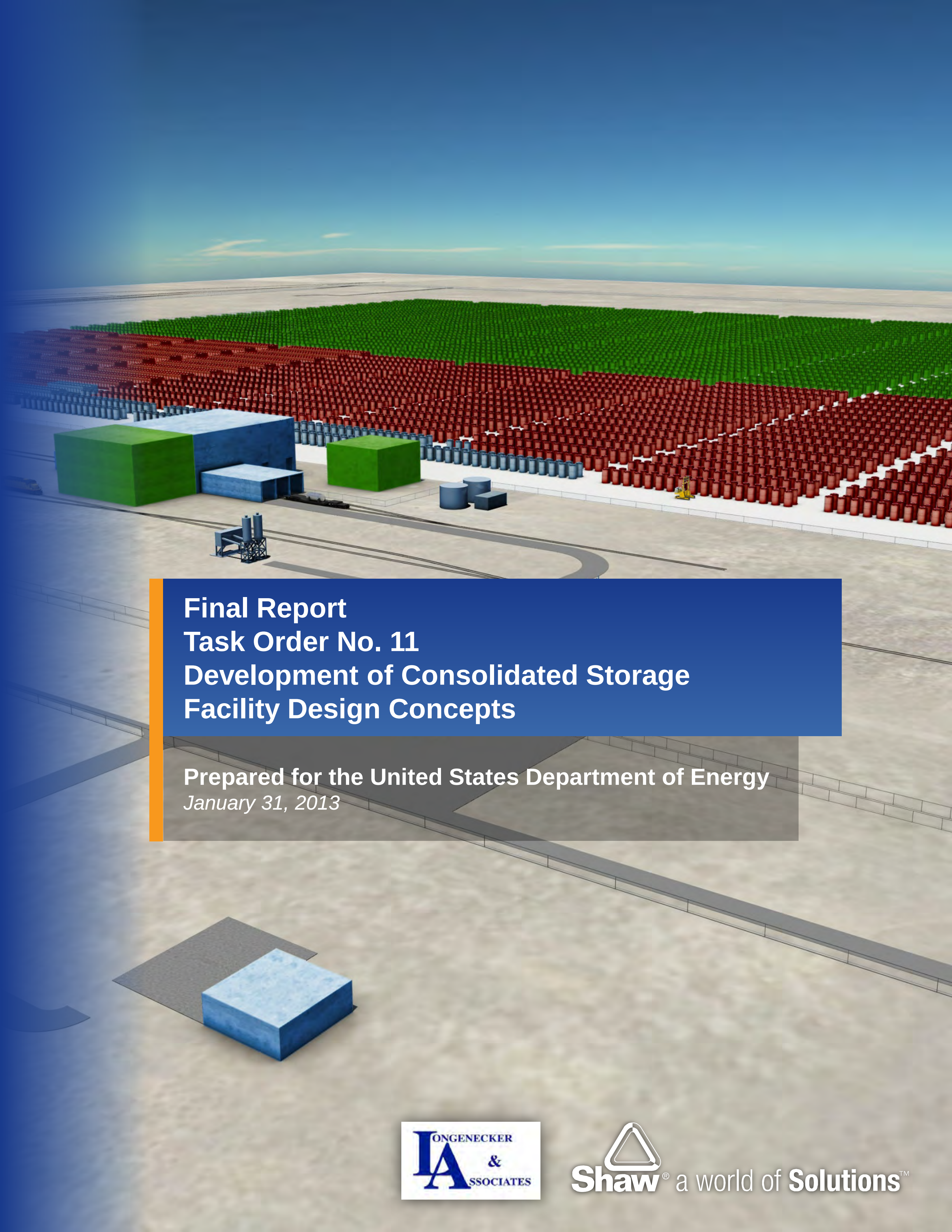

Final Report
Task Order No. 11
Development of Consolidated Storage Facility Design Concepts

Prepared for the United States Department of Energy
January 31, 2013

LONGENECKER & ASSOCIATES

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DISCLAIMER

This is a technical report that does not take into account the contractual limitations under the Standard Contract for Disposal of Spent Nuclear Fuel (SNF) and/or High-Level Radioactive Waste that DOE has in place with nuclear utilities (10 CFR 961.11). Under the Standard Contract, DOE is obligated to accept only bare SNF, also sometimes referred to as used nuclear fuel (UNF). Acceptance of canistered SNF would require a mutual agreement to modify the contract.

Contributing Authors

Program Manager	Jack Clemmens - The Shaw Group
Task Manager	Richard Berry - The Shaw Group
Section 1.0, Summary	Gary Vine - Longenecker & Associates
Section 2.0, Introduction	Gary Vine - Longenecker & Associates
Section 3.0, Consolidated Storage Facility	Wayne Lewis, Jeffrey Johns, Lisa Claus, Nancy Cox, William Fillingim, and Robert Bradbury - The Shaw Group; Brian Gutherman and Michael Duffy - Longenecker & Associates
Section 4.0, Security	Wayne Lewis - The Shaw Group; William Desmond - Longenecker & Associates
Section 5.0, Transportation	Alex Thrower, Eileen Supko, Randy Coppage, Michael Duffy - Longenecker & Associates; Robert Bradbury - The Shaw Group
Section 6.0, Research & Development	David Stahl - Longenecker & Associates
Section 7.0, Project Planning	Richard Berry - The Shaw Group
Section 8.0, Costs	Richard Berry - The Shaw Group
Section 9.0, Waste	Brian Gutherman - Longenecker & Associates
Appendices A–H, Costs	David Jansen - Longenecker & Associates
Technical Editor	Graham Watson - The Shaw Group

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Project Glossary

Bare Fuel Cask—A metal cask with a bolted lid and a fuel basket inside designed for UNF storage and/or transportation. A bare fuel cask performs the confinement function during storage and the containment function during transportation. A bare fuel cask does not employ a canister.

Canister—A fully welded and inerted metal cylinder with a fuel basket inside that is placed inside an overpack for storage at an ISFSI or CSF, and into a transport cask for off-site transportation. The canister performs the confinement function during storage at the ISFSI or CSF.

Cask Handling Building (CHB)—A building at the CSF dedicated to receiving transport casks upon arrival, preparing transport casks for off-site shipment, and transferring loaded used fuel canisters among containers, including transfer casks, transport casks, and overpacks.

Cask—A colloquial term that can mean a bare fuel cask, a transport cask, or an overpack. The term “cask,” in the context of the 10 CFR Part 72 regulations applies to bare fuel casks and dry fuel storage systems.

Cask Handling Crane (CHC)—The crane used to lift and move the transfer cask, transport cask, overpack, and/or canister.

Cask Vendor—The entity that is the design authority and supplier of a bare fuel cask, dry fuel storage system, or transportation package. The vendor is usually, but not always the CoC holder.

Certificate of Compliance (CoC)—A 10 CFR Part 72 CoC is the document issued by the NRC that indicates the acceptability of a cask or cask system for use at an ISFSI under a 10 CFR Part 72 general license or by incorporation of the design by reference into a Part 72 specific license. A 10 CFR Part 71 CoC is the document issued by the NRC that indicates the acceptability of a transportation package for use in transporting radioactive material, including used nuclear fuel, outside the area controlled by the licensee responsible for the radioactive material. The CoC contains the terms, specifications, and conditions for using the cask, DFSS, or transportation package.

CoC Holder—The entity that holds the NRC-issued Certificate of Compliance under 10 CFR Part 72 and/or 10 CFR Part 71 for a bare fuel cask, dry fuel storage system, or transportation package design.

Consist—The rolling stock, exclusive of the locomotive, making up a train.

Consolidated Interim Storage (CIS)—The concept of transporting UNF from various locations around the country to one or more interim storage facilities to await further disposition.

Consolidated Storage Facility (CSF)—A facility designed, licensed and constructed for consolidated interim storage.

Construction Specification—A document developed for the purpose of defining construction requirements for various activities.

Design Life—The minimum duration for which the CSF and/or structures, systems, and components within the CSF are engineered to perform their intended function set forth in the design bases for the facility, if operated and maintained appropriately.

Dry Fuel Storage System (DFSS)—A UNF storage technology comprised of a canister inside an overpack or horizontal storage module used at an ISFSI or CSF.

Dual Purpose Canister (DPC)—The canister component of a cask and canister system that is dual purpose certified.

Dual Purpose Certified—The concept of designing and licensing a component, or combination of components for both UNF storage in accordance with 10 CFR Part 72 and transportation in accordance with 10 Part CFR 71. Dual purpose designs become dual purpose certified upon NRC issuance of the second of the two required approvals. For storage and transportation, both the component design and the contents to be stored or transported must be approved by the NRC in a 10 CFR Part 72 specific license or CoC, and a 10 CFR Part 71 CoC.

General License—A general license is a license that has been given to 10 CFR Part 50 power licensees by regulation to store UNF from a reactor at an ISFSI on the site of that reactor. The general license requires the use of a cask or DFSS that has received a CoC from the NRC in accordance with 10 CFR Part 72, Subpart L for the cask/DFSS design and contents.

Greater than Class C (GTCC) Waste—Low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in 10 CFR 61.55.

Horizontal Storage Module (HSM)—A ventilated concrete structure used to store a canister in the horizontal orientation at an ISFSI or CSF.

Impact Limiter—Engineered device designed to attach to a radioactive material transportation package and limit the deceleration loads on the package, if dropped during transportation, to within design values.

Important to Safety (ITS)—A term used to describe an item, function, or condition required:

- To maintain the conditions required to safely store UNF, high-level radioactive waste, or reactor-related greater than class C (GTCC) waste;
- To prevent damage to the UNF, the high-level radioactive waste, or reactor-related GTCC waste container during handling and storage; or
- To provide reasonable assurance that UNF, high-level radioactive waste, or reactor-related GTCC waste can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public or workers.

Independent Spent Fuel Storage Installation (ISFSI)—A complex designed and constructed for the interim storage of UNF, solid reactor-related GTCC waste, and other radioactive materials associated with used fuel and reactor-related GTCC waste storage.

Intermodal Transfer (IMT)—The process of transferring a transport cask to/from different modes of transport (i.e., rail, barge or truck).

Not Important to Safety—An item, function, or condition related to the ISFSI, or its activities, that does not meet the definition of “Important to Safety.”

Operating Plant Site—A nuclear plant site with at least one operating reactor.

Overpack—A bolted lid metal cask or ventilated concrete cask used for storage of UNF in a canister at an ISFSI or CSF. Certain bolted-lid, metal overpack designs may also serve as transport casks for the UNF canisters if licensed to do so.

Plant (or Plant Site)—A current or former nuclear generating station that has UNF stored on site and has, or had one or more reactors on the site.

Protected Area (PA)—The area encompassed by physical barriers and to which access is controlled.

Safe Shutdown Earthquake (SSE)—The earthquake that produces the ground motion for which those features of the CSF necessary for continued operation do not need to function, but must remain standing without significant damage.

Safety Analysis Report (SAR)—A document that contains the complete licensing basis for a 10 CFR Part 72 specific license, a 10 CFR Part 72 cask certification, or a 10 CFR Part 71 transport package certification.

Shutdown Reactor—A reactor that has permanently ceased operating. A shutdown reactor may be located on an operating plant site or a shutdown plant site.

Shutdown Plant Site—A nuclear plant site where all reactors have permanently ceased operating.

Single-Failure-Proof Lifting System—A lifting system designed such that a single failure will not result in the loss of the capability of the system to prevent an uncontrolled lowering of the load. A "lifting system," comprised of the crane, lifting devices, and interfacing lifting points, must meet the guidance of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," Section 5.1.6, to be considered single-failure-proof.

Specific License—A license granted by the NRC to a specific entity to construct and operate an Independent Spent Fuel Storage Installation at a specific geographic location in response to an application submitted for review in accordance with 10 CFR Part 72.

Spent Nuclear Fuel (SNF)—Irradiated nuclear fuel removed from a nuclear reactor (also "used nuclear fuel").

SSC—Structure, System, or Component.

Start Clean Stay Clean—An over-arching facility design concept wherein the UNF assemblies are not handled individually and remain inside a sealed canister from receipt at the facility to placement on the storage pad.

Stranded Fuel—UNF stored at a shutdown plant site.

Transportation (or Transport) Cask—A bolted-lid, metal container certified by the NRC in accordance with 10 CFR Part 71 for the off-site transportation of UNF. The transport cask may be a bare fuel cask or may contain a canister as part of a combined transportation package. The transport cask provides the 10 CFR Part 71 containment function for the transportation package.

Transportation Package—Any container certified by the NRC in accordance with 10 CFR Part 71 for the off-site transportation of radioactive material.

Transfer Cask—A bolted-lid metal cask used to provide temporary shielding and structural protection for the used fuel canister during UNF loading in a spent fuel pool and during transfer of the loaded canister to or from the storage overpack or transport cask. The transfer cask has lifting trunnions to permit engagement with other components such as a transfer trailer and cask handling crane lift yoke.

Used Nuclear Fuel (UNF)—Irradiated nuclear fuel removed from a nuclear reactor (also “spent nuclear fuel”).

Vault Storage System (VSS)—An alternative storage system to using casks to store the fuel-loaded canister whereby the canisters are stored in partially or fully subterranean individual silos with lids.

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Acronyms and Abbreviations

AAR	Association of American Railroads
AC&T	American Cranes & Transport
ACD	alarm communications and display
ACS	access control system
ALARA	as low as reasonably achievable
ASLB	Atomic Safety and Licensing Board
BFS	BNFL Fuel Solutions
BRC	Blue Ribbon Commission on America’s Nuclear Future
BWR	Boiling Water Reactor
CAS	Central Alarm Station
CCTV	closed-circuit television
CEC	Cavity Enclosure Container
CFR	Code of Federal Regulations
CHB	Cask Handling Building
CHC	Cask Handling Crane
CIS	Consolidated Interim Storage
CMF	Cask Maintenance Facility
CoC	Certificate of Compliance
CSF	Consolidated Storage Facility
CTF	Cask/Canister Transfer Facility
DBTT	ductile-to-brittle transition temperature
DE	destructive examination
DFSS	Dry Fuel Storage System
DOE	U.S. Department of Energy
DPC	Dual Purpose Canister
DSC	Dry Shielded Canister
D&D	Decontamination and Decommissioning
ECP	Electronically Controlled Pneumatic
EIA	Energy Information Agency
EIS	Environmental Impact Statement (NRC)
EMAD	Engine Maintenance and Disassembly
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	Environmental Report (applicant)
FDS	Final Delivery Schedule
FMF	Fleet Management Facility
FR	Federal Register
FRA	Federal Railroad Administration
F-R-A	Functional-Requirements-Architecture
FSAR	Final Safety Analysis Report
GISF	Generic Interim Storage Facility
GNSI	General Nuclear Systems, Inc.
GTCC	Greater-than-Class C

HAC	Hypothetical Accident Conditions
HBU	High Burnup
HHT	Heavy-Haul Truck
HI-STAR	Holtec International-Storage, Transport, and Repository
HI-STORM	Holtec International-Storage and Transfer Operation Reinforced Module
HLW	High-Level Radioactive Waste
HSM	Horizontal Storage Module
HVAC	Heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
ICCPS	Impressed Current Cathodic Protection System
ICS	Incident Command System
IDS	Intrusion Detection System
IMT	Intermodal Transfer
INL	Idaho National Laboratory
ISFSI	Independent Spent Fuel Storage Installation
ISG	Interim Staff Guidance
ITS	Important to Safety
L&A	Longenecker & Associates
LEED	Leadership in Energy and Environmental Design
LLEA	local law enforcement agency
LLRW	low-level radioactive waste
LWT	Legal-Weight Highway Truck
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
MTU	Metric Tons Uranium
MWd/MTU	megawatt-day per metric ton uranium
NCT	Normal Conditions of Transport
NDE	nondestructive examination
NEPA	National Environmental Policy Act of 1969, as amended
NNSS	Nevada National Security Site
NMSS	Nuclear Material Safety and Safeguards (NRC)
NRC	U.S. Nuclear Regulatory Commission
NUHOMS	Nuclear Horizontal Modular Storage
NWPA	Nuclear Waste Policy Act
OCA	Owner Controlled Area
OCC	Operations Control Center
OCRWM	Office of Civilian Radioactive Waste Management
OWT	overweight truck
PA	Protected Area
PFS	Private Fuel Storage
PNL	Pacific Northwest Laboratory
PWR	Pressurized Water Reactor
QA	quality assurance
R&D	Research and Development
RA	Radiation Area

RCRA	Resource Conservation and Recovery Act
SAR	Safety Analysis Report (applicant)
SAS	Secondary Alarm Station
SCC	Shipment Control and Coordination Center
SER	Safety Evaluation Report (NRC)
SFP	Spent Fuel Pool
Shaw	Shaw Environmental & Infrastructure, Inc.
SNF	Spent Nuclear Fuel
SRP	Standard Review Plan
SSC	Structure, System, and Component
SSE	Safe Shutdown Earthquake
STAD	Standardized Transportable Aging Disposable
STB	Surface Transportation Board
STC	Storage Transport Cask
TAD	Transportation, Aging, and Disposal
TLD	Thermo-luminescent Dosimeter
TOM	Transportation Operations Model
TSC	Transportable Storage Canister
TSF	Transportation Security Force
TSP	Top Surface Pad
TTCI	Transportation Technology Center Inc.
U.S.	United States
UMS	Universal MPC System
UMS-T	UMS-Transportation
UNF	Used Nuclear Fuel
UPS	Uninterruptable Power Supply
USCG	U.S. Coast Guard
USDOT	U.S. Department of Transportation
UTC	Universal Transport Cask
VBS	Vehicle Barrier System
VCT	Vertical Cask Transporter
VVM	Vertical Ventilated Module
WBS	Work Breakdown Structure
YM	Yucca Mountain

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1.0 SUMMARY

This report has been prepared by the industry team of Shaw Environmental & Infrastructure, Inc. (Shaw) and Longenecker & Associates (L&A) in response to the Department of Energy (DOE) Statement of Work, “Development of Consolidated Storage Facility Design Concepts,” indefinite delivery/indefinite quantity Task Order No. 11, as specified by the DOE’s Office of Nuclear Energy.

The overall results of this report are presented in this Summary. For historical and policy context, the next section (Section 2.0, Introduction) provides an overview of the report content, relying heavily on key quotes from the recent “Report of the Blue Ribbon Commission on America’s Nuclear Future (BRC)” (January, 2012). The BRC report was directed by President Barack Obama and prepared over a 2-year period by a distinguished 12-member commission for the Secretary of Energy. The BRC report has strong bipartisan support in Congress, particularly regarding its recommendations for “prompt efforts to develop one or more consolidated storage facilities” and for a consent-based process for siting both consolidated storage sites and permanent repositories, forging a consensus among federal and state governments and local communities. The BRC also recommended “early preparation for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities.” The close alignment between the recommendations in this report and these BRC recommendations, as displayed in Section 2.0, is due largely to the close alignment between the DOE’s Statement of Work for this project and the BRC report. Section 2.0 also quotes from the recently issued “Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste” (DOE, January 2013). That Strategy report addresses several important needs, including the Administration’s response to the BRC report (with which it largely agrees). Thus, this Task Order No. 11 report is also well aligned with the DOE’s latest thinking on consolidated storage matters.

As discussed in Section 2.0, the Consolidated Storage Facility (CSF) concept developed by the Shaw-L&A team is based on an integrated system analysis and engineering approach that optimizes interfaces between reactor sites, transportation logistics, and CSF processes and storage features. Consistent with BRC recommendations, the CSF is constructed in a stepwise manner,[1] based on four unique operational phases of fuel shipment to efficiently transport used nuclear fuel (UNF) to a CSF that starts operation as a simple, relatively small “pilot” facility that expands over time in three unique construction stages to accommodate increased shipments in later phases, as shown in **Figure 1.0-1**.

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[1] This concept is based on a single CSF. The BRC report and the recent DOE Strategy report both discuss the possibility of multiple CSFs. That option is examined in this report, but its baseline assumption is a single CSF.

Figure 1.0-1
CSF Site Plan

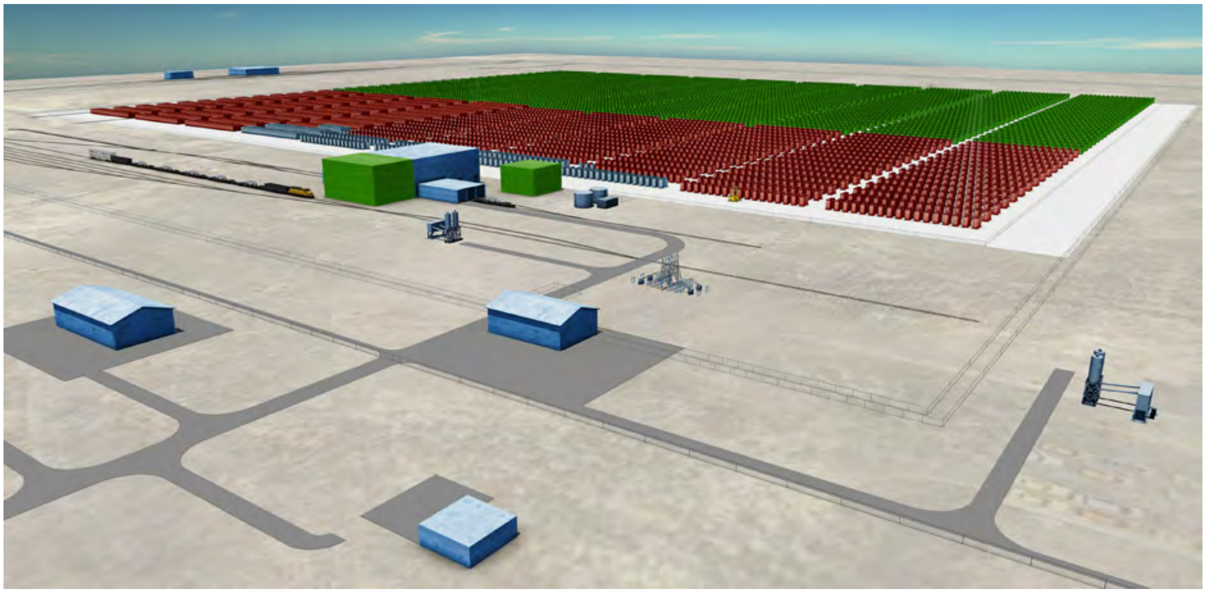

Figure 1.0-1 illustrates a flexible approach for the construction and operation of the CSF. The following is a description of the operational phases and associated construction stages depicted in **Figure 1.0-1**:

- Operational Phase 1/Construction Stage 1 (Blue)—Construct a basic CSF with storage pads, rail, and facilities to receive and store stranded UNF. The focus of Phase 1 is acceptance of stranded UNF from shutdown plant sites.
- Operational Phase 2/Construction Stage 2 (Red)—Expand CSF storage pad capacity to receive and store UNF in transportable canisters.
- Operational Phase 3/Construction Stage 3 (Green)—Add UNF pools to receive UNF in bare fuel transport casks and store UNF either in pools or in dry storage in standardized canisters. This phase provides an alternative method of receipt and initial storage of UNF from Phase 2. Construct hot cell and research and development (R&D) capability to enable on-site testing of UNF, long-term packaging reliability and remediation, and complete dry storage build-out.

As discussed in Section 7.0 (Project Planning) of this report, three stages of CSF construction are planned to support four phases of fuel and Greater-than-Class-C (GTCC) waste shipments to the CSF. (An operational Phase 4 will be implemented with Construction Stage 3, as discussed later.) Each fuel shipment phase is described in more detail below.

CSF Operational Phase 1/Construction Stage 1—Retrieval of Stranded UNF

In Phase 1, the CSF is designed to be capable of retrieving all UNF from shutdown plant sites, each of which have "stranded" UNF on site. It is currently anticipated that there will be 11 sites with a total of about 4,100 metric tons uranium (MTU) of UNF in this category by 2020. Retrieval of this fuel represents about 3 percent of the total anticipated UNF that will eventually be stored at one or more CSFs to await final disposition. To achieve this highest priority objective, consistent with the BRC recommendation that "…stranded fuel should be first in line for transfer to a CSF…," the Phase 1 CSF is recommended to be a small facility, designed for future growth, with minimum essential structures and components for receiving transport casks from these shutdown plant sites (Construction Stage 1). This approach makes the initial facility design simpler and the licensing process less complex, essentially allowing Phase 1 to be a pilot process with a well-defined success path.[2] It uses a "start clean, stay clean" approach. Phase 1 is projected to be implemented between years 0 through 6 of the CSF's operation, which will start construction in about 2019 and achieve operational status in 2021.

Currently, there are nine shutdown plant sites with stranded UNF. By 2021, it is anticipated that the Kewaunee and Oyster Creek plant sites will join this category. All of the shutdown plant sites currently have—or will have—UNF stored in dry fuel storage systems (DFSSs), which have dual purpose canisters (DPCs) that can be shipped to the CSF in a transport cask as a transportation package without having to be reopened. All of the shutdown plant sites will require additional equipment to transfer the canisters from storage overpacks or horizontal storage modules (HSMs) to transport casks and to ready the packages for transport off site (ranging from impact limiters, mobile cranes, and/or vertical cask transporters to transfer casks and equipment).

All but four of the shutdown plant sites have had their reactors and associated structures dismantled as of this writing, eliminating the permanently installed plant cranes and equipment that could have been used to transfer the canisters from storage overpacks to transport packages. Among the four remaining shutdown plant sites, Humboldt Bay is in the process of dismantling the reactor and associated structures and is expected to complete reactor decommissioning in 2015. Rancho Seco has decommissioned the reactor, spent fuel pool, and associated equipment, but the containment building and cooling towers remain. While Trojan has dismantled the reactor and associated structures, a canister transfer facility remains at the Independent Spent Fuel Storage Installation (ISFSI) site that could be used to transfer their DPCs into transport casks.[3] Some equipment needed for transferring the canister from a vertical storage cask to the transport cask, such as transfer casks, lifting

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[2] Note that the DOE Strategy (January 2013) embraces this priority for UNF from shutdown plants, and refers to CSF Phase 1/Construction Stage 1 as a "pilot interim storage facility."

[3] DOE, 2012. *Preliminary Evaluation of Removing Used Nuclear Fuel From Nine Shutdown Sites*, Draft, October 31.

yokes, and/or vertical cask transporters, may be available. However, canister transfer facilities and cranes may need to be used at nearly all of the shutdown plant sites to enable the transfer of loaded canisters from storage overpacks and HSMs into transport casks for shipment to the CSF.

The R&D up until Phase 3 operations in 2033 will be performed at the National Laboratories. Rods will be extracted from assemblies in utility fuel pools to provide test specimens to benchmark test data. Later in the test program canisters will be opened in the pools to obtain additional UNF for testing and evaluation. After the commencement of Phase 3 operations, testing and evaluation will continue at the National Laboratories and at the CSF laboratory facilities. The testing and evaluation of UNF will support predictive modeling of the UNF confinement systems and support the design of monitoring systems to prevent and mitigate any potential releases. The R&D program will be included as part of the Aging Management Program to continually monitor and enhance the safe storage of UNF.

The following is summary of estimated Operational Phase 1 and Construction Stage 1 costs:

- Capital Cost Estimate for Construction Stage 1 in 2012 Dollars—$1,012,000,000
- Operational Costs for Phase 1 in 2012 Dollars—$282,000,000
- Transportation Costs for Phase 1 in 2012 Dollars—$187,000,000
- Total Cost for Operational Phase 1/Construction Stage 1 in 2012 Dollars—$1,481,000,000

(Escalation costs are excluded. Period of performance is 2013 through 2026.)

CSF Operational Phase 2/Construction Stage 2—Retrieval of Dual Purpose Canister Systems

Currently, nearly all commercial reactor sites utilize DPCs at their ISFSIs. DPCs are the components of those DFSSs that are licensed for both storage (in a vertical cask or horizontal module) under 10 Code of Federal Regulations (CFR) Part 72 and transportation under 10 CFR Part 71 (in a separate transport cask). A large majority of operating plant sites utilize a DPC-based DFSS and the few remaining sites yet to build an ISFSI plan to use DPC systems.

As of mid-2012, approximately 11,200 MTU of UNF are stored in DPC designs that are already licensed for transportation under 10 CFR Part 71[4], which represents approximately 59 percent of the total UNF in dry cask storage. Another 2,100 MTU of UNF are stored in

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[4] It is important to note that while the DPC designs may be licensed for transportation, not all contents currently stored in those DPC designs are included in the approved contents of the transportation Certificates of Compliance (CoCs) for those packages. Approval of all contents will require additional licensing efforts by the CoC holders.

canister designs intended to be licensed for transportation at some point in the future. Further, 3,150 MTU of UNF are currently stored in canisters not designed or licensed for transportation. The balance of UNF currently stored at ISFSIs is stored in bare fuel casks, both transportable and non-transportable.

Of the total 140,000 MTU estimated to be discharged by commercial reactor sites, a large majority of the UNF is likely to be stored in DPC systems. Therefore, retrieving DPCs from plant sites and storing them at the CSF is necessary to address the government's UNF collection burden, notwithstanding whether a standardized storage system is implemented at a later date that would decrease the use of DPC-based systems. Phase 2 is projected to be implemented in 2026 and continuing through approximately 2055.

In Phase 2, the CSF can continue operating with the same structures constructed in Construction Stage 1 by simply expanding the number of storage pads. In Construction Stage 1, the CSF would be constructed with the minimum essential structures and components needed for receiving transport casks from the shutdown plant sites. The same "minimum essential equipment" used in Phase 1 will serve the needs in Phase 2. Since the DPCs (which are welded closed) do not need to be opened, the CSF in both Phase 1 and Phase 2 would operate as a "start clean, stay clean" facility.

Unlike Phase 1 however, the UNF in Phase 2 originates from operating plant sites, so the cask handling equipment, including cask handling cranes inside the plant, will be available. This allows postponing the need to use a significant amount of temporary equipment to load transport casks at the plant sites. Some plant sites have dismantled or abandoned their rail access and/or have no viable barge access, so some heavy-haul truck transport and intermodal transfer from a truck trailer to a railcar or barge will still be required. The following is a summary of the Operational Phase 2 and Construction Stage 2 costs:

- Capital Cost Estimate for Construction Stage 2 in 2012 Dollars—$953,000,000
- Operational Costs for Phase 2 in 2012 Dollars—$2,080,000,000
- Transportation Costs for Phase 2 in 2012 Dollars—$742,000,000
- Total Cost for Operational Phase 2/Construction Stage 2 in 2012 Dollars—$3,775,000,000

(Escalation costs are excluded. Period of performance is 2026 through 2055.)

CSF Operational Phase 3/Construction Stage 3—Retrieval of Dual Purpose Casks and Bare Fuel

Phase 3 is intended to offset the rising flood of current-generation, commercially available, DPCs used at the operating nuclear plants with one or more standardized canister systems that would be compatible with a future geological repository. Standardized systems could be implemented at the operating plant sites if they were available in lieu of their current canister systems. This would be an enormous and expensive task that could require substantial modifications at more than 60 plant sites and their dry cask storage facilities. A better path is to implement the standardized canister operating process at one location, the CSF, and ship bare fuel from the operating nuclear plants to the CSF where the UNF could be packaged into the standardized system.

This phase also would remove UNF from the Spent Fuel Pools (SFPs) rather than the ISFSIs, which the reactor owners may prefer since its objective would be to decrease the amount of UNF that must be transferred to on-site ISFSIs. This, in turn, creates available pool space for upcoming UNF discharges during reactor outages. It would also lower or totally eliminate the number of DPCs that the owner would need to load and place into interim storage at the plant ISFSI. The UNF from the SFP would need to cool for the required licensed period specified in the 10 CFR Part 71 (transport) Certificate of Compliance for the bare fuel casks.

Another advantage of standardized canisters that are compatible with a future repository is that they reduce the accumulation of low-level radioactive waste (LLRW). The longer that nondisposable commercial types of DPCs are used to store UNF, the more LLRW will be created, if and when they are eventually replaced by a disposable canister. Once a standardized canister program is implemented, the CSF could begin to receive UNF assemblies in bare fuel casks that are licensed for both storage under 10 CFR Part 72 and transportation under 10 CFR Part 71. The concept is that a bare fuel cask could be dispatched to a nuclear plant, loaded with UNF in the spent fuel pool, and shipped back to the CSF where the UNF assemblies would be repackaged into a standardized canister and placed into storage in a storage overpack. To initiate Phase 3, bare fuel casks will need to be procured and UNF pools (separate pools for Boiling Water Reactor [BWR] and Pressurized Water Reactor [PWR] assemblies) for the UNF would be constructed at the CSF as part of Construction Stage 3. There are a number of bare fuel casks designed for storage and transport already in service at existing nuclear plants. This estimate assumes that approximately 9000 disposal canisters, similar to Yucca Mountain Project Transportation, Aging and Disposal Canisters will be used to package UNF from the CSF UNF pools. Phase 3 would be implemented in year 12 of facility operation and would continue through the end of the retrieval period. In addition to the UNF pools, Construction Stage 3 would also include the addition of a hot cell and the associated laboratory hot cells to support the on-site testing of UNF and UNF storage systems, and dry remediation of storage systems.

Phase 3 will also enable UNF to begin to be removed from the Morris Wet Storage ISFSI located in Illinois. The Morris ISFSI stores approximately 700 MTU and is not allowed to receive any additional UNF. All of the fuel that is stored at the facility has been in storage and cooling for more than 20 years.

- Capital Cost Estimate for Construction Stage 3 in 2012 Dollars—$1,465,000,000
- Operational Costs for Phase 3 in 2012 Dollars—$13,704,000,000 (note that this total operational cost includes $11,500,000,000 for canisters and overpacks, and $2,204,000,000 for pool-to-pool operations)
- Transportation Costs for Phase 3 in 2012 Dollars—$627,000,000
- Total Cost for Phase 3 in 2012 Dollars—$15,796,000,000

(Escalation costs are excluded. Period of Performance is 2033 through 2055.)

CSF Operational Phase 4—Retrieval of Non-Transportation Dry Canister Storage Systems

Phase 4 will retrieve the remaining storage inventory—only about 2.2 percent of the total anticipated MTU in the full-capacity CSF. Note that all the CSF construction work needed to support Phase 4 will have already been completed during Construction Stages 1, 2, and 3, in support of Phase 3 shipments (i.e., hot cell and laboratory facilities to enable on-site research and development of DFSSs and UNF are constructed during Phase 3). Hence, Phase 4 shipments could proceed any time after Phase 3 shipments begin.

When dry fuel storage was first introduced, there were no DFSSs developed that were designed and licensed for both storage and transportation. A few nuclear plants needed to remove inventory from their SFPs in order to continue operating until the DOE began waste acceptance of UNF. These plants opted to use DFSS designs that were available at the time. Some of these DFSSs were bolted metal cask designs and others were canister-based systems. Most of these non-transportable DFSSs are no longer manufactured in the United States (U.S.), which has resulted in a limited number of non-transportable DFSSs applicable to this phase.

As of mid-2012, there were 29 non-transportable bolted bare fuel casks and 288 non-transportable canisters in storage, representing about 17 percent of the current dry cask storage inventory. The overall impact to the CSF in terms of required storage space for 317 storage units is small, so there would be few changes to the CSF for Phase 4.

The purpose of Phase 4 is to retrieve UNF in non-transportable bare fuel casks or non-transportable canisters. Although the addition of these DFSSs has a small impact on the CSF, retrieval of these DFSSs or the UNF inside them will be one of the most challenging objectives of the CSF.

There are two basic options available to retrieve UNF stored in non-transportable DFSSs: (1) obtain a one-time transportation license exemption from the Nuclear Regulatory Commission (NRC) to ship the casks or canisters within certified transport casks to the CSF or (2) repackage the UNF into a transportable system at the originating nuclear plant site. If a one-time exemption is obtained, then the CSF would need to be equipped to receive, process, and place into storage these types of systems. If the UNF is repackaged into a transportable system, the effort to receive, process, and place the UNF from these systems into storage at the CSF would be the same as the work in Phase 2 or Phase 3.

- Capital Cost Estimate for Phase 4 in 2012 Dollars (no construction stage)—$0
- Operational Costs for Phase 4 in 2012 Dollars—$441,000,000
- Transportation Costs for Phase 4 in 2012 Dollars—$125,000,000
- Total Cost for Phase 4 in 2012 Dollars—$566,000,000

(Escalation costs are excluded. Period of Performance is 2033 through 2055.)

(Operational costs beyond 2055 and escalation costs are presented in the detailed cost data in the appendices to this report.)

Transportation Systems

This report models throughput for three different UNF acceptance scenarios after start-up and ramp-up to 3,000, 4,500, and 6,000 MTU/year. This report also models three sub-scenarios for UNF pickup priority: Oldest Fuel First (OFF), shutdown plants first, and an "OFF-Plus" option. **The recommended priority ranking is "OFF-Plus at 4500 MTU per year**—an enhanced UNF pickup priority queue that starts with acceptance of stranded UNF, followed by shipments of UNF from operating plant sites in dedicated shipping campaigns. That is, the priority ranking for UNF would still be based on the OFF methodology; however, annual acceptance allocations would be grouped with the goal of having fewer shipping campaigns over a specified time period, while maintaining the total UNF accepted from any utility being maintained over that time period (i.e., 5-year shipping campaigns or reducing the number of sites shipping annually while preserving current Standard Contract priority provisions). All the scenarios envision picking up the UNF at shutdown sites first.

It is also recommended that consideration be given to the strategic acquisition of existing transportable overpacks for dual purpose canisters and of dual purpose casks to build an initial transport fleet for retrieving canisters (Phases 1 and 2) and bare UNF (Phase 3). Bare fuel transport (pool-to-pool transfers) will accommodate a transition to standardized packaging, which will reduce nondisposable canister waste buildup. This report also discusses alternatives for accepting UNF with high decay heat. This report also recommends an approach to deliver all rolling stock required to support the start of transportation operations for all phases of operation. This estimate for all rolling stock ($342 million) is included in the capital cost of the CSF and is not included as a transportation cost, nor are cask, canister and escalation costs.

- Total Transportation Cost Estimate in 2012 Dollars—$2,191,000,000

Life Cycle Costs

The life cycle costs for the facility include assumes a 100-year operating life for the CSF and an average forward inflation rate of 2 percent. The life cycle cost is as follows:

- Total Capital Cost—$3.4 billion
- Operation Cost—$19.0 billion
- Transportation—$2.2 billion
- Decontamination and Decommissioning Cost—$3.8 billion
- Total Life Cycle Cost—$28.4 billion (2012 Dollars)

Applying an annual 2 percent forward escalation rate over the 100-year operating life of the plant, the total project cost is $52.5 billion.

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2.0 INTRODUCTION

2.1 Background

The concept of consolidated interim storage of UNF has been considered one of the three key elements of an integrated UNF management strategy for decades, complementing (1) one or more permanent geologic repositories and (2) the longer-term option of reprocessing UNF. Various concepts for UNF storage were being evaluated in the 1980s to support language in the Nuclear Waste Policy Amendments Act of 1987 that called for the creation of the Office of Nuclear Waste Negotiator to assist in finding a site for a Monitored Retrievable Storage (MRS) facility. Failure to identify a willing site for an MRS was viewed at the time as largely due to the requirement in the 1987 Act that allowed the DOE to construct one consolidated storage facility with limited capacity, but only after construction of a nuclear waste repository had been authorized.

As explained in the BRC Report, the situation has fundamentally changed, with waning confidence in the federal government's capability to deliver on nuclear waste management obligations, earlier federal decisions to defer UNF processing, and a more recent administration decision to terminate the licensing of the Yucca Mountain repository. Storage of UNF has become more important and is the only currently functioning element of the nation's integrated UNF management system, albeit dispersed at various sites.

This situation prompted the BRC to offer a strong recommendation in favor of consolidated storage, as follows:

> **"5. Prompt Efforts to Develop One or More Consolidated Storage Facilities**
>
> "Safe and secure storage is another critical element of an integrated and flexible national waste management system. Fortunately, experience shows that storage—either at or away from the sites where the waste was generated—can be implemented safely and cost-effectively. Indeed, *a longer period of time in storage offers a number of benefits because it allows the spent fuel to cool while keeping options for future actions open*. [5]
>
> "Developing consolidated storage capacity would allow the federal government to begin the orderly transfer of spent fuel from reactor sites to safe and secure centralized facilities independent of the schedule for operating a permanent repository. The arguments in favor of consolidated storage are strongest for "stranded" spent fuel from shutdown plant sites. Stranded fuel should be first in line for transfer to a consolidated facility so that these plant sites can be completely decommissioned and put to other beneficial uses. Looking beyond the issue of today's stranded fuel, the availability of consolidated storage will provide valuable flexibility in the nuclear waste management system that could achieve meaningful cost savings for both ratepayers and taxpayers when a significant number of plants are shut down

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[5] The BRC uses the term "spent fuel" throughout its report, while DOE uses the term "used fuel" in its Statement of Work. For purposes of this report, the two terms are synonymous.

> in the future, can provide backup storage in the event that spent fuel needs to be moved quickly from a reactor site, and would provide an excellent platform for ongoing R&D to better understand how the storage systems currently in use at both commercial and DOE sites perform over time.
>
> "For consolidated storage to be of greatest value to the waste management system, the current rigid legislative restriction that prevents a storage facility developed under the NWPA from operating significantly earlier than a repository should be eliminated. At the same time, efforts to develop consolidated storage must not hamper efforts to move forward with the development of disposal capacity. To allay the concerns of states and communities that a consolidated storage facility might become a *de facto* disposal site, a program to establish consolidated storage must be accompanied by a parallel disposal program that is effective, focused, and making discernible progress in the eyes of key stakeholders and the public. Progress on both fronts is needed and must be sought without further delay. (BRC Executive Summary)"

In Section 5 of its report, the BRC made the following "Case for Consolidated Storage":

> *"The fundamental policy question for spent fuel storage in the United States today is whether the federal government should proceed to develop one or more consolidated storage facilities as a way to begin the orderly transfer of the fuel to federal control pending its ultimate disposition through reuse or disposal.* The Commission concludes that there are several compelling reasons to move as quickly as possible to develop safe, consolidated storage capacity on a regional or national basis.
>
> 1. Consolidated Storage Would Allow for the Removal of "Stranded" Spent Fuel from Shutdown Reactor Sites
> 2. Consolidated Storage Would Enable the Federal Government to Begin Meeting Waste Acceptance Obligations
> 3. Consolidated Storage Would Provide Flexibility to Respond to Lessons Learned from Fukushima and Other Events
> 4. Consolidated Storage Would Support the Repository Program
> 5. Consolidated Storage Offers Technical Opportunities for the Waste Management System
> 6. Consolidated Storage Would Provide Options for Increased Flexibility and Efficiency in Storage and Future Waste Handling Functions

The DOE's Statement of Work that preceded development of this report mirrors well the recommendations of the BRC. It envisions an aggressive schedule for constructing a facility and emphasizes flexibility and innovation. It calls for optimization of both the CSF and its associated transportation system "…to identify <u>the most efficient and economical</u> methods…" and "…<u>the most efficient</u> storage system and means for improving efficiency…" for the transportation and storage options evaluated. The Statement of Work also accommodates the BRC's recommendation to give priority to shutdown sites in developing the overall plan and priorities for transfer of UNF from plant sites to a CSF.

This approach is also supported by the recently-issued "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste" (DOE, January 2013).

> "The Administration supports an approach to system design that integrates consent-based siting principles and makes progress in demonstrating the federal commitment to addressing used nuclear fuel and high-level radioactive waste disposal, including building the capability to begin executing that commitment within the next 10 years. The Administration supports a nuclear waste management system with the following elements:
>
> - A pilot interim storage facility with limited capacity capable of accepting used nuclear fuel and high-level radioactive waste and initially focused on serving shut-down reactor sites;
> - A larger, consolidated interim storage facility, potentially co-located with the pilot facility and/or with a geologic repository, that provides the needed flexibility in the waste management system and allows for important near-term progress in implementing the federal commitment; and
> - A permanent geologic repository for the disposal of used nuclear fuel and high-level radioactive waste.
>
> "The objective is to implement a flexible waste management system incrementally in order to ensure safe and secure operations, gain trust among stakeholders, and adapt operations based on lessons learned…[T]he Administration agrees with the Blue Ribbon Commission that a consent-based siting process offers the promise of sustainable decisions for both storage and disposal facilities.
>
> "This system would initially be focused on acceptance of used nuclear fuel from shut-down reactors; such fuel provides an opportunity to build waste handling capability as well as to relieve surrounding communities and utility contract holders of the burdens associated with long-term storage of used nuclear fuel at a shut-down reactor. Following these initial efforts, capacity will be developed to enable the acceptance and transportation of used nuclear fuel at rates greater than that at which utilities are currently discharging it in order to gradually work off the current inventory…
>
> "The BRC recommended that 'one or more consolidated (interim) storage facilities be developed to start the orderly transfer of used nuclear fuel from reactor sites to safe and secure centralized facilities independent of the schedule for operating a permanent repository.' The Administration agrees that interim storage should be included as a critical element in the waste management system and has several benefits, including flexibility in system planning and execution and the opportunity to move expeditiously to fulfill government contractual responsibilities.
>
> "The Administration also agrees with the BRC that a linkage between opening an interim storage facility and progress toward a repository is important so that states and communities that consent to hosting a consolidated interim storage facility do not face the prospect of a de facto permanent facility without consent…"

2.2 Approach

This report embraces this emphasis on flexibility and efficiency. It uses a systems engineering approach that relies heavily on a phased implementation of the CSF, and on an integrated evaluation of options. Importantly, Phase 1 of the proposed approach is simple, flexible, and relatively low cost in comparison to the fully developed CSF. Phase 1 is focused on moving the stranded fuel from shutdown plant sites first; and only includes the necessary capabilities at the initial CSF needed to handle this canisterized stranded fuel in a "start clean, stay clean" facility. This initial CSF would not include hot cells, wet storage capability, R&D facilities, etc. These capabilities could be added as needed in later phases in a modular approach to designing and licensing the facility.

This approach is fully consistent with the BRC's encouragement for a cautious, stepwise strategy:

> "It should be emphasized that the development of one or more storage facilities does not require, or even imply, an irreversible commitment to any particular long-term plan for moving fuel to these facilities or performing any specific set of activities at these sites. All of the capabilities that would ultimately be desirable do not have to be developed at once, particularly since it is not clear at this time exactly what features will be needed over the many decades such a facility or facilities would be in operation. A storage facility or system of facilities can be developed in a stepwise manner, as the need for expansion of capacity and capability becomes clearer. Furthermore, the initial cost to site, design, and license a storage facility is relatively low (less than $100 million), so that the money put "at risk" in giving future decision makers the option to proceed with construction and operation of a storage facility is small compared to the potential benefits from having that option available. Siting, licensing, building and operating a storage facility with even limited initial capabilities would substantially resolve uncertainties about the costs and time required for these activities, including associated transportation needs, thereby providing a firmer basis for future decision-making with regard to potential expansion."

The DOE Strategy fully embraces this approach:

> "Consistent with legislation recently under consideration in Congress, the Administration supports the development of a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites. Acceptance of used nuclear fuel from shut-down reactors provides a unique opportunity to build and demonstrate the capability to safely transport and store used nuclear fuel, and therefore to make progress on demonstrating the federal commitment to addressing the used nuclear fuel issue. A pilot would also build trust among stakeholders with regard to the consent-based siting process and commitments made with a host community for the facility itself, with jurisdictions along transportation routes, and with communities currently hosting at-reactor storage facilities if enabled by appropriate legislation. The Administration would plan to undertake activities necessary to enable the commencement of operations at this facility in 2021, including conducting a consent-based siting process with interested parties, undertaking the requisite analyses associated with siting such a facility, and initiating engineering and design activities as warranted. Full execution of this plan depends on enactment of revised legislative authority.
>
> "Beyond a pilot-scale facility, the Administration supports the development of a larger consolidated interim storage facility with greater capacity and capabilities that will provide flexibility in operation of the transportation system and disposal facilities. In addition, a larger-scale facility could take possession of sufficient quantities of used nuclear fuel to make progress on the reduction of long-term financial liabilities. Depending on the outcome of a

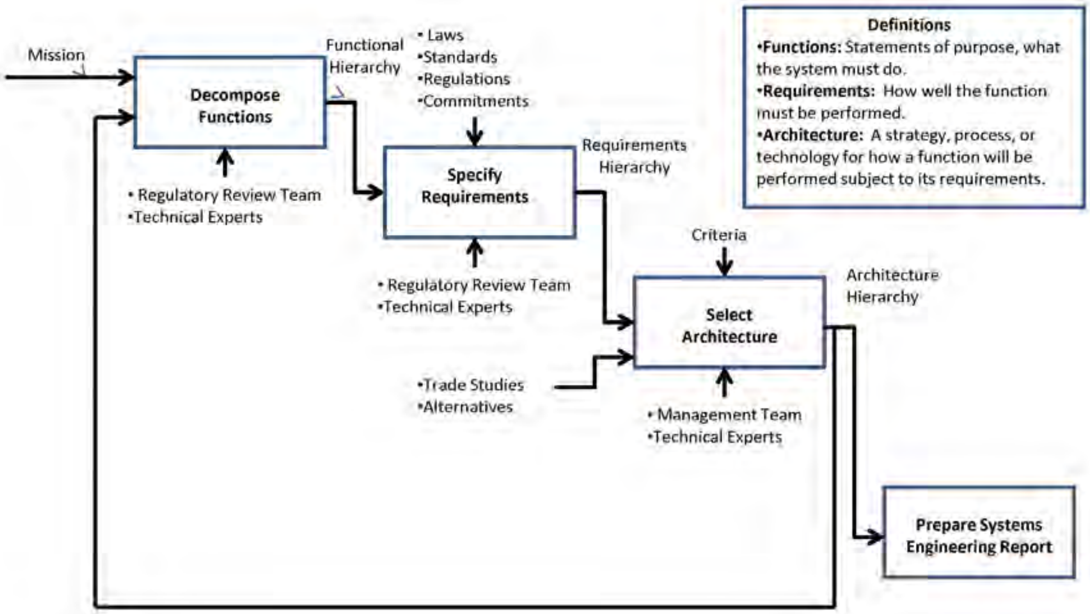
> consent-based process, this facility could have a capacity of 20,000 MTHM or greater, and could be co-located with the pilot facility or the eventual geologic repository. In the context of the overall waste management system, the Administration supports the goal of siting, designing, licensing, constructing and commencing operations at a consolidated interim storage facility by 2025."

The systems engineering approach used in this report is a structured process, based on hierarchical decomposition, that transforms the mission need for long-term management of commercial UNF into a preferred storage concept which best satisfies the need. The basic approach was to apply the functions-requirements-architecture (F-R-A) process (**Figure 2.2-1**). Functions define what the system must do, requirements specify how well it must be done, and architecture (at the top levels of the hierarchy) identifies the preferred strategy for accomplishing it. The F-R-A process was applied to each of the functions encountered over the lifecycle of the CSF—accept UNF, transport UNF, and store UNF—with a recognition that the CSF would eventually be decontaminated and decommissioned with the UNF going to a permanent disposal facility (**Figure 2.2-2**).

This systematic approach ensured the following:

- All functions that are both necessary and sufficient to satisfy the mission were identified.
- Important requirements associated with each function were specified.
- Specific strategies, technologies, and systems for performing the functions subject to their requirements were formulated, consistently evaluated, and decisively recommended.
- The preferred concept is a well-integrated system.

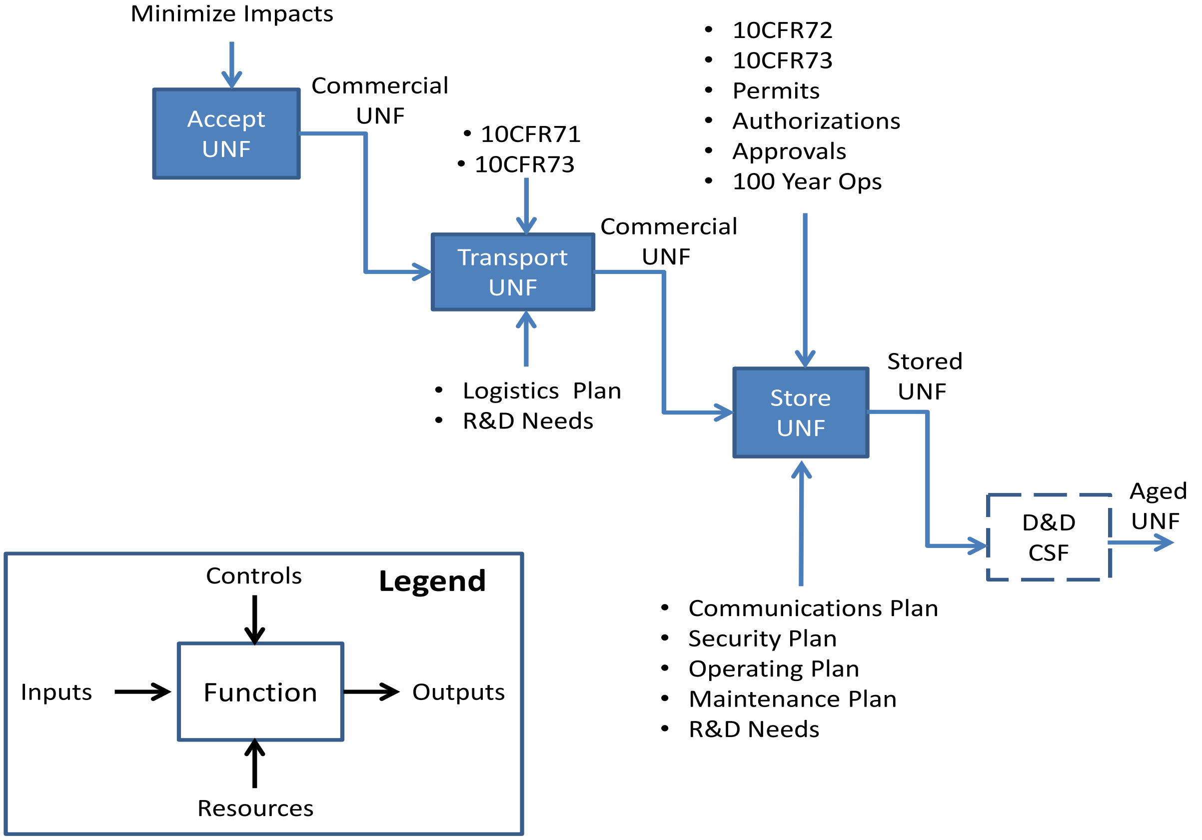
Figure 2.2-1
Functional Analysis Approach



Definitions

- **Functions:** Statements of purpose, what the system must do.
- **Requirements:** How well the function must be performed.
- **Architecture:** A strategy, process, or technology for how a function will be performed subject to its requirements.

Figure 2.2-2
Primary Activities Involved in the Consolidated Storage of Commercial Used Nuclear Fuel



2.3 Section Summaries

The long-range planning schedule in this report covers a 100-year operating life for the CSF and identifies schedule milestones required to support the four CSF phases of UNF storage described in Section 3.0, “Consolidated Storage Facility.” These four phases, discussed in more detail later, are as follows:

- CSF Phase 1—Retrieval of Stranded UNF in DPCs
- CSF Phase 2—Retrieval of Operating Plant DPCs
- CSF Phase 3—Retrieval of Bare Fuel in Dual Purpose Casks and addition of R&D facilities
- CSF Phase 4—Retrieval of Non-transportable Casks and Canisters

The phases defined above represent the minimum functional requirements and UNF storage priority for the CSF. The phases do not necessarily exclude the previous or subsequent modes of UNF receipt. For instance, in Phase 1 the facility may receive some DPCs from operating plants provided the focus and priority remains on stranded fuel removal. Likewise, in Phases 3 and 4, the CSF may continue to receive fuel in DPCs from operating plants while also receiving and re-packaging UNF in bare fuel casks.

As will be evident throughout this report, assumptions made on various key parameters and the time sequencing of various processes and events have a major impact on the cost and schedule for implementing the CSF. The phase sequencing accepts stranded UNF based on transportation assumptions. Hence, many foundational assumptions are evaluated in Section 5.0, “Transportation,” where three different scenarios are evaluated, with throughputs ramping up to 3,000, 4,500, and 6,000 MTU/year. Sub-scenarios examine OFF, shutdown plants first, and an “OFF-Plus” option that accepts stranded UNF followed by efficient, modified pickup of UNF from operating sites while preserving current Standard Contract priority provisions.

These transportation assumptions serve as a foundation for the cost and schedule evaluations for each of the CSF Phases evaluated in Section 3.0, culminating in the design basis assumptions for the final CSF design (final storage capacity of 140,000 MTU, the maximum projected capacity by 2087). Section 3.0 is organized around the four phases identified above, and identifies the types of canisters, casks, overpacks, and ancillary equipment required. It defines the infrastructure requirements for each phase, including buildings, cask handling equipment, auxiliary systems, etc., along with site and building layout plans, etc. It makes use of process flow diagrams to organize the steps for implementing each phase.

Note that Section 3.3 contains an evaluation of the tradeoffs between the lower costs of a single CSF with higher transportation costs against one, two, or three smaller, regional facilities that reduce transportation costs but result in increased capital costs for the facilities. Section 3.3 also contains an evaluation of above ground versus underground storage.

Section 4.0 addresses security requirements for the CSF. It is based on the current NRC regulations governing physical protection of stored spent fuel as set forth in 10 CFR Part 73 as well as U.S. Department of Transportation (USDOT) regulations. It covers controlled area requirements, CSF protected area requirements, individual security facilities and equipment, and security organization and staffing. It also addresses transportation security and security interfaces with off-site agencies, transport companies, etc.

As noted in the BRC Report, the NRC is considering potential changes to security requirements:

> “The NRC is currently undertaking a rulemaking to revise existing security requirements that apply to the storage of spent fuel at an ISFSI and to the storage of spent fuel and/or high level waste at a monitored retrievable storage installation (it will not address requirements that

> apply to storage in reactor pools). The rulemaking is intended to (a) examine the effectiveness of security orders imposed after the 9/11 terrorist attacks; (b) apply lessons learned from previous NRC inspections; and (c) ensure regulatory clarity and consistency between general and specific ISFSI licensees. The NRC issued a draft "regulatory basis" document in December 2009 and has received numerous comments on proposed technical approaches. Among other issues, the NRC is considering whether to require comprehensive "denial" capability on site—that is, sufficient security forces and weaponry for facility personnel to repel an attack on their own—or instead to require a detect/ assess/communicate strategy that would rely on assistance from local, state and federal authorities."

As noted above, Section 5.0 involves extensive planning and evaluations of various system capacity assumptions and alternatives. It also addresses technical and regulatory issues associated with transport of UNF that must be addressed, intermodal transport requirements, and development of fleet management and cask maintenance facilities, etc. Since transportation costs dominate the overall CSF system costs, Section 5.0 serves as a basis for a careful evaluation of single versus multiple CSFs, as discussed in Section 3.0.

Note that the BRC identifies this transportation element as critical to the successful management of spent fuel, with the following recommendation:

> **"6. Early Preparation for the Eventual Large-Scale Transport of Spent Nuclear Fuel and High-Level Waste to Consolidated Storage and Disposal Facilities"**

This report draws from BRC recommendations, BRC Subcommittee reports, the Energy Resources International January 2011 report prepared for the BRC, Office of Civilian Radioactive Waste Management (OCRWM) plans, and other studies. It also addresses transportation planning and coordination with states, Native American tribes, and local governments.

Section 6.0 of this report addresses R&D needs, which include initial UNF testing by National Laboratories using rods pulled at plant sites, and standardized and consolidated long-term monitoring of UNF and storage systems. It establishes a baseline prior to long-term storage, including nondestructive and destructive examination of selected fuel rods (focusing on cladding hydride morphology and mechanical properties). This will provide confirmatory data for NRC licensing, with a focus on high-burnup UNF. The R&D plan envisions periodic exams (every 10 to 20 years) to measure changes. The plan also includes testing and analysis of cask seals and criticality control materials to assure long-term performance, and will include testing and monitoring systems to support predictive monitoring. The plan will include R&D to support design concepts to mitigate degraded storage systems.

Section 7.0 addresses project planning; Section 8.0 addresses cost. These are "roll-up" sections that tie all the other sections together for cost estimating. They use a work breakdown structure (WBS) approach and rely on DOE and AACE International ground rules and methodologies for cost estimating. Both project cost estimates and life cycle cost estimates are provided, with sensitivity analyses to establish high and low ranges. Contingency and management reserve are included in cost estimates. Section 7.0 also provides summary level schedules for the overall CSF phased construction program.

Section 9.0 addresses waste (contaminated waste generated and disposition pathways).

3.0 CONSOLIDATED STORAGE FACILITY

3.1 Function and Purpose

The purpose of the CSF is to provide one or more centralized interim storage areas for the commercial UNF. The CSF would be an away-from-reactor type Independent Spent Fuel Storage Installation (ISFSI), which is not located at any of the current operating plant sites, but rather located at a consent-based location, as recommended by the BRC.

This section provides the engineering and systems analysis for developing a design concept for the CSF, including the design basis, regulatory requirements, design parameters and assumptions, systems engineering, and UNF retrieval and storage processes. This section also includes studies of different variations in the logistical layout of the CSF and how those compare with the base case outlined in the four phases of the CSF implementation.

3.1.1 Design Basis

Specific conditions and needs that must be met by the engineering and systems CSF logistics include the following:

- The CSF must be able to accept all UNF and GTCC produced from U.S. commercial reactors, including decommissioned, operating, and future (planned) reactors.
- The CSF must be able to accept any transport casks licensed under 10 CFR Part 71 that are required for transportation of existing commercial UNF.
- The CSF must be able to process the various DFSSs, i.e., receive, configure for storage, store, and monitor.

3.1.2 Regulatory Requirements for Siting an Away-From-Reactor ISFSI

3.1.2.1 Overview

10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste and Reactor-Related Greater than Class C Waste,” governs ISFSI licensing. There are two options for licensing an ISFSI: (1) a specific license and (2) a general license. However, 10 CFR 72.210 only authorizes the use of a general license at a power reactor site with a 10 CFR Part 50 or 10 CFR Part 52 license. Since it is not anticipated that the CSF would be located at the site of a nuclear power plant, the CSF would be governed by a 10 CFR Part 72 specific license.

The process for obtaining a specific ISFSI license is similar to that for obtaining a license for a fuel cycle facility under 10 CFR Part 70. The applicant submits a license application in accordance with 10 CFR 72.16 that includes the information required by 10 CFR 72.22 through 10 CFR 72.28. The primary documents comprising the application are as follows:

- A Safety Analysis Report (SAR) that assesses safety of the storage system and the ISFSI facility
- The proposed technical specifications
- A quality assurance (QA) program
- A decommissioning plan
- An environmental report
- An emergency plan
- A security plan

3.1.2.2 Licensing Process

Upon receipt of the application, the NRC establishes a docket number and reviews the application for completeness. If the application is deemed complete, the NRC prepares and publishes a notice of docketing in the Federal Register (FR). The notice of docketing identifies the site of the CSF and includes either a notice of hearing or a notice of proposed action and opportunity for hearing pursuant to 10 CFR 72.46. 10 CFR 72.46 provides the regulations governing the hearing process with references to 10 CFR Part 2, as appropriate.

The NRC will request a hearing upon the notice of docketing if a statute specifically requires it, or if they believe it to be in the public interest, notwithstanding any requests for hearing submitted by parties who believe they having standing in the licensing action. 10 CFR 2.105(a)(7) specifies that if the NRC is not required by statute to conduct a hearing and does not find that a hearing is in the public interest, a notice of proposed action is instead published in the FR.

The notice of proposed action includes the time frame for any person whose interest may be affected by the proceeding to file a request for a hearing or a petition for leave to intervene if a hearing has already been requested. A request for hearing on a 10 CFR Part 72 license application must be submitted, with the contentions upon which the hearing would be litigated, within 60 days of the notice of docketing. It is worth noting that if the 10 CFR Part 72 specific license applicant is incorporating design information pertaining to a previously NRC-certified spent fuel storage cask design by reference into the application, any hearing held to consider the application will not include any cask design issues pursuant to 10 CFR 72.46(e).

If any requests for hearing are received on the notice or proposed action, the NRC will establish an Atomic Safety Licensing Board (ASLB) to review the hearing requests and contentions for admittance. For the ASLB to admit a contention and grant a hearing, the requestor needs to have standing in the proceeding per 10 CFR 2.309(d), and at least one contention must meet the criteria in 10 CFR 2.309(f). The NRC may also permit discretionary intervention of someone not having standing under the strict requirements of 10 CFR 2.309(e).

Admitted contentions are litigated through a review of documents submitted by the petitioner and may require court testimony and/or documents to be submitted by the applicant, at the discretion of the ASLB. Hearings would take place after issuance of the Final Environmental Impact Statement (EIS). The ASLB may decide to start the hearings prior to completion of the NRC staff Safety Evaluation Report (SER). A license would not be granted until all hearings are completed and the contentions resolved in favor of the applicant. At that point, the Director of the Office of Nuclear Material Safety and Safeguards would request Commission authorization to issue the license pursuant to 10 CFR 72.46(d). While petitioners may appeal the resolution of contentions in the courts, the license would likely be issued without awaiting resolution of those court appeals.

The NRC reviews the application for a specific license, and generally there are several rounds of requests for additional information.

10 CFR 72.42, Duration of License; Renewal, paragraph (a) states the following:

> Each license issued under this part must be for a fixed period of time to be specified in the license. The license term for an ISFSI must not exceed 40 years from the date of issuance. The license term for an MRS must not exceed 40 years from the date of issuance. Licenses for either type of installation may be renewed by the Commission at the expiration of the license term upon application by the licensee for a period not to exceed 40 years and under the requirements of this rule.

3.1.2.3 License Application

NUREG-1571, “NRC Information Handbook on Independent Spent Fuel Storage Installations,” summarizes key requirements for a specific license application, as follows:

- Siting Evaluation Factors (10 CFR 72 Subpart E)—The site characteristics, including external, natural, and manmade events, that may directly affect the safety or the environmental impact of the ISFSI.
- General Design Criteria (10 CFR 72 Subpart F)—Applies to the design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety.

