x 10-8
NPA	7.4 x 10-5	3.7 x 10-8

Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Popula-	

tion of 1,539,002	3.4 x 10-1	1.7 x 10-4

Table F.1.4.1.4-7. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operatio
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.7 x 10-5	3.9 x 10-8
MOI	5.0 x 10-5	2.5 x 10-8
NPA	3.5 x 10-4	1.7 x 10-7

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	5.5 x 10-2	2.7 x 10-5

Table F.1.4.1.4-8. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operatio
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.6 x 10-8
MOI	1.2 x 10-5	5.8 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	1.4 x 10-1	7.2 x 10-5

Table F.1.4.1.4-9. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors oper
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	3.7 x 10-9	1.5 x 10-12
MOI	3.4 x 10-7	1.7 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13,792	1.8 x 10-4	9.0 x 10-8

Table F.1.4.1.4-10. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors oper
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-4	4.8 x 10-8
MCW	1.3 x 10-7	5.1 x 10-11
MOI	1.0 x 10-4	5.1 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.0 x 10-1	5.0 x 10-5

F.1.4.1.5 Dry Storage. This section presents tabulated radiation exposure results for the dry

storage option at INEL, Navy shipyard sites, and the Kesselring Site. Dry storage
River, the Nevada Test Site, and Oak Ridge is not included in this section as it is
1, Appendices A, C, and F, respectively. The following summary provides an indicat
tal change at each location due to the addition of dry storage areas. The health e
spent fuel is largest at the Navy shipyards and is extremely small at all DOE locat
Summary of Exposure Calculation Results
For Normal Operations - Dry Storage only
At all sites

	INEL	Puget Sound	Pearl Harbor	Norfolk	Portsmouth
Worker EDE (rem)	1.1 x 10-2	5.4 x 10-3	2.1 x 10-3	5.8 x 10-3	2.7 x 10-3
MOI EDE (rem)	6.5 x 10-1	8.9 x 10-5	1.5 x 10-6	2.9 x 10-3	5.6 x 10-5
NPA EDE (rem)	N/A	7.4 x 10-3	2.3 x 10-2	2.9 x 10-3	2.2 x 10-2
Total EDE (person-rem)	1.7 x 10-1	2.4 x 10-3	1.9 x 10-5	4.3 x 10-2	4.6 x 10-4
Number of Fatal Cancers	8.6 x 10-1	1.2 x 10-6	9.3 x 10-9	2.1 x 10-5	2.3 x 10-7

Tables F.1.4.1.5-1 through -6 present the results if a dry storage area is ad
continuing Naval Reactors operations at all locations.

Table F.1.4.1.5-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.1 x 10-2	4.4 x 10-6
MOI	1.1 x 10-10	5.5 x 10-14
NPA	6.5 x 10-14	3.3 x 10-17

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7 x 10-12	8.6 x 10-16

Table F.1.4.1.5-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.4 x 10-3	2.2 x 10-6
MOI	1.1 x 10-4	5.3 x 10-8
NPA	7.5 x 10-3	3.8 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	3.6 x 10-2	1.8 x 10-5

Table F.1.4.1.5-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-3	8.5 x 10-7
MOI	5.3 x 10-6	2.7 x 10-9
NPA	2.3 x 10-2	1.2 x 10-5

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	3.3 x 10-2	1.7 x 10-5

Table F.1.4.1.5-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8 x 10-3	2.3 x 10-6
MOI	2.9 x 10-3	1.5 x 10-6
NPA	2.9 x 10-3	1.5 x 10-6

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,539,002	9.7 x 10-2	4.9 x 10-5

Table F.1.4.1.5-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.7 x 10-3	1.1 x 10-6
MOI	6.3 x 10-5	3.1 x 10-8
NPA	2.2 x 10-2	1.1 x 10-5

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	9.2 x 10-3	4.6 x 10-6

Table F.1.4.1.5-6. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.6 x 10-4	2.7 x 10-7
MOI	5.1 x 10-6	2.6 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	5.7 x 10-2	2.9 x 10-5

F.1.4.1.6 Dry Cell Operations. This section presents tabulated radiation exposure results for

the dry cell operations option. Since a facility like the proposed dry cell would alternatives which include examination of all naval spent fuel, this analysis was o INEL, Savannah River, Hanford, the Nevada Test Site, and Oak Ridge locations. The provides an indication of the incremental change at each location due to the additi The calculated health effect to the general population is roughly proportional to t population with Oak Ridge being the worst and Nevada Test Site being the best.

Summary of Exposure Calculation Results
For Normal Operations - Dry Cell Operations
At all sites

	INEL/N-RF	Savannah River	Hanford	Nevada Test Site	Oak
Worker EDE (rem)	6.3 x 10-5	8.3 x 10-5	8.1 x 10-5	3.5 x 10-5	1.1
MOI EDE (rem)	2.5 x 10-7	4.8 x 10-7 3.8 x 10-6*	2.4 x 10-7 4.4 x 10-7**	3.4 x 10-7	8.9
NPA EDE (rem)	N/A	2.1 x 10-8	1.3 x 10-8	N/A	N/A
Total EDE (person-rem)	1.7 x 10-3	3.6 x 10-2	8.0 x 10-3	1.8 x 10-4	1.0
Number of Fatal Cancers	8.5 x 10-7	1.8 x 10-5	4.0 x 10-6	9.0 x 10-8	5.0

* MOI (Barnwell Plant)
** MOI (FMEF)

Tables F.1.4.1.6-1 through -5 present the detailed analysis results.

Table F.1.4.1.6-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.3 x 10-5	2.5 x 10-8
MCW	4.2 x 10-8	1.7 x 10-11
MOI	2.5 x 10-7	1.3 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7 x 10-3	8.5 x 10-7

Table F.1.4.1.6-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.3 x 10-5	3.3 x 10-8
MCW	1.3 x 10-6	5.3 x 10-10
MOI (New ECF)*	4.8 x 10-7	2.4 x 10-10
MOI (Barnwell Plant)	3.8 x 10-6	1.9 x 10-9
NPA	2.1 x 10-8	1.1 x 10-11

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579,541	3.6 x 10-2	1.8 x 10-5

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah Rive
**MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nu

Table F.1.4.1.6-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.1 x 10-5	3.2 x 10-8
MCW	1.5 x 10-6	6.1 x 10-10
MOI (New ECF)*	2.4 x 10-7	1.2 x 10-10
MOI (FMEF)**	4.4 x 10-7	2.2 x 10-10
NPA	1.3 x 10-8	6.5 x 10-12

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375,800	8.0 x 10-3	4.0 x 10-6

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on t
**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materia Facility.

Table F.1.4.1.6-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.5 x 10-5	1.5 x 10-8
MCW	3.7 x 10-9	1.5 x 10-12
MOI	3.4 x 10-7	1.7 x 10-10

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 13,792	1.8 x 10-4	9.0 x 10-8

Table F.1.4.1.6-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer

Worker	1.1 x 10-4	4.4 x 10-8
MCW	1.1 x 10-7	4.6 x 10-11
MOI	8.9 x 10-5	4.5 x 10-8

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.0 x 10-1	5.0 x 10-5

F.1.4.2 Accident Evaluation. The analysis of airborne releases from hypothetical accidents is

evaluated with RSAC-5. Unless stated otherwise, the following conditions were used calculations with RSAC-5. In most cases, these conditions are taken directly as de
Meteorological Data

- Wind speed, direction, and Pasquill stability are taken from 50% and 95% See Section F.1.3.5 for a discussion of meteorological conditions.
- The release is calculated as occurring at ground level (0 m).
- Mixing layer height is 400 meters (1320 feet). Airborne materials freel atmosphere near ground level in what is known as the mixing depth. A st above the mixing depth which restricts vertical diffusion.
- Wet deposition is zero (no rain occurs to accelerate deposition and redu affected).
- Dry deposition of the cloud is modeled. During movement of the radioact fraction of the plume is deposited on the ground due to gravitational fo available for exposure by ground surface radiation and ingestion.
- The quantity of deposited radioactive material is proportional to the ma speed. The following dry deposition velocities (m/s) were used:
  solids = 0.001 halogens = 0.01 noble gases = 0.0
  cesium = 0.001 ruthenium = 0.001.
- If radioactive releases occur through a stack, then additional plume dis accounted for by calculating a jet plume rise. In this analysis, jet pl
- When released gases have a heat content, the plume can disperse more qui calculation, buoyant plume effects are ignored.

