Summary Engineering Description of Underwater Fuel Storage Facility for Foreign Research Reactor Spent Nuclear Fuel

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ABSTRACT

The purpose of this technical report is to provide preliminary planning information for an Underwater Fuel Storage Facility for foreign research reactor spent nuclear fuel. The facility design is generic and can be constructed at any one of five designated U.S. Department of Energy sites. The information contained in this report was taken from and patterned after the Fluorinel Dissolution Process and Fuel Storage Facility operations at the Idaho National Engineering Laboratory's Idaho Chemical Processing Plant and from detailed studies performed on dry storage facilities.

EXECUTIVE SUMMARY

This document is a summary description for an Underwater Fuel Storage Facility (UFSF) for foreign research reactor (FRR) spent nuclear fuel (SNF). A FRR SNF Environmental Impact Statement (EIS) is being prepared for the U.S. Department of Energy (DOE) by Science Applications International Corporation-Washington, D.C. This EIS will include both wet and dry storage facilities as storage alternatives. For the UFSF presented in this document, a specific site is not chosen. This facility can be sited at any one of the five locations under consideration in the EIS. These locations are the Idaho National Engineering Laboratory, Savannah River Site, Hanford, Oak Ridge National Laboratory, and Nevada Test Site. Generic facility environmental impacts and emissions are provided in this report. Impacts and emissions will need to be tailored to each site under consideration to determine effects on water, the public, and the environment.

A baseline fuel element is defined in Section 2.2, and the results of a fission product analysis are presented in Table 1. Requirements for a storage facility have been researched and are summarized in Section 3.

Section 4 describes three facility options: (1) the Centralized-UFSF, which would store the entire fuel element quantity in a single facility at a single location, (2) the Regionalized Large-UFSF, which would store 75% of the fuel element quantity in some region of the country, and (3) the Regionalized Small-UFSF, which would store 25% of the fuel element quantity, with the possibility of a number of these facilities in various regions throughout the country.

The operational philosophy is presented in Section 5, and Section 6 contains a description of the equipment. Section 7 defines the utilities required for the facility. Cost estimates are discussed in Section 8, and detailed cost estimates are included in Appendix A— Impacts to worker safety, public safety, and the environment are discussed in Section 9. Accidental releases are presented in Section 10. Standard Environmental Impact Forms are included in Section 11. Because the facility is not given a defined site, all releases are from the facility. Impacts particular to the site are not given.

CONTENTS

ABSTRACT	iii
EXECUTIVE SUMMARY	v
ACRONYMS AND ABBREVIATIONS	xiii
1. INTRODUCTION	1
1.1 Background	1
1.2 Descriptive Summary	2
2. FUEL ELEMENT CHARACTERISTICS	3
2.1 Fuel Cladding	3
2.2 Baseline Fuel Element	3
2.3 Decay Time	4
2.4 Fission Product Inventory	4
2.5 Decay Heat	4
3. IDENTIFICATION OF REQUIREMENTS	7
3.1 Siting Evaluation Factors	7
3.1.1 General Considerations	7
3.1.2 Siting Limitations	7
3.1.3 Potential Effects on the Region	7
3.1.4 Geological and Seismological Characteristics	7
3.1.5 Criteria for Radioactive Materials in Effluents and Direct Radiation from an UFSF	8
3.1.6 Controlled Area	8
3.1.7 Spent Fuel Transportation	8
3.2 General Design Criteria	8
3.2.1 Quality Standards	8
3.2.2 Protection Against Natural Phenomena	8
3.2.3 Protection Against Fires and Explosions	9
3.2.4 Sharing of Structures, Systems, and Components	9
3.2.5 Proximity of Sites	9
3.2.6 Testing and Maintenance of Systems and Components	9
3.2.7 Emergency Capability	9
3.2.8 Confinement Barriers and Systems	9

3.2.9 Instrumentation and Control Systems	10
3.2.10 Control Room or Control Area	10
3.2.11 Utility or Other Services	10
3.3 Criteria for Nuclear Criticality Safety	10
3.3.1 Design for Criticality Safety	10
3.3.2 Methods of Criticality Control	11
3.3.3 Criticality Monitoring	11
3.4 Criteria for Radiological Protection	11
3.4.1 Exposure Control	11
3.4.2 Radiological Alarm Systems	11
3.4.3 Effluent and Direct Radiation Monitoring	11
3.4.4 Effluent Control	11
3.5 Criteria for Spent Fuel Storage and Handling	12
3.5.1 Spent Fuel Storage and Handling Systems	12
3.5.2 Waste Treatment	12
3.6 Criteria for Decommissioning	12
3.6.1 Decommissioning	12
3.7 Quality Assurance	12
4. FACILITY DESCRIPTION	14
4.1 Cask Vehicle Receiving Area	21
4.2 Cask Receiving and Decontamination Area	24
4.3 Fuel Handling and Transfer Area	24
4.3.1 Fuel Unloading Pools	27
4.3.2 Transfer Channel	27
4.3.3 Isolation Pool	29
4.3.4 Cutting/Canning Pool	29
4.4 Fuel Storage Pool Area	29
4.5 Operations Room	34
4.6 Contaminated Equipment Storage Room	35
4.7 Heating and Ventilation System	35
4.7.1 Supply Air System	35
4.7.2 Exhaust Air System	35
4.8 Water Treatment System	36

4.9	Radioactive Waste Management and Disposal	37
4.10	Chemical Makeup	37
4.11	Support Area	37
4.11.1	Raw Water	38
4.11.2	Fire Water	38
4.11.3	Plant Air	38
4.11.4	Breathing Air	38
4.11.5	Sanitary Waste	38
4.11.6	Electricity	39
5.	OPERATION THEORY	40
5.1	Fuel Receipt, Handling, and Storage	40
5.2	Rack Handling Operations	41
6.	EQUIPMENT DESCRIPTION	42
6.1	Cranes	42
6.2	Fuel Storage Buckets	42
6.3	Fuel Bucket Loading Fixture	43
6.4	Fuel Storage Racks	43
6.5	Criticality Barriers for Storage Rack Arrays	44
7.	UTILITY REQUIREMENTS	45
7.1	Water	45
7.2	Sewage	45
7.3	Plant Air	45
7.4	Breathing Air	45
7.5	Ventilation	46
7.6	Electrical	46
7.7	Safety Communications and Alarms	46
7.8	Waste Handling	46

8. COST ESTIMATE	48
9. IMPACT OF WORKER SAFETY, PUBLIC SAFETY, AND ENVIRONMENT	49
9.1 Occupational Exposure to Radiation	49
9.1.1 Facility Personnel Internal Exposures	50
9.1.2 Facility Personnel External Exposures	50
9.2 Atmospheric Releases	50
9.3 Waste Production	51
9.3.1 Gaseous Waste	51
9.3.2 Liquid Waste	51
9.3.3 Solid Waste	52
9.4 Natural Phenomena Hazards	53
9.4.1 Earthquake Design and Evaluation Criteria	53
9.4.2 Wind Design and Evaluation Criteria	53
9.4.3 Flood Design	54
9.5 Systems Failure	54
9.5.1 Loss of Commercial Electrical Power	54
9.5.2 Temporary Ventilation System Failure	54
9.5.3 Mechanical Failure	54
10. ACCIDENTAL RELEASES	56
10.1 Design Events	56
10.1.1 Design Event I	56
10.1.2 Design Event II	56
10.1.3 Design Event III	56
10.1.4 Design Event IV	57
10.2 Accidental Releases	57
11. ENVIRONMENTAL IMPACT FORMS	59
REFERENCES	69
Appendix A-Cost Estimate	A-1
Appendix B-Source Term Data	B-1

FIGURES

Figure 1. C-UFSF plan view.	15
Figure 2. RL-UFSF plan view.	16
Figure 3. RS-UFSF plan view.	17
Figure 4. C-UFSF FSA plan view.	18
Figure 5. RS-UFSF FSA plan view.	19
Figure 6. Fuel handling logic flow diagram.	20
Figure 7. UFSF block flow diagram.	22
Figure 8. C-UFSF FSA elevation view.	23
Figure 9. Two-compartment fuel storage bucket (FSB-2).	25
Figure 10. Four-compartment fuel storage bucket (FSB-4).	26
Figure 11. FSB holding fixture.	28
Figure 12. Storage rack.	31
Figure 13. FSP with racks installed with physical barriers in front.	32
Figure 14. Stacked FSBs in storage rack.	33

TABLES

1. Fission product inventory	5
2. Construction environmental impact forms	60
3. Operating environmental impact summaries.	66

ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
CSE	criticality safety evaluation
C-UFSF	Centralized-Underwater Fuel Storage Facility
CVRA	cask vehicle receiving area
DBA	design basis accident
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
FAST	Fluorinel Dissolution Process and Fuel Storage Facility
FHU	fuel handling unit
FRR	foreign research reactor
FSA	fuel storage area
FSB	fuel storage bucket
FSP	fuel storage pool
FUP	fuel unloading pool
H&V	heating and ventilation
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HLW	high-level waste
HVAC	heating, ventilating, and air conditioning
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
LEU	low-enriched uranium
NEPA	National Environmental Policy Act

NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
PC	performance category
RCT	radiation control technician
RL-UFSF	Regionalized Large-Underwater Fuel Storage Facility
ROD	Record of Decision
RS-UFSF	Regionalized Small-Underwater Fuel Storage Facility
SAIC	Science Applications International Corporation
SNF	spent nuclear fuel
SRS	Savannah River Site
SSCs	structures, systems, or components
t	metric tonne
UFSF	Underwater Fuel Storage Facility

Summary Engineering Description of Underwater Fuel Storage Facility for Foreign Research Reactor Spent Nuclear Fuel

1. INTRODUCTION

1.1 Background

As part of the "Atoms for Peace" program, the United States has provided highly enriched uranium (HEU) for research reactors in countries that agreed to forego the development of nuclear weapons. After irradiation in the foreign research reactors (FRRs), the spent nuclear fuel (SNF) was transported back to the U.S., where it was reprocessed to extract uranium still remaining in it. To reduce the danger of nuclear weapons proliferation, the U.S. began a program in 1978 aimed at minimizing and eventually eliminating use of HEU in civilian reactor programs worldwide and replacing it with low-enriched uranium (LEU), a material not usable in nuclear weapons. Research reactors converting to LEU fuel viewed it as essential that the U.S. accept spent LEU fuel as well as spent fuel containing HEU. The U.S. accepted HEU spent fuel for several decades, until the program was allowed to expire in 1988. At that time, the U.S. Department of Energy (DOE) committed to prepare an environmental review of the potential impacts of a 10-year extension of the program for accepting FRR SNF.

In June 1994, DOE issued a Draft Environmental Impact Statement¹ that covers both DOE's programmatic SNF management and the environmental restoration and waste management programs at the INEL. This EIS is presently under review. The Record of Decision (ROD) is scheduled for July 1995. The ROD has been prepared for programmatic SNF decisions across the complex and for operations at the INEL. The programmatic SNF contains five alternatives for SNF storage throughout the U.S., ranging from no action, to regionalization, to centralization. Five DOE sites are being considered for storage of SNF. These locations are the Idaho National Engineering Laboratory (INEL), Savannah River Site (SRS), Hanford, Oak Ridge National Laboratory (ORNL), and Nevada Test Site (NTS).

DOE started in mid-1993 to prepare a FRR SNF EIS on a new proposed policy to accept, over a 10-15 year period, up to 22,000 spent fuel elements containing uranium enriched in the U.S. The goal of the proposed long-term policy would be to recover HEU exported from the U.S., while giving FRR operators sufficient time to develop their own long-term solutions for SNF storage and disposal of spent fuel.

This evaluation, being documented in a FRR SNF EIS, will be a sub-tier National Environmental Protection Act (NEPA) document to the programmatic SNF EIS. The FRR SNF EIS will also serve as the NEPA document to build any new facilities at the site chosen by the programmatic EIS. The FRR EIS is being prepared for DOE by Science Applications International Corporation (SAIC)-Washington, D.C.

1.2 Descriptive Summary

The FRR EIS document being prepared by SAIC-Washington, D.C. will include both wet and dry storage of SNF as facility alternatives. A summary engineering description document for the dry storage facility has been addressed,² while this document is a descriptive summary for an UFSF.

Storing fuel under water requires continuous facility utilities and monitoring as well as personnel. An underwater environment causes corrosion of metals placed in it. When aluminum contacts stainless steel in water, galvanic corrosion occurs. In fuel storage pool water, galvanic corrosion causes the aluminum to erode an average of five times faster than without stainless steel contact. To prevent galvanic corrosion, the UFSF design will incorporate ceramic insulation material between aluminum and stainless steel wet interfaces, thus facilitating a life span in excess of 40 years.

The UFSF consists of two main parts: the working area, known as the fuel storage area (FSA), and the support area, consisting of FSA water recirculation equipment; facility heating, ventilation, and air conditioning (HVAC); office area and equipment; etc. The FSA will be capable of receiving, storing, and managing a wide variety of irradiated aluminum-clad and TRIGA fuel elements. Primary design parameters for the UFSF have been patterned after the Fluorinel Dissolution Process and Fuel Storage Facility (FAST) at the INEL Idaho Chemical Processing Plant (ICPP) Building 666, which is a modern underwater fuel storage facility meeting all applicable design standards. The building is currently being used for receipt and storage of numerous spent fuels.

2. FUEL ELEMENT CHARACTERISTICS

The purpose of this section is to establish the characteristics of future fuel stored within the UFSF and to determine a fuel element baseline for input into accident scenarios.

2.1 Fuel Cladding

Fuel elements would be leak tested and canned if necessary, prior to placement in the FSA of the UFSF if leakage is suspected or detected. However, the condition of the cladding is required to be known to establish the fission gas diffusion through the cladding during normal operation and for accident scenarios. The condition of the cladding depends on reactor operational history both in and out of the reactor core during the life of each element, with specific interests in the following facility areas:

- Operational handling conditions
- Reactor operational accidents/stresses/power levels
- Design form and type
- Decay heat times
- Transport times
- Release rates
- Operational corrosion considerations
- Others.

2.2 Baseline Fuel Element

The initial uranium enrichment ranged from 20 to 93% with varying geometric configurations and, although the fuel matrix form is considered aluminum based, the exact matrix form varies from fuel type to fuel type. The baseline fuel element composition includes characteristics for the accident scenario involving reactor cycle operating data such as:

- Reactor flux spectrum—fast and thermal
- Reactor fuel element loading changes
- Reactor power densities—power levels
- Reactor cycle time—MW·d
- Others.

A reactor core known as NRU that is operated by Canada was chosen for baseline calculations because of the high enrichment, burnup, and relative high average operating power compared with other fuel elements. The NRU fuel elements were operated in the reactor at an average power of 1.389 fission-atoms/MW, an initial enrichment of 93% with 491 g (1.08 lb) of U^{235} , and a 76% burnup 373 g (0.82 lb) of U^{235} burnt. The configuration of the element is in the form of fuel pins. This baseline fuel element was chosen to be a conservative representation of the majority of the FRR fuel.

2.3 Decay Time

In order to determine the total fission product inventory at the time of delivery, an estimated decay time of each element was needed. The decay time prior to shipment was assumed at 365 days following reactor operations. This time allows a minimum time for cooling, packaging, handling, and shipping prior to receiving the fuel for storage at the UFSF. This is a significantly conservative estimate, because much of the fuel has been out of the reactor already for a long period.

2.4 Fission Product Inventory

Table 1 lists the major fission product inventory for the baseline fuel element. See Appendix B for baseline fuel element information. The fission product inventory was obtained from an ORIGEN2 calculation.³

2.5 Decay Heat

Decay heat from the fuel elements tend to raise the element temperature, if adequate cooling is not present. A decay heat calculation was performed to provide the bases for a loss of pool water accident. An estimated 143.3 W was calculated for the baseline fuel element for the UFSF.³ Free convection of air alone is sufficient to prevent meltdown for canned fuel at 100 W per element stored in air with a 7.6 cm (3 in.) spacing.² The UFSF would utilize racks with a 20.3 cm (8 in.) spacing between stored assemblies, thus increasing the relative safety of the spacing by more than 2-1/2 times. Therefore, if a loss of pool water accident occurred, there would be no concern of fuel meltdown.

Table 1. Fission product inventory.

Isotope	0 days decay	365 days decay	Isotope	0 days decay	365 days decay
H 3	4.169E+00	3.942E+00	C 14	1.074E-06	1.074E-06
KR 85	1.178E+02	1.106E+02	RB 86	1.311E+02	1.692E-04
RB 87	2.591E-07	2.592E-07	SR 89	5.240E+04	3.496E+02
SR 90	9.226E+02	9.009E+02	Y 90	1.184E+03	9.012E+02
Y 91	6.213E+04	8.290E+02	ZR 93	1.962E-02	1.967E-02
NB 93M	2.829E-04	1.197E-03	NB 94	1.969E-07	1.969E-07
ZR 95	6.687E+04	1.282E+03	NB 95	5.916E+04	2.880E+03
NB 95M	4.671E+02	9.513E+00	TC 99	1.162E-01	1.188E-01
RU103	3.542E+04	5.651E+01	RH103M	3.193E+04	5.095E+01
RU106	1.654E+03	8.319E+02	RH106	5.475E+03	8.319E+02
PD107	1.415E-04	1.416E-04	AG110	8.888E+02	3.181E-02
CD113M	1.517E-01	1.448E-01	IN114	3.046E-02	4.042E-05
IN114M	6.995E-03	4.224E-05	CD115M	1.575E+01	5.413E-02
IN115M	1.920E+02	3.804E-06	SN119M	1.643E+00	5.851E-01
SN121M	8.452E-04	8.336E-04	SN123	4.545E+01	6.410E+00
TE123M	1.441E-01	1.741E-02	SB124	1.808E+01	2.704E-01
SB125	6.170E+01	4.945E+01	TE125M	9.143E+00	1.198E+01
SN126	3.442E-03	3.442E-03	SB126	2.518E+01	4.819E-04
SB126M	7.689E+00	3.442E-03	TE127	1.868E+03	1.886E+01
TE127M	1.865E+02	1.926E+01	TE129	7.753E+03	4.102E-01
TE129M	1.168E+03	6.302E-01	I129	1.926E-04	1.997E-04
XE129M	2.558E-01	4.715E-15	I131	3.325E+04	7.379E-10
XE131M	3.727E+02	6.766E-07	XE133	7.221E+04	1.012E-16
CS134	1.953E+03	1.396E+03	CS135	1.284E-03	1.308E-03
CS136	8.288E+02	3.405E-06	BA136M	1.366E+02	5.612E-07
CS137	9.598E+02	9.379E+02	BA137M	9.111E+02	8.873E+02
BA140	7.142E+04	1.831E-04	LA140	7.585E+04	2.107E-04
CE141	6.604E+04	2.771E+01	CE142	2.687E-07	2.688E-07
PR143	6.498E+04	5.770E-04	CE144	2.558E+04	1.050E+04
PR144	2.974E+04	1.051E+04	PR144M	3.074E+02	1.261E+02
ND147	2.486E+04	2.894E-06	PM147	1.021E+03	1.007E+03
PM148	6.952E+03	3.177E-02	PM148M	2.582E+02	5.640E-01
EU152	7.599E-03	7.221E-03	GD153	2.230E-01	7.838E-02
EU154	8.094E+01	7.468E+01	EU155	4.548E+01	3.956E+01
EU156	6.239E+03	3.629E-04	TB160	3.887E+00	1.175E-01
PA233	2.184E-03	4.154E-03	PA234M	2.948E-04	1.196E-05
PA234	2.723E-04	1.555E-08	U232	5.612E-06	4.381E-05
U233	2.893E-08	4.810E-08	U234	8.763E-05	1.484E-04
U235	2.407E-04	2.407E-04	U236	3.978E-03	3.978E-03
U237	8.204E+04	1.887E-04	U238	1.196E-05	1.196E-05
NP235	8.490E-05	4.482E-05	NP236	1.030E-07	1.030E-07
NP237	3.445E-03	4.154E-03	NP239	6.843E+03	9.850E-04

Table 1. (continued).

Isotope	0 days decay	365 days decay	Isotope	0 days decay	365 days decay
PU236	4.301E-03	3.526E-03	PU237	7.348E-03	2.862E-05
PU238	1.966E+01	2.137E+01	PU239	1.918E-02	2.103E-02
PU240	2.045E-02	2.046E-02	PU241	8.071E+00	7.691E+00
PU242	1.027E-04	1.027E-04	AM241	8.345E-04	1.345E-02
AM242M	5.730E-05	5.704E-05	AM242	5.611E+00	5.676E-05
AM243	9.714E-04	9.850E-04	CM242	6.871E-01	1.499E-01
CM243	2.863E-04	2.794E-04	CM244	1.067E-01	1.029E-01
CM245	7.813E-06	7.812E-06	CM246	1.627E-06	1.626E-06
TOTAL (Ci)				6.578E+06	3.466E+04
TOTAL (W)				8.298E+04	1.433E+02

Note: The isotopes that have an M following the number are metastable states of the isotopes.

3. IDENTIFICATION OF REQUIREMENTS

General design criteria for SNF storage facilities are specified in ANSI/ANS-57.7-1988,⁴ DOE Order 6430.1A,⁵ and 10 CFR 72, Subpart F.⁶ These design criteria establish the design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components (SSCs) important to safety.

3.1 Siting Evaluation Factors

3.1.1 General Considerations

Site characteristics that may directly affect the safety or environmental impact of the UFSF must be investigated and assessed. Proposed sites must be examined with respect to the frequency and the severity of external natural and human-induced events that could affect the safe operation of the UFSF.

Pursuant to 10 CFR 51, Subpart A, the potential for radiological and other environmental impacts on the region must be evaluated for the proposed site with due consideration of the characteristics of the population, including its distribution, and of the regional environs, including their historical and aesthetic values.

The facility must be sited so as to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains.

3.1.2 Siting Limitations

An UFSF owned and operated by DOE must not be located at a site where there is a candidate location for a high-level waste (HLW) repository.

3.1.3 Potential Effects on the Region

The proposed site must be evaluated with respect to the effects on population in the region resulting from the release of radioactive materials under normal and accident conditions during operation and decommissioning of the UFSF. Each site must be evaluated with respect to the effects on the regional environment resulting from construction, operation, and decommissioning of the UFSF.