- Quality Assurance (10 CFR 72 Subpart G)—The planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service as applied to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, modification, and decommissioning.
- Physical Protection (10 CFR 72 Subpart H)—The detailed plans for ISFSI security.
- Personnel Training (10 CFR 72 Subpart I)—The program for training, proficiency testing, and certification of ISFSI personnel who operate equipment or controls important to safety.

The NRC will review the specific license application and complete an evaluation of potential environmental impacts of the ISFSI in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended. The NRC will prepare an EIS in accordance with 10 CFR Part 51. Following its safety review and resolution of comments, the NRC issues a Materials License along with its SER and final EIS. The SER describes the conclusions of the staff's safety review based on the applicant's SAR and assesses the technical adequacy of the ISFSI and the spent fuel storage system(s).

Safety Analysis Report

The level of effort associated with preparation of the ISFSI SAR for a specific license can be reduced considerably by taking advantage of the permission granted in 10 CFR 72.46€ to select storage systems with SARs that have been reviewed and approved by the NRC (with Certificate of Compliances [CoC] having been issued for the storage systems), or storage systems that are currently undergoing NRC review per 10 CFR 72, Subpart L. With this approach, the NRC will focus its review on site-specific issues and storage system/site interface issues. This helps streamline the specific licensing process. Should the applicant select a storage system that has neither been reviewed and approved by the NRC nor is currently undergoing NRC review, the NRC must review information associated with the proposed spent fuel storage system as part of the specific license application, which would extend the review time.

Detailed guidance as to information that needs to be included in the ISFSI SAR that is submitted with the license application is provided by Regulatory Guide 3.48, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)." Additional information to enable the NRC staff review in accordance with NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities" should also be included in the SAR, along with information from any applicable NRC Interim Staff Guidance (ISG). The SAR for the CSF will need to identify and evaluate each of the storage systems that will be used at the

CSF to store UNF. For each individual system, the CSF SAR will need to address the following key topics specified in the NUREG-1567 Standard Review Plan:

- General description of the storage system
- Design criteria
- Structural evaluation
- Thermal evaluation
- Shielding evaluation
- Criticality evaluation
- Confinement evaluation
- Material evaluation
- Operating procedures
- Acceptance tests and maintenance program
- Radiation protection (occupational exposures, public exposures, ALARA measures)
- Accident analyses
- Operating controls (technical specifications)
- Quality assurance
- Decommissioning

The previous topics are addressed in the storage system vendors' SARs that have been approved by the NRC for general and specific ISFSI licenses; these documents can be incorporated by reference into the CSF SAR. It is envisioned that the CSF SAR will have a main body that describes and analyzes the CSF design and generic operations, with a separate appendix that serves as the SAR for each individual storage system. The CSF SAR will benefit in that it will primarily use UNF storage systems that have already been licensed under the provisions of 10 CFR Part 72, Subpart K, and have existing Final Safety Analysis Reports (FSARs) that have been approved by the NRC and can be referenced. A specific revision of the vendors' FSARs would need to be chosen for incorporation into the CSF ISFSI SAR. Changes to the vendors' FSARs thereafter would not automatically be incorporated by reference into the CSF SAR, but would require evaluation by the CSF license applicant for incorporation.

The SAR would include descriptions of the safety analyses and other technical evaluations for the ISFSI in each SAR chapter, incorporating by reference any required information for the storage system designs. The format and content would coincide with the chapters of the SRP in NUREG-1567 and any applicable Interim Staff Guidance documents amending that guidance. Formatting the ISFSI SAR in this manner sets the stage for a more efficient NRC technical review because the SRP establishes the format and content template for the NRC's SER.

Environmental Report

The Environmental Report (ER) that is submitted with the License Application is prepared to address the requirements of Subpart E of 10 CFR Part 72, Siting Evaluation Factors, and Subpart A of 10 CFR Part 51, National Environmental Policy Act - Regulations Implementing Section 102(2), using the guidance provided in U.S. NRC NUREG-1748, Environmental Review Guidance for Licensing Actions Associated with NMSS Programs. The ER contains the following key topics:

- General description of the proposed activities and discussion of need for the facility
- Site interfaces with the environment, including geography, demography, land use, ecology, climatology, hydrology, geology and seismology, historical and cultural features, and background radiation levels.
- Description of the facility, including appearance, construction, operations and effluent control
- Environmental effects of facility construction and operation, including transportation of radioactive material, and effects of decontamination and decommissioning
- Environmental effects of accidents involving radioactive materials, including transportation accidents
- Proposed environmental monitoring programs
- Economic and social effects of facility construction and operation, including cost benefit analysis
- Facility siting (site selection process) and design alternatives
- Environmental approvals including federal, state, and local regulations and permits

As noted above, the NRC will need to prepare a complete EIS for the CSF based on the ER submitted by the licensee, in accordance with 10 CFR Part 51 requirements.

3.1.2.4 Regulations of Special Interest for the CSF

The following is a summary of regulations considered to be of special interest, including those that apply to an ISFSI for which the DOE is the license applicant and license holder. 10

CFR Part 72 regulations permit an ISFSI to provide interim storage of power reactor spent nuclear fuel (SNF), solid reactor-related GTCC waste, and other radioactive materials associated with SNF and reactor-related GTCC waste storage.

The following are not, for the most part, direct quotes from the regulations, but instead identify those requirements considered to be of particular interest for the CSF, an away-from-reactor ISFSI that will use a 10 CFR Part 72 specific license issued to the DOE. Regulations that are applicable for a specific license are identified in 10 CFR 72.13, “Applicability.”

10 CFR Part 72 Subpart A—General Provisions

§ 72.1 Purpose

This section states the purpose of 10 CFR Part 72, which is to establish requirements, procedures, and criteria for the issuance of licenses to receive, transfer, and possess power reactor SNF, power reactor-related GTCC waste, and other radioactive materials associated with SNF storage in an ISFSI, and the terms and conditions under which the Commission will issue these licenses.

§ 72.2, Scope

§ 72.2(a)(1) states that licenses issued under 10 CFR Part 72 are limited to the receipt, transfer, packaging, and possession of power reactor SNF to be stored in a complex that is designed and constructed specifically for storage of power reactor SNF aged for at least one year, other radioactive materials associated with SNF storage, and power reactor-related GTCC waste in a solid form in an ISFSI. It is not clear that this permits R&D testing of UNF such as could be conducted in a hot cell at the CSF.

§ 72.2(c) states that the requirements of this regulation are applicable, as appropriate, to both wet and dry modes of storage of SNF in an ISFSI.

10 CFR Part 72 Subpart B—License Application, Form, and Contents

§ 72.22, Contents of Application, General and Financial Information

§ 72.22(d)(5)(i) states that if the DOE is the applicant for an ISFSI license, the DOE must identify in the license application the DOE organization responsible for the construction and operation of the ISFSI, including a description of any delegations of authority and assignments of responsibilities. § 72.22(e) indicates that in cases where the DOE is the applicant for a specific ISFSI license, the DOE is not required to demonstrate its financial qualifications to the NRC for constructing, operating, and decommissioning the ISFSI (as would be required for any other applicant).

§ 72.24 Contents of Application: Technical Information

A SAR evaluates safety of the proposed ISFSI for the receipt, handling, packaging, and storage of SNF, and/or reactor-related GTCC waste as appropriate, including how the ISFSI will be operated. The SAR needs to include the following items that may be of interest for the CSF:

- A description and discussion of the ISFSI structures with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations.
- A description of the design of the ISFSI in sufficient detail to support the license duration requested in the application in accordance with § 72.40 (up to 40 years for the initial license duration). This section identifies applicable codes and standards and demonstrates how the ISFSI complies with the general design criteria of 10 CFR Part 72, Subpart F, with identification and justification for any additions to or departures from the general design criteria.
- The means for controlling and limiting occupational radiation exposures within the limits given in 10 CFR Part 20, and for meeting the objective of maintaining exposures as low as is reasonably achievable (ALARA).
- The features of ISFSI design and operating modes to reduce to the extent practicable radioactive waste volumes generated at the installation.
- A plan for the conduct of operations, including the planned managerial and administrative controls system, the applicant's organization, and program for training of personnel pursuant to 10 CFR Part 72, Subpart I.
- If the proposed ISFSI incorporates Important to Safety (ITS) Structures, Systems and Components (SSCs) whose functional adequacy or reliability have not been demonstrated by prior use for that purpose or cannot be demonstrated by reference to performance data in related applications or to widely accepted engineering principles, the SAR will include an identification of these SSCs along with a schedule showing how safety questions will be resolved prior to the initial receipt of SNF and/or reactor-related GTCC waste for storage at the ISFSI.
- A description of the equipment to be installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal operations and expected operational occurrences. The description must identify the design objectives and the means to be used for keeping levels of radioactive material in effluents to the environment ALARA and within the exposure limits stated in § 72.104, including an estimate of the quantity of each of the principal radionuclides expected to be released

to the environment; a description of the equipment and processes used in radioactive waste systems; and a general description of the provisions for packaging, storage, and disposal of solid wastes.

- An analysis of the potential dose equivalent or committed dose equivalent to an individual outside the controlled area from accidents or natural phenomena events that result in the release of radioactive material to the environment or direct radiation from the ISFSI.
- A description of the QA program that satisfies the requirements of 10 CFR Part 72, Subpart G, to be applied to the design, fabrication, construction, testing, operation, modification, and decommissioning of the ITS SSCs of the ISFSI. The description must identify the ITS SSCs.
- For an application from the DOE for an ISFSI, the DOE needs to provide a description of the physical protection plan for protection against radiological sabotage as required by 10 CFR Part 72, Subpart H.
- A description of the program covering preoperational testing and initial operations.

§ 72.30 Financial Assurance and Recordkeeping for Decommissioning

§ 72.28 requires each application for a specific license under 10 CFR Part 72 to include a proposed decommissioning plan that identifies those design features of the ISFSI that facilitate its decontamination and decommissioning at the end of its life. The proposed decommissioning plan must also include a decommissioning funding plan. For the DOE, financial assurance for decommissioning must be provided by a statement of intent containing a cost estimate for decommissioning, and indicating that funds for decommissioning will be obtained when necessary. The licensee is required to keep records of information important to the decommissioning of a facility in an identified location until the site is released for unrestricted use, including records of spills or other unusual occurrences that involve the spread of contamination; as-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored; and of locations of possible inaccessible contamination, such as buried pipes.

§ 72.32 Emergency Plan

§ 72.32(a) requires each application for a specific ISFSI license under 10 CFR Part 72, where the ISFSI is not located on the site of a nuclear power reactor that has an operating license (which will be the case for the CSF), to include an emergency plan that contains a description of the facility, identification of the types of accidents that could occur, classification of accidents, detection of accidents, mitigation of consequences, assessment of releases, responsibilities, notification and coordination, training, and off-site assistance.

§ 72.32(b) provides similar requirements for an emergency plan for an ISFSI that may process and/or repackage SNF, which is planned for the CSF in its later phases of operation.

§ 72.34 Environmental Report

Each application for an ISFSI under 10 CFR Part 72 must be accompanied by an Environmental Report that meets the requirements of Subpart A of 10 CFR Part 51.

10 CFR Part 72 Subpart C—Issuance and Conditions of License

§ 72.42 Duration of License; Renewal

§ 72.42(a) states that each license issued under 10 CFR Part 72 for an ISFSI (which includes that for the CSF) must be for a fixed period of time, to be specified in the license. The license term for an ISFSI must not exceed 40 years from the date of issuance. Licenses for an ISFSI may be renewed by the Commission at the expiration of the license term upon application by the licensee for a period not to exceed 40 years. Application for ISFSI license renewals must include: 1) Time-Limited Aging Analyses that demonstrate that SSCs classified ITS will continue to perform their intended function for the requested period of extended operation; and 2) a description of the Aging Management Program for management of issues associated with aging that could adversely affect SSCs classified ITS. § 72.42(b) states that applications for renewal of a license should be filed in accordance with the applicable provisions of Subpart B of 10 CFR Part 72 at least 2 years before the expiration of the existing license. § 72.42(c) states that when a licensee has filed an application in proper form for renewal of a license, the existing license shall not expire until a final decision concerning the application for renewal has been made by the Commission.

§ 72.44 License Conditions

§ 72.44 requires each application for a specific license under 10 CFR Part 72 to include license conditions that are derived from the analyses and evaluations included in the SAR. License conditions pertain to design, construction and operation. The Commission may also include additional license conditions as it finds appropriate. Each ISFSI license must include technical specifications that state the limits on the release of radioactive materials for compliance with limits of 10 CFR Part 20. The technical specifications need to require that operating procedures for control of effluents be established and followed, equipment in the radioactive waste treatment systems be used and maintained to meet the requirements of § 72.104, an environmental monitoring program be established to ensure compliance with the technical specifications for effluents; and an annual report be submitted with sufficient information for the Commission to estimate maximum potential radiation dose commitment to the public resulting from effluent releases.

§ 72.46 Public Hearings

§ 72.46(a) discusses the requirements for public hearings and states that with each application for a license under 10 CFR Part 72, the Commission shall issue or cause to be issued a notice of proposed action and opportunity for hearing. § 72.46(b)(2) states that the Director, NRC's Office of Nuclear Material Safety and Safeguards, or the Director's designee may dispense with a notice of proposed action and opportunity for hearing or a notice of hearing and take immediate action on an amendment to a license issued under this part upon a determination that the amendment does not present a genuine issue as to whether the health and safety of the public will be significantly affected. § 72.46 (e) states that if an application for (or an amendment to) a specific license issued under 10 CFR Part 72 incorporates by reference information on the design of a SNF storage cask for which NRC approval pursuant to subpart L of 10 CFR Part 72 has been issued or is being sought, the scope of any public hearing held to consider the application will not include any cask design issues.

§ 72.54 Expiration and Termination of Licenses and Decommissioning of Sites and Separate Buildings or Outdoor Areas

§ 72.54(d) states that when the licensee has decided to permanently cease principal activities defined under 10 CFR Part 72 at the entire site or any separate building or outdoor area that contains residual radioactivity, the licensee shall notify the Commission and submit within 12 months of this notification a final decommissioning plan, and begin decommissioning upon approval of the plan. § 72.54(j) states that except as provided in § 72.54(k), each licensee shall complete decommissioning of the site or separate building or outdoor area as soon as practicable but no later than 24 months following approval of the final decommissioning plan by the Commission. § 72.54(k) states that the Commission may approve a request for an alternate schedule for completion of decommissioning of the site or separate building or outdoor area, and license termination if appropriate, if the Commission determines that the alternate schedule is warranted by consideration of the following: (1) Whether it is technically feasible to complete decommissioning within the allotted 24-month period; (2) Whether sufficient waste disposal capacity is available to allow completion of decommissioning within the allotted 24-month period; (3) Whether a significant volume reduction in wastes requiring disposal will be achieved by allowing short-lived radionuclides to decay; (4) Whether a significant reduction in radiation exposure to workers can be achieved by allowing short-lived radionuclides to decay; and (5) Other site-specific factors that the Commission may consider appropriate on a case-by-case basis. Per § 72.54(m), decommissioning is not completed until a radiation survey has been performed that demonstrates that the premises are suitable for release in accordance with the criteria for decommissioning in 10 CFR Part 20, Subpart E.

10 CFR Part 72 Subpart D—Records, Reports, Inspections, and Enforcement

§ 72.70 Safety Analysis Report Updating

§ 72.70(c) requires each licensee to submit an original FSAR to the Commission within 90 days after issuance of the license, and submittal of FSAR updates every 24 months that reflect the effects of changes to the facility and procedures as described in the FSAR, and safety analyses performed by the licensee.

§ 72.72 Material Balance, Inventory, and Records Requirements for Stored Materials

§ 72.72(a) states that each licensee shall keep records showing the receipt, inventory (including location), disposal, acquisition, and transfer of all special nuclear material with quantities as specified in 10 CFR 74.13(a) and for source material as specified in 10 CFR 40.64. The records must include as a minimum the name of shipper of the material to the ISFSI, the estimated quantity of radioactive material per item (including special nuclear material in SNF and reactor-related GTCC waste), item identification and serial number, storage location, on-site movements of each fuel assembly or storage canister, and ultimate disposal. § 72.72(b) requires each licensee to conduct a physical inventory of all SNF and reactor-related GTCC waste containing special nuclear material at intervals not to exceed 12 months unless otherwise directed by the Commission.

§ 72.82 Inspections and Tests

§ 72.82(c) requires each licensee to provide rent-free office space for the exclusive use of the Commission inspection personnel, upon request by the Director, Office of Nuclear Material Safety and Safeguards or the appropriate NRC Regional Administrator. For a site with a single storage installation, the space provided shall be adequate to accommodate a full-time inspector, a part-time secretary, and transient NRC personnel and will be generally commensurate with other office facilities at the site. For sites containing multiple facilities, additional space may be requested to accommodate additional full-time inspectors.

10 CFR Part 72 Subpart E—Siting Evaluation Factors

§ 72.90 General Considerations

§ 72.90 requires proposed sites for the ISFSI to be examined with respect to the frequency and the severity of external natural and man-induced events that could affect the safe operation of the ISFSI. Design basis external events must be determined for each combination of proposed site and proposed ISFSI.

§ 72.96 Siting Limitations

§ 72.96(a) states that an ISFSI that is owned and operated by the DOE must not be located at any site within which there is a candidate site for a high-level radioactive waste (HLW) repository. This limitation applies until such time as the DOE decides that such candidate site is no longer a candidate site under consideration for development as a HLW repository.

§ 72.102 Geological and seismological characteristics for applications before October 16, 2003 and applications for other than dry cask modes of storage.

If the CSF uses wet storage of UNF and not exclusively dry storage, this regulation is applicable.

§ 72.102 states that east of the Rocky Mountain Front (east of approximately 104° west longitude), except in areas of known seismic activity, including but not limited to the regions around New Madrid, Missouri; Charleston, South Carolina; and Attica, New York, sites will be acceptable if the results from on-site foundation and geological investigation, literature review, and regional geological reconnaissance show no unstable geological characteristics, soil stability problems, or potential for vibratory ground motion at the site in excess of an appropriate response spectrum anchored at 0.2g. For those sites that are east of the Rocky Mountain Front, and that are not in areas of known seismic activity, a standardized design basis earthquake (DBE) described by an appropriate response spectrum anchored at 0.25g may be used. Alternatively, a site-specific DBE may be determined by using the criteria and level of investigations required by 10 CFR Part 100, Appendix A. West of the Rocky Mountain Front (west of approximately 104° west longitude), and in other areas of known potential seismic activity, seismicity will be evaluated by the techniques of 10 CFR Part 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.

§ 72.103 Geological and Seismological Characteristics for Applications for Dry Cask Modes of Storage on or After October 16, 2003

This regulation has the same requirements as § 72.102 for sites east of the Rocky Mountain Front and that are not in areas of known seismic activity. For sites west of the Rocky Mountain Front (west of approximately 104° west longitude), and in other areas of known potential seismic activity east of the Rocky Mountain Front, seismicity must be evaluated by the techniques presented in paragraph (f) of this section. § 72.102(f) indicates that uncertainties are inherent in the estimates of DBE horizontal and vertical seismic ground accelerations and these must be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analyses.

§ 72.104 Criteria for Radioactive Materials in Effluents and Direct Radiation from an ISFSI

§ 72.104(a) requires that 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 critical organ as a result of exposure to: (1) Planned discharges of radioactive materials and radon and its decay products released to the general environment, (2) Direct radiation from ISFSI operations, and (3) Any other radiation from uranium fuel cycle operations within the region.

§ 72.106 Controlled area of an ISFSI

§ 72.106 provides restrictions on doses that could result from credible accident conditions. In addition, this regulation states that the minimum distance from the SNF, HLW, or reactor-related GTCC waste handling and storage facilities to the nearest boundary of the controlled area must be at least 100 meters.

10 CFR Part 72 Subpart F—General Design Criteria

§ 72.120 General Considerations

§ 72.120(b) requires that reactor-related GTCC waste may not be stored in a cask that also contains SNF. This restriction does not include radioactive materials that are associated with fuel assemblies (i.e., control rod blades or assemblies, thimble plugs, burnable poison rod assemblies, or fuel channels). If the ISFSI is a water-pool type facility, the reactor-related GTCC waste must be in a durable solid form with demonstrable leach resistance. § 72.120(e) indicates that the NRC may authorize exceptions, on a case-by-case basis, regarding the commingling of SNF and reactor-related GTCC waste in the same cask.

§ 72.120(d) states that the ISFSI must be designed, made of materials, and constructed to ensure that there will be no significant chemical, galvanic, or other reactions between or among the storage system components, SNF, reactor-related GTCC waste, and/or HLW, including possible reaction with water during wet loading and unloading operations or during storage in a water-pool type ISFSI. The behavior of materials under irradiation and thermal conditions must be taken into account.

§ 72.122 Overall Requirements

§ 72.122(h) “Confinement barriers and systems,” states that the SNF cladding must be protected during storage against degradation that leads to gross ruptures, or the SNF must be otherwise confined such that degradation of the SNF during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning of consolidated SNF rods or unconsolidated assemblies or other means as appropriate. For underwater storage of SNF, or reactor-related GTCC waste 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. The design must preclude installations of drains, permanently connected systems, and other features that could, by abnormal operations or failure, cause a significant loss of water. Pool water level equipment must be provided to alarm in a continuously manned location if the water level in the storage pools falls below a predetermined level. Ventilation systems 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 in a manner such that the licensee will be able to determine when corrective action needs to be taken to maintain safe storage conditions. For dry SNF storage, periodic monitoring is sufficient provided that periodic monitoring is consistent with the dry SNF storage cask design requirements. The monitoring period must be based upon the SNF storage cask design requirements. Instrumentation and control systems for wet SNF and reactor-related GTCC waste storage must be provided to monitor systems that are important to safety over anticipated ranges for normal operation and off-normal operation.

§ 72.122(k) states that each utility service system must be designed to meet emergency conditions. The design of utility services and distribution systems that are 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 testing of the functional operability and capacity, including the full operational sequence, of each system for transfer between normal and emergency supply sources; and to permit 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 in amounts sufficient to allow safe storage conditions to be maintained and to permit continued functioning of all systems essential to safe storage.

§ 72.122(l) Retrievability, states that *s*torage systems must be designed to allow ready retrieval of SNF and reactor-related GTCC waste for further processing or disposal.

§ 72.124 Criteria for Nuclear Criticality Safety

§ 72.124(b) Methods of criticality control, states that when practicable, the design of an ISFSI must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons), or both. Where solid neutron absorbing materials are used, the design must provide for positive means of verifying their continued efficacy. For dry SNF storage systems, the continued efficacy may be confirmed by a demonstration or analysis before use, showing that significant degradation of the neutron absorbing materials cannot occur over the life of the facility. § 72.124(c) requires that criticality monitoring systems shall be maintained in each area where special nuclear material is handled, used, or stored which 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. Monitoring of dry storage areas where special nuclear material is packaged in its stored configuration under a license issued under this subpart is not required.

§ 72.126 Criteria for Radiological Protection

§ 72.126(b) requires that 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. § 72.126(c) requires that 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 levels in and around these areas. § 72.126(d) states that 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 § 72.104. Analyses of design basis accidents must be made to show that releases to the general environment will be within the exposure limits given in § 72.106. Systems designed to monitor the release of radioactive materials must have means for calibration and testing their operability.

§ 72.128 Criteria for Spent Fuel, High-Level Radioactive Waste, and Other Radioactive Waste Storage and Handling

§ 72.128(a) states that SNF storage, reactor-related GTCC waste storage and other systems that might contain or handle radioactive materials associated with SNF or reactor-related GTCC waste, 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, and (5) Means to minimize the quantity of radioactive wastes generated. § 72.128(b) states that provisions must be made for the packing of site-generated low-level wastes in a form suitable for storage onsite awaiting transfer to disposal sites.

§ 72.130 Criteria for Decommissioning

§ 72.130 requires that the ISFSI be designed for decommissioning.

10 CFR Part 72 Subpart H—Physical Protection

§ 72.180 Physical Protection Plan

§ 72.180 requires the licensee to establish, maintain, and follow a detailed plan for physical protection as described in 10 CFR 73.51. The plan must describe how the applicant will meet the requirements of 10 CFR 73.51 and provide physical protection during on-site transportation to and from the proposed ISFSI, and include within the plan the design for physical protection, the safeguards contingency plan, and the security organization personnel training and qualification plan. The plan must list tests, inspections, audits, and other means to be used to demonstrate compliance with the requirements.

10 CFR Part 72 Subpart I—Training and Certification of Personnel

§ 72.190 Operator Requirements

Operation of equipment and controls that have been identified as important to safety in the SAR and in the license must be limited to trained and certified personnel or be under the direct visual supervision of an individual with training and certification in the operation. Supervisory personnel who personally direct the operation of equipment and controls that are important to safety must also be certified in such operations.

§ 72.192 Operator Training and Certification Program

The applicant for a license under this part shall establish a program for training, proficiency testing, and certification of ISFSI personnel. This program must be submitted to the Commission for approval with the license application.

3.1.3 Engineering Parameters and Assumptions

Table 3.1-1 lists the various design basis parameters and assumptions that are used in development of the CSF.

Table 3.1-1
CSF Design Basis

Description	Design	Basis or Reference
UNF		
PFS Size ISFSI Storage Capacity	40,000 MTU	PFS FSAR
Current Max. ISFSI Storage Capacity	70,000 MTU	Waste Policy Act Limits
Projected Commercial UNF Qty	140,000 MTU	Section 5.0
Annual UNF Discharged	2,200 MTU	ERI Report, 2011
BWR/PWR Ratio	38% BWR/62% PWR	2008 YMP UNF Disposal Estimates
DFSSs		
Annual UNF Acceptance Rate	4,500 MTU	Section 5.0

Description	Design	Basis or Reference
Annual No. DFSS Received	350 to 650	Section 5.0
Annual No. Trains Expected	60	Section 5.0
Transport Casks per Train	5	Section 5.0
Transport Casks to be Received	Fuel Solutions TS125	Gutherman Technical Services
	HOLTEC HI-STAR 100	Gutherman Technical Services
	HOLTEC HI-STAR 190	Gutherman Technical Services
	NAC STC	Gutherman Technical Services
	NAC UMS-T	Gutherman Technical Services
	NAC MAGNATRAN	Gutherman Technical Services
	Transnuclear MP187	Gutherman Technical Services
	Transnuclear MP197 & MP197HB	Gutherman Technical Services
	Small Capacity Rail Cask	Section 5.0
	Truck Casks (limited quantities)	Section 5.0
DFSS to be Processed	HOLTEC	
	HI-STAR 100/HI-STAR HB/HI-STORM 100	Gutherman Technical Services
	- MPC-24 series	Gutherman Technical Services
	- MPC-32 series	Gutherman Technical Services
	- MPC-68 series	Gutherman Technical Services
	- MPC-HB	Gutherman Technical Services
	HI-STORM FW / HI-STAR 190	Gutherman Technical Services
	- MPC-37 series	Gutherman Technical Services
	- MPC-89 series	Gutherman Technical Services
	NAC	
	- MPC series	Gutherman Technical Services
	- UMS- 24	Gutherman Technical Services
	MAGNASTOR	Gutherman Technical Services
	- TSC with 37 PWR assembly basket	Gutherman Technical Services
	- TSC with 82 or 87 BWR assembly basket	Gutherman Technical Services
	TRANSNUCLEAR	
	- TN series	Gutherman Technical Services
	- NUHOMS 24P/24PT series	Gutherman Technical Services
	- NUHOMS 32P/32PT series	Gutherman Technical Services
	- NUHOMS 37PT series	Gutherman Technical Services
	- NUHOMS 52B series	Gutherman Technical Services
	- NUHOMS 61BT series	Gutherman Technical Services

Description	Design	Basis or Reference
	Fuel Solutions W74	Gutherman Technical Services
Cask Handling Building		
DFSS Process Rate	1.2 Transport Casks/day	Section 5.0
Access	Rail and Truck	Section 5.0
Contamination Control	Truck/Rail Cleaning Awning	10 CFR 20
Crane Capacity	200 tons	Transport Package Weight
Vertical Canister Transfer	Canister Transfer Area	Vertical Canister FSAR
Horizontal Canister Transfer	Storage Pad Area	Horizontal Canister FSAR
Min. BWR Pool Capacity	3400 BWR Assemblies	≈50 Transport Cask Quantity
Min. PWR Pool Capacity	1600 PWR Assemblies	≈50 Transport Cask Quantity
CSF Boundaries		
Security Boundaries	Protected Area	10 CFR Part 73.51
Radiation Boundary	Radiation Area	10 CFR Part 20

Dry Fuel Storage Systems

There are currently four companies that provide DFSSs: Holtec International, Inc., EnergySolutions, LLC., NAC International, Inc., and Transnuclear Inc. Of the four, EnergySolutions only maintains systems from legacy companies Sierra Nuclear and Westinghouse and does not provide new systems at this time.

There are two types of technologies that consist of cask-based DFSSs and canister-based DFSSs. The canister-based systems are further broken into vertical configuration and horizontal configuration.

Cask-Based Systems

Cask-based systems are designed to meet storage requirements of 10 CFR Part 72 or storage and transportation requirements of 10 CFR Part 72 and 10 CFR Part 71. Cask–based systems are very robust being constructed of a thick steel shell for confinement and radiological gamma shielding. The casks typically have additional materials for neutron shielding incorporated into their design. The cask shell provides the primary confinement boundary. The casks typically have a basket permanently mounted into the cask interior for UNF assembly support and geometry control. Cask-based systems utilize a bolted lid with double metallic seals. Since they employ a bolted lid, the UNF assemblies can be loaded or unloaded from the cask with relative ease. Therefore, for this report, they are referred to as bare fuel casks.

Canister-Based Systems

Canister-based systems are licensed under 10 CFR Part 72 for storage as well as 10 CFR Part 71 for transportation. They use DPC, which is a thin-walled metal container that is welded closed after the UNF assemblies have been loaded. The DPC provides the primary confinement boundary. The DPC can be placed into three different containers. During handling or transfer operations within a plant, the DPC is placed in a transfer cask; during transport, the DPC is placed in a transport cask; and during storage the DPC resides in a storage overpack or module.

The transfer cask is a metal container with trunnions that provides physical protection of the DPC, radiation shielding to personnel, and a means to be lifted and handled by the crane. The transport cask is a metal container with trunnions that protects the DPC from any credible accident that might occur during shipping. The metal cask is fitted with impact limiting devices for additional protection during transit.

The storage overpack or module is a thick concrete or metal container that provides physical protection of the DPC while resting on a concrete pad and radiation shielding to personnel and off-site persons. Two design variations of the storage container are vertical storage of the DPC inside a concrete or metal storage overpack and horizontal storage of the DPC inside a concrete horizontal storage module. The only significant difference between the two variations is the overpack or module design, DPC orientation, and DPC transfer process. In vertical systems, the DPC is transferred from the transfer cask into the storage overpack by stacking the transfer cask on top of the overpack and lowering the DPC into the overpack. This is typically done in a building with a large overhead crane. The DPC is also transferred into the transport cask using the same stack-up method by placing the transfer cask on top of the transport cask and lowering the DPC into the transport cask. In horizontal systems, the DPC is transferred from the transfer cask or transport cask outside at the storage module. The transfer or transport cask is placed horizontal on a special trailer with a hydraulic ram. The trailer is backed up against the storage module opening and the hydraulic ram pushes the DPC into the storage module.

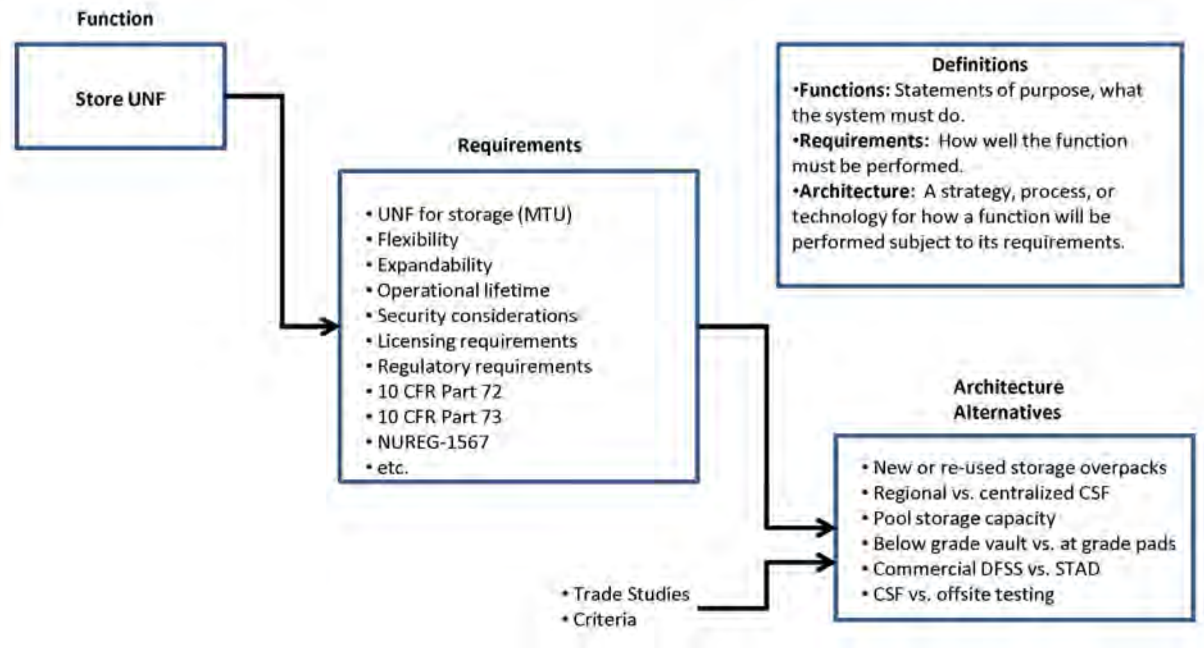
Both concrete storage overpacks and storage modules provide a means for passive heat transfer by natural convection from the DPC through air vents built into the overpack or module. The metal storage overpacks provide passive heat transfer by conduction through the overpack body.

3.1.4 Systems Engineering

3.1.4.1 Store UNF

Figure 3.1 1 shows the results of applying the systems engineering approach described in Section 2.0 to the “Store UNF” function, which will take place at the CSF. In addition to the relevant requirements imposed by the Code of Federal Regulations and recommendations of NRC NUREGS and other guidance documents (which are treated as requirements), additional requirements, such as the amount of UNF to be stored and the nature of the UNF packages to be received, must be considered and satisfied by the preferred preparation concept/strategy. A set of feasible alternatives has been formulated that could potentially satisfy the "Accept UNF" function and its allocated requirements. Trade studies were conducted to evaluate, compare, and recommend the preferred alternatives.

Figure 3.1-1
Requirements and Architecture for the "Store UNF" Function



3.1.4.2 Process Flow at the CSF

Upon receipt of the UNF at the CSF, horizontal DFSSs will flow through the top path in **Figure 3.1-2,** while vertical DFSSs (dual purpose canisters [DPCs] and bare fuel casks) will flow through the lower level path. Both horizontal and vertical systems will be placed in interim long-term storage. After storage, UNF that has been stored in systems that can be placed in a disposable waste package will be loaded directly into a transport cask for shipment to the repository, whereas UNF in non-disposable waste packages will be subjected to additional process steps and loaded into a disposable canister as shown in **Figure 3.1-3**.

Figure 3.1-2
Process Flow at the CSF

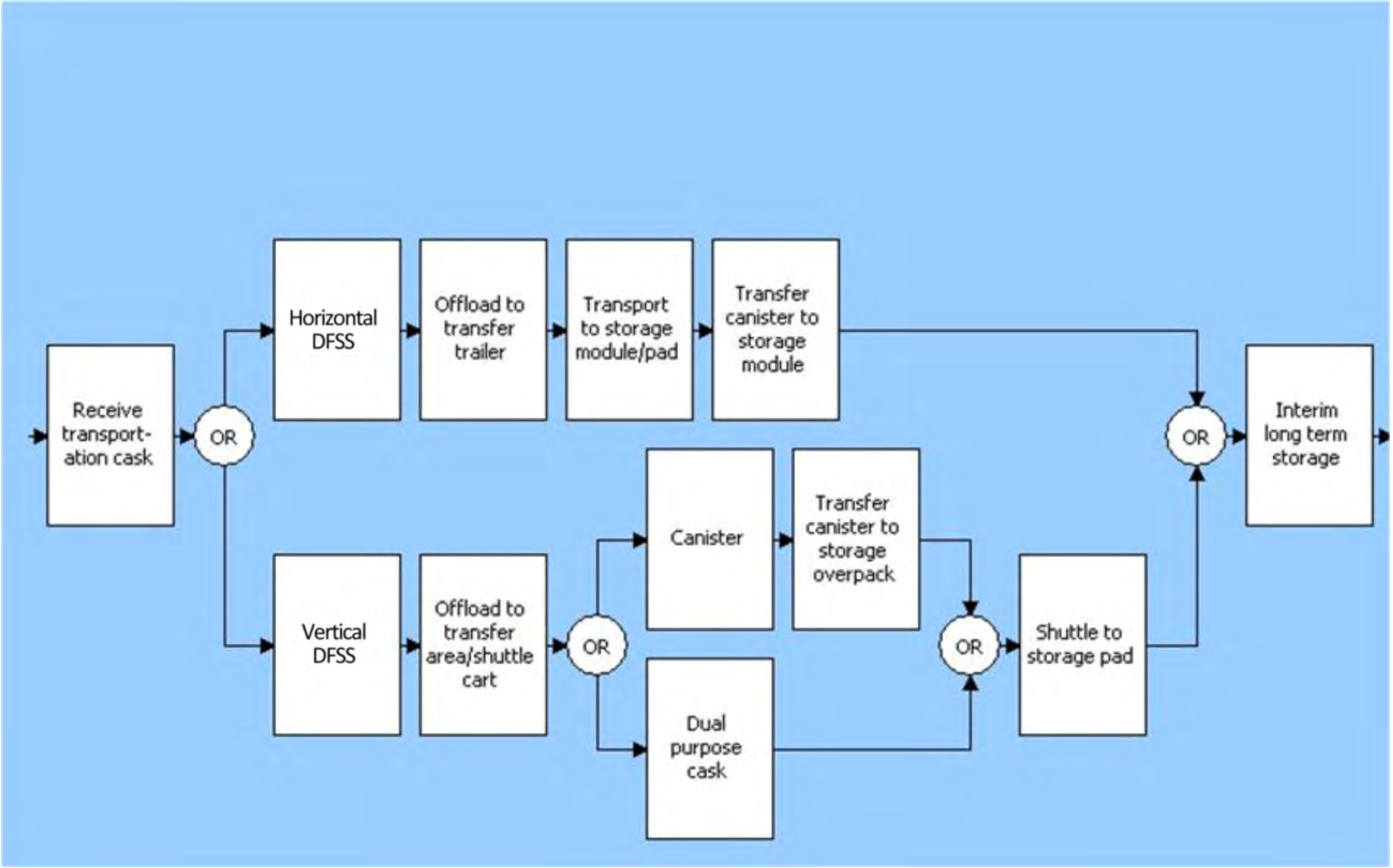
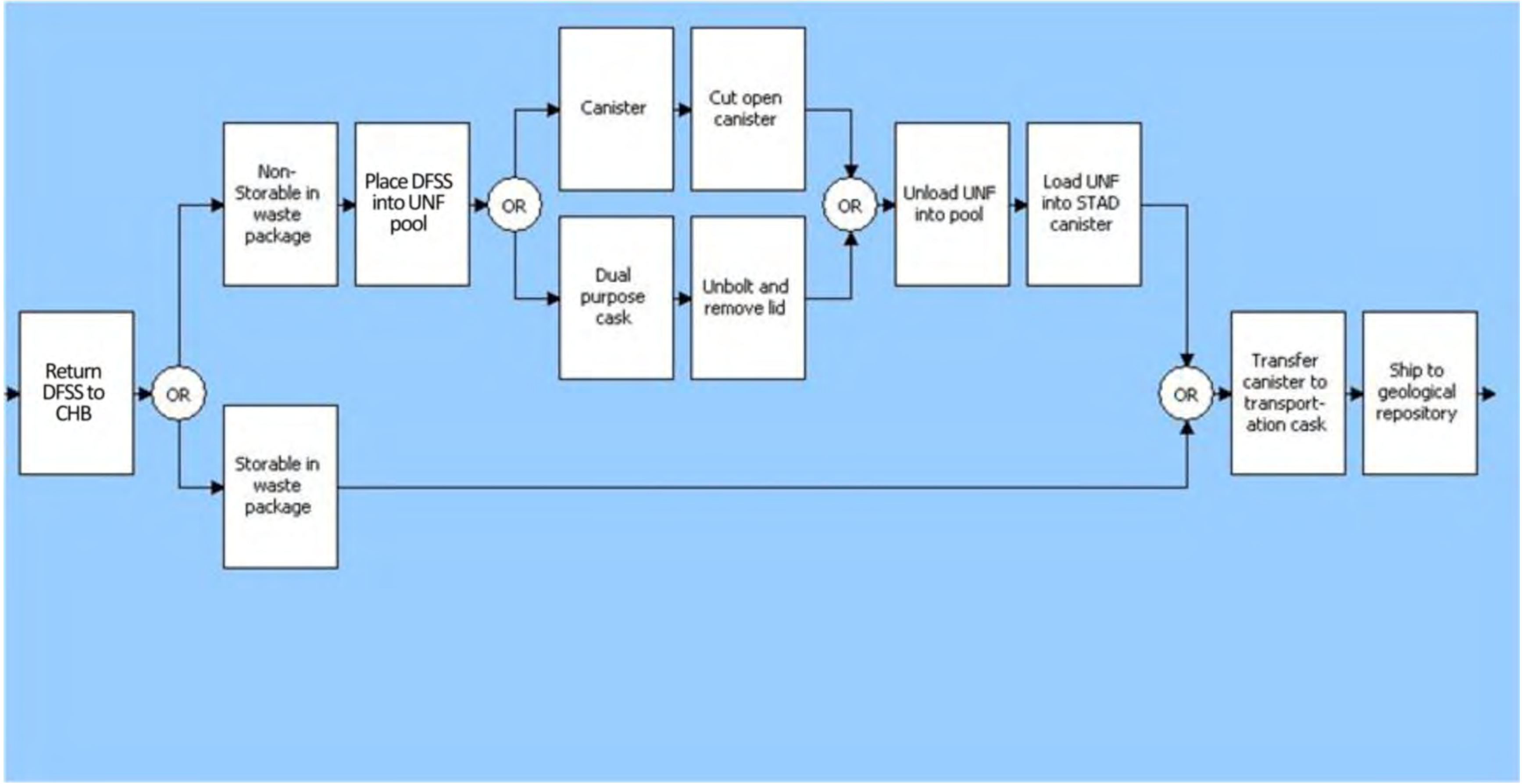


Figure 3.1-3
Process Flow at the CSF (continued)



3.2 Consolidated Storage Facility Operational Phases

The CSF concept is based on an integrated system analysis and engineering approach that optimizes interfaces between reactor sites, transportation logistics, and CSF processes and storage features. Implementation of the CSF is conducted in four unique operational phases that address the various types of UNF packaging that the CSF will need to process. The phases start operation as a simple, relatively small and inexpensive "pilot" facility that expands over time through three unique construction stages to accommodate increased shipments and UNF package issues as follows:

- Operational Phase 1 / Construction Stage 1—Construct a basic CSF with storage pads, rail, and facilities to receive and store stranded UNF. The focus of Phase 1 is acceptance of stranded UNF from shutdown plant sites (as discussed in Section 1.0, "Summary", acceptance of stranded UNF at the CSF is top priority).
- Operational Phase 2 / Construction Stage 2—Expand CSF storage pad capacity to receive and store UNF in transportable canisters from operating plant sites.
- Operational Phase 3 / Construction Stage 3—Expand CSF to add UNF pools (UFPs) to receive UNF in bare fuel transport casks and store UNF either in pools or in dry storage in standardized canisters. This phase provides an alternative method of receipt and storage of UNF from Phase 2. This construction stage includes construction of a hot cell and research and development (R&D) facility to enable on-site testing of UNF, long-term packaging reliability and remediation, and complete dry storage build-out.
- Operational Phase 4 (no construction)—Receive and store UNF that is currently stored in non-transportable storage canisters or casks. The phase requires that shipping UNF currently stored in non-transportable storage systems be addressed which could require licensing, engineering, or repackaging solutions.

3.2.1 Phase 1—Stranded UNF at Shutdown Plant Sites

3.2.1.1 Phase 1 Overview

Currently, there are nine shutdown plant sites with stranded UNF. By 2020, it is anticipated that Kewaunee and Oyster Creek will join this category. All of the shutdown plant sites currently have, or will have, UNF stored in DFSSs that have canisters that can be shipped to the CSF in a transport cask that together comprise a transportation package. All of the shutdown plant sites will require additional equipment to transfer the canisters from vertical storage overpacks or horizontal storage modules (HSMs) to transport casks[6] and ready the packages for transport off site (ranging from impact limiters, mobile cranes, and/or vertical

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[6] This activity is not required for the HI-STAR HB System.

cask transporters to transfer casks and equipment). All but four of these shutdown plant sites have been dismantled as of this writing, eliminating permanently installed plant cranes and equipment that is no longer available to transfer the canisters from storage overpacks to transport packages. Some equipment needed for transferring the canister from a vertical storage cask to the transport cask, such as transfer casks, lifting yokes, and/or vertical cask transporters, may be available. However, canister transfer facilities and cranes may need to be used at nearly all of the shutdown plant sites to enable transfer of loaded canisters from storage overpacks or HSMs into transport casks for shipment to the CSF. (Canisters inside HSMs do not require transfer casks to move the canister from the HSM to the transport cask.)

Some of the canisters contain GTCC waste. The GTCC waste is loaded into canisters similar to those used for the UNF and will need to be removed from the reactor site along with the UNF in order to allow for decommissioning of each site. Transport cask designs utilized at these shutdown plant sites have been certified to transport both UNF and GTCC waste.

In Phase 1, the CSF can be designed for future growth, yet constructed with minimum essential structures and components for receiving transport casks from the 11 shutdown plant sites and placing the canisterized UNF into long-term interim storage. Because the DPCs (which are welded closed) do not need to be opened, the CSF in Phase 1 would operate as a “start clean, stay clean” facility. Before UNF can be retrieved, specific schedules for removal of UNF under the existing Standard Contract will need to be developed with input from the owners. This would include development of site surveys, site-specific plans, status of government-furnished equipment, local permits, subcontractor contracts, etc. This could take several months or longer depending on the complexity of the task.

Also within this initial phase, a number of potential cost-saving measures are identified, which include collecting the existing storage overpacks to be shipped as overweight/oversized loads via railroad to the CSF for reuse, collecting remaining vehicles to start the necessary fleet at the CSF, and collecting remaining equipment to build a base of equipment to perform transfer operations and reduce potential waste at the stranded UNF sites. HSMs can also be disassembled at the plant sites, shipped to the CSF, and re-assembled for use there. The reduction of fabrication needs on site at the CSF will ultimately reduce costs and potential waste created and requiring disposal at the shutdown plant sites.

3.2.1.2 Stranded UNF Sites

The 11 sites that have been identified as having stranded UNF by the year 2020 are Big Rock Point, Haddam Neck (Connecticut Yankee), Humboldt Bay, Kewaunee, LaCrosse, Maine Yankee, Oyster Creek, Rancho Seco, Trojan, Yankee Rowe, and Zion.

Nuclear power plants that have permanently ceased operation and have been dismantled may no longer have on-site capability to lift heavy loads, such as a transfer cask or canister, to accomplish the operations required to transfer a canister from a storage overpack to a transfer cask and from the transfer cask to the transport cask. It will be necessary to install temporary cranes or canister transfer facilities at these sites or to bring in mobile cranes to enable loaded canisters to be transferred from the storage overpacks and HSMs to transport casks, and to lift the loaded transport casks and impact limiters onto the railcar or heavy-haul vehicle in preparation for shipment off site.

It should be noted that some of these sites still maintain equipment that may or may not be useful at the CSF. Humboldt Bay currently has a vertical cask transporter (VCT) used to move the site-specific DFSS, Trojan has a freestanding outdoor canister transfer structure, and other sites have transport casks. By sequencing the collection from shutdown plant sites, the CSF may be able to gain essential equipment for the initial operation of transferring canisters or maneuvering casks at sites and storing the DFSS at the CSF. Although some of the identified equipment might be site-specific, assessing if this equipment could be modified to accommodate more of the current DFSSs that exist may provide additional cost savings.

Table 3.2-1 shows all 11 sites that are either currently shutdown plant sites or will be by 2020, as well as their plant and ISFSI licensing status in order of year the last UNF can be shipped. The UNF from all but two of these reactors is already cooled adequately for transportation. Oyster Creek will be the last reactor to be shut down, planned for late 2019. In order to ship the last UNF from Oyster Creek, it is assumed that the fuel will need to be stored in the plant spent fuel pool (SFP) for at least 6 years before it is cooled sufficiently to be loaded into a transport cask, based on heat load limitations. Therefore, it is estimated that final UNF loading operations at Oyster Creek cannot proceed until the beginning of 2025. Depending on the start date for the CSF, this will likely be the last UNF placed in storage during Phase 1. While this analysis assumes that the UNF from Oyster Creek can be transported to a CSF during the first 6 years of operation, it will depend upon the actual burnup and decay heat of UNF discharged in the final cycles of reactor operation. As discussed in Section 5.0, it may be necessary for some UNF to be shipped from the Oyster Creek SFP in smaller-capacity transport packages that can accommodate high-decay-heat UNF.

Table 3.2-1
Stranded UNF Sites and Status

Plant Site	Year of Plant Shutdown	Type of ISFSI License	Year of Initial ISFSI Operation	Year all UNF Transportable (Based on 10-year Cooling)	Plant Decommissioning Status
Humboldt Bay	1985	Specific	2005	1995	In progress
LaCrosse	1987	General	2012	1997	In progress
Rancho Seco	1989	Specific	2000	1999	Complete
Yankee Rowe	1991	General	2002	2001	Complete
Trojan	1992	Specific	1999	2002	Complete
Haddam Neck	1996	General	2004	2006	Complete
Maine Yankee	1996	General	2002	2006	Complete
Big Rock Point	1997	General	2002	2007	Complete
Zion 1	1997	General	~ 2013	2007	In progress
Zion 2	1996				In progress
Kewaunee	2013*	General	2009	2023	Future
Oyster Creek	2019**	General	2002	2029	Future

References:

1. *Plant Shutdown: Ref. NRC Information Digest (NUREG-1350, Volume 24), Appendix B: U.S. Commercial Nuclear Power Reactors Formerly Licensed to Operate.*
2. *ISFSI license type and year of operation: Gutherman Technical Services, LLC*

**Dominion announcement, Dominion to Close and Decommission Kewaunee Nuclear Station, October 22, 2012.*

***Exelon announcement 2010, NJ Nuke Plant Closing 10 Years Early January 15, 1998.*

3.2.1.3 Origination of UNF and Applicable Storage Systems

There are expected to be approximately 367 canisters containing stranded UNF needing retrieval in Phase 1, depending on how many canisters are ultimately required at Zion, Kewaunee, and Oyster Creek. **Table 3.2-2** identifies each of the shutdown reactor sites, types and numbers of dry storage casks currently located or planned at their respective on-site ISFSIs, total number of UNF assemblies in dry cask storage, and total quantity of fuel in MTU in storage.

Table 3.2-2
Stranded UNF Locations, DFSS Types, and Quantities

Reactor	DFSS/Canister Model	Number of Canisters	Number of UNF Assemblies	Total MTU
Big Rock Point	Fuel Solutions	7 UNF, 1 GTCC	441	58
Haddam Neck	NAC MPC-26/TSC	40 UNF, 3 GTCC	1,019	422
Humboldt Bay	Holtec HI-STAR HB	5 UNF, 1 GTCC	390	31

Reactor	DFSS/Canister Model	Number of Canisters	Number of UNF Assemblies	Total MTU
	MPC-HB			
Kewaunee	TN NUHOMS-32PT	42 UNF, 1GTCC	1333	520
LaCrosse	NAC MPC-68	5 UNF, No GTCC	333	38
Maine Yankee	NAC UMS-24	60 UNF, 4 GTCC	1,438	542
Oyster Creek	TN NUHOMS-61BT	77 UNF, 1 GTCC	4,692	815
Rancho Seco	TN NUHOMS-24PT	21 UNF, 1 GTCC	493	228
Trojan	TranStor/Holtec HI-STORM MPC-24E	34 UNF, No GTCC	801	345
Yankee Rowe	NAC MPC-36	15 UNF, 1 GTCC	533	122
Zion	NAC MAGNASTOR-37	61 UNF, 4 GTCC	2,226	1,019
Total	-	367 UNF, 17 GTCC	13,699	4,140

References:

1. *Storage model: NRC Information Digest (NUREG-1350, Volume 24), Appendix O: Dry Spent Fuel Storage Licensees.*
2. *Cask and Assembly Quantities: Gutherman Technical Services and Energy Resources International, Inc.*

Table 3.2-2 shows that the total quantity of uranium that would be retrieved in this phase is 4,140 MTU. This represents approximately 3 percent of the total MTU that will ultimately need to be retrieved from all the commercial reactors, assuming the total is 140,000 MTU. In addition, there are 17 canisters containing GTCC waste to be retrieved.

Figures 3.2-1 through **3.2-7** illustrate the types of DFSS that are present at the various shutdown reactor sites.

Figure 3.2-1
Fuel Solutions W150 System at the Big Rock Point ISFSI

Figure 3.2-2
NAC MPC System at the Yankee Rowe ISFSI

(Similar systems at Haddam Neck and LaCrosse)

Figure 3.2-3
Holtec HI-STAR HB at the Humboldt Bay ISFSI

Figure 3.2-4
NAC UMS System at the Maine Yankee ISFSI

Figure 3.2-5
Transnuclear NUHOMS System at the Rancho Seco ISFSI
(Similar systems at Kewaunee and Oyster Creek)

Figure 3.2-6
Holtec MPC-24E Canister in a TranStor Storage Overpack at the Trojan ISFSI

Figure 3.2-7
NAC MAGNASTOR System that will be used at the Zion ISFSI

3.2.1.4 UNF Retrieval and CSF Design Strategy

The retrieval process must consider not only a timely collection, but also identify if the various transport casks will have future uses. Consideration should also be given to the available equipment at operating plants, such as transfer casks, cask transporters, and transfer trailers, which could be harvested for use at the CSF. Retrieval of this existing equipment will reduce the initial investment required to establish the CSF and begin the fuel removal process.

The UNF and GTCC waste at Humboldt Bay is stored in six canister-based metal cask systems that are relatively easy to retrieve, making this one of the sites that should be targeted for initial fuel removal. The Humboldt Bay ISFSI consists of a below-grade storage vault, an on-site cask transporter, and a dual purpose dry cask storage and transportation system. The owner used a modified version of the dual purpose Holtec International-Storage, Transport, and Repository (HI-STAR) 100 System, called the HI-STAR HB System. The on-site handling of the HI-STAR HB System is accomplished using a tracked transporter, which is used to handle the storage vault lid and move the HI-STAR HB cask into and out of the storage vault. Because the HI-STAR HB System is already dual purpose certified, no canister transfer operation is required. Each HI-STAR HB System may be retrieved directly from the storage vault and placed on a railcar using a mobile crane. Impact limiters and the transport cask rail skid will need to be fabricated in order to place the loaded HI-STAR HB cask on a railcar and prepare it for off-site transportation, after pre-transportation checkout and testing as required by the 10 CFR Part 71 CoC have been performed. Upon receipt at the CSF, the impact limiters and the dual purpose casks can be offloaded from the railcar by a crane at the

Cask Handling Building (CHB)[7], and the casks can be transported to the storage area by a VCT and placed on a storage pad. No additional storage overpacks will be needed for storage of Humboldt Bay UNF at the CSF.

There are shutdown plant sites that use a DFSS design employing a Nuclear Horizontal Modular Storage (NUHOMS) HSM. The canister can be transferred from the NUHOMS HSM into the transport cask at the ISFSI pad without the need to use a transfer cask or to rely on plant equipment for the canister transfer operation. A mobile crane may be needed to assist with the transfer operations by lifting the door from the HSM to allow removal of the canister, but the canister transfer itself is accomplished without a crane. A hydraulic ram located on the NUHOMS trailer grapples the canister inside the HSM and pulls it directly into the transport cask. Likewise, some type of mobile crane will be needed to install the transport cask top lid and transfer the transport cask from the NUHOMS transfer trailer to a railcar and prepare it for transport operations (i.e., install impact limiters, install personnel barrier, etc.). Upon receipt at the CSF, the impact limiters can be removed and the transport cask can be transferred to a NUHOMS transfer trailer by a crane at the CHB. The NUHOMS trailer can be towed to the storage area and the canisters can be transferred directly into HSMs by the hydraulic ram on the NUHOMS trailer. HSMs are fabricated as components that are shipped to an ISFSI and assembled for storage use. Therefore, the HSMs can be disassembled at the shutdown plant site and shipped to the CSF to save the cost of fabricating new HSMs at the CSF, if desired.

Rancho Seco uses the NUHOMS-24PT1 storage system for which the canister and its MP187 transport cask are licensed for transport under 10 CFR Part 71. Rancho Seco currently has one MP187 transport cask available on site. Impact limiters and a transport cask rail skid will need to be fabricated. Three additional MP187 transport casks and associated equipment should be procured to retrieve the 22 canisters at Rancho Seco. The MP187 transport casks can be used at a later date in Phase 2 to retrieve 17 similar canisters containing San Onofre Unit 1 UNF.

Kewaunee UNF will be stored on site in NUHOMS-32PT canisters and HSMs. The canisters can be retrieved and placed directly into transport casks like the Ranch Seco canisters. To date, Kewaunee has already loaded 8 canisters with 256 UNF assemblies and has placed them into dry storage. The rest of the Kewaunee UNF is still in the SFP. Since Kewaunee will not be shut down until 2013, the infrastructure to load canisters is still in place and is likely to remain in place for some time. Dominion Energy estimates that the SFP will remain

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[7] Note that once the impact limiters are removed, the transport cask is no longer configured to withstand a drop event. Thus, lifts of a transport cask without its impact limiters installed will require a lifting system designed for single-failure-proof lifts per NUREG-0612 or equivalent. Alternatively, drop events incorporating impact limiting devices under the cask could be analyzed to show that the consequences are acceptable.

operational for 7 years following shutdown, during which time the fuel will be transferred to dry storage. Kewaunee has barge access and should be able to ship the transport casks via waterway to an intermodal site in order to transfer the transport casks to railcars for shipment to the CSF. At least five MP197HB transport casks should be procured to efficiently retrieve the Kewaunee canisters plus the canisters at Oyster Creek (see next paragraph). These transport casks can be used at a later date during Phase 2 to ship NUHOMS 61BT canisters from Brunswick, Cooper, Duane Arnold, Monticello, Nine Mile Point, and Susquehanna.

The UNF from Oyster Creek will be stored on site in NUHOMS-61BT or 61BTH canisters and HSMs. The canisters can be retrieved and placed directly into transport casks like the Ranch Seco and Kewaunee canisters. The five MP197HB transport casks procured for Kewaunee can also be used to efficiently retrieve the 78 canisters at Oyster Creek. Because Oyster Creek will not be dismantled until after reactor shutdown in 2019, the facilities necessary to lift heavy casks at the plant should remain in place long enough to load all the canisters in transport casks onto a heavy-haul truck (HHT) trailer or barge (Oyster Creek has no rail access) for shipping to a nearby intermodal site.

The remainder of the shutdown reactor sites (Big Rock Point, Haddam Neck, LaCrosse, Maine Yankee, Trojan, Yankee Rowe, and Zion) use canisters stored in ventilated vertical storage overpacks at their on-site ISFSIs. As discussed previously, it will be necessary to employ temporary cranes and canister transfer facilities at these sites, to differing degrees, to enable loaded canisters to be transferred from the storage overpacks to transport casks, and to lift the loaded transport cask and impact limiters onto the railcar or heavy-haul vehicle in preparation for shipment off site. Likewise at the CSF, cask handling equipment will need to be in place to remove impact limiters, offload and upright the transport casks from the railcar, transfer the canisters from the transport casks to a transfer cask, and transfer the canisters from the transfer cask to a storage overpack so that they can be transported to a storage pad. The steps in this process should be performed in a controlled environment, the CHB, which will contain appropriately designed handling equipment to ensure an accidental canister drop is not credible. Therefore, the canister transfer cells of the CHB must be operational at this time.

Like Humboldt Bay and LaCrosse, Big Rock Point has fewer than 10 canisters and should be considered one of the initial sites to target so that it can be quickly eliminated from further retrieval operations. Big Rock Point has eight canisters currently at the ISFSI. One Fuel Solutions TS-125 transport cask should be procured to remove the canisters. Since the Big Rock Point DFSS is not used at any other plant site, the TS-125 transport cask cannot be used for future UNF canister retrieval, but it could be used for future GTCC waste retrieval, if desired, to maximize its use. Big Rock Point does not have any rail or barge access; therefore, a mobile crane will be needed to lift the loaded transport cask(s) to a HHT trailer.

Similar measures will need to be in place to transfer the transport cask(s) to a railcar at an intermodal site for shipment to the CSF. The W150 vertical storage overpack manufactured by Fuel Solutions at Big Rock Point is fabricated as three donut-shaped concrete segments that can be disassembled and shipped to the CSF to save the cost of fabricating new overpacks at the CSF, if desired.

The NAC MPC transportable storage canisters (TSCs) at Haddam Neck (Connecticut Yankee), LaCrosse, and Yankee Rowe use a NAC-STC transport cask. These three sites represent a total of 65 canisters. Four NAC-STC transport casks should be procured to efficiently remove all the canisters from these sites. None of these sites have rail access, but Haddam Neck and LaCrosse have barge access. Therefore, a temporary canister transfer facility will need to be erected to transfer the canisters from the storage overpacks to transport casks, and to load transport casks onto a HHT trailer or barge. An intermodal point will also need to be in place to transfer the transport cask to a railcar for shipment to the CSF.

At least four NAC UMS-Transportation (UMS-T) transport casks should be procured to make up a single train consist, which can efficiently retrieve the 64 canisters at Maine Yankee. These transport casks can be used at a later date in Phase 2 to retrieve NAC Universal MPC System (UMS) canisters at Catawba, McGuire, and Palo Verde. Maine Yankee still has rail access; therefore, no intermodal transfer site will be required for that site. However, a temporary canister transfer facility at the ISFSI site will be required to transfer all the canisters from the storage overpacks to transport casks.

The canisters at Trojan are nine inches shorter than the standard Holtec-designed MPC and will require HI-STAR 100 transport casks fitted with spacers for shipment. To accomplish this, the seven HI-STAR 100 casks at Dresden and Plant Hatch, which are licensed for both storage and transport, can be strategically retrieved through agreements with Exelon and Southern Nuclear in order to start building a HI-STAR 100 transport cask fleet. Impact limiters, spacers, and transport cask shipping skids would need to be procured. At the CSF, the HI-STAR 100 overpacks containing Dresden or Hatch canisters can be offloaded and moved to a transfer cell where the canisters can be transferred to Holtec International-Storage and Transfer Operation Reinforced Module (HI-STORM) storage overpacks and shuttled to a storage pad. Alternatively, arrangements could be made with Exelon and Southern Nuclear to move the Dresden and/or Hatch canisters into HI-STORM overpacks for continued storage at those plant ISFSIs, freeing up the HI-STAR 100 overpacks for transportation use. The HI-STAR 100 transport casks fitted with appropriately sized spacers can then be used to ship the 34 canisters at Trojan to the CSF. The Trojan canisters can then be placed into storage in shorter height HI-STORM overpacks, or the TranStor concrete casks could be shipped to the CSF for re-use. Trojan still has rail access; therefore, no intermodal site will be required. The existing canister transfer facility located at the Trojan

ISFSI, which was designed to permit transfer of a canister from a storage overpack into a HI-STAR 100 transport cask, will be used to transfer all the canisters from the storage overpacks to transport casks.

The projected 65 canisters at Zion will need at least four NAC MAGNATRAN transport casks to efficiently ship the MAGNASTOR TSCs. These transport casks can be used later in Phase 2 for shipping MAGNASTOR TSCs at McGuire, Catawba, and any other future MAGNASTOR users. It should be noted that the MAGNATRAN transport package that will be used to ship the UNF canisters from Zion Units 1 and 2 has not yet been licensed under 10 CFR Part 71. However, NAC has submitted an application to the NRC for Part 71 certification of the MAGNATRAN transportation package, which includes a MAGNASTOR canister. That CoC is expected to be in place by the time all of the MAGNASTOR canisters and concrete casks are deployed at the Zion ISFSI. Zion still has rail access; therefore, no intermodal site will be required. However, a temporary canister transfer facility will be required.

There are six DFSS models that use Holtec- or NAC-manufactured vertical storage overpacks. These overpacks are partially fabricated off site as a steel shell and then shipped to the site for concrete placement. Once on site, the shells are completed by either placing reinforcement and cast-in-place concrete between a form and inner shell (i.e., NAC concrete cask) or by filling the space between shells with concrete (i.e., HI-STORM overpack) to complete the shield barrier. These finished overpacks could be shipped as overweight/oversized loads via railroad to the CSF for reuse, if there are cost savings to be achieved. A cost analysis would need to be performed to determine if it would cost less to ship these finished overpacks to the CSF than it would to finish fabrication at the CSF and simply dispose of the used overpacks at the plant sites.

Phase 1 will require fabrication of approximately 21 transport casks and retrieval of eight existing transport casks.

3.2.1.5 UNF Retrieval Schedule

The stranded UNF can be moved from the shutdown plant sites to the CSF beginning the first year of CSF operation, with most of the effort complete within 4 years from the current shutdown sites and full completion in the sixth year of operation, with the CSF receiving stranded UNF from Kewaunee and Oyster Creek as shown in more detail in **Table 5.2-3**.