Inhalation Data

- Breathing rate is 3.33 x 10-4 cubic meters per second (cu m/s) for worke NPA; 2.66 x 10-4 cu m/s for people at site boundary and beyond.
- Particle size is 1.0 micron.
- The internal exposure period is 50 years for individual organs and tissu radionuclides committed.
- Exposure to the entire plume for the general public. The worker, MCW, a exposed as discussed in Section F.1.3.9.
- Inhalation exposure factors based on ICRP 30.

Ground Surface Exposure

- Exposed to contaminated soil for 1 year for the general public. See Sec additional details.
- Building shielding factor is 0.7 which exposes the individual to contami hours a day.

Ingestion Data

- Ingestion numbers will be reduced by a factor of 10 to account for only

consumed being grown locally (such as in a person's garden).

- The following changes from RSAC-5 defaults were used:

  Annual Dietary Consumption Rates:

  177 Kg/yr Stored Vegetables (produce)
  18.3 Kg/yr Fresh Vegetables (leafy)
  94 Kg/yr Meat
  112 L/yr Milk.

F.1.4.2.1 Water Pool Storage. In the analysis of a spent fuel storage pool, a number of

possible disturbances and minor accidents have been postulated. A prerequisite for radioactive material to the environment under more severe accident conditions is th cladding of a fairly large amount of stored fuel, with an accompanying release of g particles of radioactive material from the fuel. Several conceivable mechanisms wh situation are the possibility that the fuel overheats so that the fuel cladding los massive mechanical impact on the stored fuel.

The only way for the fuel to overheat would be to lose enough pool water such stored fuel ceases and the fuel temperature increases to fission product release te heat. The pool water could be lost by leakage at a rate in excess of the makeup sy a catastrophic event like an earthquake causes severe damage to the structure of th water from the pool structure would be a slow phenomenon with only gradually increa which corrective measures can be taken in due time. Additionally, a thermal analys demonstrate that fuel overheating is not possible in the event of a drained water p

The circumstances in which an event could lead to severe mechanical loading o been identified as:

- accidents during handling of heavy items, such as a lifting device failu

- external events (earthquake, tornado, flood, aircraft crash, etc.) which structural failure.

Prevention of inadvertent, uncontrolled nuclear chain reactions is generally of the racks for the fuel, primarily by diminishing the chances for a chain reactio element bundles far enough apart to eliminate the possibility. Special attention i accidental criticality which might be experienced in fuel transport and handling op nuclear reaction is prevented during fuel handling by applying the principle of tra element, module, or container at a time. In addition, fuel handling rules are deve criticality cannot occur. The double accident criterion is applied to ensure that following two severe, concurrent, unrelated accidents. Thus, three fuel handling a reach an uncontrolled nuclear chain reaction.

F.1.4.2.1.1 Drained Water Pool.

F.1.4.2.1.1.1 Description of Conditions. In this hypothetical accident scenario, a

catastrophic event, like an earthquake, causes severe damage to the structure of th a complete loss of pool water. A thermal analysis of spent fuel in a water pool wa demonstrate that clad failure or fuel melting is not possible in the event of an ac pool. Air circulation through the fuel racks and fuel units was shown to be suffic failure in the unlikely event of complete loss of pool water. However, the loss of increased direct radiation and a release of corrosion products.

F.1.4.2.1.1.2 Source Term. Conditions used in developing the source term are as follows:

- 300 naval fuel units would be in the water pool.

- The thermal analysis demonstrates that no fission product release would accident.

- The amount of corrosion products on the fuel units is based on best esti

- The release to the environment would occur at a constant rate over a 15-

- One percent of the original corrosion products from the fuel units might atmo-
  sphere due to thermal air currents. Additionally, 10% of the corrosion could be released to the environment with the pool water.

- The following amounts of corrosion product nuclides might be released to atmosphere. As noted above, the release to the water environment is 10 values. This listing includes nuclides that result in at least 99% of t

- No filtration by High Efficiency Particulate Air (HEPA) filters is assum

Nuclide	Curies
Co-60	3.6
Fe-55	6.6
Co-58	1.3
Mn-54	2.2 x 10-1
Fe-59	1.9 x 10-2

F.1.4.2.1.1.3 Results. The following table summarizes the public health risk to the general

population that might result from the hypothetical drained water pool accident at e number of fatal cancers would be expected to occur over a 50-year period. "Risk" i number of fatal cancers times the probability of occurrence. The results are prese accident with 50% and 95% meteorology. For INEL, the evaluation basis earthquake r peak ground acceleration at the ECF (Rizzo 1994). This is based on the event being earthquake epicenter and involving a surface rupture length of 34 kilometers. Usin spectra, which is appropriate for a risk oriented analysis, the analyses of the str indicate that damage sufficient to cause the pool to drain would not occur if the p several sections of the water pool were empty, a crack could develop in the area be floor of some of the older sections of the water pool. However, the INEL-ECF water always filled. Sections of the pool are only drained if maintenance work is necess Taking into account the probability of the initiating seismic event (1 x 10-4 per y and the probability the earthquake will occur with a section of the pool drained, t occurrence of an event leading to draining of the pool is estimated to be in the ra year. A value of 10-5 was used to develop the risk results in the table.

A beyond design basis seismic event was also considered. For INEL, this beyo earthquake is based on a scenario that results in a peak ground acceleration at the (Rizzo 1994). Analysis of this event has shown that some cracks could develop. Th beyond design basis event is estimated to be in the range of 10-6 to 10-7 per year the initiating seismic event (2 x 10-5 to 6 x 10-5), and the probability of failure would be taken to prevent the pool from draining. A value of 10-6 was selected to beyond design basis event. Any cracks developed as a result of either a design bas basis seismic event are expected to be small and mitigative actions could be taken draining. Analysis has shown that air cooling is sufficient to maintain fuel integ drained. No overheating of fuel would occur; hence, no fission products would be r were completely drained. The consequences calculated stem from the release of radi within the pool water and would be the same for the design basis and beyond design Since the consequences are the same, the following table uses the accident probabil seismic event since that results in the larger risk.

For locations other than INEL, water pools might need to be constructed. For was expected that the design approaches would be similar to or better than were use the INEL-ECF. Therefore, a probability value of 10-5 per year was also used at the probability that a design basis seismic event would lead to draining of a water poo based on site specific population data and meteorology.

Drained Water Pool Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	1.7 x 10-2	1.7 x 10-2	1.7 x 10-7

Savannah River	1.6 x 10-2	1.1 x 10-1	1.1 x 10-6
Hanford	6.3 x 10-3	4.7 x 10-2	4.7 x 10-7
Puget Sound	1.4	5.1 x 10-1	5.1 x 10-6
Pearl Harbor	7.9 x 10-1	1.1	1.1 x 10-5
Norfolk	3.0	6.0 x 10-1	6.0 x 10-6
Portsmouth	1.6	3.4 x 10-1	3.4 x 10-6
Kesselring	2.9 x 10-1	2.5 x 10-1	2.5 x 10-6
Nevada Test Site	3.3 x 10-2	1.9 x 10-3	1.9 x 10-8
Oak Ridge	5.2	1.8 x 10-1	1.8 x 10-6

The risk for this hypothetical accident is generally more severe at Navy shipyards sites. At all sites, this accident results in the highest risk of the wet storage

For the hypothetical drained water pool scenario, the radioactive plume might contamination of the ground to a downwind distance of 0.29 mile. This would yield by the accident of approximately 11 acres. The calculated downwind distance would the boundaries of all sites under evaluation with the exception of Oak Ridge and No

Table F.1.4.2.1.1-1. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	6.9 x 10-4	2.7 x 10-7
NPA	3.9 x 10-4	2.0 x 10-7
MOI	2.8 x 10-3	1.4 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	6.7	3.3 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	7.6 x 10-3	3.0 x 10-6
NPA	2.3 x 10-3	1.2 x 10-6
MOI	1.7 x 10-2	8.5 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	3.5 x 101	1.7 x 10-2