3.1.4 Geological and Seismological Characteristics

Seismicity will be evaluated by the techniques of 10 CFR 100, Appendix A. Sites that lie within the range of strong near-field ground motion from historical earthquakes on large capable faults should be avoided.

Sites other than bedrock sites must be evaluated for their liquefaction potential or other soil instabilities due to vibratory ground motion.

Site-specific investigations and laboratory analyses must show that soil conditions are adequate for the proposed foundation loading.

3.1.5 Criteria for Radioactive Materials in Effluents and Direct Radiation from an UFSF

During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of planned discharges of radioactive materials to the general environment, direct radiation from the UFSF, and any other radiation from uranium fuel cycle operations within the region.

Operational restrictions must be established to meet as low as reasonably achievable (ALARA) objectives for radioactive materials in effluents and direct radiation levels associated with UFSF operations.

3.1.6 Controlled Area

A controlled area must be established for the UFSF. Any individual located on or beyond the nearest boundary of the controlled area shall not receive a dose greater than 5 rem to the whole body or any organ from any design basis accident. The minimum distance from the spent fuel handling and storage facility to the nearest boundary of the controlled area shall be at least 100 m (328 ft).

The controlled area may be traversed by a highway, railroad, or waterway, as long as appropriate arrangements are made to control traffic and to protect public health and safety.

3.1.7 Spent Fuel Transportation

The proposed UFSF must be evaluated with respect to the potential impact on the environment of transporting the spent fuel within the region.

3.2 General Design Criteria

3.2.1 Quality Standards

SSCs important to safety must be designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety of the function to be performed.

3.2.2 Protection Against Natural Phenomena

SSCs important to safety must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, hurricanes, floods, tsunamis, and seiches, without impairing their safety features.

3.2.3 Protection Against Fires and Explosions

SSCs important to safety must be designed and located so that they can continue their safety functions under credible fire and explosion exposure conditions. Explosion and fire detection, alarm, and suppression systems shall be designed and provided with sufficient capacity and capability to minimize adverse effects of fires and explosions on SSCs critical to safety. The design of the UFSF must include provisions to protect against adverse effects that might result from either operation or failure of the fire suppression system.

3.2.4 Sharing of Structures, Systems, and Components

SSCs important to safety must not be shared between an UFSF and other facilities, unless it is shown that such sharing will not impair the capability of either facility to perform its safety functions, including the ability to return to a safe condition in the event of an accident.

3.2.5 Proximity of Sites

An UFSF located near other nuclear facilities must be designed and operated to ensure that the cumulative effects of their combined operations will not constitute an unreasonable risk to the health and safety of the public.

3.2.6 Testing and Maintenance of Systems and Components

Systems and components important to safety must be designed to permit inspection, maintenance, and testing.

3.2.7 Emergency Capability

SSCs important to safety must be designed for emergencies. Designs must provide for accessibility to the equipment of onsite and available offsite (if used) emergency facilities and services such as hospitals, fire and police departments, and other emergency agencies.

3.2.8 Confinement Barriers and Systems

The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures, or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

For underwater storage in which the pool water serves as a shield and a confinement medium for radioactive materials, systems for maintaining water purity and the pool water level must be designed so that any abnormal operations or failure in those systems from any cause will not cause the water level to fall below safe limits. Pool water level equipment must be provided to alarm in a continuously staffed location if the water level in the storage pool falls below a predetermined level.

Ventilation and off-gas systems must be provided where necessary to ensure the confinement of airborne radioactive particulate materials during normal or off-normal conditions.

Storage confinement systems must have the capability for continuous monitoring to determine when corrective action needs to be taken to maintain safe storage conditions.

3.2.9 Instrumentation and Control Systems

Instrumentation and control systems must be provided to monitor systems that are important to safety over anticipated ranges for normal operation and off-normal operation. Instruments and control systems that must remain operational under accident conditions must be identified in the Safety Analysis Report.

3.2.10 Control Room or Control Area

A control room or control area, if appropriate for the UFSF design, must be designed to permit occupancy and actions to be taken to monitor the UFSF safely under normal conditions and to provide safe control of the UFSF under off-normal or accident conditions.

3.2.11 Utility or Other Services

Each utility service system must be designed to meet emergency conditions. The design of utility services and distribution systems important to safety must include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform safety functions assuming a single failure.

Emergency utility services must be designed to permit (a) testing of the functional operability and capacity, including the full operational sequence, of each system for transfer between normal and emergency supply sources, and (b) the operation of associated safety systems.

Provisions must be made so that, in the event of a loss of the primary electric power source or circuit, reliable and timely emergency power will be provided to instruments, utility service systems, the central security alarm station, and operating systems, to allow safe storage conditions to be maintained and to permit continued functioning of all systems essential for safe storage.

3.3 Criteria for Nuclear Criticality Safety

3.3.1 Design for Criticality Safety

Spent fuel handling, transfer, and storage systems must be designed to be maintained subcritical and to ensure that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety.

3.3.2 Methods of Criticality Control

When practical, the design of the UFSF must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons), or both. Where solid neutron absorbing materials are used, the design shall provide for positive means to verify their continued efficacy.

3.3.3 Criticality Monitoring

A criticality monitoring system shall be maintained in each area where special nuclear material is handled, used, or stored. The system will energize clearly audible alarm signals if accidental criticality occurs. Underwater monitoring is not required when special nuclear material is handled or stored beneath water shielding.

3.4 Criteria for Radiological Protection

3.4.1 Exposure Control

Radiation protection systems must be provided for all areas and operations where onsite personnel may be exposed to radiation or airborne radioactive materials. SSCs for which operation, maintenance, and required inspections may involve occupational exposure must be designed, fabricated, located, shielded, controlled, and tested so as to control external and internal radiation exposures to personnel.

3.4.2 Radiological Alarm Systems

Radiological alarm systems must be provided in accessible work areas as appropriate to warn operating personnel of radiation and airborne radioactive material concentrations above a given setpoint and of concentrations of radioactive material in effluents above control limits. Radiation alarm systems must be designed with provisions for calibrating and testing their operability.

3.4.3 Effluent and Direct Radiation Monitoring

As appropriate for the handling and storage system, effluent systems must be provided. Means for measuring the amount of radionuclides in effluents during normal operations and under accident conditions must be provided for these systems. A means of measuring the flow of the diluting medium, either air or water, must also be provided.

Areas containing radioactive materials must be provided with systems for measuring the direct radiation level in and around these areas.

3.4.4 Effluent Control

The UFSF must be designed to provide means to limit to levels ALARA the release of radioactive materials in effluents during normal operations and to control the release of radioactive materials under accident conditions. Analyses must be made to show that releases to the general environment during normal operations and anticipated occurrences will be within the exposure limit

given in Section 3.1.6. Systems designed to monitor the release of radioactive materials must have means for calibrating and testing their operability.

3.5 Criteria for Spent Fuel Storage and Handling

3.5.1 Spent Fuel Storage and Handling Systems

Spent fuel storage and other systems that might contain or handle radioactive materials associated with spent fuel must be designed to ensure adequate safety under normal and accident conditions. These systems must be designed with:

- (1) A capability to test and monitor components important to safety
- (2) Suitable shielding for radioactive protection under normal and accident conditions
- (3) Confinement structures and systems
- (4) A heat-removal capability having testability and reliability consistent with its importance to safety
- (5) Means to minimize the quantity of radioactive wastes generated.

3.5.2 Waste Treatment

Radioactive waste treatment facilities must be provided. Provisions must be made for the packing of site-generated low-level wastes in a form suitable for storage onsite and transfer to disposal sites.

3.6 Criteria for Decommissioning

3.6.1 Decommissioning

The UFSF must be designed for decommissioning. Provisions must be made to facilitate decontamination of structures and equipment, minimize the quantity of radioactive wastes and contaminated equipment, and facilitate the removal of radioactive wastes and contaminated materials at the time the UFSF is permanently decommissioned.

3.7 Quality Assurance

Quality assurance requirements are specified in 10 CFR 72, Subpart G,⁶ for the UFSF. These requirements apply to the design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, modification of SSCs, and decommissioning that are important to safety. As used in that subpart, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality assurance includes quality

control, which comprises those quality assurance actions related to control of the physical characteristics and quality of the material or component to predetermined requirements.

The contractor of the UFSF shall have in place an approved quality assurance program that satisfies the applicable criteria of 10 CFR 50, Appendix B.⁷ A quality assurance program based on NQA-1⁸ also meets the U.S. Nuclear Regulatory Commission (NRC) requirements of 10 CFR 50, Appendix B.

4. FACILITY DESCRIPTION

This document describes three facility options: (1) Centralized-UFSF (C-UFSF), which will store the entire fuel element quantity of 22,000 in a single facility at a single location, (2) Regionalized Large-UFSF (RL-UFSF), which will store 75% of the fuel element quantity in some region of the country, and (3) Regionalized Small-UFSF (RS-UFSF), which will store 25% of the fuel element quantity with the possibility of a number of these facilities in various regions throughout the country. For design purposes, the C-UFSF is used as a baseline and most, if not all, functions are the same in the regionalized facilities with the exception of downsizing.

The UFSF provides the capability for receiving, preparing for storage, and storing various aluminum-clad fuels. Fuel is handled and stored in the FSA. The FSA receives fuel shipping casks by truck or railcar (depending on site location), unloads the fuel, prepares it for storage, transfers the fuel to storage, and stores the fuel. Most fuel will be received as bare individual fuel elements. Some fuel may need to be canned in the cutting/canning pool to ensure safety and operational cleanliness of the facility. This pool will hold canning devices that support placing fuel into storage canisters that can be sealed to contain the leaking radionuclides. The pool would also be available for packaging fuel for shipment out of the facility to final disposition or characterization facilities. Figure 1 shows the C-UFSF layout, and Figures 2 and 3 show the layouts for the RL-UFSF and RS-UFSF, respectively.

The UFSF consists of two main parts: (a) the working area known as the FSA and (b) the support areas. The FSA contains four main functional areas: (1) cask vehicle receiving area (CVRA), (2) cask receiving and decontamination area (i.e., "decon" rooms), (3) fuel handling and transfer area, and (4) fuel storage pool (FSP) area. FSA layouts are shown for the C-UFSF and RS-UFSF in Figures 4 and 5, respectively. The RL-UFSF is the same as the C-UFSF with the exception of pool length, the FSPs are 13 ft shorter for the RL-UFSF. The support areas consist of the operations room, storage room for contaminated equipment, heating and ventilation (H&V) area, water treatment area, radioactive waste management and disposal area, chemical makeup area, utility room, and office support areas.

The C-UFSF and RL-UFSF FSA includes two bays to receive trucks or railcars loaded with fuel shipping casks, while the RS-UFSF has only one receiving bay. The cask vehicles enter the CVRA, and all doors are closed and mechanically locked. The cask vehicle is then monitored and cleaned as necessary to remove road dust. After the cask vehicle has been cleaned, the fuel shipping cask is removed from the vehicle and placed in a decontamination room. The cask vehicle can be driven out the other side of the CVRA, and doors can once again be closed and locked, or it can wait to be moved out after the empty cask is placed back on it. Once the cask is in the decontamination room, it can be vented, sampled, filled with water and prepared for fuel unloading. The cask is then placed in a fuel unloading pool (FUP). Fuel is removed from the cask, canned if needed, installed in a fuel storage bucket (FSB), and transferred to the appropriate storage rack location. Access to the storage pools from the unloading pool is provided via the transfer channel. See Figure 6 for the fuel handling logic flow diagram. The cask and fuel (if needed) are removed from the FSA by reversing the sequence followed in bringing them into the FSPs.

Figure 1. C-UFSF plan view.

Figure 3. RS-UFSF plan view.

Figure 4. C-UFSF FSA plan view.

Figure 5. RS-UFSF FSA plan view.

Figure 6. Fuel handling logic flow diagram.

In addition to the fuel handling and storage capabilities, the FSA has water makeup and management areas for maintaining adequate high-quality water for the pools and transfer channel. An isolation pool is used for leak checking and isolation of suspected leaking FSBs. A staging area is provided between the cask vehicle receiving area and the unloading pools for handling and decontaminating the casks in a radiologically controlled manner.

All UFSF liquid and solid effluents will be transferred to appropriate waste management systems that are part of the overall DOE site infrastructure. Airborne effluents will be processed by the building ventilation and filtration system, then discharged to the environment via the exhaust air system. See Figure 7 for an UFSF block flow diagram.

The facility, whether centralized or regionalized, is equipped with two large capacity cranes for cask, fuel, and equipment handling operations in the FSA. Figure 8 shows the elevation view for the C-UFSF FSA. The cask handling crane has a 118-t (130-ton) capacity and travels from the CVRA to the FUPs.

Crane operations that require the use of the 118-t (130-ton) crane include removing the cask from the transport vehicle, relocating the cask to a decon room or pad area, and placing the cask into a FUP.

The other crane is a 9-t (10-ton) fuel handling crane that can travel the full length of the FSA. The crane is used to transfer fuel from pool to pool and relocate storage racks and pool gates. It has a guard-rail protected operator platform spanning 10.97 m (36 ft), which allows operators to be directly over the pool area being worked.

The facility also has a pool water leakage detection and collection system. The system is designed in accordance with NRC Regulatory Guide 1.13⁹ and ANSI Standard N305-1975.¹⁰ Sumps are provided for each pool and transfer channel. Each sump is a 20.3 cm (8 in.) diameter pipe extending from the top of the pool downward to 61 cm (24 in.) below the pool floor. A signal from each sump is read out in the control room to indicate the presence of a leak for a specific sump or area of the basin being monitored. A level alarm, which can be set over a range of levels, is provided in each sump and alarms in the control room when activated.

The UFSF building provides containment for the FSA and associated systems. The building prevents inadvertent releases of activity to the environment and provides a means of controlling the atmosphere over the pools, thereby protecting them from the elements.

4.1 Cask Vehicle Receiving Area

The CVRA allows trucks and railcars to enter from one side of the building, off-load the cask, and exit the other side of the building. Utilities are provided to remove road dirt from the casks and transport vehicles when in the CVRA. Washdown water is collected in floor sumps and transferred to the FSA service waste sump. This water is cleaned from sludge and dirt and sent to the pool basin recirculation water system. The CVRA creates an airlock for the facility with inner and outer rollup doors and outer personnel doors closed. When fuel or cask operations are in process, these doors will be locked shut. Cask vehicles move in and out of the CVRA when no fuel operations are in process and the area is clean.

Figure 7. UFSF block flow diagram.

Figure 8. C-UFSF FSA elevation view.

The C-UFSF and RL-UFSF CVRA is sized to accommodate two truck-trailer or railcar combinations side by side. Each bay is 4.9 m (16 ft) wide by 24.4 m (80 ft) long. The floor of the area is designed to support the combined weight of two 177-t (195-ton) shipments and to support casks weighing up to 114 t (126 tons). The RS-UFSF CVRA bay is sized to accommodate a single truck-trailer or railcar with the same dimensions and load carrying capacity as stated for the C-UFSF and RL-UFSF. The CVRA also houses a radiation control technician (RCT) field office with accompanying surveying equipment and a maintenance equipment storage room.

4.2 Cask Receiving and Decontamination Area

The cask receiving and decontamination area is where incoming and outgoing casks are surveyed, decontaminated, prepared for the FUP, or prepared for return shipment. It is a personnel-occupied area where direct contact operations are performed. The area is located between the fuel handling area and the CVRA.

A staging area is provided and equipped with tool cabinets, various crane hooks, rigging devices, and load bars. Specific crane rigging equipment can pivot horizontally shipped casks to the vertical unloading position and back again. This area has a stainless steel floor and is maintained as a contamination control area. Controlled areas are bounded by a double-railed guardrail or roped off and posted accordingly.

Two cask decontamination rooms are provided that are equipped with water, steam, and chemical sprayers for high- and low-pressure decontamination. These rooms are separated from the cask unloading area by sealed doors and walls and by directed ventilation air flow to confine chemical fumes and contamination. Liquid waste from decontamination operations is routed to the low-level radioactive waste system for eventual routing to the pool recirculation system or an outside facility. The walls and floor of the decontamination areas are covered with stainless steel to facilitate decontamination. The casks are vented (coolant is drained and sampled) and prepared for fuel unloading. Demineralized water is supplied to flush and backfill casks.

This area also provides access to the canning and equipment storage room. This room stores new fuel cans, accessories, and clean canning equipment for fuel that needs to be canned. This room has outside access for equipment delivery and staging as needed.

4.3 Fuel Handling and Transfer Area

The fuel handling and transfer area for the C-UFSF and RL-UFSF contains two FUPs, an isolation pool, a cutting/canning pool, and a transfer channel. The fuel handling and transfer area for the RS-UFSF contains only one FUP along with an isolation pool, a cutting/canning pool, and a transfer channel. The 118-t (130-ton) crane is used to move casks in this area. The 9-t (10-ton) crane and extended-reach tools are used to remove fuel from cask cavities and to transfer fuel from pool to pool.

In general, fuel will arrive at the FSA as bare fuel elements. Those fuels will be inspected and placed one at a time into an appropriate FSB held within a loading fixture. Figures 9 and 10 illustrate the two-compartment and four-compartment FSBs, respectively. The fuel units would

Figure 9. Two-compartment fuel storage bucket (FSB-2).

Figure 10. Four-compartment fuel storage bucket (FSB-4).

be placed into an end-to-end configuration or other geometrically safe configuration. The loading fixture would be provided with a protective cage so that if fuel was already in the basket and another fuel unit was brought next to it or dropped by it, the criticality distance of an 8-in. separation would be maintained even if the fuel were in a parallel configuration. See Figure 11 for the FSB loading fixture.

4.3.1 Fuel Unloading Pools

C-UFSF and RL-UFSF FUP #1 is 11.0 m (36 ft) deep, 6.1 m (20 ft) wide, and 6.1 m (20 ft) long, giving a floor area of 37.2 m² (400 ft²). FUP #2 is 13.4 m (44 ft) deep, 5.8 m (19 ft) wide, and 6.4 m (21 ft) long, giving a floor area of 37.1 m² (399 ft²). The RS-UFSF FUP is identical to previous stated FUP #1, 11.0 m (36 ft) deep, 6.1 m (20 ft) wide, and 6.1 m (20 ft) long, with said floor space. All the pools are constructed of concrete and lined with stainless steel plate.

Fuels are transferred individually from the cask, batched in a FSB, then moved to a rack position in the storage area. Fuel handling equipment can be operated from directly above the pools using the 9-t (10-ton) crane. Extended-reach tools are used to handle the various types of fuel and canisters. Design of fuel handling equipment facilitates retrieval of dropped fuel or other items within the unloading pools. The FUPs would be equipped with underwater cameras and lights to assist in reading fuel identification numbers and in examining fuel. Normal fuel handling equipment would be designed to prevent the fuel from being raised closer than 2.4 m (8 ft) from the water surface.

The FUPs would be designed to withstand the accidental drop of a cask from the highest attainable crane hook position. Only buoyancy and hydraulic drag forces would be assumed to act to reduce the cask velocity when falling through the pool water.

A cask washdown system (using sprays of deionized water) is provided near the unloading pools to wash the casks as they are lifted from the water or prior to immersion. The cask is then moved to the adjoining decontamination area for surface contamination surveying, decontaminated if necessary, and wiped dry.

4.3.2 Transfer Channel

A transfer channel with a water depth of 9.4 m (31 ft) joins all pools together allowing fuel transport to any pool while being continuously under water. The channel, which has concrete walls lined with stainless steel, would be designed to withstand the drop of FSBs, an empty fuel storage rack, or a pool gate. The transfer channel has gates to allow isolation of the unloading pool(s), fuel storage pool(s), leak check isolation pool, and fuel cutting/canning pool. The gates provide a water-tight seal to control contamination or to permit pumping the water out of any pool prior to maintenance.

Pool gates are 2.4 m (8 ft) wide by 6.4 m (21 ft) tall. The bottom of the pool gate opening is 6.1 m (20 ft) below the water level. Pool walls and gates extend 1 ft above the water level. Pool gates weigh more than storage rack weight limits (i.e., rack and fuel deformation could occur, thus changing fuel geometry). Consequently, the gateways are designed to prevent an inadvertently released gate from dropping onto the fuel storage racks in the storage pools or onto fuel in the other pools.

Note: Dimension AA = average fuel length

Figure 11. FSB holding fixture.

4.3.3 Isolation Pool

Fuel leak-checking takes place in the isolation pool. Fuels that are suspected of leaking either as a result of sampling the cask atmosphere, water activity levels in the cask unloading pools, or because of experience with similar fuel, may be transferred under water to the isolation pool by using the 9-t (10-ton) crane. Suspect fuel may then be tested in a test chamber. The chamber provides a leaktight seal and is supplied with deionized water and air for purging. Air from the chamber is vented to the FSA H&V system upstream of the final filters. A system for recirculating and sampling the water from the test chamber is provided.

Three types of sampling are possible: wet sipping, dry sipping, and partial vacuum sipping. During wet sipping the water is recirculated to a sampling and analyzing station that determines the activity of the sample. During dry sipping the test chamber is purged with deionized water and then blown dry with air. The chamber atmosphere is then allowed to stand for 30 minutes before sampling and analysis. The partial vacuum sipping process allows for partial draining of the test chamber and for placing a vacuum on the remaining atmosphere. After a given elapsed time, both portions (wet and dry) of the test chamber can be sampled and analyzed. If any of the samples are contaminated, the fuel may be moved to the cutting/canning pool and canned. If the sample is not contaminated, the fuel is transferred to the storage pool.

Inspection or leak-checking of fuel can be done periodically or as needed throughout the storage life of the fuel.