3.2.1.6 Consolidated Storage Facility

CSF Requirements

A CSF designed to store UNF from the shutdown plant sites will need to receive, handle, and store 11 different types of DFSSs, as shown in **Table 3.2-3**. All of these DFSSs are transportable, canister-type systems that will require similar types of equipment to process. The CSF must consist of the following:

- Rail yards to receive incoming train consists and prepare for outgoing train consists
- A CHB that can offload transport casks and provide canister transfer operations for vertical-type, canister-based DFSSs (except Humboldt Bay)
- A storage area with concrete storage pads to support the storage overpacks
- Support buildings, such as an office building, maintenance building, and security building
- Various fenced areas to provide radiation and security protection

The latest DFSS FSARs that have been submitted to the NRC were reviewed to determine the needs for CSF processing. Each of the DFSS FSARs and CoCs contain the general design information for their respective DFSSs and associated equipment. **Table 3.2-3** presents the critical dimensions and weights of each DFSS.

Table 3.2-3
Stranded UNF DFSS Dimensions and Weights

Dry Cask Storage System (DFSS)	Canister				Transport Cask					Storage Overpack				
	Model	Height (in.)	Dia. (in.)	Weight (Loaded) (lbs.)	Model	Height (in.)	Dia. (in.)	Weight (lbs.)	Weight Loaded (lbs.)	Model	Height (in.)	L x W or Dia. (in.)	Weight (lbs.)	Weight Loaded (lbs.)
Fuel Solutions (Big Rock Point)														
SFMS	FS Canister	192	66	81,129	TS-125	210.4	94.1	285,000	366,129	W-150	230	138	253,200	253,200
Holtec International (Trojan and Humboldt Bay)														
TranStor/MPC-24 Series	MPC-24E/EF	190.3125	68.5	90,000	HI-STAR 100	203.125	96	153,710	243,710	HI-STORM 100S Ver. B	210.5	133.875	291,000	270,000
HI-STAR HB	MPC-HB	114	68.5	59,000	HI-STAR HB	122	96	109,984	168,984	Same as transport cask				
NAC International (Connecticut Yankee, Yankee Rowe, LaCrosse, Maine Yankee and Zion)														
NAC-CY-MPC	CY-MPC	151.75	79	51,766	NAC-STC	190.5	99	157,540	209,306	VCC (CY-MPC)	190.6	128	186,000	237,766
NAC-YANKEE-MPC	YANKEE-MPC	122.5	79	45,200	NAC-STC	190.5	99	157,540	202,740	VCC (YANKEE-MPC)	160	128	155,000	200,200
NAC-MPC-LACBWR	MPC-LACBWR	116.3	70.64	54,650	NAC-STC	190.5	99	157,540	212,190	VCC (MPC-LACBWR)	160	128	141,200	195,850
NAC-UMS 24	NAC-TSC	191.75	67	72,900	UMS-T	209.3	92.9	153,500	226,400	VCC (NAC-UMS)	225.88	136	239,700	312,600
NAC-MAGNASTOR	TSC-37	191.8	72	102,000	MAGNATRAN	202	88	113,000	215,000	MAGNASTOR	225	136	321,000	326,000
Transnuclear (Rancho Seco, Kewaunee and Oyster Creek)														
NUHOMS-24PT1	24PT-1-DSC	186.5	67	82,000	MP187	203	92.7	158,580	240,580	AHSM	247	101	320,000	320,000
NUHOMS-32PT Series	32PT DSC	193	67	108,800	MP197HB	208	91.5	148,610	257,410	HSM-102	180	116.4	364,400	364,400
NUHOMS-61BT Series	61BT/61BTH-DSC	196	67	88,930	MP197HB	208	91.5	148,610	237,540	HSM-102	180	116.4	364,400	364,400

Reference: Characteristics of Spent Fuel Storage Casks, http://www.nrc.gov/pbadupws.nrc.gov/docs/ML1025/ML102580285.pdf - 2010-09-26.

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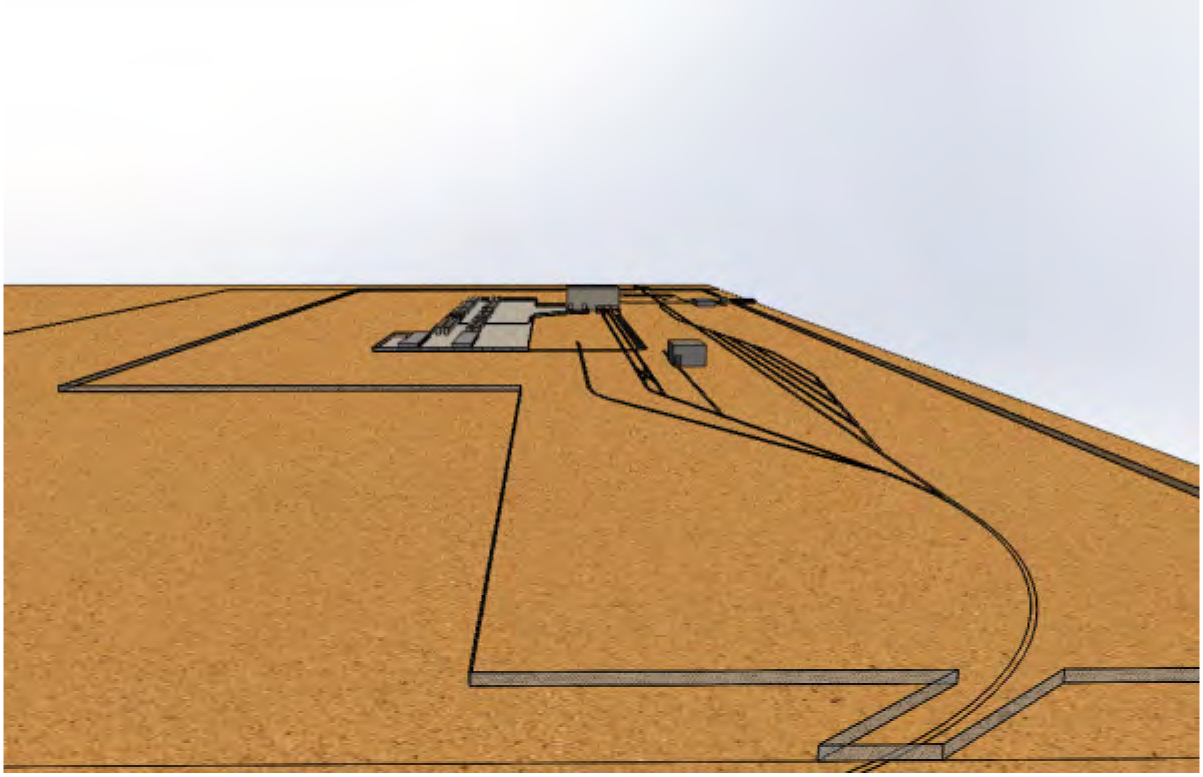
CSF Site Layout

A 3D model view of the CSF is depicted in **Figure 3.2-8**. The site layout showing a CSF that could store the stranded UNF is shown in **Figure 3.2-9** and **Figure 3.2-10**. The principal areas of the CSF consist of the Radiation Area (RA), where UNF is stored to limit personnel access; an access-controlled security area, typically called a Protected Area (PA), encompassing the RA where UNF shipments are received and processed; and the Owner Controlled Area (OCA), encompassing the PA that consists of the CSF property boundaries. These areas would be constructed under Construction Stage 1.

Figure 3.2-8
3D Model View of the Phase 1 Consolidated Storage Facility



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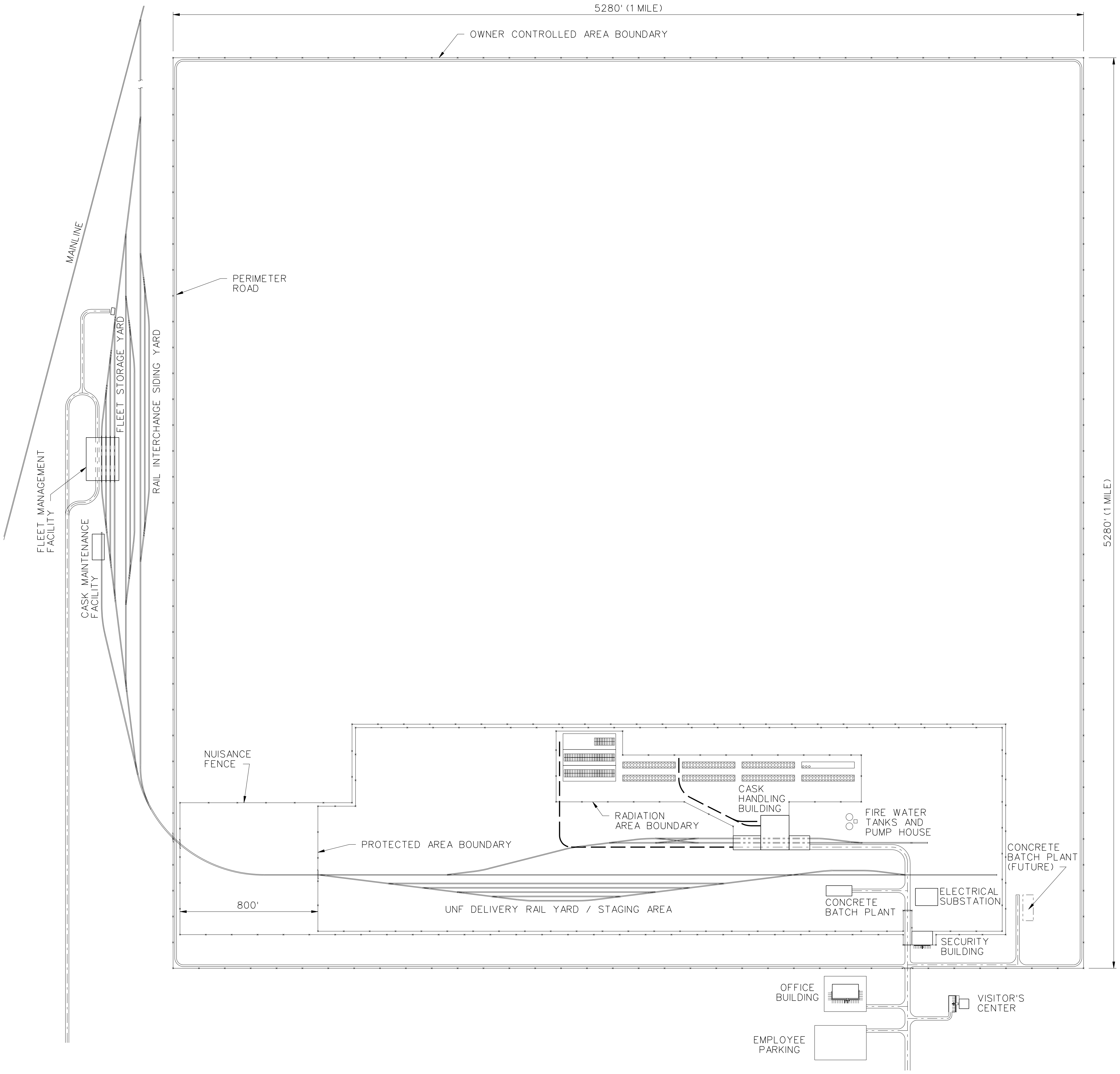

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CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 3.2-9, STAGE 1 OVERALL CSF SITE LAYOUT

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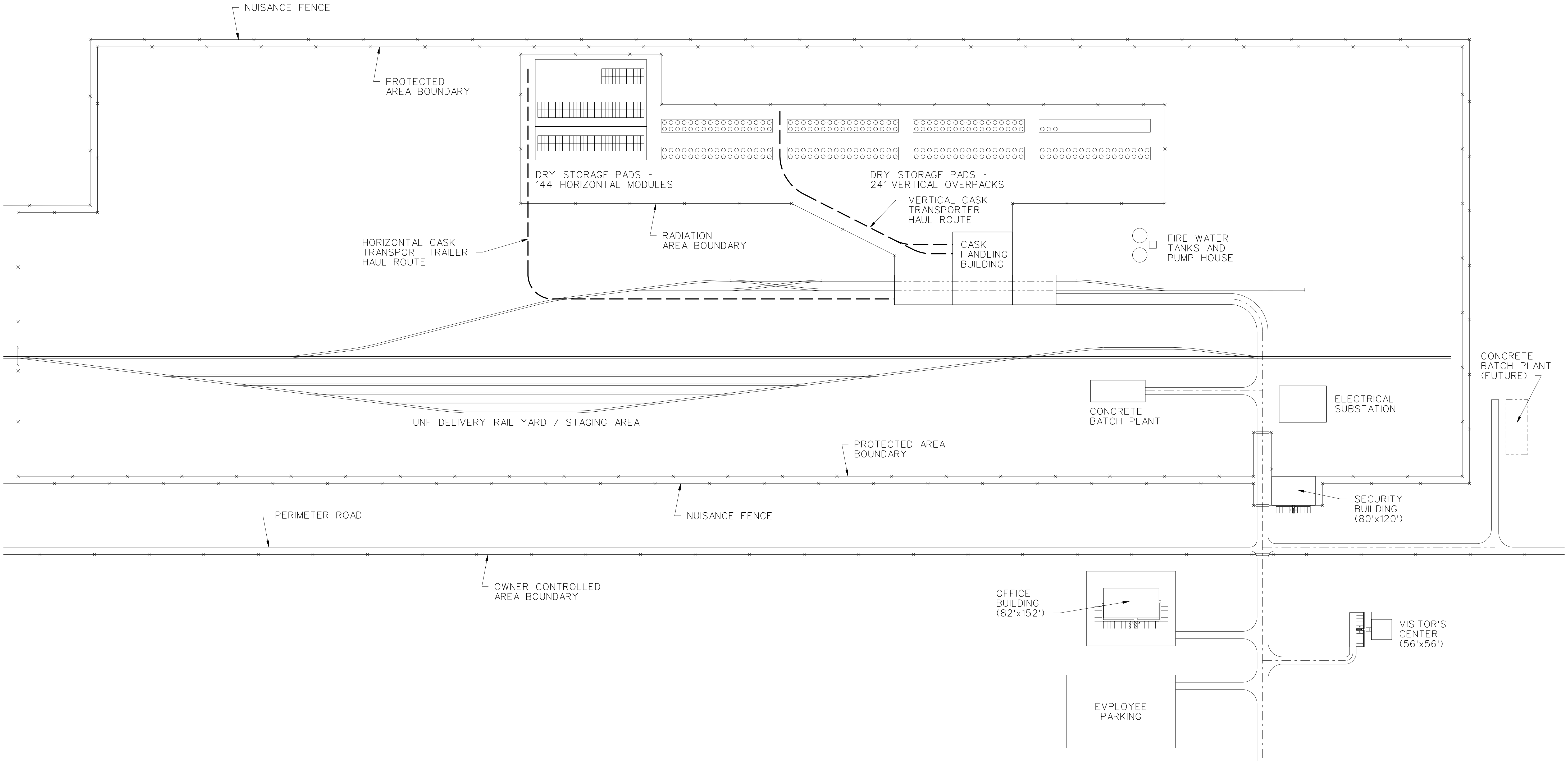

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CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 3.2-10, STAGE 1 CSF SITE FEATURES

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Radiation Area

The purpose of the RA is to limit personnel movements in the vicinity of the storage overpacks and HSMs that house the UNF. The RA boundary would be designed to encompass areas with a radiation dose rate of 5 mrem/hr. or more in accordance with 10 CFR 20.1902 and 10 CFR 20.1003. A commercial ISFSI site may not require such a radiation zone due to the low dose of each storage overpack. However, during Phase 1 the CSF will house hundreds of storage overpacks such that the expected dose rate could potentially exceed five mrem/hr in the cask array. The UNF storage pads and a portion of the CHB, as well as areas of major UNF activities, would be located within the RA. The RA would expand in size as the number of storage pads increases to accommodate more UNF. The boundary of the RA would consist of a chain-link fence with gates requiring authorized access.

Protected Area

The purpose of the PA is to prevent unauthorized persons from entering the CSF where UNF is processed and stored in accordance with 10 CFR Part 73. The PA provides physical protection of UNF and consists of an area large enough to encompass the CSF rail yards, CHB, and storage pads. The PA would expand in size as required to accommodate new storage pads. As a minimum per 10 CFR Part 73, the PA would be bounded by a chain-link security fence with a 20-foot isolation zone on either side of the fence, a chain-link nuisance fence to prevent entry into the outer isolation zone, an intrusion detection system (IDS) to detect any unauthorized entry into the outer isolation zone, closed-circuit television (CCTV) cameras and yard lighting to assess IDS alarms, and a vehicle barrier system to prevent any unauthorized vehicle entry into the PA. Additional fences and features could be added to enhance the capability of the PA boundary. A Central Alarm Station (CAS) and Secondary Alarm Station (SAS) where security staff would monitor access to the SA and control all CSF activities would be located somewhere within the PA. Additional details regarding features of the CSF security are provided in Section 4.0.

Security equipment is typically powered from normal off-site power supplies. However, in the event of a loss of off-site power, an Uninterruptable Power System (UPS) consisting of batteries would be used to provide seamless power to all electronic security equipment. The UPS and site lighting (as well as other CSF-important functions) would be backed up by an emergency diesel-powered generator located within the PA.

Access to the PA would be controlled at the security building where all incoming persons would be screened to ensure no unauthorized personnel or materials are brought into the site. The PA boundary would also need to contain at least one vehicle gate or sally port large enough to accommodate either a truck or a train of railcars loaded with UNF transport casks, where they would be inspected prior to entry.

The rail yard and the CHB would be located within the PA.

Owner Controlled Area

The purpose of the OCA is to establish a minimum distance of 100 meters (328 feet) from storage and handling operations to the owner-controlled boundary in accordance with 10 CFR 72.106. The site property boundary typically serves as the OCA boundary. To illustrate land usage for the CSF through the various phases, a 1-square-mile perimeter is established around the site to serve as the OCA or property boundary. All CSF functions are contained within this boundary. The storage area for a fully built out CSF will require approximately 0.51 square miles. Adding a railroad yard, structures and other features will require a similar amount of land. Note however, that the actual land requirements for the CSF could exceed the 1 square mile perimeter depending on the needs desired for the site.

The Office Building, Parking Area, and Visitors Center is shown just outside the OCA and PA. The Cask Maintenance Facility and Fleet Management Facility could be located near the site or anywhere between the CSF and mainline access point. They are shown next to the CSF in **Figure 3.2-9** for convenience.

CSF Principal Features and Descriptions

The principal features of the CSF required for Phase 1 include the storage pads, rail yards, a CHB, security building, maintenance building, and office building. The site will also include a number of other utilities and structures, electrical switch gear and transformers, chillers, mechanical cooling towers, a fire suppression system, underground utilities, meteorological tower, security equipment, yard lighting, a concrete batch plant, drainage structures and systems, etc. Depending on the location and cost versus benefit, solar panels or other “green energy” LEED-certified components could be employed to enhance the site. A Visitors Center at the CSF could also be constructed to allow the public to learn and understand the purpose of the CSF.

Storage Pads

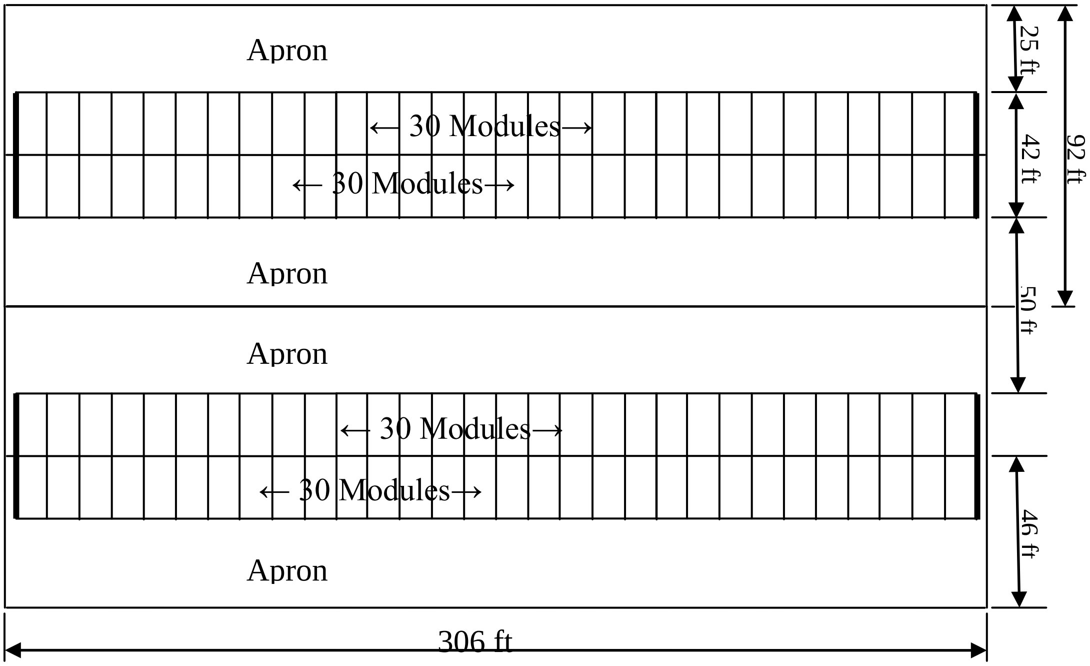
The CSF would have reinforced concrete storage pads to support all of the vertical storage overpacks and horizontal storage modules that are loaded with UNF canisters. The storage pads are designed to ensure adequate safety and to mitigate the effects of site environmental conditions, natural phenomena, and accidents in accordance with 10 CFR Part 72. This includes stability and liquefaction prevention under earthquake conditions and settling over the life of the facility.

A typical storage pad design is a 2.5- to 3-foot-thick reinforced concrete slab with longitudinal and transverse horizontal reinforcing bars each way at the top and bottom of the pad. Vertical storage overpacks and storage pads are designed so that under any condition, the storage overpack cannot tip over. However, since tip-over is a hypothetical accident that is considered, the pads are often designed with lower-strength concrete so that they would provide a soft landing in the event a vertical-type storage overpack tipped over, in order to minimize the deceleration of the overpack and UNF and ensure their integrity.

The size of the storage pad depends on the type of storage system (horizontal or vertical), the number of storage units to support, and the shape and limitations of the physical space where the pad is to be placed. Horizontal storage systems use a concrete module with a rectangular footprint, while vertical storage systems use a concrete or steel cylinder-shaped overpack that stands on end.

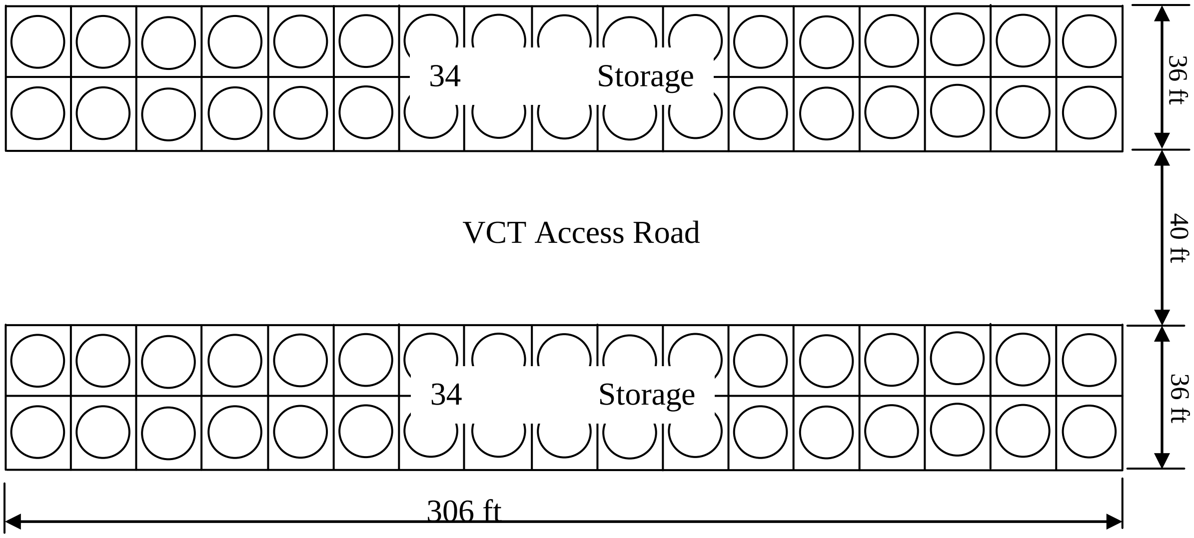
The horizontal modules are placed on a storage pad in a row and require an apron in front of the modules so that the transfer trailer and transport cask can be maneuvered to line up with the module and the canister can be pushed into and pulled out of the module with a hydraulic ram. The modules are approximately 10 feet in width by 21 feet in length so that a storage pad approximately 100 feet long could support 10 modules placed side by side. These systems use concrete end shield walls 2 to 3 feet thick to reduce radiation; therefore, a storage pad supporting 10 modules would actually need to be at least 4 feet longer. A transfer trailer is 22 feet long, so the apron needs to be approximately 25 feet wide to allow the trailer to be evenly supported. The trailer requires a tow vehicle, so the space in front of the modules (apron plus access path) must be even wider. Transnuclear has stated that a distance of 50 feet is desired. In theory, a single, very large pad could be used to support all the modules. However, due to ground elevation irregularities and construction limitations, multiple smaller pads are often the general practice. For this report, a storage pad sized for a double row of modules (back-to-back) is assumed to be 306 feet long (30 modules with 2 end shield walls) by 42 feet wide, with two adjoining aprons, one on each side of the storage pad, that are each 25 ft wide and 306 ft long. For efficiency, HSMs are placed back-to-back so that modules back up to each other to provide additional shielding at the back of the modules, while the aprons create a total width of 50 feet between module faces to allow room for the transfer trailer to maneuver in either direction (see **Figure 3.2-11**).

Figure 3.2-11
Horizontal Module Storage Pad



The vertical storage overpacks are typically placed on a storage pad in a regular array (2 by 10, 4 by 8, 7 by 9, etc.). Any array wider than two overpacks prevents a VCT from ready access to all the overpacks. Many reactor sites with very limited space use high-density arrays when real estate is unavailable. If a canister or overpack located away from the outer edge of the array had a problem, the VCT would need to remove a few overpacks to access the inner overpack. Since no canister to date has experienced a leak, this scenario has little risk. However, given adequate real estate, it is preferred to group the overpacks in arrays no wider than two (in a "two by N" pattern) so that they are all readily accessible. Additionally, this allows ready access to the canisters once a geological waste repository has been opened. An overpack requires a prescribed spacing from adjacent overpacks for heat rejection and must be located far enough from the adjacent overpacks so that a VCT can maneuver between overpacks. Overpacks are typically spaced from 14 to 18 feet center to center. Therefore, the quantity of concrete in the storage pad per overpack is roughly the same regardless of the array size or configuration. For this report, a storage pad sized for an array of 2 by 17 overpacks spaced 18 feet apart center to center (typical maximum spacing) is 306 feet long by 36 feet wide with a total capacity of 34 overpacks. Storage pads are spaced at least 40 feet apart to provide ample room for VCT travel and turning between pads (see **Figure 3.2-12**).

Figure 3.2-12
Vertical Overpack Storage Pad



For Phase 1, the total storage area capacity inside the RA must accommodate 384 storage overpacks and horizontal modules for the stranded UNF and GTCC comprised of 143 horizontal storage modules and 241 vertical storage overpacks (235 vertical concrete casks and 6 bolted lid, unventilated metal overpacks). UNF and GTCC waste from the current fleet of shutdown plants sites is comprised of 263 of these units and 121 more are required for Oyster Creek and Kewaunee UNF and GTCC waste. Three horizontal-type DFSS storage pads are required using the horizontal-type DFSS pad model that support 60 modules each. Eight vertical-type DFSS storage pads are required using the vertical-type DFSS storage pad model that can accommodate up to 34 overpacks each.

Horizontal transport trailers and VCTs are necessary to move the horizontal transport casks and storage overpacks loaded with canisters from the CHB to the storage pads. For stranded UNF operations (Phase 1), at least one of each kind is required, although two of each should be procured so that breakdowns and routine maintenance activities do not inhibit UNF canister processing throughput. While the storage pads for horizontal storage modules have concrete aprons that extend between the sides of the pads, the access roads around the storage pads for vertical storage overpacks, and the access roads around the ends of the storage pads for horizontal storage modules, would be surfaced with compacted structural gravel and be wide enough to accommodate travel of a horizontal transport trailer or a VCT (approximately 30 feet).

There are other transporters that have been produced in the last few years that can transport and align the NUHOMS casks to the HSM in much less space than 50 feet, such as the WheelLift transporter. This transporter is unique in that it is self-propelled, can travel in any direction (including side-to-side or diagonal) and is radio-controlled so that the operator can drive the transporter at a distance using remote controls to minimize radiation exposure. If the CSF utilizes this type of transporter, the storage aprons for NUHOMS HSMs can be constructed with a smaller footprint to save concrete costs.

There are at least three manufacturers of VCTs: (1) JR Engineering, (2) Lift Systems, and (3) Kone Cranes. These transporters are shaped like a horizontal fork with a lifting mechanism, designed to straddle the vertical overpack, lift it slightly above the ground and transport it to its destination. These transporters are extremely versatile. They are self-powered and can move forward, backward, and auto-rotate in place to put storage overpacks precisely where necessary. The operator sits on the fork frame either in front of or behind the vertical storage overpack to guide it to its destination. The VCTs can be either tracked or wheeled.

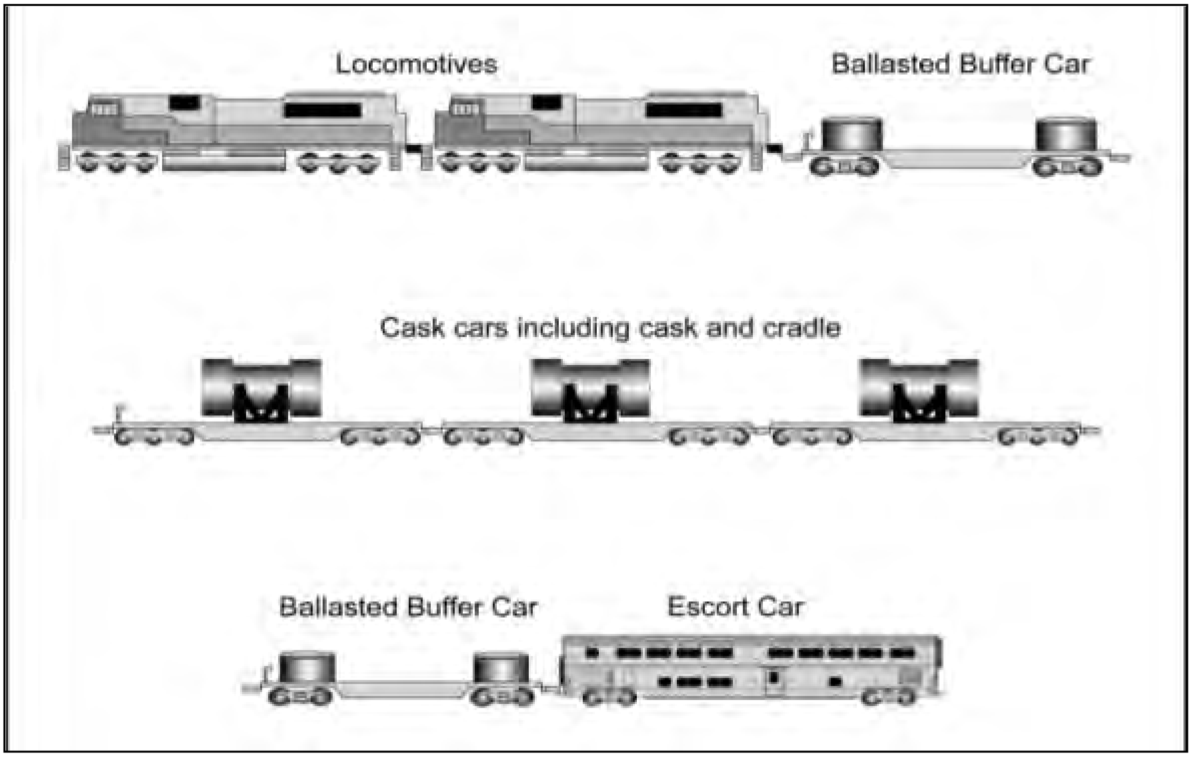
All transporters travel very slowly with top speeds typically around 1 mile per hour (mph). This ensures maximum safety of the UNF container being transported so that it does not drop, tip over, run away, or perform any other movement that is not strictly controlled. Transporters also can require considerable maintenance due to the significant loads they must lift and move, and because they have both a diesel engine and a hydraulic system, as well as a number of mechanical and electrical parts and control systems. It is very likely that near-continuous use at the CSF will require more robust designs than are currently used.

Rail Yard

The purpose for the rail yard is to provide adequate railcar storage for incoming and outgoing UNF train consists, and access to the CHB and the Cask Maintenance Facility (CMF). The rail yard must be designed to allow flexibility for maneuvering locomotives, transport cask railcars, buffer cars, and escort cars. The rail yard shown in **Figure 3.2-10** shows five siding tracks comprised of two inbound sidings, two outbound sidings, and one miscellaneous siding to sort cars. This configuration was laid out to accommodate three to four inbound trains arriving the same week due to variations in the schedule (trains may arrive in a cluster instead of uniformly staggered). A smaller yard configuration (one inbound and one outbound siding, each designed with a capacity for two trains) could be built initially to accommodate Phase 1 shipments only to reduce the initial CSF capital cost.

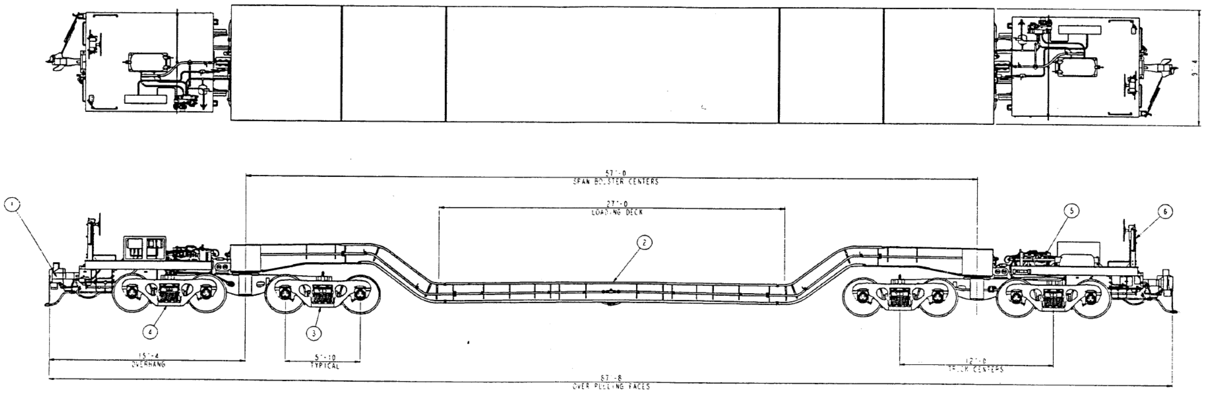
The yard siding tracks must have a capacity for one or more train consists. Each train consist is expected to have one or two locomotives, up to five UNF transport cask cars, two buffer cars, and one escort car (see **Figure 3.2-13**, with five cask cars in place of the three cask cars shown in the figure).

Figure 3.2-13
UNF Train Consist



For the purposes of this study, the double-bolster depressed-bed railcar developed by Private Fuel Storage (PFS) and tested by the American Association of Railroads is used as the basis for the CSF. This railcar was specifically designed with newer railcar components that enable it to travel on mainline routes at regular mainline speeds. This railcar is 88 feet long by 9 feet, 4 inches wide and has a capacity of 150 tons. The deck would be approximately 30 inches above the floor of the CHB (see **Figure 3.2-14**).

Figure 3.2-14
UNF Cask Railcar



The maximum weight of the transport cask with impact limiters and shipping cradle on the railcar is approximately 142 tons, which would be within the allowable load for a 150 ton-railcar.

The estimated lengths and weights of each railcar are shown in **Table 3.2-4**.

Table 3.2-4
UNF Train Consist Car Data

Unit	Quantity per Consist	Weight (estimated) (tons)	Height from Top of Rail (ft.-in.)	Overall Length (estimated) (ft.)	Truck Center Length (estimated)(ft.)	Axle Spacing (ft.-in.)	Total Number of Axles
Locomotive 4000 HP	2	200	15'-6"	75'	50'	6'-10"	6
Cask Car	5	195	15'-0"	88'	12' (bolster)	5'-10"	8
Buffer Car	2	40	4'-0" (excluding ballast)	54'	40'	6'-0"	4
Escort Car	1	85	< 15'-6"	85'	60'	8'-6"	4

Based on this information, one train consist would be approximately 783 feet long. The miscellaneous and shortest outbound siding has a length that can accommodate a single train consist. The longer outbound track can accommodate two train consists, the shortest inbound track can accommodate three trains consists, and the longest inbound track can accommodate up to four train consists. This arrangement is suitable for a CSF undergoing maximum projected full operations (all four phases in operation). The yard layout assumes No. 9 turnouts (rail switches), which are smaller than mainline turnouts, but typical for industrial applications.

Cask Handling Building

The purpose of the CHB is to accommodate the transfer of transport casks from railcars to transfer trailers (horizontal-type DFSSs) and the transfer of canisters from transport casks to storage overpacks (vertical-type DFSSs). The building will also provide physical protection of the canisters and radiation shielding to the workers. The CHB will include 2 rail bays, 1 truck bay, a 200-ton overhead bridge crane, 2 canister transfer cells, a laydown area for impact limiters, personnel barriers, and a holding area for up to 2 train consists (10 loaded transport casks) awaiting canister transfer (see **Figure 3.2-15** and **Figure 3.2-16**). A 3D model view of the CHB is shown in **Figure 3.2-17**. The CHB would be a reinforced concrete structure with thick walls to protect all UNF casks, canisters and overpacks, and cask-handling equipment housed within the building from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions in accordance with 10 CFR 72.122.

Specific CHB functions include the following:

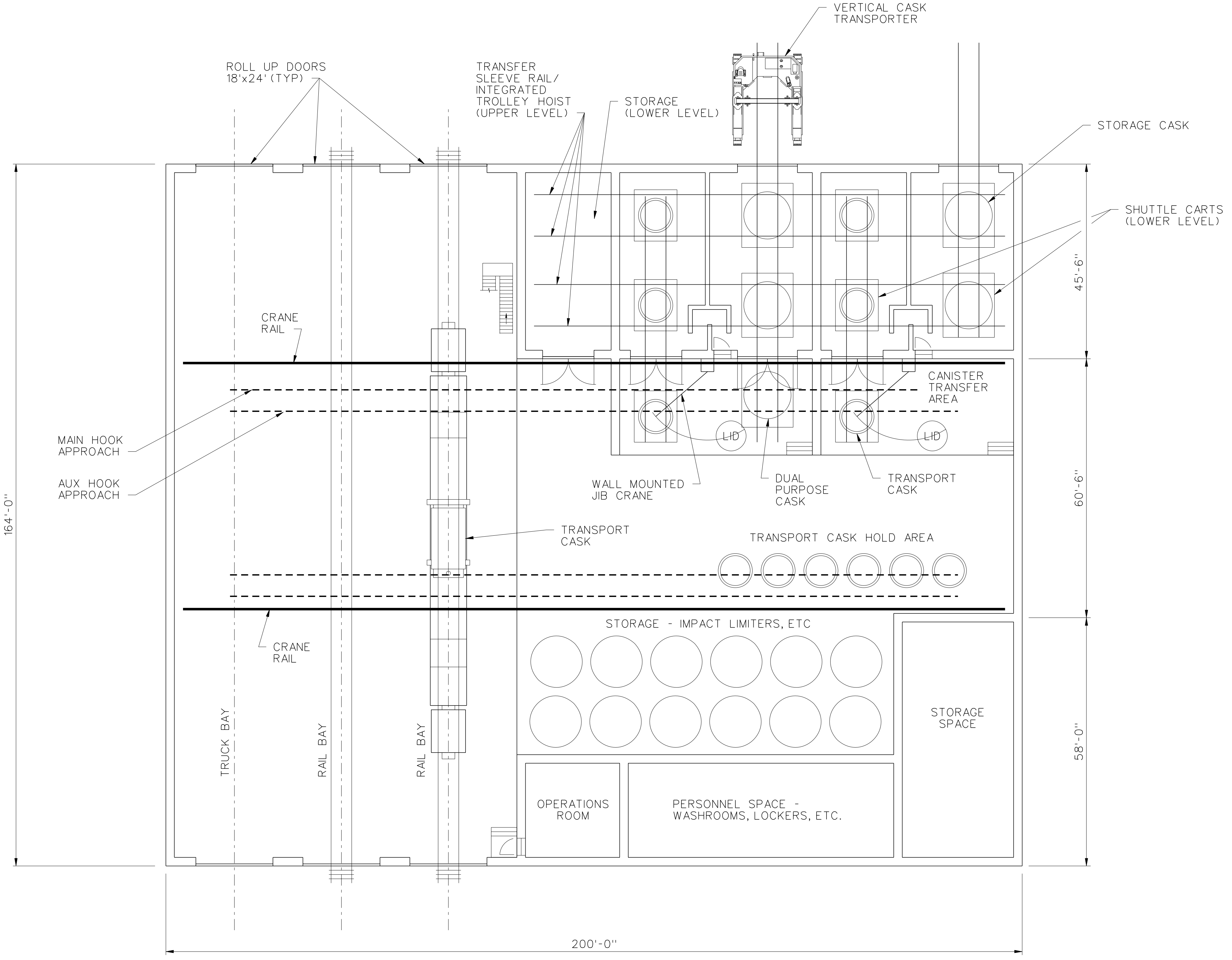
- Provide single-failure-proof crane capability to offload or load UNF transport casks from railcars or truck trailers.
- Provide a radiation shielded area with the equipment to perform canister transfer operations.
- Provide weather, tornado, and earthquake protection for transfer operations.
- Provide laydown space for impact limiters, personnel barriers, and associated components.
- Provide a staging area for loaded transport casks awaiting canister transfer operations.
- Provide the support structure for the single-failure-proof crane.

The CHB has three bays comprised of two railcar bays and one truck bay. The railcar bays enable offloading of up to two transport casks from railcars (or loading of empty transport casks). The truck bay is primarily used for transferring a NUHOMS transport cask from a railcar to a NUHOMS trailer, which is truck-towed. The truck bay would also accommodate incoming supply shipments to the CSF by truck.

To offload (or load) transport casks from the railcars, the CHB would contain a single-failure-proof overhead bridge crane. The crane should have a capacity of at least 200 tons to be able to safely lift a transport cask fitted with impact limiters and the cask cradle. Normal operations would typically remove the impact limiters before offloading the cask, but there always is the potential of some mishap that requires off-normal lifting. The crane would have three primary functions as follows:

1. Removal of the transport cask personnel barrier and impact limiters from the railcar and placement to a pallet where they can be rolled into short term storage
2. Offloading and uprighting of a vertical-type DFSS transport cask to the canister transfer area
3. Transfer of a horizontal-type transport cask from the railcar to a NUHOMS transfer trailer at the truck bay

The crane would be designed as single-failure-proof in accordance with ASME NOG-1 so that it could perform its intended functions under all loading conditions, including off-normal and accident conditions, without dropping a load. It would also be designed to withstand any seismic loads to ensure it would remain in place and support the load during and after an earthquake.



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CASK HANDLING BUILDING LAYOUT

FIGURE 3.2-15, STAGE 1 CASK HANDLING BUILDING

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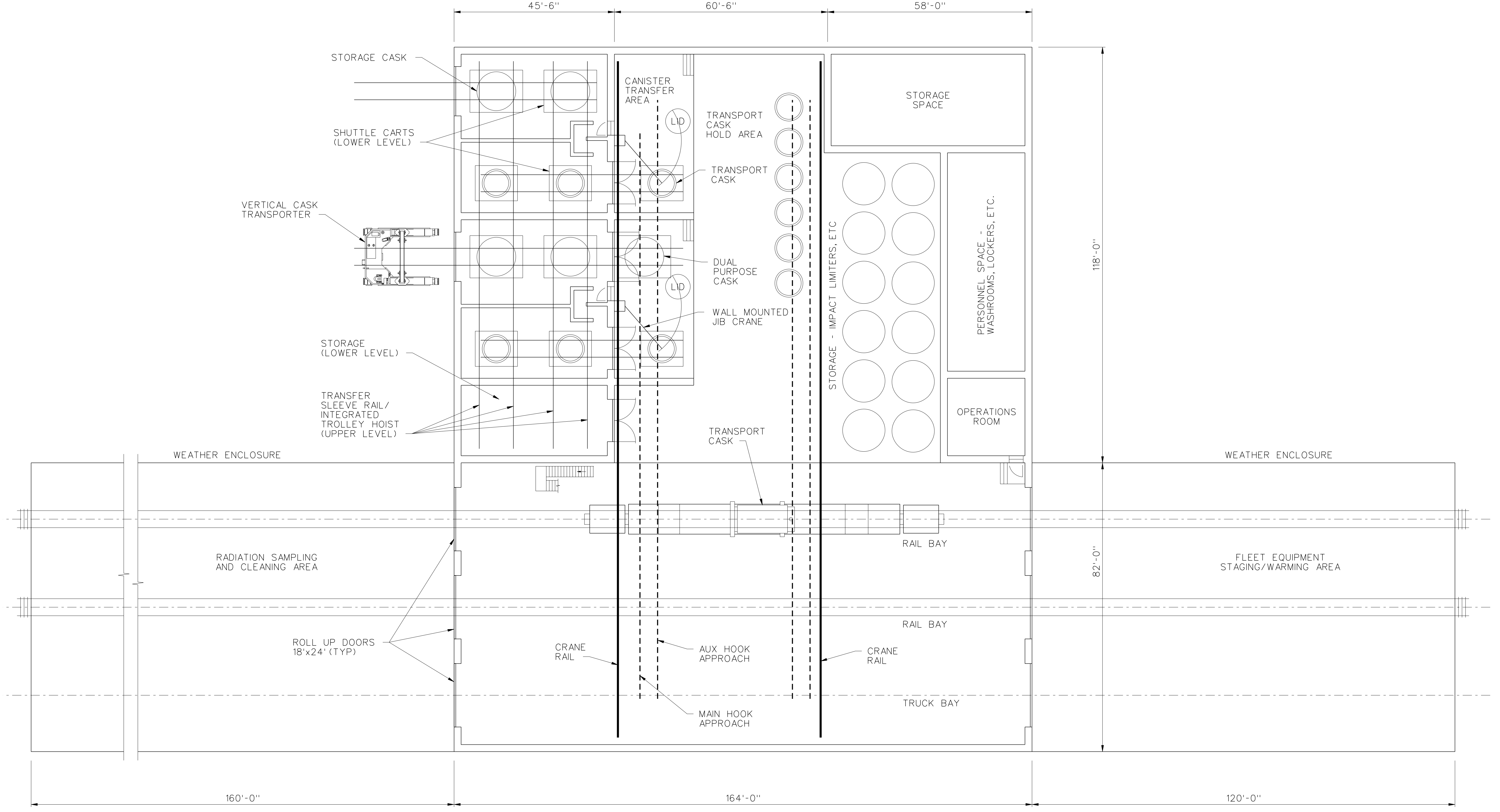

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CASK HANDLING BUILDING LAYOUT

FIGURE 3.2-16, CASK HANDLING BUILDING WEATHER ENCLOSURES

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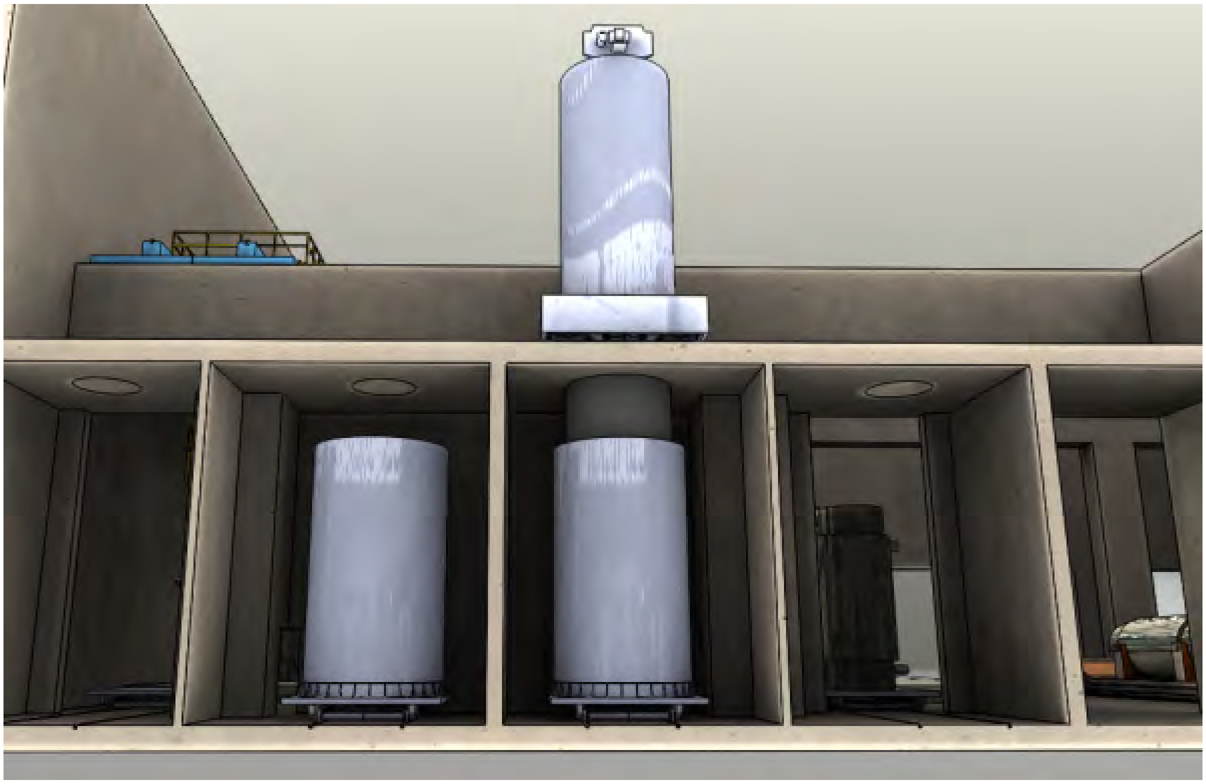
Figure 3.2-17
3D Model View of the Cask Handling Building

The CHB would be designed to provide radiological shielding during canister transfer operations. A portion of the building is divided into two canister transfer cells where canister transfer operations between a transport cask and a storage overpack are performed for vertical-type DFSSs. The cells are surrounded by concrete shield walls that would be designed to limit the radiation doses from the canister transfer operations to personnel outside of the cell. One cell could handle a throughput rate of one canister transfer every other day, but two cells are provided for times when several shipments arrive at the CSF in the same week or if one of the cells is unavailable for some reason.

Because the CSF must perform canister transfer operations every week, it is recognized that consistency while performing the activity will ensure safety, save time, and reduce radiation doses. For horizontal-type systems, canister transfer occurs at the storage pad and is well understood based on significant industry experience with this activity. For vertical-type systems, processing several different DFSSs would be cumbersome at best. Rather than employ individual transfer casks, lifting yokes, and associated handling equipment from each system, it is preferred to establish a fixed canister transfer vessel that can perform the canister transfer operation for all storage systems processed through the CSF. See a 3D model cutaway view of the transfer operation in **Figure 3.2-18**.

Figure 3.2-18
3D Model Cutaway View of the Canister Transfer Cell and Vessel



While such a system is not absolutely necessary for processing stranded UNF canisters alone, it would become invaluable once full-scale canister processing operations occur. Therefore, within the CHB, two canister transfer cells are provided with a number of components that will ensure canister transfer process consistency.

First, the overhead crane will not be used for further canister transfer operations. This frees up the overhead crane for offloading impact limiters, placing the incoming transport casks onto the shuttle carts, and transferring NUHOMS transport casks to the horizontal transport trailer. If the overhead crane was required for canister transfer, then two cranes would be necessary to meet the required throughput. Limiting overhead crane use also allows the crane span to be relatively short since it does not need to span the transfer cell.

Second, the lid to the transport cask (and the storage overpack outside the building) would be removed using a wall-mounted jib crane sized for the lid weight, and the lid would then be stored temporarily outside of the transfer cell. This keeps the transfer cell area free from lids, which consume valuable floor space.

Third, both the transport cask and storage overpack would be moved into and out of the transfer cell with rail-guided shuttle carts that would keep the casks on a prescribed path and enable the transfer cell to be fully enclosed to limit radiation dose exposure. If a building overhead crane were used, the top of the cell would need to be open, introducing unnecessary radiation doses.

Finally, and most importantly, a universal transfer cask or “sleeve” (open on top and bottom) could be positioned on the floor above to roll over a hole located directly above the transport cask and storage overpack to retrieve and place (raise and lower) the canister. The transfer sleeve would be rail-guided and operate remotely. It would be constructed with a steel and lead gamma shield and neutron shield, like any other transfer cask, so as not to preclude personnel from being near it when it contains a UNF canister. But it could operate remotely to vastly reduce radiation doses to personnel during canister transfer operations. Reactor sites can contend with the higher radiation doses associated with personnel performing activities in the vicinity of their transfer casks because canister transfer is an occasional activity. However, the CSF will be performing this activity every other day (on average), so it is essential that the canister transfer radiation doses are mitigated to the maximum extent possible.

To prevent radiation streaming, a shielding collar designed to fit each cask design could be placed on the cask and used to close the gap at the cell ceiling, or a shielding curtain could be mounted to the ceiling of the transfer cell that could be lowered over the casks during canister movements. The use of the transfer sleeve would also eliminate the cask “stack-up” configuration, in which the transfer cask is placed on top of a storage or transport cask to facilitate canister transfer between the casks. The issue of stacked cask stability during a seismic event is eliminated with use of a transfer sleeve. Some reactor sites have had to install elaborate seismic restraints or cages to ensure cask stack-up stability and prevent a tip-over event. Erection of these components can extend the duration of canister transfer operations for several hours. Use of such equipment at a CSF with ongoing canister transfer operations would be cost-prohibitive. A single-failure-proof hoist would be mounted to the top of the transfer sleeve to raise and lower the canisters.

The CHB would include a laydown storage area where impact limiters removed from transport casks could be loaded onto pallets by the overhead bridge crane and stored until reuse. Impact limiters are approximately 10 feet in diameter. Receipt of several transport casks could quickly tie up storage space, so consideration should be given to stacking two impact limiters on a pallet to conserve space.

The CHB would also include a holding area for several loaded transport casks awaiting canister transfer. This is because it is anticipated that up to four trains could arrive at the CSF during the same week. The holding area would allow the loaded transport casks to be removed so that the railcars could be loaded with empty transport casks and returned to service. Section 5.0 of this report has shown that cask loading at the reactor sites could take considerable time, so it is important to get the railcars back into service as soon as possible.

A backup diesel-powered generator would be located somewhere near the CHB to provide backup power for the crane, equipment important for safety activities, and future electrical loads (such as UNF pool cooling systems). This diesel-powered generator would be separate from the security building’s diesel-powered generator in order to keep their functions separated.

Security Building

The purpose of the security building is to provide the access point for entry into the PA and to house the security force personnel for the CSF. The security building would be located at the entrance to the PA. The security building would also house security records and security equipment, as well as communications and electrical equipment required for the operation of security systems. The backup diesel-powered power generator for security equipment would be located further inside the PA at a location central to the security system’s needs.

Perimeter Intrusion Detection and Assessment System

The CSF Perimeter Intrusion Detection and Assessment System (PIDAS) will be installed during the Construction Stage 1. The PIDAS installation will include site lighting, security cameras, vehicle portals, and design features to permit staged construction inside the security fence while minimizing impacts on CSF operations. Construction Stage 1 will include a Central Alarm Station (CAS) and a Secondary Alarm Station (SAS) sized to accommodate all equipment and operating space required for all Phases of operations.

Fleet Management Site

The Fleet Management Site will consist of a Fleet Management Facility (FMF), a Cask Maintenance Facility (CMF), and outdoor storage areas for rolling stock, truck cask trailers, and transport casks. The structures and associated infrastructure on the Fleet Management Site will be constructed during Construction Stage 1. Refer to Section 5.4 for the details of the Fleet Management Site.

Balance of Plant

The balance of plant equipment and systems, including fire protection, potable water, sanitary drains, electrical power and distribution, diesel fueling station, and communications, are included in Construction Stage 1. Construction Stage 1 will also include a concrete batch plant and concrete trucks. The local batch plant will provide a quality source of concrete for all stages of CSF construction.

Office Building

The purpose of the Office Building, located just outside the PA, would be to house all personnel not required for operations inside the PA. This would include management, administrative, engineering, licensing, and health physics personnel. In addition, the Office Building would house the facility records management center.

Visitors Center

If desired, a Visitors Center could be constructed outside the PA to allow members of the public to view the facility from a distance and learn about its operations. The center could include visual displays and information providing opportunities for the DOE to educate visitors of the importance of the facility. The Visitors Center could also include a large lecture room for meetings open to the public.

3.2.1.7 Operation Description

The following sections describe the operating steps for receiving transport casks, transferring canisters from transport casks to vertical storage overpacks and horizontal storage modules, UNF storage surveillance, and transport cask maintenance.

Shipment Receipt, Handling and Placement into Storage

The steps for receiving, handling, and placing into storage a DFSS are shown in **Table 3.2-5** and **Table 3.2-6**. The tables also show the staff requirements and anticipated radiological dose associated with each step.

Table 3.2-5
Operation Steps at the CSF for a Horizontal DFSS

Operation Step	Number of People	Task Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr)	Dose (man-mrem) Bounding Value	Dose (man-mrem) Normal Operation
1. Move NUHOMS trailer to CHB truck bay.	2 Ops	0.5	0.5	0	0.0	0.0
2. Move loaded railcar under CHB awning.	2 Ops	0.5	0.5	0	0.0	0.0
3. Measure dose rates on railcar and perform receipt inspection.	2 Ops 1 HP	0.5	0.25 0.25	5 5	2.5 1.3	0.7 0.3
4. Move railcar into CHB.	3 Ops	0.5	0	0	0	0
5. Remove personnel barrier using CHB crane.	2 Ops	0.5	0.5	5	5.0	1.4
6. Measure dose rates and perform contamination survey.	1 HP	0.5	0.5	10	5.0	1.4
7. Remove impact limiters and	2 Ops	1.5	1.5	5	15.0	4.1

Operation Step	Number of People	Task Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr)	Dose (man-mrem) Bounding Value	Dose (man-mrem) Normal Operation
tiedowns using CHB crane. Place impact limiters on pallet and roll into storage.						
8. Sample enclosed cask gas. If ok vent gas.	1 Ops 1 HP	0.5	0.5 0.5	25 1	12.5 0.5	3.4 0.1
9. Install trunnions and place slings.	2	0.5	0.5	200	10.0*	2.7*
10. Raise transport cask up off of railcar and transfer cask to NUHOMS trailer using CHB crane.	2 OP 1 HP	0.5	0.5	152	152	41.5
11. Move transport cask to open HSM, positioning in close proximity.	2 Ops	2	0	0	0.0	0.0
12. Remove transport cask lid.	2 Ops 1 HP	1	1 0	68 68	136.0 0.0	37.1 0.0
13. Align and dock the cask up to HSM.	2 Ops 1 HP	0.25	0.25	87 25	43.5 6.3	11.9 1.7
14. Position and align ram with transport cask.	2 Ops 1 HP	0.5	0.5 0	173 0	173.0 0.0	47.2 0.0
15. Remove ram access cover plate and connect ram to canister grapple ring.	1 Ops	0.25	0.25	21	5.3	1.4
16. Transfer canister from transport cask to HSM.	3 Ops	0.5	0.5	0	0.0	0.0
17. Retract ram from the canister and undock cask from HSM.	2 Ops 1 HP	.083	.083 0	29 0	4.8 0.0	1.3 0.0
18. Install HSM front access door and install vent duct shields, screens, and temperature monitoring instrumentation..	1 Ops 1 HP	0.5	0.5	21	10.5 0.0	2.9 0.0

Source: MP197 FSAR and NUHOMS HD System FSAR.

Evolution time: 9.33 hours.

Total Dose per single operation, Bounding Value: 583.1 person-mrem.

Total Dose per single operation, Normal Operation: 159.0 person-mrem.

**Note: Dose lowered by installing transport cask trunnions with manipulator arm located in the CHB rail bay.*

Table 3.2-6
Operation Steps at the CSF for a Vertical DFSS

Operation Steps	Number of People	Task Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr)	Dose (man-mrem) 5 years cooled	Dose (man-mrem) 15 years cooled
1. Remove lid from an empty storage cask and position in canister transfer area.	2 Ops	1.0	0	0	0.0	0.0
2. Move loaded railcar to cleaning awning.	1 Ops	0.25	0	0	0.0	0.0
3. Measure dose rates and perform receipt inspection.	2 Ops 1 HP	0.27	0.25 0.25	14.1	7.1 3.5	2.2 1.1
4. Move railcar into CHB.	3 Ops	0.5	0	0	0.0	0.0
5. Remove personnel barrier using CHB crane.	2 Ops	0.17	0.17	21.5	7.3	2.3
6. Measure dose rates and perform contamination survey.	1 HP	0.02	0.02	21.5	0.4	0.1
7. Remove impact limiters and tiedowns using CHB crane.	2 Ops 1 HP	0.37	0.37 0.37	14.1 1	10.3 0.4	3.3 0.1
8. Upright transport cask.	2 Ops 1 HP	0.33	0.33 0.33	9.0 3.0	5.9 1.0	1.9 0.3
9. Sample enclosed cask gas and vent.	1 Ops 1 HP	0.01	0.01 0.01	7.1 7.1	0.1 0.1	0.0 0.0
10. Transfer transport cask to a shuttle cart using CHB crane.	3 Ops	0.5	0.5	9.0	13.5	4.3
11. Remove transport cask lid using wall mounted jib crane.	2 Ops 1 HP	0.75	0.75	7.1	10.7 0.0	3.4 0.0
12. Install lifting hardware on top of canister.	2 Ops 1 HP	0.75	0.75	339.84	51.0* 0.0	16.2* 0.0
13. Install Shielding Collar.	2 Ops 1 HP	0.17	0.17 0.17	7.1 7.1	2.4 1.2	0.8 0.4
14. Move loaded shuttle cart to Canister Transfer Cell.	2 Ops 1 HP	0.25	0.25 0.25	7.1 7.1	3.6 1 1.8	1.1 0.6
15. Check and adjust cask alignment, if necessary, matching transfer sleeve to top of Shielding Collar.	2 Ops	0.25	0.25	7.1	3.6	1.1
16. Lift canister out of transport cask up into transfer sleeve.	2 Ops 1 HP	0.7	0.7 0.7	7.1 7.1	9.9 5.0	3.2 1.6
17. Move transfer sleeve to opening above storage overpack.	2 Ops 1 HP	0.25	0.25 0.25	7.1 7.1	3.6 1 1.8	1.1 0.6
18. Lower canister into storage overpack below.	2 Ops 1 HP	0.5	0.5 0.5	7.1 7.1	7.1 1 3.6	2.3 1.1
19. Remove lifting hardware from	2 Ops	0.17	0.17	487.4	16.6*	5.3*

Operation Steps	Number of People	Task Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr)	Dose (man-mrem) 5 years cooled	Dose (man-mrem) 15 years cooled
top of canister.						
20. Move shuttle cart outside CHB.	1 Ops	0.17	0.17	7.1	1.2	0.4
21. Install lid on top of storage overpack.	2 Ops	0.48	0.48	7.1	4 6.8	2.2
22. Move VCT out to cask pad.	1 Ops	0.67	0.67	69.7	46.7	14.9
23. Place storage overpack on pad and install vent duct shields, screens, and temperature monitoring instrumentation..	1 Ops	0.55	0.55	122.7	67.5	21.5

Source: HOLTEC HI-STORM FSAR.

Evolution time: 10.36 hours.

Total Dose per single Operation, 5 years cooled: 293.2 person-mrem.

Total Dose per single Operation, 15 years cooled: 93.3 person-mrem.

**Note: Dose lowered by using manipulator arm for installing and removing hardware on the top of the canister just outside the transfer cell.*

Surveillance

All incoming transport casks and cask railcars would require an inspection and swipe samples upon arrival at the CSF to determine if there is any radioactive contamination. In the event contamination above the acceptance criteria is discovered, the transport cask or railcar would be decontaminated in the CHB weather enclosure. Any equipment that handled the canisters would also need radioactive contamination surveillance after each canister transfer operation to maintain ALARA conditions.

Canister-based dry storage systems are passively cooled and therefore have minimal surveillance requirements. The storage overpack or module employs top and bottom air vents and dissipates heat by the vertical distance between the vents (stack effect). Therefore, it is required that the vent screens be inspected daily to ensure they are never blocked. Some ISFSI sites use a temperature monitoring system that can remotely monitor the thermal performance of the storage system that, in effect, accomplishes the same task as inspecting the vent screens.

At an ISFSI at a reactor site, vent inspection is not too difficult because of the few overpacks or modules that require inspection. However, vent inspection at a site such as the CSF, which would store thousands of storage overpacks or modules, would be a daunting task. Therefore, the CSF would need to use a temperature monitoring system for storage system performance surveillance. A remote system would also effectively reduce dose received by lowering the amount of time workers would be in the RA.

The purpose of the temperature monitoring system is to provide continuous surveillance of each storage system's temperature to ensure proper operation. For vertical systems, the cooling air temperature rise through the cask is measured, while concrete temperature is typically measured for the horizontal systems. In the event that the temperature acceptance criterion is not met, an alarm would inform personnel of a potential cask temperature problem (i.e., vent blockage). Vent blockage would result in an increase of the cooling air temperature or concrete temperature over several hours, which would give operations personnel time to assess and resolve the problem.

The CSF would also utilize direct radiation monitors and thermo-luminescent dosimeters (TLDs) to ensure safe working conditions for on-site personnel and the general public outside the CSF property. The purpose of the direct radiation monitors would be to detect and alarm any high radiation conditions in the storage area or CHB. The purpose of TLDs would be to record radiation doses received at the RA boundary fence and OCA boundary fence. Since the canisters are welded closed, airborne monitors are unnecessary. However, airborne monitors would likely be used to assure that no airborne radioactivity is present during canister transfer operations in the CHB even though the canisters are sealed.