Table F.1.4.2.1.1-2. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4 x 10-1	1.3 x 10-4
MCW	2.0 x 10-2	7.9 x 10-6
NPA	2.5 x 10-4	1.3 x 10-7
MOI (New ECF)	3.5 x 10-3	1.8 x 10-6
MOI (Barnwell)	1.3 x 10-2	6.3 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Can-

		cers
Population of 579541	2.4 x 101	1.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	2.5 x 10-1	1.0 x 10-4
NPA	4.3 x 10-3	2.1 x 10-6
MOI (New ECF)	1.6 x 10-2	8.0 x 10-6
MOI (Barnwell)	1.4 x 10-1	7.2 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2 x 102	1.1 x 10-1

Table F.1.4.2.1.1-3. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4 x 10-1	1.3 x 10-4
MCW	2.6 x 10-2	1.0 x 10-5
NPA	3.0 x 10-4	1.5 x 10-7
MOI (New ECF)	8.3 x 10-4	4.2 x 10-7
MOI (FMEF)	1.7 x 10-3	8.6 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	4.8	2.4 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	1.6 x 10-1	6.6 x 10-5
NPA	4.8 x 10-3	2.4 x 10-6
MOI (New ECF)	6.3 x 10-3	3.2 x 10-6
MOI (FMEF)	2.2 x 10-2	1.1 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	9.4 x 101	4.7 x 10-2

Table F.1.4.2.1.1-4. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.3 x 10-5

MCW	N/A	N/A
NPA	2.2 x 10-1	1.1 x 10-4
MOI	1.2 x 10-1	6.0 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.7 x 102	8.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	2.6	1.3 x 10-3
MOI	1.4	7.2 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.0 x 103	5.1 x 10-1

Table F.1.4.2.1.1-5. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	N/A	N/A
NPA	1.9 x 10-1	9.7 x 10-5
MOI	2.0 x 10-1	9.8 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	8.0 x 102	4.0 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	6.3	3.1 x 10-3
MOI	7.9 x 10-1	3.9 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.2 x 103	1.1

Table F.1.4.2.1.1-6. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Norfolk

50% METEOROLOGY

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	1.8 x 10-1	7.4 x 10-5
MCW	N/A	N/A
NPA	4.6 x 10-2	2.3 x 10-5
MOI	2.8 x 10-1	1.4 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.5 x 102	7.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	5.3 x 10-1	2.7 x 10-4
MOI	3.0	1.5 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.2 x 103	6.0 x 10-1

Table F.1.4.2.1.1-7. Summary of Exposure Calculation Results. For Wet Storage - Drained Water Pool At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.3 x 10-5
MCW	N/A	N/A
NPA	4.4 x 10-2	2.2 x 10-5
MOI	1.3 x 10-1	6.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.5 x 101	3.2 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	9.8 x 10-1	4.9 x 10-4
MOI	1.6	7.9 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.7 x 102	3.4 x 10-1

Table F.1.4.2.1.1-8. Summary of Exposure Calculation Results. For Wet Storage - Drained Water Pool At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8 x 10-1	7.4 x 10-5
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.0 x 10-2	1.0 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	7.1 x 101	3.6 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.9 x 10-1	1.5 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	5.0 x 102	2.5 x 10-1

Table F.1.4.2.1.1-9. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2 x 10-1	4.8 x 10-5
MCW	9.3 x 10-5	3.7 x 10-8
NPA	N/A	N/A
MOI	1.5 x 10-3	7.5 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.2 x 10-1	1.6 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	5.4 x 10-3	2.2 x 10-6
NPA	N/A	N/A
MOI	3.3 x 10-2	1.7 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.7	1.9 x 10-3

Table F.1.4.2.1.1-10. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5 x 10-1	3.0 x 10-4
MCW	2.0 x 10-2	7.9 x 10-6
NPA	2.6 x 10-1	1.3 x 10-4
MOI	8.2 x 10-1	4.1 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Can- cers
Population of 871531	7.1 x 101	3.6 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3 x 10-4
MCW	1.2 x 10-1	4.8 x 10-5
NPA	1.6	8.2 x 10-4
MOI	5.2	2.6 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Can- cers
Population of 871531	3.5 x 102	1.8 x 10-1

F.1.4.2.1.2 Accidental Criticality.

F.1.4.2.1.2.1 Description of Conditions. In this hypothetical accident scenario, an accidental uncon-

trolled chain reaction producing 1 x 1019 fissions is postulated. The criticality the water pool which is not emptied by the event and does not subsequently empty. products includes those specified in Regulatory Guide 3.34 (NUREG 1979b) from the c fission products remaining in the fuel as a result of the original use. Removal of pool water is included.

F.1.4.2.1.2.2 Source Term. Conditions used in developing the source term are as follows:

- The fraction of the fission products released to the building is 100% of 25% of the halogens, 0.1% of the ruthenium (Elder et al. 1986), and 0.05 and remaining solids.

- The original inventory of fission products from two naval fuel units are release in addition to those created by the criticality event.

- A High Efficiency Particulate Air (HEPA) filter removes 99.9% of the sol products from the plume.

- The release to the environment occurs at a constant rate over a 15-minut od. This is
conservative as compared to the 8-hour release allowed in Regulatory Gui
- The following amounts of radionuclides are released to the environ- ment. This listing includes nuclides that result in at least 99% of the

Nuclide	Curies	Nuclide	Curies
Te-133	3.4 x 103	I-132	1.7 x 1
I-134	3.5 x 102	Sr-90	1.94 x
I-135	1.2 x 102	Y-91m	4.3 x 1

Cs-138	1.6 x 10-4	Rb-88	1.7 x 1
Rb-89	6.05 x 10-4	Y-91	1.1 x 1
Pu-238	3.7 x 10-4	Cs-139	7.3 x 1
Br-84	2.3 x 102	Ba-142	4.8 x 1
I-133	2.4 x 100	Y-93	1.3 x 1
Sr-91	5.4 x 10-6	Ba-137m	1.9 x 1
Sr-92	2.4 x 10-4	Ru-106	7.6 x 1
Ba-139	6.9 x 10-6	Zr-95	1.4 x 1
Ba-141	8.8 x 10-4	Sr-89	7.01 x
I-129	5.1 x 10-3	Eu-154	1.3 x 1
I-131	3.2 x 10-1		
H-3	1.42 x 102		
Cs-134	1.5 x 10-2		
Ba-140	2.5 x 10-5		
I-136	1.1 x 104		
Cs-137	2.0 x 10-2		
Ce-144	4.5 x 10-2		
Nb-95	2.7 x 10-2		
Rb-90	2.2 x 10-2		

F.1.4.2.1.2.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical criticality accident at each loc fatal cancers would be expected to occur over a 50-year period. "Risk" is defined cancers times the probability of occurrence. An accidental criticality during spen operations is extremely unlikely. There are no known events of this type which hav handling of fuel modules either in or out of water. Due to the need for a neutron large quantities of naval fuels would be required to achieve criticality in a dry s procedures in water in conjunction with required physical barriers ensure that a do met. This criterion specifies that the fuel will not attain a critical condition e unrelated accidents occur at the same time. The DOE criticality control requiremen contingency criterion which specifies that a second unlikely and unrelated accident a critical condition to result. To satisfy the NNPP double accident criterion, nav are conducted in the following manner:

- No more than one module is to be handled in one area at a time.
- If two modules are capable of achieving a critical condition, separation maintained by a positive barrier between them which is locked in place.
- If three modules are required to achieve criticality, a physical barrier to be locked is required to be placed between them.
- If four or more modules are needed to achieve criticality, no barriers a modules are to remain separated.

Based on the above requirements, at least three distinct errors are needed to criticality. For example, bringing two or more modules in close proximity is alway maintain separation constitutes an error. Secondly, failure to recognize and use p required also constitutes an error. A human error rate of 10-3 per operation (Swai taken as the probability of error for trained personnel. Further, because all fuel be checked by an independent verifier, an additional factor of 10-1 may be taken fo for each independent error. For naval fuel handling, an error in which two modules a violation of a fundamental requirement. Compliance with this requirement alone e subcritical state is maintained. Therefore, the bringing of two or more modules to considered separate and independent of all other errors. Because a second error mu criticality, an additional reduction in the probability is warranted. For example, need to install a barrier when required is such an error. Because this mistake is and has been checked, a second value of 10-4 is appropriate for a total value of 1 This probability is taken as the likelihood of a criticality for movement of a sing an estimated 1,000 fuel handling operations a year, a value of 10-5 per year has been used in the risk assessment of accidental criticality.