4.3.4 Cutting/Canning Pool

The fuel cutting/canning pool area consists of a pool and a control area that are isolated from each other. The control area is located in the operations room. The pool is located just outside the operations room and is 9.4 m (31 ft) deep and 5.8 m (19 ft) wide by 10.4 m (34 ft) long, giving a floor area of 60.0 m² (646 ft²). The pool can be isolated from the transfer channel. A cutting table is provided to remove fuel element end boxes to enable elements to be more efficiently stored in FSBs or canisters. A canister holding fixture is also provided with applicable tools and accessories for bolting or welding canister lids on and seal-checking the canister. Fuel can be dried once placed in a sealed canister if necessary. Underwater cameras and lights are provided for operations requiring a close-up view. The cutting/canning pool area allows for the confinement and removal of airborne contamination, which is treated by prefilters and high-efficiency particulate air (HEPA) filters prior to discharge into the FSA H&V system upstream of the facility exhaust air system.

4.4 Fuel Storage Pool Area

Water-filled FSPs are provided for storing the SNF in geometrically favorable storage racks. The C-UFSF and RL-UFSF storage pool area consists of two storage pools that contain fuel storage racks. Each FSP in the C-UFSF is 10.4 m (34 ft) wide by 16.5 m (54 ft) long, giving a floor area of 170.6 m² (1836 ft²). Each FSP in the RL-UFSF is 10.4 m (34 ft) wide by 12.5 m (41 ft) long, giving a floor area of 129.5 m² (1,394 ft²). The RS-UFSF single FSP is 8.2 m (27 ft) wide by 10.4 m (34 ft) long, giving a floor area of 85.3 m² (918 ft²). Each FSP has a nominal water depth of 9.4 m (31 ft), is lined with stainless steel, and equipped with a 2.4 m (8 ft) wide by 6.4 m (21 ft) tall gateway to permit isolation. The pools and transfer channel are designed to provide a normal

waterflow from the FUP(s), cutting/canning pool, and isolation pool, through the transfer channel to the back end of the FSP(s). This is required to allow operating with a directed-flow concept where pool water normally flows from the "cleanest" pools to successively more highly contaminated pools.

FSP storage racks are constructed from stainless steel. Each rack has a 5×5 array of 20.3 cm (8 in.) square storage holes for a total of 25 FSB hole locations per rack. See Figure 12 for the storage rack configuration. Geometric control requires at least 20.3 cm (8 in.) of space between holes. The racks are designed to allow at least a 25.4 cm (10 in.) space between the top of the fuel units and the top of the racks. The outer fuel storage positions and the edges of the racks have a 10.2 cm (4 in.) spacing. A steel grid is emplaced around the outside of the rack array to ensure that fuel cannot be placed directly alongside any of the storage positions.

Open-faced storage racks require a physical barrier to ensure 20.3 cm (8 in.) of space is provided between outer peripheral rack elements and any arbitrary element inadvertently placed by its side. Figure 13 shows a FSP partially loaded with racks, with the exception being the two racks closest to the gateway. These are shown removed with rack-face-barriers installed. It should be noted that the FSP can be filled to capacity with racks because the bottom of the gate is above the height of the racks; therefore, there would be no exposed sides to a rack located at the gateway corner of the FSP.

Each C-UFSF FSP can accommodate 40 storage racks. With all 40 storage racks in place, the pool has a capacity of 1,000 FSB storage holes. Each storage hole is able to hold three FSBs stacked vertically. See Figure 14 for FSB stacking in a storage rack. With FSBs stacked three high, the pool has the capacity of storing 3,000 FSBs. If each FSB is the four-compartment type (FSB-4), each pool would have a capacity of 12,000 fuel element storage compartments. Both C-UFSF FSPs combined offer a capacity of 24,000 fuel element storage compartments.

Some fuel elements are diametrically larger than is physically able to fit into the FSB-4 and therefore will be put into FSB-2s. Approximately 10% of the required 22,000 fuel elements to be stored can be stored in FSB-2s. This reduces the overall compartment quantity, but it is felt that the 22,000 fuel element requirement for storage would still be met because the TRIGA fuel and some aluminum elements are significantly smaller than the design basis fuel elements.

Each RL-UFSF FSP can accommodate 30 storage racks. With all 30 racks in place, the pool has a capacity of 750 FSB storage holes. With each FSB hole holding three FSBs, the pool has a capacity to store 2,250 FSBs. Using only FSB-4s, the pool capacity for fuel element storage compartments is 9,000. Both FSPs combined offer a maximum of 18,000 fuel element storage compartments. Elements too large to fit in FSB-4s will need to be taken into account and placed in FSB-2s. The ratio of FSB-2s to FSB-4s will have to be coordinated with other regional UFSFs in order to meet the 22,000 fuel element storage requirement.

Figure 12. Storage rack.

Figure 13. FSP with racks installed with physical barriers in front.

Figure 14. Stacked FSBs in storage rack.

The RS-UFSF single FSP can accommodate 20 storage racks. With all 20 racks in place, the pool has a capacity of 500 FSB storage holes. With each FSB hole holding three FSBs, the pool has a capacity to store 1,500 FSBs. Using only FSB-4s, the pool maximum capacity for fuel element storage compartments is 6,000. Again, those elements too large to fit in FSB-4s will need to be taken into account and placed in FSB-2s, thus reducing the amount of fuel element storage compartments. The ratio of FSB-2s to FSB-4s will have to be coordinated with other UFSFs in order to meet the 22,000 fuel element storage requirement.

Water is withdrawn from the surface of the pools across skimming plates to enhance the removal of surface scum. A mobile high-pressure water spray system is provided for stripping waterline scum from the pool walls. A vacuum cleaning system is also provided for removing sludge or other solids from the pools.

The 9-t (10-ton) crane is used for fuel handling operations within the storage pool area and for removing fuel storage racks from the pools for periodic inspection or replacement.

All equipment in the FSP is designed for direct contact maintenance if there is a need. Fuel storage racks can be removed from the pools for inspection and repair. Individual pools are designed to allow isolating a pool and pumping the water to the service waste system whenever repair of the pool liners or structure is necessary. Piping and valving arrangements provide for selectively withdrawing or returning water to any individual pool or combination of pools.

4.5 Operations Room

The operations room is part of the support area in the UFSF and is sized accordingly. It is located between the FSA personnel main access and the UFSF personnel main entrance. Directly across from the operations room is the RCT office.

The operations room is the control center for the FSA. It has two large radiation protected windows so the FSA can be seen at any time while in the operations room. Two computers are used for all recordable data, i.e., fuel shipping/receiving records, fuel element storage rack location, records on chemicals used by the facility, chemical and resin expiration data, and records of all effluents created by the UFSF. Applicable backups are made and stored separately.

An operations console consisting of indicators on all critical processes and operations associated with the UFSF is conveniently located in the center of the room. All doors to the FSA, including the vehicle roll-up doors are monitored to show when they are open, closed, and locked closed. Cranes are monitored to show which crane is in use. Each pool and the transfer channel are monitored for radiation levels and water leakage. The water recirculation systems are monitored for flow, pressure, and temperature. FSA H&V systems are monitored for air flow, temperature, and applicable exhaust side radiation levels. Utility lines, such as incoming water, plant air, breathing air, electricity, etc. are also monitored. Radiation detection equipment report locally, to the operations room, and to a central facilities emergency control area.

Television monitors are housed inside the operations room and are used with the remote underwater television cameras and lights. With the use of the cameras, monitors, windows, communications system and supporting equipment, fuel operations can be viewed and monitored from

the operations room. Also included in the control room are the cutting, canning, and leak-check operations controls. These operations can be witnessed in the operations room. All alarms, the voice paging system, operations radio transmission, etc. are centered in the operations room.

4.6 Contaminated Equipment Storage Room

Many extended-reach hand tools are used to perform FSA functions. These tools are used primarily in the water and are generally 6.1 to 9.1 m (20 to 30 ft) long. The contaminated equipment storage room houses these tools and any other potentially contaminated equipment, i.e., underwater cameras and lights. This room is located directly across the FSA from the operations room between the basin cleaning and radioactive liquid management areas. The room vents into the FSA H&V system and is contained within the controlled area boundary. Hangers, shelves, and racks are provided to allow tools to be placed in a safe and out-of-the-way condition.

4.7 Heating and Ventilation System

Facility H&V is divided into two systems: (1) the supply air system, and (2) the exhaust air system. All H&V systems are located on the first floor mezzanines. Together, these two systems control the environment inside the UFSF. When the systems operate, a negative pressure results in the FSA. This ensures that all radioactive air particulates are contained. Brief descriptions of the two systems follow.

4.7.1 Supply Air System

This system is rather simple in delivering the outside environment air to certain areas within the facility. The supply air mechanical equipment room is located above the utility room. It houses the entire FSA supply air prefilters, air heating coils, air washers, air conditioner, blowers, and office/support area HVAC system. The office/support area HVAC system is independent from the rest of the facility and does not require exhausting air to be filtered as in the FSA. Supply air for the FSA enters the facility by passing through the prefilters, heating coils, and air washers to the blowers. The blowers continue to move the air through the air ducts to various parts of the facility. The heating coils are used when facility inside temperatures drop below a given comfort zone temperature. The air washers and air conditioners are used when facility inside temperatures exceed a given comfort zone temperature. Specific settings for these systems will depend on the facility location. Various controls, i.e., thermostats, dampers, etc., are included to maintain adequate air flow and temperature.

4.7.2 Exhaust Air System

Potentially radioactive and radioactive exhaust air systems are far more complicated because of the need to filter and monitor the air before it is released back to the outside environment. The exhaust air mechanical equipment room is located above the basin water cleanup room. It houses the final prefilters and HEPA filters, exhaust air radiation monitors, heat recovery coils, and exhaust blowers. Subsystems that make up the exhaust air system include: (1) FSA Main, (2) Decontamination Rooms Off-Gas, (3) Cutting/Canning and Leak-Check Pools Off-Gas, and (4) Equipment Rooms. A brief description follows.

4.7.2.1 FSA Main. The main exhaust system ducting comes from the FSA. Other subsystems add into this one. The exhaust vents are located in the wall just above the floor, which causes slight air flow over the top of the pools before leaving the FSA. Smaller vents are located near the FSA ceiling and can be controlled with dampers to maintain air circulation throughout the FSA. Supply air enters near the ceiling.

Air, including any airborne radioactive material, is transferred by direct airflow to the exhaust air equipment room where it passes through a prefilter and HEPA filter in series for removal of any particulate radionuclides. The air is monitored and proceeds through the heat recovery coils, exhaust blowers, and is discharged to the atmosphere. If the monitor detects "contaminated" air, alarms are activated to alert operators of the needed action. Redundant filters are installed parallel to allow for filter changeout.

4.7.2.2 Decontamination Rooms Off-Gas. The two decontamination rooms are equipped with a prefilter and small blowers. When casks are in the decontamination room being deconned, degassed, etc., this system is operated to pick up possible harmful gasses. This exhaust air is routed to the FSA main exhaust system where it is HEPA filtered and released to the atmosphere.

4.7.2.3 Cutting/Canning and Leak-Check Pools Off-Gas. This is a suspended mobile hood with a prefilter and small blower inside. When cutting, canning, or leak-checking cans, this mobile exhaust hood is placed just above the area of work to catch any off-gases that may escape. Radiation monitors are also present. This exhaust hood is routed directly into the FSA main exhaust system, filtered, and released to the atmosphere.

4.7.2.4 Equipment Rooms. Vents are provided throughout the equipment room and accompanying areas. They are strategically placed to enable adequate air circulation. The air is routed directly to the FSA main exhaust system, filtered, and released to the atmosphere.

4.8 Water Treatment System

The water treatment area consists of a shielded area and an unshielded area. These areas house the pool water recirculation and cleanup components. The water treatment system consists of recirculation pumps and piping, filters, deionizers, and a microorganism control system. The system contains redundant filters and deionizers equipped with mixed resin beds that clean up radionuclides leached or released from stored fuel. Microorganism control is provided by ultraviolet treatment.

The ion-exchange beds are designed to permit remote resin changeout. Two receiving vessels are provided to receive the resin from the resin exchange beds. The waste loadout system is designed with adequate shielding to minimize radiation exposure to operating personnel during packaging and shipping. Chillers are provided for cooling pool water that are capable of maintaining bulk water temperature at desired levels. Water is collected at the far ends of the fuel storage pools to create a water flow pattern starting with the cleaner FUP(s), isolation pool, etc. The water is then recirculated through the treatment process.

A deionizer provides deionized water for pool water makeup, deconning rooms, and cask washing area. Makeup capabilities are based on an evaporation rate of $0.0061 \text{ m}^3/\text{d}/\text{m}^2$ ($0.15 \text{ gpd}/\text{ft}^2$) of pool surface at 10°C (50°F). Primary pool water is routed to the FUP(s), cutting/canning pool, and isolation pool. Valving is in place after branching off the main header, to isolate water flow in any or all pools. Normal operation is when all valves are open and water flows from these pools, through the transfer channel into the fuel storage pools. Water from other areas of the facility are cleaned and reused in the pool recirculation system. Pool water is refreshed by evaporation and makeup water.

4.9 Radioactive Waste Management and Disposal

Liquids are preferably used and reused in the pool recirculation system until evaporated and continually refreshed by the water makeup system. Unusable liquid and solid wastes from the FSA are transferred to other waste handling systems and areas outside the UFSF. All systems that receive FSA effluent must meet applicable waste management standards.

FSA solid waste loadout consists of basin water solids waste loadout and spent resin loadout. The solid waste consists of waste accumulated from the storage pools and washdown areas, and is retrieved via the basin water recirculation filters. The deconning rooms drain into a sump tank, which is then pumped into the basin water waste system just before the filters. The solid waste is accumulated in the filter backwash hold tank, decanted, and put in a canister for drying and loadout.

The spent resin is composed of a mixed ion resin that becomes depleted normally after several years of service. The resin is used only for the basin water recirculation system. The spent resin is removed from one train and stored in an appropriate storage vessel. When necessary, the resin is removed from storage, treated as required (dewatered, etc.), and packaged for disposal at the solid waste disposal area/facility.

Gaseous effluent is handled by the exhaust air systems, which pass it through several stages of filtration, monitor it for radioactivity, and discharge it to the environment.

4.10 Chemical Makeup

The two deionizer trains, through which the pool recirculation water passes, consists of a mixed resin bed that gleans radionuclides from the water. Bypasses are provided around trains to allow changeout of resin. The deionizer trains require changeout approximately once every 5 to 8 years.

When this occurs, the resin is flushed from the bed with recirculating water and is transferred to the spent resin tank. The resin is stored until disposal operations are initiated.

4.11 Support Area

The UFSF support area consists of office space, restrooms, change rooms, shower facilities, training room, lunch room, janitorial storage rooms, and utility room.

The utility room is where outside utilities interface with the building, i.e., raw water, fire water, plant air, breathing air, sanitary waste, and electricity. The utility room consists of the water and air room, and the electrical substation room. Each utility is briefly described below.

4.11.1 Raw Water

Raw water is supplied to the UFSF from a well-water source. It must provide a water capacity for all water-based makeup systems, potable water for restrooms and drinking water, demineralized water for air washers, and the pool basin. The C-UFSF pool basin has a capacity of 5,048 m³ (1.33 million gal). The RL-UFSF pool basin has a capacity of 4,272 m³ (1.13 million gal). The RS-UFSF pool basin has a capacity of 2,098 m³ (0.55 million gal). The pool volume water would be a one-time fill with occasional draining and refilling for maintenance purposes, if necessary. Recirculation piping system water volumes were not included in this calculation.

Once entering the facility, the main header branches in various directions to serve the facility needs. Drinking water and potable water service the office support area, which includes restrooms, showers, etc. A large portion of the raw water goes to the demineralizer area, where the water is treated and supplied to other facility areas as demineralized water. This system also provides pool water makeup.

4.11.2 Fire Water

Fire water is independent from the raw water supply. It enters the facility at the utility room and is then dispersed throughout the entire UFSF. The fire water protection system is a wet-pipe sprinkler system.

4.11.3 Plant Air

Pressurized plant air is supplied from an outside facility but could be an independent system. Pressurized air is used in such operations as purging and drying the fuel when canned. Pressurized plant air line piping is marked accordingly so it won't be confused with other pipe lines. Its pressure is regulated, and all connections are quick-disconnect type. Plant air supplies air at a reduced pressure for instrument air throughout the facility.

4.11.4 Breathing Air

Breathing air is supplied from outside the facility but could also be an independent facility system. Breathing air is piped to various areas in the facility that might necessitate its use during a fuel storage operation or an emergency.

4.11.5 Sanitary Waste

Sanitary waste generated by the UFSF is collected by sanitary waste drains and routed to an outside sanitary waste handling facility.

4.11.6 Electricity

Electrical power enters the facility at the utility electrical substation room. This independent room interfaces with the standby power generator, which is located just outside the UFSF utility room, and with various panels that distribute power throughout the facility.

5. OPERATION THEORY

Fuel-based activities (e.g., fuel receiving, handling, and storage) include cask handling, cask unloading, fuel inspection, fuel canning, and fuel transfer. The fuel is irradiated and can pose a severe radiation hazard if inappropriately handled. The fuel contains significant quantities of fissile material, the principal fissile isotope being U^{235} , so inadvertent criticality is also a hazard. Casks provide shielding for radiation protection. Criticality safety of fuel in casks is provided by geometry of the fuel array and/or the inclusion of fixed nuclear poisons in the cask design. Fuel-based operations, conducted under water and external to the cask, are shielded by the pool water. Since water enhances the reactivity of fuel systems of this type, physical barriers and administrative controls will ensure criticality safety in underwater operations. A minimum of 2.4 m (8 ft) of water is to be above the fuel for proper shielding.

Fuel element leakage and underwater hardware inspections would be made periodically as required to ensure proper fuel storage. If a fuel element "package" is leaking, it can be transferred to the isolation pool to be leak-checked and inspected and then to the cutting/canning pool to be "overcanned." It would then be returned to its storage location.

5.1 Fuel Receipt, Handling, and Storage

Aluminum fuel would be shipped to the UFSF in shielded shipping casks. These casks are delivered to the CVRA on transport vehicles, e.g., flat-bed or low-boy trailers, or railway cars. The cask is disassembled from the shipping package configuration and removed from the transport vehicle. RCT surveys are completed at this time to ensure personnel radiological safety. Disassembly of the shipping package involves removal of impact limiters, if present, and release of the cask tiedowns.

When the external cask surfaces are cleaned, the cask is placed into a decontamination room. Cask lids and closures are prepared as needed to facilitate underwater removal. Generally, the cask atmosphere is vented by filling the cask cavity with water for those casks that are equipped with piping and venting features. The water displaces the cask atmosphere and the decontamination vent system directs the off-gas to the facility decontamination exhaust H&V system. When water is added, it acts as a coating on the internal cask surfaces and fuel surfaces, minimizing the potential spread of contamination (if any) from these surfaces to the pool water. Based on similar expectations, the external cask surfaces would be sprayed with water as the cask is being placed in or out of the pool water to prevent contamination spread to and from the water.

The cask would be placed in a FUP using the 118-t (130-ton) crane and the appropriate rigging, usually a cask yoke or load bar. The lid remains in place on the cask secured by a sufficient number of closure devices to ensure that it remains in place and fuel is not spilled from the cask. The sufficient number of closure devices would be established on a case-by-case basis, with consideration given to cask design, vulnerabilities, and identified consequences of various events. Once the cask is placed on the FUP floor the lid closure devices, usually bolts, are removed from the cask followed by removal of the lid. At this point, the fuel in the cask is accessible. The cask lid can be temporarily stored in the water or removed, washed down, and placed in a specified storage area.

The fuel handling operation consists of unloading the fuel from the cask cavity, assembling it in a FSB for storage, and transferring the fuel to the designated storage pool. The quantity of fuel out of storage, out of the cask, or out of packaging equipment is limited for criticality safety reasons and would be administratively controlled. These limits are based on individual fuel reactivity characteristics, i.e., k_{eff} and minimum critical number, which are determined in criticality safety evaluations.

A FSB-2 or FSB-4, depending on the particular fuel size being handled, is placed in a loading fixture. Fuel assemblies, pieces, or units are removed from the cask one at a time and placed in the bucket compartment. When the bucket loading operation is complete, the FSB is removed from the loading fixture and transferred to the appropriate storage pool rack.

During loading of the FSB, the individual fuel pieces can be handled by an operator with extended-reach tools or handled with the tool attached to one of the fuel handling cranes. Once loaded, the FSB is considerably heavier than the individual fuel assembly, and it is handled with the tool attached to the fuel handling cranes.

The FSB would be transferred to the designated storage pool with a previously selected storage position and placed in storage. End-to-end stacking of fuel-loaded buckets in the rack position is permitted, as long as the required water gap is maintained over the top of fuel in the rack position. This water gap provides separation between stored fuel and fuel placed on top of the rack during handling operations. The storage racks accommodate stacking FSBs three high. For those situations when only one or two FSBs are installed in a rack storage hole, or an unusually long element is stored, a dummy post made of aluminum plate would be installed to show that the rack position is occupied. The dummy post serves as a physical and visual indication that the position contains fuel.

5.2 Rack Handling Operations

Racks must be entirely empty of fuel before being handled. Storage racks are handled using one of the cranes. The rack is attached to the crane by lifting bails and slings.

To install a "clean" rack in the FSP, the rack will be moved from the deck area over the water to the far end of the FSP. Installation of racks should begin at the back of each FSP and continue forward toward the pool gateway.

During rack movements, the clearance between the bottom of the rack and the facility surface (deck area, isolation pool, transfer channel, pool gate openings, etc.) is kept as small as possible. This practice limits the potential energy of the load (rack and lifting bail or other rigging), thus minimizing the extent of any damage to the rack or the impacted facility surface in the event that the load is dropped.

Pool reracking is not necessary. Racks are designed for the life of the stored fuel, i.e., stainless steel lasts longer than aluminum in marine conditions. Ceramic insulator sleeves will be designed to be separately replaced if needed.

6. EQUIPMENT DESCRIPTION

6.1 Cranes

The FSA is equipped with two cranes. The larger of the two is a 118-t (130-ton) capacity crane used to move casks, including holding a cask for horizontal-to-vertical rotation and vice versa. This crane travels from the CVRA to the FUPs. The maximum lifting height from the floor to the hook is approximately 13.7 m (45 ft). Administrative controls direct crane operations in a way that always minimizes the distance between the bottom of the cask and the floor. With various rigging equipment attached to the hook, the maximum lifting height can be limited to prevent accidental high lifts.