Maintenance

Routine maintenance would be performed on transport casks and railcars. Minor maintenance or repair activities would be conducted at the CMF and FMF. If extensive maintenance or repair activities are required, they may need to be performed at an off-site vendor facility.

No special contamination control measures are anticipated for repair or maintenance activities since the UNF is contained within sealed canisters. Likewise, canisters, storage overpacks, and storage modules are passive; therefore, there are very little maintenance requirements other than occasional inspections to ensure surfaces, such as paint or concrete, are not chipped or damaged from environmental conditions. The temperature monitoring system will also require normal maintenance and occasional replacement of components.

There would also be maintenance requirements on equipment throughout the CSF. Major components requiring ongoing maintenance would include the CHB overhead bridge crane, canister transfer equipment, cask transport vehicles (NUHOMS transfer trailers and vertical cask transporters), heavy-haul tow vehicles, backup diesel-powered generators, temperature monitoring equipment, fire protection equipment, etc. The maintenance would need to be performed in accordance with manufacturer's standards.

3.2.2 Phase 2—Transportable Canisters

3.2.2.1 Phase 2 Overview

Currently, nearly all commercial plant sites utilize transportable canisters at their ISFSIs. Transportable canisters are components of those DFSSs that are licensed for both storage under 10 CFR Part 72 and transportation under 10 CFR Part 71, either with the same overpack used for storage or in a separate transport cask. These canisters are referred to as DPCs. Nearly all plants storing UNF at an on-site ISFSI currently use DPC-based systems and the few remaining sites yet to build an ISFSI plan to use DPC-based systems. As of mid-2012, approximately 11,200 MTU of UNF is stored in 979 DPCs of various designs that are already licensed for transportation under 10 CFR Part 71[8], which represents approximately 59 percent of the total UNF in dry cask storage. Another 2,200 MTU of UNF are stored in 166 DPCs of canister designs intended to be licensed for transportation at some point in the future and 3,150 MTU are currently stored in 288 canisters not designed for transportation. The balance of UNF currently stored at ISFSIs is stored in bare fuel casks, both transportable and non-transportable.

Of the total 140,000 MTU estimated to be discharged by commercial plants, a large majority of the UNF is likely to be stored in DPC-based systems. Therefore, retrieving DPCs from plant sites and storing them at the CSF is necessary to address the government's UNF collection burden, notwithstanding whether a standardized storage system is implemented at a later date that will decrease the use of DPC-based systems.

In Phase 2, the CSF can continue operating with the Phase 1 design by simply expanding the number of storage pads. In Construction Stage 1, the CSF would be constructed with minimum essential structures and components for receiving transport casks from the shutdown plant sites. The same "minimum essential equipment" used in Phase 1 will serve the needs in Phase 2. Because the DPCs (which are welded closed) do not need to be opened, the CSF in Phase 2 would continue to operate as a "start clean, stay clean" facility.

Unlike Phase 1 however, the UNF in Phase 2 originates from operating plant sites, so the cask handling equipment, including cask handling cranes inside the plant, will be available (until such time that the reactor is shut down and decommissioning commences). This allows postponing the need for the use of a significant amount of temporary equipment to load transport casks at the plant sites. Many plant sites have dismantled or abandoned their rail access and/or have no viable barge access; therefore, some HHT transport and intermodal transfer from a HHT trailer to a railcar will still be required.

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[8] It is important to note that while the DPC designs may be licensed for transportation, not all contents currently stored in those DPC designs are included in the approved contents of the transportation CoCs for those packages. Approval of all contents will require additional licensing efforts by the CoC holders.

Until the operating plant sites shut down all of the reactors on the site, no canisters containing GTCC waste will be shipped in Phase 2. When all of the plant sites shut down, there could be a total of 400 canisters filled with GTCC that will need to be stored at the CSF.[9]

As with the stranded UNF retrieval, site-specific plans for removal of UNF will need to be established with the UNF owners before it can be removed from the site. Site surveys, site-specific plans, government-furnished equipment, local permits, and subcontractor contracts will need to be put in place. The process for development of site-specific plans will have been established to remove UNF during Phase 1. While there will be more plant sites from which UNF will be accepted during Phase 2, the overall time required to develop each site-specific plan would be expected to be shorter than needed for the site plans in Phase 1.

Within Phase 2, a number of potential cost-saving measures are identified, which include continuation of Phase-1-type operations with little or no cask processing changes, the reuse of overpacks and modules shipped as overweight/oversized loads via railroad to the CSF, and additional collection of plant equipment no longer needed at the plant sites.

3.2.2.2 Transportable Canister Plant Sites

Table 3.2-7 shows the 41 plant sites that have already implemented at least a portion of their dry cask storage using DPCs as of June 30, 2012, including the reactor and ISFSI initiation dates and the planned reactor shutdown dates. **Table 3.2-8** shows the 16 additional plant sites that are either in the process or planning to implement dry fuel storage after June 30, 2012 (D.C. Cook, Nine Mile Point, and Perry will have moved UNF to the ISFSI in DPCs for the first time as of this writing). **Table 3.2-9** shows the 18 planned new reactors that could go online in the next 20 years and add to the current UNF storage burden. Fourteen of these reactors are located at existing plant sites and four are new plant sites. It is possible that the 14 reactors could be built in the future, based on applications pending before the NRC, but the schedule for construction and operation of these additional 14 reactors is not certain at this time. The projected UNF discharges assumed in this report that contribute toward the total assumed UNF inventory of 140,000 MTU include UNF that will be discharged from the five new reactors that are currently undergoing construction as described in Section 5.2.2.1: Watts Bar 2, Vogtle 3 and 4, and V.C. Summer 2 and 3 (the additional potential reactors included in **Table 3.2-9** are identified for information only and are not assumed to contribute UNF). New reactors located at existing sites may be able to utilize dry cask storage and associated equipment used by their predecessors thereby reducing their UNF pickup impacts.

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[9] Supko, E.M. and M.H. Schwartz, 2011. *Overview of High-Level Nuclear Waste Materials Transportation: Processes, Regulations, Experience and Outlook in the U.S.*, Section 2.1.3, ERI-2030-1101, Energy Resources International, Inc., January.

UNF stored in DPCs would be retrieved from all of the operating plant sites. However, since the plants are in operation, much of the UNF is freshly out of the reactor and must cool for a prescribed time as outlined in the CoC for the package being used before it can be loaded for storage or transportation. As discussed in Section 5.0, there may be a difference between the required cooling times to load UNF for storage and transport, with transport packages generally requiring longer cooling times than those required for storage. In addition, many reactors are discharging fuel with increasingly high-burnup (HBU) fuel and very few transport cask systems are presently licensed to ship HBU fuel, though transport cask vendors are currently pursuing licensing of their transport cask systems for HBU fuel. This is an ongoing effort between the industry and the NRC, and the technical issues inhibiting widespread licensing of HBU fuel for transportation are expected to be resolved prior to the opening of the CSF. As discussed in Section 6.2, additional R&D is likely to be needed to qualify HBU fuel for transport in order to provide NRC with data to support a technical basis for transport of this UNF.

Table 3.2-7
Operating Plant Sites with an ISFSI Currently Using DPCs

Plant/Reactor	Initial Reactor Operation	Initial ISFSI Operation	Planned Reactor Shutdown	Date all UNF Transportable
ANO 1 & 2	1974, 1978	1996	2034, 2038	2054, 2058
Braidwood 1 & 2	1988	2011	2046, 2047	2066, 2067
Browns Ferry 1, 2 & 3	1973, 1974, 1976	2005	2033, 2034, 2036	2052, 2053, 2055
Brunswick 1 & 2	1976, 1974	2010	2036, 2034	2051, 2049
Byron 1 & 2	1984, 1986	2010	2044, 2046	2064, 2066
Catawba 1 & 2	1984, 1986	2007	2043, 2046	2063, 2066
Columbia Gen. Sta	1983	2002	2043	2062
Comanche Peak 1 & 2	1990, 1993	2012	2050, 2053	2070, 2073
Cooper	1974	2010	2034	2049
Diablo Canyon 1 & 2	1981, 1985	2009	2041, 2045	2061, 2065
Dresden 1***, 2 & 3	1960, 1969, 1971	2000	1978 (Act.), 2029, 2031	1997, 2048, 2050
Duane Arnold	1974	2003	2034	2049
Farley 1 & 2	1977, 1980	2005	2037, 2041	2057, 2061
FitzPatrick	1974	2002	2034	2053
Fort Calhoun	1973	2006	2033	2053**
Ginna	1969	2010	2029	2049**
Grand Gulf	1982	2006	2044	2063
Hatch 1 & 2	1974, 1978	2000	2034, 2038	2053, 2057
HB Robinson 2	1970	1986	2030	2050**

Plant/Reactor	Initial Reactor Operation	Initial ISFSI Operation	Planned Reactor Shutdown	Date all UNF Transportable
Indian Point 1***, 2 & 3*	1962, 1971, 1975	2008	1974 (Act.), 2033, 2035	1994, 2053, 2055
LaSalle 1 & 2	1982, 1983	2010	2042, 2043	2061, 2062
Limerick 1 & 2	1984, 1989	2008	2044, 2049	2059, 2064
McGuire 1 & 2	1981, 1983	2001	2041, 2043	2061, 2063**
Millstone 1***, 2 & 3	1970, 1975, 1985	2005	1998 (act.), 2035, 2045	2018, 2055, 2065**
Monticello	1970	2008	2030	2045
North Anna 1 & 2	1977, 1980	1998	2038, 2040	2058, 2060**
Palisades	1971	1993	2031	2051**
Palo Verde 1, 2 & 3	1984, 1985, 1987	2003	2045, 2046, 2047	2066, 2067, 2068
Point Beach 1 & 2	1970, 1971	1995	2030, 2033	2050, 2053**
Quad Cities 1 & 2	1971, 1972	2005	2032, 2032	2051, 2051
River Bend	1985	2005	2045	2064
St. Lucie 1 & 2	1976, 1983	2008	2036, 2043	2056, 2063**
Salem 1 & 2/Hope Creek	1976, 1980, 1986	2006	2036, 2040, 2046	2056, 2060, 2065
San Onofre 1***, 2 & 3	1967, 1982, 1982	2003	1992 (Act.), 2042, 2042	2012, 2062, 2062**
Seabrook	1986	2008	2046	2066**
Sequoyah 1 & 2	1980, 1981	2004	2040, 2041	2060, 2061
Surry 1 & 2	1972, 1973	1986	2032, 2033	2052, 2053**
Susquehanna 1 & 2	1982, 1984	1999	2042, 2044	2057, 2059
Turkey Point 3 & 4	1972, 1973	2011	2032, 2033	2052, 2053**
Vermont Yankee	1972	2008	2032	2051
Waterford 3	1984	2011	2044	2064

References:

1. *Reactor License and Shutdown Dates: U.S. Energy Information Administration (www.eia.gov/nuclear/reactors).*
2. *ISFSI Initial Operation Dates: Gutherman Technical Services, LLC.*

** Assumes 20-year license renewal for all operating reactors. Operating license renewal has not yet been approved for all reactors.*

***These plants use DPC designs that are not yet licensed for transportation. Because the DPCs are not licensed, the 10 CFR Part 71 CoCs are not part of the public record, and the Cooling Time remains proprietary information. A Cooling Time of 20 years has been assumed.*

****These plants are shutdown reactors that are not included in Phase 1 because they are located at an operating plant site.*

Table 3.2-8
Operating Plant Sites Planning an ISFSI Using DPCs

Plant/Reactor	Initial Reactor Operation	Estimated ISFSI Operation	Planned Reactor Shutdown*	Date all UNF Transportable
Beaver Valley 1 & 2	1976, 1987	2014	2036, 2047	2056, 2067
Callaway	1984	2015	2044	2064**
Clinton	1986	2015	2046	2065
Crystal River 3	1976	2015	2036	2056**
D.C. Cook 1 & 2	1975, 1978	2012	2034, 2037	2054, 2057
Fermi 2	1985	2014	2045	2064
Nine Mile Point 1 & 2	1969, 1987	2012	2029, 2046	2044, 2061
Perry	1986	2012	2046	2065
Pilgrim	1972	2013	2032	2051
Shearon Harris***	1986	later	2046	2066
South Texas 1 & 2***	1987, 1988	2016	2047, 2048	2067, 2068
Three Mile Island 1***	1974	later	2034	2054
VC Summer	1982	2015	2042	2062**
Vogtle 1 & 2	1987, 1989	2013	2047, 2049	2067, 2069
Watts Bar 1	1995	2014	2055	2075**
Wolf Creek***	1985	2016	2045	2065

Reference: Reactor License and Shutdown Dates: U.S. Energy Information Administration (www.eia.gov/nuclear/reactors).

** Assumes 20-year license renewal for all operating reactors. Operating license renewal has not yet been approved for all reactors.*

*** These plants use DPC designs not yet licensed for transportation. Because the DPCs are not licensed, the 10 CFR Part 71 CoCs are not part of the public record, and the cooling time remains proprietary information. A cooling time of 20 years has been assumed.*

**** These plants have not yet chosen the canister system they plan to use. A cooling time of 20 years has been assumed.*

Table 3.2-9
Future Plant Sites Assuming Will Use DPCs

Plant/Reactor	MWe	Est. Plant Operation	Est. Plant Shutdown (60-year Operation)	Date all UNF Transportable
Bellefonte 1*	1263	2020	2080	2100
Comanche Peak 3 & 4*	3400	Late 2020s	Late 2080s	Early 2100s
Fermi 3*	1500	Late 2020s	Late 2080s	Early 2100s
Lee 1 & 2*	2400	2021, 2023	2081, 2083	2101, 2103
Levy County 1 & 2*	2400	2024, 2025	2084, 2085	2104, 2105
North Anna 3*	1700	Late 2020s	Late 2080s	Early 2100s
Shearon Harris 2 & 3*	2400	Late 2020s	Late 2080s	Early 2100s

Plant/Reactor	MWe	Est. Plant Operation	Est. Plant Shutdown (60-year Operation)	Date all UNF Transportable
Turkey Point 6 & 7*	2400	2022, 2023	2082, 2083	2102, 2103
VC Summer 2 & 3	2400	2017, 2018	2077, 2078	2097, 2098
Vogtle 3 & 4	2400	2016, 2017	2076, 2077	2096, 2097
Watts Bar 2	1218	2015	2075	2095

References:

1. *NEI Table on New Nuclear Plant Status, http://www.nei.org/resourcesandstats/documentlibrary/newplants/graphicsandcharts/newnuclearplantstatus/.*
2. *TVA Approval of Bellefonte 1, http://www.tva.gov/power/nuclear/bellefonte.htm, Aug 18, 2011.*

**These plants are not included in the overall projection of commercial UNF due to their uncertain status.*

Table 3.2-7, **Table 3.2-8**, and **Table 3.2-9** show that retrieval of UNF, from either dry storage at an ISFSI or the plant SFP storage, could need to continue into the late 2090s or early 2100s. As noted above, this analysis includes new plant UNF discharges only from those plants currently under construction. However, as noted in Section 5.0, additional transport capacity would be available by approximately 2070 (or earlier, depending upon the overall acceptance rate) to transport UNF from additional new reactors or from further extension of licenses for existing reactors.

3.2.2.3 Origination of UNF and Applicable Storage Systems

Table 3.2-10 identifies each of the operating plant sites that currently use DPCs to store UNF at their ISFSI, the storage technology used, and the approximate numbers of DPCs in dry storage as of June 30, 2012[10]. Data may not exactly match that from other sources, such as the DOE. As of mid-2012, approximately 11,200 MTU of UNF is stored in 979 DPCs of various designs that are already licensed for transportation under 10 CFR Part 71 , which represents approximately 59 percent of the total UNF in dry cask storage. Another 2,200 MTU of UNF is stored in 166 DPC of canister designs intended to be licensed for transportation at some point in the future.

Table 3.2-10
Current Operating Plant Site ISFSI UNF Storage Using DPCs*

Plant/Reactor*	Storage Technology and DPC Model	No. of DPCs (June 30, 2012)
ANO 1 & 2	HI-STORM MPC-24/MPC-32	37 (20/17)
Braidwood 1 & 2	HI-STORM MPC-32	3

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[10] Oyster Creek and Kewaunee are not included because these plants intend to shut down permanently prior to the end of their respective operating licenses and are included in Phase 1 of this report.

Plant/Reactor*	Storage Technology and DPC Model	No. of DPCs (June 30, 2012)
Browns Ferry 1, 2, & 3	HI-STORM MPC-68	31
Brunswick 1 & 2	STD NUHOMS 61BTH	8
Byron 1 & 2	HI-STORM MPC-32	14
Catawba 1 & 2	UMS TSC-24	24
Columbia Gen. Station	HI-STORM MPC-68	27
Comanche Peak 1 & 2	HI-STORM MPC-32	9
Cooper	STD NUHOMS 61BT	8
Diablo Canyon 1 & 2	HI-STORM MPC-24/MPC-32	23 (0/23)
Dresden 1, 2, & 3	HI-STAR/HI-STORM MPC-68	51 (4/47)
Duane Arnold	STD NUHOMS 61BT	20
Farley 1 & 2	HI-STORM MPC-32	15
FitzPatrick	HI-STORM MPC-68	15
Fort Calhoun	STD NUHOMS 32PT	10
Ginna	STD NUHOMS 32PT	6
Grand Gulf	HI-STORM MPC-68	17
Hatch 1 & 2	HI-STAR/HI-STORM MPC-68	48 (3/45)
H.B. Robinson	STD NUHOMS 24PTH	14
Indian Point 1, 2, & 3	HI-STORM MPC-32	19
LaSalle 1 & 2	HI-STORM MPC-68	6
Limerick 1 & 2	STD NUHOMS 61BT	17
McGuire 1 & 2	UMS/MAGNASTOR TSC-24/TSC-37	28 (28/0)
Millstone 1, 2, & 3	STD NUHOMS 61BT/32PT	18 (0/18)
Monticello	STD NUHOMS 61BT	10
North Anna 1 & 2	NUHOMS HD 32PTH	13
Palisades	STD NUHOMS 24PTH/32PT	24 (13/11)
Palo Verde 1, 2, & 3	UMS TSC-24	94
Point Beach 1 & 2	STD NUHOMS 32PT	17
Quad Cities 1 & 2	HI-STORM MPC-68	35
River Bend	HI-STORM MPC-68	15

Plant/Reactor*	Storage Technology and DPC Model	No. of DPCs (June 30, 2012)
St. Lucie 1 & 2	NUHOMS HD 32PTH	14
Salem 1 & 2/Hope Creek	HI-STORM MPC-32/MPC-68	27 (11/16)
San Onofre 1, 2 & 3	ADVANCED NUHOMS 24PT1/24PT4	50 (17/33)
Seabrook	NUHOMS HD 32PTH	6
Sequoyah 1 & 2	HI-STORM MPC-32	32
Surry 1 & 2	NUHOMS HD 32PTH	18
Susquehanna 1 & 2	STD NUHOMS 61BT	40
Turkey Point 3 & 4	NUHOMS HD 32PTH	18
Vermont Yankee	HI-STORM MPC-68	13
Waterford 3	HI-STORM MPC-32	9
Totals		903

Reference: StoreFUEL and Decommissioning report. Used by permission from Ux Consulting, www.uxc.com.

** DPC count does not include GTCC canisters.*

In addition to accepted UNF already loaded into DPCs from plant sites, it is also possible that DPC systems could be used to accept UNF directly from SFPs. As discussed in Section 3.2.3, under Phase 3 of the CSF, UNF could also be accepted using bare fuel transport casks. It is projected that approximately 44,000 MTU of UNF would be in dry storage by 2025, the approximate time that Phase 2 operations would begin. If, during the 2025 to 2035 time period, all of the UNF accepted from operating plants is transported in DPC systems that are loaded directly from SFPs, then an additional 30,000 MTU of UNF would be loaded into DPCs, for a total of 74,000 MTU in DPCs. **Table 3.2-10** shows that as of June 2012, 903 DPCs have been loaded for storage at plant sites (approximately 11,000 MTU). This represents about eight percent of the total of approximately 140,000 MTU discharged from just the current fleet of shutdown and operating commercial reactors. This percentage is likely to be more than half of the total UNF if all of the remaining UNF is stored in DPCs.

Figures 3.2-19 through 3.2-25 illustrate the types of DPC-based storage systems that are present at the various operating plant sites.

Figure 3.2-19
Holtec HI-STAR 100 Storage System at the Hatch ISFSI

Figure 3.2-20
Holtec HI-STORM 100 Storage System at the Hatch ISFSI

Figure 3.2-21
NAC UMS Storage System at the Catawba ISFSI

Figure 3.2-22
NAC MAGNASTOR Storage System at the McGuire ISFSI

Figure 3.2-23
Transnuclear Std. NUHOMS Storage System at the Ft. Calhoun ISFSI

Figure 3.2-24
Transnuclear HD NUHOMS Storage System at the North Anna ISFSI

Figure 3.2-25
Transnuclear Advanced NUHOMS Storage System at the San Onofre ISFSI

3.2.2.4 UNF Retrieval and CSF Design Strategy

The equipment needed to transfer the DPCs from storage overpacks (existing dry storage) or from SFPs (freshly loaded canisters) at operating plant sites to transport casks is available at the plant.

Eighteen of the 41 operating plant sites with an ISFSI in operation as of June 30, 2012 use a DFSS design employing a NUHOMS horizontal storage module (HSM) with a DPC. The DPC can be transferred directly from the HSM into the transport cask at the ISFSI pad without the need to use a transfer cask or to rely on plant equipment for the canister transfer operation. A mobile crane will be needed to lift the HSM door and transfer the transport cask from the NUHOMS transfer trailer to a railcar or heavy-haul truck (HHT) and to prepare it for transport operations (i.e., install impact limiters, install personnel barrier, etc.).

The other 23 operating plant sites involved in Phase 2 operations use canisters stored in vertical storage overpacks at their on-site ISFSIs. Operations at these plants will require that the storage overpack be moved to a location where the DPC can be transferred into a transfer cask and then transferred from the transfer cask into a transport cask. The 10 CFR Part 72 storage CoCs contain requirements for the performance of this activity that must be followed, which could be satisfied by moving the overpack back into the power plant facility to allow use of the cask handling crane. As noted previously for the Phase 2 plant sites, it is considered likely that the facilities associated with fuel movement will be available for use to conduct the canister transfer operation. Alternatively, it would be possible to use an outdoor cask/canister transfer facility (CTF). Like the horizontal system, a mobile crane may be needed to place the transport cask on a railcar or HHT and prepare it for transport. The mobile crane or CTF will need to lift the transport cask and down-end it onto the railcar or HHT.

In order to accept UNF from an operating plant in a DPC system, the UNF does not need to have already been loaded into a DPC. In Phase 2, UNF can also be loaded directly into DPC from the SFP for transport off site. As discussed in Section 5.2.6, during at least the first 10-15 years of acceptance from operating plants, the nuclear operating companies are likely to prefer to have UNF accepted directly from SFPs since their objective would be to lessen the UNF that must be transferred to dry storage at their plants. Acceptance of UNF from SFPs, would, in turn, create available pool space for upcoming UNF discharges during refueling outages. In addition, it would lower the number of DPCs that the owner would need to load and place into interim storage at the ISFSI. Some of the UNF from SFPs may not qualify for transport off site in accordance with existing 10 CFR Part 71 transport cask CoCs, because longer cooling times are typically required for transport than for storage. However, as discussed in Section 5.2.6, one alternative for acceptance of UNF with high decay heat directly from SFPs would be to develop smaller capacity transport casks, with a smaller DPC that could be used in Phase 2. If existing DPC designs were to be used, these systems could also be short-loaded, although this approach would likely not be cost effective over the long term. Utilizing a range of options for accepting UNF from SFPs, a UNF loading strategy could be established that would optimize the number of DPCs that could be shipped directly to the CSF and minimize the number of DPCs that would need to be placed in a storage overpack and stored on site at the ISFSI once Phase 2 acceptance begins.

A second alternative would be to deliver new DPCs to plant sites. Already loaded DPCs, in which the UNF has cooled sufficiently to qualify for transport, could be loaded into a transport cask for shipment to the CSF. The new DPCs would then be loaded from SFPs with UNF that is has cooled sufficiently and is qualified for storage, and the loaded DPC would be transferred to the onsite ISFSI for further cooling (perhaps re-using the storage overpack or HSM from which a DPC has been removed for transport). At some point in the future, these “new” DPCs would also be sufficiently cooled to enable transport. The ability to exercise this alternative would depend on whether a plant site has UNF in dry storage that has been sufficiently cooled to qualify for transport.

If the plant site no longer has direct rail access, the transport cask would be delivered to the plant site via HHT trailer or barge that would be loaded to and from rail transport at an intermodal transfer location as discussed in Section 5.3.3.5. Transfer of the DPC from the transport cask to the DFSS on the storage pad will be conducted as described for Phase 1 using the CHB.

In Phase 1, a number of transport casks will have been acquired that can be used in Phase 2 as follows:

- Four TN MP187 transport casks used to retrieve UNF at Rancho Seco can be used to retrieve the 18 NUHOMS 24PT DPCs at San Onofre 1.
- Five TN MP197HB transport casks used to retrieve UNF at Kewaunee and Oyster Creek can be used to retrieve NUHOMS 61BT, 24PT series, and 32PT series DPCs from various NUHOMS-user plants around the nation.
- Five NAC-UMS-T transport casks used to retrieve UNF from Maine Yankee can be used to retrieve NAC-UMS canisters at Catawba, McGuire, and Palo Verde.
- Seven Holtec HI-STAR 100 transport casks from Dresden and Plant Hatch used to retrieve UNF from Trojan can be used to retrieve Holtec MPC-24 series, MPC-32 series, and MPC-68 series DPCs at various Holtec-user plants around the nation.
- Four NAC MAGNATRAN transport casks used to retrieve UNF from Zion can be used to retrieve MAGNASTOR DPCs at McGuire and Catawba.

Section 5.0 of this report analyzes several overall acceptance rates ranging from 3,000 MTU to 6,000 MTU accepted annually. Assuming a base case rate of 3,000 MTU being accepted annually after a five-year ramp up period, an average of approximately 330 cask shipments per year would result. If the system capacity is later increased to enable the acceptance of 4,500 MTU annually as discussed in Section 5.2.4.2, the average number of casks shipped annually would increase to approximately 495 casks. The overall acceptance rate of 3,000 MTU will require approximately 100 to 115 casks and railcars to transport UNF. A 4,500 MTU acceptance rate would require 145 to 170 casks and railcars. Therefore, more transport casks, in addition to the casks fabricated to accept stranded UNF from shutdown plants in Phase 1, will need to be procured and fabricated. The exact mix of cask designs to be utilized will depend upon: (1) the number and types of dry storage technologies deployed at reactor sites at the time Phase 2 acceptance begins, (2) whether UNF is accepted directly from SFPs or from already loaded DPCs in onsite ISFSIs, and (3) the availability of new transport cask designs capable of transporting HBU UNF with relatively short cooling times. **Tables 5.2-4**, **5.2-6**, **5.2-9**, and **5.2-11** in Section 5.0 summarize the recommended number of transport casks that should be procured for the CSF, assuming both a 3,000 MTU and a 4,500 MTU annual rate of acceptance and based on the current mix of DFSSs in commercial use. Note that as discussed above, additional lower capacity 7-MTU DPCs with transport casks would also be needed to transport high decay heat UNF directly from SFPs.

As discussed in Section 3.2.1, Phase 1, storage overpacks or storage modules used at the originating plant sites could be shipped via railroad to the CSF for reuse to save cost. In Phase 2, as hundreds of DPCs are moved from their originating plant sites to the CSF, this option becomes much more important. Not only will reuse of the storage overpacks/modules save millions of dollars in fabrication costs, it will save waste disposal quantities and their associated costs. Currently, there are about 900 storage overpacks/modules in service at plant ISFSIs. Hundreds more will need to be fabricated to store future DPCs. Reuse of storage overpacks/modules can occur in two ways; 1) at the CSF by shipping the overpacks/modules from the plant site to the CSF, or 2) to house new DPCs at the originating ISFSI when existing DPCs are removed from the ISFSI and shipped to the CSF. In this second possibility, the storage overpacks/modules that are emptied when their DPC is shipped to the CSF could be used to store newly loaded DPCs that still have a high heat loading and may not be eligible for transport until further cooling. Once the DPC meets the transport heat requirements, it could be shipped to the CSF and the overpack/module would be ready for a DPC with new UNF from the SFP.

Even with reuse of the storage overpacks/modules from originating plant sites, there will be a need to fabricate overpacks/modules at the CSF. Section 3.2.2.6 discusses the concrete requirements for fabrication of the storage overpacks/modules and the construction of new storage pads.

3.2.2.5 UNF Retrieval Schedule

This report assumes the UNF in transportable canisters can be moved from operating plants to the CSF beginning with the fourth year of CSF operation after most of the stranded UNF is placed in storage at the CSF. Depending on the future storage technology, shipment of transportable canisters could continue until the final UNF is delivered to the CSF, in approximately 2087.

3.2.2.6 Consolidated Storage Facility

CSF Requirements

In Phase 2, the CSF will need to continue to receive, handle, and store DPCs as in Phase 1. The Phase 1 CSF will contain most of the facilities necessary for Phase 2, including rail yards to receive incoming train consists and prepare for outgoing train consists, a CHB that can offload transport casks and provide canister transfer operations for vertical-type canister-based DFSSs, a storage area with concrete storage pads to support the storage overpacks, an office building, a cask maintenance facility, a FMF, a security building, and various fenced areas to provide radiation and security protection. The primary difference will be in the increased volume of shipments arriving at the CSF and the number of storage pads to support thousands of incoming DPCs.

Table 3.2-11 provides the dimensions and weights for the DPCs and their associated transport cask and storage overpack/modules to be received in Phase 2.

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Table 3.2-11
Transportable Canister DFSS Dimensions and Weights

Dry Fuel Storage System (DFSS)	Canister				Transport Cask					Storage Overpack				
	Model	Height (in.)	Dia. (in.)	Weight Loaded (lbs.)	Model	Height (in.)	Dia. (in.)	Weight (lbs.)	Weight Loaded (lbs.)	Model	Height (in.)	LxW or Dia. (in.)	Weight (lbs.)	Weight Loaded (lbs.)
Holtec International														
HI-STAR/HI-STORM MPC-24 Series	MPC-24	190.3125	68.5	90,000	HI-STAR 100	203.125	96	145,726	235,726	HI-STORM 100S Ver. B	210.5	133.875	320,000	410,000
HI-STORM MPC-32 Series	MPC-32	190.3125	68.5	90,000	HI-STAR 100	203.125	96	145,726	235,726	HI-STORM 100S Ver. B	210.5	133.875	320,000	410,000
HI-STAR/HI-STORM MPC-68 Series	MPC-68	190.3125	68.5	90,000	HI-STAR 100	203.125	96	145,726	235,726	HI-STORM 100S Ver. B	210.5	133.875	320,000	410,000
HI-STORM FW MPC-37 Series	MPC-37	182	75.5	116,400	HI-STAR 190	203.125	96	N/A	N/A	HI-STORM FW	207.75	140	228,100	425,700
HI-STORM FW MPC-89 Series	MPC-89	182	75.5	116,400	HI-STAR 190	203.125	96	N/A	N/A	HI-STORM FW	207.75	140	228,100	425,700
NAC International														
NAC-UMS 24	NAC-TSC	191.75	67	72,900	UMS-T	209.3	92.9	161,700	234,600	VCC (NAC-UMS)	225.88	136	239,700	312,600
NAC-MAGNASTOR	NAC-TSC	191.8	72	102,000	MAGNATRAN	202	88	113,000	215,000	MAGNASTOR	225	136	326,000	428,000
Transnuclear														
NUHOMS-24PT1	24PT1-DSC	186.5	67	82,000	MP187	203	92.7	158,580	240,580	AHSM	247	101	320,000	402,000
NUHOMS-24 Series (except PT1)	24P-DSC	186	67	78,129	N/A	N/A	N/A	N/A	N/A	HSM-102	180	116.4	364,400	442,529
NUHOMS-32PT Series	32PT/H-DSC	193	62.2	98,400	MP197HB	208	91.5	154,220	252,620	AHSM	247	101	320,000	418,400
NUHOMS-61BT Series	61BT/H-DSC	196	67	88,930	MP197HB	208	91.5	154,220	243,150	HSM-102	180	116.4	364,400	453,330

References:

1. *HI-STORM 100 Updated Final Safety Analysis Report, Docket Number 72-1014.*
2. *HI-STAR 100 Updated Final Safety Analysis Report, Docket Number 72-1008.*
3. *NAC MAGNASTOR Updated Final Safety Analysis Report, Revision 1, Docket Number 72-1031.*
4. *NAC UMS Updated Final Safety Analysis Report, Revision 9, Docket Number 72-1015.*
5. *Transnuclear NUHOMS HD Updated Final Safety Analysis Report, Docket Number 72-1030.*
6. *Transnuclear Advanced NUHOMS Updated Final Safety Analysis Report, Docket Number 72-1029.*
7. *Transnuclear Standardized NUHOMS Updated Final Safety Analysis Report, Revision 10, Docket Number 72-1004.*
8. *HI-STORM FW Updated Final Safety Analysis Report, Docket Number 72-1032.*

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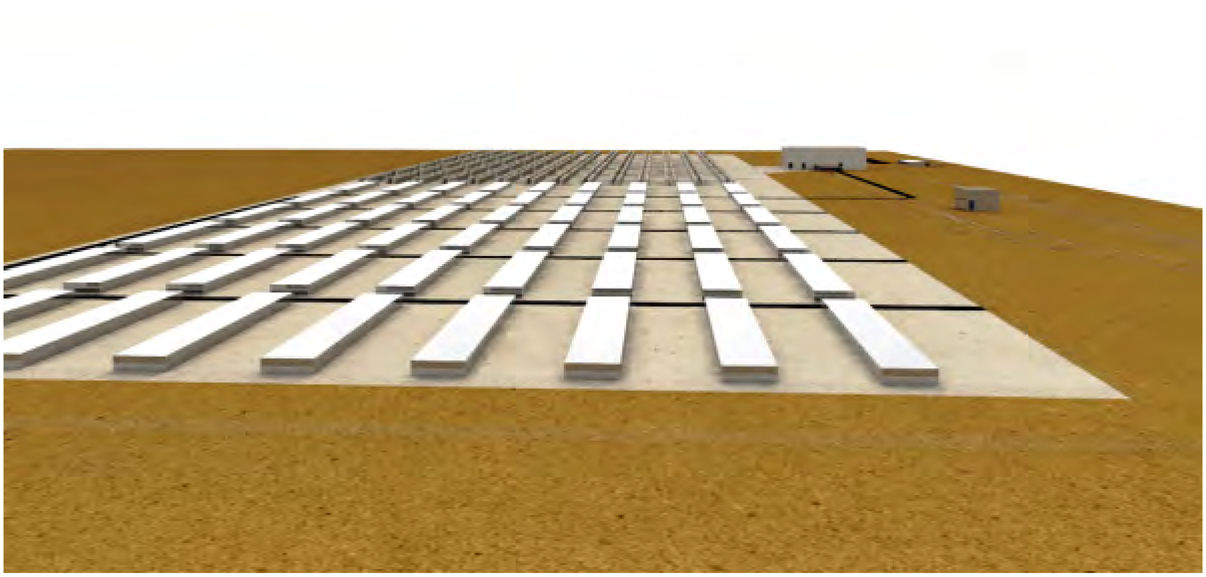
CSF Site Layout

The site layout for a CSF that could store all of the UNF in DPCs is shown in **Figure 3.2-27**. A 3D model view of the site is shown in **Figure 3.2-26**. In Construction Stage 2, the RA and PA would be expanded over time to encompass the growing number of storage pads. The OCA would remain unchanged.

Figure 3.2-26
3D Model View of Phase 2 CSF



Radiation Area

The RA, designated to limit personnel movements in the vicinity of the storage overpacks that house the UNF, would need to grow as new storage systems are placed on the storage pads. The storage of additional UNF will bring additional radiation in the RA. The radiation to an individual in the RA will not change significantly due to the fact that the storage systems will be spread out over a large area. However, a substantial increase in storage overpacks or modules will result in an overall increase in direct radiation and sky-shine seen at the CSF yard and buildings and around the CSF OCA. Analysis of the on-site and off-site radiation doses will need to be performed to determine that the occupational doses remain within 10 CFR Part 20 limits and show that any individual member of the public outside of the OCA will not experience an annual radiation dose of more than 25 mrem in accordance with 10 CFR 72.104.

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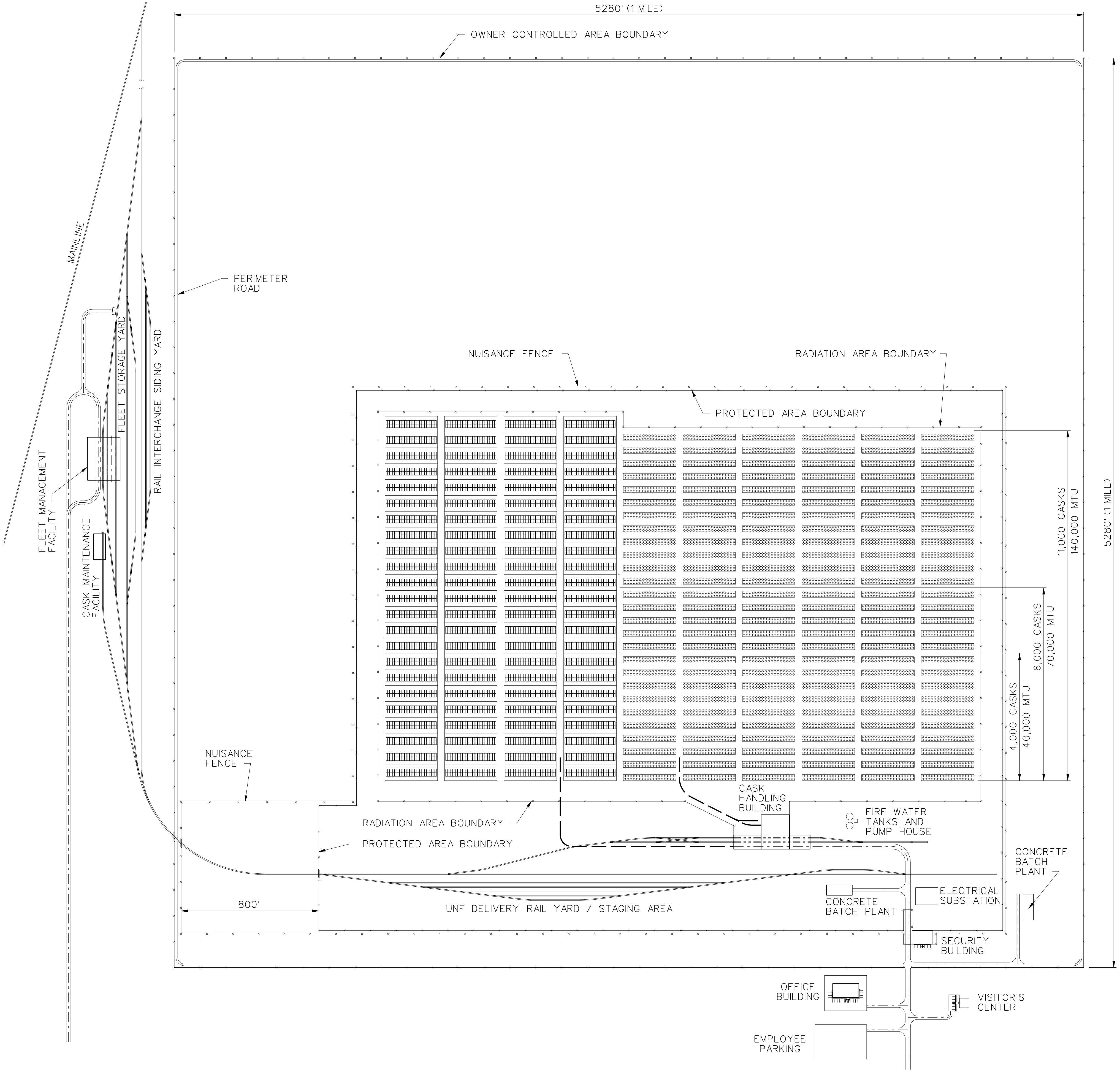

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Task Order #11
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Storage Facility Design Concepts

CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 3.2-27, STAGE 2 OVERALL CSF SITE LAYOUT

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Protected Area

The PA would also need to be increased in area to encompass the larger RA to prevent unauthorized persons from entering the CSF where UNF is handled and stored. Construction techniques will need to be employed to accommodate construction of new storage pads with minimal security interference, yet allow the PA to expand around new storage pads before they can be used. This might be accomplished by constructing groups of pads followed by the construction of new chain-link security fencing, intrusion detection systems, closed-circuit television cameras, vehicle barrier systems, and yard lighting around the groups.

A different option is to build the PA that would be required to encompass all the UNF planned to be stored and construct all the storage pads inside the PA. While this minimizes the need to construct new security boundaries every few years, it will require construction workers, incoming and outgoing construction equipment, and trucks to undergo constant security inspections. Some plant sites have assigned security personnel to travel with the construction equipment to avoid constant inspections. This is convenient for short-term projects, but could be prohibitive for a construction project that occurs over many years.

As the security boundary grows, the CAS and SAS will need to add video equipment and computers. The number of security personnel required would also grow to ensure that the larger CSF site can be adequately monitored.

Normal off-site power will need to be assessed at every construction stage of expansion to ensure adequate power is available. Unless overall security requirements are deemed too large, the Uninterruptable Power System (UPS) and security backup emergency diesel-powered generator should be sized with expansion in mind before being sized in Phase 1. An alternative is to add a second UPS and backup emergency diesel-powered generator as site growth demands. This allows for new state-of-the-art equipment to be incorporated into the CSF, which may provide higher energy efficiencies.

Owner Controlled Area

The OCA of 1 square mile assumed in Phase 1 will not change for Phase 2. However, the new storage pads will need to be constructed so that they maintain a minimum distance of 100 meters (328 feet) from the OCA in accordance with 10 CFR 72.106.

CSF Principle Features and Descriptions

The principle features of the CSF required for Phase 2 include the same features in Phase 1 (storage pads, rail yards, CHB, security building, maintenance building, office building, and associated utilities and structures).

Storage Pads

As in Phase 1, the Phase 2 CSF would have reinforced concrete storage pads to support all of the HSMs and storage overpacks that are loaded with UNF canisters. For Phase 2, the total storage area capacity inside the RA would need to accommodate thousands of additional overpack/modules depending on the licensed quantity of UNF for the CSF. For example, the CSF would need to store an estimated 4,000 storage overpack/modules for 40,000 MTU based on a mix of low capacity DPCs (approximately 10 MTU per DPC) already in service and high capacity DPCs (approximately 13 MTU per DPC) expected to be used in the near future. Extending the estimate out further, it will take slightly less than 6,000 overpack/modules for 70,000 MTU, the current MTU limit in the Nuclear Waste Policy Act and slightly more than 11,000 storage overpack/modules to store the projected 140,000 MTU.

As in Phase 1, the horizontal-type DFSS storage pads would have a capacity of 60 modules per pad and the vertical type DFSS storage pads would have a capacity of 34 overpacks. The exact number of each of these pads will be dependent upon future dry storage decisions by nuclear operating companies. For this analysis, a breakdown of 50 percent horizontal storage pads and 50 percent vertical storage pads is assumed since this is the approximate breakdown of systems currently in storage. A typical arrangement is shown in **Figure 3.2-27** which highlights the CSF storage area land useage by the three MTU levels discussed above.

For Phase 2, the CSF will need to procure additional NUHOMS transfer trailers and VCTs to accommodate the growth of the site. During this time, the CSF will experience its maximum canister process rate of one canister per day. Although one NUHOMS trailer and one VCT could handle the flow, it is recommended that the CSF should employ at least three of each type of transporter. With the continual work, it is very likely one transporter (on average) could be in maintenance status at all times. The second transporter would alleviate any backups that occur.

All access roads around the vertical storage pads and along the ends of the horizontal storage pads added beyond Construction Stage 1 would be 30 ft. wide to accommodate travel of a NUHOMS trailer or a VCT and be surfaced with compacted structural gravel. The storage pads for horizontal storage modules have concrete aprons that extend between the sides of the adjacent pads.

Another consideration for a storage area where thousands of vertical storage overpacks will be stored is the use of a more automated system with fewer moving parts that can replicate travel paths numerous times with minimal operator involvement and can be operated by programmed input or radio control. A track-guided, remotely operated gantry crane could be mounted on tracks straddling a single row of vertical storage overpack positions of a storage pad. The pads could be arranged in a series of contiguous slabs so that the gantry could transport storage overpacks from an area near the CHB and access hundreds of storage positions. When a row is filled, the gantry could be repositioned onto the next row until it is fully loaded. This would also eliminate the need for VCT access roads and temporary storage pads for accessing inner casks, which would reduce the overall footprint of the CSF. The aisles between storage pad rows would need to be wider to accommodate the gantry legs. In addition, if ready access to all storage overpacks is required, the gantry would need to raise overpacks high enough so that it could pass over other overpacks in that row. This would necessitate a single-failure-proof type hoist on the gantry to prevent any possibility of a dropped overpack.

Concrete Batch Plant

In Phase 2, the number of concrete storage pads required to be constructed would need a regular supply of concrete. A permanent concrete batch plant (if not installed in Construction Stage 1) is mandatory during Phase 2 to provide the continual supply of concrete for the storage pads (and potential overpacks/module fabrication) at the CSF.

The maximum incoming UNF to the CSF is assumed to be 4,500 MTU/yr. If all the DFSS units housed only 10 MTU, then there would be about 450 casks added to the CSF storage area every year. Assuming the split between horizontal type systems and vertical type systems is 50/50, then the number of pads added per year would be 450×50%÷60 modules per pad = 3.7 (horizontal type) and 450×50%÷34 overpacks per pad = 6.6 (vertical type). From Section 3.2.1.6 of this report, a horizontal-type system pad would be 306 ft. long by 42 ft. wide by 3 ft. thick, which equates to 38,556 cu ft. per year (1,428 cy per year). The apron would be 306 ft long by 50 ft wide by 1.5 ft thick, which equates to 22,950 cu ft per year (850 cy per year). Therefore, horizontal-type system pad construction requires (1,428+850)×3.7 = 8,429 cy of concrete per year. A vertical-type system pad would be 306 ft. long by 36 ft. wide by 3 ft. thick, which equates to 33,048 cu ft per year (1,224 cy per year). Therefore, vertical-type system pad construction requires 1,224×6.6 = 8,078 cy of concrete per year. Total required concrete is 8,429+8,078 = 16,507 ≈ 18,000 cy per year (with 10 percent waste allowance).

Assume concrete will only be placed during warmer months, 6 months at 5 days/week, day shift only. The concrete batch plant will only operate part of a day and will require time to warm up in the morning and shut down in the evening. It is assumed that it is only in operation for 5 hours per day. The total operating time would be 5 hours × 5 days × 26 weeks = 650 hours per year. Therefore, the required batch plant capacity is 18,000÷650 = 28 cy/hr.

Concrete batch plants typically have a capacity between 30 and 130 cy/hr which will satisfy the annual concrete requirements calculated above. Two concrete batch plants should be installed to allow for maintenance and inadvertent shutdowns and to allow for DFSS overpack/module fabrication. Four concrete trucks should be procured so there can be two delivering concrete while the other two are being reloaded. Two concrete pumper trucks should be procured to facilitate construction. A dual-batch plant operation is shown in **Figure 3.2-28**.

Figure 3.2-28
Typical Dual-Batch Plant Arrangement

The storage pad concrete pour at Perry performed on November 11, 2009, is shown in **Figure 3.2-29**. These photos show two concrete pumper trucks and two concrete trucks in operation. A variety of other equipment was used for pad construction, including a mobile crane to lift rebar and pad components, backhoes for excavation and placing drainage components, a front-end loader and dump truck for moving soil, a vibratory roller for compacting subgrade under the pad and structural fill around the pad, a laser screed to vibrate and level the concrete, a power float to provide a smooth finish, a cutting machine to cut control joints, and several operators and hand tools. Concrete pads are constructed with large (#10 to #14) steel reinforcing placed on 12-inch centers (approximate) running both directions and at the top and bottom of the pad. They can also contain conduit and electrical boxes if temperature or pressure monitoring equipment is required. Long pads are divided into roughly square sections so that each pour can be easily managed. These sections are separated by a construction joint, allowing each section some flexibility so that they can move independently of each other. They are doweled together with reinforcing so that they will settle the same and so that there are no uneven surfaces. A pad 306 ft. long would be divided into about six sections. Pours would typically be performed on every other section (1, 3, 5 and 2, 4, 6) and staggered over a few days to accommodate concrete shrinkage. Pours on consecutive sections on the same day would result in a large gap between the pads.

Each of the CSF layouts for the different phases shows one batch plant inside the PA for facility, initial pads and overpack construction. A second concrete batch plant is shown outside the PA in Phases 2 and 3 so that new storage pads can be constructed without affecting security. Once the new pads are completed, the security fence would be relocated around the new pads.

Figure 3.2-29
Pad Pour at the Perry ISFSI

Rail Yard

If minimal rail yard tracks were installed for Phase 1, then additional yard tracks would need to be constructed for Phase 2, since this phase would experience the highest number of inbound and outbound trains. The rail yard shown in **Figure 3.2-27** shows five siding tracks comprised of two inbound sidings, two outbound sidings, and one miscellaneous siding to sort cars. This configuration was laid out to accommodate three to four inbound trains arriving the same week to accommodate variances in the schedule (trains may arrive in a cluster instead of uniformly staggered). This arrangement is suitable for a CSF undergoing maximum projected full operations.

Cask Handling Building

The CHB constructed for Phase 1 can accommodate all canister processing for Phase 2, including receipt of the transport cask/railcar, transfer of transport casks from railcars to transfer trailers (horizontal-type canisters), and the transfer of canisters from transport casks to storage overpacks (vertical-type canisters). The Phase 2 canisters will not change the physical protection or radiation shielding aspects of the CHB. As in Phase 1, the CHB will include two rail bays, one truck bay, a 200-ton overhead bridge crane, two canister transfer cells each consisting of a transport cask and overpack transfer room (see 3D model view in **Figure 3.2-30**), a laydown area for impact limiters, personnel barriers, and a holding area for up to 2 train consists (10 loaded transport casks) awaiting canister transfer (see 3D model view in **Figure 3.2-31**). For a full description of the CHB and its canister transfer capabilities, refer to Section 3.2.1.6.

Figure 3.2-30
3D Model View of the CHB Canister Transfer Area

Figure 3.2-31
3D Model View of the CHB Transport Cask Holding Area

Security Building

No changes to the security building are anticipated in Phase 2. Although the PA will increase in size, the access point for entry into the PA should remain the same unless new regulations redirect the security building parameters. The backup emergency diesel-powered generator that provides power for security equipment may need to be supplemented with a second diesel-powered generator if the first unit cannot adequately handle the new loads from the expanding storage area's lighting and security equipment.

Fleet Management Site

Routine maintenance on transport casks, rolling stock, and truck cask trailers would continue to be performed at the FMS as in Phase 1. The railcar fleet will expand to well over 100 cars in Phase 2; however, major overhauls and maintenance of railcars should continue to be performed at a commercial railroad equipment servicing shop approved for such activities and inspections. Commercial facilities service thousands of railcars yearly. The cost for the equipment (high-capacity cranes, truck overhaul workshops, transfer tables, and special tools) to provide self-servicing does not justify this activity on site for the CSF railcar fleet.

Office Building

The Office Building, located just outside the SA, would continue to service the CSF and is not expected to need modifications for Phase 2.

Visitors Center

The Visitors Center would remain unchanged in Phase 2.

3.2.2.7 Operation Description

The following sub-sections describe the operating steps for receiving transport casks, transferring canisters from transport casks to storage overpacks, UNF storage surveillance, and transport cask maintenance.

Plant Site Shipment Requirements

Plant site procedures are already in place at operating plant sites to remove a DPC from its storage overpack or horizontal module, or to load a DPC in the SFP and transfer it into a transport cask. However, procedures may need to be revised or new procedures created (and pre-operational testing performed), to demonstrate the capability to transfer a DPC from the storage overpack to a transfer cask, and from a transfer cask to the transport cask (or in the case of the NUHOMS System, directly from the storage module to the transport cask). Additional procedures will need to be created to prepare the package for transportation and intermodal transfer from a site transporter to a railcar or barge to a railcar.

Horizontal-Type System

For UNF already in storage in a NUHOMS System, DPC transfer from a storage module to a transport cask is a relatively seamless process in which the DPC is transferred directly from the storage module to the transport cask without the need for an intermediate transfer cask to facilitate the canister transfer process. The key operations for canister transfer operation are as follows:

- Removing the storage module door.
- Placing the transport cask in front of the storage module cavity opening using the NUHOMS transfer trailer.
- Positioning the transfer trailer so the transport cask cavity is lined up with the DPC that is supported by rails in the storage module.
- Pulling the DPC from the storage module into the transport cask (the Transnuclear transport cask is designed with a port in the bottom, sealed by a bolted ram closure plate with O-ring during shipping operations that enables a hydraulic ram to pull the DPC from the storage module into the transport cask).

- Bolting the top closure lid and bottom ram port closure in place.
- Filling the transport cask cavity with helium and leak testing.
- Performing radiation and contamination surveys.
- Fastening the impact limiters to both ends of the transport cask and placing the personnel barrier over the cask for shipment.

A high-capacity crane will be needed to lift the transport cask to and from the horizontal transfer trailer and remove and replace it onto the railcar. This could be done using the cask-handling crane since the building will be designed with rail access.

Vertical-Type System

For UNF already in dry storage in a vertical-type cask storage system, the DPC will need to be transferred from a storage overpack into the transport cask using a transfer cask. This involves the following key operations, which include cask stack-up configurations:

- Removing the storage overpack lid
- Placing the transfer cask on top of the storage overpack (typically with a mating device between the casks)
- Lifting the DPC from the storage overpack into the transfer cask and installing the bottom lid of the transfer cask
- Lifting the transfer cask off the storage overpack and placing it on top of the transport cask (again with a mating device typically used between the casks)
- Removing the bottom lid of the transfer cask and lowering the DPC from the transfer cask into the transport cask
- Removing the transfer cask from the mating device that connects it to the transport cask
- Bolting the closure lid onto the top of the transport cask
- Filling the transport cask cavity with helium and leak testing
- Lifting the loaded transport cask onto the cask skid and lowering it from a vertical to horizontal position
- Performing radiation and contamination surveys
- Fastening the impact limiters to both ends of the transport cask and placing the personnel barrier over the cask for shipment

A high-capacity crane will be needed to lift the transfer cask and DPC during the canister transfer operation, and seismic restraints may be needed to support the casks during the cask stackup configurations. A crane would also be needed to lift the loaded transport cask onto its cask skid and conveyance vehicle (either a railcar or heavy-haul trailer). A single-failure-proof crane is much preferable to ensure that a DPC drop accident is not a credible event. If a single-failure-proof crane is not available, impact limiters and/or analyses of cask/DPC drop accidents will be necessary.

Direct Pool Loading

For UNF in SFP storage, an empty DPC in a transfer cask will need to be placed in the SPF and loaded with UNF before it can be transferred into the transport cask[11]. The key operations for this process include the following:

- Removing the DPC lid
- Placing the DPC/TC into the fuel SFP
- Loading the UNF assemblies into the DPC
- Placing the DPC lid back on the DPC
- Lifting the DPC out of the SFP
- Welding the lid onto the DPC
- Draining, drying, and inerting the DPC
- Welding the vent and drain ports closed.

Welding the DPC redundant boundary (i.e., top cover, closure ring, etc.)

Once the DPC is at this stage, it can be transferred into a transport cask by either of the methods described above for the horizontal-type system or vertical-type system.

CSF Processing of DPCs

Transport casks arriving at the CSF will be received and processed in accordance with the applicable 10 CFR Part 71 CoC, just as they were in Phase 1. The personnel barrier and impact limiters would be removed from an incoming transport cask and the transport cask moved to the canister transfer area of the CHB. The CHB will be equipped with cranes capable of lifting and placing the transport cask in a vertical position in preparation for canister transfer activities. See Section 3.2.1.7 for the detailed steps that would occur at the CSF.

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[11] Some plants, if they have sufficient crane capacity, can load the DPC in the transport cask in the SFP without using a transfer cask. For discussion purposes, it is assumed a transfer cask is needed.

Surveillance

As in Phase 1, all incoming transport casks and cask railcars in Phase 2 would require an inspection and swipe samples upon arrival at the CSF to determine if there was any radioactive contamination. In the event that contamination above acceptance levels is discovered, the transport cask or railcar would need to be decontaminated. Any equipment that handled the canisters would also need radioactive contamination surveillance after each canister transfer operation to maintain ALARA conditions.

The DPCs stored in Phase 2 are passively cooled like the DPCs in Phase 1 and therefore have minimal surveillance requirements. The temperature monitoring system constructed in Phase 1 would need to be expanded for surveillance of the DPCs in Phase 2. The electrical connections for the temperature monitoring system are typically embedded in the storage pads, so as new pads are added, the provisions for the temperature monitoring system would also be added.

As the storage area increases, additional direct radiation monitors and thermo-luminescent dosimeters (TLDs) will need to be added to ensure safe working conditions for on-site personnel and the general public outside the OCA due to the significant increase in the number of DFSS units.

Maintenance

The maintenance activities on the storage overpacks/modules in Phase 2 would be minimal as in Phase 1 and consist of occasional inspections to ensure surfaces, such as paint or concrete, are not chipped or damaged from environmental conditions. However, the volume of maintenance will increase due to the substantial increase in DFSS units.

Maintenance on equipment and structures throughout the CSF will continue (and possibly increase due to the increased process load), including the CHB overhead bridge crane, canister transfer equipment, cask transport vehicles (NUHOMS transfer trailers and vertical cask transporters), heavy-haul tow vehicles, backup diesel-powered generators, temperature monitoring equipment, fire protection equipment, etc. The maintenance would need to be performed in accordance with manufacturer’s standards.

3.2.3 Phase 3—Dual Purpose Casks and Bare Fuel

3.2.3.1 Phase 3 Overview

Phase 3 is intended to offset the increasing number of current-generation, commercially available, DPCs that are not disposable by transitioning to one or more standardized canister systems that would be compatible with a future geological repository. As more UNF is stored in standardized canisters, less would be stored in the current-generation commercial DPCs in Phase 2.

Phase 3 involves the transport of UNF to the CSF using metal (bare fuel) casks, and packaging of this UNF at the CSF for storage. Existing metal casks that are currently being used to store UNF at several ISFSIs could be used (as well as new bare fuel cask designs) to transport UNF to the CSF. Once at the CSF, these casks could either be moved to storage pads for storage or unloaded into a UNF pool at the CSF and sent back to operating reactor sites for perpetual re-use to pick-up UNF assemblies from their SFPs and transported back to a UNF pool at the CSF to be unloaded. UNF in the CSF UNF pool could then either be loaded into a standardized canister, such as a Standardized Transportable, Aging, and Disposable (STAD) canister, (if a STAD canister has been developed), or loaded into a DPC designed for future disposal. The STAD or DPC would be transferred from a transfer cask into a storage overpack in the CHB and moved to a storage pad.

Phase 3 operations, involving receipt of UNF in bare fuel casks at the CSF and packaging into STADs or DPCs, could (and would be expected to) proceed concurrently and in parallel with Phase 2 operations, involving continued receipt of DPCs shipped from the plants.

While it would be beneficial to have a STAD canister developed for Phase 3, since this would reduce the quantity of low level radioactive waste (LLRW) that will eventually require disposal and reduce the number of canister repackaging operations, this is not a requirement for commencement of Phase 3 and UNF could be loaded into DPCs at the CSF as well as at the plants. Once a STAD canister has been developed, Phase 3 could also involve repackaging of UNF from DPCs stored at the CSF into STAD canisters in the CHB UNF pools at the CSF. One or more used fuel pools will need to be available at the CSF before Phase 3 operations can commence.

Phase 3, as in Phase 2, also would remove UNF from the SFPs rather than the ISFSIs, which the reactor owners may prefer since its objective would be to decrease the amount of UNF that must be transferred to on-site ISFSIs. This, in turn, creates available pool space for upcoming UNF discharges during reactor outages. The UNF from the SFP would need to cool for the required licensed period specified in the 10 CFR Part 71 transport CoC for the bare fuel casks before shipment.

Phase 3 will also enable UNF to begin to be removed from the Morris Wet Storage ISFSI located in Illinois. The Morris ISFSI stores approximately 3,200 UNF assemblies (640 MTU) and is not allowed to receive any additional UNF. All of the fuel that is stored at the facility has been in storage and has been cooled for more than 30 years. The NRC renewed the Morris ISFSI license for UNF storage in 2004 for an additional 20 years, which enables continued operation through May 2022. It is likely that the license for the Morris ISFSI will need to be renewed for a third time to allow sufficient time to remove its inventory of UNF and transport it to the CSF.

Phase 3 would be a good phase to construct hot cells for R&D work. This phase would mark the end of the “start clean, stay clean” philosophy, as bare fuel is no longer contained and inaccessible. In Phase 3, the CSF would require additional safety analyses for certain processes and some areas of the CSF (i.e., those housing the used fuel pools) would require confinement barriers and heating, ventilation, and air conditioning (HVAC) control. The CSF would turn from a mostly passive facility into a facility having active components required to maintain system operation. The hot cells would enable research on UNF and transportation and storage container components. Such research facilities would enable the CSF to be a self-contained center for researching UNF issues and canister/cask aging.

As with the previous phases, site-specific plans for removal of UNF will need to be established with the UNF owners before the bare fuel casks can be removed from plant sites and shipped to the CSF. Site surveys, site-specific plans, government-furnished equipment, local permits, subcontractor contracts, etc., will need to be to be established and put in place. The process for development of site-specific plans to remove UNF will have been established during Phase 1.

The primary cost-saving measure of Phase 3 is terminating use of those canisters that may not be disposable at a repository and could become LLRW in the future, and replacing these with standardized canisters. However, Phase 3 will require additional costs to construct the UNF pools and other features required to receive and repackage bare fuel. In addition to the UNF pools, the CSF will need to implement canister closure operations (welding, draining, inerting, and testing), fabrication of storage overpacks for the standardized canisters and install confinement barriers in the CHB.

3.2.3.2 Operating Plant Sites Using Bare Fuel Casks

Table 3.2-12 shows the five operating plant sites that utilize the Transnuclear bare fuel casks. The table lists the number of casks, and notes whether they are licensed for transportation and HBU fuel as of June 2012. All of the bare fuel casks are designed for transportation; however, the 10 CFR Part 71 application to transport the TN-32 casks has yet to be submitted since there has been no need established for transport from those plant sites to date. Transnuclear intends to submit an application for a 10 CFR Part 71 CoC for the TN-32 casks around the end of 2014. It is estimated that once submitted, the CoC will take up to 3 years to be approved.

Bare UNF stored in the SFPs would be retrieved from all operating plant sites. However, since the plants are in operation, much of the UNF is freshly out of the reactor and must cool for a prescribed time before it can be transported, as specified in the applicable CoC. In addition, many plants are licensed to burn fuel in the reactor to 45GWd/MTU or higher (known as high burnup (HBU) fuel). However, among the TN-series bare fuel cask designs, only the TN-68 and TN-40HT are currently licensed to store HBU fuel assemblies. Once the TN-40HT is licensed for HBU UNF under its 10 CFR Part 71 CoC, Transnuclear plans to submit a CoC amendment application to license the TN-68 to transport HBU UNF as well.

Table 3.2-12
Operating Plant Sites with Transportable Bare Fuel Casks

Plant Site	Cask Model and Capacity	Number of Casks as of June 30, 2012	Licensed for Transportation	Licensed to Transport HBU Assemblies
McGuire	TN-32	10	No	No
North Anna	TN-32	27	No	No
Peach Bottom	TN-68	59	Yes	No
Prairie Island	TN-40/40HT	29*	Yes/No	No
Surry	TN-32	26	No	No

Reference: StoreFUEL and Decommissioning Report. Used by permission from Ux Consulting, www.uxc.com.

3.2.3.3 Origination of UNF and Applicable UNF Date

Table 3.2-13 identifies each of the operating plant sites, their nuclear fuel types, and the potential bare fuel cask design that could transport that fuel. Although the TN-32 cask is currently only licensed to store Westinghouse fuel, it is assumed that it can and will be analyzed and licensed to transport other types of PWR UNF. **Table 3.2-14** identifies the nuclear fuel types being stored at the Morris Wet Storage ISFSI and potential bare fuel cask designs that could transport that fuel. **Table 3.2-15** identifies the nuclear fuel types that will be used at the under construction and potential new nuclear power plants and the potential bare fuel cask designs that could transport that fuel. The fuel type determines whether the fuel can be loaded into a TN bare fuel cask or if it will require a new cask design. The table also provides the plant fuel area crane capacity, which may or may not be adequate to lift a TN bare fuel cask. For plants that cannot accommodate a TN bare fuel cask, there are two new types of bare fuel casks that may need to be developed to support UNF acceptance in Phase 3, assuming that a STAD system is available to be loaded at the CSF:

- Type 1 bare fuel cask—Plants with a cask handling crane capacity less than 125T cannot lift any of the TN bare fuel casks due to their weight. These plants will need to utilize a new lightweight bare fuel cask or upgrade their cask handling cranes for a higher capacity. If the small capacity cask that may be developed to accept UNF directly from SFPs in Phase 2 using smaller capacity DPCs is also designed to accommodate removable PWR and BWR fuel basket inserts, the same small capacity cask could be used in Phase 2 and Phase 3 to accept DPCs and bare fuel, respectively.

- Type 2 bare fuel cask—TN bare fuel casks cannot accommodate CE 16x16, WE 17x17XL or USAPWR 17x17 fuel because their length exceeds existing cask cavity lengths. New-generation plants also use fuel assemblies longer than the cavity length of typical DFSSs and will need to use a new bare fuel cask that has a longer cavity.