Accidental Criticality Summary

Maximal-
ly ex-
No. of fatal cancer

Site	posed off-site individual (MOI) (rem)	if accident occurs	Risk per year
INEL	9.2 x 10-3	6.4 x 10-3	6.4 x 10-8
Savannah River	9.4 x 10-3	4.5 x 10-2	4.5 x 10-7
Hanford	2.8 x 10-3	1.6 x 10-2	1.6 x 10-7
Puget Sound	1.3	2.8 x 10-1	2.8 x 10-6
Pearl Harbor	6.7 x 10-1	6.0 x 10-1	6.0 x 10-6
Norfolk	2.7	3.5 x 10-1	3.5 x 10-6
Portsmouth	1.4	1.5 x 10-1	1.5 x 10-6
Kesselring	2.3 x 10-1	1.1 x 10-1	1.1 x 10-6
Nevada Test Site	2.0 x 10-2	7.0 x 10-4	7.0 x 10-9
Oak Ridge	4.7	8.8 x 10-2	8.8 x 10-7

The risk for this hypothetical accident is more severe at Navy shipyards than all sites, this accident results in the second highest risk of the wet storage acci

For the hypothetical criticality accident scenario, the radioactive plume mig of the ground to a downwind distance of 0.25 mile. This would yield a total area i of approximately 8 acres. The calculated downwind distance would be contained with all sites under evaluation with the exception of Oak Ridge and Norfolk.

Table F.1.4.2.1.2-1. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2 x 10-3
MCW	1.3 x 10-3	5.1 x 10-7
NPA	5.9 x 10-4	2.9 x 10-7
MOI	2.0 x 10-3	1.0 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.5	2.8 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	1.3 x 10-2	5.0 x 10-6
NPA	2.8 x 10-3	1.4 x 10-6
MOI	9.2 x 10-3	4.6 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.3 x 101	6.4 x 10-3

Table F.1.4.2.1.2-2. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3 x 10-4

MCW	6.8 x 10-2	2.7 x 10-5
NPA	7.4 x 10-4	3.7 x 10-7
MOI (New (ECF)	3.3 x 10-3	1.6 x 10-6
MOI (Barnwell)	1.2 x 10-2	5.9 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2 x 101	1.1 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	7.9 x 10-1	3.1 x 10-4
NPA	6.4 x 10-3	3.2 x 10-6
MOI (New ECF)	9.4 x 10-3	4.7 x 10-6
MOI (Barnwell)	1.1 x 10-1	5.3 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	8.9 x 101	4.5 x 10-2

Table F.1.4.2.1.2-3. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3 x 10-4
MCW	8.9 x 10-2	3.5 x 10-5
NPA	6.6 x 10-4	3.3 x 10-7
MOI (New (ECF)	4.7 x 10-4	2.4 x 10-7
MOI (FMEF)	1.3 x 10-3	6.7 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	2.2	1.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	4.9 x 10-1	2.0 x 10-4
NPA	6.9 x 10-3	3.5 x 10-6
MOI (New ECF)	2.8 x 10-3	1.4 x 10-6
MOI (FMEF)	1.2 x 10-2	6.1 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	3.1 x 101	1.6 x 10-2

Table F.1.4.2.1.2-4. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	7.7 x 10-1	3.8 x 10-4
MOI	1.1 x 10-1	5.6 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	2.3 x 102	1.1 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	8.8	4.4 x 10-3
MOI	1.3	6.3 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	5.6 x 102	2.8 x 10-1

Table F.1.4.2.1.2-5. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2 x 10-3
MCW	N/A	N/A
NPA	7.0 x 10-1	3.5 x 10-4
MOI	1.8 x 10-1	8.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.6 x 102	2.8 x 10-1

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	2.2 x 101	2.2 x 10-2
MOI	6.7 x 10-1	3.4 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	1.2 x 103	6.0 x 10-1

Table F.1.4.2.1.2-6. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality

At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	1.6 x 10-1	8.2 x 10-5
MOI	2.7 x 10-1	1.3 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6 x 102	8.1 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	1.8	8.8 x 10-4
MOI	2.7	1.4 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	7.0 x 102	3.5 x 10-1

Table F.1.4.2.1.2-7. Summary of Exposure Calculation Results. For Wet Storage - Accidental Criticality At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	1.5 x 10-1	7.7 x 10-5
MOI	1.2 x 10-1	5.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	7.9 x 101	4.0 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	3.3	1.6 x 10-3
MOI	1.4	7.0 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.9 x 102	1.5 x 10-1

Table F.1.4.2.1.2-8. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4 x 10-1	2.9 x 10-4
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.9 x 10-2	9.7 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1148587	5.6 x 101	2.8 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.3 x 10-1	1.2 x 10-4
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1148587	2.2 x 102	1.1 x 10-1

Table F.1.4.2.1.2-9. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.8 x 10-1	1.9 x 10-4
MCW	2.1 x 10-4	8.0 x 10-8
NPA	N/A	N/A
MOI	1.5 x 10-3	7.3 x 10-7
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 13792	4.3 x 10-1	2.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	8.1 x 10-3	3.3 x 10-6
NPA	N/A	N/A
MOI	2.0 x 10-2	9.9 x 10-6
	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers

Population of 13792	1.4	7.0 x 10-4

Table F.1.4.2.1.2-10. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2 x 10-3
MCW	6.6 x 10-2	2.6 x 10-5
NPA	9.1 x 10-1	4.6 x 10-4
MOI	7.6 x 10-1	3.8 x 10-4
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.4 x 101	3.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2 x 10-3
MCW	3.6 x 10-1	1.4 x 10-4
NPA	5.6	2.8 x 10-3
MOI	4.7	2.4 x 10-3
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.8 x 102	8.8 x 10-2

F.1.4.2.1.3 Mechanical Damage from Operator Error, Crane Failure, or Similar

Accidents

F.1.4.2.1.3.1 Description of Conditions. Accidental mechanical damage to spent fuel was

evaluated. The hypothetical accident included damage to one fuel unit, allowing fi the elements to escape through the clad failures. All gas and some volatile and so calculated to be released to the pool. The release fractions are consistent with s Regulatory Guide 1.4. Due to the presence of pool water, no solids would be releas the facility.

F.1.4.2.1.3.2 Source Term. Conditions used in developing the source term are as follows:

- One fuel unit is damaged because only one fuel unit would be handled at storage facility design prevents damage to stored units from such events
- One percent of the fuel is damaged and those fission products are availa
- All (100%) of the noble gases are released to the environment.
- Approximately 25% of the halogens are released to the pool and 90% of th products are absorbed in the water as they rise through the pool water. the halogens are released to the air inside the facility.
- Due to the gaseous nature of the released fission products, installed HE

not remove them once they are released to the air in the building.

- The release to the environment occurs at a constant rate over a 15-minut
- There is no particulate fission product release to the atmosphere due to pool water.
- The following amounts of radionuclides could be released to the envir ment. This listing includes nuclides that result in at least 99% of the possible

Nuclides	Curies
H-3	1.42
I-129	2.52 x 10-6
I-131	5.37 x 10-5

F.1.4.2.1.3.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical mechanical damage accident at ea number of fatal cancers would be expected to occur over a 50-year period. "Risk" i number of fatal cancers times the probability of occurrence. The probability of th damage is small based on the conservative fuel handling rules. At the INEL-ECF, it drop of a heavy container into a storage rack could crush the rack and the stored f are never moved over the storage rack area. The heavy containers are brought only receiving area to discharge a single fuel unit. The spent fuel is removed from the next fuel unit is brought into the receiving area. Therefore, two errors must occu possible. The first is that fuel is improperly left in the discharge station while over the discharge station. The second is that the cask must accidentally fall fro the crane must fail. The probability of failure associated with crane failure has Further, the crane failure must also occur in the right location and the drop must sufficient energy is available to damage both the discharge station structurals and additional factor of 10-2 has been taken for this event, giving the total probabili cask in the right location. Allowing a fuel unit to remain in the stand requires a fuel handling procedures call for the fuel unit to be removed from the stand and ta storage location away from the receiving area. In addition, because independent ov for all fuel movement, an error by a verifier is also required. Therefore, based o (Swain and Guttman 1983), the likelihood of this error is taken as 10-4 per year. probability of cask drop on a fuel unit is taken as 10-8 per year per fuel movement estimated rate of 1,000 fuel movements per year, the overall probability is taken as 10-5 events per year.