The smaller crane has a 9-t (10-ton) capacity and is used to remove fuel from the cask cavities, transfer fuel from pool to pool, and relocate pool equipment, storage racks, and pool gates. It can travel the entire length of the FSA. Maximum hook height is 7.9 m (26 ft) from the floor. When used with specific extended-reach tools, the lifting height is limited so as to prevent inadvertently lifting fuel closer than within 2.4 m (8 ft) of the water surface. Attached to the rails of this crane is a rail-guarded operator platform 1.2 m (4 ft) wide and 11.0 m (36 ft) long designed to meet OSHA requirements. The platform can move side-to-side above the FSP(s), transfer channel, FUP(s), etc. It can be moved to the opposite side the decontamination rooms are on to allow the crane to be moved to the CVRA for maintenance. The platform moves independent of the hook. It allows operators to be directly over the work, yielding better accuracy in fuel movement and inspection.

Both cranes operate in a fail-safe mode, i.e., if power fails during a suspended load, the crane brake will hold the load.

6.2 Fuel Storage Buckets

Aluminum fuel is placed into fuel storage buckets for transfer to the designated storage pool rack for storage. The design of the buckets facilitates both storage of multiple fuel pieces in a single FSB (two compartments, four compartments) and storage of multiple buckets in an end-to-end configuration in a single rack position. The bucket storage mode greatly optimizes storage density of aluminum fuel and contributes to the necessary margin for criticality safety. There are two basic configurations of FSBs, the two-compartment bucket, FSB-2, and the four-compartment bucket, FSB-4. Plan and side views of the buckets are shown in Figures 9 and 10. Most aluminum fuel cross-section dimensions are compatible with FSB-4. However, there are some fuels whose cross-section dimensions are such that the fuel cannot be inserted into the compartment opening of the FSB-4 and are stored in the FSB-2.

The compartments are formed by plates that section the overall bucket opening. One of the bucket dividers in the FSB-4 and the single dividing plate in the FSB-2 extends above the length of the compartments and has a circular cutout to provide an attachment for handling. The overall length of the storage portion of the bucket varies to accommodate different fuel lengths. The extension of the divider plate adds several inches to the bucket length for handling. Some typical lengths are 76.2, 101.6, and 127.0 cm (30, 40, and 50 in.) for the compartments, with typical overall bucket lengths

being in the range of 86.4 to 142.2 cm (34 to 56 in.). The bucket walls, dividers, and bottom are constructed of 0.32 cm (0.125 in.) thick aluminum sheet. The buckets weigh approximately 8.2 kg (18 lb) each.

6.3 Fuel Bucket Loading Fixture

Fuel batching is the operation in which the individual fuel assemblies are placed in a FSB. The storage bucket loading fixture consists of an insert support stand (i.e., bucket loading station) with a criticality cage. The FSB loading fixture is shown in Figure 11. The support stand holds the fuel storage bucket upright and stable during the loading operation. The criticality cage provides 30.5 cm (12 in.) of separation between the bucket contained in the center support portion and the external surfaces of the station. This separation provides nuclear isolation between fuel in the bucket and fuel placed at the cage surface. This prevents interaction between the fuels in the side-by-side positioning; it is not intended to prevent interaction in the end-to-end orientation when fuel is positioned above fuel already in the stand. End-to-end interaction has been shown not to be a criticality concern by virtue of the generic infinite-length fuel reactivity calculations. The stand and cage assembly are covered with stainless steel sheet.

6.4 Fuel Storage Racks

When in place, the racks are free-standing and rest on the pool floor in contact with the pool liner. The racks are not attached to each other, to the pool floor, or to the pool walls. All racks have lids at the top of each position and are covered on all four sides to prevent insertion of fuel into the storage tube array.

The storage racks are designed to ensure criticality safety of the stored fuel arrays by separation, given compliance with applicable administrative controls on fuel storage. Principal design features for criticality safety are the edge-to-edge boundary spacings around the outside of the storage racks and lids at the top of the fuel positions. Dimensions given are nominal.

The storage racks are constructed of stainless steel with ceramic insulated sleeves and are provided for aluminum fuel storage. Ceramic insulation is needed to prevent galvanic corrosion between stainless steel and aluminum wet interfaces. Each of these storage racks consists of a 5×5 array of 25 fuel storage positions. The overall rack dimensions are 2.0 m (6 ft-8 in.) long by 2.0 m (6 ft-8 in.) wide by 3.2 m (10 ft-6 in.) high. The fuel storage positions are about 20.3 cm (8 in.) square by 3.1 m (10 ft-4 in.) high. The edge-to-edge spacing between adjacent positions is 20.3 cm (8 in.). Rack configuration is shown in Figure 12. Racks weigh approximately 635 kg (1,400 lb) each.

Where feasible, FSBs are stacked in an end-to-end configuration, with two or three buckets as the physical limit. Each fabricated rack is assigned a rack number, and each FSB hole is assigned an array number and letter. The letter designates the column, the digit after the letter designates the row, and the first two digits designate the rack number, e.g., 22B3 is rack number 22, column B, row 3.

6.5 Criticality Barriers for Storage Rack Arrays

The criticality safety evaluations (CSEs) considered the reactivity of an infinite array of storage positions, with the interstitial spacing (nominal 20.3 cm [8 in.] or more) consistent everywhere within the array. Boundary effects such as fuel against the side of the rack or between two racks were not enveloped by the evaluations.

There is a need to consider exposed rack faces. Exposed rack faces result when a portion of the pool is empty. These exposed rack faces must be covered with criticality barriers because they are considered boundary effects not enveloped by the scope of the CSEs. Criticality barriers must increase the separation between the peripheral storage positions and any fuel that may possibly come against the external surface of the barrier to at least that of the interstitial spacing considered on the CSEs. An example of these barriers is shown in Figure 13. An alternative approach is to not store fuel in the rack outer peripheral storage positions, but to insert dummy posts. This would be preferential.

7. UTILITY REQUIREMENTS

Utility systems include water, sewage, plant air, breathing air, ventilation, electrical, safety communications and alarms, and waste handling. Under this design, these systems or services must be provided outside the UFSF.

7.1 Water

Raw water must be supplied to the UFSF to meet demands of filling the pool basin, provide for basin makeup water due to evaporation, susceptible pool leakage makeup water, potable water, and fire water. The C-UFSF water capacities are 5,048 m³ (1.33 million gal) to fill the pool basin. This does not include recirculation piping volumes, 3.1 m³/d (820 gpd) of basin evaporation makeup water, 2.3 m³/h (10 gpm) for susceptible pool leakage to maintain adequate pool levels, 22.7 m³/h (100 gpm) of potable water, and 227.1 m³/h (1,000 gpm) for fire water. The RL-UFSF is the same as the C-UFSF, with exception of the basin volume which is 4,272 m³ (1.13 million gal) and the pool evaporation makeup water which is 2.6 m³/d (683 gpd). The RS-UFSF basin capacity is 2,098 m³ (0.55 million gal), pool evaporation makeup water is 1.3 m³/d (352 gpd), susceptible pool leakage is 2.3 m³/d (10 gpm), potable water is 17.0 m³/h (75 gpm), and fire water is 170.3 m³/h (750 gpm). Backup storage would be required and backup power to pump the water independent of the UFSF, or equivalent gravity-flow water from elevated storage tanks would be required.

7.2 Sewage

On the average, a 20.3 cm (8 in.) sewage line would be required to handle sanitary sewage: showers, lavatories, toilets, urinals, and drinking fountain wastewater. The UFSF design includes a sewage line leaving the facility. Sewage holding tanks, treatment facilities, etc. must be provided outside the UFSF.

7.3 Plant Air

Plant and instrument air must be supplied from a 689 kPa (100 psig) air distribution system. The system must provide air at a dewpoint of 5°C (41°F) to areas throughout the UFSF at 689 kPa (100 psig) and reduced pressure branch lines at 345 kPa (50 psig) and 138 kPa (20 psig). Air connection points would be spaced so that normally no more than 7.6 m (25 ft) of hose is required to use at any location. Average consumption of pressurized air to be used is estimated at 0.5 m³/min (15 scfm). This system may be supplemental or replaced with a nitrogen tank system, providing it is feasible and meets UFSF requirements.

7.4 Breathing Air

Breathing air for use in fresh air masks and "Bubble Suits" must be provided as an independent system with a backup system. Plant air can be used as backup, providing appropriate filtering and metering components are used. An average pressure of 586 kPa (85 psig) is required to deliver breathing air to the various stations throughout the UFSF. The system must be capable of supplying breathing air for eight breathing masks and two suits simultaneously.

7.5 Ventilation

Air taken from outside the UFSF will be used for ventilation. If air is relatively clean, it can be used directly. Otherwise, more extensive air cleaning equipment will be required.

Design criteria require that (a) ventilation flow from uncontaminated toward potentially contaminated and probably contaminated areas be ensured by pressure differentials and other features, (b) radioactivity releases be ALARA, and (c) heat be recovered from the exhaust air and basin water recirculation system.

Air usage for the UFSF is estimated to be 991 m³/min (35,000 cfm). The H&V system must be capable of sealing the facility air supply of atmospheric pressure drops to near the building pressure. The system must incorporate an automatic balancing system to avoid over-pressurizing the building.

Prefilters, HEPA filters, and radiation monitoring of the exhaust air system are required. Heat recovery systems are also required to remove heat from the exhaust air and the basin water. These systems have been accounted for in the current UFSF design; however, these services could be supplied outside the UFSF, providing they meet all applicable requirements.

7.6 Electrical

Commercial electrical power will be supplied from outside the UFSF. Included in this design is a backup power generator for use when there is an outside power loss. Estimated C-UFSF and RL-UFSF power consumption is projected to range from 1,000,000 to 1,500,000 kW·h/y depending on the facility location. RS-UFSF power consumption is projected to range from 500,000 to 800,000 kW·h/y. Typical 480/277 V power supply is required for the UFSF.

7.7 Safety Communications and Alarms

The UFSF communication lines and alarm systems must be compatible with outside facilities and services such as telephones, fire alarm signals, etc. These outside communication lines interface with the UFSF system to provide enhanced personnel safety response in case of an emergency. Backup power must be continuously available for these systems so they can be used at any time.

7.8 Waste Handling

Outside facilities for handling the UFSF wastes generated will be required. Figure 7 shows the facility inputs and outputs. The following are services not included in the current UFSF design:

- Mixed hazardous waste facility to handle mixed radioactive chemicals such as regenerating and decontaminating chemicals, etc.

- Contaminated solid waste facility to handle solid waste, such as expired hardware used in the fuel storage process, contaminated worker clothing, etc.
- Noncontaminated solid waste facility or landfill to handle uncontaminated waste items.
- An evaporator or percolator pond to handle liquid wastes.

8. COST ESTIMATE

Cost data were based on information from floor plans of the C-UFSF, RL-UFSF, and RS-UFSF, similar construction projects at the INEL, and waste management facilities cost information.¹¹ There are two cost estimates for each facility. The first, or baseline estimate, starts design in October of 1995 and begins construction in July of 1997. The second, or deferred estimate, which has a 2-year delayed shift, begins design in October of 1997 and construction in July of 1999. Construction is estimated to take 4 years. Title I and Title II design are estimated to take 18 months. The C-UFSF total baseline estimated cost for facility construction and design is \$141,000,000. The total deferred cost is \$150,000,000. The RL-UFSF total baseline estimated cost is \$134,000,000. The total deferred cost is \$142,000,000. The RS-UFSF total baseline estimated cost is \$98,000,000. The total deferred cost is \$105,000,000. Conceptual design activities and post construction activities have not been included in these estimates. It has been assumed that the facility will be constructed in a location where utilities, railway, water and sewage, hazardous and radioactive waste handling facilities are readily available and accessible and a perimeter security fence already exists. A detailed cost breakdown is provided in Appendix A.

9. IMPACT OF WORKER SAFETY, PUBLIC SAFETY, AND ENVIRONMENT

9.1 Occupational Exposure to Radiation

This section describes potential impacts on the environment from the UFSF during normal operations. The UFSF would be designed to limit measurable release amounts of radioactivity to the environment. Underwater storage for handling of fuel and the canning of a fuel known to be leaking preclude the release of measurable amounts of radioactivity during normal operations. Therefore, the FSA is not expected to release measurable amounts of radioactivity to the environment during normal operations.

The UFSF requirements for quantities of fuel element assemblies were established at 22,000.¹² The number of canned fuel elements that would need to be canned during the lifetime of the facility was assumed at 10% of the total 22,000 elements, leaving 19,800 uncanned fuel elements. Although the UFSF is not expected to release any measurable amounts of radioactivity, a means of determining the release of fission products from these uncanned fuel elements was needed. The Fluorinel Dissolution Process and Fuel Storage Facility (FAST) is a similar facility. The FAST has two areas consisting of a fluorine dissolution process area and a FSA. The analysis of the FAST is based upon 20,000 fuel handling units (FHUs) stored within the basins. A FHU consists of a spent fuel assembly, canned spent fuel, and consolidated fuel rack. Each FHU within the FSA of FAST contains a minimum of two fuel elements, which equates to a minimum of 40,000 fuel elements. Calculations for the FAST were performed to determine the onsite air emissions, based on the assumption that 10% of the fuel would have 1% (release amounts) of its cladding failure during a 1-year period.¹³ The estimated onsite release exposure for the FSA facility within the FAST was 6.5×10^{-8} rem/y.¹³ Although the analysis supporting FAST was based on uncanned fuel elements, the supporting documentation for the FAST facility was determined to be conservative and the information was utilized as the bases for the UFSF. The data from the FAST included the area involving dissolution processing, but only the operations data directly associated with the fuel storage area were included in the results.

The maximum number of radiological personnel involved at the facility would occur during the loading and unloading of fuel elements from casks and placing in the UFSF FSA for storage. The number of radiological workers for the facility is estimated at 21. The personnel would consist of five operators for unloading fuel and three operators for routine operations and maintenance support, five facility engineers, and a maintenance support crew of about eight to cover all shifts of operation.

The major portions of the UFSF radiological doses included normal maintenance operations, atmospheric releases from the UFSF, sampling operations, fuel handling/movement, and others. The normal maintenance operations would be performed only by trained operations personnel. Therefore, no support personnel would be involved in the normal operations of the facility and would be limited to administrative support not directly involved in the facility operations.

The potential impact on the environment included occupational exposure to radiation, airborne releases, and waste production resulting from normal operations of the UFSF.

9.1.1 Facility Personnel Internal Exposures

The major portions of the UFSF radiological doses included normal maintenance operations, atmospheric releases from the UFSF, sampling operations, fuel handling/movement, and others. The normal maintenance operations would be performed only by trained operations personnel. Therefore, no support personnel would be involved in the normal operations of the facility and would be limited to administrative support not directly involved in the facility operations.

9.1.2 Facility Personnel External Exposures

The normal maintenance operation exposure would include only the areas involved at the FSA of FAST:¹⁴ water treatment area exposures (2.2 rem/y), solid loadout area (0.22 rem/y), and water treatment exhaust filter changeout (3.4 rem/y) for total exposure of 5.82 rem/y. The sampling operation exposures were calculated for an annual dose from routine operations of 8.0 rem/y for the FAST. The fuel loading and unloading exposures were determined to be less than 0.125 mrem/h dose rates, thus allowing full-time occupancy in the pool areas during fuel handling. Assuming 2,080 hours per year within the facility during loading and unloading results in a total of 0.260 rem/y. The doses from other operations included resin transfers at 0.083 rem per resin transfer. Based on the FAST changeout of resins occurring once every 5-8 years and an UFSF lifespan of at least 40 years, there would be a maximum of eight resin changeouts for a total of 0.664 rem/y. The combined annual radiological exposure is therefore 14.71 rem/y.

9.2 Atmospheric Releases

Normal airborne releases from the UFSF would be limited to radioactive noble gases and some radioactive iodine which could be released from the stored fuel prior to canning. The airborne materials released to the building atmosphere during normal operations would be filtered by the building H&V system. Radioactive and nonradioactive effluent gases would then be routed through double banked HEPA filters prior to release to the environment through an exhaust air system. The HEPA filter would have a minimum efficiency of 99.97% for 0.3 micron diameter particles and would allow in-place dioctyl phthalate testing.

The UFSF would discharge all ventilated gas, except truck exhaust, to the facilities exhaust system. The truck exhaust would be discharged directly to the environment during cask off-loading operation in the truck receiving area. The exhaust air system effluent would be continuously monitored by gaseous and particulate monitoring systems. The exhaust air system particulate monitoring system would employ an isokinetic sampler to draw representative samples of the effluent through a fixed filter. Utilization of a scintillation detector would monitor the cesium-137. The scintillation detector would be calibrated to a single radionuclide, and based upon known ratios between radionuclides and other fission products the exhaust air system effluent would be determined. For other building areas that could be sources of airborne radioactive contamination, the HVAC system would be designed to maintain air flow from areas of low potential contamination into areas of higher potential contamination. These airborne effluents would be required to be below the radioactivity concentration guides listed in DOE Order 5480.1A for both onsite and offsite concentrations.

9.3 Waste Production

The waste production of the UFSF was considered identical to the waste production at the FSA within the FAST. Various materials considered part of the facility that would not be disposed of during normal annual operations of the facility were not included in the overall annual waste production. Additional materials identified in the Data Sheets included hazardous waste, carbon steel, stainless steel, and electrical power backup waste. The total hazardous waste inventory at the FAST facility is being maintained at 0 kg. Carbon steel is not expected to be used in the facility due to the corrosive characteristics in a water environment. Therefore, minimal carbon steel waste is expected to be generated during the life of the facility. Stainless steel will be utilized for the storage racks and the liner within each pool. It is not expected that the liners or racks will be replaced during the life of the facility. Therefore, minimal stainless steel waste is expected to be generated during the life of the facility. The expected backup power demands (fuel, i.e., diesel, gas generators) designed within the facility were assumed operational only during emergencies and maintenance activities. Because of the limited operation of the backup equipment, it is expected that fuel usage will be minimal during the life of the facility.

9.3.1 Gaseous Waste

The annual air emission for the FAST was designed to result in ground-level site boundary concentrations of less than $3 \times 10^{-3}\%$ of DOE Order 5480.1A limits for uncontrolled areas. The UFSF would also be designed to ensure the requirement was met by discharging gaseous wastes through the exhaust air system as described in Section 9.2. The FAST facility releases 0 kg of NO_x, SO_x and VOC. Therefore, no nonradiological emissions (NO_x, SO_x, and VOC) from the UFSF would be expected.

9.3.2 Liquid Waste

Liquid wastes would include both radioactive and nonradioactive waste from the UFSF. Liquid wastes would be produced from cask decontamination solutions, cask coolant liquids (possible), UFSF basin water, water treatment deionization system resin beds, and nonradioactive waste systems. Treatment systems would include intermediate-level and low-level radioactive wastes and nonradioactive wastes.

The liquid radioactive wastes would be routed to a holding tank for monitoring. The waste would then be transferred to a process equipment waste system to be concentrated and combined with other wastes until final disposition. Potential liquid chemical wastes would include cask decontamination solutions and chemical reagents as well as decontamination solutions utilized in the facility.

Nonradioactive wastes would include sewage and service wastewater routed through to service waste, chemical waste, and sanitary waste systems. The sewage would be transferred to a sewage treatment plant separate from the facility.

9.3.2.1 Low-Level Liquid Waste. Liquid waste generated at the facility would be minimal. Decontamination of the casks would occur over the pools causing the solution to become part of the pool water system. The amounts of liquids used during decontamination were considered negligible compared with the total volume in the pools. Water used for rinsing the resin beds would also be returned to the pool water system. In addition, the water within the treatment facility was assumed to be negligible compared with the pools. Leakage from the system would be designed to collect back into the system; therefore, the total liquid waste released to the environment is considered negligible. Pool water is refreshed as a result of evaporation and makeup water being added.

9.3.3 Solid Waste

Radioactive solid waste would include spent HEPA filters; spent ion-exchange resin; contaminated rags, paper, and trash; sludge from pool water cleanup; basin water filter solids; and contaminated tools and personnel protective equipment. The solid wastes generated would be packaged to ensure containment of radioactive material and transferred to a storage facility for ultimate disposition.

Nonradioactive solid waste would include nonradioactive rags, paper, trash, and personnel protective equipment. The nonradioactive solid waste material would be disposed of in accordance with sanitary landfill requirements.

9.3.3.1 Low-Level Solid Radioactive Waste. Resin changeout, based on FAST data of changing out every 5 to 8 years, equates to a volume of 6.1 m³ (216 ft³) for the C-UFSF, 5.2 m³ (183 ft³) for the RL-UFSF, and 2.5 m³ (90 ft³) for the RS-UFSF. Over a 40-year period, maximum anticipated resin waste is 48.8 m³ (1,728 ft³) for the C-UFSF, 41.6 m³ (1,464 ft³) for the RL-UFSF, and 20.3 m³ (720 ft³) for the RS-UFSF. Annual resin waste is approximately 1.22 m³ (43 ft³) for the C-UFSF, 1.0 m³ (36.6 ft³) for the RL-UFSF, and 0.5 m³ (18 ft³) for the RS-UFSF.

Based on FAST reracking¹⁵ for pool #1 and #5, the additional solid waste generated was estimated at 450 m³ (15,900 ft³) for protective clothing, polyvinylchloride liners and bags, etc. used during the process of transferring and reloading fuel into racks. The process at the UFSF would be similar. Therefore, the total solid radiological waste generated at the UFSF over a 40-year operation is conservatively 11 m³ (389 ft³) in 1 year. The combined total annual waste is approximately 12.2 m³ (432 ft³) for the C-UFSF, 12 m³ (425 ft³) for the RL-UFSF, and 11.5 m³ (407 ft³) for the RS-UFSF.

9.3.3.2 Solid Nonradioactive Waste. Based on FAST reracking¹⁵ for pool #1 and #5, the estimated transportation packaging of the new racks was 300 m³ (10,600 ft³); assuming the same cask transportation operations during unloading/loading of the fuel for UFSF, the total solid nonradioactive waste generated at the UFSF over a 40-year operation is conservatively 7.5 m³ (265 ft³) for the C-UFSF, 5.6 m³ (199 ft³) for the RL-UFSF based on 75% of C-UFSF storage capacity, and 1.9 m³ (66 ft³) for the RS-UFSF based on 25% of C-UFSF storage capacity.