If a STAD system is not available for use at the CSF, Phase 3 operations would accommodate acceptance of UNF from plant sites that have loaded UNF into bare fuel storage/transport casks. In addition, acceptance of bare fuel from SFPs from other plant sites could be done using existing bare fuel transport casks, if these bare fuel transport casks are compatible with a plant's cask handling capability and fuel. Alternatively, acceptance of UNF from SFPs from other sites could be accomplished under Phase 2 operations as previously discussed.

Table 3.2-13
Operating Plant Sites, Fuel Information, and Bare Fuel Cask Compatibility

Plant Site		Fuel Information		Bare Fuel Cask Compatibility	
Operating Plant	Fuel Assembly Class	Fuel Width, (in.)	Fuel Length, (in.)	Bare Fuel Cask	Cask Handling Crane Capacity
ANO 1	B&W 15x15	8.54	165.7	TN-32	130T
ANO 2	CE 16x16	8.1	176.8	Type 2	130T
Beaver Valley 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Braidwood 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Browns Ferry 1, 2 & 3	GE BWR/4-6	5.44	176.2	TN-68	125T
Brunswick 1 & 2	GE BWR/4-6	5.44	176.2	TN-68	125T
Byron 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Callaway	WE 17x17	8.44	159.8	TN-32	150T
Calvert Cliffs 1 & 2	CE 14x14	8.1	157	TN-32	150T
Catawba 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Clinton	GE BWR/4-6	5.44	176.2	TN-68	125T
Columbia	GE BWR/4-6	5.44	176.2	TN-68	125T
Comanche Peak 1 & 2	WE 17x17	8.44	159.8	TN-32	130T
Cooper	GE BWR/4-6	5.44	176.2	Type 1	100T
Crystal River 3	B&W 15x15	8.54	165.7	TN-32A	130T
D.C. Cook 1	WE 15x15	8.44	159.8	TN-32	150T
D.C. Cook 2	WE 17x17	8.44	159.8	TN-32	150T
Davis-Besse	B&W 15x15	8.54	165.7	TN-32A	140T

Plant Site		Fuel Information		Bare Fuel Cask Compatibility	
Operating Plant	Fuel Assembly Class	Fuel Width, (in.)	Fuel Length, (in.)	Bare Fuel Cask	Cask Handling Crane Capacity
Diablo Canyon 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Dresden 2 & 3	GE BWR/2,3	5.44	171.2	TN-68	125T
Duane Arnold	GE BWR/4-6	5.44	176.2	Type 1	100T
Farley 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Fermi 2	GE BWR/4-6	5.44	176.2	TN-68	125T
FitzPatrick	GE BWR/4-6	5.44	176.2	TN-68	125T
Fort Calhoun	CE 14x14 short	8.1	146	Type 1	100T
Ginna	WE 14x14	7.76	159.8	TN-40	125T
Grand Gulf 1	GE BWR/4-6	5.44	176.2	TN-68	150T
Hatch 1 & 2	GE BWR/4-6	5.44	176.2	TN-68	125T
HB Robinson 2	B&W 15x15	8.54	165.7	TN-32A	125T
Hope Creek 1	GE BWR/4-6	5.44	176.2	TN-68	130T
Indian Point 2	WE 15x15	8.44	159.8	Type 1	110T
Indian Point 3	WE 15x15	8.44	159.8	Type 1	Uses Indian Point 2 crane
La Salle 1 & 2	GE BWR/4-6	5.44	176.2	TN-68	125T
Limerick 1 & 2	GE BWR/4-6	5.44	176.2	TN-68	125T
McGuire 1 & 2	WE 17x17	8.44	159.8	TN-32	>115T
Millstone 2	CE 14x14	8.1	157	Type 1	110T
Millstone 3	WE 17x17	8.44	159.8	Type 1	110T
Monticello	GE BWR/2,3	5.44	171.2	Type 1	105T
Nine Mile Point 1	GE BWR/2,3	5.44	171.2	TN-68	125T
Nine Mile Point 2	GE BWR/4-6	5.44	176.2	TN-68	125T
North Anna 1 & 2	WE 17x17	8.44	159.8	TN-32	>115T
Oconee 1, 2 & 3	B&W 15x15 B&W 17x17	8.54 8.54	165.7 159.8	Type 1	100T
Palisades	Palisades	8.2	147.5	Type 1	100T
Palo Verde 1, 2 & 3	CE 16x16 Sys 80	8.1	178.3	Type 2	150T
Peach Bottom 2 & 3	GE BWR/4-6	5.44	176.2	TN-68	125T
Perry	GE BWR/4-6	5.44	176.2	TN-68	125T
Pilgrim	GE BWR/2,3	5.44	171.2	Type 1	100T
Point Beach 1 & 2	WE 14x14	7.76	159.8	TN-40	125T
Prairie Island 1 & 2	WE 14x14	7.76	159.8	TN-40	125T

Plant Site		Fuel Information		Bare Fuel Cask Compatibility	
Operating Plant	Fuel Assembly Class	Fuel Width, (in.)	Fuel Length, (in.)	Bare Fuel Cask	Cask Handling Crane Capacity
Quad Cities 1 & 2	GE BWR/2,3	5.44	171.2	TN-68	125T
River Bend	GE BWR/4-6	5.44	176.2	TN-68	125T
Saint Lucie 1 & 2	CE 14x14	8.1	157	TN-32	150T
Salem 1 & 2	WE 17x17	8.44	159.8	Type 1	110T
San Onofre 2 & 3	CE 16x16	8.1	176.8	Type 2	125T
Seabrook	WE 17x17	8.44	159.8	TN-32	125T
Sequoyah 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Shearon Harris	WE 17x17	8.44	159.8	TN-32	150T
South Texas 1 & 2	WE 17x17XL	8.43	199	Type 2	150T
Surry 1 & 2	WE 15x15	8.44	159.8	TN-32	>115T
Susquehanna 1 & 2	GE BWR/4-6	5.44	176.2	TN-68	125T
Three Mile Island 1	B&W 15x15	8.54	165.7	Type 1	110T
Turkey Point 3 & 4	WE 15x15	8.44	159.8	Type 1	105T
VC Summer	WE 17x17	8.44	159.8	TN-32	125T
Vermont Yankee	GE BWR/4-6	5.44	176.2	Type 1	110T
Vogtle 1 & 2	WE 17x17	8.44	159.8	TN-32	125T
Waterford 3	CE 16x16	8.1	176.8	Type 2	125T
Watts Bar 1	WE 17x17	8.44	159.8	TN-32	125T
Wolf Creek	WE 17x17	8.44	159.8	TN-32	150T

References:

1. *SR/CNEAF/96-01, Spent Nuclear Fuel Discharges from U.S. Reactors 1994, U.S. Department of Energy, February 1996.*
2. *Indian Point 3 transfers spent fuel to Indian Point 2 in order to move spent fuel to dry storage.*

Table 3.2-14
Morris Wet Storage, Fuel Information, and Bare Fuel Cask Compatibility

Morris	Fuel Information			Bare Fuel Cask Compatibility	
Originating Plant	Fuel Assembly Class	Fuel Width, (in.)	Fuel Length, (in.)	Bare Fuel Cask	Cask Handling Crane Capacity
Cooper	GE BWR/4-6	5.44	176.2	TN-68	125T
Dresden 2	GE BWR/2,3	5.44	171.2	TN-68	
Haddam Neck	Haddam Neck WE 15x15	8.42	137.1	TN-32	
Monticello	GE BWR/2,3	5.44	171.2	TN-68	
San Onofre 1	San Onofre 1 WE 14x14	7.76	137.1	TN-40	

References:

1. *The Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste, Planning Information Corporation, September, 1996.*
2. *SR/CNEAF/96-01, Spent Nuclear Fuel Discharges from U.S. Reactors 1994, U.S. Department of Energy, February 1996.*

Table 3.2-15
New Plant Sites, Fuel Information, and Bare Fuel Cask Compatibility

New Plant Site		Fuel Information			Bare Fuel Cask Compatibility	
New Plant	NSSS	Fuel Assembly Class	Fuel Width (in.)	Fuel Length (in.)	Bare Fuel Cask	Cask Handling Crane Capacity
Bellefonte 1	B&W	B&W 15x15	8.54	165.7	TN-32A	150T
Comanche Peak 3 & 4	US APWR	17x17	8.44	199	Type 2	165T (150mT)
Fermi 3	ESBWR	Shortened GE14 - 10x10	3.94	120	TN-68	165T (150mT)
Lee 1 & 2	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
Levy County 1 & 2	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
North Anna	US APWR	17x17	8.44	199	Type 2	165T (150mT)
Shearon Harris 2 & 3	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
Turkey Point 6 & 7	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
VC Summer 2 & 3	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
Vogtle 3 & 4	AP1000	17x17 XL Robust Fuel	8.426	199	Type 2	150T
Watts Bar 2	WE PWR	17x17 Vantage 5H	8.44	159.8	TN-32	125T

References:

1. *Table 9.1.5-1, US EPR FSAR.*
2. *Docket No. 50-438 TVA Letter.*
3. *Chapter 9, US-APWR Design Control Document.*
4. *Section 9.1.5.5, ESBWR Design Control Document.*
5. *Table 9.1-5, AP1000 Design Control Document.*
6. *Section 3.8.6.2.1, WBNP Amendment 99 to FSAR.*

Figures 3.2-32 through 3.2-35 illustrate the types of casks that could be used to transport bare UNF.

Figure 3.2-32
TN Series Bolted Cask Diagram

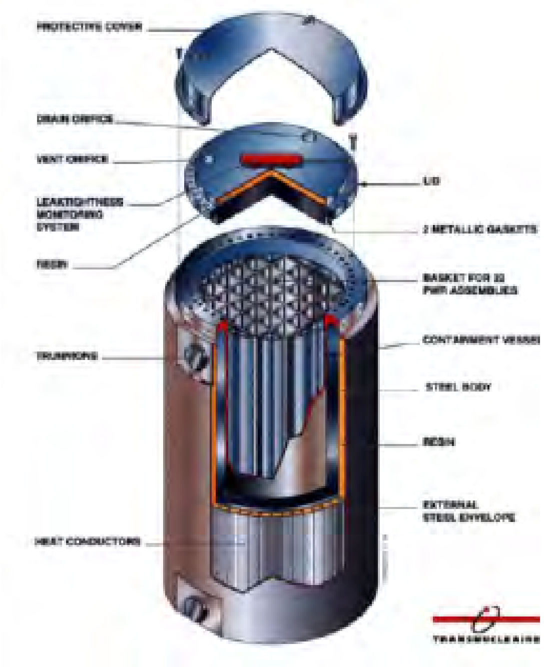

Figure 3.2-33
TN-32 at McGuire

Figure 3.2-34
TN-40 at Prairie Island

Figure 3.2-35
TN-68 at Peach Bottom

3.2.3.4 UNF Retrieval and CSF Design Strategy

The longer that nondisposable commercial types of DPCs are used to store UNF, the more LLRW will be created. For example, if the entire quantity of projected commercial UNF (140,000 MTU) is stored in nondisposable commercial DPCs and is ultimately repackaged into a canister that will be accommodated in a geological repository, then the amount of LLRW generated in used canister steel will approach 300,000 tons[12]. As of 2012, approximately 8 percent of total projected UNF is stored in commercial DPCs. Every year, 100 to 150 additional DPCs are placed into service containing up to 2,000 MTU of UNF. These quantities will continue to rise as more ISFSIs are placed into service and the capacities of DPCs are increased. At that rate, the potential LLRW stream will grow at an average of 1 percent annually. For every year that implementation of a disposable canister design is delayed, another 1,800 to 2,700 tons of DPC steel LLRW is created.

There are three options to eliminate or minimize this growing waste stream:

1. Store UNF in nondisposable DPCs indefinitely.
2. Build a geological repository that can accommodate DPCs.
3. Implement a standardized transportation, storage, and disposal canister program to be used at the plant sites.

The first option is highly unlikely. Although the certifications for these canister-based DFSSs can be theoretically renewed forever, there are questions about the longevity and aging integrity of the canisters, and UNF cladding that are yet to be resolved. A test facility at one of the national laboratories or the CSF may be used to show that the canisters and their contents can remain in service for long durations. However, those tests are yet to be initiated and most likely would conclude that the service life of a DPC is finite.

The second option has been debated for some time. In 2003, a report was prepared for the DOE titled, “The Potential of Using Commercial Dual Purpose Canisters for Direct Disposal”[13]. The report evaluated the potential for direct disposal of licensed commercial DPCs inside waste packages to be placed in the Yucca Mountain repository. The report concluded that there were a number of difficulties that prevented the DPCs from being suitable for direct disposal in waste packages without changes. The difficulties included post-closure criticality due to neutron absorber instability or inability to use burnup credit in the licensing process, physical incompatibility between the DPCs and waste packages, handling issues, and waste package decay heat limits. But the report did conclude that with changes to

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[12] This assumes that 140,000 MTU of UNF are stored in approximately 11,000 canisters, each with an average weight of 24 tons storing 10–13 MTU of UNF.

[13] Bechtel SAIC Company, 2003. *The Potential of Using Commercial Dual Purpose Canisters for Direct Disposal*, LLCTDR-CRW-SE-000030, Revision 00, November.

future DPCs, these issues could be remediated. It should be noted that this 2003 report was written assuming disposal at the Yucca Mountain Project national geological repository. Since a new repository would most likely be sited in different geologies than Yucca Mountain, these conclusions are not necessarily relevant. Disposal capability of current commercial canisters would need to be restudied for any new repository model. A future repository model should consider making disposal of DPCs a design objective, since this option could eliminate altogether the LLRW problem created by repackaging, resulting in cost and radiation dose savings.

The third option would ensure that future generations of DPCs are constructed for very long-term storage of UNF. Such designs could mitigate problems with the current DFSSs by incorporating materials with negligible adverse aging properties, better neutron poisons, and a whole array of UNF and container monitoring capabilities. The development of a STAD canister is one such attempt. If a standardized canister program is implemented, the CSF could begin to receive UNF assemblies in bare fuel casks that are licensed for both storage under 10 CFR Part 72 and transportation under 10 CFR Part 71. The concept is that a bare fuel cask could be dispatched to a nuclear plant, loaded with UNF in the SFP, and shipped back to the CSF where the UNF assemblies would be repackaged into a standardized canister and placed into storage in a storage overpack.

To initiate Phase 3, bare fuel casks will need to be procured and used fuel pools for BWR and PWR UNF assemblies would need to be constructed at the CSF. There are a number of bare fuel casks designed for storage and transport already in service at existing nuclear plants that can be used as a starting point for Phase 3.

Transnuclear has fabricated three bare fuel casks designed for both storage and transportation: (1) the TN-32 for PWR assemblies, (2) the TN-40/40HT for PWR assemblies, and (3) the TN-68 for BWR assemblies. The TN-32 design is in service at the Surry, North Anna, and McGuire ISFSIs (63 total casks). The TN-32 cask is not yet licensed for transportation and no additional TN-32 casks are expected to be placed into service for storage. The TN-40 is used exclusively at the Prairie Island ISFSI. Prairie Island had 29 casks in service as of June 30, 2012 and continues to place fuel into dry storage in TN-40/40HT casks. The TN-40 design is licensed for transportation and the TN-40HT is not yet licensed under 10CFR Part 71. The TN-68 is used exclusively at the Peach Bottom ISFSI. Peach Bottom had 59 casks in service as of June 30, 2012 and continues to place fuel into dry storage in TN-68 casks. The TN-68 design is licensed for transportation.

The TN-series bare fuel cask designs are a single integrated unit consisting of a thick, steel containment vessel; a basket assembly; a neutron shield; a containment lid; trunnions; a pressure monitoring system, and a weather cover. The containment lid is bolted to the vessel so that it can be opened and closed. Double metallic O-ring seals are used to maintain containment. The interspace between the metallic seals is monitored by a pressure monitoring system. Because these TN-series casks are designed for transportation as well as storage, they are ideal for bare fuel shipments to the CSF.

These casks are used at five operating plant sites and could be acquired to build several bare cask train fleets. A smaller bare fuel cask may also need to be designed, licensed, and fabricated to accommodate operating plant sites that do not have high-capacity cranes (i.e., 125 tons or greater), adequate SFP space for larger casks, or that require acceptance of high heat load UNF. As the new generation of nuclear plants comes online, another bare fuel cask may need to be developed to accommodate newer assembly designs. These issues are discussed in detail below. There are a few bare fuel casks in use that are not designed to be transported. A plan of action for those casks is discussed in Section 3.2.4.

Not all of the TN-series casks would be needed for bare fuel transport; many would be placed into storage at the CSF. Processing these casks is less complicated than with the dual purpose canisters since no UNF or canister transfer operations are required. The cask can be offloaded, transported to a storage pad, and placed into storage. Once in storage, a pressure monitoring system must be established to monitor closure O-ring interspace pressure so that a potentially leaking closure seal can be identified promptly.

As discussed in Section 3.2.3.3, not all fuel assembly designs can be transported in the TN casks due to fuel assembly dimensions, both at existing plants and new reactors. It may be necessary to develop a new set of transportable bare fuel casks (Type 1 and Type 2). These casks would be constructed as lightweight casks for low-capacity cask handling cranes or long-cavity casks suited for the next-generation nuclear reactors that use longer fuel assemblies. The lightweight cask would need to be built to handle both BWR and PWR assemblies—possibly the same containment vessel with interchangeable baskets. Such casks may also be needed to accept UNF with high decay heat. If the smaller capacity cask that is developed to accept UNF directly from SFPs in Phase 2 using DPCs is also designed to accommodate removable PWR and BWR fuel basket inserts, the same small capacity cask could be used in Phase 2 and Phase 3 to accept DPCs and bare fuel, respectively, without the need for a new Type 1 cask to be built.

If the reactor site no longer has rail access, the transport cask will need to be loaded onto a HHT trailer or barge, which would be loaded to and from rail transport at an intermodal location. At the intermodal location, a mobile crane or similar lifting device will need to be employed to move the transport cask and impact limiters to and from a railcar.

Upon receipt at the CSF, the personnel barriers and impact limiters would be removed and the bare fuel cask transferred by crane at the CHB to one of the cask pits located adjacent to the UNF pools. At least two cask pits would be located in the CSF with access to a UNF pool. The CSF would need to have two UNF pools: (1) a BWR UNF pool equipped with fuel racks designed for BWR fuel and (2) a PWR UNF pool equipped with fuel racks for PWR fuel. The PWR pool would need to be borated for criticality control. Both pools would have the necessary cooling, filtering, and water makeup systems. These are active systems requiring new levels of facility safety controls such as backup power; radiation shielding; HVAC systems; and associated waste processes, etc.

The CHB cask handling crane would be designed to access the cask pits, but would be designed to ensure that heavy loads are not carried over the pools even though it is single-failure-proof. Each pool would have its own fuel bridge that would traverse the pool and cask pits to safely move fuel assemblies. The pools should be designed to store the number of UNF assemblies to provide lag storage for future UNF loading. A 40 ft by 40 ft BWR pool would have a capacity of about 3400 BWR assemblies and a PWR pool would have a capacity of about 1600 PWR assemblies. This would provide enough lag storage space in each pool to accommodate fluctuations in receiving and loading schedules and to accommodate operational evolutions such as fuel shuffles, sipping, neutron absorber testing and surveillance coupons. The pools could be increased in size (or more pools constructed) so that the CSF could store hundreds of UNF assemblies should a standardized canister design not be available at the time of Phase 3 implementation. The UNF pools could also provide additional capability to blend various fuel assemblies to optimize canister decay heat levels or radiation doses. In addition, the pools allow access to the fuel assemblies so that fuel rods could be pulled and assemblies examined for R&D.

During Phase 3, storage overpacks that house the standardized canisters would be fabricated. The design characteristics of such storage overpacks cannot be determined at this time until they are conceptualized, but the CSF would need to have the capability to fabricate them. Major components could be manufactured off site and shipped to the CSF. But, like current commercial overpacks, some of the fabrication may need to be performed on site to lessen shipping weights or load dimensions.

The Phase 3 strategy can be summarized in the following steps:

1. Develop standardized canister storage systems for use in a geological repository.
    a. STAD canister
    b. Commercially developed standardized canister designs based on a standardized specification from the DOE

2. Retrieve TN bare fuel casks at McGuire, North Anna, Peach Bottom, Prairie Island, and Surry.
    a. Retrieve TN-68s at Peach Bottom for bare fuel retrieval at BWR reactors
    b. Retrieve TN-32s at McGuire, North Anna, and Surry for bare fuel retrieval at PWR reactors
    c. Retrieve TN-40s at Prairie Island for bare fuel retrieval at W14x14 PWR reactors
3. Develop new Type 1 and Type 2 transportable bare fuel casks (and potentially a smaller capacity cask in order to accept UNF with high decay heat) to retrieve UNF that cannot use the TN-68, TN-32 or TN-40 casks.
    a. Type 1 can accommodate plants with low capacity cask handling cranes
    b. Type 2 can accommodate longer fuel assemblies (CE 16x16 and new generation reactor fuel assembles)
4. Retrieve bare fuel.
    a. Retrieve UNF from all operating nuclear plants in the bare fuel casks
    b. Retrieve UNF from the Morris ISFSI
5. Unload bare fuel assemblies into CSF UNF pools.
    a. Use pool for short-term storage for an upcoming standardized canister loading
    b. Use pool for long-term storage until UNF can be loaded into a standardized canister
    c. Use pool to blend various assemblies to achieve optimum decay heat mixes for standardized canister storage and disposal
    d. Use pool to gain access to UNF for R&D purposes
6. Package UNF in pool into new standardized canister systems.
7. Place UNF into interim dry fuel storage at CSF.

3.2.3.5 UNF Retrieval Schedule

This report assumes that bare fuel shipments from the operating plants to the CSF can begin as early as one or more UNF pools have been constructed (approximately the fifth year of CSF operation after most of the currently stranded UNF is placed in storage at the CSF). Retrieval of bare UNF would continue until the final commercial nuclear plant is shut down and the UNF allowed to adequately cool, in approximately 2087.

3.2.3.6 Consolidated Storage Facility

CSF Requirements

In Phase 3, the CSF will need to receive, handle, and place in pool pits bare fuel casks; unload bare fuel and place it in the pool; load UNF in standardized canister systems; weld or bolt, drain, dry, and inert the canisters; load the canisters into storage overpacks; and transport the storage units to a storage pad at the storage area for interim storage. Construction Stage 3 will need to add pools, canister handling and closure ancillary equipment, a storage overpack fabrication area, and associated support systems. Phase 3 would also initiate the presence of hot cells for R&D of UNF and its conveyance containers.

From the previous phases, the site contains rail yards to receive incoming train consists and prepare for outgoing train consists; a CHB that can offload bare fuel casks and access the UNF pool pits; a storage area with concrete storage pads to support the storage overpacks; an office building; a CMF; a FMF; a security building; and various fenced areas to provide radiation and security protection.

Table 3.2-16 provides the critical dimensions and weights of the transportable bare fuel casks that would be required for bare fuel shipment service.

Table 3.2-16
Transportable Bare Fuel Cask Dimensions and Weights

Cask Model	Cask Data			
	Capacity (assemblies)	Height (in.)	Diameter (in.)	Weight Loaded (lbs.)
TN-32	32	201.9	97.8	231,200
TN-32A	32	201.9	97.8	231,200
TN-40	40	202.0	99.5	240,000
TN-40TH	40	199.6	101.0	242,400
TN-68	68	215.0	98.0	230,000

Reference: Characteristics of Spent Fuel Storage Casks
http://www.nrc.gov/, pbadupws.nrc.gov/docs/ML1025/ML102580285.pdf, as of 09/26/2010.

These are the dimensions and weights that the storage pads, CHB, and handling equipment must be designed to accommodate.

CSF Site Layout

The site layout showing a CSF that could store all of the UNF in standardized storage canisters is shown in **Figure 3.2-36** and **Figure 3.2-37**. Since it is unknown whether a standardized system would utilize a horizontal module, vertical storage overpack, both, or neither, the system will simply be referred to as a storage unit. For the purposes of this report, it will be assumed that the standardized system is similar to the transport, aging, and disposal (TAD) canister planned for use at the yucca Mountain repository which has a capacity of 21 PWR assemblies or 44 BWR assembles. In Phase 3, the RA and PA would be expanded over time (like in Phase 2) to encompass the growing number of storage pads supporting the storage units. The OCA would remain unchanged.

Radiation Area

The RA, designated to limit personnel movements in the vicinity of the standardized storage units that house the UNF, would need to grow as new systems are placed on the storage pads. The storage of additional UNF will result in additional radiation levels in the RA. The radiation to an individual in the RA will not significantly change due to the fact that the storage units will be spread out over a large area. However, a substantial increase in storage units will result in an overall increase in direct radiation and sky-shine seen at the CSF yard and buildings, and around the CSF OCA. A new generation of standardized DFSSs could require additional shielding that would substantially reduce the radiation levels. In any event, analysis of the off- and on-site radiation dose will need to be performed to determine the occupational doses remain within 10 CFR Part 20 limits and that any individual from the public outside of the OCA will not experience an annual radiation dose of more than 25 mrem in accordance with 10 CFR 72.104.

Protected Area

The PA would also need to be increased in area to encompass the larger RA to prevent unauthorized persons from entering the CSF where UNF is handled and stored. Construction techniques will need to be employed to accommodate construction of new storage pads with minimal security interference, yet allow the PA to expand around new storage pads before they can be used as in Phase 2.

Owner Controlled Area

The previously assumed OCA of 1 square mile will not change for Phase 3. However, the new storage pads will need to be constructed so that they maintain a minimum distance of 100 meters (328 ft) from the OCA in accordance with 10 CFR 72.106.

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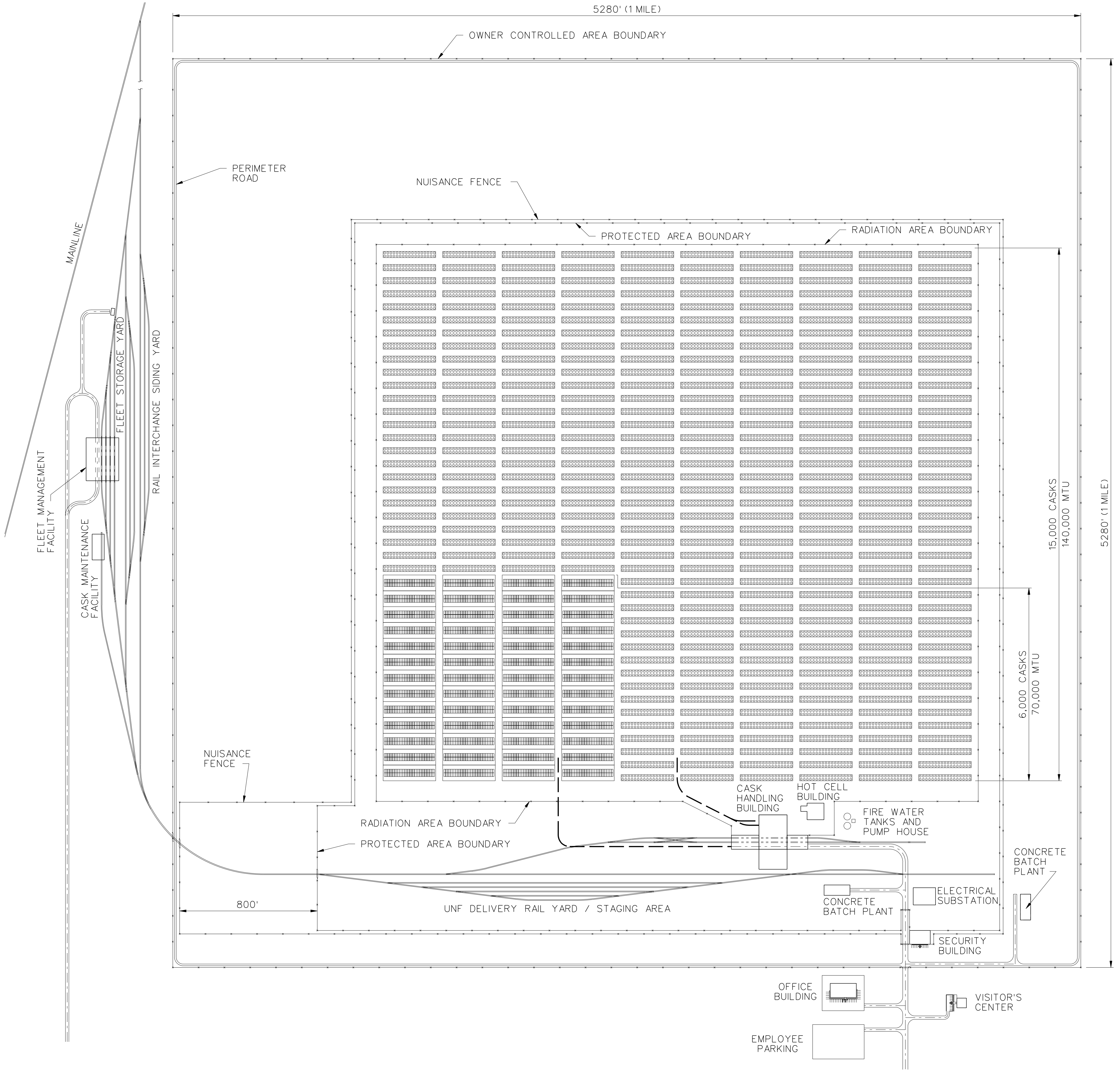

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CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 3.2-36, STAGE 3 OVERALL CSF SITE LAYOUT

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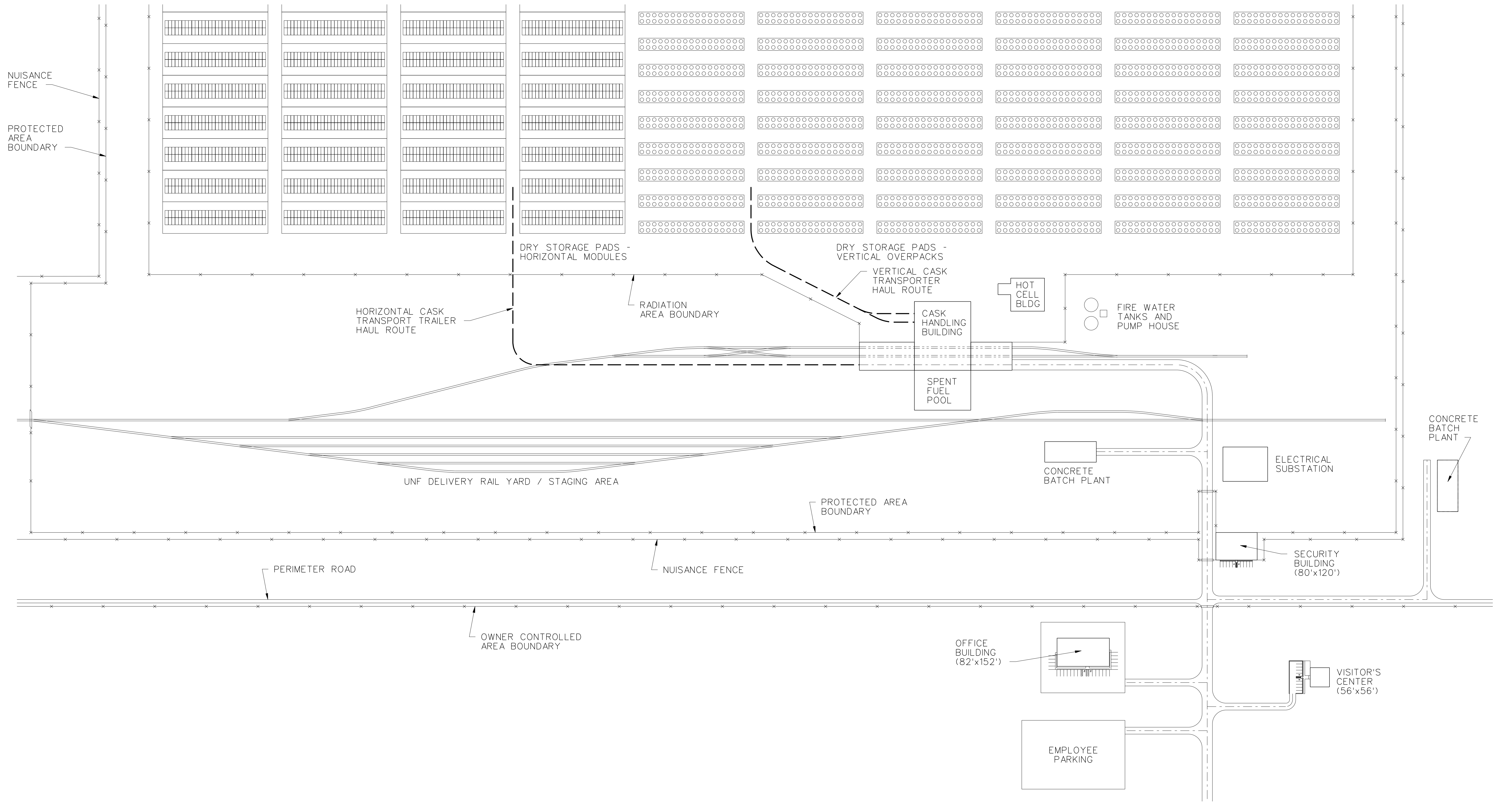

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CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 3.2-37, STAGE 3 CSF SITE FEATURES

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CSF Principle Features and Descriptions

The principle features of the CSF required for Phase 3 include the same features in Phase 1 and 2 (storage pads, rail yards, a CHB, a security building, a maintenance building, an office building, and associated utilities and structures) and the addition of a building that can house the UNF pools and the hot cell research facility.

Storage Pads

The Phase 3 CSF may continue to use reinforced concrete storage pads like those used in Phases 1 and 2 if the standardized canisters are similar to the current commercial DFSSs. It is not known at this time what a standardized canister will look like. Based on recent DOE presentations, the standardized canister could be constructed to house a single assembly, 4 PWR/9 BWR assemblies, 21 PWR/44 BWR assemblies, or more assemblies like the commercial designs. The concrete pad design used in Phases 1 and 2 could be used for any size DFSS unit, or a new pad design could be developed. However, as the capacity of the DFSS is reduced, more DFSSs will need to be employed. Smaller DFSSs would take up less space, but not enough to offset the increased number of DFSSs. Each DFSS design has to contain enough shielding to keep radiation doses ALARA. For example, one of the illustrations in Phase 2 shows a CSF with approximately 4,000 DFSS units housing approximately 200,000 fuel assemblies. Storing 200,000 single assembly DFSSs would likely require a totally different type of storage layout. In addition, a new standardized DFSS design could require a new concept for the transporter, ancillary equipment, etc.

Figure 3.2-36 shows a layout using TAD-sized storage units. It is assumed that it will take some time to transition to a standardized storage unit so the first 70,000 MTU is shown stored in approximately 6,000 existing commercial DFSSs. If the remainder of the total UNF (140,000 – 70,000 = 70,000 MTU) is stored in TAD-sized storage units, it would take an additional 9,000 TAD storage units for a total of 15,000 DFSSs overall.

Concrete Batch Plant

The type of standardized canister that is developed will determine if the concrete batch plant would be used. The batch plants shown in Phase 2 should continue to be adequate.

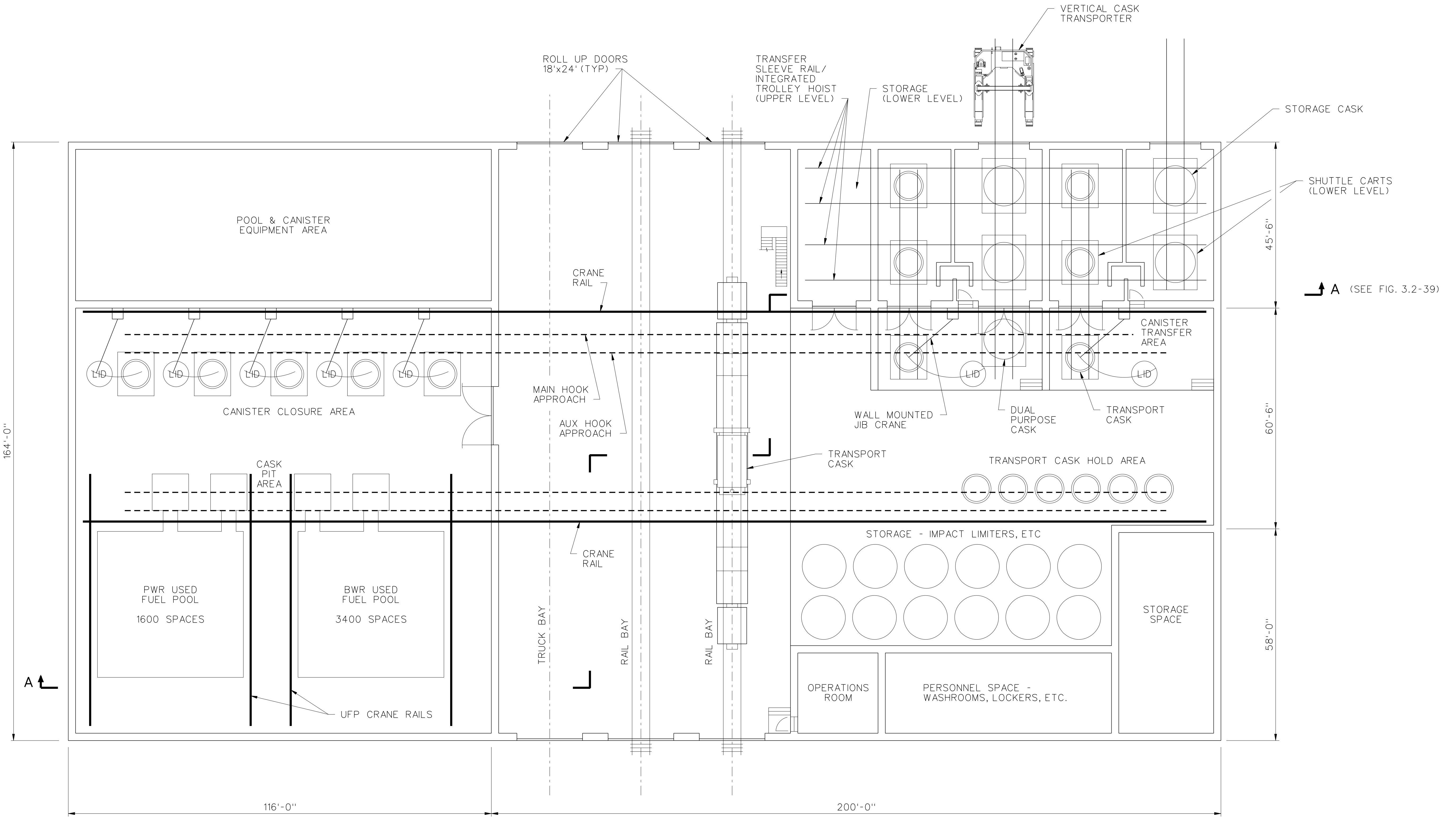
Rail Yard

In Phase 3, the rail yard will be the same as the rail yard for Phase 2, except if any addition track needs to be routed to the hot cell R&D facility.

Cask Handling Building

Phase 3 requires the addition of BWR and PWR UNF pools. The CHB constructed for Phase 1 could be built with the pool structure inside the CHB, completing them later in Phase 3 with the supporting systems in service. A CHB with two integral UNF pools is shown in

Figure 3.2-38 and **Figure 3.2-39**. The Phase 1 CHB will not be constructed with UNF pools; however, it will be constructed with a deep foundation concrete wall so that when the pools, which are in excess of 40 feet deep, are added to the facility, they will not undermine the CHB foundation. The deep foundation wall will allow adjacent excavation in construction without interruption of the CHB activities.



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CASK HANDLING BUILDING LAYOUT

FIGURE 3.2-38, STAGE 3 CASK HANDLING BUILDING

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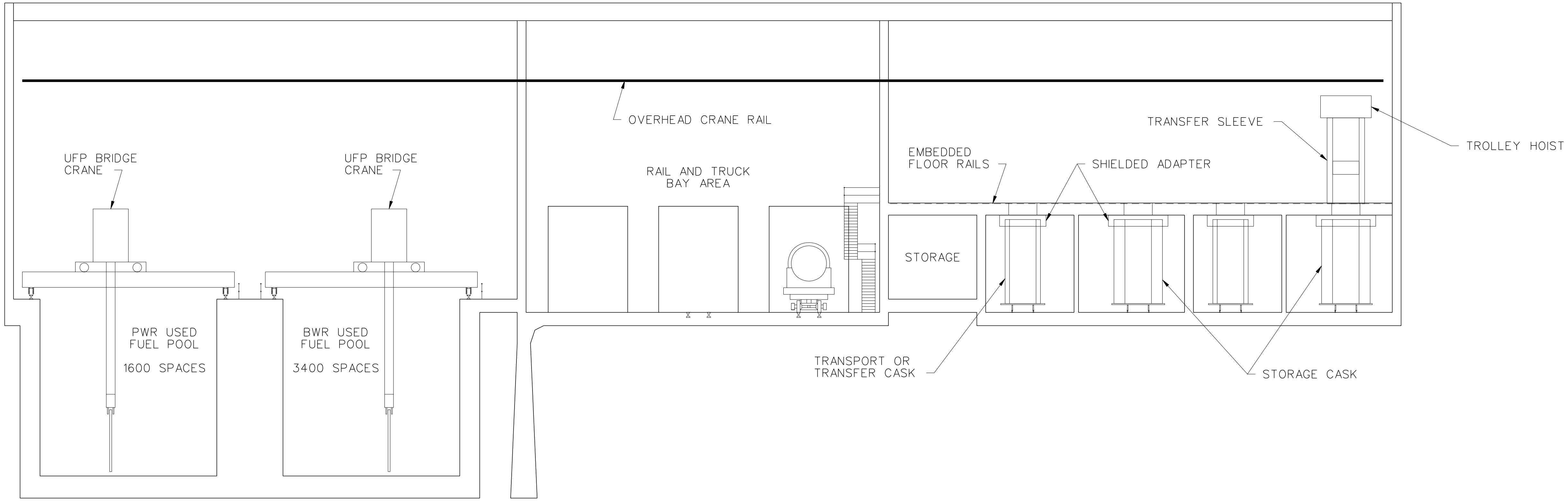

SECTION A-A

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CASK HANDLING BUILDING LAYOUT

FIGURE 3.2-39, STAGE 3 ELEVATION CASK HANDLING BUILDING

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The UNF pool area would consist of 2 UNF pools; 4 pool pits; 2 fuel handling bridges (one for each pool); an area for pool cooling, filtering, and chemical input; and associated equipment. A 3D model view of the CHB rail bay is shown in **Figure 3.2-40**. An artist's view of a UNF pool is shown in **Figure 3.2-41.**

Figure 3.2-40
3D Model View of the CHB Rail Bay

Figure 3.2-41
3D Model View of a CHB UNF Pools

Hot Cell Research Facility

The hot cell and research and development (R&D) facility would be constructed as part of Construction Stage 3 to enable on-site testing of UNF and UNF storage or transport containers. The Hot Cell Facility would consist of a large cask cell capable of receiving and housing UNF casks or canisters so that the UNF assemblies or rods could be removed for testing. The walls of the facility would be constructed to shield workers from high radiation doses of the UNF. The Hot Cell Facility would also include four smaller laboratory hot cells for on-site testing of UNF. A layout of the hot cell facility is shown on **Figure 3.2-42**.

Security Building

No changes to the security building are anticipated in Phase 3.

Fleet Management Site

Routine maintenance on transport casks, rolling stock, and truck cask trailers would continue to be performed at the CMF and FMF as in Phase 3. The railcar fleet will expand as it did for Phase 2, but the yard is designed to handle the larger fleet.

Office Building

The Office Building, located just outside the SA, would continue to service the CSF and is not expected to need modifications for Phase 3.

Visitors Center

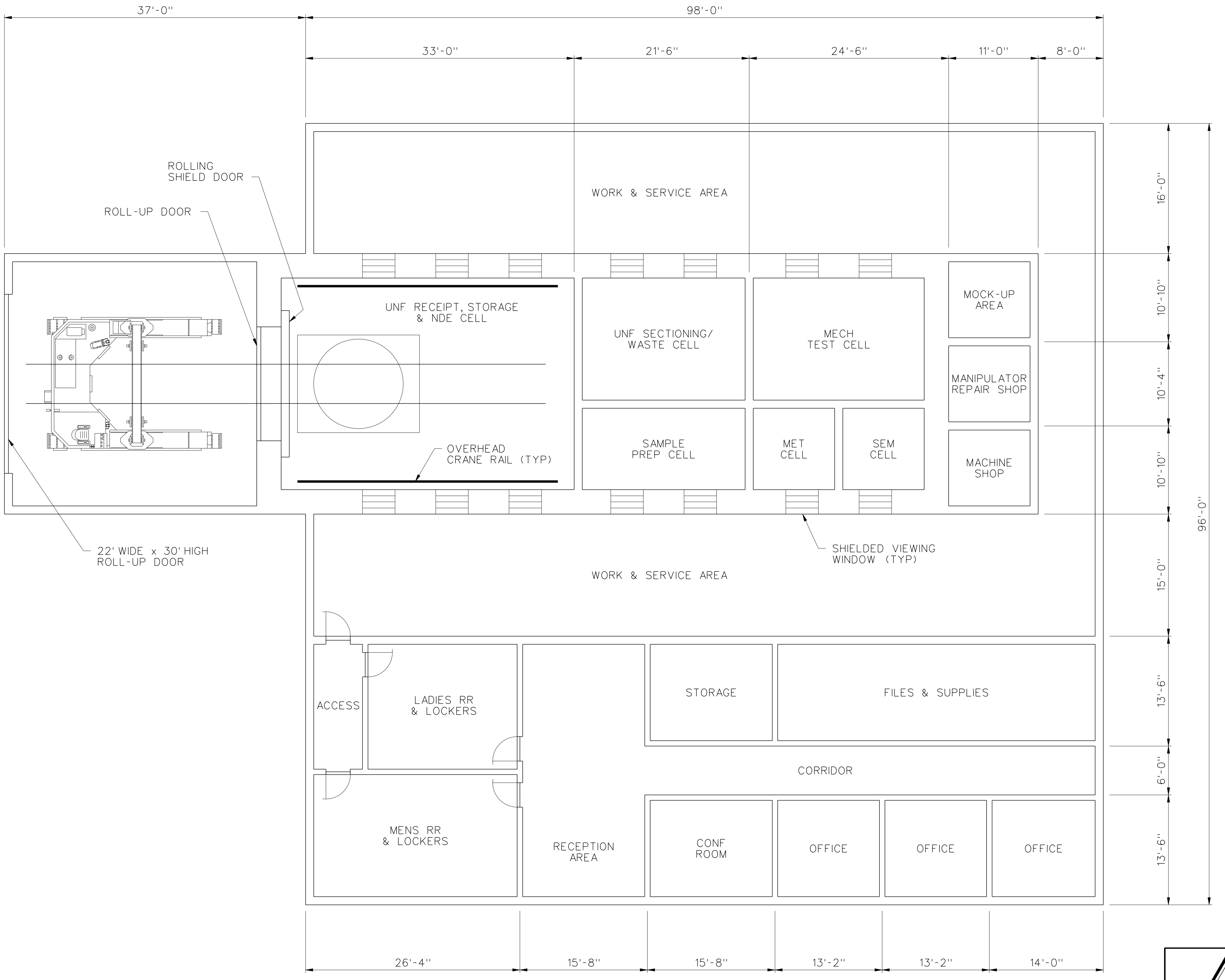
The Visitors Center would remain unchanged in Phase 3 except that displays inside the center would be developed to show pool storage and R&D work at the CSF.

3.2.3.7 Operation Description

The following sections describe the operating steps for receiving transportable bare fuel casks, placement in the UNF pool pit, UNF pool storage and fuel assembly handling, and standardized canister loading, closure and storage operations. A separate table shows the operating steps for receiving bare fuel casks and their placement into storage and pressure-monitoring surveillance.

Operating Plant Site Shipment Requirements

Operating plants that use bolted bare fuel casks would need to develop procedures that outline the process for removing them from the ISFSI and placing them on a railcar for shipment to the CSF. If the plant no longer has railroad access, then additional procedures would need to be prepared to load the casks at a new on-site cask loading station for barge or truck service to a nearby intermodal transfer station. Once at the intermodal transfer station, the cask can be loaded on to a railcar.



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HOT CELL BUILDING LAYOUT

FIGURE 3.2-42, STAGE 3 HOT CELL BUILDING LAYOUT

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CSF Processing of Bare Fuel Casks

Transportable bolted bare fuel casks arriving at the CSF would be received and processed in accordance with the applicable 10 CFR Part 71 CoC, just as casks containing canisters were in Phases 1 and 2. The personnel barrier and impact limiters would be removed and the cask moved to the UNF pool pit for fuel assembly unloading operations, or transported to a storage pad. The CHB or UNF pool building would be equipped with a crane capable of lifting, up-righting, and placing the cask in a vertical position in the pool pit or at the canister transfer area for pick-up by a cask transporter. **Table 3.2-17** outlines the steps for cask receipt, placement in the pool, and removal of fuel assemblies. **Table 3.2-18** outlines the steps for cask receipt, transport to the storage area, placement on a storage pad, and pressure monitor hookup. **Table 3.2-19** shows the operation steps to load bare fuel from the UNF pool to a canister and place the canister into storage.

Table 3.2-17
Operation Steps to Receive and Unload a Bare Fuel Cask in the UNF Pool

Operation Steps	Number of People	Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr) 10 years cooled	Dose (man-mrem) 10 years cooled	Dose (man-mrem) 20 years cooled
1. Move the loaded railcar to the cleaning awning, measure dose rates, and perform receipt inspection.	2 Ops 1 HP	0.5	0	0	0.0	0.0
2. Wash the cask to remove road dirt.	2 Ops	0.5	0	0	0.0	0.0
3. Move railcar into CHB.	3 Ops	0.5	0	0	0.0	0.0
4. Prepare the railcar for cask removal.	2 Ops	1.15	1.15	5.0	11.5	5.5
5. Place the cask into the pool pit.	2 Ops 1 HP	2.0	2.0	5.0	20.0 0.0	9.5
6. Process and open the cask.	2 Ops 1 HP	6.0	6.0	20	240.0 0.0	114.2
7. Unload the fuel to the pool racks.	2 Ops 1 HP	5.0	5.0	5.0	50.0 0.0	23.8
8. Remove the empty cask from the pool, drain, and prepare for the next shipment.	2 Ops 1 HP	2.25	2.25	5.0	22.5	10.7

Source: Prairie Island ISFSI FSAR for TN-40.

Evolution time: 17.9 hours.

Total dose per single operation for 10 years cooled: 344.0 person-mrem.

Total dose per single operation for 20 years cooled: 163.7 person-mrem.

Table 3.2-18
Operation Steps to Receive and Place a Bare Fuel Cask in Storage

Operation Steps	Number of People	Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr) 10 years cooled	Dose (man-mrem) 10 years cooled	Dose (man-mrem) 20 years cooled
1. Move the loaded railcar to the cleaning awning, measure dose rates, and perform receipt inspection.	2 Ops 1 HP	0.5	0	0	0.0	0.0
2. Wash the cask to remove road dirt.	2 Ops	0.5	0	0	0.0	0.0
3. Move railcar into CHB.	3 Ops	0.5	0	0	0.0	0.0
4. Prepare the railcar for cask removal.	2 Ops	1.15	1.15	5.0	11.5	5.5
5. Transfer transport cask to a shuttle cart using CHB crane.	3 Ops	0.5	0.5	4.7	7.1	3.4
6. Move shuttle cart outside CHB.	1 Ops	0.17	0.17	3.9	0.7	0.3
7. Transfer cask from shuttle cart to VCT.	2 Ops	0.48	0.48	3.9	3.7	1.8
8. Move VCT out to cask pad.	1 Ops	0.67	0.67	23.2	15.5	7.4
9. Place storage overpack on pad.	1 Ops	0.55	0.55	40.9	22.5	10.7

Source: Prairie Island ISFSI for TN-40.

Evolution time: 5.02 hours.

Total dose per single operation for 10 year cooled: 61.0 person-mrem.

Total dose per single operation for 20 year cooled: 29.0 person-mrem.

Table 3.2-19
Operation Steps to Load Bare Fuel from the UNF Pool to a Canister and Place in Storage

Operation Steps	Number of People	Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr) 10 years cooled	Dose (man-mrem) 10 years cooled	Dose (man-mrem) 20 years cooled
1. Prepare the empty storage canister.	2 Ops	9.0	9.0	0	0.0	0.0
2. Place the transfer cask with the storage canister in the pool pit.	5 Ops 1 HP	0.5	0.5	5.0	12.5 0.0	5.9 0.0
3. Load the fuel into the canister.	2 Ops 1 HP	5.0	5.0	5.0	75.0 0.0	23.8 0.0
4. Place the lid on the cask.	2 Ops	1.0	1.0	5.0	10.0	4.8
5. Remove the cask from the fuel	3 Ops	1.0	1.0	2.0	6.0	2.9

Operation Steps	Number of People	Duration (hours)	Time in Dose Area (hours)	Area Dose Rate (mr/hr) 10 years cooled	Dose (man-mrem) 10 years cooled	Dose (man-mrem) 20 years cooled
pool and place in the decon area.	1 HP				0.0	0.0
6. Drain the water from the cask.	1 Ops	.083	.083	250	21.0	10.0
7. Set up the welding machine.	1 Ops	0.25	0.25	204	51.0	24.3
8. Weld the inner top cover to the DSC Shell and Perform NDE	2 Ops	6	6	2	24.0	11.4
9. Drain the cask/DSC annulus and the DSC cavity	1 Ops	0.25	0.25	112	28.0	13.3
10. Vacuum dry the canister and backfill with helium.	1 Ops 1 HP	0.78	0.78	42	32.8 0.0	15.6
11. Prepare the cask for transfer.	1 Ops 1 HP	2.25	1.0	112	112.0 0.0	60.0
12. Perform NDE	2 Ops	14	14	2	56.0	25.7
13. Install the transfer cask lid	2 Ops	1	1	9	18.0	8.6
14. Transfer the canister to a storage module (horizontal system).	2 Ops 1 HP	10	2	30	60.0 0.0	28.6

Source: Transnucelar FSAR for NUHOMS 32P.

Evolution time: 51.113 hours.

Total dose per single operation for 10 years cooled: 506.3 person-mrem.

Total dose per single operation for 20 years cooled: 234.9 person-mrem.

Surveillance

All incoming bare fuel casks and cask railcars would require an inspection and swipe samples upon arrival at the CSF to determine if there was any radioactive contamination. In the event that contamination above acceptance levels was discovered, the transport cask or railcar would need to be decontaminated.

Bare fuel casks use a bolted lid, which requires surveillance to ensure the lid remains sealed. The seal is provided by metallic double O-rings placed between the containment vessel and the lid. Pressure is applied between the O-rings at a higher pressure than the cask internal pressure. Any decrease in the pressure may indicate one of the seals is failing. If an O-ring is leaking, the cask must be returned to the UNF pool where its lid can be removed, the double O-ring replaced, and the lid re-bolted. After the cask has been drained of water and re-inerted, it can be transported back to the storage pad and placed back into storage.

As the storage area increases, additional direct radiation monitors and TLDs will need to be added to ensure safe working conditions for on-site personnel and the general public outside the CSF property due to the significant increase in DFSSs.

Maintenance

The maintenance activities on the bare fuel casks used for transport casks would be minimal with routine inspections to ensure surfaces, such as painted and machined surfaces (especially at the double O-ring sealing location), are not damaged.

Maintenance on the standardized canister storage overpacks and HSMs would be similar to maintenance on existing canister-type storage overpacks. The overpacks and HSMs would receive routine inspections to ensure the concrete (if constructed of such) is not chipped or damaged from environmental conditions.

Maintenance of equipment and structures throughout the CSF will continue (and possibly increase due to the increased process load), including the CHB overhead bridge crane, canister transfer equipment, cask transport vehicles, heavy-haul tow vehicles, backup diesel-powered generators, temperature monitoring equipment, pressure monitoring systems, and fire protection equipment, etc. The maintenance would need to be performed in accordance with manufacturer’s standards.

3.2.4 Phase 4—Non-Transportable Canisters and Bolted Casks

3.2.4.1 Phase 4 Overview

When dry fuel storage was first introduced, there were no DFSSs developed that were designed and licensed for both storage and transportation. A few nuclear plants needed to remove inventory from their SFPs in order to continue operating until the DOE began waste acceptance of UNF. These plants had to use DFSS designs that were available at the time. Some of these DFSSs were bolted metal cask designs and others were canister-based systems. Most of these non-transportable DFSSs are no longer manufactured in the U.S., which has resulted in a limited number of non-transportable DFSSs applicable to this phase.

As of mid-2012, there were 29 non-transportable bolted bare fuel casks (all at Surry Power Station) and 288 non-transportable canisters in storage, representing about 17 percent of the current dry cask storage inventory. The overall impact to the CSF in terms of required storage space for 317 storage units is small, so there would be few changes to the CSF for Phase 4.

The purpose of Phase 4 is to retrieve UNF that is currently stored in non-transportable bare fuel casks or non-transportable canisters. Although the addition of these DFSSs has a small impact on the overall size of the CSF, retrieval of these DFSSs or the UNF inside them will be one of the most challenging objectives of the CSF.

There are two basic options available to retrieve UNF stored in non-transportable DFSSs: (1) license the non-transportable canister for shipment in a certified transport cask to the CSF or

(2) re-package the UNF into a transportable system at the originating nuclear plant site. If a one-time exemption is obtained, then the CSF would need to be equipped to receive, process, and place into storage these types of systems. If the UNF is re-packaged into a transportable system, the effort to receive, process, and place the UNF from these systems into storage at the CSF would be the same as the work in Phase 2 or Phase 3.

In the case of non-transportable bare fuel casks, it is highly unlikely they could be licensed for transportation. Thus the option that would be the most efficient for removal of UNF is to repackage the UNF in the 29 bare fuel casks at Surry into DPCs. For bolted bare fuel casks, repackaging UNF into a transportable system (either a DPC or a bare fuel transport cask) would be feasible since the cask can be easily opened so that the UNF can be placed back in the SFP.

In the case of non-transportable canisters, the UNF inside the canisters will need to be re-packaged at either the plant site or at the CSF. The option that would be the most economical for removal of UNF is to develop and implement a strategy to obtain NRC approval to ship the canisters to the CSF inside Part 71 certified transport casks. Repackaging the UNF in the canisters at the plant sites would be much more costly than doing so at the CSF because the CSF would be designed to facilitate canister cutting operations. Once at the CSF, the UNF could be stored in the non-transportable canisters until a STAD or other disposable canister is available. At that time the non-transportable canisters could be cut open to remove the UNF where it could be placed into the UNF pool and then transferred to a STAD or other disposable canister. Repackaging of UNF at either location would require that the non-transportable system components be disposed of following removal of the UNF. However, transferring UNF from the non-transportable canister to a transportable one would also incur costs in equipment procurement and possible plant modifications if the plant is not currently configured for loading transportable systems. Transferring UNF assemblies from one system to another system would also be a distraction and burden to nuclear plant site operations and would cause additional radiation exposure and risk.

3.2.4.2 Non-Transportable Casks and Canisters at Operating Plant Sites

Table 3.2-20 shows nine operating plant sites that currently utilize storage systems that were not designed for transportation. The table is arranged by plant shutdown date to show an approximate timeframe when a plant will need more attention so that their UNF can be totally removed and the plant site fully decommissioned.

Table 3.2-20
Operating Plant Sites Using Non-Transportable Bare Fuel Casks or Canisters

Plant/Reactor	Initial Reactor Operation (Grid Connection)	Initial ISFSI Operation	Planned Reactor Shutdown*
ANO 1 & 2	1974, 1978	1996	2034, 2038
Calvert Cliffs 1 & 2	1975, 1976	1992	2034, 2036
Davis-Besse	1977	1995	2037
H.B. Robinson	1970	1986	2030
Oconee 1, 2, & 3	1973, 1973, 1974	1990	2033, 2033, 2034
Palisades	1971	1993	2031
Point Beach 1 & 2	1970, 1972	1995	2030, 2033
Surry 1 & 2	1972, 1973	1986	2032, 2033
Susquehanna 1 & 2	1982, 1984	1999	2042, 2044

References:

1. *Initial Plant Operation and Shutdown Dates: http://www.eia.gov/nuclear/reactors/stats_table3.html.*
2. *ISFSI Operation Dates: Gutherman Technical Services, LLC.*

** Assumes 20-year license renewal for all operating reactors. Operating license renewal has not yet been approved for all reactors.*

3.2.4.3 Origination of UNF and Applicable Storage Systems

Table 3.2-21 identifies the non-transportable bare fuel cask designs used at the Surry Power Station and the number of assemblies and estimated UNF MTU as of June 30, 2012 that will ultimately need to be retrieved and placed in storage at the CSF.

Table 3.2-21
Surry Power Station Non-Transportable Bare Fuel Casks and Current Quantities for UNF Storage

Plant/Reactor	Cask Model	Number of Casks as of June 30, 2012	Number of UNF Assemblies	Est. of Total UNF (MTU)
Surry 1 & 2	Castor V/21 & X/33	26	558	257
	NAC I28	2	56	26
	Westinghouse MC-10	1	24	11
Total		29	638	294

Reference: StoreFUEL and Decommissioning Report, used by permission from Ux Consulting, www.uxc.com.

Table 3.2-22 identifies the operating plant sites that use non-transportable canisters, the model and numbers of dry storage system units located at their on-site ISFSIs, and the number of assemblies and estimated UNF MTU as of June 30, 2012 that will ultimately need to be retrieved and placed in storage at the CSF.

Table 3.2-22
Operating Plant Sites Using Non-Transportable Canisters and Current Quantities for UNF Storage

Plant/Reactor	DFSS/Canister Model	Number of Canisters (2012)	Est. Number of UNF Assemblies	Est. of Total UNF MTU
ANO 1 & 2	Fuel Solutions VSC-24	24	576	268
Calvert Cliffs 1 & 2	NUHOMS 24P	48	1152	510
	NUHOMS 32P	21	672	298
Davis–Besse	NUHOMS 24P	3	72	35
Oconee 1, 2, & 3	NUHOMS 24P/24PHB	123	2952	1426
Palisades	Fuel Solutions VSC-24	18	432	180
Point Beach 1 & 2	Fuel Solutions VSC-24	16	384	154
H. B. Robinson	NUHOMS 7P	8	56	26
Susquehanna 1 & 2	NUHOMS 52B	27	1404	250
Total		288	7700	3147

Reference: StoreFUEL and Decommissioning Report, used by permission from Ux Consulting, www.uxc.com, with some variations reflecting industry correspondence.

The MTU from these systems (294 MTU and 3147 MTU) represents 2.2 percent of the total 140,000 MTU that will ultimately need to be retrieved from all the plants.

Figure 3.2-43 is a photo of the Surry ISFSI showing the CASTOR V/21 and X33, NAC-I28, and Westinghouse MC-10 casks in the foreground. TN-32 casks are shown in the background.

Figure 3.2-43
Castor V/21 and X/33, NAC-I28, and Westinghouse MC-10 at Surry

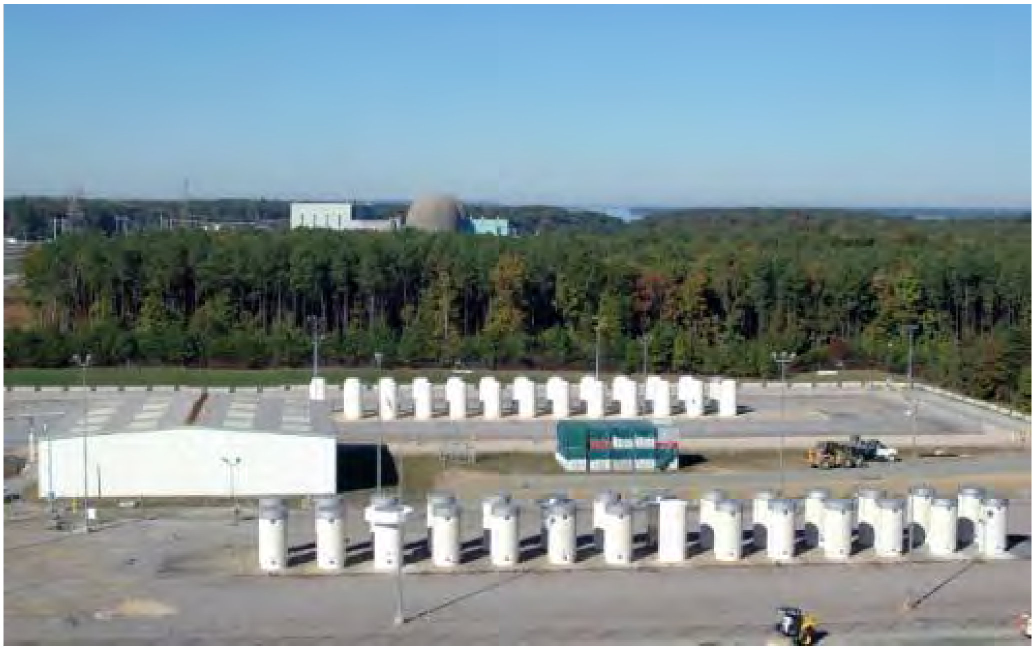

Figure 3.2-44 shows a close-up photo of the CASTOR V/21 Casks. Surry currently loads the DPC-based NUHOMS HD System.

Figure 3.2-44
Castor V/21 Bolted Bare Fuel Casks

Figure 3.2-45 shows the NUHOMS horizontal modules housing the 24P and 32P canisters at the Calvert Cliffs ISFSI. The horizontal storage modules for the NUHOMS 7P, 24P, 32P, and 52B are similar. **Figure 3.2-46** shows the Fuel Solutions Ventilated Storage Cask (VSC)-24 DFSS at the Palisades ISFSI, which is the same DFSS used at the ANO and Point Beach ISFSIs. Oconee and Calvert Cliffs continue to load non-transportable NUHOMS canisters. The remaining sites have ceased loading non-transportable canisters and currently load only DPCs.