Wet Storage Mechanical Damage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cance if accident occurs	Risk per year
INEL	2.6 x 10-6	5.3 x 10-6	5.3 x 10-11
Savannah River	2.2 x 10-6	2.0 x 10-5	2.0 x 10-10
Hanford	9.8 x 10-7	8.6 x 10-6	8.6 x 10-11
Puget Sound	1.7 x 10-4	7.2 x 10-5	7.2 x 10-10
Pearl Harbor	9.3 x 10-5	1.5 x 10-4	1.5 x 10-9
Norfolk	3.5 x 10-4	8.0 x 10-5	8.0 x 10-10
Portsmouth	1.9 x 10-4	5.6 x 10-5	5.6 x 10-10
Kesselring	3.6 x 10-5	6.0 x 10-5	6.0 x 10-10
Nevada Test Site	4.6 x 10-6	5.6 x 10-7	5.6 x 10-12
Oak Ridge	5.9 x 10-4	3.4 x 10-5	3.4 x 10-10

The risk for this hypothetical accident is generally more severe at Navy ship sites. At all sites, this accident results in the lowest or next to the lowest ris evaluated.

For the hypothetical wet storage mechanical damage accident scenario, the rad might cause contamination of the ground to a downwind distance of less than 0.06 mi a total area impacted by the accident of less than 0.5 acre. The calculated downwi

contained within the boundaries of all sites under evaluation.

Table F.1.4.2.1.3-1. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9 x 10-4	7.6 x 10-8
MCW	2.5 x 10-7	9.6 x 10-11
NPA	1.5 x 10-7	7.4 x 10-11
MOI	5.7 x 10-7	2.9 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.0 x 10-3	2.5 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	2.4 x 10-6	9.6 x 10-10
NPA	8.3 x 10-7	4.2 x 10-10
MOI	2.6 x 10-6	1.3 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1 x 10-2	5.3 x 10-6

Table F.1.4.2.1.3-2. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MCW	5.2 x 10-6	2.1 x 10-9
NPA	9.1 x 10-8	4.5 x 10-11
MOI (New ECF)	3.9 x 10-7	1.9 x 10-10
MOI (Barnwell)	1.5 x 10-6	7.4 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	7.1 x 10-3	3.5 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	6.7 x 10-5	2.6 x 10-8
NPA	1.4 x 10-6	7.2 x 10-10
MOI (New ECF)	2.2 x 10-6	1.1 x 10-9
MOI (Barnwell)	1.8 x 10-5	9.0 x 10-9

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1 x 10-2	2.0 x 10-5

Table F.1.4.2.1.3-3. Summary of Exposure Calculation Results. For Wet Storage - Mechanical Damage At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4 x 10-5	3.4 x 10-8
MCW	7.1 x 10-6	2.9 x 10-9
NPA	1.0 x 10-7	5.1 x 10-11
MOI (New (ECF)	1.3 x 10-7	6.5 x 10-11
MOI (FMEF)	2.4 x 10-7	1.2 x 10-10
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	9.4 x 10-4	4.7 x 10-7

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	4.4 x 10-5	1.8 x 10-8
NPA	1.6 x 10-6	7.9 x 10-10
MOI (New ECF)	9.8 x 10-7	4.9 x 10-10
MOI (FMEF)	3.1 x 10-6	1.5 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.7 x 10-2	8.6 x 10-6

Table F.1.4.2.1.3-4. Summary of Exposure Calculation Results. For Wet Storage - Mechanical Damage At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	N/A	N/A
NPA	5.5 x 10-5	2.7 x 10-8
MOI	1.3 x 10-5	6.7 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	6.0 x 10-3	3.0 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer

Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	6.5 x 10-4	3.2 x 10-7
MOI	1.7 x 10-4	8.4 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.5 x 10-1	7.2 x 10-5

Table F.1.4.2.1.3-5. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9 x 10-4	7.6 x 10-8
MCW	N/A	N/A
NPA	4.9 x 10-5	2.4 x 10-8
MOI	2.3 x 10-5	1.2 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	1.1 x 10-1	5.6 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	1.6 x 10-3	7.9 x 10-7
MOI	9.3 x 10-5	4.6 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	3.1 x 10-1	1.5 x 10-4

Table F.1.4.2.1.3-6. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.9 x 10-8
MCW	N/A	N/A
NPA	1.2 x 10-5	6.0 x 10-9
MOI	3.2 x 10-5	1.6 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.4 x 10-2	7.0 x 10-6

95% METEOROLOGY

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	1.4 x 10-4	7.0 x 10-8
MOI	3.5 x 10-4	1.7 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6 x 10-1	8.0 x 10-5

Table F.1.4.2.1.3-7. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Portsmouth

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.8 x 10-8
MCW	N/A	N/A
NPA	1.1 x 10-5	5.6 x 10-9
MOI	1.5 x 10-5	7.4 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	3.8 x 10-3	1.9 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	N/A	N/A
NPA	2.5 x 10-4	1.3 x 10-7
MOI	1.9 x 10-4	9.3 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.1 x 10-1	5.6 x 10-5

Table F.1.4.2.1.3-8. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6 x 10-5	1.9 x 10-8
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.2 x 10-6	1.6 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	4.7 x 10-2	2.3 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.6×10^{-5}	1.8×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.2×10^{-1}	6.0×10^{-5}

Table F.1.4.2.1.3-9. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0×10^{-5}	1.2×10^{-8}
MCW	3.0×10^{-8}	1.5×10^{-11}
NPA	N/A	N/A
MOI	3.8×10^{-7}	1.9×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	4.5×10^{-4}	2.3×10^{-7}

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	1.8×10^{-6}	7.1×10^{-10}
NPA	N/A	N/A
MOI	4.6×10^{-6}	2.3×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1×10^{-3}	5.6×10^{-7}

Table F.1.4.2.1.3-10. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9×10^{-4}	7.6×10^{-8}
MCW	5.4×10^{-6}	2.2×10^{-9}
NPA	6.6×10^{-5}	3.3×10^{-8}
MOI	9.3×10^{-5}	4.7×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0×10^{-2}	1.0×10^{-5}

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2 x 10-4	2.1 x 10-7
MCW	3.3 x 10-5	1.3 x 10-8
NPA	4.2 x 10-4	2.1 x 10-7
MOI	5.9 x 10-4	3.0 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.7 x 10-2	3.4 x 10-5

F.1.4.2.1.4 Airplane Crash.

F.1.4.2.1.4.1 Description of Conditions. Impact into water pools by aircraft with resulting

damage to the naval fuel units stored inside the pool was evaluated. Based on the occurrence, as discussed in Section F.3, specific analyses were only performed for Nevada Test Site, Oak Ridge, Pearl Harbor, Norfolk, and Kesselring locations. At o likelihood of occurrence is less than 10-7 per year. The hypothetical accident inc units stored at the water pool. Fission products and corrosion products are releas the water pool; however, the pool water is not released to the environment. An air pool would not produce enough force to cause the pool to leak because the walls of constructed of thick, reinforced concrete with earth surrounding them, making them addition, it was judged unlikely that an airplane would impact the water pool at an expose the floor of the pool or the walls of the pool below the water level to the presence of pool water results in only a release of gaseous fission products to the sphere.

F.1.4.2.1.4.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of the fission products from each of the fuel units stored i available for release.
- Of the available fission products, 100% of the noble gases and 25% of th released to the pool water. Due to the presence of pool water, a reduct release by a factor of 10 prior to release to the atmosphere occurs.
- No solid fission products or corrosion products are released to the envi continued presence of pool water.
- The release to the environment occurs at a constant rate over a 15-minut
- 300 naval fuel units would be in the water pool.
- No filtration by HEPA filters is assumed.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the

Nuclide	Curies
I-129	7.59 x 10-4
I-131	1.61 x 10-2
H-3	4.28 x 102

F.1.4.2.1.4.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical airplane crash accident at each fatal cancers would be expected to occur over a 50-year period. "Risk" is defined

cancers times the probability of occurrence.