9.4 Natural Phenomena Hazards

The UFSF must be designed to meet requirements set forth by the NRC and DOE design criteria. Fuel storage facilities are classified as safety class structures by DOE Order 6430.1A⁵ and thus must be designed to withstand design basis accidents (DBAs). These accident analyses include the effects of natural phenomena hazards, such as earthquakes, extreme winds or tornadoes, and floods. General design criteria for these hazards that apply to storage facilities are specified in Subpart F, "General Design Criteria," of 10 CFR 72⁶ and in DOE Order 6430.1A and the appropriate DOE standards. Because natural phenomena hazards are site-specific, DBA requirements differ for the five alternative sites chosen in the Preliminary Environmental Impact Statement.¹

The DBA for a particular SSC is based on performance goals established for a certain performance category (PC) of the SSC and the location of this particular SSC. The DOE General Design Criteria⁵ classifies any fuel storage facility as a safety class structure, and DOE Standard DOE-STD-1021-93¹⁶ places such a facility in the moderate hazard category or PC-3.

9.4.1 Earthquake Design and Evaluation Criteria

The magnitude of the Design Basis Earthquake to be considered for the design and analysis of the storage facility depends on the PC of the SSC. If site-specific data have been developed for a particular site, they are to be used in the design and evaluation of the SSCs as specified in DOE Standard DOE-STD-1020-94, Appendix A.¹⁷ If no site-specific data exist, the values listed in UCRL-53582¹⁸ are to be used.

SSCs in PC-3 are to be designed or analyzed for a seismic hazard accedence level of 5×10^{-4} or an earthquake return period of 2,000 years, since none of the five alternative sites are located near a tectonic plate boundary. A dynamic analysis is required by the seismic design and evaluation criteria; the recommended approach is to perform an elastic response spectrum dynamic analysis to evaluate elastic seismic demand on the SSCs.

9.4.2 Wind Design and Evaluation Criteria

In determining wind design criteria for PC-3 SSCs, the first step is to determine if tornadoes should be included in the criteria. This decision is logically made on the basis of geographical location using historical tornado occurrence records. Alternately, the straight wind/tornado hazard models for DOE sites published in UCRL-53526¹⁹ are used to establish site-specific wind criteria. If the annual accedence probability at the intersection of the straight wind and tornado hazard curves is greater than or equal to 2×10^{-5} , then tornado design criteria are to be specified. By these criteria, tornado wind speeds are determined at an accedence probability of 2×10^{-5} for PC-3 SSCs. If only straight wind criteria apply, the accedence probability is 1×10^{-3} for PC-3 SSCs.

In addition to the wind or tornado criteria, the effects of missile impact need to be considered in the design or the analysis. For SSCs subjected only to straight winds and for a SSC of PC-3 the missile criteria are a 2 x 4 timber plank of 6.8 kg (15 lb) impacting the SSC at a horizontal velocity of 94.7 m/s (100 mph), or are vertical velocity of 31.3 m/s (70 mph) at a maximum height of 45.7 m (150 ft) and a 7.6 cm (3 in.) diameter standard steel pipe section of 34 kg (75 lb) traveling at 22.4 m/s (50 mph) horizontally, or are 15.6 m/s (35 mph) vertically, striking the SSC at a maximum

height of 22.9 m (75 ft). DOE Standard DOE-STD-1020-94¹⁷ lists recommended straight wind missile barriers for PC-3 categories in Table 3-3 and recommended tornado missile barriers for tornadoes in Table 3-4.

9.4.3 Flood Design

The flood design criteria, which are applicable to new and existing construction, consider the design of SSCs for regional flood hazards (i.e., river flooding) and local precipitation that affects roof design and site drainage. The criteria establish the Design Basis Flood (e.g., hydrostatic loads, runoff due to local precipitation) that is specified for the design of the SSCs in DOE Order 6430.1A.⁵ The criteria are specified in terms of the flood hazard input, hazard-annual probability, design requirements, and emergency operation plan requirements. For PC-3 SSCs, the mean hazard annual probability is 1×10^{-4} .

The design basis flood events to be considered as part of the site-specific flood hazard assessment are listed in Table 4-2, "Design Basis Flood Events," of DOE Standard DOE-STD-1020-94.¹⁷

9.5 Systems Failure

9.5.1 Loss of Commercial Electrical Power

A backup diesel power generator system is included in the facility for long-term power loss. If power is lost during fuel storage operations or cask movement, the operations or movement would cease administratively as well. All powered equipment stop in a fail-safe mode. There would be no threat to the fuel because it is always under water or in a cask. If, however, the cask was suspended and being moved, the backup generator would be used to supply temporary power to the crane to complete the operation. A long period (weeks and possibly months) is required for heat generation by the fuel to increase the pool water temperature significantly. The backup diesel generator would be used primarily for generating power to run the water recirculation system and ventilation system to keep the FSA and pool water clean and cool when a power outage of significant length occurs.

9.5.2 Temporary Ventilation System Failure

FSA ventilation is needed when there is movement in the area. Any operation that may potentially cause radioactive particles to enter the FSA air stream would require the ventilation system to be operating. A power outage would necessitate running the ventilation system on the backup generator to control any potential radioactivity in the facility.

9.5.3 Mechanical Failure

Appropriate safety factors, redundancies, and assumptions have been made to account for possible mechanical failures. Such a failure might consist of a rigging equipment failure causing a cask being moved to fall to the floor. Floor areas under such operations are structurally sufficient to withstand such possible accidents. The facility safety analysis report would include more detail on all

facility operations and safety aspects pertaining to mechanical failures. Operational procedures would be written to minimize the impacts of any mechanical failure, e.g., not raising the cask more than 1 ft above the floor when transporting it with a crane.

10. ACCIDENTAL RELEASES

The purpose of this section is to categorize design events⁴ and to establish design requirements that satisfy the operational and safety criteria of the installation. These design events are:

- Normal operations (Design Event I)
- Abnormal conditions based on an expected frequency of occurrence (Design Events II and III)
- Postulated accidents whose occurrence may result in the maximum potential impact on the immediate environs (Design Event IV).

10.1 Design Events

10.1.1 Design Event I

Design Event I for normal operations consist of a set of events that are expected to occur regularly or frequently in the course of normal operations at the installation. These operations include releases during cask receipt, inspection, unloading/loading, maintenance, fuel transfers from cask to pool or vice versa, canning operations, and sample collection. The UFSF will be designed such that the releases during these normal operation events would not exceed the maximum allowable for the facility. Criteria for radioactive materials in effluents and direct radiation from an UFSF are given in 10 CFR 72.104 for normal operations and anticipated occurrences.

10.1.2 Design Event II

Design Event II for abnormal operations consists of that set of events that, although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during any calendar year of the operation of the UFSF. These operations may include the failure of any single active component to perform its intended function upon demand, spurious operation of certain active components, a loss of external power supply for a limited duration, a minor leakage from a piping system or component connection, or a single operator error that is followed by a proper corrective action. The UFSF will be designed such that releases during these events would not exceed the allowables given in 10 CFR 72.104.

10.1.3 Design Event III

Design Event III for abnormal operations consists of that set of infrequent events that could reasonable be expected to occur once during the lifetime of the installation. These operations may include a credible passive failure of a radioactive liquid retaining boundary.

10.1.4 Design Event IV

Design Event IV consists of events that are postulated because their consequences may result in the maximum potential impact on the immediate environs. Their consideration establishes a conservative design basis for certain systems with important confinement features. Typically, this set of events will consist of site-specific design events as defined in 10 CFR 72, Subparts E and F. These events include natural phenomena hazards and personnel-induced low-probability events for which the UFSF will be designed. The *Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel*²⁰ classifies the following four accident scenarios as Design Event IV:

- Nuclear criticality
- Fuel rupture in storage
- Fuel rupture in cutting and canning operation
- Release of resin regeneration waste tank activity.

Additionally, one might consider the following:

- Cask drop during transfer or unloading
- Pool leakage due to corrosion of liner weld
- Explosion or facility fire that breaches external confinement.

10.2 Accidental Releases

Radionuclide releases and frequencies associated with the first four potential accidents listed above have been calculated for the Savannah River Site in the Environmental Assessment, Table 6.1-11,²⁰ for a storage of up to 1,000 foreign research reactor fuel elements that were assumed to have been discharged from the reactor exactly 150 days prior to shipment. These potential accident consequences, frequencies, and risks are taken from the site-specific safety analysis reports. Frequencies of the postulated accidents are determined from fault-tree analyses. The primary sources of data used in these fault trees for the Savannah River Site are internal documents, audits, logbooks, and incident reports. Quantities of radionuclides potentially released to the environment are estimated from the inventory present within the spent fuel, the airborne release mechanisms, and potential severity of each accident.

A calculation was performed to address normal operating releases during the course of a 1-year operation, see Appendix B. The calculation was based on the assumption that 10% of the fuel elements would release 1% of the fission product inventory over a 1-year period, or on the assumption of 22 elements releasing 100% of the fission products to the UFSF building. The source

term (see Appendix B) was calculated utilizing the fission product inventory calculation addressed in Section 2.4. The source was allowed to be filtered through the double bank of HEPA filters before releasing to the exhaust air system. Based on a known population and distance from the facility, a follow-on calculation could be performed to address the exposure at the location of choice.

11. ENVIRONMENTAL IMPACT FORMS

The environmental impact has been summarized for the construction and operating period for the centralized and regionalized underwater fuel storage facilities for FRR SNF. The information is taken from this report or is calculated based on information in this report. Construction data summary tables (Table 2) include impact for the total period of construction. Operating data summary tables (Table 3) are annualized.

Table 2. Construction environmental impact forms.

CENTRALIZED UFSF BASELINE CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-95; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.5		
Disturbed	ha	2.8		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m²	3,517	UFSF first floor	
	m²	329	H&V second floor	
Total Capital Cost	\$ Million	141.0		
Material (total)				
Water	m³	17,800		
Poured Concrete	m³	12,430		
Precast Concrete	m³	0		
Carbon Steel	t ^a	2,867		
Stainless Steel	t ^a	263		
Other Metals	t ^a	54	Aluminum	
Fuel (diesel, etc.)	m³	600		
Electricity	MW·y	.8		
Work Force				
Total Effort	Wkr-y	625		
Peak	Wkr	184		
Waste (total)				
Hazardous	m³	2		
Nonhaz. Solids	m³	2,625		
Nonhaz. Liquids ^b	m³			
Sewage ^b	m³	2,812		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 2. (continued).

CENTRALIZED UFSF DEFERRED CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-97; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.5		
Disturbed	ha	2.8		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m²	3,517	UFSF first floor	
	m²	329	H&V second floor	
Total Capital Cost	\$ Million	150.0		
Material (total)				
Water	m³	17,800		
Poured Concrete	m³	12,430		
Precast Concrete	m³	0		
Carbon Steel	t ^a	2,867		
Stainless Steel	t ^a	263		
Other Metals	t ^a	54	Aluminum	
Fuel (diesel, etc.)	m³	600		
Electricity	MW·y	.8		
Work Force				
Total Effort	Wkr·y	625		
Peak	Wkr	184		
Waste (total)				
Hazardous	m³	2		
Nonhaz. Solids	m³	2,625		
Nonhaz. Liquids ^b	m³			
Sewage ^b	m³	2,812		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 2. (continued).

REGIONALIZED LARGE UFSF BASELINE CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-95; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.5		
Disturbed	ha	2.8		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m ²	3,314	UFSF first floor	
	m ²	327	H&V second floor	
Total Capital Cost	\$ Million	134.0		
Material (total)				
Water	m ³	17,390		
Poured Concrete	m ³	12,173		
Precast Concrete	m ³	0		
Carbon Steel	t ^a	2,867		
Stainless Steel	t ^a	258		
Other Metals	t ^a	40	Aluminum	
Fuel (diesel, etc.)	m ³	600		
Electricity	MW·y	.8		
Work Force				
Total Effort	Wkr-y	578		
Peak	Wkr	170		
Waste (total)				
Hazardous	m ³	2		
Nonhaz. Solids	m ³	2,428		
Nonhaz. Liquids ^b	m ³			
Sewage ^b	m ³	2,601		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 2. (continued).

REGIONALIZED LARGE UFSF DEFERRED CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-97; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.5		
Disturbed	ha	2.8		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m ²	3,314	UFSF first floor	
	m ²	327	H&V second floor	
Total Capital Cost	\$ Million	142.0		
Material (total)				
Water	m ³	17,390		
Poured Concrete	m ³	12,173		
Precast Concrete	m ³	0		
Carbon Steel	t ^a	2,867		
Stainless Steel	t ^a	258		
Other Metals	t ^a	40	Aluminum	
Fuel (diesel, etc.)	m ³	600		
Electricity	MW·y	.8		
Work Force				
Total Effort	Wkr·y	578		
Peak	Wkr	170		
Waste (total)				
Hazardous	m ³	2		
Nonhaz. Solids	m ³	2,428		
Nonhaz. Liquids ^b	m ³			
Sewage ^b	m ³	2,601		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 2. (continued).

REGIONALIZED SMALL UFSF BASELINE CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-95; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.1		
Disturbed	ha	2.1		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m ²	2,477	UFSF first floor	
	m ²	196	H&V second floor	
Total Capital Cost	\$ Million	98.0		
Material (total)				
Water	m ³	14,000		
Poured Concrete	m ³	9,815		
Precast Concrete	m ³	0		
Carbon Steel	t ^a	2,068		
Stainless Steel	t ^a	145		
Other Metals	t ^a	13	Aluminum	
Fuel (diesel, etc.)	m ³	470		
Electricity	MW·y	.5		
Work Force				
Total Effort	Wkr·y	425		
Peak	Wkr	125		
Waste (total)				
Hazardous	m ³	2		
Nonhaz. Solids	m ³	1,785		
Nonhaz. Liquids ^b	m ³			
Sewage ^b	m ³	1,913		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 2. (continued).

REGIONALIZED SMALL UFSF DEFERRED CONSTRUCTION SUMMARY

Parameter	Units	Quantity	Comments/Assumptions	Reference
Schedule				
Est. Start Date	CY		10-97; design time of 18 months included	
Duration	Year	5½	Design time of 18 months included	
Facilities		1		
Land Use				
Occupied	ha	1.1		
Disturbed	ha	2.1		
Facility Size				
Number of floors		2	FSA is single floor @ 64 ft high	
Area per floor	m ²	2,477	UFSF first floor	
	m ²	196	H&V second floor	
Total Capital Cost	\$ Million	105.0		
Material (total)				
Water	m ³	14,000		
Poured Concrete	m ³	9,815		
Precast Concrete	m ³	0		
Carbon Steel	t ^a	2,068		
Stainless Steel	t ^a	145		
Other Metals	t ^a	13	Aluminum	
Fuel (diesel, etc.)	m ³	470		
Electricity	MW·y	.5		
Work Force				
Total Effort	Wkr-y	425		
Peak	Wkr	125		
Waste (total)				
Hazardous	m ³	2		
Nonhaz. Solids	m ³	1,785		
Nonhaz. Liquids ^b	m ³			
Sewage ^b	m ³	1,913		

a. Metric tonne.

b. Nonhazardous liquids are included in sewage.

Table 3. Operating environmental impact summaries.

CENTRALIZED UFSF OPERATING SUMMARY

PARAMETER	UNITS	QUANTITY
SCHEDULE		-
Duration		-
Est. Start Date	CY	-
Canisters		22,000 fuel elements
Facilities		1
ANNUAL O&M BUB.	\$ Million	\$6.0
MATERIAL (total)		
Water	m ³ /y	2,210
Carbon Steel	t ^a	0
Stainless Alloy(s)	t ^a	0
Fuel (diesel, etc.)	m ³	0
Electricity	MW·y	0.11-0.17
ANNUAL WORK FORCE		
Rad Workers	Wkr	21
Total Dose	Pers-rem	14.71
Support ^b	Wkr	-
HAZ. MATERIAL INV.	kg	0
TOT. ANNUAL WASTE		
HLW	m ³	-
TRUW-CH	m ³	-
TRUW-RH	m ³	-
LLW-CH	m ³	12.2
LLW-RH	m ³	-
Mixed LLW	m ³	-
Hazardous	m ³	-
Nonhaz. Solids	m ³	7.5
Nonhaz. Liquids	m ³	-
Sewage	m ³	-
AIR EMISSION PT.		
Height	m	0
Flow Rate	m ³ /h	0
Cross Section	m ³	0
RAD. ANNUAL EMISS.	Ci/y	-
NONRAD. ANN. EMISS.		
NOx	kg	0
SOx	kg	0
VOC	kg	0

a. Metric tonne.

b. Administrative support not included in direct support of operations.

Table 3. (continued).

REGIONALIZED LARGE UFSF OPERATING SUMMARY

PARAMETER	UNITS	QUANTITY
SCHEDULE		-
Duration		-
Est. Start Date	CY	-
Canisters		22,000 fuel elements
Facilities		1
ANNUAL O&M BUB.	\$ Million	\$6.0
MATERIAL (total)		
Water	m ³ /y	1,819
Carbon Steel	t ^a	0
Stainless Alloy(s)	t ^a	0
Fuel (diesel, etc.)	m ³	0
Electricity	MW·y	1.0-1.5
ANNUAL WORK FORCE		
Rad Workers	Wkr	21
Total Dose	Pers-rem	14.71
Support ^b	Wkr	-
HAZ. MATERIAL INV.	kg	0
TOT. ANNUAL WASTE		
HLW	m ³	-
TRUW-CH	m ³	-
TRUW-RH	m ³	-
LLW-CH	m ³	12.0
LLW-RH	m ³	-
Mixed LLW	m ³	-
Hazardous	m ³	-
Nonhaz. Solids	m ³	5.6
Nonhaz. Liquids	m ³	-
Sewage	m ³	-
AIR EMISSION PT.		
Height	m	0
Flow Rate	m ³ /h	0
Cross Section	m ²	0
RAD. ANNUAL EMISS.	Ci/y	-
NONRAD. ANN. EMISS.		
NOx	kg	0
SOx	kg	0
VOC		0

a. Metric tonne.

b. Administrative support not included in direct support of operations.

Table 3. (continued).

REGIONALIZED SMALL UFSF OPERATING SUMMARY

PARAMETER	UNITS	QUANTITY
SCHEDULE		-
Duration		-
Est. Start Date	CY	-
Canisters		22,000 fuel elements
Facilities		1
ANNUAL O&M BUB.	\$ Million	\$5.0
MATERIAL (total)		
Water	m ³ /y	1,552
Carbon Steel	t ^a	0
Stainless Alloy(s)	t ^a	0
Fuel (diesel, etc.)	m ³	0
Electricity	MW·y	0.5-1.0
ANNUAL WORK FORCE		
Rad Workers	Wkr	21
Total Dose	Pers-rem	14.71
Support ^b	Wkr	-
HAZ. MATERIAL INV.	kg	0
TOT. ANNUAL WASTE		
HLW	m ³	-
TRUW-CH	m ³	-
TRUW-RH	m ³	-
LLW-CH	m ³	11.5
LLW-RH	m ³	-
Mixed LLW	m ³	-
Hazardous	m ³	-
Nonhaz. Solids	m ³	1.9
Nonhaz. Liquids	m ³	-
Sewage	m ³	-
AIR EMISSION PT.		
Height	m	0
Flow Rate	m ³ /h	0
Cross Section	m ²	0
RAD. ANNUAL EMISS.	Ci/y	-
NONRAD. ANN. EMISS.		
NOx	kg	0
SOx	kg	0
VOC		0

a. Metric tonne.

b. Administrative support not included in direct support of operations.

REFERENCES

1. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement*, DOE/EIS-0203-D, June 1994.
2. D. Hale and E. Reutzel, *Summary Engineering Description Dry Storage Facility for Foreign Research Reactor Spent Nuclear Fuel*, EG&G Idaho, Inc., B430-93-076, October 1993.
3. A. G. Croft, July 1980, ORIGEN2 -- A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code, ORNL-5621, Oak Ridge National Laboratory, Oak Ridge, TN.
4. *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, Standard ANSI/ANS-57.7-1988, March 1989.
5. U.S. Department of Energy, *General Design Criteria*, DOE Order 6430.1A, April 6, 1989.
6. Code of Federal Regulations, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste*, Title 10, Energy, Chapter I, Part 72, p. 240, January 1, 1994.
7. Code of Federal Regulations, *Domestic Licensing of Production and Utilization Facilities*, Title 10, Energy, Chapter I, Part 50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants*, January 1994.
8. American Society of Mechanical Engineers, *Quality Assurance Program Requirements for Nuclear Facilities*, ASME NQA-1-1989 Edition, 1989.
9. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.13, Rev. 1, *Spent Fuel Storage Facility Design Basis*, December 1975.
10. ANSI, Standard N305-1975, *Design Objectives for Highly Radioactive Solid Material Handling and Storage Facilities in a Reprocessing Plant*.
11. *Waste Management Facilities Cost Information Report for Spent Nuclear Fuel*, EG&G-WM-10670, March 1993.
12. Letter from R. Karimi, SAIC, to Distribution, "FRR Shipment Estimates," August 26, 1994 (Draft).
13. *Environmental Evaluation of Fluorinel Dissolution Process and Fuel Storage Facility*, WIN-159, June 1985.
14. *Fluorinel Dissolution Process and Fuel Storage Facility Final Safety Analysis Report*, WIN-105-5.6, Rev. 2, Vol. III, February 1993.
15. *Underwater Handling and Storage of Aluminum Clad Fuels in the FAST*, WIN-105-5.6, Vol. III, Addendum A, Rev. 3, May 1994.
16. *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*, DOE Standard DOE-STD-1021-93, July 1993.
17. *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE Standard DOE-STD-1020-94, April 1994.

18. Lawrence Livermore National Laboratory, *Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites*, UCRL-53582, Rev. 1, November 1984.
19. *Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites*, UCRL-53526, Rev. 1, August 1985.
20. Department of Energy, *Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel*, DOE/EA-0912, April 1994.