Figure 3.2-45
NUHOMS 24P and 32P Non-Transportable Canister Horizontal Storage Modules at Calvert Cliffs

Figure 3.2-46
VSC-24 Non-Transportable Canister DFSS at Palisades

3.2.4.4 UNF Retrieval and CSF Design Strategy

The UNF in Phase 4 is currently stored into two types of storage containers. The first type of container is a non-transportable bolted bare fuel cask. The various casks, listed in **Table 3.2-21**, are the CASTOR V/21 and X/33, NAC-I28, and Westinghouse MC-10.

The CASTOR V/21, designed and manufactured by General Nuclear Systems, Inc. (GNSI), is a metal bare fuel cask with a bolted lid designed to store up to 21 PWR UNF assemblies. The CASTOR X/33, also manufactured by GNSI, is a metal bare fuel cask that is very similar to the V/21 but is able to store up to 33 PWR UNF assemblies. These casks use two stainless steel lids bolted onto the cask body and sealed with both metallic and elastomeric O-rings. The fuel basket is comprised of square tubes constructed of welded stainless steel with borated stainless steel plates for criticality control. The cask body is made of ductile cast-iron. CASTOR casks are licensed for transport in Europe, but never gained NRC certification in the U.S., and there are no plans to seek domestic transport certification.

The NAC-I28 cask, designed and manufactured by NAC International, is a metal bare fuel cask with a bolted lid designed to store up to 28 PWR assemblies. The cask uses a stainless steel lid bolted onto the cask body and sealed with two metallic O-rings seals. The fuel basket uses 28 aluminum fuel tubes that are separated and supported by an aluminum and stainless steel grid of spacers and tie bars, with borated neutron poison material for criticality control.

The MC-10, designed and manufactured by Westinghouse, is a metal bare fuel cask designed to store up to 24 PWR UNF assemblies. The cask uses four lids. The first two lids are metal and are bolted to the cask body and sealed with metallic O-rings. The third lid provides neutron shielding and the fourth lid is welded over the sealing area of the first two lids to provide sealing redundancy. Each of the 24 removable cell storage locations consists of a stainless steel enclosure, borated neutron poison plates for criticality control, and steel wrappers.

All of the bare fuel casks have four trunnions (two on the top and two on the bottom) to aid in cask lifting and handling operations. All four of these bare fuel casks were originally approved for use at the Surry ISFSI and are not used at any other ISFSI location.

The second type of container is a non-transportable canister-based system. Canister-based systems utilize a thin-walled cylindrical metal shell and an internal fuel basket. The canister is placed inside a ventilated concrete storage overpack that provides for decay heat removal, structural support for the canister, as well as radiation shielding. Depending on the number and enrichment level of UNF assemblies, neutron absorbers are sometimes required in transport package fuel baskets to demonstrate that the package contents remain subcritical under all conditions required to be analyzed by 10 CFR Part 71. Even with neutron absorbers, subcriticality may be demonstrated by taking credit for the negative reactivity created by UNF burnup. That is, credit can be taken in the criticality analysis for the reduction in the fissile content of the UNF and the presence of neutron absorbing fission products (referred to as burnup credit). Alternatively, the NRC regulations and guidance allow, for specific package designs and circumstances, demonstrating that water intrusion into the package is not credible (referred to as moderator exclusion).

The VSC-24 was manufactured by Sierra Nuclear Corp., now owned by Energy Solutions. The canister stores up to 24 PWR UNF assemblies. The VSC-24 system consists of a carbon steel canister, basket, and vertical ventilated concrete storage overpack. The canister lid is a thick shield plug and steel cover plates that are welded to the canister body.

The NUHOMS 7P system was manufactured by VECTRA Technologies, Inc. which is now owned by Transnuclear. The canister is designed to store up to seven UNF assemblies. The principal components of the NUHOMS 7P system are a stainless steel canister, basket, and concrete horizontal storage module. The canister lid is made up of a stainless steel plate and shield plug assembly filled with lead that is welded to the top of the canister body with double seal welds. The basket is made of seven guide sleeves consisting of stainless steel Boral cladding.

The NUHOMS 24P/52B was also manufactured by VECTRA Technologies, Inc., and is now owned by Transnuclear. The canister is designed to store either 24 PWR UNF assemblies or 52 BWR UNF assemblies. The principal components of the Standardized NUHOMS System are a stainless steel canister, internal fuel basket, and a concrete horizontal storage module. The stainless steel canister is sealed with a stainless steel lid filled with lead that is welded to the canister body with redundant seal welds. The basket assembly for BWR UNF assembly loading has additional neutron-absorbing plates. As of mid-2012 there were a total of 288 non-transportable canisters in use.

Licensing of Non-Transportable Canisters for Transport

Non-transportable canisters contain little or no neutron absorbers (poisons) as would generally be needed to withstand flooding of the containment system with water (unborated), and were not specifically designed to be able to withstand the hypothetical accident conditions for a transport package under 10 CFR Part 71 requirements. In order to transport such canisters to the CSF, a strategy would need to be developed and implemented to obtain NRC approval to transport these canisters in 10 CFR Part 71 certified transport casks that utilizes moderator exclusion or burnup credit as noted earlier in this report. The following paragraphs discuss the usage of moderator exclusion or burnup credits.

Moderator Exclusion

10 CFR 71.55(b) requires that a fissile material transport package must be designed and the contents limited such that a single package “would be subcritical if water were to leak into the containment system.” This applies to both normal conditions of transport and accident conditions. 10 CFR 71.55(c) states, “The Commission may approve exceptions to the requirements of paragraph (b) of this section if the package incorporates special design features that ensure that no single packaging error would permit leakage, and if appropriate measures are taken before each shipment to ensure that the containment system does not leak.”. Moderator exclusion means that it is not credible that moderator (i.e., water) would enter the cavity where the UNF is contained under normal or accident conditions. Commercial nuclear fuel, whose enrichment is limited to 5 weight percent U-235, cannot become critical in the absence of a moderator. A fissile material transportation package application must demonstrate that a single package is subcritical under normal conditions of transport (§71.55(d) and §71.71) and under hypothetical accident conditions (§71.55(e) and §71.73). Accident conditions include immersion under water following the 30-foot free drop, puncture, and 30-minute engulfing fire conditions. §71.55(d)(2) requires that for normal conditions of transport “the geometric form of the package contents would not be substantially altered.” The provisions of §71.55(e) require that a fissile material transport package be subcritical under hypothetical accident conditions, assuming that the fissile material is in the most reactive credible configuration consistent with the damaged condition

of the package and the chemical and physical form of the contents, and water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents.

Regulatory guidance for addressing the requirements of §71.55 for UNF are included in NUREG-1617, “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel”, and NUREG/CR-5661, “Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages”. However, the guidance in these two documents does not specifically address the requirements of §71.55(e). Therefore, the NRC issued Interim Staff Guidance (ISG) ISG-19, “Moderator Exclusion under Hypothetical Accident Conditions and Demonstrating Subcriticality of Spent Fuel under the Requirements of 10 CFR 71.55(e)”, dated May 2, 2003, to specifically address compliance with §71.55(e).

ISG-19 indicates that UNF with non-brittle cladding that is undamaged (Interim Staff Guidance ISG-1 defines damaged UNF) has been shown to remain intact under impact loads associated with hypothetical accident conditions, so it is not necessary to assume that the UNF configuration changes in criticality analyses involving undamaged fuel that is not HBU (greater than 45,000 MWd/MTU). However, ISG-19 states that HBU cladding may become brittle due to effects of irradiation. If excessively brittle, the cladding could fracture under impact loads associated with hypothetical accident free-drop test conditions (a 30-foot cask drop onto a flat, essentially unyielding surface, per §71.73(c)(1)). Consequently, criticality safety of the reconfigured fuel assemblies must be demonstrated. Thus, §71.55(e) guidance can be met considering undamaged, non-HBU in its as-packaged configuration with water intrusion, or by considering damaged and/or HBU in a reconfigured geometry with water intrusion.

ISG-19 permits an alternate method to demonstrating criticality safety, which is based on moderator exclusion. In order to obtain NRC approval, the licensee must demonstrate that the water-tight barrier functions to keep water out under the hypothetical accident conditions of §71.73, and show subcritical requirements are met assuming reconfigured fuel. For welded canister-based systems, ISG-19 requires the 30-foot cask/impact limiter drop test of a scale model, with leak rate testing before and after each drop to demonstrate leakage rates acceptably low to prevent water in-leakage into the canister. For canister-based cask systems and bare fuel (direct-loaded) casks, the transport cask bolt closure system is required to be tested in a scale model of the cask in the 30-foot cask drop test to demonstrate leakage rates acceptably low to prevent water in-leakage into the canister. The closure bolts need to conform to the guidance in NUREG/CR-6007, “Stress Analysis of Closure Bolts for Shipping Casks”, dated January 1993, which includes a testing program, an analysis that shows the bolts behave elastically with stresses that do not exceed yield strength, and bolt replacement requirements based on a fatigue analysis.

Since moderator exclusion was considered to be a departure from accepted practice, the NRC staff sought input from the NRC Commissioners on how best to proceed. In SECY-07-0185, "Moderator Exclusion in Transportation Packages", dated October 22, 2007, the NRC staff provided information to the Commissioners regarding the staff's recommended approach for considering moderator exclusion for UNF transportation packages, including consideration of rulemaking. The NRC staff presented the following three options, and recommended that the Commissioners adopt Option 3:

> Option 1: Permit Moderator Exclusion for hypothetical accident conditions (in accordance with the guidance of ISG-19), for limited-shipment use of the §71.55(c) exception;
>
> Option 2: Permit Moderator Exclusion in spent fuel cask-design approvals under the §71.55(c) exception, as justified by additional risk information; and
>
> Option 3 (staff-recommended option): Undergo rulemaking to codify the acceptable uses of Moderator Exclusion for spent fuel transportation packages, while continuing current staff practices in the interim.

SECY-07-0185 indicated that the NRC staff had made presentations to the Advisory Committee on Nuclear Waste (ACNW), who recommended that the NRC staff use the exception in §71.55(c) regarding applications for moderation exclusion on a case-by-case basis to gain more experience before proceeding with rulemaking. The ACNW also recommended that the NRC guidance be made risk-informed and include consideration of both moderator exclusion and burnup credit (ACNWR-0260, dated April 23, 2007).

The Commission unanimously disapproved the staff's recommendation in SECY-07-0185, stating their desire not to have exceptions as a preferred approach to licensing, and indicating this requirement for flooding of the UNF containment should not be eliminated based on a low risk (low probability is not a sufficient basis to eliminate an effective safety assumption). The Commission encouraged the staff to focus on development of a better technical basis for burnup credit (as opposed to moderator exclusion) based on a more realistic description of fuel composition as a means to allow more UNF assemblies in a transport cask without creating the potential for a criticality event.

During this timeframe, the NRC certified Holtec International's HI-STAR 180 bare fuel transport cask for transport of HBU UNF using moderator exclusion. As stated in the NRC's SER for the HI-STAR-180 (NRC SER on the HI-STAR 180 Package, CoC No. 9325, Rev. 0, October 1, 2009), the HI-STAR 180 cask closure system includes two independent closure lids, each equipped with two concentric annular metallic seals. Each lid is bolted independently to the containment closure flange. Since the inner and outer lid each has two concentric annular metallic seals, there are a total of four independent barriers against leakage. The HI-STAR 180 application applied the guidance in ISG-19 for demonstrating subcriticality for certain hypothetical accident conditions. The NRC's SER states the following:

> "This specific package design ensures that in-leakage of water through the containment boundary seals is a non-credible event under hypothetical accident conditions. Based on this design and analyses that were performed, the staff approved moderator exclusion in compliance with 10 CFR 71.55(e) . . ."
>
> "Two fuel baskets, the F-32 and F-37 models, made entirely of Metamic-HT, are available for this package. … The F-37 basket relies on burnup credit to meet the subcriticality requirements under optimal moderation conditions, while the F-32 basket is designed for all fresh fuel . . ."
>
> "ISG-19 prescribes that, in lieu of demonstrating moderator exclusion through physical tests and analyses, a structural analysis can determine the geometry of reconfigured fuel and the criticality analysis may demonstrate that the bounding reconfiguration is subcritical under full moderation. The applicant did not attempt to demonstrate that all possible reconfigurations were subcritical. However, criticality analyses for a limited number of fuel reconfigurations were performed by the applicant for a fully flooded package as defense in depth. The applicant demonstrated that even under damaged fuel condition (and resulting fuel reconfiguration), no significant increase in reactivity occurred compared to intact fuel. The staff determined that the package design also included sufficient margins for additional credible reconfigurations due to random rod movements . . ."
>
> "The staff finds that the package containment space will remain inaccessible to the moderator under the immersion event of 10 CFR 71.73, which follows the free drop, puncture and fire events. The staff considers that the package design ensures that in-leakage of water through the containment system boundary seals is a non-credible event. The staff finds that the double lid closure system with each bolted lid joint being engineered to meet the leaktight criterion of ANSI N14.5 under all NCT [normal conditions of transport] and HAC [hypothetical accident conditions] conditions of transport, ensures moderator exclusion by complying with the 'intent' of ISG-19."

In licensing the HI-STAR 180 transport cask, the NRC used the guidance contained in NUREG-1617 and ISG-19, as well as that in ISG-8, Rev. 2, "Burnup Credit in the Criticality Safety Analysis of PWR Spent Fuel in Transport and Storage Casks". Licensing of the HI-STAR 180 transport cask in 2009 demonstrated that the NRC is willing to grant moderator exclusion associated with hypothetical accident conditions provided there is adequate justification.

A presentation by John Vera at the NRC Spent Fuel Storage and Transportation (SFST) Technical Exchange on November 1, 2011, stated that moderator exclusion for hypothetical accident conditions is still a valid approach under the current §71.55 regulations, and identified a possible path that could meet the regulatory intent with the following key points:

- Double containment:

  - At least two redundant barriers
  - Elastic closure performance
  - Assurance of leaktight containments
  - Possible three-barrier "insert" system (per the Idaho National Laboratories report, discussed below)

- Demonstration process:
  - Qualification of impact limiter performance and obtaining accelerations (g-loads) from full or scale model 30-foot drop tests.
  - Benchmark of fully dynamic finite element analysis with obtained data. Dynamic finite element analyses that demonstrate adequate structural performance of the package for 30-foot drop configurations.

- For evaluation of overpack bolt closures, the following conditions should be satisfied:
  - The bolts behave elastically and are analyzed according to the recommendations of NUREG-6007.
  - The mating surfaces surrounding the closure have returned to their original configuration at the end of the 30-foot drop simulations.
  - The minimum seal compression per manufacturer's recommendation is maintained at all times during the dynamic finite element drop simulations.

- Structural analysis demonstrating adequate behavior (i.e., below yield) of canister welded closure under NCT and HAC.
- Consideration of potential surface scratch/mishandling, such as removing a portion of canister thickness for structural considerations.
- In addition to the transportation package containment system, the canister would need to meet 10 CFR 71.61 requirements (water pressure).

The NRC presentation concludes that the above considerations are being explored at the NRC as a basis for a revision to ISG-19, and that there are still some regulatory challenges for moderator exclusion as an option for transport of HBU UNF. The lack of data regarding the material properties for HBU UNF cladding presents problems with characterizing fuel behavior. The NRC stated that, if moderator is excluded, justification is needed that the physical form of the contents has inconsequential effects on criticality, or bounding UNF reconfigurations need to be assumed for the criticality analyses and to determine effects on packaging integrity (i.e., effects of UNF in a localized cluster at the canister or cask lid producing heat and radiation). Consideration needs to be given to fuel handling requirements, UNF retrievability, post-transport storage, post-storage transport, and disposal by the receiving facility.

Idaho National Laboratory (INL) issued a report titled, “Transportation Task Report on Achieving Moderator Exclusion and Supporting Standardized Transportation”, dated September 2011 (INL/EXT-11-22559). INL contended that it may be desirable to have alternative approaches (in addition to demonstrations of fuel integrity) to meet 10 CFR 71.55(b) criticality requirements for transportation. INL requested that the NRC consider its proposed conceptual approach when deliberating the potential for regulatory changes as part of NRC’s ongoing Regulatory Program Review for Extended Storage and Transportation. INL’s proposed approach would allow general use of the 10 CFR 71.55(c) option with appropriate justification based on probabilistic risk assessments that reflect the use of a “watertight inner component” (storage canister or inner containment that encloses the storage canister) for both normal and hypothetical accident conditions.

INL’s proposed concept is to provide a separate and distinct component inside of a transport cask capable of performing the watertight function needed to achieve moderator exclusion. The inner component (which serves as a secondary containment vessel) acts as a special design component ensuring no single packaging error would permit in-leakage of moderator. The inner component can be physically leak tested to demonstrate its capacity to be watertight.

In order to implement this approach, which uses moderator exclusion, the inner component is credited to provide the watertight function. The inner component would consist of the storage canister itself, if it can be demonstrated capable of retaining its watertight integrity during NCT and HAC, or if it is not capable of performing this function under NCT and HAC, then a separate additional inner containment could be used to completely enclose the storage canister. An “insert” with an affixed lid becomes the inner containment.

The INL states that this approach is consistent with current international transportation safety standards, which do not require the assumption of moderator leakage past multiple barriers (2009 Edition, IAEA TS-R-1), with not less than two high-standard water barriers. Each barrier can be demonstrated to remain watertight under normal conditions followed by accident condition tests (including immersion). Testing would be performed to demonstrate the leak-tight closure of each containment package before each shipment.

Burnup Credit

The NRC issued “Revision 3 to Interim Staff Guidance ISG-8, Burnup Credit in the Criticality Safety Analysis of PWR Spent Fuel in Transport and Storage Casks”, on

September 26, 2012, which addresses the use of burnup credit in UNF storage and transport casks. Burnup credit permits the applicant for licensing a UNF storage or transport system to account for a decrease in the fuel reactivity resulting from the effects of fission reactions that took place in the reactor, both the decrease in fissile nuclides, such as U-235, and the increase of relatively long-lived fission product poisons. Without burnup credit, fresh (unburned) fuel is assumed with the original relatively high concentration of fissile U-235 and no buildup of fission product poisons. Burnup credit can be used to demonstrate that a transportation package is subcritical with water in-leakage, as required by §71.55(b), assuming moderator exclusion is not credited. A fissile material transportation package application must demonstrate that a single transport package is subcritical under normal conditions of transport (§71.55(d) and §71.71) and under hypothetical accident conditions (§71.55(e) and §71.73), and burnup credit can be applied in these evaluations with proper justification.

ISG-8 states the following regarding burnup credit:

> "Extensive investigations have been performed both within the United States and by other countries in an effort to understand and document the technical issues related to the use of burnup credit.
>
> This Interim Staff Guidance (ISG) provides recommendations to the staff for accepting, on a design-specific basis, a burnup credit approach in the criticality safety analysis of pressurized water reactor (PWR) SNF storage and transportation systems."

Revision 3 to ISG-8 includes two major changes: (1) optional credit for fission product and minor actinide neutron absorbing isotopes in the UNF composition, and (2) the option to perform a misload analysis and additional administrative procedures in lieu of a burnup measurement at the time of loading. The revision also includes an increase in the maximum assembly average burnup recommended for burnup credit from 50 gigawatt days per metric ton of uranium (GWd/MTU) to 60 GWd/MTU, and for fuel enrichment up to 5.0 weight percent U-235.

ISG-8 indicates that the misload analysis "should address potential events involving the placement of assemblies into a UNF storage or transportation system that do not meet the proposed loading criteria. The applicant should demonstrate that the system remains subcritical for misload conditions, including calculation biases, uncertainties and an appropriate administrative margin that is not less than 0.02Δk." The misload analysis should consider the misloading of a single severely underburned assembly, and the misloading of multiple moderately underburned assemblies. It should consider the effects of placing the underburned assemblies in the most reactive positions within the loaded systems, such as the middle of the fuel basket. This ISG was developed with PWR fuel as the basis. The ISG states, "Boiling Water Reactor (BWR) burnup credit has not typically been sought by dry storage and transportation applicants due to the complexity of the fuel and irradiation parameters, the lack of code validation data to support burnup credit, and a general lack of need for such credit in existing designs. Although the ISG does not provide explicit guidance on BWR burnup credit, criticality analyses which include such credit should be reviewed on a case-by-case basis."

In 2003, BNFL Fuel Solutions (BFS, now EnergySolutions), began meeting with the NRC to pursue an amendment of the TS125 transport cask to allow transport of the VSC-24 canisters as part of the approved contents. The VSC-24 canisters do not have any neutron poison. Thus, assuming a fresh fuel assumption, under Part 71.55, the fuel could not be shown to be subcritical under the HACs that require an assumption of full moderation in the package.

BFS proposed either a burnup credit or a moderator exclusion approach be used to show that the package would not be in a critical configuration under HAC. At that time, NRC permitted actinide-only BUC with ISG-8 R2. This did not provide BFS with enough of a reduction in the neutron multiplication factor to meet the criticality acceptance criteria. Moderator exclusion would require an exception to §71.55(b). BFS proposed that it would follow ISG-19 guidance for HAC, including physical testing of a containment system to demonstrate a watertight boundary following the HAC 30-foot free drop.

In order to comply with the §71.55(c) for transport of VSC-24 canisters, the TS125 transport cask design would need to be modified to include special design features, as follows:

- Multiple independent containment boundaries to ensure that no single packaging error would permit leakage (this included using an internal "sleeve" with a bolted closure and a secondary lid that would require lengthening the TS125 cask body)
- Potential failure of the containment boundary may not be associated with one common packaging error
- No credit taken for containment provided by carbon steel Multi-assembly Sealed Basket shell
- Package will include provisions to permit helium leak testing of each containment O-ring seal in accordance with ANSI N 14.5 before each shipment to ensure that the containment system does not leak

Essentially, BFS was asking the NRC to approve an exception to 71.55(b), granting moderator exclusion if they added "special features" to show that water in-leakage to the UNF in the VSC-24 canister was not credible. In addition, BFS planned to perform full burnup credit analysis to show margin; that is, with credit for decrease in k-eff for both actinides and fission products in UNF, a fully flooded package would be subcritical. For additional margin, BFS would also design the package with special features to ensure that water could not intrude during HAC (moderator exclusion).

EnergySolutions submitted a request to amend TS125 in October 2006 to add 48 currently loaded VSC-24s to the TS125 approved contents. In May 2008, EnergySolutions sent a letter to the NRC that said that they had prepared a partial response to NRC's July 2007 RAI, but that “due to a lack of utility funding in 2008, it will not submit the completed RAI response to NRC until early 2009.” Since that time, the amendment request has not been pursued further.

In order for any of the VSC-24 or NUHOMS non-transportable canisters to be shipped, these issues must be resolved. A lack of credit for moderator exclusion will require that the canisters be cut open and the UNF repackaged into transportable canisters.

Transport Cask Suitable for Transport of Canisters

Even if the NRC approves transport of these canisters, it would be necessary to first develop a new transport cask design(s), or amend an existing cask design, to allow transport of these canisters as part of the approved cask contents. As discussed in Section 5.2.5 of this report, a lead time of 4 to 8 years would be needed in order to design, certify, and fabricate the new cask design, while amendments to existing certified casks would require a lead time of 4 to 6 years.

Conclusion

It is recommended that a combination of moderator exclusion and burnup credit be applied to obtain NRC approval for transport of DPCs to the CSF, for those DPCs (such as VSC-24) that are currently not qualified nor authorized for transport under 10 CFR Part 71. This approval would enable these DPCs to be shipped to the CSF for storage. Since the DPC baskets have either no or insufficient neutron poison material to ensure the contents are adequately subcritical when fully flooded with fresh (unborated) water, it is necessary to demonstrate that water will not leak into the DPC in the event of a hypothetical cask drop accident with water assumed to leak past the transport cask confinement barrier. In order to demonstrate moderator ingress to the UNF is not credible, it may be necessary to use the canister-within-a-canister concept recommended by INL and demonstrate that both the added outer canister and the transport cask retain their water-tight integrity under normal and hypothetical accident conditions of transport, including the 30-drop accident prescribed in 10 CFR 71.73. In addition to the redundant watertight barriers, additional safety margin could be demonstrated by showing that with burnup credit that considers the decrease in k-eff due to the decrease in U-235 along with the increase in both actinide and fission product neutron poisons, as permitted by ISG-8 Rev. 3, a fully flooded package would be subcritical. This conservative approach would be expected to provide adequate redundancy and safety margin to obtain the NRC’s approval for transport of these DPCs to the CSF.

Repackaging the UNF into Transportable Canisters or Bare Fuel Casks

If the CASTOR V/21 and X/33, NAC-I28, and Westinghouse MC-10 non-transportable bare fuel casks cannot be shipped to the CSF, they could be taken back into the Surry plant where the casks could be placed into the SFP after the closure lid is unbolted, the lid(s) removed, and the UNF assemblies transferred into the SFP ready for re-loading. There are a total of 638 UNF assemblies in the 29 non-transportable bare fuel casks. Surry is currently using the NUHOMS 32PTH canister DFSS, which is designed for storage and transportation. The plant is set up for the loading and closure operations of this transportable canister. The 638 UNF assemblies could be re-packaged into 20 NUHOMS 32PTH canisters and then shipped to the CSF, as with Surry’s other NUHOMS 32PTH canisters.

Most of the effort is straightforward. However, there would need to be considerable coordination with the plant so that the time to unload and reload UNF would not interfere with normal plant operations. There would also have to be sufficient space in the Surry SFP in order to unload these packages and reload the UNF into transportable systems. In addition, repackaging the contents of the MC-10 cask would require removal of the seal lid weld, which may necessitate special tools to cut the weld in a radiation shielded area and foreign material exclusion zone to capture cutting and grinding debris.

Re-packaging UNF assemblies currently inside non-transportable canisters is not as straightforward. These systems are sealed closed with substantial welds between the lid (or shield plug) and the canister body and a redundant or secondary weld required by the regulator. None of these systems have been cut open to date. Cutting the lid welds may require that the canister be placed into a cask loading pit for the cutting operation if it cannot be shown that the process will not expose personnel to potential radiation from the UNF. Equipment to perform these operations would need to be developed. The Yucca Mountain Project developed some conceptual cutting machines, but the equipment has not been fabricated; therefore, the process has not been implemented.

There are a number of issues that must be addressed prior to implementation of cutting open seal-welded canisters, including identification of a preferred cutting location (dry or wet); debris collection (especially if the canister is cut open in the pool); radiation exposure; means to lift the canister if the existing lifting mechanisms are affected by the cutting process; canister integrity after the cut; and whether it is safe to lift or handle the canister, etc. Cutting open one or two canisters could be achieved by a special dedicated task, but cutting open 288 canisters at 8 operating plant sites will be a major undertaking. The cost for canister cutting operations is likely to dominate the UNF retrieval program.

3.2.4.5 UNF Retrieval Schedule

The transport of UNF in non-transportable bare fuel casks or canisters can be scheduled to take place anytime during the life of the CSF, beginning the fourth year of CSF operation after most of the stranded UNF is placed in storage at the CSF. If these packages are to be opened, and the UNF loaded into DPCs or bare fuel transport casks and transported to the CSF, it is recommended that such an operation take place prior to the plant sites undergoing decommissioning and dismantlement operations since the availability of SFPs, cask cranes, and confinement provided by specialized buildings and their HVAC systems would be crucial to such an operation.

3.2.4.6 Consolidated Storage Facility

CSF Requirements

In Phase 4, the CSF will receive, handle, and store UNF that is currently stored in 29 non-transportable bare fuel casks and 288 non-transportable canisters. The CSF will contain all of the facilities necessary for Phase 4.

Table 3.2-23 and **Table 3.2-24** provide the critical dimensions and weights for non-transportable bare fuel casks and canisters that must be considered in the CSF design if they are allowed to be shipped to the CSF.

Table 3.2-23
Non-Transportable Bare Fuel Cask Dimensions and Weights

Cask Model	Cask Data			
	Capacity	Height (in.)	Dia. (in.)	Weight Loaded (lbs.)
CASTOR				
V/21	21 assembly	192	96	234,000
X/33	33 assembly	190	94	236,000
NAC International				
NAC I28	28 assembly	181.3	95	210,000
Westinghouse				
MC-10	24 assembly	188.5	107	226,000

Reference: Characteristics of Spent Fuel Storage Casks, http://www.nrc.gov/, pbadupws.nrc.gov/docs/ML1025/ML102580285.pdf - 2010-09-26.

Table 3.2-24
Non-Transportable Canister DFSS Dimensions and Weights

Dry Fuel Storage System	Canister				Storage Overpack				
	Model	Height (in.)	Dia. (in.)	Weight Loaded (Lbs.)	Model	Height (in.)	LxW or Dia. (in.)	Weight (Lbs.)	Weight Loaded (Lbs.)
FuelSolutions									
VSC-24	MSB	192.25	62.5	80,261	VCC	225.1	132	217,402	297,663
Transnuclear									
NUHOMS-7P	DSC-7P	181.1	35.5	20,932	HSM	146	247 x 67	320,000	340,932
NUHOMS-24P/24PHB	DSC-24P/24PHB	186	67	78,129	HSM-102	180	247 x 116	364,400	442,529
NUHOMS-32P	DSC-32P	186	67	90,976	HSM-102	180	247 x 116	364,400	455,376
NUHOMS-52B	DSC-52B	196	67	74,925	HSM-102	180	247 x 116	364,400	439,325

Reference: Characteristics of Spent Fuel Storage Casks, http://www.nrc.gov/pbadupws.nrc.gov/docs/ML1025/ML102580285.pdf - 2010-09-26.

These are the dimensions and weights that the storage pads, CHB, and handling equipment must be designed to accommodate.

CSF Site Layout

The overall site layout and site features of the CSF for Phase 4 will not change.

Radiation Area

The RA of the CSF for Phase 4 will not change.

Protected Area

The PA of the CSF for Phase 4 will not change.

Owner Controlled Area

The OCA of the CSF for Phase 4 will not change.

CSF Principle Features and Descriptions

The principle features of the CSF required for Phase 4 will not change, except for the addition of the pads required to store the UNF from the Phase 4 storage systems—whether in their current DFSS or re-packaged in a transportable DFSS.

Storage Pads

In Phase 4, the CSF may need to add concrete storage pads for the additional UNF, which would be constructed as part of Construction Stage 3. There could be up to 29 DPCs added for the non-transportable bare fuel casks. If the non-transportable systems are shipped in a one-time transportation license exemption, there would be 58 vertical-type canisters and 230 horizontal-type canisters. This would require an additional three vertical-type DFSS storage pads and seven horizontal-type DFSS storage pads.

Concrete Batch Plant

The concrete batch plant for Phase 4 will not change.

Rail Yard

The rail yard for Phase 4 will not change.

Cask Handling Building

The CHB for Phase 4 will not change.

Hot Cell Facility

The hot cell facility for Phase 4 will not change.

Security Building

The security building for Phase 4 will not change.

Fleet Management Site

The Fleet Management Site for Phase 4 will not change.

Office Building

The Office Building for Phase 4 will not change.

Visitors Center

The Visitors Center for Phase 4 will not change.

3.2.4.7 Operation Description

Depending on the package in which the UNF arrives, the operation steps will be the same as those in Phase 2 for canister-type DFSSs and Phase 3 for bare-fuel-cask-type DFSSs.

Surveillance

As with all phases, all incoming transport casks and cask railcars would require an inspection and swipe samples upon arrival at the CSF to determine if there was any radioactive contamination.

Any bare fuel casks arriving at the CSF in Phase 4 will be processed like the bare fuel casks in Phase 3. Since they use O-rings for sealing, they require pressure monitoring systems to satisfy the continuous surveillance to ensure they do not have a leak at the cask body-cask lid interface.

Any canisters, whether non-transportable or transportable, will be processed as in Phase 2. Vertical-type canisters would need to pass through the canister transfer cell in the CHB, where they are transferred into a vertical storage overpack and transported to a storage pad. Horizontal-type canisters would be transported with the transport cask by the NUHOMS trailer and transferred to a horizontal storage module. Temperature monitoring systems would need to be connected to the storage units for continuous monitoring to ensure the ventilation ducts are not blocked.

The radiation monitoring equipment for Phase 4 will not change.

Maintenance

Routine maintenance would continue to be performed on transport casks, rolling stock, and transport cask trailers, as in all the phases.

3.3 Evaluation of Alternatives

3.3.1 Single Versus Multiple Consolidated Storage Facilities

3.3.1.1 Background

The President's Blue Ribbon Commission on America's Nuclear Future (BRC) includes among its recommendations the establishment of "one or more" consolidated storage facilities (CSFs) until final disposition of the spent nuclear fuel is known. From a technical and operational perspective, interim storage of UNF could be provided equally effectively at one or more CSFs located within the U.S. If proximity to nuclear plant sites was the primary factor, one might begin by siting four facilities (i.e., one in each NRC region) to have optimum efficiency in transportation of the UNF from the plants to the CSFs. However, while a technically and logistically feasible site is certainly a necessity for each CSF, the BRC recommends that the actual number and location of one or more CSFs be decided through a consent-based process in collaboration with interested states, Native American tribes, regional and local authorities, and affected communities. In other words, if only one state and one locality expresses interest, only one CSF will be designed, licensed, and operated, notwithstanding the attractiveness of more sites for other reasons.

While the BRC recommends a consent-based approach for siting, this assessment of the advantages and disadvantages of a central versus regional consolidated storage approach focuses on the evaluation of the technical, logistical, cost, and other attributes of one versus more-than-one CSF. This approach is taken for several reasons. First, this is a technical report that must fit within the scope of work authorized for the task. Second, the consent-based process will be a policy and political undertaking involving negotiations with interested host parties. These negotiations may have little nexus to the technical and logistical merits of a particular site, and may not consider an optimum engineering solution.

Third, the focus on issues not related to siting or the siting process in this assessment will inform future decision-makers of the attractiveness of the options irrespective of any political overtones that may accompany siting decisions. One non-technical area that is discussed in this assessment is the estimated number of personnel required to operate and maintain a CSF, which determines the number and type of jobs created for the local community.

The following assumptions are used in this assessment:

1. Total interim storage required: 140,000 MTU UNF
2. Total number of casks: 14,000 (assumes 10 MTU/cask)[14]
3. Storage pad and adjacent access path size: 27,000 ft^2 each
4. Casks or modules per pad: 32
5. Total number of storage pads: 450

The above assumptions are used in the conceptual designs discussed elsewhere in this report and the discussion that follows. The assumed individual storage pad size determines the number of casks per pad and total number of pads required. These assumptions are based on experience and may change as the design progresses. However, the actual individual pad size ultimately chosen for use and, in turn, the total number of pads does not materially affect the recommendation on the number of CSFs.

3.3.1.2 Single Facility

Land Requirements

One CSF to provide interim storage for all 140,000 MTU of UNF in 14,000 casks would require about 315 acres (0.51 square miles) for the storage pad and about the same area again for cask transporter, train, and vehicle travel paths; support facilities inside and outside the protected area; and a rail yard. Thus, a single CSF requires 630 acres (one square mile) of land if it will be constructed and used to store 140,000 MTU of UNF.

Cost

The cost[15] to design, license, construct, and start up a single, 40,000-MTU-capacity, generic interim storage facility (GISF, synonymous with a CSF) was estimated by the Electric Power Research Institute (EPRI) to be $561 million (M), including capital construction costs and excluding operating, labor, and decommissioning costs. Annual operating costs were estimated to range between $100M and $105M with the difference being labor costs for caretaker periods ($3.7M) and for periods where loading and unloading operations were

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[14] 10 MTU per cask is a conservatively low estimate. Today's commercial storage system designs hold anywhere from 12 to 15 MTU per cask, depending on the fuel assembly capacity of the cask or canister (61–89 BWR and 24–37 PWR).

[15] All cost data in 2009 dollars from EPRI Report No. 1018722, Tables 2-15, and 3-5 through 3-8.

taking place ($8.5M). A value of $103M will be used in this evaluation for simplicity. These annual O&M costs appear high, but it must be remembered that the cost to procure storage overpacks and payment of railroad fees are included in EPRI's estimate and comprise $80M (78 percent) of this cost.

The facility concept assumed for the EPRI estimate was simply to provide the capability to receive spent fuel in canisters and bare fuel casks that have been loaded at plant sites and to place them into dry storage at the CSF until they can be shipped off site for final disposition. Design features for canister transfer between a transportation package and a storage overpack, security, and the storage pads were included, as well as support buildings for operations, maintenance, security, health physics, and administration. No hot cell, wet pool storage, or any other capability to remove, store, or repackage individual fuel assemblies was assumed for the GISF.

The 40,000-MTU GISF costs from the EPRI report can be modified to estimate the cost for a single, 140,000-MTU capacity CSF. The cost to design, license, construct, and start up a CSF, excluding capital costs ($67.4M) would be the same, irrespective of the storage capacity of the facility. An increase in capital construction cost of $196.6M was estimated by EPRI for an additional 20,000 MTU of fuel storage. Thus, for a 140,000-MTU single storage facility, an additional capital construction cost of $196.6M x 100,000/20,000 = $983M is estimated.

The total cost to design, license, construct, and start up a single 140,000-MTU CSF, including capital construction costs is estimated to be the following:

- $561M (40,000 MTU) + $983M (100,000 MTU) = $1.54 billion (B)

Annual operating and labor costs for an additional 20,000 MTU of storage range from a low of $46M for caretaker periods to $48.1M ($47M will be used here). Thus, for a 140,000-MTU single storage facility, additional annual operating and labor costs of $47M x 5 = $235M are estimated.

The total annual cost to operate a single 140,000-MTU CSF (including overpacks and railroad fees) is estimated to be the following:

- $103M (40,000 MTU) + $235M (100,000 MTU) = $338M/yr

We note that these costs assume 2 cask cars per rail shipment and a cask capacity of 10 MTU of fuel. An increase in either of these numbers would reduce operating costs proportionally by reducing the number of casks and train shipments required.

The cost of a single CSF could be spread out over time if a single CSF of 140,000-MTU capacity was designed, but one of smaller capacity was licensed, constructed, and started up to achieve a modest objective, and then expanded later. For example, a single CSF of 10,000-MTU capacity (or less) would be more than adequate to take receipt of all stranded fuel located at the shutdown plant sites in the country (about 4,200 MTU[16]) plus the GTCC waste currently in storage at those sites, in a “start clean, stay clean” manner at the CSF. Such an approach may be more likely to receive all of the funding necessary to complete the project and ship the fuel, particularly if funding is subject to Congressional appropriation.

The EPRI cost estimate for a 20,000-MTU capacity CSF provides a conservatively high estimate for a smaller facility targeted at just the stranded fuel at the shutdown plant sites in Phase 1, as follows:

- Engineering, construction, and startup: $67.4M + $273.2M = $340.6M
- Annual Operating and Labor Costs: $54 to 56M

Transportation and Logistics

A single CSF is advantageous from a rail design, permitting, and construction cost perspective because only a single rail spur to the CSF site will be required, and cask and rail fleet maintenance and management costs would be less than for multiple CSFs. Rail transportation can be made available to almost any location in the mainland U.S., through the use of intermodal transport (such as rail to barge or rail to HHT).

Employment

A single CSF is estimated by EPRI to provide approximately 150 local construction jobs for 18 months. Jobs during operations will range anywhere from 40 to 115, depending on the size of the CSF and the activities taking place. These job numbers are based on a CSF having the capability to receive and offload transportation packages, transfer dual purpose canisters into storage overpacks, move the overpacks to the storage pads, and reverse those operations when the fuel is ready to be transported off-site. The jobs will be in operations, security, health physics, engineering, maintenance, and quality assurance.

If any CSF was to eventually include a hot cell and/or SFPs, additional jobs would be created for both construction and operation. In the operational phase, a hot cell in particular would create an estimated dozen high-level jobs for engineers, technicians, support staff, and scientists who would perform UNF research and development activities.

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[16] Does not include Fort St. Vrain fuel. Includes Kewaunee and Oyster Creek total fuel discharges projected through 2013 and 2019, respectively.

Challenges

A single CSF subjects spent fuel receipts and subsequent off-site shipments to the risk of shutdown due to labor actions or a single man-made or natural phenomena event. One on-site or off-site event (i.e., fire, earthquake, tornado, or flood), train accident, or security event could shut down operations for an extended time period due to the inability to get the cask trains to or from the site. Any of these events could cause a shutdown, whether they happen at the CSF site or close enough to the site to affect rail transportation infrastructure or logistics.

3.3.1.3 Multiple Facilities

There are several obvious advantages and disadvantages with multiple CSFs. The advantages include lower per-shipment transportation costs if the facilities are strategically located in proximity to the power plant sites. Multiple facilities also provide assurance that fuel can continue to be removed from sites and will not be stranded somewhere between the plants and the CSF if a labor action or a man-made or natural phenomena event shuts down a single CSF. Further, multiple CSFs also create more total job opportunities for the local communities in which the facilities are located than the number that would be created for just one CSF.

Land

Each CSF will require land for train operations, vehicle travel paths, and a rail yard, plus land for facilities supporting cask handling, operations, maintenance, health physics, security, and other support functions. Thus, the EPRI GISF estimate of 315 acres (0.51 square miles) for land, excluding storage pads, would be required for all CSFs. The estimated required storage pad area from the EPRI report is 315 acres for 140,000 MTU (at 10 MTU per cask). Thus, each 10,000 MTU of stored UNF requires 22.5 acres of land for pad space. Land requirements for multiple CSFs to accommodate a total of 140,000 MTU of UNF would therefore depend on the number and size of the CSFs, as shown in **Table 3.3-1**.

Table 3.3-1
Land Requirements for CSFs to Store 140,000 MTU

Number of CSFs	Storage Capacity Each (MTU)	Facility Land Each (Acres)	Storage Pad Land Each (Acres)	Total Land Required Each (Acres)
1	140,000	315	315	630
2	70,000	315	157.5	472.5
3	47,000	315	105.75	420.75
4	35,000	315	78.75	393.75

Cost

Operating and maintenance costs for multiple CSFs to store a given total amount of UNF would be more than storing all of the fuel at one facility. There would not be a change in the total cost of storage overpacks between a single CSF and multiple CSFs. In addition, rail transport costs per shipment should be similar, or possibly lower, due to shorter average travel distances between the plants and multiple CSFs. Administrative, operational, and security functions would need to be duplicated at each CSF site, whereas a single facility could combine those functions and only increase the cost as the increasing amount of fuel being stored at the CSF demands. A breakdown of the costs for one or more CSFs is provided in **Table 3.3-2**.

Table 3.3-2
Total Costs for CSFs to Store 140,000 MTU ($ Millions)

Number of CSFs	Storage Capacity Each (MTU)	Design, License, Construct, and Startup*	Transportation Infrastructure**	Total Project Costs	Annual O&M***
1	140,000	1,540	337	1,877	338
2	70,000	2,047	674	2,721	412
3	47,000	2,128	1,011	3,139	486
4	35,000	2,182	1,348	3,530	560

[*] The same $67.4M is assumed for these activities at each CSF. It will likely be lower for the second and later facilities if the same design is used at each site.

*** Includes costs of rail branch line, rail sidings/yards, cask maintenance facility, and rail fleet maintenance facility for each CSF.*

[***] For multiple facilities, annual costs for storage overpacks and railroad fees (78% of $338M = $264M) is the same for all options because the total amount of fuel shipped and stored remains the same. Annual labor costs for a single facility (22% of 338M = $74M) are multiplied by the number of CSFs. Does not include rail transportation costs for transporting UNF to and from the CSF.

Transportation and Logistics

For multiple CSFs, rail spurs from mainline railroads to the facilities would have to be designed, permitted, and constructed, which will increase the initial cost compared to a single facility. Because the costs associated with building transportation infrastructure, such as a rail spur, rail siding, and site access roads, would be site-specific and depend upon the location of each CSF site in proximity to existing transportation infrastructure, the site topography, local environmental conditions, etc., it is difficult to precisely estimate the costs for site-specific transportation infrastructure. For purposes of this analysis, if one or more CSFs were built within equal proximity to existing transportation infrastructure and on sites with similar topographical features, the transportation infrastructure costs would be expected to increase proportionally with the number of CSF sites.

Employment

Multiple CSFs will employ more total people than a single CSF because the administrative and other support functions will need to be duplicated. Operations, maintenance, health physics, and security supervision will need to be duplicated at each facility. However, the size of the working staffs will be proportional to the amount of fuel being received and stored at each facility. Multiple facilities also offer the opportunity to have different capabilities and employment opportunities among the CSFs. For example, one or more CSFs could have a hot cell and another one or more could have SFPs. These options, along with the ability to construct CSFs of differing capacities (i.e., the total stored UNF does not need to be split evenly among the CSFs), create the possibility for additional jobs of different types and numbers across the facilities.

Challenges

The primary disadvantage of multiple CSFs is cost. Multiple CSFs will require costs for site facilities and transportation infrastructure to be duplicated once, twice, or three times. The added cost of design and licensing more than one CSF can be dampened by licensing a common, basic design to be used at all CSF sites that could be augmented with other facilities as needed at a later time. This way, the specific license applications for the second and later sites could refer to the previously-licensed facility and only address site-specific matters, such as environmental impacts, off-site dose estimates, and emergency response program implementation. The cost for construction and capital costs for each facility would be expected to be similar. The costs of operations and maintenance increase as the number of facilities increase and would need to be weighed against potential transportation savings for some shipments.

Multiple facilities could also present a challenge in finding a large enough parcel of land for the CSF and rail spur in certain areas of the country to meet the facility capacity requirements, especially in the northeast region.

3.3.1.4 Recommendations

Either a single CSF or multiple CSFs will accomplish the objective of removing UNF from the power plant sites and storing it until the method and location for final disposition is determined. A single CSF has clear cost advantages, while the multiple-CSF concept may have advantages in optimizing transportation logistics from the plants to the CSFs.

In either case, the focus of the near-term CSF effort should be on moving stranded UNF away from the shutdown plant sites as soon as possible in the most cost-effective manner. To that end, a phased approach is recommended. The near-term effort should involve designing, licensing, constructing, and placing into operation one consolidated storage facility of approximately 5,000- to 10,000-MTU capacity (500 to 1,000 casks) to receive and store all of the stranded fuel from the shutdown plant sites. Alternatively, a larger capacity (i.e., 20,000 to 40,000 MTU) could be licensed and construction staggered as more storage capacity is desired. A relatively small first facility would permit "piloting" the detailed design, licensing, construction, and operation of a CSF so that lessons learned can be incorporated into future facilities and/or expanding the first facility. This approach would keep the initial cost for design, licensing, and construction well under the EPRI-estimated $500M for a 40,000 MTU facility. This approach would also keep operating and security costs minimized and only growing as the first CSF expands in capacity over time.

While a phased approach is recommended for construction, there may be benefits associated with developing and licensing a larger capacity design, or at a minimum, including the environmental impacts associated with the larger facility in the Environmental Report. For example, if the environmental impacts associated with construction and operation of a larger-capacity CSF are evaluated for a CSF that will be built with a phased approach, there would not be a need for another EIS process in order to expand the facility. This would also ensure that the project is in strict compliance with the NEPA, which prohibits "segmentation" of a large project to avoid full disclosure of adverse environmental or social impacts.

It is also recommended that an initial CSF be a simple, "start clean, stay clean" facility that can receive transportation packages, transfer canisters from the transportation overpack to the storage overpack, as necessary, and place fuel into storage. A precedent for such an approach is the Private Fuel Storage Facility, the experience from which can be used to inform the design and licensing of a CSF. In the initial phase, it is recommended that the CSF not include wet storage pools or a hot cell in order to keep the design simple, costs low, and the schedule for licensing and construction clear and predictable. This will help to ensure that the goal of moving stranded fuel from the shutdown plant sites can be realized in as short a time frame as possible.

Based strictly on cost, a single CSF is recommended. In the longer term, if there are reasons not to expand the initial CSF as presented in this report, a second CSF could be designed, licensed, constructed, and placed into operation. Two or more CSFs would ensure the ability to continue to remove fuel from power plant sites, and to place it into interim storage in case a labor action or any man-made or natural phenomena event renders a single CSF unavailable. Additional CSFs may be considered at appropriate locations for additional capabilities, such as a hot cell for research and development activities or a wet storage pool to permit re-packaging individual fuel assemblies. Two CSFs would be more expensive overall than a single facility to design, license, construct and operate, but would clearly have operational advantages and provide a hedge against an unexpected shutdown of one of the facilities.

Transportation costs have been evaluated for a single CSF versus two, three, and four CSFs. It was determined that any cost savings realized from shorter transportation distances for UNF shipped from plant sites closer to the regional CSFs than a single CSF site are significantly out-weighed by the additional capital and O&M costs incurred with multiple CSFs.

3.3.2 Aboveground Versus Underground Storage

3.3.2.1 Background and System Design Summary

An alternative to the customary vision of dry UNF storage in aboveground casks or modules on a concrete pad is storing the UNF canisters in partially subterranean silos. The HI-STORM 100U System® is one example of an underground storage system. **Figure 3.3-1** and **Figure 3.3-2** depict the HI-STORM 100U storage module, in which the UNF-loaded canister would reside, and an ISFSI employing the underground system. Because the HI-STORM 100U design has been licensed by the NRC, it is discussed herein as an example of this technology. The use of this system as an example of underground storage technology is not an endorsement of the HI-STORM 100U system. It should be noted that while the HI-STORM 100U has been certified by NRC, the system has not yet been constructed at any site[17].

The HI-STORM 100U system stores UNF in a vertical, almost completely subterranean storage silo known as a Vertical Ventilated Module (VVM.) The VVM is comprised of the following major subcomponents (refer to **Figure 3.3-1**):

- Carbon steel container shell and welded baseplate called the Cavity Enclosure Container (CEC)
- Carbon steel divider shell with bottom cutouts
- Concrete-filled carbon steel closure lid
- Container flange
- Concrete support foundation
- Concrete VVM interface pad
- Concrete Top Surface Pad (TSP)
- Carbon/stainless steel canister guide ribs and bearing pads (center and outer)

There is a single, monolithically constructed support foundation for all VVMs in any one ISFSI pad. Each VVM has a structurally independent interface pad at the top, which supports

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[17] All HI-STORM 100U system information is from its Part 72 CoC Amendment 7 and HI-STORM FSAR Revision 9 (©Holtec International 2010).

the closure lid assembly and the CEC flange. The CEC rests on the support foundation at the bottom of the VVM and the CEC flange rests on the VVM interface pad at the top. The TSP surrounds the VVM interface pad but is structurally independent from the interface pad, separated by an expansion joint all around. There may or may not be a concrete encasement surrounding the CEC, depending on site-specific soil conditions, as discussed further below.

The buried, carbon steel CEC shell outside surface must be coated with a preservative to minimize corrosion. Outside the CEC, along the vertical length of the CEC shell between the support foundation and the VVM interface pad, there may be only soil, or a reinforced concrete encasement between the soil and the CEC, at the preference of the user. An impressed current cathodic protection system (ICCPS) may be required to provide additional corrosion protection for the CEC, depending on the corrosivity of the surrounding soil. For mildly corrosive soil, the user has the choice of employing only the concrete encasement or an ICCPS. For aggressively corrosive soil, the user must install an ICCPS, while an additional concrete encasement is optional. The ICCPS is subject to operability and surveillance requirements in the technical specifications in the CoC.

The divider shell is a cylinder concentric with the CEC and resting on the CEC baseplate. The bottom of the divider shell has six cutouts to permit cooling air flow into the canister storage cavity. The divider shell also has insulation affixed to its outer wall in the cooling air annulus that is formed by the divider shell and the CEC shell. The canister bearing pads on the CEC baseplate maintain the canister above the surface of the CEC baseplate and create a two-inch minimum air plenum to allow cooling air to flow directly under the canister.

The closure lid contains built-in air inlet and outlet passages arranged in a labyrinth manner that provides for natural convection cooling while providing the necessary shielding for the UNF inside the canister. The closure lid is fitted with appropriate interfacing lift devices to allow installation and removal with a crane.

In the aboveground systems, including ventilated overpacks and HSMs, ambient air enters the storage system at grade and moves past the hot canister, exiting the storage system at the top. Air flow is driven in one direction by the buoyant forces created by the hot canister surface heating the adjacent air, and that air rising. The rising air draws more ambient air into the bottom ducts, creating a continuous natural convection cooling system through the cask or module.

The underground system provides cooling for the stored fuel in a manner similar to, but hydraulically more complex than, the aboveground systems. The underground system uses the hot canister shell outer surface in the same manner as the aboveground systems to heat the adjacent air, causing that air to become buoyant, rise, and draw fresh cooling air into the

VVM. However, that cooling air must enter the VVM closure lid at grade level, travel downward a distance of over 18 feet in the annulus between the CEC and divider shell outer wall, make a 180-degree turn, and flow up the annulus between the inside wall of the divider shell and the MPC, and exit the closure lid.

The center-to-center spacing of the VVMs is determined by two things: 1) the dimensions of the canisters and the subcomponent radial spacing required for thermal performance (i.e., divider-shell-to-CEC annulus width, divider shell and CEC material thickness, divider shell insulation thickness, etc.) and 2) the width of the top surface pad required to accommodate the cask transporter. The minimum required center-to-center VVM spacing specified by Holtec is 12 feet. Although Holtec specifies the use of a VCT to move the individual fuel canisters inside a transfer cask to the ISFSI, an alternative approach might include the use of a gantry crane that spans the ISFSI and can reach each storage location. For a facility of the size contemplated for the CSF, a very large gantry crane would be required, which would be costly. There are costs and benefits associated with each alternative that would need to be evaluated.

3.3.2.2 Loading Operations Overview

The major unique feature of the underground system is the absence of a storage overpack, which is required for use with the aboveground system. The underground system entails the storage of a UNF-loaded canister directly in a vault, or silo, with a specially-designed lid and internals to provide for decay heat removal, shielding, structural protection, and retrieval of the canister. Loading the canisters destined for underground storage inside the power plant is exactly the same as for the aboveground systems. The differences in operation pertain to how the canister is transferred to its final storage location at the ISFSI, storage operations at the ISFSI, and retrieval of the canister from the ISFSI. These differences also apply to the CSF.

For the aboveground system, the UNF-loaded, helium-filled canister would arrive at the CSF inside the transport cask, and the transfer sleeve in the CHB would be used to transfer the canister into a storage overpack. After canister transfer into the overpack, the loaded overpack is then attached to a transporter and moved to the storage pad.

With the underground system, the canister arriving in the transport cask would need to be transferred to a traditional transfer cask that otherwise would not be used at the CSF, given the “transfer sleeve” concept currently in the design. The transfer cask containing the loaded canister would be moved to the storage pad in the vertical orientation using a cask transporter, where it stops above the designated open VVM with a mating device installed. The mating device is used to remove the transfer cask bottom lid and the canister is lowered into the VVM by the transporter using slings. After detaching the transporter lifting equipment and slings from the canister, the transporter or a mobile crane is used to retrieve and install the closure lid on the VVM.

The underground system requires handling the fuel-loaded canister in a transfer cask for longer periods of time than for the aboveground system because the canister is moved all the way to the storage pad in the transfer cask rather than being transferred to a more heavily shielded overpack inside the CHB prior to going to the storage pad. The transfer cask provides significantly less shielding than a concrete and steel overpack. Thus, CSF operations personnel would likely receive a higher dose per canister placed into storage. Over thousands of canisters, this could be a substantially higher occupational dose to personnel over the life of the CSF.

3.3.2.3 Advantages and Disadvantages

The main attractive features of an underground system are as follows:

- Aesthetic visual appeal of its low profile
- Lower dose to personnel during storage operations at the ISFSI
- Cost savings for fabricating and transporting unneeded storage overpacks
- Better protection from terrorist attacks and natural phenomena events such as wind-borne missiles and explosions
- Better response to earthquakes

The major disadvantages compared to an aboveground system are as follows:

- The need to build out the entire storage pad or install a 24-inch thick retaining wall on the side of the ISFSI to be expanded
- Design, material, and installation costs of a 5-inch-thick concrete encasement around the canister enclosure container (if used)
- Design, material, installation, and maintenance costs for an ICCPS
- Periodic maintenance of coatings, seals, expansion joints, gaskets, and thermal insulation
- Periodic maintenance to remove debris buildup at the bottom of the CEC
- Potential significant costs for recovery from a flood event
- Potential lower heat removal capability than aboveground systems

- Potential to have undetected reduced decay heat removal capability due to blockage of cooling air passages at the bottom of the divider shell in the VVM caused by the accumulation of wind-borne dirt and debris.
- Additional costs for one or more transfer casks and mating devices
- Higher personnel dose for each VVM loading operation
- More difficult to add and maintain active monitoring instrumentation, which may become necessary to support license extensions

3.3.2.4 Summary

An underground storage system offers a viable, but as yet commercially untested storage option for the CSF. The benefits must be weighed against the disadvantages of the system in a systematic way. The overall construction, operation, and maintenance costs, as well as personnel dose for thousands of canisters over decades, needs to be evaluated for the underground system and compared to the aboveground system, and a decision made on a cost-benefit basis. Lacking such a cost-benefit analysis and given the disadvantages listed above, the CSF discussed in this report utilizes aboveground storage.

Figure 3.3-1
HI-STORM 100U Vertical Ventilated Module

(© Holtec International, 2010)

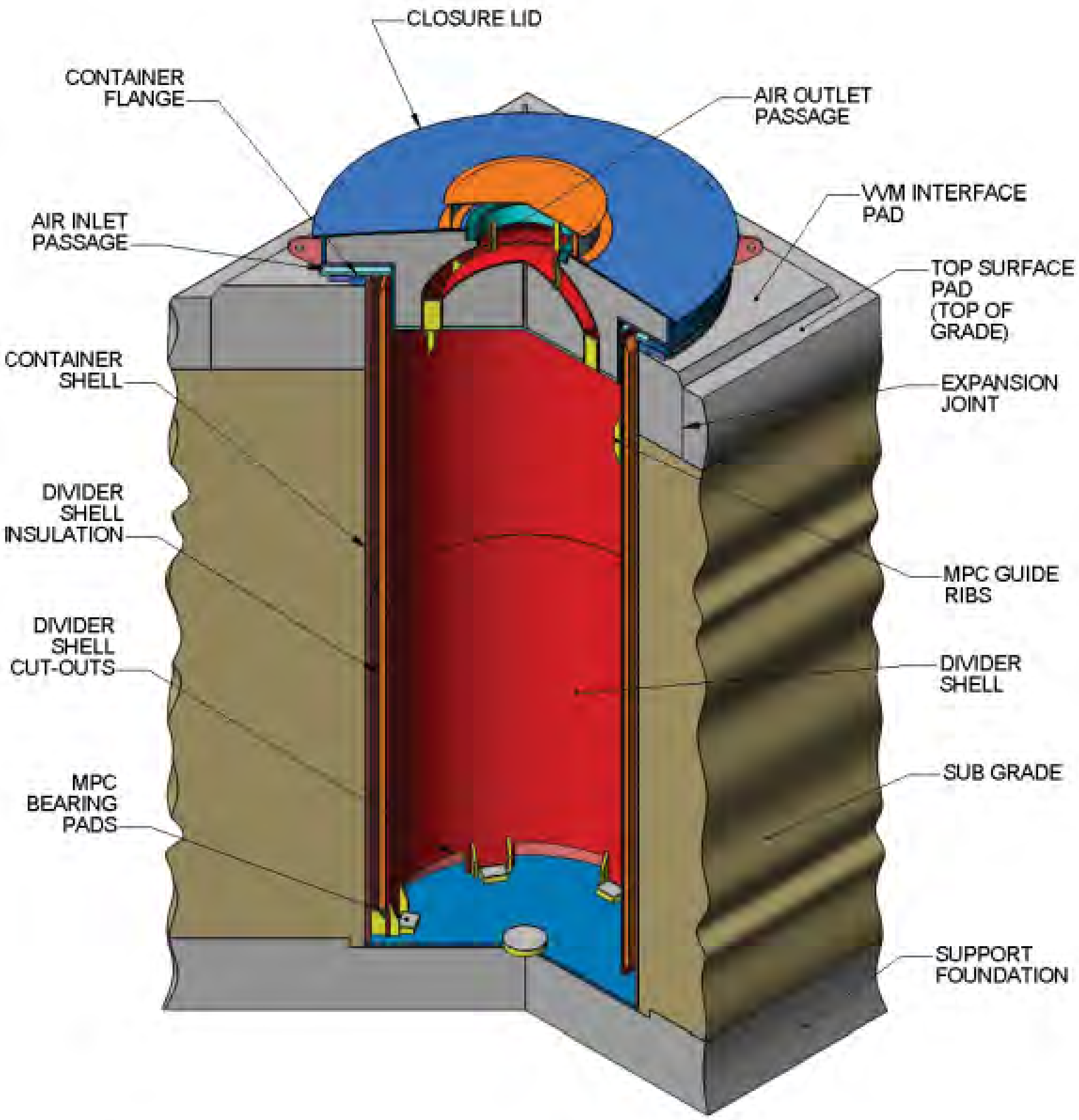
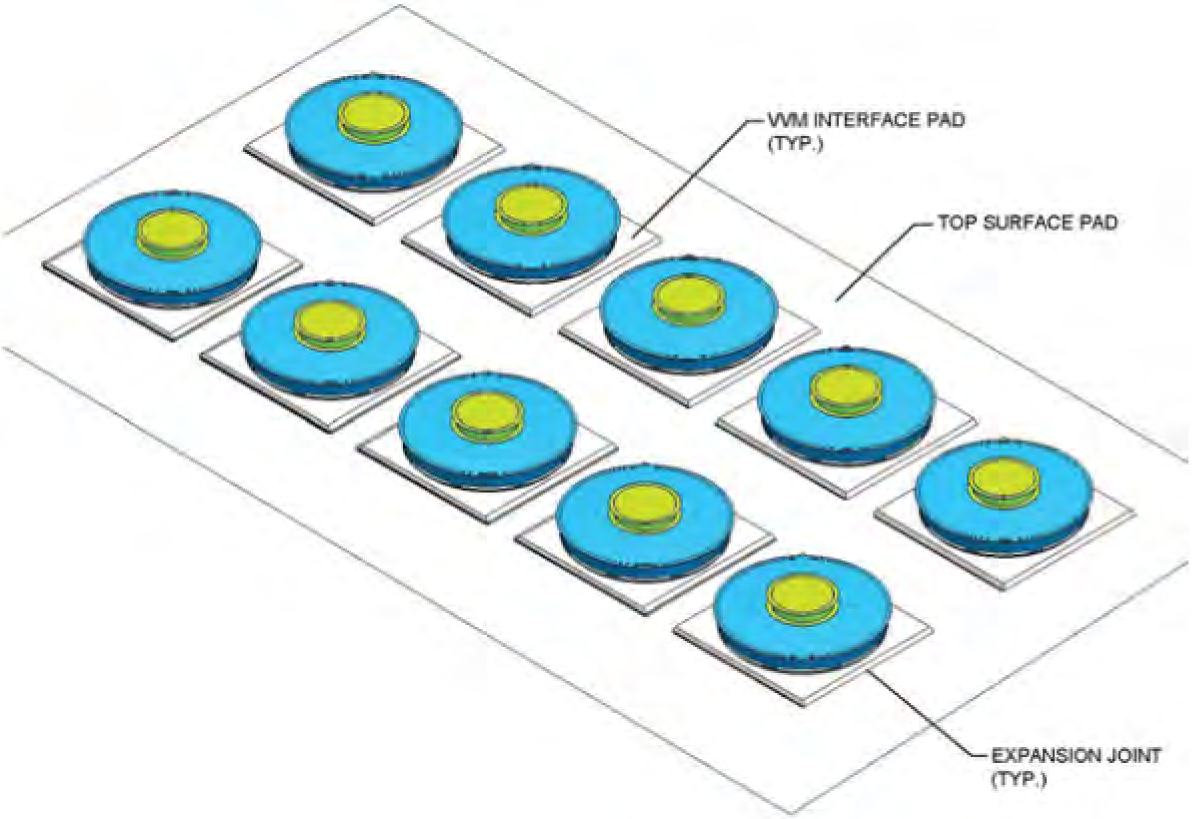


Figure 3.3-2
HI-STORM 100U ISFSI Layout
(© Holtec International, 2010)



3.3.3 Universal Storage Overpack

Another alternative to using the various storage systems at the CSF is to use a single type of "universal" storage overpack that could house any DPC. The purpose for this would be to provide consistency for storage, DPC loading operations and overpack construction, maintenance and monitoring.

Currently the concept is to store each DPC within their licensed storage overpack or module. Using the storage container for which the DPC is designed alleviates the CSF of having to design and license any alternatives. But it also means that the CSF has to be designed to process and store several different types of storage containers; the CHB transfer cells have to accommodate various sized overpacks; the VCTs have to be able to transport different overpacks with unique lifting arrangements; and the concrete pads have to support each overpack and be designed to meet their CoC requirements.

Use of a single universal overpack could reduce the design and operation variables and permit a more simplified process that is consistent and therefore potentially safer. The universal overpack could be designed specifically for the site conditions such as moisture, temperature, tornadoes, and earthquakes which would ensure a high degree of storage integrity. Since the CSF will store thousands of DPCs filled with UNF, the overpack could be more robust, designed with more radiation shielding properties to minimize onsite and offsite radiation doses and better physical protection to counter terrorist attacks. The overpack design could also incorporate various instrumentation that could monitor the UNF conditions over long term storage use. Lastly, the universal overpack could employ the best features of the overpacks or modules currently in use – from fabrication to DPC transfer - whether the DPC is stored vertically or horizontally.

The main advantages of a universal overpack are as follows:

- CSF operation consistency
- Better radiation shielding
- Onsite fabrication consistency and elimination of transporting storage overpacks
- Better protection from terrorist attacks and natural phenomena events such as wind-borne missiles and explosions
- Tailored instrumentation for long term storage monitoring

The main disadvantages of a universal overpack are as follows:

- New design that would need to accommodate several DPC conditions, sizes, heat loads and CoC requirements
- Additional licensing process to consider in the CSF schedule
- Additional costs to analyze each different canister when in the universal storage overpack to show that the canister and contents meet the design criteria in their respective SARs and CoC requirements for normal, off-normal, and accident conditions and the associated licensing process

A universal overpack offers a number of advantages that could improve long term storage of UNF at the CSF. Consideration should be made to solicit companies to offer a universal overpack design.