Water Pool Airplane Crash Summary

Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs
Savannah River	2 x 10-6	6.4 x 10-4	6.1 x 10-3
Pearl Harbor	2 x 10-5	2.8 x 10-2	4.6 x 10-2
Norfolk	4 x 10-7	1.1 x 10-1	2.4 x 10-2
Kesselring	2 x 10-7	1.1 x 10-2	1.8 x 10-2
Nevada Test Site	4 x 10-7	1.3 x 10-3	1.7 x 10-4
Oak Ridge	1 x 10-6	1.8 x 10-1	1.0 x 10-2

The risk for this hypothetical accident is most severe at Pearl Harbor. For probabilities less than 10-7 per year, consequences were not calculated since it is not substantially contribute to the risk.

For the hypothetical airplane crash into a wet storage facility accident scen plume might result in contamination of the ground to a downwind distance of less th would yield a total area impacted by the accident of less than 0.5 acre. The calcu would be contained within the boundaries of all sites that are at risk for this acc

Table F.1.4.2.1.4-1. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.5 x 10-2	1.0 x 10-5
MCW	1.6 x 10-3	6.3 x 10-7
NPA	2.8 x 10-5	1.4 x 10-8
MOI	1.1 x 10-4	5.5 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2	1.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	2.0 x 10-2	8.0 x 10-6
NPA	4.3 x 10-4	2.2 x 10-7
MOI	6.4 x 10-4	3.2 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	1.2 x 101	6.1 x 10-3

Table F.1.4.2.1.4-2. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Pearl Harbor

50% METEOROLOGY

Likelihood

Location	Total EDE (rem)	of Fatal Cancer
Worker	5.7 x 10-2	2.3 x 10-5
MCW	N/A	N/A
NPA	1.5 x 10-2	7.3 x 10-6
MOI	6.9 x 10-3	3.5 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	3.3 x 101	1.7 x 10-2

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	4.7 x 10-1	2.4 x 10-4
MOI	2.8 x 10-2	1.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.2 x 101	4.6 x 10-2

Table F.1.4.2.1.4-3. Summary of Exposure Calculation Results. For Wet Storage - Airplane Crash At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-2	5.6 x 10-6
MCW	N/A	N/A
NPA	3.6 x 10-3	1.8 x 10-6
MOI	9.6 x 10-3	4.8 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.2	2.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	4.2 x 10-2	2.1 x 10-5
MOI	1.1 x 10-1	5.3 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.8 x 101	2.4 x 10-2

Table F.1.4.2.1.4-4. Summary of Exposure Calculation Results. For Wet Storage - Airplane Crash At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-2	5.6 x 10-6
MCW	N/A	N/A
NPA	N/A	N/A
MOI	9.5 x 10-4	4.8 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.4 x 101	7.1 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.1 x 10-2	5.4 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	3.6 x 101	1.8 x 10-2

Table F.1.4.2.1.4-5. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.0 x 10-3	3.6 x 10-6
MCW	9.1 x 10-6	3.7 x 10-9
NPA	N/A	N/A
MOI	5.5 x 10-5	2.8 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.3 x 10-1	6.5 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.4 x 10-5
MCW	5.3 x 10-4	2.2 x 10-7
NPA	N/A	N/A
MOI	1.3 x 10-3	6.5 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.3 x 10-1	1.7 x 10-4

Table F.1.4.2.1.4-6. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.7 x 10-2	2.3 x 10-5
MCW	1.6 x 10-3	6.5 x 10-7
NPA	2.0 x 10-2	9.9 x 10-6
MOI	2.8 x 10-2	1.4 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.0	3.0 x 10-3

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6 x 10-1	6.3 x 10-5
MCW	9.9 x 10-3	3.9 x 10-6
NPA	1.3 x 10-1	6.3 x 10-5
MOI	1.8 x 10-1	8.9 x 10-5
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0 x 101	1.0 x 10-2

F.1.4.2.1.5 HEPA Filter Fire.

F.1.4.2.1.5.1 Description of Conditions. In this hypothetical accident scenario, a fire in the

ECF High Efficiency Particulate Air (HEPA) filter banks is postulated. This accide the ignition of a flammable mixture released upstream of the system or by an extern spreads to this system. Although the risks associated with this accident are relat analyzed to bound the higher probability, lower consequence type accident category. fractions associated with this accident were conservatively chosen so that a HEPA f crushing or impact was also bounded.

F.1.4.2.1.5.2 Source Term. Conditions used in developing the source term are as follows:

- The original inventory of fission products in the filters is based on th unabated ECF releases over a 5-year period.

- One percent of the radionuclide inventory present on the filters becomes the fire. Release fractions for HEPA filters are small because the filt structed of
material containing glass fibers which would melt during a fire and trap medium. Measurements from experiments show that one one-hun- dredth of 1% of the
material in HEPA filters could be released during a fire, but 1% has bee analyses to allow for uncertainties in the final results of an individua

- The release to the environment occurs at a constant rate over a 15-minut

- There is no increase in direct radiation due to this accident.

- The following amounts of radionuclides could be released to the environ- ment. This

listing includes nuclides that result in at least 99% of the possible ex

- No filtration by HEPA filters is assumed.

Nuclide	Curies	Nuclide	Curies
Cs-137	1.46 x 10-3	Co-60	2.09 x 10-3
Cs-134	2.04 x 10-4	Sr-90	8.90 x 10-4
Ba-137M	6.26 x 10-6	Y-90	8.90 x 10-4
Fe-55	2.32 x 10-3	Eu-154	9.80 x 10-5
Ni-63	2.98 x 10-3		

F.1.4.2.1.5.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical HEPA filter fire accident at eac of fatal cancers would be expected to occur over a 50-year period. "Risk" is defin cancers times the probability of occurrence. The probability of a fire in a HEPA f on the probability of other fires spreading to the HEPA filter system. As discusse probability of 5 x 10-3 is assigned to chemical fires. The probability of HEPA fir a chemical fire since chemicals would not be stored in the immediate vicinity of th Additionally, HEPA filters are not inherently volatile or explosive. It is estimat an existing chemical fire to spread to the HEPA filters is less than 0.1. This res than 5 x 10-4 for a HEPA filter fire. A value of 5 x 10-4 was used to develop the

HEPA Filter Fire Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per year
INEL	2.5 x 10-5	5.3 x 10-5	2.7 x 10-8
Savannah River	2.1 x 10-5	1.3 x 10-4	6.5 x 10-8
Hanford	7.0 x 10-6	5.3 x 10-5	2.7 x 10-8
Puget Sound	1.6 x 10-3	6.4 x 10-4	3.2 x 10-7
Pearl Harbor	8.7 x 10-4	1.2 x 10-3	6.0 x 10-7
Norfolk	3.3 x 10-3	6.9 x 10-4	3.5 x 10-7
Portsmouth	1.7 x 10-3	3.9 x 10-4	2.0 x 10-7
Kesselring	3.5 x 10-4	3.3 x 10-4	1.7 x 10-7
Nevada Test Site	4.3 x 10-5	5.7 x 10-6	2.9 x 10-9
Oak Ridge	5.7 x 10-3	2.2 x 10-4	1.1 x 10-7

The risk for this hypothetical accident is generally more severe at the Navy DOE sites.

For the hypothetical HEPA filter fire accident scenario, the radioactive plum contamination of the ground to a downwind distance of less than 0.06 mile. This wo impacted by the accident of less than 0.5 acre. The calculated downwind distance w within the boundaries of all sites under evaluation.