Appendix A

Cost Estimate

Appendix A

Cost Estimate

"Providing research and development services to the government"

INTEROFFICE CORRESPONDENCE

Date: August 24, 1994
To: D. K. Searle, MS 3740
From: S. L. Johnston, MS 3655 *S. Johnston*
Subject: SNF UNDERGROUND FUEL STORAGE FACILITY - SLJ-06-94

Cost Estimating has prepared the attached Planning Cost Estimate for the above project. The estimate was based on a floor plan sketch, information from you, and previously completed cost estimates for similar type projects. Two Summary Sheets indicating different escalation schedules have been included for your information. One estimate was escalated to July, 1996 (midpoint of construction). The Total Estimated Cost (TEC) for this estimate is \$132,000,000. The other estimate was escalated to July, 2001 (midpoint of construction). The TEC for this estimate is \$140,000,000. The cost estimates encompass those items and assumptions as shown on the attached Recap Sheets, Summaries and Detail Sheets.

If you have any questions or comments regarding this estimate, feel free to contact me at 526-0399 (OV-ID SLJ).

mm

Attachments:
As Stated

cc: Estimate File #8369
S. L. Johnston Files *S. Johnston*

COST ESTIMATE SUPPORT DATA RECAPITULATION

Project Title: SPENT NUCLEAR FUEL (SNF)
UNDERWATER FUEL STORAGE FACILITY

Estimator: Sherry Johnston

Type of Estimate: Planning

Date: September 26, 1994

File No: 8369-A

Approved By:

I. SCOPE OF WORK: *Brief description of the proposed project.*

Design and construct a wet storage facility for Spent Nuclear Fuel. The facility will consist of administrative areas, basin water cleanup area, support systems, pools, and a cask receiving area. The following three estimates, each with two separate escalation midpoints of construction, have been issued:

- SNF Centralized Underwater Fuel Storage Facility (41,400 SF)
- SNF Regionalized (Large) Underwater Fuel Storage Facility
(40,000 SF)
- SNF Regionalized (Small) Underwater Fuel Storage Facility
(26,663 SF)

II. BASIS OF THE ESTIMATE: *Drawings, Design Report, Engineers notes, and/or other documentation upon which the estimate is originated.*

- (a) Sketch of the Floor Plan
- (b) A previous cost estimate for the "ICPP Fuels Canning Facility", dated 11/16/92 - DNS-51-92.
- (c) Cost Estimate for the "Waste Characterization Facility", currently being completed, August, 1994.
- (d) "Waste Management Facilities Cost Information Report for Spent Nuclear Fuel", EG&G-WM-10670, dated March, 1993.
- (e) Cost Estimate for the "SNF Underground Fuel Storage Facility" - SLJ-06-94, dated August 24, 1994.

COST ESTIMATE SUPPORT DATA RECAPITULATION
(CONTINUATION)

File No: 8369-A

Page 2 of 4

III. ASSUMPTIONS: *Condition statements accepted or supposed true without proof or demonstration. An assumption has a direct impact on total estimated cost.*

The following assumptions were made in order to provide a cost estimate for this project:

- Three estimates have been included in this project. The Centralized - UFSF was based on a 41,400 square feet floor plan. The Regionalized (Small) - UFSF was based on 26,663 square feet with fewer pools. All other items remain basically the same as the original centralized estimate. The Regionalized (Large) - UFSF was based on the original Centralized - UFSF, but the fuel storage pools and overall facility were 13' shorter than in the original centralized estimate.
- The following were assumed for improvements to land and site work:
 - All area within 70' of the perimeter of the building was cleared and grubbed.
 - Sidewalks extending around the perimeter of the building (at 30' out) and 3 concrete stoops were included in the estimate.
 - An asphalt area extending from the receiving area to the end of the building, and a parking lot, capable of accommodating 40 cars and 5 semi-trucks, were included in the estimate.
 - Minimal landscaping within 50' of the perimeter of the building was included.
- It was assumed that the railroad track would loop around the end of the building and extend 1/2 mile out in one direction. At such time as the building site is defined, the costs will have to be adjusted to accommodate the particular conditions.
- Due to lack of siting information, utilities were calculated at 20% of the building structure costs.
- It was assumed that all walls and floors within the pools, the interior of the decontamination rooms, and the floor within the staging area will be stainless steel lined. All other walls, with the exception of the administrative areas, will be painted with a decontaminable paint.

- Continued on Page 3 -

**COST ESTIMATE SUPPORT DATA RECAPITULATION
(CONTINUATION)**

File No: 8369-A

Page 3 of 4

III. ASSUMPTIONS: (Continued)

- It was assumed that rock would be encountered in approximately 1/3 of the total excavation. An allowance was included in the estimate to cover these costs.
- The building included 1' and 3' thick concrete walls, extending 63'4" high in the cask receiving, pools, and staging area. The radioactive liquid management and disposal areas, basin water cleanup, and facility support systems room all have an elevation of 42' high with both 1' and 3' thick concrete walls. The administrative areas are enclosed with a pre-engineered metal building. With the exception of the pool floors, the concrete floor within the building was assumed to be 1' thick. The roof consists of a cellular deck, 2" rigid insulation board, light-weight concrete, and a standing seam metal roof. The exterior of the building is covered with 2" rigid insulation with 22-gauge metal siding.
- With the exception of the fuel unloading pools, the wall height of the pools are calculated at 31 feet. The fuel unloading pools have a wall height of 45' and 37' for the Centralized UFSF and 36' for the Regionalized UFSFs. The pits are all 4' deep.
- The costs for the interior wall framing specified on the estimate consist of the framing for the equipment storage, RCT office/equipment, and washdown equipment room. The basin water cleanup room and utility room have costs included in the estimate for an additional 2nd floor.
- Building utilities are calculated based on a square foot cost, derived from a detail design of a waste characterization facility.
- Although no secondary containment provisions for firewater and spills were indicated, costs were included for housing and/or holding tanks, etc.
- It was assumed that each of the sub-contractors would require a full-time non-working supervisor to coordinate the project with the general contractor.
- It was assumed that Title I and Title II design will have an 18-month schedule. Construction duration was assumed at 4 years for all three estimates. Even though the estimate for the Regional (Small) UFSF was based on a smaller floor plan, it is reasonable to assume construction will still take 4 years.

**COST ESTIMATE SUPPORT DATA RECAPITULATION
(CONTINUATION)**

File No: 8369-A

Page 4 of 4

- IV. CONTINGENCY GUIDELINE IMPLEMENTATION:** *The percentage used for contingency as determined by the contingency allowance guidelines can be altered to reflect the type of construction and conditions that may impact the total estimated cost.*

Due to lack of detail at this planning stage of the estimate, a contingency of 36%-37% (including Management Reserve of 10%) was included. At such time as detailed design is available, the cost estimate shall be revised.

A 10% Management Reserve has been included in the Total Estimated Cost (TEC).

V. OTHER COMMENTS/CONCERNS SPECIFIC TO THE ESTIMATE:

- Due to the lack of a specific siting, the following costs have not been included:
 - No costs have been included to repair any utilities that may be damaged during excavation.
 - No costs have been included for possible congestion/contamination that could be encountered during excavation, etc.
 - Productivity has not been adjusted to accommodate possible congestion/contamination, or overtime conditions.
- Special circuit allowance includes costs for special outlets for equipment in the operators' area.
- Construction Management costs were based on historical percentages incurred at the INEL.

COST ESTIMATE SUMMARY

Rev 10-93

Type of Est. Planning File No 8369-A Date 09/28/94
 Project SNF Underwater Fuel Storage Facility - Centralized
 Prepared By S. L. Johnston Appr'd By

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION			9,321,000
Performance Specification			
Title I and II Design	7,480,000	417,000	
Title III Inspection	1,229,000	195,000	
ED&I Costs are <u>12%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS			74,864,000
DIRECT COSTS			58,487,000
4000 Improvement to Land	710,000	113,000	
5000 Buildings/Structures	29,573,000	4,699,000	
6000 Utilities	6,057,000	963,000	
7000 Equipment	12,909,000	2,051,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	194,000	
INDIRECT COSTS	14,131,000	2,246,000	16,377,000
CONSTRUCTION MANAGEMENT	14,218,000	2,259,000	16,477,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,270,000	361,000	2,631,000
MANAGEMENT RESERVE	7,882,000	1,253,000	9,135,000
SUBTOTAL			112,428,000
CONTINGENCY <u>25%</u> of Subtotal			28,572,000
ESCALATION (included in above Totals)		14,751,000	

TOTAL ESTIMATED COST: \$141,000,000* Total Contingency is 37%, including Management Reserve.

Rev 5-92

	Type of Est.	Planning
Source	(E) Eng. Est.	
	(V) Vendor	
	(P) Pur. Order	
	(H) Handbook	Ref.

Date 09/28/94

Prep'd By S. L. Johnston

Chk'd By

Appr'd By

Project	SNF Underwater Fuel Storage Facility
	Centralized – UFSF
Location	Generic
Requester	D. K. Searle

[illegible]

Date 09/28/94

[illegible]

Rev 5-92

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Type of Est. PlanningFile No. 8369-ADate 09/28/94Project SNF Underwater Fuel Storage Facility
Centralized - UFSF

ACCT. NO.	DESCRIPTION	E,V, P,H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
7000	EQUIPMENT:										
	Office Furnishings	E	12 EA	3,800				Included	45,800		45,800
	Shop Equipment - Allowance	E	1 LOT	70,000				Included	70,000		70,000
	Monitoring - CAMS and RAMS	E	8 EA	12,000				Included	96,000		96,000
	Overhead Bridge Crane (10 - Ton, Hi Rad)	E	1 EA	1,100,000				Included	1,100,000		1,100,000
	Overhead Bridge Crane (130 - Ton, Regular)	E	1 EA	1,675,000				Included	1,675,000		1,675,000
	10,000 Gal. SST Containment Tanks (@ \$6/Gal)	E	3 EA	60,000				Included	180,000		180,000
	Transfer Tote	E	2 EA	32,000				Included	64,000		64,000
	Allowance for Misc. Equipment, incl.										
	SST Storage Racks, SST Tables, etc.	E	1 LOT	1,500,000				Included	1,500,000		1,500,000
	CCTVs	E	9 EA	14,000				Included	126,000		126,000
	Leak Detection System - Allowance	E	1 LOT	100,000				Included	100,000		100,000
	Contamination Containment Device	E	1 EA	155,000				Included	155,000		155,000
	Pressure Wash & Accessories	E	1 LOT	120,000				Included	120,000		120,000
	Filtration Unit	E	2 EA	37,000				Included	74,000		74,000
	Storage Tanks - 100 Gal.	E	2 EA	9,000				Included	18,000		18,000
	Decontamination Equipment	E	2 LOTS	50,000				Included	100,000		100,000
	Water Sprayers (incl. Piping)	E	1 LOT	165,000				Included	165,000		165,000
	Holding Jigs/Fixtures	E	1 LOT	150,000				Included	150,000		150,000
	Survey Equipment	E	2 LOTS	1,000,000				Included	2,000,000		2,000,000
	Storage/Sample Tanks - 1000 Gal.	E	2 EA	45,000				Included	90,000		90,000
	Analysis Equipment - Allowance	E	1 EA	1,800,000				Included	1,800,000		1,800,000
	Forklift Truck - 10 TN	E	1 EA	100,000				Included	100,000		100,000
	Truck Scale Platform Type - 200 TN	E	1 EA	80,000				Included	80,000		80,000
	Cutter (Arc Type)	E	1 EA	458,000				Included	458,000		458,000
	SUBTOTAL - This Page (Equipment)								10,266,600		10,266,600

Date 09/28/94[illegible]

File No. 8369-A

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Centralized - UFSF

ACCT. NO.	DESCRIPTION	E,V, P,H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
9000	OTHER DIRECT COSTS:										
	Full - Time Non - Working Supervisor (4 People for 4 Years)	E	4 EA		7,680	30,720	37	1,136,640			1,136,640
	Training (60 People for 40 Hrs. Each)	E	1 LOT			2,400	34	81,600			81,600
	TOTAL - 9000 ACCOUNT							1,218,240			1,218,240
										USE	1,218,000
	TITLE III INSPECTION	E	1 FTE		7,680	7,680	80	614,400			614,400
	FIELD ENGINEERING	E	1 FTE		7,680	7,680	80	614,400			614,400
	PROJECT MANAGEMENT	E	2 FTE		7,680	15,360	95	1,459,200			1,459,200
	Misc. PM Support Costs:										
	Safety	E	0.5 FTE		7,680	3,840	75	288,000			288,000
	Quality	E	0.5 FTE		7,680	3,840	75	288,000			288,000
	Cost Estimating	E	1 LOT		2,000	2,000	80	160,000			160,000
	Administrative	E	1 LOT	75,000					75,000		75,000
	TOTAL - PROJECT MANAGEMENT AND SUPPORT							2,195,200	75,000		2,270,200
										USE	2,270,000
	ENGINEERING:										
	Architectural/Structural/Civil	E	130 DRWG	11,000					1,430,000		1,430,000
	Mechanical	E	230 DRWG	11,000					2,530,000		2,530,000
	Electrical	E	160 DRWG	11,000					1,760,000		1,760,000
	Special Processes	E	160 DRWG	11,000					1,760,000		1,760,000
	TOTAL - ENGINEERING								7,480,000		7,480,000

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Centralized - UFSF
 Location Generic
 Requestor D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prep'd By S. L. Johnston
 App'd By [Signature]

PROBABLE % VARIATION							
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency
			-	+	-	+	
Performance Specification							
Title I & II	7,897,000	8	5	35	0.38	2.68	2.37%
Title III	1,424,000	1	5	30	0.07	0.41	0.37%
4000 Account	823,000	1	10	50	0.08	0.40	0.35%
5000 Account	34,272,000	33	10	50	3.32	16.59	14.60%
6000 Account	7,020,000	7	10	50	0.68	3.40	2.99%
7000 Account	14,960,000	14	5	50	0.72	7.24	6.44%
8000 Account							
9000 Account	1,412,000	1	10	30	0.14	0.41	0.36%
Indirects	16,377,000	16	10	40	1.59	6.34	5.55%
Construction Management	16,477,000	16	5	20	0.80	3.19	2.79%
GFE							
Project Management	2,631,000	3	10	20	0.25	0.51	0.43%
Subtotal	103,293,000	100			8.03	41.17	

Contingency	37,443,045						36.25%
Suggested TEC	140,736,045						

Rounded TEC	141,000,000						
Calculated Contingency	37,707,000						36.50%

Management Reserve	9,135,000						
Project Contingency	28,572,000						

Risk to Project							17.74%
-----------------	--	--	--	--	--	--	--------

Total	141,000,000						
-------	-------------	--	--	--	--	--	--

PROJECT CONTINGENCY	
%	Cost
6.54%	1,868,000
1.01%	288,000
0.97%	276,000
40.27%	11,507,000
8.25%	2,357,000
17.78%	5,080,000
0.98%	280,000
15.31%	4,374,000
7.70%	2,200,000
1.19%	341,000

SUMMARY	
Total Cost by Element	
	9,765,000
	1,712,000
	1,099,000
	45,779,000
	9,377,000
	20,040,000
	1,692,000
	20,751,000
	18,677,000
	2,972,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% - 30%
Experimental / Special Conditions	Up to 50%
CONCEPTUAL	15% - 25%
Experimental / Special Conditions	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II / AFC	Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project Centralized - UFSF
 Location Generic
 Requester D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prepared By S. L. Johnston
 Approved By *[Signature]*

Calendar Years	CY93	CY94	CY95	CY96	CY97	CY98	CY99	
Fiscal Years	FY94	FY95	FY96	FY97	FY98	FY99		
	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS		TOTAL
Escalation Period and Annual Escalation Rate	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate		COMPOUNDED RATE
<i>Design Period</i>	Design will start October, 1995 and be completed April, 1997 Midpoint to July, 1996							
Title I, II	2 0.4	12 2.8	9 2.3					5.57%
<i>Construction Period</i>	Construction will begin July, 1997 and last 4 years until July, 2001 Midpoint to July, 1999							
Title III	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Labor	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Mat'l & Subcontracts	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Equipment or GFE	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Indirects	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
CM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
PM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.7	3.0	3.3	3.3	3.2	3.1	
-------------------------	-----	-----	-----	-----	-----	-----	--

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	3.5	3.6	3.7	4.0	3.9	3.7	
-------------------------	-----	-----	-----	-----	-----	-----	--

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	3.2	3.4	3.6	3.8	3.6	3.5	
-------------------------	-----	-----	-----	-----	-----	-----	--

* It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

Type of Est. Planning File No 8369-A
 Project SNF Underwater Fuel Storage Facility - Centralized (Deferred)
 Prepared By S. L. Johnston

Date 09/28/94Appr'd By

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION			9,915,000
Performance Specification			
Title I and II Design	7,480,000	924,000	
Title III Inspection	1,229,000	282,000	
ED&I Costs are <u>12%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS			79,400,000
DIRECT COSTS			62,031,000
4000 Improvement to Land	710,000	163,000	
5000 Buildings/Structures	29,573,000	6,776,000	
6000 Utilities	6,057,000	1,388,000	
7000 Equipment	12,909,000	2,958,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	279,000	
INDIRECT COSTS	14,131,000	3,238,000	17,369,000
CONSTRUCTION MANAGEMENT	14,218,000	3,258,000	17,476,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,270,000	520,000	2,790,000
MANAGEMENT RESERVE	7,882,000	1,806,000	9,688,000
SUBTOTAL			119,269,000
CONTINGENCY	<u>26%</u> of Subtotal		30,731,000
ESCALATION (included in above Totals)		21,592,000	
TOTAL ESTIMATED COST:			\$150,000,000

* Total Contingency is 37%, including Management Reserve.

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

[illegible]

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Centralized - UFSF

[illegible]

Type of Est. Planning

File No. 8369-A

Date 09/28/94

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Centralized - UFSF

[illegible]

Type of Est. Planning

File No. 8369-A

Date 09/28/94

Project	SNF Underwater Fuel Storage Facility
	Centralized – UFSF

[illegible]

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Centralized - UFSF (Deferred)
 Location Generic
 Requestor D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prep'd By S. L. Johnston
 App'd By for

PROBABLE % VARIATION							
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency
			-	+	-	+	
Performance Specification							
Title I & II	8,404,000	8	5	35	0.38	2.68	2.38%
Title III	1,511,000	1	5	30	0.07	0.41	0.37%
4000 Account	873,000	1	10	50	0.08	0.40	0.35%
5000 Account	36,349,000	33	10	50	3.32	16.59	14.60%
6000 Account	7,445,000	7	10	50	0.68	3.40	2.99%
7000 Account	15,867,000	14	5	50	0.72	7.24	6.44%
8000 Account							
9000 Account	1,497,000	1	10	30	0.14	0.41	0.36%
Indirects	17,369,000	16	10	40	1.59	6.34	5.55%
Construction Management	17,476,000	16	5	20	0.80	3.19	2.79%
GFE							
Project Management	2,790,000	3	10	20	0.25	0.51	0.43%
Subtotal	109,581,000	100			8.03	41.17	

Contingency	39,720,920						36.25%
Suggested TEC	149,301,920						

Rounded TEC	150,000,000						
Calculated Contingency	40,419,000						36.89%

Management Reserve	9,688,000						
Project Contingency	30,731,000						

Risk to Project							17.36%
-----------------	--	--	--	--	--	--	--------

Total	150,000,000						
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PROJECT CONTINGENCY	
%	Cost
6.56%	2,016,000
1.01%	310,000
0.97%	297,000
40.26%	12,374,000
8.25%	2,534,000
17.78%	5,463,000
0.98%	301,000
15.30%	4,703,000
7.70%	2,366,000
1.19%	367,000

SUMMARY
Total Cost by Element
10,420,000
1,821,000
1,170,000
48,723,000
9,979,000
21,330,000
1,798,000
22,072,000
19,842,000
3,157,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% - 30%
Experimental / Special Conditions	Up to 50%
CONCEPTUAL	15% - 25%
Experimental / Special Conditions	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II / AFC	Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project SNF Underwater Fuel Storage Facility
 Centralized - UFSF (Deferred)
 Location Generic
 Requester D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prepared By S. L. Johnston
 Approved By *[Signature]*

Calendar Years	CY93	CY94	CY95	CY96	CY97	CY98	CY99	
Fiscal Years	FY94	FY95	FY96	FY97	FY98	FY99		TOTAL
Escalation Period and Annual Escalation Rate	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS		COMPOUNDED RATE
	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate		
Design Period	Design will start October, 1997 and be completed April, 1999 Midpoint to July, 1998							
Title I, II	2 0.4	12 2.8	12 3.0	12 3.1	9 2.5			12.35%
Construction Period	Construction will begin July, 1999 and last 4 years until July, 2003 Midpoint to July, 2001							
Title III	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Labor	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Mat'l & Subcontracts	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Equipment or GFE	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Indirects	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
CM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
PM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.7	3.0	3.3	3.3	3.2	3.1
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The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	3.5	3.6	3.7	4.0	3.9	3.7
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	3.2	3.4	3.6	3.8	3.6	3.5
-------------------------	-----	-----	-----	-----	-----	-----

*It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

Type of Est. Planning File No 8369-A
 Project SNF Underwater Fuel Storage Facility - Regionalized (Large)
 Prepared By S. L. Johnston

Date 09/29/94Appr'd By

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION			9,321,000
Performance Specification			
Title I and II Design	7,480,000	417,000	
Title III Inspection	1,229,000	195,000	
ED&I Costs are <u>13%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS			70,913,000
DIRECT COSTS			55,401,000
4000 Improvement to Land	697,000	111,000	
5000 Buildings/Structures	27,784,000	4,415,000	
6000 Utilities	5,696,000	905,000	
7000 Equipment	12,409,000	1,972,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	194,000	
INDIRECT COSTS	13,385,000	2,127,000	15,512,000
CONSTRUCTION MANAGEMENT	13,468,000	2,140,000	15,608,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,270,000	361,000	2,631,000
MANAGEMENT RESERVE	7,466,000	1,186,000	8,652,000
SUBTOTAL			107,125,000
CONTINGENCY <u>25%</u> of Subtotal			26,875,000
ESCALATION (included in above Totals)		14,023,000	
TOTAL ESTIMATED COST:			\$134,000,000

* Total Contingency is 36%, including Management Reserve.