3.4 Permits and Approvals

Federal, state, and local laws and regulations will need to be reviewed to identify the various permits and approvals towards the development of the CSF. Each of the permits will have requirements for which pertinent data will need to be obtained for the various subjects of the permits.

The following is a list of potential permits that will need to be secured for the CSF planning, construction, and operation.

Water Quality

Discharge permits are required for release of any pollutant into surface or underground waters that may be harmful to the public, wildlife, or fish, or impair domestic, agricultural, industrial, recreational, or other uses of water. Permits that are typically required for a facility similar to the CSF include the following:

- NPDES—National Pollution Discharge Elimination System permit
- SWPPP—Storm Water Pollution Prevention Plan
- SPCC—Stormwater Pollution Control and Countermeasures plan
- Construction Permit—Septic Tank Systems
- Construction Permit—Wastewater Detention Ponds
- Ground Water Permit
- Section 404 Permit (discharges into U.S. waters)
- Underground Injection (UIC)—Leach Field discharges
- Drinking Water Requirements
- Well Permit

Air Quality

Discharge permits are required for release of any pollutant into the air that may be harmful to the public or environment. Permits that are typically required for a facility similar to the CSF include the following:

- Fugitive Dust Permit (construction activities)
- Title V Permit of the Clean Air Act (i.e., diesel generator emissions)

RCRA

A Resource Conservation and Recovery Act (RCRA) permit is required if any hazardous waste is produced that exceed Environmental Protection Agency (EPA) RCRA limits.

Spill Prevention for Diesel Fuel 40 CFR 112.3(b)

Any system using diesel fuel, such as a diesel-powered generator, will require a permit to show that spill prevention measures have been included in the design and operation of the unit.

Construction Permit

Permits and plans associated with construction activities will need to be obtained and filed with the appropriate agency prior to the commencement of construction. Building permits will be required from the local governing entity for construction activities associated with engineered structures, electrical systems, and many other construction features.

High Level Nuclear Waste Transfer, Storage, or Disposal

Many states require legislative approval for any activities involving nuclear waste.

Rail Construction

A rail construction permit may be required by the State.

Excavation in State Right-of-Way

Excavation within a right-of-way of a state highway typically requires approval from the State. Access roads from the CSF to a highway fall under this permit.

State Lands

Easements, rights of way, or use of State lands may require State approval.

Underground Storage Tank(s)

Underground storage of petroleum products typically requires a permit from the State or Federal EPA.

Fire Prevention

Installation of certain fire prevention or suppression systems may require a permit.

Operational Permits

There may be operational permits required by the State or local governing agency. Plans for facility operations addressing impacts from the number of employees, traffic, noise, etc. will need to be prepared and filed prior to facility operation.

3.5 Design to Facilitate Decontamination and Decommissioning

10 CFR 72.130 requires that the ISFSI be designed for decommissioning, with provisions to facilitate decontamination of structures and equipment, to minimize the quantity of radioactive wastes and contaminated equipment, and to facilitate the removal of radioactive wastes and contaminated materials.

The objective of decontamination and decommissioning activities at the end of CSF life is to remove all radioactive materials having radioactivity levels above the applicable NRC release limits, in order that the site may be released for unrestricted use and the NRC license terminated. As such, the CSF shall be designed to facilitate safe and economical decommissioning activities in an expedient manner, and shall be required to operate in a manner that supports decommissioning activities throughout the life of the facility.

Where feasible and economical, design features that support decontamination and dismantlement will be selected over competing alternatives. During the design process, structures, systems, and components will be reviewed for decontamination and dismantlement considerations to ensure that features that support waste minimization and worker safety are incorporated and ALARA principles are considered for decontamination and dismantlement activities.

The following requirements and criteria will be applied as the design progresses to ensure that the design features facilitate and support decontamination and dismantlement, while maintaining radiation doses to workers and the public ALARA:

- Selection of materials and processes to minimize waste production
- Minimizing materials that are susceptible to neutron activation, in order to minimize production of radioactive waste
- Selection of materials and incorporation of features intended for ease of decontamination and dismantlement or waste processing procedures, such as reinforced concrete structures, that facilitate demolition techniques
- Use of construction materials and surface finishes to minimize porosity, crevices, and rough machine marks on structures, systems, and components, to limit the potential for contamination and facilitate ease of decontamination
- Use of smooth or special protective coatings or polished stainless steel metal surfaces, where applicable, that preclude penetration into porous materials by radioactive gas, condensate, deposited aerosols, or spills, to facilitate decontamination by surface treatment
- Use of stainless-steel-lined UNF pools with a leak-detection drainage system to minimize the contamination of concrete around the pools
- Use of confinement systems to contain and minimize the spread of potential radioactive contamination generated during process operations and to isolate non-contaminated areas from potentially contaminated areas where applicable

- Incorporation of features to contain leaks and spills, such as curbs, to minimize the number and extent of contaminated areas
- Incorporation of waste minimization techniques
- Use of exhaust ducting and HEPA filters for the exhaust ventilation system of areas or rooms that may become contaminated, including the UNF pool areas
- Incorporation of features that would maintain occupational and public radiation doses ALARA during decommissioning

Canister-based DFSSs are used in CSF Phases 1 and 2, with the canisters designed to confine the UNF and associated radioactivity. The UNF is sealed within the canister at the originating plant site to enable the sealed canisters to be shipped and stored without having to open the canister or handle individual UNF assemblies. Phases 3 and 4 involve handling of bare fuel assemblies, which increases the potential for contamination. However, following receipt of the bare fuel transport casks at the CSF and prior to handling of individual UNF assemblies, the casks are flooded and placed underwater in a cask pit (or UNF pool), which minimizes the potential for airborne contamination.

The CSF shall be designed to minimize the quantity of radioactive wastes generated and the amount of equipment that becomes contaminated. It is not anticipated that the storage overpacks (vertical or horizontal) involved in storing DPCs will have residual radioactive contamination once the canisters are removed because of the following:

- The canisters are sealed by welding that precludes leakage.
- Measures are applied at the originating plant sites or at the CSF when UNF is loaded into the canisters to prevent contamination of the canister outer surfaces.
- The canisters are not permitted to be transported to the CSF from plant sites unless surveys determine that surface contamination levels of accessible portions of the canisters are below specified limits.
- Integrated neutron flux levels generated by the UNF are expected to be sufficiently low, such that activation of storage overpack and storage pad materials will not be significant, with radiation levels expected to be below the applicable NRC criteria for unrestricted release of equipment/materials.

As canisters are shipped offsite and storage overpacks become available at the CSF, the overpacks will be reused for storage of any new incoming UNF canisters, in order to minimize potential future waste volume.

The CSF will be designed to facilitate the removal of radioactive wastes and contaminated materials. The design of the storage overpacks, with internal surfaces typically lined with steel, facilitates decontamination efforts that may be required. Prior to the commencement of CSF decommissioning activities, the loaded UNF canisters stored at the CSF will be shipped off-site in licensed transport casks. The empty storage overpacks would then be surveyed to determine activation and contamination levels. Storage overpacks with activation and contamination levels below the applicable NRC limits for unrestricted release would be disposed of as non-controlled material. Any contaminated storage overpacks would be decontaminated to the extent practicable using conventional methods, and overpacks that were decontaminated below the applicable NRC limits for unrestricted release would be disposed of as non-controlled material. Storage overpacks with contamination or activation levels above the applicable NRC limits for unrestricted release would be dismantled, with the activated or contaminated portions segregated to minimize the quantity of LLRW and disposed of as LLRW. Storage overpack decontamination and decommissioning may be performed at any time following the removal of the canister from the overpack. This will allow storage overpack decommissioning efforts to be performed while canisters are being shipped off site. The transport casks and transfer sleeves would be similarly decommissioned after they are no longer required for CSF operations.

Bare fuel casks used to transport and/or store UNF will likely require disposal as LLRW following removal of the UNF. In order to minimize the number of such casks that need to be disposed of, it is planned to use existing bare fuel casks (i.e., TN-32, TN-40, and TN-68 bare fuel casks) to the maximum extent possible. It is also likely that DPCs used to transport UNF to the CSF and to store UNF at the CSF will need to be disposed of as LLRW, once the UNF has been removed (if repackaged in a disposal canister). Therefore, the strategy is to use existing DPCs to the maximum extent possible, without repackaging the UNF until such time as a disposal canister has been developed to minimize the number of canisters that need to be disposed of as LLRW.

The fences, electrical support structures, and other storage area equipment will not require special decommissioning activities since no contamination is expected to be transferred to these structures.

Records important to decommissioning will be maintained over the life of the CSF, as required by 10 CFR 72.30(d), and will be used to plan the actual decommissioning efforts. These records include the following:

- Records of spills or off-normal occurrences involving the spread of contamination

- As-built drawings and modifications of structures and equipment involved in the use and/or storage of radioactive materials, and locations of possible inaccessible contamination
- A document containing a list of all areas designated at any time as restricted areas, and a list of all areas outside of restricted areas involved in a spread of contamination

4.0 SECURITY

The general performance objective of the security program is to maintain a physical protection system with the goal of providing high assurance that activities involving UNF do not constitute an unreasonable risk to public health and safety. To achieve this end, security at the CSF will meet the requirements for physical protection of stored spent nuclear fuel set forth in 10 CFR 73.51. At the highest level, this means the following:

- UNF is processed and stored only within a PA.
- Access to the PA is granted only to individuals who are authorized entry.
- Any unauthorized penetration of the PA and/or activities within the PA are detected promptly and assessed by an on-site armed security force.
- The security organization assigned to the facility is managed in a manner that maintains its effectiveness.

Additionally, the following specific security design criteria will be applied at the CSF:

- Radiological sabotage (as opposed to theft of nuclear material) by an external adversary will be prevented.
- NRC regulatory guidance will be used to characterize the capabilities of an external adversary group.
- A dose-based approach will be used to determine whether the effects of a radiological sabotage attack within the CSF will have an adverse impact (or unreasonable risk) on public health and safety.
- An OCA will be established at the property boundary at which the results of adversary attack scenarios are measured.
- The OCA will be of sufficient size and distance from a security event so as to minimize the impact of a facility attack on the environment and public health and safety.
- Security forces will be tested regularly and assessed for performance effectiveness.
- Response to a security event will be the responsibility of the on-site security organization, thus minimizing the requirement for off-site entities to play a role in the overall protection strategy at the CSF.
- Cooperation with local law enforcement agencies (LLEA) will be established for routine and emergency support, i.e., traffic control, investigatory and criminal follow-

up, fresh pursuit, etc., that can be expected from external sources during a security event. Redundant communications capabilities (i.e., radio frequency systems, telephone, and direct hard-wired voice systems) will be maintained with all external entities that are expected to provide support of any kind during a security event.

- After Construction Stage 1, subsequent construction or expansion will be conducted outside of the CSF PA and new facilities will be brought into the PA under controlled conditions.

4.1 CSF Security

4.1.1 Controlled Area Requirements

The entire CSF property will be designated as an OCA. A three-strand barbed-wire demarcation barrier will be established at the boundary, with vehicular access points clearly marked with “no trespassing” signs. Staffed, bullet-resistant security portals will be established at entrances to verify the identification and authorization of all persons and vehicles entering the site. Portals will be equipped with gates, which are to be closed during hours of darkness. Adequate lighting will be provided at portals to assist in personnel verification. Visitors and vendors will be provided temporary access credentials. Roadways approaching all security portals will be designed to slow the speed of approaching vehicles by means such as turns, speed humps, or a serpentine design.

4.1.2 CSF Requirements

4.1.2.1 General

A physical barrier will be established at the security perimeter of the CSF, which will include personnel and vehicle access barriers, redundant intrusion detection and assessment systems, and illumination. All security system components (i.e., sensors, video, and badge readers) annunciate in a Central Alarm Station (CAS) (see Section 4.1.3.1) and in a Secondary Alarm Station (SAS) (see Section 4.1.3.2), both of which will be staffed continually by security force personnel.

Access points to the CSF will be minimized by having limited vehicle and railroad portals to the area. The railroad portal will be manned only during rail movement into or out of the CSF; otherwise, it will be locked and alarmed. Signs warning against trespass and the introduction of prohibited articles (i.e., firearms, controlled substances, and other items prohibited by law) will be posted at all personnel/vehicle access points. Security force personnel will be posted continuously at routine access portals. All persons entering the CSF will be required to exit/dismount from their vehicles for identification and authorization checks. Deliveries of UNF by rail will be checked for authorization and visually for explosives by security force personnel. All individuals, vehicles, and hand-carried packages entering the CSF will be checked for proper authorization and searched for explosives.

Portals will be equipped with lighting sufficient for personnel identification, and package and vehicle inspection. Closed-circuit television (CCTV) cameras will be used to assist in the inspection of vehicle undercarriages. Vehicles exiting the PA will be inspected for concealed items.

A sufficient number of ingress/egress lanes will be provided to maximize throughput of persons and vehicles. Only vehicles with a mission-related purpose will be permitted entry. All private vehicles will be excluded from entering the CSF and will be required to use the parking lots for private vehicles, which will be located at least 100 feet from the access portals; this will minimize the impact of vehicle-borne explosive devices.

4.1.2.2 CSF Protected Area

The PA for the storage of UNF will be located within the OCA and will be surrounded by two physical barriers: (1) a security fence and (2) a nuisance fence. The barrier pathways will be graded and leveled. The barrier will consist of a 7-foot-high No. 11 American Wire Gauge chain-link fence topped with three strands of barbed tape on outriggers angled inward and outward at 30 degrees from vertical and fence fabric extending to within 2 inches of the ground. The overall height of the barrier will be 8 feet. All vegetation external to this barrier will be cleared and illumination provided to facilitate detection of activities immediately adjacent to the barrier. At the base of the barrier, there will be a 2-foot-wide, 2-foot-deep concrete-filled trench to prevent erosion and tunneling. Posts, bracings, and other structural members of the security fence will be located on the inside of the PA. A ground surveillance radar system will be installed at the security fence line looking outward to detect unauthorized activity immediately exterior to the CSF. The fence lines will be constructed on straight paths to improve intrusion detection. A passive vehicle barrier system (VBS) will be installed at the security fence in order to deny access to the CSF by a vehicle-born improvised explosive device. The VBS will be constructed of 5-foot-high by 5-foot-wide reinforced concrete blocks anchored on a continuous concrete foundation. Active VBSs, such as bollards or wedges controlled by the security force, will be installed exterior to security portals on access roads. VBSs will be designed to meet ASTM International, Department of Homeland Security, or Department of State standards for VBS performance for mid-size trucks.

Illumination will be provided along all points of the PA perimeter. A 20-foot-wide isolation zone will be established on both sides of each barrier. A CCTV system, consisting of both fixed and pan-tilt-zoom cameras with automated assessment features, will be installed along the PA to monitor unauthorized activities and to detect intrusion. Random foot and vehicle patrols interior and exterior to the PA barrier will be conducted by security force personnel. A hardened security portal will be established at the routine access control point. Security force personnel will check the authorization of all persons entering the PA and maintain a record of such access. All hand-carried items will be checked by X-ray and explosives detection devices. All entry/access activities will be under the observation of a security force member who will be within a bullet-resistant enclosure. Any vehicle entering the PA must have specific authorization for access. Vehicles will be visually inspected for unauthorized items and explosives.

An exterior intrusion detection system will be installed between the security fence and the nuisance fence. The integration of sensors into the PA sensor system will consider the effects of the physical and environmental conditions and sensor performance (high probability of detection, low nuisance alarms, and vulnerability to defeat). Three generically different but complementary sensor types will comprise the sensor system. Candidate sensor types include microwave, ground-based terrain-following radar, electric field, buried cable, taut wire, fence disturbance, fiber optic, and active and passive infrared. Security system components at the PA barrier will be equipped with tamper alarms, self-tests, and line supervisory features. The intrusion detection security system will include a documented testing and maintenance program of the system as well as all components. The security system will be powered by the CSF electrical power system and will have an independent auxiliary diesel/battery backup power source.

Security locks and keys will be subject to a formal system of controls, including records of issuance, turn-in, and annual inventory (unless more frequent inventory is warranted). Unused keys, key blanks, and key cutting codes will be stored in locked containers (see Section 4.1.4.7).

4.1.2.3 Cask Handling Building

Doors to the CHB will be locked at all times and personnel access will be controlled via an automated personnel identification system. This system uses a unique Personal Identification Number (PIN) and a biometric feature of the individual (i.e., hand geometry, fingerprint, or eye retinal pattern). A security force member in a bullet-resistant enclosure will be posted adjacent to all personnel entry portals. Vehicle entry portals will be opened by security force personnel as needed.

4.1.3 Security Facilities

4.1.3.1 Central Alarm Station

A Central Alarm Station (CAS), continuously staffed with at least two security force personnel, will be located within the PA. Its location and function will not be identified, nor will it be visible from outside of the PA. It will be located below grade and equipped with hardened, penetration-resistant doors. An access control system, controlled from inside the CAS, will be installed on the primary and emergency access/exits doors to the CAS. All penetrations into the CAS (i.e., wiring, HVAC, and water and sewer lines) will be equipped with barriers to prevent their use as an entry point into the CAS. The floor, walls, and ceiling of the CAS will be constructed of reinforced concrete or similar material designed and rated to withstand forcible entry through the use of explosives or cutting bars, and will be seismically qualified. All security detection, assessment, monitoring, and surveillance systems annunciate in the CAS. Redundant and independent power supplies will be provided to the CAS. CSF security communications systems will report out in the CAS. Creature comfort stations will be located within the CAS.

4.1.3.2 Secondary Alarm Station

A continuously staffed Secondary Alarm System (SAS) will be located in an unmarked building within the PA. The SAS will be equipped with video assessment monitoring of the CAS and will be provided with command and control capabilities in the event the CAS fails to operate or becomes ineffective during a security event. The SAS will be provided with the same full range of communications capabilities as the CAS and will have alternate alarm, assessment, and monitoring systems sufficient to exercise effective command and control during a security event. It will have penetration-resistant doors, walls, and ceiling equivalent to the CAS. Access to the SAS via an automated system will be controlled from inside the SAS. Creature comfort stations will be located within the SAS.

4.1.3.3 Entry Control Portals

Security force entry control portals will be constructed of bullet-resistant material. Illumination around portals will be a minimum of 0.2 foot-candles at ground level for at least 30 feet in all directions. The portals will be provided with at least two means of reliable communication to the CAS/SAS, which may include a dedicated protective radio system with two-channel capability (minimum), a telephone, or a hard-wired voice system. The portals will be provided with an auxiliary power supply. Water and restroom facilities will be provided at all 24-hour portals.

4.1.3.4 Package Inspection Station

There will be a dedicated Package Inspection Station external to the CSF PA for the checking of packages, mail, and material delivered to the facility. Inspections will be either visual in nature or, where possible, through the use of X-ray machines. Delivery vehicles will be offloaded at the reception facility and, after inspections, the offloaded material will be delivered to the CSF by cleared and authorized personnel using dedicated CSF vehicles. Bulk delivery vehicles, if any, will be subject to a thorough visual inspection and escorted into the CSF. The Package Inspection Station will be of standard construction.

4.1.3.5 Security Force Headquarters and Training Facility

A building of standard construction will be located in the OCA and will serve as the headquarters of the on-site security force. It will be equipped with locker rooms and classrooms for the training of security force personnel. It will have a common area of sufficient size to handle a shift and one half of security force personnel for guard meeting activities. It will also house the administrative offices of the security force. An armory constructed of explosive- and bullet-resistant material will be housed in this building.

4.1.3.6 Bullet Resistant Enclosures

Bullet resistant enclosures will be situated at strategic locations within the PA to provide protected locations for security force personnel during a security event. The exact number and location of bullet resistant enclosures will be determined based on further vulnerability assessments.

4.1.3.7 Firearms Training Facility[18]

Outdoor live-fire firearms training ranges will be provided to accommodate all weapons assigned to the security force personnel for both day and night qualification and training. A sufficient number of firing lanes will be provided to accommodate initial and recurring firearms training and qualification programs in an efficient manner. Berms and other barriers will be constructed around the facility at a distance determined by engineered surface danger zones and risk analyses. Warning signs will be posted around the perimeter and range safety rules posted within the facility. The training facility will have break and restroom facilities, and exterior lighting. It will also be provided with two means of communications and a backup power supply for emergency conditions.

4.1.4 Security Equipment

4.1.4.1 General

The protection performance objective of the physical security system is to deter and/or provide a combination of detection, delay, and response to unauthorized actions. The physical security system is designed with redundancy so that no single element can lead to catastrophic failure of the protection performance objectives.

All security equipment will be tested and calibrated prior to being placed in service and then will be subject to periodic testing and maintenance procedures. All procedures will be periodically reviewed for adequacy and currency. Individual elements of systems will be functionally checked (i.e., determined to be working or out of service) on each shift; calibrated (i.e., determined to be performing at intended specification) according to manufacturer’s specification, but no less than once per year; and tested as part of the system every 6 months.

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[18] An alternative to outdoor firing ranges is an indoor range. Any indoor facility must be capable of using all assigned firearms. There are several very good indoor ranges, each capable of handling the variety of anticipated weaponry at the CSF, currently in use and design criteria should be readily available. Examples of such ranges are at NNSA Y-12 National Security Site, and the Federal Law Enforcement Training Center.

Utility lines, manholes, and storm drains passing over or under the CSF PA will be protected through the use of sensors or barriers so they do not provide intrusion pathways. Most system components will be tamper-protected and self-tested. Nuisance and false alarms should be kept to a minimum. As-built engineering drawings of all system elements will be maintained and controlled.

4.1.4.2 Exterior Intrusion Systems

Exterior intrusion detection systems will consist of intrusion sensors, video alarm assessment, entry control, and alarm communication systems. Due consideration will be given to environmental, meteorological, local wildlife, background noise, and soil conditions prevalent at the CSF. Exterior sensor systems will be protected against lightning strikes using shielding or grounding techniques or through the use of transient suppression devices.

All external sensors will be engineered to prevent against bypass and spoofing (i.e., jumping over sensors, crawling through sensors, bridging over sensors, tunneling under sensors, and walking between sensors). Overlapping fields of sensor coverage will be provided. Sensors to be used are classified as active or passive; concealed or visible; line-of-sight or terrain-following; volumetric or line detection; or application based (i.e., buried line, fence associated, or freestanding).

4.1.4.3 Alarm Assessment Systems

Alarm assessment systems will be used to determine the cause of sensor alarms and will provide information about an intrusion (i.e., number of adversaries, equipment, and direction of adversary travel). Major components of alarm assessment systems will include cameras; lighting systems; transmission systems; and video switching, recording, monitoring, control, and synchronization equipment.

The integration and interaction of various alarm assessment elements (i.e., lighting and video) will be achieved prior to being placed in service and will be influenced by site layout and sources of interference. Thus, clear zones will be maintained, sensor spacing will be uniform, grading and removal of any vegetation will be performed periodically, and adequate illumination intensity will be provided.

4.1.4.4 Alarm Communications and Display Systems

Alarm communications and display (ACD) systems will transmit alarm signals from intrusion detection sensors and display this information at the CAS and SAS. The ACD system will control the flow of information between detection, delay, and response elements of the protection performance system. The ACD system will have alarm signals that are multiplexed, ensuring two-way transmission signals that are reported in real time. The cables will be buried and monitored to display failures due to breaks or tampering. Individual sensors can be displayed, isolated, and controlled in the event of sensor failure. The system will be sufficiently flexible to accommodate future expansion.

The ACD equipment located in the CAS and SAS will receive information from the sensors. The types of information displayed will include “access,” “secure,” “alarm,” or “tamper” status of sensors within a zone; the geographical location of the zone; the time of an alarm; information about any special hazards or conditions within a zone; instructions for special actions; contact information of person or entities to notify; and maps of the area.

To assist operator interface, computer-driven color monitors will be provided. In addition to display, all alarms will annunciate with an audible signal. Fully redundant and duplicate consoles will be provided in the CAS, while a single console will be located in the SAS. A “summary of events” display will be located in the CAS for the security force supervisor assigned to that location.

Sufficient HVAC will be provided to maintain the effective operating temperature of the equipment. Highly reliable backup power will be provided. Processing equipment will be located in a separate room within the CAS in order to improve system accessibility and visibility, and to minimize operator distractions. Communications equipment, such as microphones and telephones, will be a part of the system.

4.1.4.5 Access Control System

The access control system (ACS) will consist of hardware and procedures used to verify entry authorization and to detect prohibited items. Performance objectives of the ACS will include difficulty to bypass, accommodation of peak loads, and blockage of passage of persons and packages until authorization is verified. Further, the ACS will be designed for both entry and exit. The ACS will be under the immediate observation of a security force member, and the system will be monitored at the CAS. A local audible or visual alarm will annunciate when a prohibited item (i.e., major metal) is detected.

The personnel access control element of the ACS will authorize entry and verify the authorization of the person seeking access to the PA. All personnel assigned to the CSF will be provided with a color photo-identification credential containing a unique identifier. Each person will be assigned a Personal Identification Number, which will be memorized and not shared. Access will require the person to insert the credential into a reader and then enter the Personal Identification Number. A Personal Identity Verification system using a unique physical biometric characteristic (i.e., fingerprint, hand geometry, or eye retinal pattern) will be used in tandem with the credential reader.

Hand-carried items and packages will be screened for prohibited items (i.e., firearms and explosives) using metal and explosive detectors, which will be located inboard of the ACS.

4.1.4.6 Access Delay System

The access delay system will increase adversary task time by introducing impediments along the adversary pathway to the target (spent fuel). The access delay system will compliment other features of the physical protection system and will be intended to ensure that on-site responding security force personnel arrive in time to prevent the adversary from accomplishing their goal, i.e., radiological sabotage. Passive barriers will be in place at the CSF and will include concrete barriers, vehicle arresting cables, and dual chain-link fences at the PA; locked gates; bullet-resistant glazing material at the security force position; and reinforced building construction (refer to Section 4.1.3.1).

An inspection program will be established to routinely inspect passive barriers for wear. The inspection results will be documented and wear issues will be resolved.

4.1.4.7 Locking Systems

Locks are an important element of an overall physical protection system, but are typically low-technology and susceptible to defeat. There are a wide variety of locks, depending on the specific application, including key locks; combination locks; mechanical and electrical bolts, strikes and latches; and self-contained electronic locks. No lock will serve as a stand-alone component of the physical protection system.

Locks will meet national or military specifications and will have unique identifiers. A program to protect and manage locks and keys will be formalized and documented. Locks and keys will be included in an inventory system, which will contain details as to individual locks and keys issued and the location where used. A 100 percent site-wide inventory will be conducted annually, and a certified locksmith(s) will be a part of the security force.

4.1.4.8 Security Force Equipment

Security force personnel will use a wide variety of equipment in accomplishing their mission, including the following:

- Side arms
- Rifles
- Shotguns and heavy caliber weapons
- Ammunition carriers
- Flashlights

- Multichannel, encrypted radios and other communications devices (i.e., cellular telephones)
- Personal protective gear (i.e., protective masks, hearing protection)
- Night vision equipment
- Binoculars
- Handcuffs and other personal restraining devices
- Duress alarms
- Body armor, tactical vests, boots and helmets
- Tear gas, mace or other alternates to deadly force
- Sedans, pickups, and specialized (i.e., hardened, response) vehicles
- Vehicular emergency devices (i.e., sirens, flashing light bars, spotlights)
- X-ray machines
- Fixed and handheld metal detectors
- Fixed explosive detectors

All security force equipment will be inventoried and inspected prior to being placed in service and then inspected monthly for serviceability. Equipment that requires periodic maintenance (i.e., vehicles, firearms, and radios) will be part of a formal and documented maintenance program. Operational tests of security force equipment will be conducted on a documented and frequent basis to ensure functionality and operability.

Certified armorers will be a part of the security force and will be the only persons permitted to inspect, repair, or modify firearms systems. An armorer certification/recertification program will be documented and put in place.

4.1.4.9 Security System Component Maintenance

All security related systems, sub-systems, and components will be maintained in operable condition in accordance with a formal maintenance program. Regularly scheduled testing and preventive maintenance programs will be established for each system, subsystem, and component.

Corrective actions will be implemented when systems, sub-systems, and components do not meet specified performance requirements. Formal compensatory measures will be put in place until equipment is restored to serviceability.

Testing and maintenance records will be maintained for all security system components.

4.1.5 Security Force[19]

4.1.5.1 General

In view of its unique status within the U.S. nuclear industry, the CSF will have its own fully capable on-site security force. Reliance on off-site LLEAs for immediate response to security events is not part of the protection strategy. LLEAs will be used for support during security events and plant emergencies, but this support will generally be limited to traffic patrols, fresh pursuit of fleeing adversaries, and ongoing intelligence functions. All security force personnel will be armed and uniformed. Unarmed escorts who do not perform response duties will also be used to augment armed personnel. Members of the security force will be hired, trained, and qualified in accordance with Appendix B of 10 CFR Part 73—General Criteria for Security Personnel, and will be distinctively uniformed. The security force will report directly to the General Manager of the CSF.

4.1.5.2 Staffing

Suitability

All members of the security force will possess a high school diploma or pass an equivalent performance-based examination. They will not have a history of felony conviction involving the use of a weapon, or felony or other convictions that reflect on their reliability.

Prior to employment, prospective security force members will pass a physical examination by a licensed physician to confirm that they have no physical weaknesses or abnormalities that would adversely affect their performance of assigned duties. Elements of the physical examination include vision, hearing, and prior alcohol or drug addictions (if an alcohol or drug addiction has existed, then proof of completion of a rehabilitation program will be provided). The medical examination will also include medical history (including any uncontrolled medical conditions, diseases, operations, and injuries that could negatively impact the individual’s job performance) and the individual’s ability to pass a physical fitness testing program.

Prospective security force members will also demonstrate mental alertness and the capacity to make good judgments, implement instructions, assimilate assigned security tasks, and possess the acuity of senses and ability sufficient to permit accurate communication by written, spoken, audible, visible, or other signals required by assigned duties. The standardized Minnesota Multiphasic Personality Inventory will also be administered and scored by a licensed and trained psychologist for all prospective security force members.

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[19] The following discussion applies whether the security force is contracted or proprietary (in-house).

Prospective security force members will also complete a physical exercise fitness program involving prescribed tasks within defined time limits. The elements of the exercise program will be based on job-related functions such as strenuous activity, physical exertion, levels of stress, and exposure to the elements. Results of tests will be documented and retained.

All security force personnel will be observed while performing assigned duties by responsible supervisors for indications of emotional instability.

Training and Qualification

Prior to any security duty assignments, security force personnel will be trained in the knowledge, skills, and abilities necessary to perform each task. The formal training program will include, but will not be limited to, the following elements:

- National and site regulations for the protection of nuclear facilities and material
- Individual role and authority in protection of the CSF
- Use of deadly force and alternates to use of deadly force
- Legal aspects of the job (i.e., arrest authority)
- Threats to nuclear facilities
- Security equipment and personal protective equipment
- Principles of security vulnerability analysis
- Security event response tactics
- Rules of adversary engagement
- Firearms training in accordance with Appendix H of 10 CFR Part 73—General Criteria for Security Personnel
- Recognition of nuclear material
- Fixed and mobile post operations
- General, Special, and Post Orders
- Coordination with LLEAs
- Self-defense and unarmed defensive tactics
- Vehicle and package inspection techniques

Prospective security force personnel will demonstrate their knowledge, skill, or ability to perform job-related tasks and will be tested in these elements. Their qualifications will be recorded and attested to by the security force training supervisor. Security force personnel will be trained and retested every 12 months on all tasks associated with normal and contingency operations, including firearms training, Failure to maintain qualifications will place the individual in a remedial training and requalification program.

Organization

The security force will be supervised by a Chief. Shifts will be supervised by a Captain. Sub-elements (i.e., CAS/SAS and response force) on each shift will be supervised by a Lieutenant. Each shift will operate as an integrated entity and all elements of the shift will be trained as units and as part of the whole. The security force will operate on a basis of four, rotating, 10-hour-long shifts. A training/relief shift will also operate on some days.

A training cadre will be used to provide initial, recurring, and requalification training programs and testing. Performance testing specialists will be used to evaluate and document the continuing readiness of individuals and shifts to perform all normal and security emergency duties.

4.2 Transportation Security

4.2.1 General

UNF is currently maintained at storage sites in 33 states, with the majority of these sites located in the eastern sector of the U.S., close to heavily populated areas. The physical protection of UNF becomes the responsibility of the DOE upon the passage of the title of the UNF and GTCC waste to the DOE. Shipments will normally be by rail, although highway or barge transport will be required when the railroad does not enter the shipper’s property.

The physical security program of UNF in transit will conform to the requirements set forth in 10 CFR 73.37, any additional NRC-mandated measures and International Atomic Energy Agency guidelines.

The in-transit physical security system will impede attempts at radiological sabotage within heavily populated areas or attempts to illicitly move such shipments into heavily populated areas; provide early detection and assessment of attempts to gain unauthorized access to or control over the shipment; notify local, regional, and state LLEAs of a security event in progress and the need for immediate armed response; and be protective in depth.

The details of the transportation security program will be documented in a generic transportation security plan, which will be reviewed and updated periodically, but no less than annually. A written addendum to the generic transportation security plan will be developed for each individual shipment.

4.2.2 Shipment Operations

4.2.2.1 Notifications

Advance written notification will be made to the NRC, and to states and Native American tribes through which the UNF will transit, providing routing information and shipment dates. Notification will be made to the governor's office or to a designated representative of the governor and to the tribal official or the tribal official's designee. To the extent practicable, shipments will be planned so as to achieve continuous transit and avoid intermediate stops along the route.

Notifications to state governors and tribal officials or their designated representatives will be postmarked at least 7 days prior to transport and received at least 4 days prior to the shipment passing through the state. Notifications will contain the following:

- The name, address, and contact information (including telephone number) of the shipper, carrier and receiver
- A description of the shipment per 49 CFR 172.202 and 172.203 (d)
- A list of the routes to be used within the state
- A disclosure that such notifications are made in accordance with NRC regulations and that it must be protected from unauthorized disclosure

A separate enclosure to the notification letter will include the following:

- The estimated date and time of shipment departure from the point of origin
- The estimated date and time of shipment entry into the state
- A statement that schedule information must be protected until at least 10 days after the last shipment has entered or originated within the state
- An estimate of the date on which the last shipment will enter or originate within the state (for recurring shipments only)

The CSF will also provide telephonic notification to the responsible individual in the governor's and tribal official's offices or their designated representatives of any change in schedule that differs by more than 6 hours from the original schedule and provide an updated estimate of the revised timeline.

Formal written arrangements will be developed with each LLEA along the routes of road, rail, and barge shipments. Such arrangements will include the following:

- A general description of the material in transit and the types of security and nuclear emergencies that may be encountered by LLEAs
- The names and contact information of personnel within each LLEA who may be requested to provide assistance during a shipment
- The types of assistance that may be required and the anticipated timelines for arrival at the shipment location
- Interface coordination procedures between the escorts and arriving LLEA during emergencies
- Contact information for the Transportation Operations Control Center (OCC)

Formal written procedures for coping with circumstances that threaten deliberate damage to the shipment and other emergencies will be developed, tested, reviewed, and maintained.

4.2.2.2 Additional Requirements for Road Shipments

Any road shipment, whether in a heavily populated area or not, will be led by a dedicated security vehicle occupied by two trained and armed CSF escorts and trailed by a dedicated security vehicle occupied by two additional armed CSF escorts, which will be designated as the shipment “response” vehicle. Alternatively, one escort vehicle may be used if the shipment is accompanied by an armed member of the jurisdictional LLEA in a separate vehicle.

Normally, escorts leading a shipment will maintain visual proximity to the transport vehicle. The escorts following the shipment will maintain at least a half mile of separation from the transport vehicle or the last vehicle in a convoy. In heavily populated areas, shipment convoys will maintain close contact, but no closer than 50 meters (165 feet). During scheduled or unanticipated stops in the route, the response vehicle will maintain no more than 100 meters (330 feet) of separation from the transport vehicle.

All CSF escort and escort response vehicles will have communications capability to permit radio frequency, citizens band, and radiotelephone contact with the OCC, LLEAs, other CSF escort vehicles, and the transport vehicle; global positioning system links for real-time location monitoring; and have extended-range fuel cells.

Escort vehicles will be equivalent to vehicle manufacturers’ “police special package” with heavy-duty suspension, brakes, alternator, transmission, and cooling systems; be unmarked; and be equipped with handheld emergency firefighting equipment and other emergency gear.

Response vehicles will be commercially available and hardened to meet National Institute of Justice Standard 0108.01 Level IV bullet resistance. They will be equipped with reinforced front and rear bumpers for ramming, run-flat/self-sealing tires, a high-intensity spotlight, and concealed “police type” strobe visual warning lights.

Road transport vehicles will be equipped with NRC-approved vehicle immobilization systems. Drivers of transport vehicles will be trained in the operational use of immobilization systems, when they should be deployed, and procedures for interfacing with the CSF escorts. Both the transport vehicle driver and the on-duty escort supervisor will have the ability to immobilize the transport vehicle.

Routes will be chosen to avoid, to the extent possible, heavily populated areas, natural restrictions, and areas that could provide cover and concealment for an adversary attack.

4.2.2.3 Additional Requirements for Rail Shipments

At least two armed CSF escorts will be continuously on-duty during rail shipments, whether in heavily populated areas or not, and located on the train in a position to maintain continuous visual surveillance of the shipment car at all stops and while in route.

Escort railcars will be of “cupola” design to provide 360-degree visual observation of the transport railcars, the balance of the train, and the surroundings; and be hardened to meet National Institute of Justice Standard 0108.01 Level IV bullet resistance. These railcars will be equipped with redundant communications capabilities (i.e., multichannel radio and radiotelephone) to communicate with the SCC, LLEA, railroad police, and the train engineer; global positioning system links for real-time location monitoring; and emergency gear including handheld firefighting equipment.

4.2.2.4 Additional Requirements for Barge Shipments

The location of some facilities will require the use of barges for transport of the UNF to the CSF. In this case, U.S. Coast Guard (USCG) or Corp of Engineers guidelines (or both) will apply. In addition, any Captain of the Port or Captain of the Port Zone orders affecting security will be enforced. Maritime Security Levels may also apply, depending on national threat levels.

At least two armed escorts are continuously on-duty during maritime shipments and are stationed either on the barge or on the lead tug vessel. The escort-in-charge will also serve as the Vessel Security Officer, which involves, *inter alia*, providing security awareness training for all maritime transport employees. The escort duties are as follows:

- Visually inspect barges, piers, cranes, and other structures prior to the loading of nuclear material. As necessary, divers will be used to inspect the underside of the barge, pier, and associated structures prior to loading.

- Maintain visual surveillance of the loading, unloading, and maritime movement of the shipment.
- Maintain continuous communication with the tow vessel(s) and the OCC.
- Maintain communication with the USCG or Corp of Engineers maritime security staff.

A Vessel Security Assessment and a Vessel Security Plan will be completed, as necessary, by USCG requirements.

4.2.2.5 Shipment Communications and Coordination

A Transportation OCC will be staffed in the Fleet Maintenance Facility (FMF) as discussed in Section 5.4.1 with a minimum of two persons during all in-transit movements. OCC personnel will monitor the progress of the shipment and provide a redundant ability for requests for assistance to LLEAs during a security or other event.

Logs will be maintained by the shipment escorts and at the OCC for each shipment. Log entries will include the following:

- Location of the plant site
- Beginning and end dates of the shipment
- Names of the escort staff
- Name of the escort commander
- Full description of any unusual event that occurs during transit

Logs will be kept for review by authorized NRC personnel for 3 years following the completion of each shipment.

4.2.2.6 Incident Command System

A formal Incident Command System (ICS) will be established along frequently travelled routes. The ICS will periodically train with civil jurisdictions, LLEA, and railroad police. The ICS will identify the incident command and command authority and describe the personnel, policies, procedures, equipment, facilities, and coordination interfaces that come into play during an emergency.

4.2.3 Escorts

4.2.3.1 General

While some states and political jurisdictions may elect to provide LLEA escorts for shipments passing through their jurisdiction, a Shipment Coordination and Escort cadre will be established within the CSF security force for the purpose of providing end-to-end escorts of all shipments. In addition to specific escorting procedures, members of the cadre will be trained and qualified similar to all members of the security force. They will also have secondary training and qualify as CSF security force trainers, and will carry the job classification of Lieutenant.

CSF escorts will accompany all shipments from the plant site to the CSF. Escorts will be armed, possess a DOE Q-clearance, and be issued a numbered police-type identification credential containing a current color photograph. The credential will reflect that the individual is armed and will provide contact information at the CSF to confirm escort identity.

Trained, qualified CSF escorts will accompany all shipments; at least two will be on duty and continuously available during a shipment. Escorts will be trained in accordance with Appendix D of 10 CFR Part 73 (see Section 4.2.3.2).

Escorts will be given formal written procedures for responding to the detection of the abnormal presence of unauthorized persons or vehicles in the vicinity of a shipment, or upon the detection of a deliberately induced situation that has the potential for damaging the shipping container(s). These procedures prepare escorts to do the following:

- Determine whether or not a threat to the shipment exists
- Assess the threat potential
- Inform LLEA of the threat and request assistance
- Take immediate and aggressive action to protect the shipment vehicles and spent nuclear material from acts of attempted radiological sabotage or illicit attempts to move the shipment vehicle

CSF escorts will not be uniformed, but will be armed during all shipment activity. A senior individual will be designated as the escort-in-charge of each shipment. A shipment security supervisor will be on duty at all times. The escort-in-charge will be the primary interface with the shipping organization and with the appropriate LLEA during the shipment. A second-in-command for each shipment will be designated in writing.

Escorts will be provided with two individual means of communication (i.e., multichannel radio and telephone) between the shipment cadre and outside organizations, and will make communications and status checks with the Transportation OCC every 2 hours.

Escorts will perform thorough visual inspections of transport vehicles prior to exiting the shipper's site, and will maintain continuous visual surveillance during all phases of the shipment. Escorts will maintain a strict code of conduct during shipments, to include abstention from the use of alcohol and illegal drugs.

4.2.3.2 Escort Training Program

Escorts will receive specific training in truck and rail procedures in accordance with Appendix D of 10 CFR Part 73, which includes the following:

- Route planning and selection criteria
- Escort vehicle operations
- Escort vehicle specialized equipment operations
- Transport vehicle familiarity
- Function and characteristics of shipping casks
- Description of radioactive cargo
- Radiation levels
- Federal, state, and local ordinances relative to radioactive material shipments and responsible agencies
- Procedures at scheduled and unanticipated stops
- Detours and use of alternative routes
- Avoiding suspicious situations
- Status reporting
- Contacts and interface with LLEA
- Procedures for reporting incidents and accidents
- Procedures for handling radioactive spills
- Responding to threats, including but not limited to the following:
  - Reporting
  - Calling for assistance
  - Use of vehicle immobilization features
  - Rules of adversary engagement
  - Handling hostage situations

Escorts will also receive firearms training and qualification/requalification, which will follow the schedule and scope established for CSF security force personnel, including the use of deadly force and specific transport rules of engagement. They will be trained and qualified to be proficient in all firearms assigned to shipment convoys.

Escorts will also receive firearms training, qualification, and requalification following the schedule and scope established for CSF security force personnel, to include the use of deadly force and the specific transport rules of engagement. They will be trained, qualified, and proficient in all firearms assigned to shipment convoys.

4.3 Cask Maintenance Facility Security

4.3.1 General

The CMF will be located outside the CSF PA. The CMF will operate routinely on a 5-days-per-week day shift, but second shift and around-the-clock operations may occasionally be necessary. Security for the CMF will be provided on a continuous basis.

4.3.2 Security Features

The CMF will be surrounded by a standard 7-foot-high chain-link fence of construction similar to the PA fence. It will have exterior illumination and CCTV assessment systems.

A continuously staffed security portal will provide non-emergency personnel access to the CMF area. It will be made of standard industrial construction with exterior illumination and redundant means of communication (i.e., multi-channel radio and telephone) to the CAS/SAS, and will also be equipped with a duress alarm. The portal will be equipped with a badge reader and a biometric identifier, metal detector, and explosives detector for entry. All personnel entering the CMF must possess a site security photo identification badge and be on a list of personnel specifically authorized for access by building operations. This list will be kept as small as possible, and records will be maintained of personnel entering and exiting the CMF area. A security force member will be stationed at the security access portal to monitor access and conduct visual and secondary inspections when needed. A second security force member will be stationed in the vicinity of the personnel access lanes in a bullet resistant enclosure.

A single (routine use) personnel access door to the CMF will be equipped with a badge reader. Not all personnel will be required to use the badge reader as long as the individual opening the door verifies the identity and authorization of others entering. A CCTV camera will be mounted exterior to the door to observe entry/exit operations and will be monitored at the CAS/SAS. All other doors to the CMF will be locked and alarmed, but will have crash-out capability, and can be opened as needed by the security force.

All pedestrian and vehicular access points to the CMF will be reinforced to provide hardening equivalent to the walls and roof. All pedestrian and vehicular portals will be equipped with “open/closed” balanced magnetic switches, which annunciate at the CAS/SAS. All exterior doors that cannot be opened from the exterior will be equipped with crash-out features.

Vehicle and rail portals will be adjacent to the security portal, with a sally port, two-gate design. Gates to access lanes will be normally closed and controlled remotely from inside the security portal. When opened, two security force members will be stationed in the vicinity of the portal. Vehicle operators entering the CMF area will exit/dismount from the vehicle when the vehicle is within the first gate, and then they will pass individually through the access control station. At least one driver-capable individual will remain with the vehicle at all times. The vehicle and its occupants will be allowed to enter the CMF area by remote opening of the second gate after all occupants pass through the access control process.

The entire CMF will be equipped with a volumetric alarm system, for use when the building is not occupied, which will annunciate at the CAS/SAS. Nuclear material within the CMF, being processed outside of the transport/storage casks, will be compartmentalized by rooms secured with badge readers. Doors to compartmented spaces will also be equipped with CCTV cameras located at strategic locations within the CMF and monitored at the CAS/SAS.

4.4 Fleet Management Facility Security

4.4.1 General

The FMF will be located outside the CSF PA. The FMF will operate normally on a 5-days-per-week day shift, but the Transportation OCC inside the FMF will be in operation whenever off-site shipments of UNF are in process. Security for the FMF will be provided on a continuous basis.

4.4.2 Security Features

The FMF will be surrounded by a standard 7-foot-high chain link fence of construction similar to the PA fence. It will have exterior illumination and CCTV assessment systems.

Security will be staffed whenever the FMF is in operation. At other times, the portal and all gates will be locked and the FMF and surrounding area will be subject to random roving patrol by the security organization. The security portal will be of standard construction with exterior illumination and redundant means of communication to the CAS/SAS and will also be equipped with a duress alarm. The portal will be equipped with a badge reader and a biometric identifier, metal detector, and explosive detector for entry. All personnel entering the FMF must possess a site security photo identification badge and be on the list of personnel specifically authorized for access by building operations.

The FMF is accessed by personnel, truck, and railroad portals that have lockable doors. When operations are underway, the door may be left open, but a “day-gate” will be installed at unattended openings. All vehicles entering the FMF fenced area will be searched by the security organization for explosives and other contraband. Vehicle and railroad entrances will have remotely operated vehicle barriers and/or train derailers to prevent unauthorized access by large vehicles. All personnel accompanying trucks or trains will be subject to access controls described above.

The FMF houses the Transportation OCC, which will have a separate personal access control system consisting of a badge reader and biometric identifier. The access portal to the OCC and the emergency access/egress portal are made of bullet-resistant material. Access portals are equipped with a CCTV system monitored by OCC staff, with secondary monitoring at the CAS/SAS. The OCC will have redundant communications to the CAS/SAS and have a duress alarm. The OCC is manned whenever an off-site shipment is underway. During off-shift hours, OCC staff will be permitted access to the FMF fenced area by the security staff.

4.5 Security Interfaces

4.5.1 General

The security force will have a variety of ongoing interactions and interfaces with other organizations on the CSF site and external to it. These interfaces will generally involve coordination for specific events or activities in which the security organization will play a role.

4.5.2 CSF Organizational Interfaces

The security organization will routinely interface with the CSF operations group. This interaction will be designed to permit the security staff to anticipate events/routine activities such as opening gates, arranging escorts for movements, being prepared to accept casks arriving from plant sites, and so forth. Second-shift or around-the-clock operations would require the scheduling of additional security personnel. Routinely planned meetings between security and operations will be scheduled on a periodic basis.

4.5.3 Off-Site Coordination

4.5.3.1 Cask Transfers from Plant Sites

The security organization’s escorting section will handle routine planning and coordination with state governors’ and tribal offices and their designated representatives, for the movement of UNF from plant sites to the CSF. This planning will involve the development of detailed route planning and emergency response information. Periodic exercises will also be held with state governors' and tribal offices to practice and test the validity of procedures.

Extensive planning will also be conducted with state and tribal law enforcement organizations and agencies for transport awareness, notification, and response purposes. "Safe havens" would also be identified in the event shipments must be halted for weather or other emergency situations. LLEAs must know the kinds of support that might be needed, as well as any limitations on responses. In addition to an armed response, LLEAs may provide traffic control, advance information to the escort group on rail or road conditions that might impact the shipment schedule, and routine intelligence on any individuals or groups in the locale who might represent a threat to the nuclear material movement.

Railroad police organizations are a unique LLEA entity with whom the security escort group will routinely interface. Because railroad police organizations have interstate jurisdiction, they will be an important partner in planning and escorting long-haul shipment operations.

4.5.3.2 Federal and State Regulatory Agencies

An emergency response to a radiological event would put the escort unit in cooperation with the Department of Homeland Security (DHS), the Federal Emergency Management Agency, the USDOT (relating to the hazardous material transportation requirements set out in Title 49 of the USDOT Code), the DOE Regional Coordinating Offices for the region in which the event occurs, and the DOE Regional Radiological Response Teams. Federal Emergency Management Agency-coordinated emergency response drills will be a recurring activity requiring extensive planning and advance collaboration. Coordinating with the DHS on protective matters and intelligence programs will be ongoing. Shipments also require notification to the NRC and related state nuclear regulatory bodies. The escort unit will plan for and complete such notifications on a per-shipment basis. Shipment security will also be subject to periodic review by the NRC. Liaison with the USCG and/or the U.S. Army Corps of Engineers will be necessary for maritime-specific security requirements.

4.5.3.3 Railroad, Truck, and Maritime Transport Companies

Advance and per-shipment coordination will be required with railroads and truck transport entities. Coordination will be conducted to ensure engineers, drivers, and other transport staff will be knowledgeable of the shipment communication requirements between escorts, engineers, and drivers. Transport staff will exercise routine and emergency communications as well as exercise assigned duties prior to actual shipments in an effort to provide seamless and effective practices for spent fuel transport. Truck transport drivers will also practice remote disabling techniques using simulated casks. For maritime shipments, the Vessel Security Assessment and Vessel Security Plan will be reviewed in advance by CSF transportation staff so that security is seamless between CSF and shipping entities.

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5.0 TRANSPORTATION

5.1 Design Basis

5.1.1 Design Basis Conditions and Needs

Specific conditions and needs that must be met by the transportation logistics system include the following:

- One or more CSFs must be available to accept UNF.
- Plant sites (beginning with shutdown plant sites with stranded UNF and GTCC low-level radioactive waste) must be able to properly load and offer the material to be shipped, when the CSF is ready to receive it.
- Contractual, production, and staffing arrangements must be in place for trained and qualified personnel to fabricate and maintain transport casks, develop and maintain rolling stock to meet special requirements, assist in the loading of UNF and GTCC waste into transport casks, perform inspections and document compliance with requirements, and ship the casks to one or more CSF sites. (The term “cask” in this section refers to a transport cask unless otherwise specified.)
- States, Native American tribes, and local governments along potential shipping corridors will need to be involved in planning for such shipments and will need to be prepared to respond in case of an emergency or other event involving the shipments. Section 180(c) of the Nuclear Waste Policy Act requires the DOE to provide technical assistance and funds to prepare for such shipments. Based on the experience of other, previous campaigns (discussed later in this section), it may be necessary to make arrangements for state and tribal officials to perform equipment inspections and security assessments, provide escorts, monitor shipments passing through their jurisdictions, and perform other activities.

5.1.2 Design Basis Regulatory Requirements

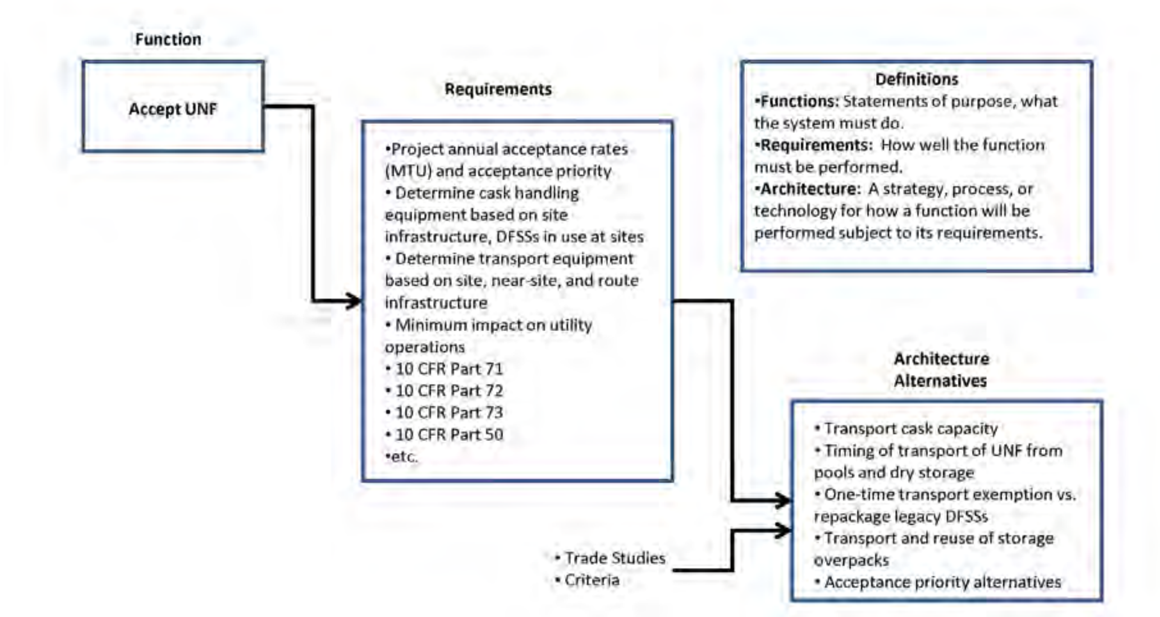
Requirements that must be met by the transportation logistics system are defined by specific statutes, federal and state/tribal regulations (as applicable), and procedures defined in DOE orders and implementing guidance. At the federal level, regulatory oversight is shared primarily between the NRC and different modal administrations within the USDOT. The regulatory framework governing UNF transportation is comprehensive. A full discussion of the key relevant regulations can be found in a report developed for the BRC titled, “Overview of High-Level Nuclear Waste Materials Transportation: Processes, Regulations, Experience and Outlook in the U.S.,” ERI-2030-1101, (January 2011, p. 17 et seq.) and is not repeated here; however, regulatory requirements of special interest are discussed as appropriate. The discussion that follows assumes strict compliance with all regulations. Going above and beyond regulatory requirements, where experience and established best practices indicate doing so would be prudent, may also be appropriate under certain circumstances.

5.1.3 Transportation System Requirements and Architecture

5.1.3.1 Accept UNF

Figure 5.1-1 shows the results of applying the systems engineering approach described in Section 2.0 to the "Accept UNF" function, which will take place at the plant sites. In addition to the relevant requirements imposed by the CFRs, additional requirements, such as "minimize the impact on reactor operations", must be considered and satisfied by the preferred waste acceptance concept/strategy. A set of feasible alternatives was formulated that could potentially satisfy the "Accept UNF" function and its allocated requirements. Trade studies, which are described later in this section, were conducted to evaluate, compare, and recommend the preferred alternatives.

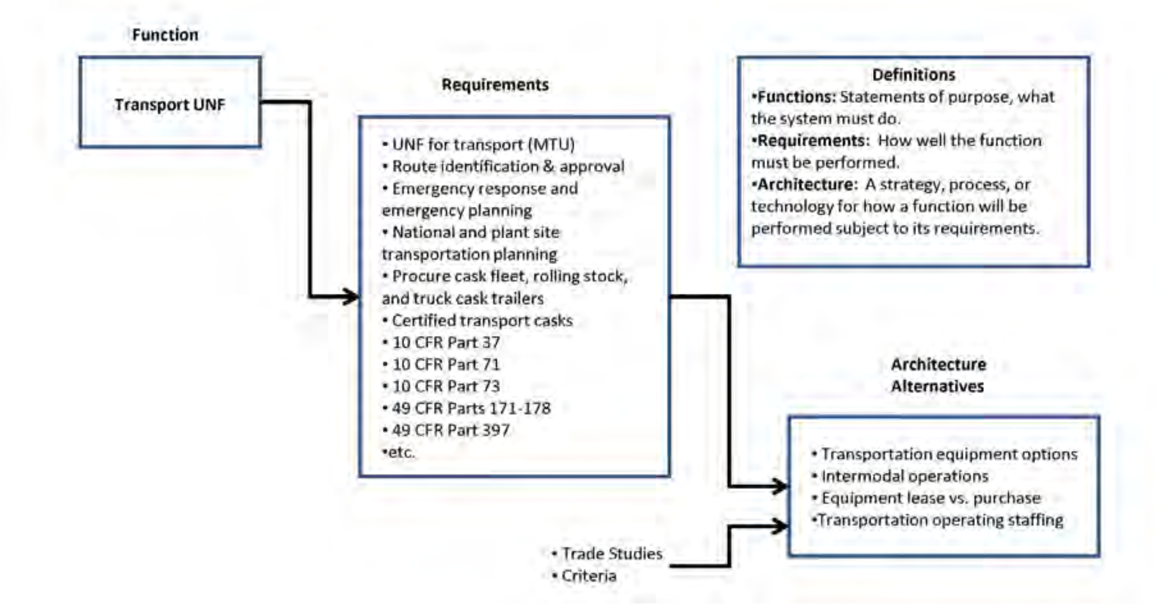
Figure 5.1-1
Requirements and Architecture for the "Accept UNF" Function



5.1.3.2 Transport UNF

Figure 5.1-2 shows the results of applying the systems engineering approach to the "Transport UNF" function, which will take place following acceptance of UNF from the reactor sites. In addition to the relevant requirements imposed by the CFRs, additional requirements, such as route identification and route approval, national and plant site planning, emergency response and emergency preparedness, and procurement of a cask fleet and rolling stock, must be considered and satisfied by the preferred preparation concept/strategy. A set of feasible alternatives was formulated that could potentially satisfy the "Transport UNF" function and its allocated requirements. Trade studies, which are described later in this section, were conducted to evaluate, compare, and recommend the preferred alternatives.

Figure 5.1-2
Requirements and Architecture for the "Transport UNF" Function



5.1.3.3 Process Flow at the Plant Sites

The process flow diagrams in **Figure 5.1-3**, **Figure 5.1-4**, and **Figure 5.1-5** show how the UNF will be handled at the plant sites from its initial removal from either wet or dry storage through its placement in a transport cask and onto a railcar. The top path through the diagram in **Figure 5.1-3** shows the logic for handling UNF that had been stored in pools and had been sufficiently cooled for transport. Bare UNF will either be loaded directly into a dual purpose cask for transport to the CSF or loaded into a canister, which will flow through the additional steps shown in **Figure 5.1-4** and **Figure 5.1-5**, similar to those required for UNF originally in dry storage.

Figure 5.1-3
Process Flow at the Reactor Sites

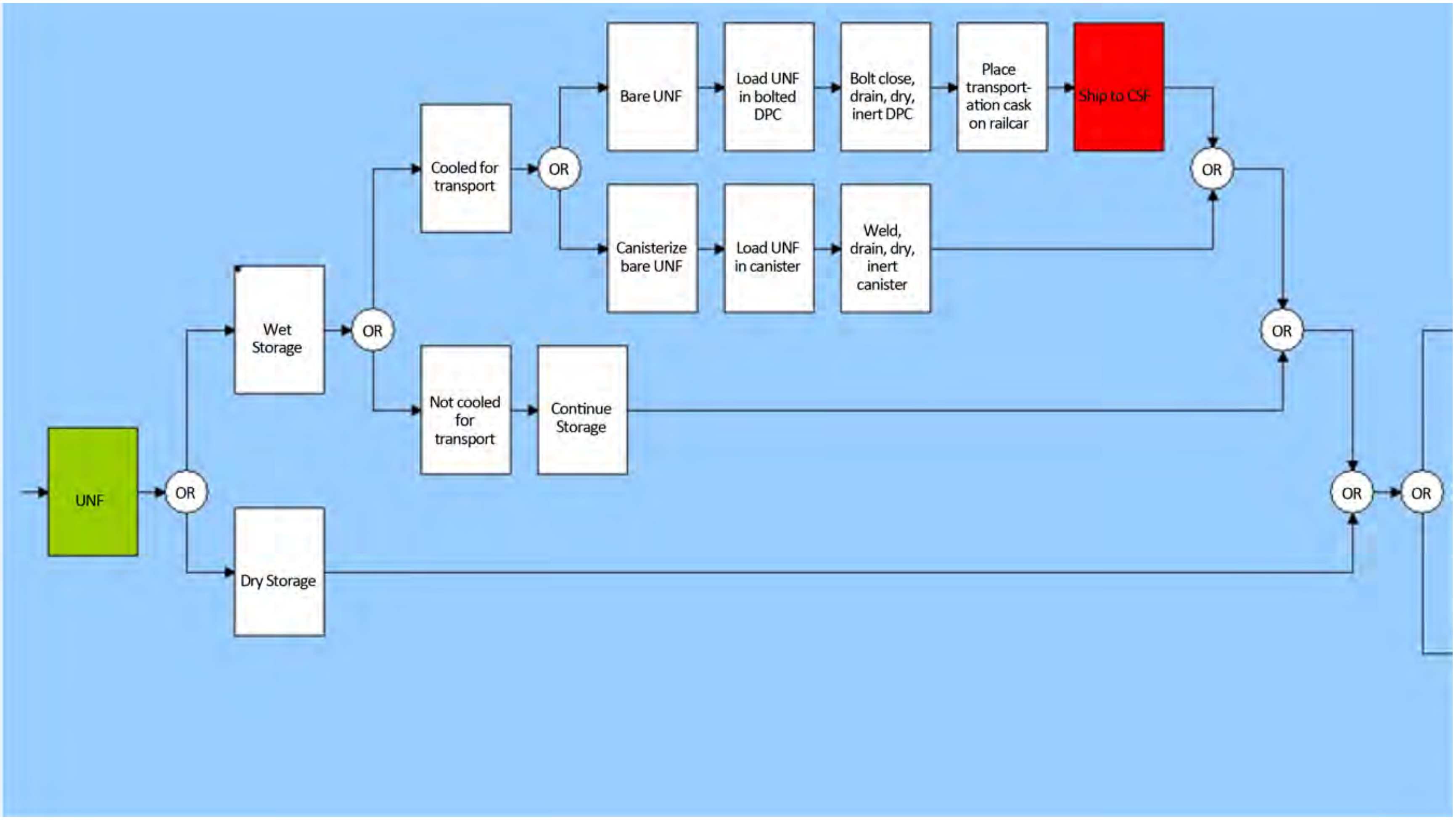


Figure 5.1-4
Process Flow at the Reactor Sites (continued)

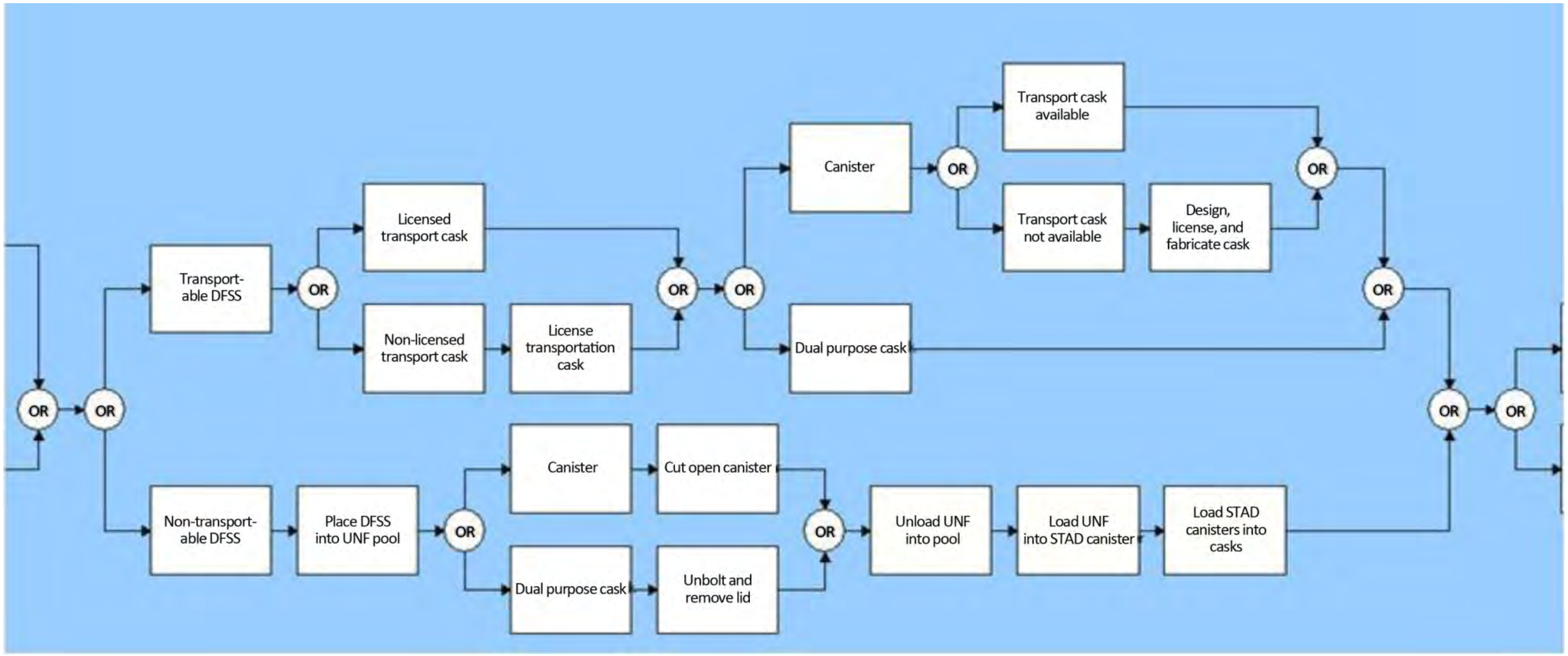
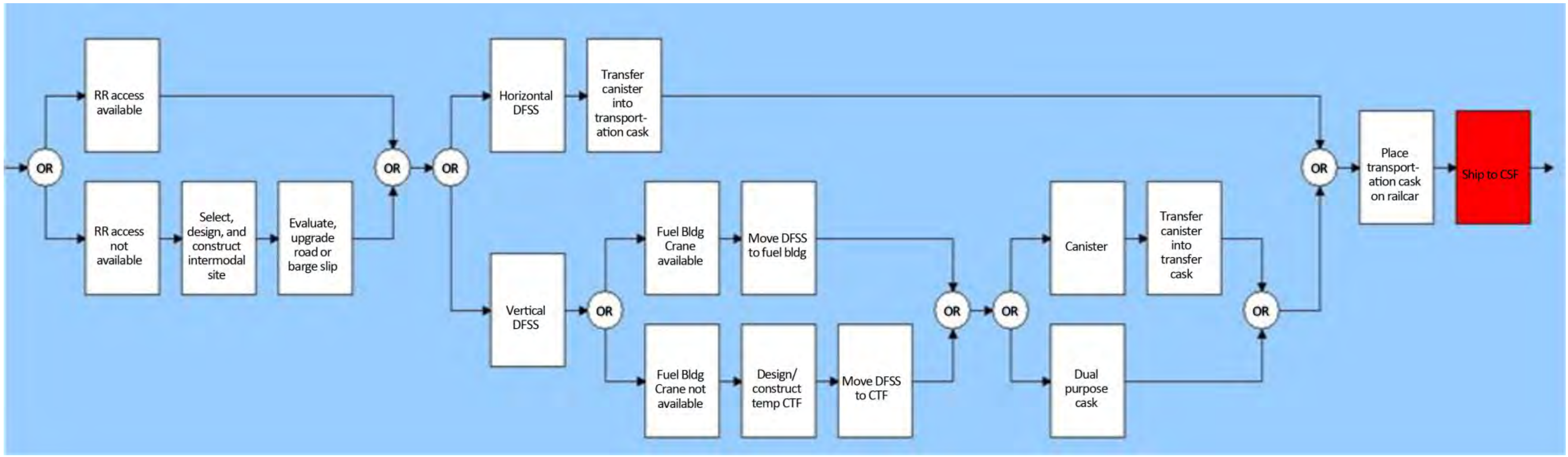


Figure 5.1-5
Process Flow at the Reactor Sites (continued)



5.1.4 Design Basis Transportation Best Practices

In 2007, the Office of Civilian Radioactive Waste Management (OCRWM) completed a comprehensive benchmarking study and issued a report titled, “Radioactive Waste Logistics Benchmarking: Project Status Report and Interim Findings,” DOE-PLN-ECT-EI000001 (May 2007). The benchmarking project began in 2005 and was intended to identify, document, and better understand best practices for logistics enterprises. The project team examined lessons learned from historical waste transportation campaigns and also focused on three ongoing logistics enterprises that were very different in scope, yet were widely viewed as successful: (1) the Waste Isolation Pilot Plant; (2) the Naval Nuclear Propulsion Program; and (3) the domestic and foreign research reactor UNF acceptance programs located at the Savannah River Site in South Carolina and at the Idaho National Laboratory.