Table F.1.4.2.1.5-1. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7
MCW	7.9 x 10-7	3.2 x 10-10
NPA	4.5 x 10-7	2.2 x 10-10
MOI	9.9 x 10-6	5.0 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	7.6 x 10-2	3.8 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	8.8 x 10-6	3.5 x 10-9
NPA	2.7 x 10-6	1.4 x 10-9
MOI	2.5 x 10-5	1.3 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1 x 10-1	5.3 x 10-5

Table F.1.4.2.1.5-2. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9 x 10-4	1.5 x 10-7
MCW	2.3 x 10-5	8.8 x 10-9
NPA	2.9 x 10-7	1.4 x 10-10
MOI (New ECF)	7.2 x 10-6	3.6 x 10-9
MOI (Barnwell)	1.7 x 10-5	8.6 x 10-9
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1 x 10-2	2.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	2.9 x 10-4	1.1 x 10-7
NPA	4.9 x 10-6	2.5 x 10-9
MOI (New ECF)	2.1 x 10-5	1.0 x 10-8
MOI (Barnwell)	1.6 x 10-4	8.1 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.5 x 10-1	1.3 x 10-4

Table F.1.4.2.1.5-3. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9 x 10-4	1.5 x 10-7
MCW	3.0 x 10-5	1.2 x 10-8
NPA	3.5 x 10-7	1.8 x 10-10
MOI (New ECF)	9.6 x 10-7	4.8 x 10-10
MOI (FMEF)	1.9 x 10-6	9.7 x 10-10

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	6.7 x 10-3	3.4 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	1.9 x 10-4	7.5 x 10-8
NPA	5.5 x 10-6	2.7 x 10-9
MOI (New ECF)	7.0 x 10-6	3.5 x 10-9
MOI (FMEF)	2.4 x 10-5	1.2 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.1 x 10-1	5.3 x 10-5

Table F.1.4.2.1.5-4. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Puget Sound

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.4 x 10-8
MCW	N/A	N/A
NPA	2.5 x 10-4	1.2 x 10-7
MOI	1.4 x 10-4	6.8 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	3.4 x 10-1	1.7 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	2.9 x 10-3	1.5 x 10-6
MOI	1.6 x 10-3	8.0 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.3	6.4 x 10-4

Table F.1.4.2.1.5-5. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Pearl Harbor

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7

MCW	N/A	N/A
NPA	2.2 x 10-4	1.1 x 10-7
MOI	2.2 x 10-4	1.1 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.0 x 10-1	4.5 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	7.2 x 10-3	3.6 x 10-6
MOI	8.7 x 10-4	4.3 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.4	1.2 x 10-3

Table F.1.4.2.1.5-6. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Norfolk

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.5 x 10-8
MCW	N/A	N/A
NPA	5.3 x 10-5	2.7 x 10-8
MOI	3.2 x 10-4	1.6 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	2.3 x 10-1	1.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	6.2 x 10-4	3.1 x 10-7
MOI	3.3 x 10-3	1.7 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.4	6.9 x 10-4

Table F.1.4.2.1.5-7. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Portsmouth

50% METEOROLOGY

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	2.1 x 10-4	8.4 x 10-8
MCW	N/A	N/A
NPA	5.0 x 10-5	2.5 x 10-8
MOI	1.4 x 10-4	7.2 x 10-8
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 2432627	1.2 x 10-1	6.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	1.1 x 10-3	5.6 x 10-7
MOI	1.7 x 10-3	8.7 x 10-7
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 2432627	7.9 x 10-1	3.9 x 10-4

Table F.1.4.2.1.5-8. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Kesselring

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1 x 10-4	8.5 x 10-8
MCW	N/A	N/A
NPA	N/A	N/A
MOI	5.5 x 10-5	2.7 x 10-8
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 1148587	2.0 x 10-1	9.8 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.5 x 10-4	1.8 x 10-7
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 1148587	6.7 x 10-1	3.3 x 10-4

Table F.1.4.2.1.5-9. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Nevada Test Site

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4 x 10-4	5.5 x 10-8
MCW	1.1 x 10-7	4.2 x 10-11
NPA	N/A	N/A
MOI	8.5 x 10-6	4.2 x 10-9
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 13792	7.6 x 10-3	3.8 x 10-6

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	6.2 x 10-6	2.5 x 10-9
NPA	N/A	N/A
MOI	4.3 x 10-5	2.2 x 10-8
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 13792	1.1 x 10-2	5.7 x 10-6

Table F.1.4.2.1.5-10. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Oak Ridge

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7 x 10-4	3.5 x 10-7
MCW	2.3 x 10-5	8.8 x 10-9
NPA	3.0 x 10-4	1.5 x 10-7
MOI	9.0 x 10-4	4.5 x 10-7
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 871531	1.2 x 10-1	6.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4 x 10-3	9.6 x 10-7
MCW	1.4 x 10-4	5.6 x 10-8
NPA	1.9 x 10-3	9.4 x 10-7
MOI	5.7 x 10-3	2.9 x 10-6
Exposure to Population within 50-mile Radius	(person-rem)	Number of Fatal Cancers
Population of 871531	4.3 x 10-1	2.2 x 10-4

F.1.4.2.1.6 Minor Water Pool Leakage.

F.1.4.2.1.6.1 Description of Conditions. In this hypothetical accident scenario, a minor

leak develops in the water pool resulting in a gradual discharge to the environment uncovering any spent nuclear fuel in the water pool, since the leak is so small tha water level is maintained in the water pool. Since a strict accounting of water ad the water pool is maintained, the magnitude of this leak would be less than 4,400 g 4,400 gallons per year value is the maximum amount of water which might leak out of before periodic review of the water balance would detect a leak.

F.1.4.2.1.6.2 Source Term. There is no airborne release above normal levels in this

hypothetical accident scenario. The radionuclide inventory in the leaking water is analysis of ECF water pool water. The isotopes that were analyzed for but not dete minimum detection limit.

Nuclide	Sample Results (-Ci/mL)	10CFR20 Effluent Limit (-Ci/mL)	Annu (Ci/
H-3	2.0 x 10-4	1.0 x 10-3	3.3
Mn-54	2.5 x 10-8	3.0 x 10-5	4.1
Fe-55	1.0 x 10-8 *	1.0 x 10-4	1.6
Co-58	7.0 x 10-8	2.0 x 10-5	1.1
Co-60	1.6 x 10-5	3.0 x 10-6	2.6
Ni-63	2.3 x 10-7	1.0 x 10-4	3.8
Sr-90	4.0 x 10-9	5.0 x 10-7	6.5
Y-90	4.0 x 10-9	7.0 x 10-6	6.5
I-129	4.0 x 10-7 *	2.0 x 10-7	6.5
Cs-137	4.2 x 10-8	1.0 x 10-6	6.9

* These radionuclides were not detected in the ECF water. The numbers quoted detection limit of the analysis.

It should be noted that the sample results for the water pool indicate that t below the Code of Federal Regulations limits for liquid effluent in 10CFR20 with th The level of I-129 used in the calculations was based on the minimum detection limi level exceeds the effluent limit; however, I-129 was not actually detected in the w has comparable water solubility to I-129 and exists in spent nuclear fuel at about higher than I-129, it is inferred from the detected level of Sr-90 that the actual the 10CFR20 effluent limit.

F.1.4.2.1.6.3 Results. The following table summarizes the public health risk to the general

population that might result from the hypothetical minor water pool leak at each lo fatal cancers would be expected to occur over a 50-year period. "Risk" is defined cancers times the probability of occurrence. The probability of a leak developing

Minor Water Pool Leakage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per ye
INEL	2.5 x 10-9	1.3 x 10-8	1.3 x 10-9
Savannah River	7.9 x 10-10	1.3 x 10-9	1.3 x 10-10
Hanford	9.9 x 10-12	1.7 x 10-10	1.7 x 10-11
Puget Sound	3.2 x 10-10	4.2 x 10-9	4.2 x 10-10
Pearl Harbor	1.3 x 10-10	4.6 x 10-10	4.6 x 10-11
Norfolk	2.7 x 10-10	1.8 x 10-9	1.8 x 10-10
Portsmouth	1.3 x 10-10	1.4 x 10-9	1.4 x 10-10

Kesselring	6.0 x 10-9	8.5 x 10-9	8.5 x 10-10
Nevada Test Site	2.5 x 10-9	1.4 x 10-9	1.4 x 10-10
Oak Ridge	1.5 x 10-9	3.9 x 10-9	3.9 x 10-10

At all sites except the Nevada Test Site, this accident results in the lowest the wet storage accidents evaluated.