Rev 5-92

DETAILED COST ESTIMATE SHEET

Project	SNF Underwater Fuel Storage Facility Regionalized (Large) – UFSF
Location	Generic
Requester	D. K. Searle

Type of Est. Planning

File No. 8369-A

Date 09/28/94

Source (E) Eng. Est.

(M) Vendor

(P) Pur. Order

(H) Handbook Ref.

Prep'd By S. L. Johnston

Chk'd By

Appr'd By *[Signature]*

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Regionalized (Large) – UFSF

[illegible]

Page 3 of 6

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Regionalized (Large) – UFSF

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Project SNF Underwater Fuel Storage Facility
Regionalized (Large) - UFSF

Type of Est. Planning File No. 8369-A Date 09/28/94

ACCT. NO.	DESCRIPTION	E.V. P,H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
7000	EQUIPMENT:										
	Office Furnishings	E	12 EA	3,800				Included	45,600		45,600
	Shop Equipment - Allowance	E	1 LOT	70,000				Included	70,000		70,000
	Monitoring - CAMS and RAMS	E	8 EA	12,000				Included	96,000		96,000
	Overhead Bridge Crane (10-Ton, Hi Rad)	E	1 EA	1,100,000				Included	1,100,000		1,100,000
	Overhead Bridge Crane (130-Ton, Regular)	E	1 EA	1,675,000				Included	1,675,000		1,675,000
	10,000 Gal. SST Containment Tanks (@ \$6/Gal.)	E	3 EA	60,000				Included	180,000		180,000
	Transfer Tote	E	2 EA	32,000				Included	64,000		64,000
	Allowance for Misc. Equipment, incl										
	SST Storage Racks, SST Tables, etc	E	1 LOT	1,000,000				Included	1,000,000		1,000,000
	CCTVs	E	9 EA	14,000				Included	126,000		126,000
	Leak Detection System - Allowance	E	1 LOT	100,000				Included	100,000		100,000
	Contamination Containment Device	E	1 EA	155,000				Included	155,000		155,000
	Pressure Wash & Accessories	E	1 LOT	120,000				Included	120,000		120,000
	Filtration Unit	E	2 EA	37,000				Included	74,000		74,000
	Storage Tanks - 100 Gal.	E	2 EA	9,000				Included	18,000		18,000
	Decontamination Equipment	E	2 LOTS	50,000				Included	100,000		100,000
	Water Sprayers (incl. Piping)	E	1 LOT	165,000				Included	165,000		165,000
	Holding Jigs/Fixtures	E	1 LOT	150,000				Included	150,000		150,000
	Survey Equipment	E	2 LOTS	1,000,000				Included	2,000,000		2,000,000
	Storage/Sample Tanks - 1000 Gal.	E	2 EA	45,000				Included	90,000		90,000
	Analysis Equipment - Allowance	E	1 EA	1,800,000				Included	1,800,000		1,800,000
	Forklift Truck - 10 TN	E	1 EA	100,000				Included	100,000		100,000
	Truck Scale Platform Type - 200 TN	E	1 EA	80,000				Included	80,000		80,000
	Cutter (Arc Type)	E	1 EA	458,000				Included	458,000		458,000
	SUBTOTAL - This Page (Equipment)								9,766,600		9,766,600

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Large) -- UFSF

[illegible]

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Regionalized (Large)
 Location Generic
 Requestor D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/29/94
 Prep'd By S. L. Johnston
 App'd By ML

PROBABLE % VARIATION							
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency
			-	+	-	+	
Performance Specification							
Title I & II	7,897,000	8	5	35	0.40	2.81	2.49%
Title III	1,424,000	1	5	30	0.07	0.43	0.38%
4000 Account	808,000	1	10	50	0.08	0.41	0.36%
5000 Account	32,199,000	33	10	50	3.27	16.35	14.39%
6000 Account	6,601,000	7	10	50	0.67	3.35	2.95%
7000 Account	14,381,000	15	5	50	0.73	7.30	6.50%
8000 Account							
9000 Account	1,412,000	1	10	30	0.14	0.43	0.37%
Indirects	15,512,000	16	10	40	1.58	6.30	5.51%
Construction Management	15,608,000	16	5	20	0.79	3.17	2.77%
GFE							
Project Management	2,631,000	3	10	20	0.27	0.53	0.45%
Subtotal	98,473,000	100			8.00	41.09	

Contingency	35,627,485						36.18%
Suggested TEC	134,100,485						

Rounded TEC	134,000,000						
Calculated Contingency	35,527,000						36.08%

Management Reserve	8,652,000						
Project Contingency	26,875,000						

Risk to Project							18.10%
-----------------	--	--	--	--	--	--	--------

Total	134,000,000						
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PROJECT CONTINGENCY	
%	Cost
6.87%	1,847,000
1.06%	285,000
1.00%	268,000
39.77%	10,687,000
8.15%	2,191,000
17.96%	4,827,000
1.03%	277,000
15.24%	4,095,000
7.67%	2,060,000
1.26%	337,000

SUMMARY
Total Cost by Element
9,744,000
1,709,000
1,076,000
42,886,000
8,792,000
19,208,000
1,689,000
19,607,000
17,668,000
2,968,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide

PLANNING	20% - 30%
Experimental / Special Conditions	Up to 50%
CONCEPTUAL	15% - 25%
Experimental / Special Conditions	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II / AFC	Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project SNF Underwater Fuel Storage Facility
 Location Regionalized (Large)
 Requester Generic
D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prepared By S. L. Johnston
 Approved By

Calendar Years	CY93		CY94		CY95		CY96		CY97		CY98		CY99		
Fiscal Years	FY94		FY95		FY96		FY97		FY98		FY99		TOTAL COMPOUNDED RATE		
Escalation Period and Annual Escalation Rate	ONDJFMAMJJAS		ONDJFMAMJJAS		ONDJFMAMJJAS		ONDJFMAMJJAS		ONDJFMAMJJAS		ONDJFMAMJJAS				
	Months	Rate	Months	Rate	Months	Rate	Months	Rate	Months	Rate	Months	Rate			
<i>Design Period</i>	Design will start October, 1995 and be completed April, 1997 Midpoint to July, 1996														
Title I, II	2	0.4	12	2.8	9	2.3								5.57%	
<i>Construction Period</i>	Construction will begin July, 1997 and last 4 years until July, 2001 Midpoint to July, 1999														
Title III	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
Labor	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
Mat'l & Subcontracts	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
Equipment or GFE	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
Indirects	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
CM	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	
PM	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	9	2.3		15.89%	

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.6	2.7	3.0	3.3	3.3	3.2
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	2.8	3.5	3.6	3.7	4.0	3.9
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	2.5	3.2	3.4	3.6	3.8	3.6
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* It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

COST ESTIMATE SUMMARY

Rev 10-93

Type of Est. Planning File No 8369-A
 Project SNF Underwater Fuel Storage Facility - Regionalized (Large) (Deferred)
 Prepared By S. L. Johnston

Date 10/02/94Appr'd By

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION			9,915,000
Performance Specification			
Title I and II Design	7,480,000	924,000	
Title III Inspection	1,229,000	282,000	
ED&I Costs are <u>13%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS			75,209,000
DIRECT COSTS			58,757,000
4000 Improvement to Land	697,000	160,000	
5000 Buildings/Structures	27,784,000	6,366,000	
6000 Utilities	5,696,000	1,305,000	
7000 Equipment	12,409,000	2,843,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	279,000	
INDIRECT COSTS	13,385,000	3,067,000	16,452,000
CONSTRUCTION MANAGEMENT	13,468,000	3,086,000	16,554,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,270,000	520,000	2,790,000
MANAGEMENT RESERVE	7,466,000	1,711,000	9,177,000
SUBTOTAL			113,645,000
CONTINGENCY	25% of Subtotal		28,355,000
ESCALATION (included in above Totals)		20,543,000	
TOTAL ESTIMATED COST:			\$142,000,000
• Total Contingency is <u>36%</u> , including Management Reserve.			

DETAILED COST ESTIMATE SHEET

Project SNF Underwater Fuel Storage Facility
 Regionalized (Large) - UFSF (Deferred)
 Location Generic
 Requester D. K. Searle

Type of Est. Planning
 Source (E) Eng. Est.
 (M) Vendor
 (P) Pur. Order

(H) Handbook Ref.

File No. 8369-A
 Date 09/29/94
 Prep'd By S. L. Johnson
 Ck'd By
 Appr'd By

ACCT. NO.	DESCRIPTION	E.V.	P.H.	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
4000	IMPROVEMENTS TO LAND:											
	Clearing & Grubbing (70' outside of bldg area)	E, H		17,400 SY	0.50				Included	8,700		8,700
	Concrete Sheds	E		3 EA	250				Included	750		750
	Sidewalk (around Perimeter of building)	E, H		1,300 LF	5.20	0.3	390	30	Included	6,760		18,460
	Asphalt Paving	E, H		1,100 SY	22.25				Included	24,475		24,475
	Landscaping (50' around perimeter of building)	E, H		9,100 SY	7				Included	63,700		63,700
	Railroad Spurs (Extend 1/2 Mile)	E, H		3,150 LF	175				Included	551,250		551,250
	Parking Area (40 Cars & 5 Semi-trucks)	E, H		1 LOT	30,000				Included	30,000		30,000
	TOTAL - IMPROVEMENTS TO LAND								11,700	685,635		697,335
	USE											697,000
6000	UTILITIES:											
	Due to lack of definitive siting, utilities are estimated at 20% of the building structure costs											
	Allowance			1 LOT	5,696,000					5,696,000		5,696,000

Type of Est. Planning

Date 09/29/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Large) – UFSF (Deferred)

[illegible]

DETAILED COST ESTIMATE (CONT. SHEET)

Type of Est. Planning

File No.

8369-A

Date _____

09/29/94

SNF Underwater Fuel Storage Facility

Regionalized (Large) - UFSF (Deferred)

[illegible]

Date 09/29/94

ACCT. NO.	DESCRIPTION	E.V. P.H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
7000	EQUIPMENT:										
	Office Furnishings	E	12 EA	3,800				Included	45,600		45,600
	Shop Equipment - Allowance	E	1 LOT	70,000				Included	70,000		70,000
	Monitoring - CAMS and RAMS	E	8 EA	12,000				Included	96,000		96,000
	Overhead Bridge Crane (10-Ton, Hi Rad)	E	1 EA	1,100,000				Included	1,100,000		1,100,000
	Overhead Bridge Crane (130-Ton, Regular)	E	1 EA	1,675,000				Included	1,675,000		1,675,000
	10,000 Gal. SST Containment Tanks (@ \$6/Gal.)	E	3 EA	60,000				Included	180,000		180,000
	Transfer Tote	E	2 EA	32,000				Included	64,000		64,000
	Allowance for Misc. Equipment, incl										
	SST Storage Racks, SST Tables, etc.	E	1 LOT	1,000,000				Included	1,000,000		1,000,000
	CCTVs	E	9 EA	14,000				Included	126,000		126,000
	Leak Detection System - Allowance	E	1 LOT	100,000				Included	100,000		100,000
	Contamination Containment Device	E	1 EA	155,000				Included	155,000		155,000
	Pressure Wash & Accessories	E	1 LOT	120,000				Included	120,000		120,000
	Filtration Unit	E	2 EA	37,000				Included	74,000		74,000
	Storage Tanks - 100 Gal.	E	2 EA	9,000				Included	18,000		18,000
	Decontamination Equipment	E	2 LOTS	50,000				Included	100,000		100,000
	Water Sprayers (incl. Piping)	E	1 LOT	165,000				Included	165,000		165,000
	Holding Jigs/Fixtures	E	1 LOT	150,000				Included	150,000		150,000
	Survey Equipment	E	2 LOTS	1,000,000				Included	2,000,000		2,000,000
	Storage/Sample Tanks - 1000 Gal.	E	2 EA	45,000				Included	90,000		90,000
	Analysis Equipment - Allowance	E	1 EA	1,800,000				Included	1,800,000		1,800,000
	Forklift Truck - 10 TN	E	1 EA	100,000				Included	100,000		100,000
	Truck Scale Platform Type - 200 TN	E	1 EA	80,000				Included	80,000		80,000
	Cutter (Arc Type)	E	1 EA	458,000				Included	458,000		458,000
	SUBTOTAL - This Page (Equipment)								9,766,600		9,766,600

Rev 5-92

DETAILED COST ESTIMATE (CONT.SHEET)

Type of Est. Planning

File No. 8369-A

Date 09/29/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Large) – UFSF (Deferred)

[illegible]

Type of Est. Planning

Date 09/29/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Large) – UFSF (Deferred)

[illegible]

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Regionalized (Large) (Deferred)
 Location Generic
 Requestor D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 10/02/94
 Prep'd By S. L. Johnston
 App'd By *[Signature]*

PROBABLE % VARIATION							
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency
			-	+	-	+	
Performance Specification							
Title I & II	8,404,000	8	5	35	0.40	2.82	2.49%
Title III	1,511,000	1	5	30	0.07	0.43	0.38%
4000 Account	857,000	1	10	50	0.08	0.41	0.36%
5000 Account	34,150,000	33	10	50	3.27	16.34	14.38%
6000 Account	7,001,000	7	10	50	0.67	3.35	2.95%
7000 Account	15,252,000	15	5	50	0.73	7.30	6.50%
8000 Account							
9000 Account	1,497,000	1	10	30	0.14	0.43	0.37%
Indirects	16,452,000	16	10	40	1.57	6.30	5.51%
Construction Management	16,554,000	16	5	20	0.79	3.17	2.77%
GFE							
Project Management	2,790,000	3	10	20	0.27	0.53	0.45%
Subtotal	104,468,000	100			8.00	41.09	

Contingency	37,794,985						36.18%
Suggested TEC	142,262,985						

Rounded TEC	142,000,000						
Calculated Contingency	37,532,000						35.93%

Management Reserve	9,177,000						
Project Contingency	28,355,000						

Risk to Project							18.25%
-----------------	--	--	--	--	--	--	--------

Total	142,000,000						
-------	-------------	--	--	--	--	--	--

PROJECT CONTINGENCY	
%	Cost
6.89%	1,955,000
1.06%	300,000
1.00%	283,000
39.76%	11,273,000
8.15%	2,311,000
17.96%	5,092,000
1.03%	292,000
15.24%	4,320,000
7.66%	2,173,000
1.25%	356,000

SUMMARY
Total Cost by Element
10,359,000
1,811,000
1,140,000
45,423,000
9,312,000
20,344,000
1,789,000
20,772,000
18,727,000
3,146,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% - 30%
Experimental / Special Conditions	Up to 50%
CONCEPTUAL	15% - 25%
Experimental / Special Conditions	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II / AFC	Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project SNF Underwater Fuel Storage Facility
Regionalized (Large) (Deferred)
 Location Generic
 Requester D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/29/94
 Prepared By S. L. Johnston
 Approved By *ML*

Calendar Years	CY93		CY94		CY95		CY96		CY97		CY98		CY99			
Fiscal Years	FY94 ONDJFMAMJJAS		FY95 ONDJFMAMJJAS		FY96 ONDJFMAMJJAS		FY97 ONDJFMAMJJAS		FY98 ONDJFMAMJJAS		FY99 ONDJFMAMJJAS				TOTAL COMPOUNDED RATE	
Escalation Period and Annual Escalation Rate	Months	Rate	Months	Rate	Months	Rate	Months	Rate	Months	Rate	Months	Rate				
<i>Design Period</i>	Design will start October, 1997 and be completed April, 1999 Midpoint to July, 1998															
Title I, II	2	0.4	12	2.8	12	3.0	12	3.1	9	2.5					12.35%	
<i>Construction Period</i>	Construction will begin July, 1999 and last 4 years until July, 2003 Midpoint to July, 2001															
Title III	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
Labor	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
Mat'l & Subcontracts	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
Equipment or GFE	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
Indirects	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
CM	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	
PM	2	0.4	12	2.8	12	3.0	12	3.1	12	3.3	33	8.5			22.91%	

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.6	2.7	3.0	3.3	3.3	3.2
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	2.8	3.5	3.6	3.7	4.0	3.9
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	2.5	3.2	3.4	3.6	3.8	3.6
-------------------------	-----	-----	-----	-----	-----	-----

* It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

COST ESTIMATE SUMMARY

Rev 10-93

Type of Est. Planning File No 8369-A
 Project SNF Underwater Fuel Storage Facility - Regionalized (Small) - UFSF
 Prepared By S. L. Johnston

Date 09/28/94Appr'd By

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION.....			7,579,000
Performance Specification			
Title I and II Design	5,830,000	325,000	
Title III Inspection	1,229,000	195,000	
ED&I Costs are <u>15%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS.....			50,820,000
DIRECT COSTS.....			39,703,000
4000 Improvement to Land	651,000	103,000	
5000 Buildings/Structures	17,437,000	2,771,000	
6000 Utilities	3,618,000	575,000	
7000 Equipment	11,335,000	1,801,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	194,000	
INDIRECT COSTS	9,593,000	1,524,000	11,117,000
CONSTRUCTION MANAGEMENT	9,652,000	1,534,000	11,186,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS.....			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,255,000	358,000	2,613,000
MANAGEMENT RESERVE	5,350,000	850,000	6,200,000
SUBTOTAL.....			78,398,000
CONTINGENCY <u>25%</u> of Subtotal.....			19,602,000
ESCALATION (included in above Totals)		10,230,000	

TOTAL ESTIMATED COST: \$98,000,000* Total Contingency is 36%, including Management Reserve.

Rev 5-92

DETAILED COST ESTIMATE SHEET

Type of Est. Planning

File No. 8369-A

Date 09/28/94

Source (E) Eng. Est.

Prep'd By S. L. Johnston

(M) Vendor

Chk'd By

(P) Pur. Order

Appr'd By

(H) Handbook Ref.

75

[illegible]

Date 09/28/94

[illegible]

Page 3 of 6

Date 09/28/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Small) - UFSF

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Type of Est. PlanningFile No. 8369-ADate 09/28/94

Project SNF Underwater Fuel Storage Facility
Regionalized (Small) - UFSF

ACCT. NO.	DESCRIPTION	E.V. P.H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
7000	EQUIPMENT:										
	Office Furnishings	E	8 EA	3,800				Included	30,400		30,400
	Shop Equipment - Allowance	E	1 LOT	70,000				Included	70,000		70,000
	Monitoring - CAMS and RAMS	E	8 EA	12,000				Included	96,000		96,000
	Overhead Bridge Crane (10 - Ton, Hi Rad)	E	1 EA	1,100,000				Included	1,100,000		1,100,000
	Overhead Bridge Crane (130 - Ton, Regular)	E	1 EA	1,675,000				Included	1,675,000		1,675,000
	10,000 Gal. SST Containment Tanks (@ \$6/Gal.)	E	3 EA	60,000				Included	180,000		180,000
	Transfer Tote	E	2 EA	32,000				Included	64,000		64,000
	Allowance for Misc. Equipment, incl										
	SST Storage Racks, SST Tables, etc	E	1 LOT	1,000,000				Included	1,000,000		1,000,000
	CCTVs	E	7 EA	14,000				Included	98,000		98,000
	Leak Detection System - Allowance	E	1 LOT	100,000				Included	100,000		100,000
	Contamination Containment Device	E	1 EA	155,000				Included	155,000		155,000
	Pressure Wash & Accessories	E	1 LOT	120,000				Included	120,000		120,000
	Filtration Unit	E	2 EA	37,000				Included	74,000		74,000
	Storage Tanks - 100 Gal.	E	2 EA	9,000				Included	18,000		18,000
	Decontamination Equipment	E	2 LOTS	50,000				Included	100,000		100,000
	Water Sprayers (incl. Piping)	E	1 LOT	165,000				Included	165,000		165,000
	Holding Jigs/Fixtures	E	1 LOT	150,000				Included	150,000		150,000
	Survey Equipment	E	2 LOTS	800,000				Included	1,600,000		1,600,000
	Storage/Sample Tanks - 1000 Gal.	E	2 EA	45,000				Included	90,000		90,000
	Analysis Equipment - Allowance	E	1 EA	1,800,000				Included	1,800,000		1,800,000
	Forklift Truck - 10 TN	E	1 EA	100,000				Included	100,000		100,000
	Truck Scale Platform Type - 200 TN	E	1 EA	80,000				Included	80,000		80,000
	Cutter (Arc Type)	E	1 EA	458,000				Included	458,000		458,000
	SUBTOTAL - This Page (Equipment)								9,323,400		9,323,400

Page 5 of 6

Type of Est.	Planning
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Date 09/28/94

Regionalized (Small) – UFSF

[illegible]

Date 09/28/94

Project SNF Underwater Fuel Storage Facility
Regionalized (Small) – UFSF

ACCT. NO.	DESCRIPTION	E.V. P.H	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
9000	OTHER DIRECT COSTS:										
	Full-Time Non-Working Supervisor (4 People for 4 years)	E	4 EA		7,680	30,720	37	1,136,640			1,136,640
	Training (60 People for 40 Hrs. Each)	E	1 LOT			2,400	34	81,600			81,600
	TOTAL - 9000 ACCOUNT							1,218,240			1,218,240
										USE	1,218,000
	TITLE III INSPECTION	E	1 FTE		7,680	7,680	80	614,400			614,400
	FIELD ENGINEERING	E	1 FTE		7,680	7,680	80	614,400			614,400
	PROJECT MANAGEMENT	E	2 FTE		7,680	15,360	95	1,459,200			1,459,200
	Misc. PM Support Costs:										
	Safety	E	0.5 FTE		7,680	3,840	75	288,000			288,000
	Quality	E	0.5 FTE		7,680	3,840	75	288,000			288,000
	Cost Estimating	E	1 LOT		2,000	2,000	80	160,000			160,000
	Administrative	E	1 LOT	60,000					60,000		60,000
	TOTAL - PROJECT MANAGEMENT AND SUPPORT							2,195,200	60,000		2,255,200
										USE	2,255,000
	ENGINEERING:										
	Architectural/Structural/Civil	E	100 DRWG	11,000					1,100,000		1,100,000
	Mechanical	E	200 DRWG	11,000					2,200,000		2,200,000
	Electrical	E	115 DRWG	11,000					1,265,000		1,265,000
	Special Processes	E	115 DRWG	11,000					1,265,000		1,265,000
	TOTAL - ENGINEERING								5,830,000		5,830,000

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Regionalized (Small) - UFSF
 Location Generic
 Requestor D. K. Searle

Type of Est. PlanningFile No. 8369-ADate 09/28/94Prep'd By S. L. JohnstonApp'd By BSL

PROBABLE % VARIATION								PROJECT CONTINGENCY		SUMMARY
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency	%	Cost	Total Cost by Element
			-	+	-	+				
Performance Specification										
Title I & II	6,155,000	9	5	35	0.43	2.98	2.64%	7.38%	1,446,000	7,601,000
Title III	1,424,000	2	5	30	0.10	0.59	0.52%	1.46%	286,000	1,710,000
4000 Account	754,000	1	10	50	0.10	0.52	0.46%	1.28%	251,000	1,005,000
5000 Account	20,208,000	28	10	50	2.80	13.99	12.32%	34.38%	6,740,000	26,948,000
6000 Account	4,193,000	6	10	50	0.58	2.90	2.56%	7.13%	1,399,000	5,592,000
7000 Account	13,136,000	18	5	50	0.91	9.10	8.10%	22.61%	4,431,000	17,567,000
8000 Account										
9000 Account	1,412,000	2	10	30	0.20	0.59	0.51%	1.42%	278,000	1,690,000
Indirects	11,117,000	15	10	40	1.54	6.16	5.39%	15.05%	2,949,000	14,066,000
Construction Management	11,186,000	15	5	20	0.77	3.10	2.71%	7.57%	1,484,000	12,670,000
GFE										
Project Management	2,613,000	4	10	20	0.36	0.72	0.62%	1.72%	337,000	2,950,000
Subtotal	72,198,000	100			7.79	40.66				
Contingency	25,858,960						35.82%			
Suggested TEC	98,056,960									
Rounded TEC	98,000,000									
Calculated Contingency	25,802,000						35.74%			
Management Reserve	6,200,000									6,200,000
Project Contingency	19,602,000									
Risk to Project							18.08%			
Total	98,000,000								19,601,000	98,000,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide.