Table F.1.4.2.1.6-1. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6 x 10-13	6.4 x 10-17
NPA	1.6 x 10-13	8.0 x 10-17
MOI	2.5 x 10-9	1.3 x 10-12

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 115690	2.6 x 10-5	1.3 x 10-8

Table F.1.4.2.1.6-2. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	4.8 x 10-13	1.9 x 10-16
NPA	4.8 x 10-13	2.4 x 10-16
MOI	7.9 x 10-10	4.0 x 10-13

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 579541	2.5 x 10-6	1.3 x 10-9

Table F.1.4.2.1.6-3. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	8.3 x 10-15	3.3 x 10-18
NPA	8.3 x 10-15	4.2 x 10-18
MOI	9.9 x 10-12	5.0 x 10-15

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 375860	3.3 x 10-7	1.7 x 10-10

Table F.1.4.2.1.6-4. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Puget Sound

	Total EDE	Likelihood of Fatal

Location	(rem)	Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	1.2 x 10-11	6.0 x 10-15
MOI	3.2 x 10-10	1.6 x 10-13

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 2975810	8.4 x 10-6	4.2 x 10-9

Table F.1.4.2.1.6-5. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8 x 10-12	2.4 x 10-15
MOI	1.3 x 10-10	6.5 x 10-14

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 817385	9.2 x 10-7	4.6 x 10-10

Table F.1.4.2.1.6-6. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	9.9 x 10-12	5.0 x 10-15
MOI	2.7 x 10-10	1.4 x 10-13

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers
Population of 1539002	3.6 x 10-6	1.8 x 10-9

Table F.1.4.2.1.6-7. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8 x 10-12	2.4 x 10-15
MOI	1.3 x 10-10	6.5 x 10-14

	Exposure to Population within 50-mile Radius (person-rem)	Number of Fatal Cancers

Population of 2432627	2.7 x 10-6	1.4 x 10-9

Table F.1.4.2.1.6-8. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	N/A	N/A
MOI	6.0 x 10-9	3.0 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.7 x 10-5	8.5 x 10-9

Table F.1.4.2.1.6-9. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6 x 10-13	6.4 x 10-17
NPA	1.6 x 10-13	8.0 x 10-17
MOI	2.5 x 10-9	1.3 x 10-12

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	2.7 x 10-6	1.4 x 10-9

Table F.1.4.2.1.6-10. Summary of Exposure Calculation Results. For Wet Storage - Minor Water Pool Leakage At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	9.4 x 10-13	3.8 x 10-16
NPA	9.4 x 10-13	4.7 x 10-16
MOI	1.5 x 10-9	7.5 x 10-13

Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.7 x 10-6	3.9 x 10-9

F.1.4.2.2 Dry Storage.

F.1.4.2.2.1 Wind-driven Missile Impact into Storage Casks with Mechanical

Damage.

F.1.4.2.2.1.1 Description of Conditions. In this hypothetical accident, no fuel damage

would result from any impact because of the strength of the containers used. Dry s experience a major wind storm or tornado which could propel a large object into a s causing the container seal to be breached. However, container analysis for this si container is strong enough to prevent crushing of the spent nuclear fuel and releas

Winds produced by tornados are higher than hurricane winds and thus the impac would be travelling with higher velocity and would have higher kinetic energy. Eve velocity, analysis has shown that the missile would not penetrate the container. T penetration at the lower velocity of a hurricane (212 miles per hour) would be even probability of penetration for a missile propelled by the winds of a tornado (trave hurricanes can have high winds, hurricane winds normally cannot generate the very l missiles analyzed for tornados. While hurricanes may occur more frequently than to risk from a hurricane is lower because the container would not be penetrated.

The analysis of wind damage using missiles propelled by the winds of tornados done for design of nuclear power plants. Hurricanes very infrequently have winds t such missiles, so the analyses provided for tornados provide an upper limit for the Examination of damage caused by recent severe hurricanes shows that robust structur hurricanes.

F.1.4.2.2.1.2 Source Term. Conditions used in developing the source term are as follows:

- The source term is based on best estimate spent nuclear fuel corrosion p
- One percent of the original corrosion products associated with the fuel from the cask to the atmosphere. This is based on experimental measurem fraction of corrosion products loosened from naval spent nuclear fuel by vibration and the fact that a wind-driven missile would not penetrate th damage the fuel inside. Only loose corrosion products would be avail- able for release
from the container, and any release from the container would have to occ convoluted path through the damaged seal.
- The release to the environment occurs at a constant rate over a 15-minut
- There is no increase in direct radiation due to this accident.
- The following amounts of radionuclides could be released to the environ- ment. This
listing includes nuclides that result in at least 99% of the possible ex

Nuclide	Curies
Co-60	9.58 x 10-2
Fe-55	1.76 x 10-1
Co-58	3.54 x 10-2
Mn-54	5.98 x 10-3
Fe-59	5.11 x 10-4

F.1.4.2.2.1.3 Results. The following table summarizes the public health risk to the general

population that would result from the hypothetical wind-driven missile accident at number of fatal cancers would be expected to occur over a 50-year period. "Risk" i number of fatal cancers times the probability of occurrence. The probability of co due to the very strong container design. The dry storage containers are expected t shipping containers so that they would not be penetrated by environmentally caused would not be affected. However, an analysis was performed for a case in which the missile might topple a container on a railcar and cause unseating of the container radioactive material in the form of corrosion products.

The probability of the occurrence of a tornado was obtained using the data in WASH-1300 (AEC 1974). The maximum likelihood of a tornado occurrence at all storag

being evaluated in the continental United States is 10-3 per year. The probability the tornado striking a container and causing the damage analyzed has been estimated Thus, the total probability of a wind-driven missile damaging a container is less t probability of 10-5 per year was used in the risk assessment.

Dry Storage Mechanical Damage Summary

Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancer if accident occurs	Risk per year
INEL	4.6 x 10-4	4.9 x 10-4	4.9 x 10-9
Savannah River	4.9 x 10-4	3.0 x 10-3	3.0 x 10-8
Hanford	1.7 x 10-4	1.3 x 10-3	1.3 x 10-8
Puget Sound	3.9 x 10-2	1.7 x 10-2	1.7 x 10-7
Pearl Harbor	2.1 x 10-2	3.0 x 10-2	3.0 x 10-7
Norfolk	8.1 x 10-2	1.8 x 10-2	1.8 x 10-7
Portsmouth	4.2 x 10-2	1.0 x 10-2	1.0 x 10-7
Kesselring	8.1 x 10-3	7.4 x 10-3	7.4 x 10-8
Nevada Test Site	8.8 x 10-4	5.3 x 10-5	5.3 x 10-10
Oak Ridge	1.4 x 10-1	5.1 x 10-3	5.1 x 10-8

The risk for this hypothetical accident is generally more severe at Navy ship sites. This accident results in the lowest risk of the two dry storage accidents e

For the hypothetical wind-driven missile accident scenario, the radioactive p contamination of the ground to a downwind distance of less than 0.06 mile. This wo impacted by the accident of less than 0.5 acre. The calculated downwind distance w within the boundaries of all sites under evaluation.

Table F.1.4.2.2.1-1. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At INEL

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0 x 10-2	8.0 x 10-6
MCW	1.8 x 10-5	9.2 x 10-9
NPA	1.0 x 10-5	5.2 x 10-9
MOI	8.0 x 10-5	4.0 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	2.3 x 10-1	1.2 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	2.0 x 10-4	1.0 x 10-7
NPA	6.3 x 10-5	3.1 x 10-8
MOI	4.6 x 10-4	2.3 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	9.8 x 10-1	4.9 x 10-4

Table F.1.4.2.2.1-2. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Savannah River

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-3	3.6 x 10-6
MCW	5.3 x 10-4	2.1 x 10-7
NPA	6.7 x 10-6	3.4 x 10-9
MOI (New ECF)	1.6 x 10-4	8.1 x 10-8
MOI (Barnwell)	4.0 x 10-4	2.0 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	9.4 x 10-1	4.7 x 10-4

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	6.7 x 10-3	2.6 x 10-6
NPA	1.1 x 10-4	5.7 x 10-8
MOI (New ECF)	4.9 x 10-4	2.5 x 10-7
MOI (Barnwell)	3.9 x 10-3	2.0 x 10-6
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	6.1	3.0 x 10-3

Table F.1.4.2.2.1-3. Summary of Exposure Calculation Results. For Dry Storage - Mechanical Damage At Hanford

50% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9 x 10-3	3.6 x 10-6
MCW	7.0 x 10-4	2.8 x 10-7
NPA	8.1 x 10-6	4.1 x 10-9
MOI (New ECF)	2.3 x 10-5	1.1 x 10-8
MOI (FMEF)	4.6 x 10-5	2.3 x 10-8
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.4 x 10-1	7.0 x 10-5

95% METEOROLOGY

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6 x 10-2	2.2 x 10-5
MCW	4.4 x 10-3	1.8 x 10-6
NPA	1.3 x 10-4	6.3 x 10-8
MOI (New ECF)	1.7 x 10-4	8.4 x 10-8
MOI (FMEF)	5.9 x 10-4	2.9 x 10-7
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Can-