PLANNING	20% - 30%
Experimental / Special Conditions	Up to 50%
CONCEPTUAL	15% - 25%
Experimental / Special Conditions	Up to 40%
TITLE I	10% - 20%
TITLE II	5% - 15%
TITLE II / AFC	Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project SNF Underwater Fuel Storage Facility
 Location Regionalized (Small) - UFSF
 Requester D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prepared By S. L. Johnston
 Approved By *SL*

Calendar Years	CY93	CY94	CY95	CY96	CY97	CY98	CY99	
Fiscal Years	FY94	FY95	FY96	FY97	FY98	FY99		TOTAL
Escalation Period and Annual Escalation Rate	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS		COMPOUNDED RATE
	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate		
Design Period	Design will start October, 1995 and be completed April, 1997 Midpoint to July, 1996							
Title I, II	2 0.4	12 2.8	9 2.3					5.57%
Construction Period	Construction will begin July, 1997 and last 4 years until July, 2001 Midpoint to July, 1999							
Title III	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Labor	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Mat'l & Subcontracts	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Equipment or GFE	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
Indirects	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
CM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%
PM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	9 2.3		15.89%

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.7	3.0	3.3	3.3	3.2	3.1
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	3.5	3.6	3.7	4.0	3.9	3.7
-------------------------	-----	-----	-----	-----	-----	-----

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	3.2	3.4	3.6	3.8	3.6	3.5
-------------------------	-----	-----	-----	-----	-----	-----

* It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

COST ESTIMATE SUMMARY

Rev 10-93

Type of Est. Planning File No 8369-A Date 09/28/94
 Project SNF Underwater Fuel Storage Facility - Regionalized (Small) - UFSF (Deferred)
 Prepared By S. L. Johnston Appr'd By *Boley*

	Unescalated	Escalation	Totals
ENGINEERING, DESIGN AND INSPECTION			8,061,000
Performance Specification			
Title I and II Design	5,830,000	720,000	
Title III Inspection	1,229,000	282,000	
ED&I Costs are <u>15%</u> of Construction Costs and GFE/M			
CONSTRUCTION COSTS			53,899,000
DIRECT COSTS			42,108,000
4000 Improvement to Land	651,000	149,000	
5000 Buildings/Structures	17,437,000	3,995,000	
6000 Utilities	3,618,000	829,000	
7000 Equipment	11,335,000	2,597,000	
8000 Demolition & Removal			
9000 Other Direct Costs	1,218,000	279,000	
INDIRECT COSTS	9,593,000	2,198,000	11,791,000
CONSTRUCTION MANAGEMENT	9,652,000	2,212,000	11,864,000
GOVERNMENT FURNISHED EQUIPMENT/MATERIALS			
Purchased By OC			
Procurement Fee			
PROJECT MANAGEMENT	2,255,000	517,000	2,772,000
MANAGEMENT RESERVE	5,350,000	1,226,000	6,576,000
SUBTOTAL			83,172,000
CONTINGENCY	26% of Subtotal		21,828,000
ESCALATION (included in above Totals)			
		15,004,000	

TOTAL ESTIMATED COST: \$105,000,000* Total Contingency is 37%, including Management Reserve.

Rev 5-92

DETAILED COST ESTIMATE SHEET

	Type of Est.	Planning
Source	(E) Eng. Est.	
	(V) Vendor	
	(P) Pur. Order	
	(H) Handbook	Ref.

File No. 8369-A Date 09/28/94
 Prep'd By S. L. Johnston
 Chk'd By [Signature]
 Appr'd By [Signature]

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

[illegible]

Date 09/28/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Small) - UFSF (Deferred)

[illegible]

DETAILED COST ESTIMATE (CONT. SHEET)

Type of Est. PlanningFile No. 8369-ADate 09/28/94

Project SNF Underwater Fuel Storage Facility
Regionalized (Small) - UFSF (Deferred)

ACCT. NO.	DESCRIPTION	E.V. P.H.	MAT'L UNIT	MAT'L UT. COST	UNIT LAB. HRS	TOTAL LAB. HRS.	LABOR RATE	LABOR COST	MAT'L COST	OTHER COST	TOTAL COST
7000	EQUIPMENT:										
	Office Furnishings	E	8 EA	3,800				Included	30,400		30,400
	Shop Equipment - Allowance	E	1 LOT	70,000				Included	70,000		70,000
	Monitoring - CAMS and RAMS	E	8 EA	12,000				Included	96,000		96,000
	Overhead Bridge Crane (10 - Ton, Hi Rad)	E	1 EA	1,100,000				Included	1,100,000		1,100,000
	Overhead Bridge Crane (130 - Ton, Regular)	E	1 EA	1,675,000				Included	1,675,000		1,675,000
	10,000 Gal. SST Containment Tanks (@ \$6/Gal.)	E	3 EA	60,000				Included	180,000		180,000
	Transfer Tote	E	2 EA	32,000				Included	64,000		64,000
	Allowance for Misc. Equipment, incl										
	SST Storage Racks, SST Tables, etc	E	1 LOT	1,000,000				Included	1,000,000		1,000,000
	CCTVs	E	7 EA	14,000				Included	98,000		98,000
	Leak Detection System - Allowance	E	1 LOT	100,000				Included	100,000		100,000
	Contamination Containment Device	E	1 EA	155,000				Included	155,000		155,000
	Pressure Wash & Accessories	E	1 LOT	120,000				Included	120,000		120,000
	Filtration Unit	E	2 EA	37,000				Included	74,000		74,000
	Storage Tanks - 100 Gal	E	2 EA	9,000				Included	18,000		18,000
	Decontamination Equipment	E	2 LOTS	50,000				Included	100,000		100,000
	Water Sprayers (incl. Piping)	E	1 LOT	165,000				Included	165,000		165,000
	Holding Jigs/Fixtures	E	1 LOT	150,000				Included	150,000		150,000
	Survey Equipment	E	2 LOTS	800,000				Included	1,600,000		1,600,000
	Storage/Sample Tanks - 1000 Gal.	E	2 EA	45,000				Included	90,000		90,000
	Analysis Equipment - Allowance	E	1 EA	1,800,000				Included	1,800,000		1,800,000
	Forklift Truck - 10 TN	E	1 EA	100,000				Included	100,000		100,000
	Truck Scale Platform Type - 200 TN	E	1 EA	80,000				Included	80,000		80,000
	Cutter (Arc Type)	E	1 EA	458,000				Included	458,000		458,000
	SUBTOTAL - This Page (Equipment)								9,323,400		9,323,400

Type of Est. Planning

File No. 8369-A

Date 09/28/94

Project	<u>SNF Underwater Fuel Storage Facility</u>
	<u>Regionalized (Small) - UFSF (Deferred)</u>

[illegible]

DETAILED COST ESTIMATE (CONT.SHEET)

Date 09/28/94

Project	SNF Underwater Fuel Storage Facility
	Regionalized (Small) - UFSF (Deferred)

[illegible]

Rev 4-94

SNF Underwater Fuel Storage Facility

Project Regionalized (Small) - UFSF (Deferred)

Type of Est. Planning

Location Generic

File No. 8369-A

Requestor D. K. Searle

Date 09/28/94

Prep'd By S. L. Johnston

App'd By *for*

PROBABLE % VARIATION							
Cost Estimate Element	Escalated Cost	% Total Cost	Prob % Var From Est		WT % of Prob		Contingency
			-	+	-	+	
Performance Specification							
Title I & II	6,550,000	9	5	35	0.43	2.99	2.65%
Title III	1,511,000	2	5	30	0.10	0.59	0.52%
4000 Account	800,000	1	10	50	0.10	0.52	0.46%
5000 Account	21,432,000	28	10	50	2.80	13.99	12.31%
6000 Account	4,447,000	6	10	50	0.58	2.90	2.55%
7000 Account	13,932,000	18	5	50	0.91	9.09	8.09%
8000 Account							
9000 Account	1,497,000	2	10	30	0.20	0.59	0.51%
Indirects	11,791,000	15	10	40	1.54	6.16	5.39%
Construction Management	11,864,000	15	5	20	0.77	3.10	2.71%
GFE							
Project Management	2,772,000	4	10	20	0.36	0.72	0.62%
Subtotal	76,596,000	100			7.79	40.66	

PROJECT CONTINGENCY	
%	Cost
7.40%	1,616,000
1.46%	319,000
1.28%	280,000
34.38%	7,503,000
7.13%	1,557,000
22.60%	4,933,000
1.42%	310,000
15.04%	3,284,000
7.57%	1,652,000
1.72%	375,000

SUMMARY
Total Cost by Element
8,166,000
1,830,000
1,080,000
28,935,000
6,004,000
18,865,000
1,807,000
15,075,000
13,516,000
3,147,000

Contingency	27,432,925						35.82%
Suggested TEC	104,028,925						

Rounded TEC	105,000,000						
Calculated Contingency	28,404,000						37.08%

Management Reserve	6,576,000						
Project Contingency	21,828,000						

Risk to Project							16.73%
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Total	105,000,000						
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21,829,000	
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6,576,000

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105,000,000

CONFIDENCE LEVEL AND ASSUMED RISKS:

The EG&G Idaho Cost Estimate Contingency Analysis Model is based on the applied contingency and the assumptions upon which the estimate was predicated. The model is applied with a suggested risk level of 18%, and a level of confidence of 90% the estimate will fall within the bid range. The Contingency Analysis is based on a weighted average to provide a 90% probability of underrun and 10% probability of overrun.

CONTINGENCY ANALYSIS GUIDE BY TYPE OF ESTIMATE:

Guidelines established by DOE/MA-0063 Vol 6., Cost Estimating Methods and Techniques, and as presented in the INEL Cost Estimating Guide.

PLANNING

20% - 30%

Experimental / Special Conditions

Up to 50%

CONCEPTUAL

15% - 25%

Experimental / Special Conditions

Up to 40%

TITLE I

10% - 20%

TITLE II

5% - 15%

TITLE II / AFC

Market Conditions

EG&G Idaho, Inc.

ESCALATION SHEET

Rev 3-94

Project SNF Underwater Fuel Storage Facility
Regionalized (Small) - UFSF (Deferred)
 Location Generic
 Requester D. K. Searle

Type of Est. Planning
 File No. 8369-A

Date 09/28/94
 Prepared By S. L. Johnston
 Approved By *[Signature]*

Calendar Years	CY93	CY94	CY95	CY96	CY97	CY98	CY99	
Fiscal Years	FY94	FY95	FY96	FY97	FY98	FY99		
Escalation Period and Annual Escalation Rate	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS		TOTAL COMPOUNDED RATE
	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate	Months Rate		
<i>Design Period</i>	Design will start October, 1997 and be completed April, 1999 Midpoint to July, 1998							
Title I, II	2 0.4	12 2.8	12 3.0	12 3.1	9 2.5			12.35%
<i>Construction Period</i>	Construction will begin July, 1999 and last 4 years until July, 2003 Midpoint to July, 2001							
Title III	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Labor	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Mat'l & Subcontracts	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Equipment or GFE	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
Indirects	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
CM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%
PM	2 0.4	12 2.8	12 3.0	12 3.1	12 3.3	33 8.5		22.91%

The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Defense Programs & General Construction).

% Change/Composite Rate	2.7	3.0	3.3	3.3	3.2	3.1
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The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Environmental Restoration).

% Change/Composite Rate	3.5	3.6	3.7	4.0	3.9	3.7
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The following rates are based on the Feb 1994 Economic Escalation Indices for DOE Construction Projects (Waste Management).

% Change/Composite Rate	3.2	3.4	3.6	3.8	3.6	3.5
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* It will be the responsibility of the estimator to determine the appropriate escalation rate to use, based on project funding and type.

Appendix B
Source Term Data

Appendix B

Source Term Data

"Providing research and development services to the government"

INTEROFFICE CORRESPONDENCE

Date: September 1, 1994

To: J. K. Rawlins, MS 3765

From: P. R. Leonard, MS 2110 *ARL*

Subject: SOURCE TERM FOR RELEASE FROM SPENT NUCLEAR FUEL STORAGE POOLS - PRL-17-94

References: M. L. Carboneau letter MLC-02-94, "ORIGEN2 Calculation For A High Enriched NRU Fuel", dated August 19, 1994.

Clawson, K. L., G. E. Start, and N. R. Ricks (1989), "Climatography of the Idaho National Engineering Laboratory", 2nd Edition, DOE/ID-12118, December 1989.

WINCO, "Environmental Evaluation of Fluorinel Dissolution Process and Fuel Storage Facility, WIN-159, June 1985

Mishima, J., "Recommended Values and Technical Bases for Airborne Release Fractions (ARFs), Airborne Release Rates (ARRs), and Respirable Fractions (RFs) for Materials from Accidents at DOE Non-Reactor Nuclear Facilities", October 1993.

This letter transmits a list of radionuclides that could be released under normal conditions from a building containing spent nuclear fuel (SNF) in water-filled storage pools. The beginning point for determining which radionuclides to include in this list was the full inventory of fission products and actinides reported in the referenced ORIGEN2 computer code calculation (Carboneau 1994).

The next step was to determine how much of this full inventory would be released to the fuel storage pools. It is anticipated that there could be as many as 22,000 fuel elements (FEs) stored in the proposed pools. Of these, it is expected that 10% (2,200 FEs) will be immediately enclosed in a container upon arrival because of existing cladding failures. Of the remaining 19,800 FEs, it was assumed that an additional 10%, or 1,980, will experience cladding failure the first year. From these 1,980 defected FEs, it was assumed that 1% of the FE inventory would leak from the FE and into the pool water. Thus, it was assumed that an effective 19.8 FEs would release their entire contents into the pools the first year. These assumptions were taken from WINCO (1985).

In order to obtain a workable number of radionuclides, this rather large inventory was then subjected to a screening calculation to select those radionuclides most likely to make the greatest contribution to radiation dose. This was done by determining a hazard index (HI) for each radionuclide, ranking the radionuclides in order of decreasing HI, and selecting the top contributors. The HI was determined by dividing the number of curies of a given radionuclide assumed to be in found in the pool water every year by the appropriate concentration levels taken from Table 2 of Appendix E, 40 CFR Part 61. For example, the Table 2 concentration limit for Cs-134 is $2.7\text{E}-14 \text{ Ci/m}^3$. Dividing this number into the activity of Cs-134 assumed to be in the pool ($2.76\text{E}+4 \text{ Ci}$) yields an HI of $1.0\text{E}+18$. The individual HIs for all the radionuclides were summed to obtain a total HI, and the percent contributions of each radionuclide to the total HI were calculated. Those radionuclides which comprise 99.999% of the total HI were selected for inclusion in the next step.

That next step was to estimate how much of the activity from the selected radionuclides in the water is released to the building. The pan evaporation rate outside at the INEL is estimated to be 43 inches per year (Clawson 1989). The evaporation rate from a pool inside a building will certainly be less than that value, but this number was chosen as an upper bound. Another upper bound assumption was that 1/1000 of the radionuclides in that 43 inches is released into the building when the water evaporates. This is clearly not the case, the particulate matter tending to remain behind, but it simulates the phenomenon of resuspension from surfaces where the particulate is depositing and drying on the pool walls directly above the water surface. This value was taken from 40 CFR Part 61, Appendix D, 2.(b)(ii). Another approach was taken in Mishima (1993). In that report one finds a range of airborne release rates (ARRs) from $4\text{E}-7/\text{hr}$ to $4\text{E}-8/\text{hr}$ for resuspension from aqueous solutions. Taken over the 8760 hours in a year, this yields a range of releases from $0.35\text{E}-3$ to $3.5\text{E}-3$ per year. These values bracket the E-3 value given in 40 CFR Part 61. Thus, I decided to use the E-3 value.

A final calculation assumed that the air in the building passes through two banks of high efficiency particulate air (HEPA) filters before being released to the atmosphere. The efficiencies of the two sets of filters were assumed to be 99.97% and 99.95% in accordance with accepted practice. The decontamination factor (DF) for these filters are calculated from the following:

$$\text{DF} = 1/(1-.9997) * 1/(1-.9995) = (3.33\text{E}+3)(2.00\text{E}+3) = 6.67\text{E}+6$$

The amount of particulate matter escaping capture on the filters is calculated to be that amount entering the filters divided by the DF. This filtration calculation was applied to the activity released from the pools.

J. k. Rawlins
September 1, 1994
PRL-17-94
Page 3

This process ignores the behavior of gasses and tritium (H-3). A higher fraction of gasses and volatile materials will escape from the FEs into the water, a high fraction will escape from the water, and most will not be affected at all by the HEPA filters. Thus, the total quantities of H-3, C-14, and Kr-85 calculated to be in the FEs and assumed to leak from the FEs into the water were assumed to escape from the pools and to be released to the atmosphere.

The end result of these assumptions and calculations are presented in a table in the Appendix. The table lists the activities of the 41 radionuclides that are assumed to be released to the atmosphere in one year from a building in which SNF is stored in pools.

If you have any questions on this matter, please contact me at 526-8523.

Attachment:
As Stated

cc: (w/Attachment)
W. E. Harrison, MS 2110
L. N. Peterson, MS 2110
ROU-94-006 Project File
P. R. Leonard Letter File - 2

Appendix

RADIONUCLIDES RELEASED TO THE ATMOSPHERE FROM A FUEL WET STORAGE FACILITY

<u>Radionuclide</u>	<u>Curies Released</u>	<u>Radionuclide</u>	<u>Curies Released</u>
Cs-134	4.9E-07	Ag-110m	8.5E-10
Cs-137	3.3E-07	Ru-103	2.0E-08
Sr-90	3.2E-07	Pu-239	7.5E-12
Sr-89	1.9E-05	Pu-240	7.3E-12
Ru-106	3.0E-07	Cd-113m	5.1E-11
Ce-144	3.7E-06	Sn-121m	3.0E-13
Pu-238	7.6E-09	Am-241	4.8E-12
Eu-154	2.6E-08	Sn-123	2.3E-09
Zr-95	4.6E-07	Pu-242	3.7E-12
Nb-95	1.0E-06	Te-129m	2.2E-10
Y-91	2.9E-07	Np-237	1.5E-12
Ag-110	1.1E-11	Cm-242	5.3E-11
Sb-125	1.8E-08	Tc-99	4.2E-11
Te-127m	6.8E-09	Pm-148	1.1E-11
Pm-147	3.6E-07	Np-239	3.5E-13
Pu-241	2.7E-09	Sn-126	1.2E-12
Y-90	3.2E-07	Pu-236	1.3E-12
Eu-155	1.4E-08	Pr-144	3.7E-06
Te-125m	4.3E-09	H-3	7.8E+03
Cm-244	3.7E-11	C-14	2.1E-03
Kr-85	2.2E+05		

INTEROFFICE CORRESPONDENCE

Date: August 19, 1994

To: J. K. Rawlins, MS 3765

From: M. L. Carboneau, MS 3890

M Carboneau

Subject: ORIGEN2 CALCULATION FOR A HIGH ENRICHED NRU FUEL - MLC-02-94

Reference: (a) G. W. WACHS, PERSONAL COMMUNICATION CONCERNING THE CANADIAN NRU FUEL DESCRIPTION, AUGUST 1994

An ORIGEN2 calculation was performed for a 93% ^{235}U enriched NRU fuel element. The initial mass of ^{235}U for the fuel element was 491 grams and the ^{238}U mass was 36.0 grams. The irradiation period consisted of a constant power of 1.389 MW for 215.0 days followed by a 365.0 day cooling period. The fission product cross-section and decay library used for this calculation was the standard "pwrxsliba2" library. The expected ^{235}U burnup was 76%.

The results of the ORIGEN2 calculation, printed at scram (e.g., at 215 days of irradiation) and at 365 days of decay time are shown on the microfiche card attached to Page 2. The detailed ORIGEN2 results are calculated in terms of grams, curies, and watts. The calculated ^{235}U mass at the end of the 215 days of irradiation is 111.3 grams. Therefore, the ^{235}U burnup based on the ORIGEN2 calculation is 77.3 atom-percent [e.g., $(491-111.3)/491.0$].