The benchmarking project adapted a standard best practices study format based on guidance from the Government Accountability Office and the Department of Defense. The report focused on four key aspects of logistics planning: (1) management structures and processes; (2) contract management/procurement; (3) stakeholder relations; and (4) continuity planning.[20] The study findings can be summarized as follows.

Management Structures and Processes

- Involve both waste origin and destination sites in transportation planning—these sites have other ongoing activities that need to be factored in when scheduling shipments.
- Build “matrixed” teams of logistics professionals from different disciplines, such as engineering, risk management and communications, and cross-train them.
- Develop comprehensive transportation plans, and manage and adapt them on an ongoing basis.
- Keep decision-making delegation chains short, as logistics is a “hands-on” activity.
- Extensively pilot-test and refine plans, equipment, and operations.
- Anticipate new developments in tracking and emergency technology, and plan for ongoing integration of them.

Contract Management and Procurement

- Transportation-related goods and services, such as cask manufacturing and carrier services, are commonly outsourced. However, overall responsibility remains with the management entity.

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[20] DOE-PLN-ECT-EI000001, at iii.

- Whether purchasing or leasing equipment, it is important to retain strong control over mission-critical assets and functions. Examples include acquisition of casks and related customized vehicles, such as trailers and railcars; equipment design, testing, and inspection services; equipment maintenance; and carrier availability.

Stakeholder Relations

- Safety is a shared concern of shippers, carriers, and federal, state, tribal and local officials. Safety must be the basis for working relationships with stakeholders (i.e., effective communications contributes to safety and is not just good public relations).
- Make cooperative shipment planning involving state, tribal, and local officials the rule, not the exception.
- Build working relationships using training, demonstrations, and exercises.
- Work through well-established stakeholder networks (i.e., use state/regional groups and other organizations with experience).
- Integrate stakeholder relations and technical operations (i.e., there are no purely technical logistics issues that are beyond the potential scope of stakeholder concern).
- Carefully track and manage commitments to planning partners.

Continuity Planning

- Integrate backup plans and communications into system planning. Events will inevitably arise that impact logistics operations and communications/monitoring services. Have backup systems and procedures in place and ensure all parties are familiar with them.

5.2 System Capacity Alternatives

5.2.1 Overview

Three alternative system capacities (i.e., maximum system acceptance rates of 3,000 MTU, 4,500 MTU, and 6,000 MTU annually) have been considered, all of which place a high priority at the beginning of the process on preparing and shipping stranded UNF from the existing shutdown reactor sites to the CSF. Acceptance of UNF from operating reactor sites would then commence. The BRC Report (p. 39) states the following:

> “Considering current uncertainties about long-term degradation phenomena in dry storage systems, it would be prudent to initiate a planned, deliberate, and reliable process for moving spent fuel from shutdown reactor sites to a central facility before any issues arise and where problems can be dealt with much more easily and cost effectively than at multiple shutdown sites.”

Consideration of the three alternative system capacities examines system throughput, system efficiency (i.e., how long can the maximum throughput be sustained), the ability of operating nuclear power plants to load UNF into transport systems for shipment off site under maximum system acceptance rates, and the impact of the start date for waste acceptance on system capacity. The analysis assumes that a CSF could be available in 2020 for shipment of a limited quantity of UNF from existing shutdown nuclear power plants that are not located at operating reactor sites (referred to as “stranded plants”). Acceptance of UNF from operating nuclear power plants would not begin until the fourth year of waste acceptance, which is 2023 in this analysis. In terms of system capacity, the longer acceptance is delayed beyond 2020, the more throughput capacity will be needed (although capacity could be increased incrementally depending on then-relevant circumstances). Absent increased shipping capacity, UNF will remain at shutdown plants for longer periods.

As discussed in more detail later in this section, within the analysis of the three alternative system capacities, alternatives for UNF acceptance priority are also considered. The BRC Report (p. 42) states the following:

> “The Commission recognizes that existing contracts have created a “queue” in terms of federal commitments to accept spent fuel from specific utilities. Unfortunately, the existing queue was not set up to maximum efficiencies or to minimize the impacts of fuel handling and transportation.”

Under all the UNF acceptance priority alternatives evaluated, shipment of UNF from the existing shutdown plant sites takes place in the initial 6 years of waste acceptance. For the remaining UNF from operating plant sites, the analysis conducted examines three alternative acceptance priority scenarios: (1) UNF acceptance that is based on an OFF acceptance priority ranking as called for in the Standard Contract;[21] (2) priority is provided for shutdown plant sites; and (3) an “OFF-Plus” priority ranking, which utilizes the ranking basis provided in the Standard Contract but structures UNF acceptance in campaigns in order to minimize the number of sites that ship UNF on an annual basis and thus increase transportation efficiency. The acceptance priority scenarios are discussed in more detail later in this section and are evaluated based on working within the language of the Standard Contract, impacts on waste acceptance and transportation system planning and logistics, and ease of implementation both contractually and logistically.

5.2.2 Inventory and Site Interface Assumptions

The following sections identify the assumptions utilized in this study regarding the expected inventories of UNF from existing shutdown plant sites, operating plant sites, and new reactors over the next 60 years. The interface with dry storage equipment and plant facilities

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[21] 10 CFR Part 961, “Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste.”

at existing shutdown plants is described, including identification of the transport cask designs that will be required, the number of cask shipments, and the amount of GTCC low-level radioactive waste at these plants. While a more detailed summary of the various dry storage systems that are deployed at operating plant sites is provided elsewhere in the report, the transportation interface at operating plant sites is also described later in this section.

5.2.2.1 Used Nuclear Fuel Inventory

This analysis assumes that the majority of licensed commercial nuclear power plants in the U.S. continue to operate for a period of 60 years through the end of their renewed licenses. Two units, Kewaunee and Oyster Creek, are assumed to shut down in 2013 and 2019, respectively, as announced by Dominion and Exelon, respectively. The analysis also includes UNF discharges from the following new nuclear power plants: Tennessee Valley Authority’s Watts Bar 2, Southern Nuclear’s Vogtle Units 3 and 4, and South Carolina Electric & Gas Company’s V.C. Summer Units 2 and 3. Total lifetime arisings of UNF are estimated to be 140,000 MTU through 2082, as shown in **Figure 5.2-1**.

It should be noted that it is possible that existing nuclear power plants could operate for an additional 20 years with renewed licenses, and that additional new nuclear power plants (beyond the five new plants noted above) will begin operating during the time period analyzed. While this analysis does not quantitatively calculate the UNF discharges associated with new reactors or 80-year reactor lifetimes, the ability to accommodate these additional quantities of UNF in the waste acceptance and transportation system capacity alternatives analyzed is discussed. A typical new nuclear power plant, with a rated capacity between 1,000 and 1,600 MWe, operating for 60 years, would generate between 1,500 and 2,000 MTU of UNF over its lifetime. An existing 1,000-MWe nuclear power plant would be expected to generate an additional 500 MTU of UNF if its license was extended from 60 years to 80 years.

At present, there are nine shutdown plant sites, as shown in **Figure 5.2-2**. In addition, this analysis assumes that the Oyster Creek plant will permanently cease operation in 2019 after 50 years of operation, and Kewaunee will permanently cease operation in 2013 after 39 years of operation. **Figure 5.2-2** also presents the annual number of shutdown plant sites with no operating nuclear power plants. For a multi-unit site, a site is considered to be a shutdown plant site when the last operating unit at that site permanently ceases operation. There is a large number of nuclear power plant sites that will reach the expiration of their 60-year extended licenses between 2032 and 2036 and again between 2042 and 2048. The three plant sites with new reactors do not become shutdown plant sites until the new reactors reach the end of their 60-year renewed licenses after 2070. These reactors are not depicted in **Figure 5.2-2**.

Figure 5.2-1
Historical and Projected Pool Storage and Dry Storage UNF Inventories from Commercial Nuclear Power Plants through 2055

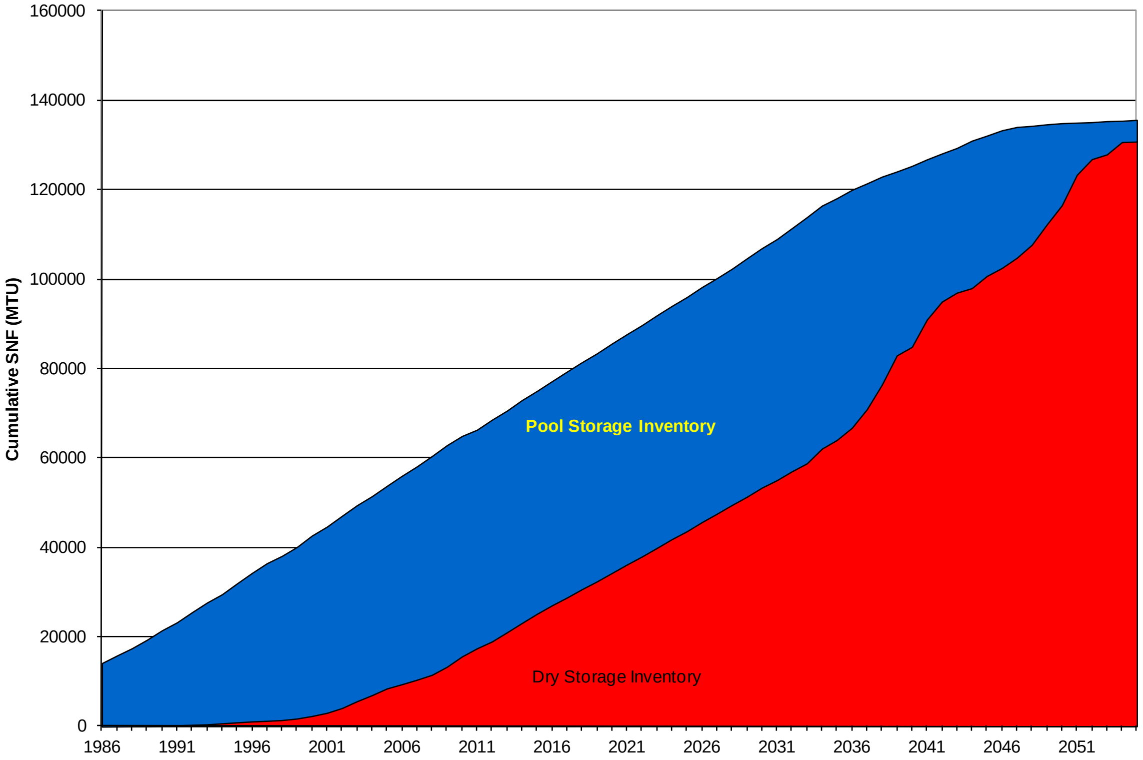


Figure 5.2-2
Number of Shutdown Nuclear Power Plant Sites Through 2055

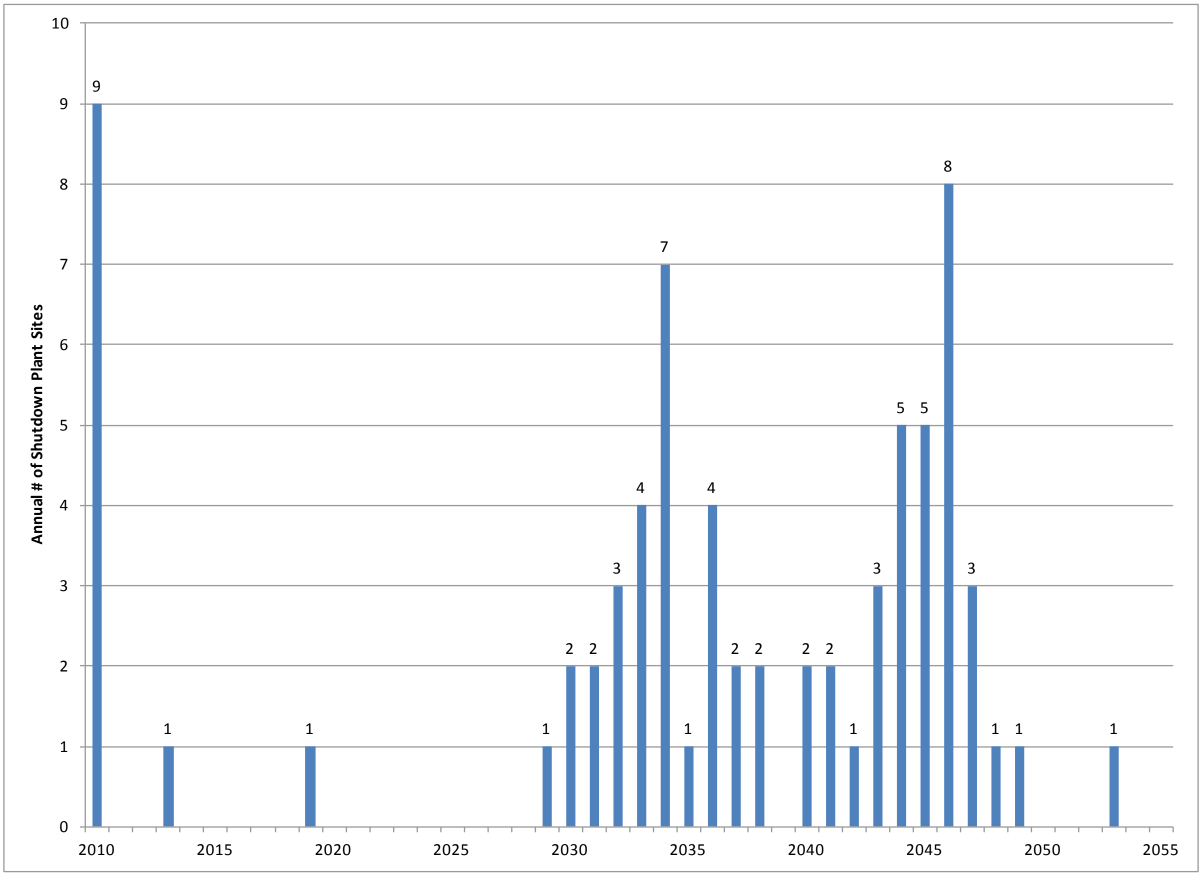


Table 5.2-1 identifies the existing and expected shutdown sites through 2020 and the number of canisters of UNF and GTCC waste at these sites in 2012. In the case of Zion 1 and 2, loading operations for canisters of UNF and GTCC waste are expected to begin in 2013.

Table 5.2-1
Existing and Expected Shutdown Plant Sites through 2020

Shutdown Plant Site	Plant Owner/Operator	Dual Purpose Storage/Transport System	Transport Status of Dual Purpose System	Number of Systems Loaded/(Expected)
Big Rock Point (Michigan)	Entergy Operations	Fuel Solutions	CoC 71-9276	7 UNF, 1 GTCC
Haddam Neck (Connecticut)	Connecticut Light & Power	NAC MPC-26 NAC STC	CoC 71-9235	40 UNF, 3 GTCC
Humboldt Bay (California)	Pacific Gas & Electric	HI-STAR HB, MPC-HB	CoC 71-9261	5 UNF, (1 GTCC)
LaCrosse (Wisconsin)	Dairyland Power Corporation	NAC MPC-68 NAC STC	CoC 71-9235	5 UNF
Maine Yankee (Maine)	Maine Yankee Atomic Power	NAC UMS-24 NAC UTC	CoC 71-9270	60 UNF, 4 GTCC
Rancho Seco (California)	Sacramento Municipal Utility District	NUHOMS-24PT MP-187	CoC 71-9302	21 UNF, 1 GTCC
Trojan (Oregon)	Portland General Electric	TranStor/HI-STORM MPC-24 HI-STAR 100	CoC 71-9261	34 UNF
Yankee Rowe (Massachusetts)	Yankee Atomic Electric Company	NAC MPC-36 NAC STC	CoC 71-9235	15 UNF, 1 GTCC
Zion 1 & 2 (Illinois)	Energy Solutions	NAC MAGNASTOR-37 (planned) MAGNATRAN	License application submitted to NRC, system not yet certified	(61 UNF, 4 GTCC)
Total System Loaded or Expected at Existing Shutdown Plant Sites				248 UNF, 15 GTCC
Oyster Creek (expected 2018) (New Jersey)	Exelon Corporation	NUHOMS-61BT MP-197	CoC 71-9302	77 UNF, 1 GTCC (23 currently loaded. An additional 54 expected through end of license.)
Kewaunee (expected 2013) (Wisconsin)	Dominion Energy	NUHOMS-32PT MP 197	CoC 71-9302	42 UNF, (1 GTCC) (8 currently loaded. An additional 34 expected through end of license.)

5.2.2.2 Transportation Interface with Existing Shutdown Nuclear Power Plant Sites

As shown in **Table 5.2-1**, all the existing shutdown plant sites have transferred or are planning to transfer UNF from spent fuel storage pools (SFPs) to dry storage using dual purpose storage and transport systems. All these systems are or will be licensed or certified by NRC under 10 CFR Part 71 (for transport) and 10 CFR Part 72 (for storage). The Zion plant has not yet started transfer of UNF to dry storage, but is expected to begin dry storage in 2014. All the shutdown plant sites utilize canister-based dual purpose systems, and the canisters currently in storage have been certified for transport. Only the NAC MAGNASTOR canisters are not yet certified for transport, but NAC has submitted a license application to the NRC for certification of the MAGNATRAN transport cask with a MAGNASTOR canister. As shown in **Table 5.2-1**, a total of 248 dual purpose canister systems will be loaded with UNF at existing shutdown plant sites (including those planned to be loaded at the Zion site) and another 15 dual purpose canisters will be loaded with GTCC waste (including 1 canister planned at Humboldt Bay and 4 GTCC canisters at Zion). An additional 78 dual purpose canisters (77 UNF and 1 GTCC canister) are projected to be loaded at Oyster Creek. A total of 43 dual purpose canisters (42 UNF and 1 GTCC) are projected to be loaded at Kewaunee. It should be noted that UNF remaining in the Oyster Creek and Kewaunee SFPs at the time the plants shut down could also be shipped directly from the SFPs in standard bolted transport casks, if such a cask system is available.

While all the dry storage canister designs currently loaded at shutdown plant sites are certified for transport in a transport cask, only two of the canister designs have transport casks that have been fabricated. Sacramento Municipal Utility District (SMUD) owns one MP-187 transport cask that is certified to transport SMUD’s NUHOMS-24PT canisters. However, not all of the equipment needed for transportation has been fabricated. Needed transportation equipment may include impact limiters, metallic seals, a cask transport skid, and a personnel barrier. Since SMUD has 21 canisters loaded with UNF and 1 canister storing GTCC waste, additional MP-187 transport casks (and related equipment) would also need to be fabricated as discussed in more detail later in this section.

Humboldt Bay is currently storing UNF in five HI-STAR HB systems, while one GTCC canister is expected to be loaded and stored in a HI-STAR HB. The HI-STAR HB system is comprised of a bolted-lid, metal cask that houses a sealed metal canister, the MPC-HB. It is licensed for storage under Humboldt Bay’s 10 CFR Part 72 site-specific license and certified for transport under 10 CFR Part 71. The Humboldt Bay ISFSI consists of a below-grade storage vault, an on-site cask transporter, and the HI-STAR HB DFSS. The HI-STAR HB systems would have to be retrieved from the below-grade storage vaults for transport off site, and transport equipment (such as impact limiters, a cask transport skid, and personnel barriers) would need to be fabricated. The HI-STAR HB cask is shorter than the HI-STAR 100 cask; it is unlikely that the HI-STAR HB casks could be reused to transport UNF from other sites using the Holtec HI-STORM system.

All of the remaining existing shutdown plant sites utilize dry storage technologies for which casks have not yet been fabricated. The following cask designs would need to be fabricated in order to remove UNF from the existing shutdown sites:

- FuelSolutions TS125 (CoC 71-9276) for transport of UNF from Big Rock Point
- NAC STC (CoC 71-9235) for transport of UNF from Haddam Neck, LaCrosse, and Yankee Rowe
- NAC Universal Transport Cask (UTC; CoC 71-9270) for transport of UNF from Maine Yankee
- Holtec HI-STAR 100 (CoC 71-9261) for transport of UNF from Trojan
- NUHOMS MP-187 (CoC 71-9302) for transport of UNF from Rancho Seco
- NAC MAGNATRAN for transport of UNF from Zion
- NUHOMS MP-197HB for transport of UNF from Oyster Creek

There are seven HI-STAR 100 casks that are being used for dry storage of UNF at Dresden 1 (four casks) and Hatch (three casks). It may be possible to strategically transport these HI-STAR casks to the CSF, unload the canisters to dry storage, and utilize the HI-STAR casks to transport UNF canisters from the shutdown Trojan plant, rather than fabricating additional HI-STAR casks for acceptance of UNF from current shutdown plant sites.

It is unlikely that the FuelSolutions and NAC STC casks would be reused to transport UNF from operating nuclear power plants in the future, since the dry storage systems associated with these casks are not used at any operating nuclear power plant sites. The NAC UTC, HI-STAR 100, MAGNATRAN, NUHOMS MP-187 (Rancho Seco), and NUHOMS MP-197 (Oyster Creek) casks fabricated to transport UNF from existing shutdown plants could be utilized as part of the cask fleet to transport UNF from operating sites. Transport cask CoCs are valid for five years and may be renewed every five years. All of the existing transport cask have been certified under current NRC regulations and are expected to be suitable for use for several decades.

Transport equipment that would generally accompany a cask to a site would include a cask lift yoke, slings, impact limiters, a cask transport skid, a personnel barrier, and other ancillary equipment needed for canister transfer. In addition, shutdown nuclear power plant sites using canister-based, vertical ventilated storage cask systems that have decommissioned spent fuel storage pools and cask cranes will require portable cranes that are capable of supporting the canister transfer operation from the concrete storage overpack to the transport cask. This may require use of a temporary canister transfer facility to provide seismic stability during the canister transfer operation. In horizontal dry storage systems, such as the NUHOMS system, canisters can be transferred directly from the horizontal storage module to the transport cask without the need for a canister transfer facility. However, it is likely that a portable crane will be needed to lift the transport cask lid and HSM door, and for other operations during transfer of the canister for transport off site.

In addition to identification and acquisition of equipment required to retrieve and accept UNF from shutdown plant sites, the logistics associated with movement of loaded transport casks from the sites would be developed in advance of waste acceptance. This would include development of site surveys and site-specific routing plans including identification of heavy-haul routes, receipt of local permits, etc. Many shutdown sites established heavy-haul routes for removal of reactor pressure vessels and other large components as part of the decommissioning process and this experience can be relied upon for the removal of UNF.

5.2.2.3 Transportation Interface with Operating Nuclear Power Plant Sites

In order to embark on a nationwide program to transport UNF from operating plant sites to a CSF, it will be necessary to procure UNF cask systems as well as the transportation equipment needed to transport the casks. Since almost all U.S. commercial nuclear power plant sites are expected to implement dry storage by approximately 2025, this analysis assumes that the majority of UNF will be transported by rail in large-capacity rail casks. Assuming that the CSF begins operation in 2020, at least a decade prior to currently operating nuclear power plants reaching the end of their renewed license terms (as shown in **Figure 5.2-1**), nuclear operating companies are likely to want UNF to be removed from SFPs first, prior to the removal of already-loaded dry storage systems, so that the companies do not have to load additional dry storage systems. If UNF is being removed directly from SFPs, it may be efficient to load UNF into standard bare fuel casks (i.e., casks that transport bare fuel assemblies housed in an inner basket, but that do not utilize a welded metal canister for containment of UNF). Such a standard cask, along with the necessary transportation equipment, would need to be designed, certified, and fabricated. If bare fuel casks are utilized to transport UNF from SFPs, the CSF would need to have pool capacity in place to unload the casks and repackage the UNF into storage casks. The timeline for development of new cask designs is discussed in more detail in Section 5.2.5. Another option is the development of a standard transport, storage, and disposal canister that could be shipped in a standardized transport cask.

In addition, assuming that some quantity of UNF is removed directly from SFPs, Indian Point 3 does not have the capability to lift a large rail cask. Indian Point 3 has a 40-ton crane.

For dry storage, the site is transferring UNF in a 12-assembly transfer cask to the SFP of Indian Point 2 in order to load a 32-assembly 125-ton dual purpose canister system. Indian Point 3 may need to utilize standard truck casks for removing UNF from its SFP for transport, unless the site is willing to continue to utilize the 12-assembly transfer cask to transfer UNF to the Indian Point 2 SFP so that a rail cask can be loaded for transport off-site. It is also possible that other sites would need to ship some limited quantity of UNF using truck casks. For example, if only a few assemblies are required to be shipped in order to complete removal of UNF from a plant, it may be more efficient to use truck casks rather than not fully loading a rail cask. At present, the NAC Legal-Weight Highway Truck (LWT) Cask, has been certified and fabricated. The GA-4 truck cask has been certified, but none have been fabricated. In addition, Transnuclear submitted a new legal-weight truck cask design, the TN-LC, to the NRC for certification. That design is currently undergoing NRC review.

Dual purpose canisters that are already loaded with UNF in vertical ventilated cask systems would be transferred from the concrete storage overpack to a transfer cask, and then to a transport cask for shipment off site. This can likely be accomplished using a plant’s existing cask handling crane and transfer cask. Currently, the dual purpose canister-based, vertical ventilated systems that are utilized for storage at operating nuclear power plant sites include the Holtec HI-STORM, the NAC UMS, and the NAC MAGNASTOR systems. The horizontal NUHOMS system permits the canister to be moved directly from the HSM into a transport cask and does not require a transfer cask for this operation. Transport casks for these various storage systems would need to be fabricated, along with equipment needed to lift and load the cask and for transport off-site. Equipment might include transport cask lift yokes, lift slings, impact limiters, metallic seals, a transportation skid, a personnel barrier, and other ancillary equipment required by the transport cask CoC.

Several sites utilize dual purpose bare-fuel casks (i.e., metal casks that are certified for storage and transport). These systems (TN-68, TN-40, and TN-40HT) would need to be prepared for transport, including fabrication of needed transportation equipment such as impact limiters, cask skids, and personnel barriers. The TN-32 cask, while not currently certified for transport, should be able to be certified under 10 CFR Part 71. A plant’s existing cask handling crane and cask transporter could be utilized to transfer the loaded cask from the ISFSI to the cask crane to be lifted onto the transport vehicle for transport off site.

5.2.3 Waste Acceptance and Transportation System Capacity Alternatives

Three alternative system capacities (i.e., maximum system acceptance rates of 3,000 MTU, 4,500 MTU, and 6,000 MTU annually) have been considered, all of which place priority at the beginning of the process on preparing and shipping UNF from the existing shutdown plant sites to the CSF. Acceptance of UNF from operating plant sites would then commence. All scenarios assume that acceptance begins in 2020. As shown in **Table 5.2-2**, the 3,000 MTU scenario assumes that the maximum 3,000-MTU overall acceptance rate is reached by the fifth year of operation. This overall acceptance rate was previously used by the DOE.

Under the 4,500 MTU overall acceptance rate, it is assumed that acceptance of UNF initially ramps up to an overall rate of 3,000 MTU by the fifth year of waste acceptance. Additional acceptance capacity is assumed to be added to the system beginning in 2030, either at the same facility initially operational in 2020 or at a second CSF. This additional capacity adds 1,500 MTU of additional capacity so that the maximum overall acceptance rate reaches 4,500 MTU per year by 2033. The additional 1,500 MTU of acceptance capacity could be used to transport UNF from current operating plants when they begin to reach the end of 60-year license terms, to transport UNF from new reactors, or to continue to transport UNF from existing plants under 60-year license terms (or possibly 80-year license terms).

Under the 6,000 MTU overall acceptance rate, it is assumed that acceptance of UNF ramps up to an overall rate of 6,000 MTU per year by 2027, the eighth year of waste acceptance. This capacity could be provided by one or more CSFs.

Table 5.2-2
Waste Acceptance and Transportation System Capacities

Acceptance Year	Maximum Rate 3,000 MTU	Maximum Rate 4,500 MTU	Maximum Rate 6,000 MTU
2020	400	400	400
2021	600	600	600
2022	1,200	1,200	1,200
2023	2,000	2,000	2,000
2024	3,000	3,000	3,000
2025	3,000	3,000	4,000
2026	3,000	3,000	5,000
2027	3,000	3,000	6,000
2028	3,000	3,000	6,000
2029	3,000	3,000	6,000
2030	3,000	3,400	6,000
2031	3,000	3,600	6,000
2032	3,000	4,200	6,000
2033	3,000	4,500	6,000
Thereafter	3,000	4,500	6,000

The following three alternative acceptance priority alternatives are evaluated in this analysis:

- UNF acceptance is based on an OFF acceptance priority ranking as called for in the Standard Contract.
- Priority is provided for shutdown nuclear power plants.
- An "OFF-Plus" priority ranking, which utilizes the ranking basis provided in the Standard Contract, but structures UNF acceptance in campaigns in order to minimize the number of sites that ship UNF on an annual basis.

As noted previously, all three acceptance priority alternatives assume that UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. Acceptance of UNF from operating plant sites begins in the fourth year of waste acceptance, 2023.

5.2.3.1 Oldest Fuel First

According to the Standard Contract, the priority ranking for assigning UNF acceptance rights is based on the age of the UNF as determined from the date that the UNF was permanently discharged from a nuclear reactor. This priority ranking methodology is typically referred to as "Oldest Fuel First" (OFF), since the oldest UNF receives the earliest ranking in the acceptance queue. While the priority ranking is based on the age of the UNF, nuclear operating companies can utilize their acceptance rights for the acceptance of any UNF, regardless of fuel age. A company that operates multiple nuclear plants sites can apply its acceptance rights to any plant site that it operates.

To illustrate, assume a utility operates two plant sites, Plant A and Plant B. Plant A began operations several decades ago, while Plant B commenced operations only 10 years ago. The utility has acceptance rights in the first year of waste acceptance for UNF that was discharged from the reactor at Plant A at an early date. Plant B acceptance rights are based on more recent discharges and those rights would not enable shipments for decades. In the first year of UNF acceptance, the utility is free to ship any UNF (meeting the acceptance criteria) from either Plant A or Plant B. If UNF is shipped from Plant A, the utility does not have to ship the specific fuel that was discharged decades ago, but can choose any UNF that meets the limits in the transport cask CoC and the requirements of the Standard Contract. The analysis contained herein does not evaluate intra-company use of acceptance rights since it is not possible to predict from which plant sites a given company would ship UNF in the future. Evaluation of the OFF alternative, assuming that each plant site uses its own allocations, provides a useful reference point from which to evaluate the other two acceptance priority ranking alternatives considered.

5.2.3.2 Shutdown Reactor Priority

The Standard Contract contains provisions that allow the DOE to grant acceptance priority for any UNF or high-level radioactive waste (HLW) removed from a nuclear reactor that has reached the end of its useful life or has been permanently shut down. This is typically referred to as "shutdown reactor priority."

UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. Since there would be additional capacity to accept UNF from operating plant sites beginning in 2023, the shutdown reactor priority alternative assumes that priority is provided to ship UNF from shutdown plant sites, but if there is additional capacity available in the UNF acceptance queue and there is no UNF remaining at shutdown plant sites, UNF is then accepted from operating plants based on OFF acceptance priority. For example, in the period 2023 to 2028, there would be additional acceptance capacity available above that used for transport of UNF from existing shutdown plants. UNF would be shipped from operating plants, up to the maximum amount of UNF to be accepted in that year (as shown **Table 5.2-2**). Once currently operating plants reach the end of their 60-year license terms, shutdown reactor priority would be accorded to these plants.

5.2.3.3 "OFF-Plus" Priority

UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. For UNF from operating plant sites, an "OFF-Plus" priority ranking would be utilized. The "OFF-Plus" acceptance priority alternative assumes that UNF will be shipped in dedicated shipping campaigns. That is, the priority ranking for UNF would still be based on the OFF methodology; however, annual acceptance allocations would be grouped with the goal of having fewer shipping campaigns over a specified time period while maintaining the total UNF accepted from any utility over that time period. Hence, the term, "OFF-Plus" is used. For example, if Company A had allocations of 20 MTU per year in 2025, 30 MTU in 2026, 0 MTU in 2027, 30 MTU in 2028, and 20 MTU in 2029 under an OFF priority ranking, instead of transporting 2 casks in 2025, 3 casks in 2026, 3 casks in 2028, and 2 casks in 2029, a total of 10 casks would be transported in 2 shipping campaigns between 2025 and 2029. Company A maintains the total UNF that would have been picked up over that 5-year period under the OFF alternative but only two shipping campaigns take place. At multi-reactor sites, there may be 2 or 3 years during a 5-year period in which transport campaigns take place, or there could be more than one campaign in a given year. The OFF-Plus alternative can benefit the utilities in that they would have more flexibility to schedule cask loading campaigns to avoid refueling outages and other activities that utilize the cask crane and SFP. The OFF-Plus alternative would also benefit the transport system by reducing the number of sites visited each year, as demonstrated later in this report. Another benefit of the OFF-Plus alternative is that it does not alter the fundamental structure of the OFF priority ranking methodology; instead, it alters the scheduling process.

5.2.4 Analysis of System Capacity and Acceptance Priority Alternatives

This section provides a summary of the analysis of the three acceptance capacity alternatives examined (3,000 MTU, 4,500 MTU, and 6,000 MTU) and the three acceptance priority alternatives (OFF, shutdown reactor priority, and OFF-Plus). For the OFF-Plus scenarios, annual acceptance allocations under OFF are grouped over a 5-year period (i.e., 2023 to 2027), such that a company with acceptance allocations during that 5-year period would have all of its UNF accepted before the end of the period.

The results for each scenario provide a summary of the annual amount of MTU accepted, an analysis of the number of years that the full transportation system capacity can be utilized (i.e., 3,000, 4,500, or 6,000 MTU), the number of sites that are estimated to ship annually, and the average quantity of UNF that may be accepted from sites over the acceptance period. Transportation system requirements are also estimated for each scenario examined, including the number of casks and rolling stock required. Technical and logistical issues are also discussed. Based on the results of this analysis, a recommended system capacity and acceptance priority ranking are identified.

In order to estimate the equipment needed to transport UNF casks from reactor sites, a transport cask turnaround time of 10 weeks per rail cask consist was assumed. This assumes 1 week for five empty casks to be shipped to the plant site, 6 weeks to load five casks at the plant site, 1 week in transport from the plant site to the CSF, and 2 weeks to unload the casks, perform cask maintenance, and return the casks to service. This assumes that a rail consist will include five casks and cask cars, two buffer cars, and one escort car. As discussed in Section 5.3.1.3, it is recommended that locomotives be leased from the railroads. The number of locomotives required is estimated later in this report in order to calculate leasing costs.

Cask turnaround times for picking up previously loaded dual purpose canisters from dry storage are expected to be shorter than 10 weeks. However, as noted earlier, nuclear operating companies are likely to want UNF removed from SFPs first, prior to removal of already-loaded dry storage systems, so that the companies do not have to load additional dry storage systems. Thus, it is prudent to size the cask fleet and rolling stock based on turnaround times for loading casks from SFPs.

It should be noted that the estimates of the truck cask fleet size assumes that one to two plant sites will ship some or all UNF by truck, up to an annual maximum of 150 MTU per year. A four-assembly PWR truck cask has a capacity of approximately 2 MTU; however, the acceptance of UNF with high decay heat could result in loading only two assemblies in some truck cask shipments for a capacity of 1 MTU per cask. In order to be conservative, all of the scenarios analyzed assume that the same number of truck casks will be deployed; therefore, the truck cask fleet size is the same for all cases. It is expected that if there are two plant sites shipping some or all UNF in truck casks, approximately 1,500 MTU of UNF shipped by truck, an estimated 1,000 truck cask shipments over the life of the program would result.

5.2.4.1 3,000 MTU Acceptance Capacity

Case 1, 3,000 MTU, OFF Acceptance Priority

Case 1 assumes a steady-state rate of 3,000 MTU per year is reached in the fifth year of transport and that UNF acceptance allocations will be based on the OFF priority ranking, as provided for in the Standard Contract. That is, Case 1 assumes that UNF is shipped from the plant sites on which the OFF priority ranking is based, but it does not specifically assume that the oldest UNF will be shipped from those sites. While the OFF priority ranking allocates acceptance rights to a nuclear operating company based on the age of UNF, a nuclear operating company may utilize its acceptance rights to ship any UNF (not just the oldest UNF) from any of its reactors (not just the reactor from which the allocations originate).

Under Case 1 (and all other Cases evaluated), UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation, as shown in **Table 5.2-3**. Shipments of UNF from currently operating plant sites would begin in 2024 and be accepted through approximately 2068, as shown in **Figure 5.2-3**.

Table 5.2-3
Projected Acceptance Schedule for Stranded UNF from Shutdown Plant Sites

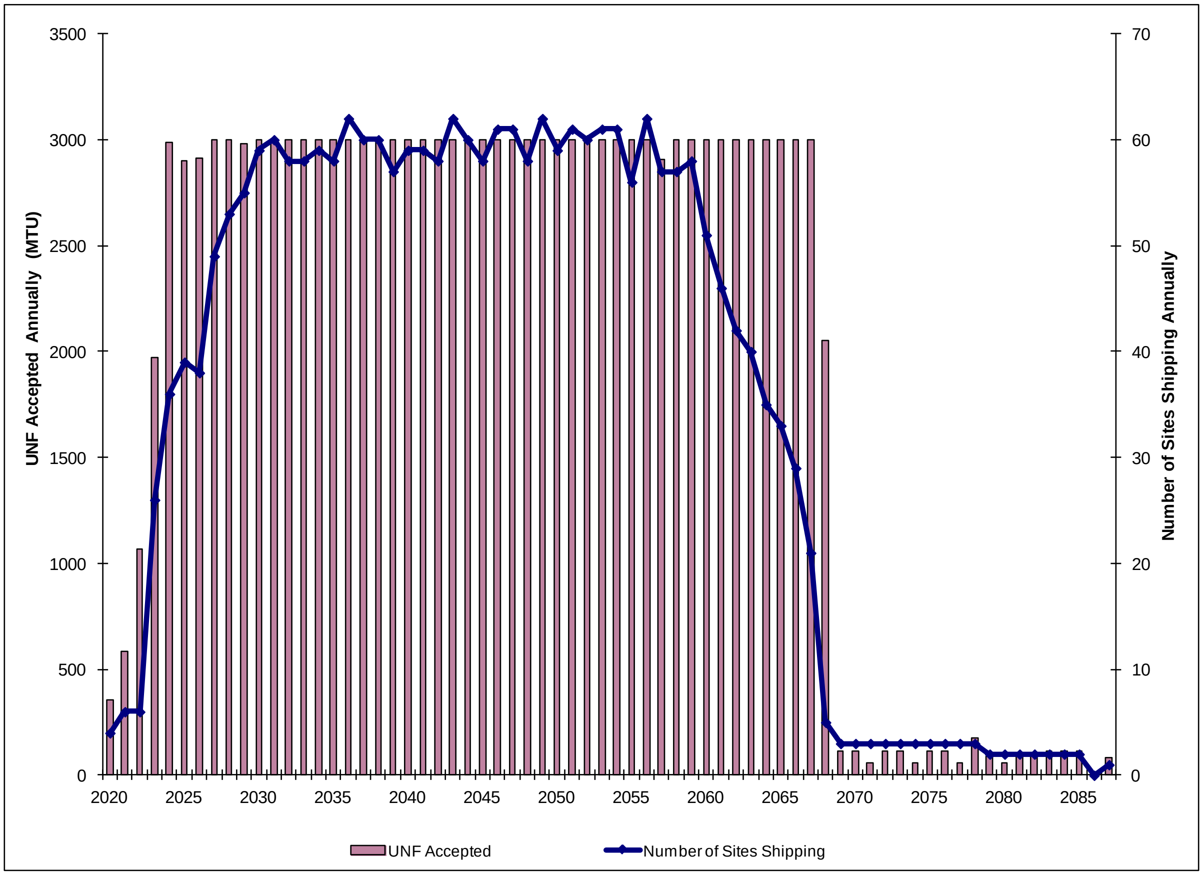
Plant Site	Number of Canisters Shipped from Shutdown Plant Sites						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Big Rock Point	8						8
Haddam Neck		10	20	13			43
Humboldt Bay	6						6
Kewaunee			9	9	12	13	43
LaCrosse	5						5
Maine Yankee		15	25	24			64
Oyster Creek			20	20	20	18	78
Rancho Seco	15	7					22
Trojan		10	10	14			34

Plant Site	Number of Canisters Shipped from Shutdown Plant Sites						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Yankee Rowe		6	10				16
Zion 1 & 2		10	20	35			65

Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance. If existing plants operated for license terms of up to 80 years or if additional new reactors begin operating, there would not be additional capacity in the system until after 2065 to accept UNF from these reactors (or alternatively, the post-shutdown storage period at existing sites would be longer). An annual steady-state rate of 3,000 MTU per year can be fully utilized through approximately 2067. However, UNF would remain at nuclear power plant sites for an average of 25 to 30 years after plants reach the end of their extended 60-year license terms.

During the years in which UNF is shipped at the 3,000 MTU steady-state rate (2024 through 2067), an average of 54 sites would ship UNF annually. The average amount of UNF accepted from each of these sites during the period 2024 to 2067 is approximately 69 MTU. That means that if UNF is shipped in rail consists with five transport casks each, most sites would make one to two shipments of five casks, depending upon cask capacity.

Figure 5.2-3
Case 1, 3,000 MTU Maximum Annual Acceptance Rate, OFF Acceptance Priority Ranking



As shown in **Table 5.2-4**, in order to estimate the number of casks needed for a cask fleet, it is necessary to estimate the capacity of the cask in MTU and the utilization of the cask on an annual basis (i.e., how many MTU can a cask transport with a turnaround time of 10 weeks?). In this analysis, it is assumed that the average cask capacity is 13 MTU. Note that dual purpose canister systems that are currently being loaded at nuclear power plant sites contain 10 to 16 MTU. However, since it may be necessary to ship UNF with short cooling times and high decay heat from SFPs, the utilization for a lower-capacity 7-MTU transport cask is also estimated. Multiplying the cask capacity (7 MTU or 13 MTU) by 52 weeks in a year and dividing by the cask turn-around time results in each 7-MTU cask being able to ship 36 MTU annually and each 13-MTU cask being able to ship 68 MTU annually, assuming an efficient system. Since it is unlikely that one standard transport cask design can be used to ship the variety of dual purpose canister systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to ship the range of dual purpose canisters. Additional transport casks will also be needed to account for casks in maintenance, casks being prepared for service, tie-ups at plant sites or during transit, and the inefficiencies associated with OFF priority ranking (since many shipments could be fewer than five casks). A 75 percent increase in the calculated minimum cask fleet size is assumed to provide for the previous considerations.

This case assumes that 50 percent of the UNF is shipped directly from SFPs. For the purposes of estimating cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 115 rail casks (the estimate was rounded up to be divisible by 5 cask consists). In addition, assuming that a CSF begins operation in 2020 while current reactors are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of 4 weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks, in addition to the rail casks. This brings the total number of casks to 133.

Table 5.2-4
Case 1, 3,000 MTU, OFF Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.75x50%
3,000	13	10	68	44	40
	7 (low)	10	36	83	75
Truck Cask Assumptions					(e)x1.5
Truck Casks	1-2	4	13	12	18
TOTAL					133

Table 5.2-5 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 3,000 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars. Ancillary equipment could be transported in the escort car (if there is sufficient room), on a buffer car, or by general freight.

Equipment required for truck transport would include the truck cask, a transport skid, a personnel barrier, a cask lift yoke and slings, and any ancillary equipment required. This analysis assumes that the flatbed trucks would be leased, although if a higher-capacity legal-weight truck is used, there may need to be a dedicated fleet of trucks in order to ensure that the weight of the truck cab, trailer, and cask cargo remain within legal-weight truck limits.

For the purpose of this analysis, it is assumed that one equipment truck would be dispatched with every three casks to plant sites. **Table 5.2-5** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-5
Case 1, 3,000 MTU, OFF Acceptance Priority, Transportation Equipment Requirements

Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	115	46	23	23	
Equipment Type	**Truck Casks & Transport Skids**	**Trailers**	**Trucks**	**Equipment Truck**	**Escort Vehicle**
Truck Equipment	18	18	18	6	18

Case 2, 3,000 MTU, Shutdown Reactor Priority

Shutdown reactor acceptance priority is described in Section 5.2.3.2. Under Case 2, the steady-state rate of 3,000 MTU per year is assumed to be reached in the fifth year of transportation. The Case 2 analysis assumes that a maximum of 200 MTU is shipped from any one shutdown plant site per year, and that the priority for acceptance of UNF among multiple shutdown plant sites is based on OFF, or the age of the UNF at those plants.

Under Case 2, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 3,000 MTU per year, UNF from operating plant sites would be accepted beginning in 2023 through approximately 2068 as shown in **Figure 5.2-4**. Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance. An annual steady-state rate of 3,000 MTU per year can be fully utilized through approximately 2067. However, UNF would remain at nuclear power plant sites for an average of 22 to 27 years after reactors reach the end of their extended 60-year license terms.

As shown in **Figure 5.2-4**, during the period 2023 through approximately 2032, 35 to 55 plant sites would ship each year. During this time period, only two or three plant sites become shutdown plant sites (i.e., all reactors on the site have reach the end of their 60-year extended licenses). Thus, much of the UNF shipped comes from operating plant sites under an OFF priority. During the period 2033 to 2048, as more reactors reach the end of their 60-year extended licenses, 15 to 34 plant sites are projected to ship UNF each year. As more reactors begin to reach the end of their 60-year extended licenses in the late 2040s, the number of plant sites that would ship UNF annually again increases to more than 50 sites each year. Because many reactors reach the end of their operating licenses during the early-to-mid 2030s and then again during the early-to-mid 2040s, there would be large inventories of UNF that could be granted shutdown priority; thus, a large number of plant sites are assumed to ship UNF during these time periods.

During the years in which UNF is shipped at the 3,000-MTU steady-state rate (2024 through 2067), an average of 34 plant sites would ship UNF annually. The average amount of UNF accepted from each of these sites during the period 2024 to 2067 is approximately 110 MTU. That means that if UNF is shipped in rail consists with five transport casks each, most sites would ship two to three rail consists of five casks, depending upon cask capacity. Since Case 2 utilizes the same overall acceptance capacity as Case 1 and there is still the possibility of UNF being transported from more than 50 plant sites annually, this analysis assumes that the cask fleet and transportation equipment requirements identified in **Table 5.2-4** and **Table 5.2-5** would be the same in Cases 1 and 2. Because of the large number of reactors that reach the end of their 60-year extended licenses during the same time period, the large inventories of UNF that require transport annually during the period between 2034 and approximately 2050, as shown in **Figure 5.2-5**, result in UNF being shipped from a large number of sites with OFF priority ranking, as occurred in Case 1.

Figure 5.2-4
Case 2, 3,000 MTU Maximum Annual Acceptance Rate, Shutdown Reactor Priority Ranking

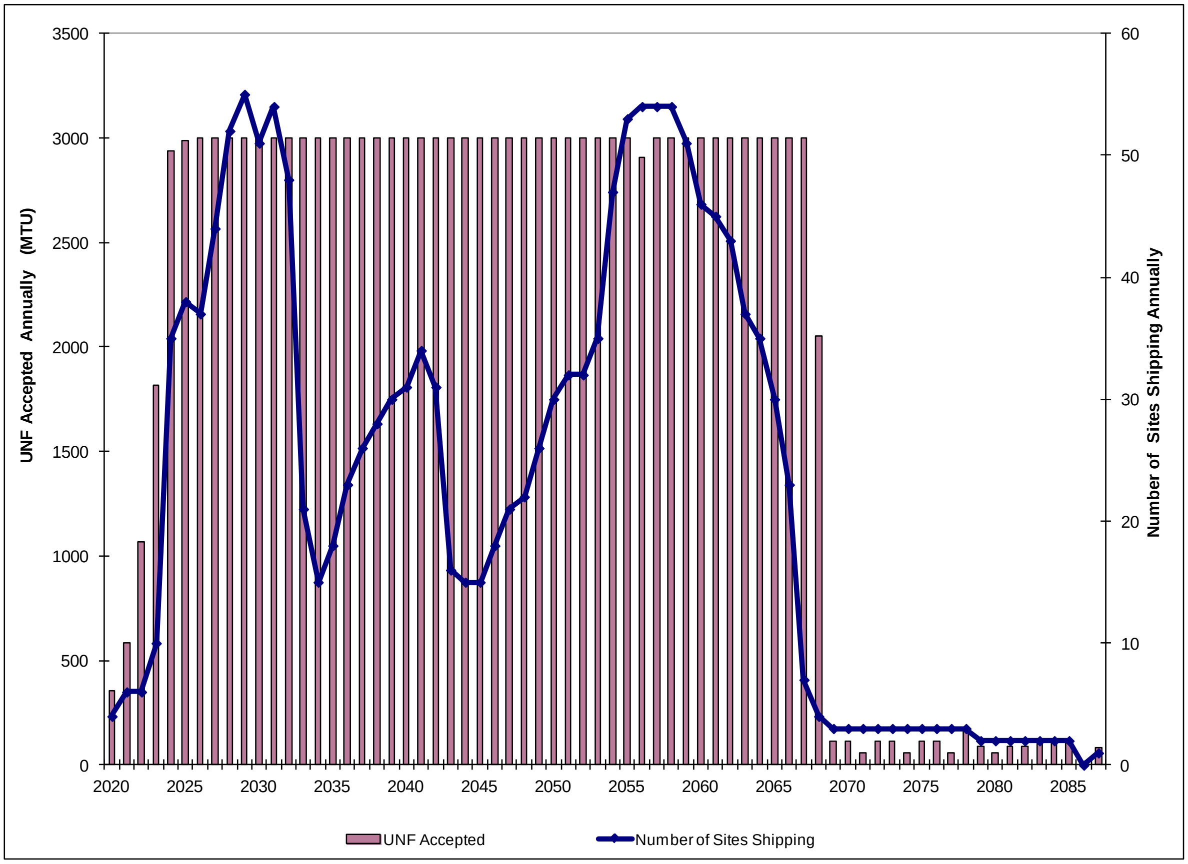
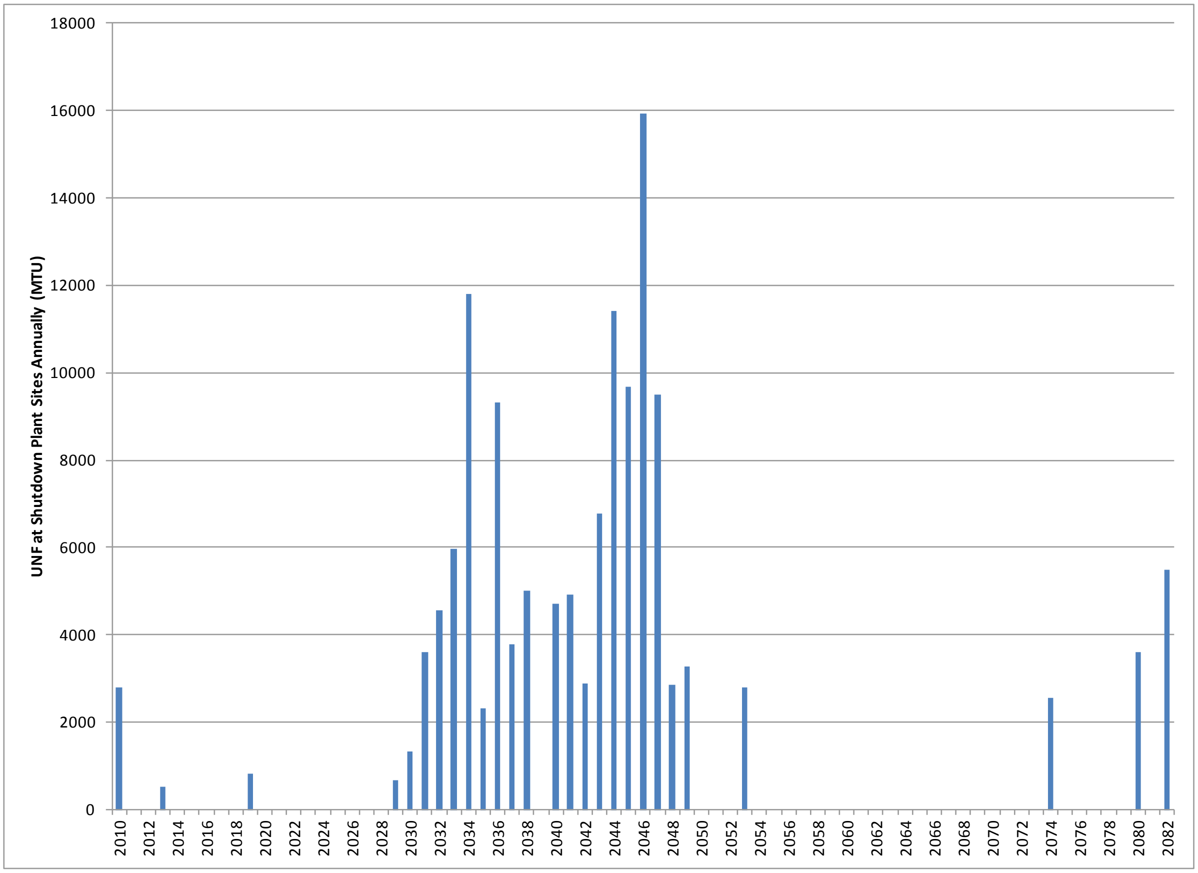


Figure 5.2-5
Projected UNF Inventories at Shutdown Nuclear Power Plant Sites



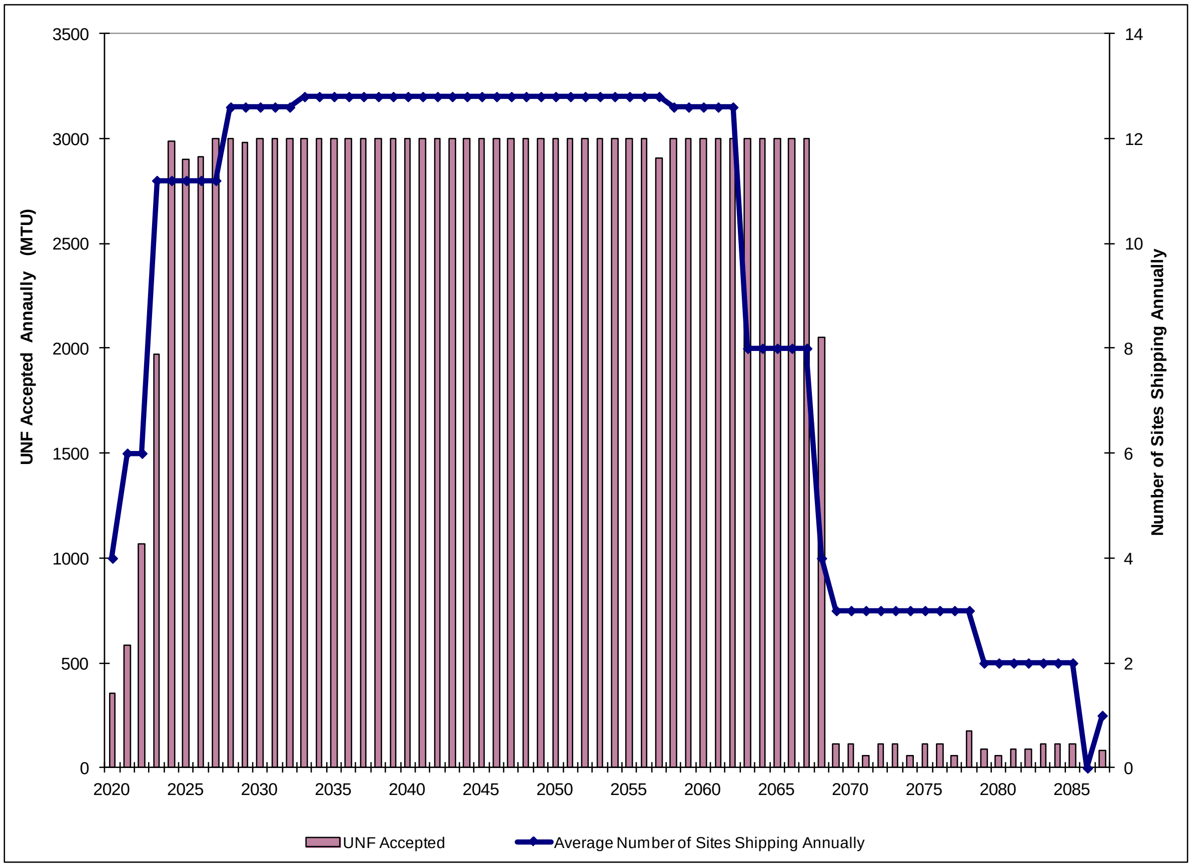
Case 3, 3,000 MTU, OFF-Plus Priority

Under Case 3, the steady-state rate of 3,000 MTU per year is assumed to be reached in the fifth year of transport, and priority to transport UNF would be based on the OFF-Plus priority. As discussed earlier, the priority ranking for UNF would still be based on OFF; however, annual acceptance allocations could be grouped with the goal of having fewer shipping campaigns over a specified time period while maintaining the total UNF accepted from any utility over that time period. See Section 5.2.3.3 for a detailed description of how the OFF-Plus priority methodology would work.

Under Case 3, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 3,000 MTU per year, UNF from currently operating plants would be accepted beginning in 2023 through approximately 2068 as shown in **Figure 5.2-6**. Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance. An annual steady-state rate of 3,000 MTU per year can be fully utilized through approximately 2067. However, UNF would remain at nuclear power plant sites for an average of 25 to 30 years after reactors reach the end of their extended 60-year license terms, although this time period could be reduced by approximately 4 years depending upon the timing of the last UNF accepted under the OFF-Plus priority.

As shown in **Figure 5.2-6**, during the period 2023 through approximately 2060, an average of 13 plant sites would ship each year, based on 5-year OFF-Plus shipping campaigns. This assumes that under a standard OFF priority, as many as 60 sites could be shipping each year. However, if each of these sites shipped their UNF allocations in one shipping campaign (which is unlikely), an average of 12 sites would ship UNF each year. Since many of the 5-year OFF allocations are several hundred MTU of UNF and most operating plant sites do not have the resources or SFP and cask crane availability to load several hundred MTU of UNF into casks each year, it is likely that most sites would elect to have shipping campaigns in 2 to 3 years of the 5-year period. Thus, for the purposes of this analysis, it is likely that between 24 and 36 plant sites would conduct 1 or more shipping campaigns annually. As reactors reach the end of their 60-year extended operating licenses, it is possible that sites could conduct larger annual campaigns rather than conducting shipping campaigns over several years.

Figure 5.2-6
Case 3, 3,000 MTU Maximum Annual Acceptance Rate, OFF-Plus Priority



During the years in which UNF is shipped at the 3,000-MTU steady-state rate (2024 through 2067), an average of 12 plant sites are shipping UNF in any given year. However, since the 5-year average allocation that could be accepted from sites during the period of 2024 to 2067 is approximately 250 MTU, it is likely that most 5-year OFF-Plus allocations would be shipped over a 2- or 3-year period, increasing the average number of plant sites shipping to between 24 and 36 per year. That means if UNF is shipped in rail consists with five casks each, most plant sites would ship four to seven full rail consists of five casks each over that 5-year period, depending upon cask capacity.

While Case 3 utilizes the same overall acceptance capacity as Cases 1 and 2, it is possible that UNF can be transported more efficiently under OFF-Plus than under a strict OFF acceptance priority. This would result in more shipping campaigns being conducted with a full five-casks-per-rail consist. For the purpose of this analysis, it is assumed that the transport cask fleet would be used more efficiently than under the OFF or shutdown priority ranking in Case 1 and Case 2. As shown in **Table 5.2-6**, the same transport cask capacities were assumed: a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask. Since it is unlikely that one standard transport cask design can be used to transport the variety of dual purpose systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to transport the range of dual purpose canisters. Additional transport casks will also be needed to account for casks in maintenance, casks being prepared for service, and/or delays at plant sites or during transit. Since there would be transport system efficiencies associated with OFF-Plus, a 50 percent increase in the cask fleet size is assumed to provide for the previous considerations (as compared to the 75 percent size increase assumed for the OFF and shutdown reactor acceptance priorities).

This case assumes that 50 percent of the UNF may be shipped directly from SFPs. For the purposes of estimating cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 100 rail casks (the estimate was rounded up to be divisible by 5 cask consists). In addition, assuming that a CSF begins operation in 2020 while current reactors are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of 4 weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks, in addition to the rail casks. This brings the total number of casks to 118.

Table 5.2-6
Case 3, 3,000 MTU, OFF-Plus Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.50x50%
3,000	13	10	68	44	35
	7 (low)	10	36	83	65
Truck Cask Assumptions					(e)x1.5
Truck Casks	1-2	4	13	12	18
TOTAL					118

Table 5.2-7 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 3,000 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars.

Equipment required for truck transport would not be expected to change from that evaluated in Case 1 and Case 2 since only a limited number of plant sites would be expected to transport UNF directly from SFPs using truck casks. For the purpose of this case, it is assumed that one equipment truck would be dispatched with every three casks to plant sites. **Table 5.2-7** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-7
Case 3, 3,000 MTU, OFF-Plus Acceptance Priority, Transportation Equipment Requirements

Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	100	40	20	20	
Equipment Type	Truck Casks & Transport Skids	Trailers	Trucks	Equipment Truck	Escort Vehicle
Truck Equipment	18	18	18	6	18

3,000 MTU Acceptance Capacity: Estimated Casks Shipped Annually

Table 5.2-8 provides a summary of the estimated number of transport cask shipments for Cases 1 to 3, assuming an overall acceptance capacity of 3,000 MTU. During 2020 to 2022, the number of shipments is based on the acceptance of UNF from existing shutdown sites.

Additional UNF is accepted from these shutdown sites from 2023 to 2026; however, UNF is also accepted from operating plants beginning in 2023. The minimum and maximum numbers of shipments are based on the maximum acceptance rate in a given year divided by an assumed cask capacity (7 MTU or 13 MTU per cask). The average assumes that 50 percent of the UNF will be shipped in 7-MTU casks and 50 percent will be shipped in 13-MTU casks.

Table 5.2-8
Estimated Annual Cask Shipments for 3,000-MTU Capacity

Acceptance Year	Maximum Rate 3,000 MTU	Number of Transport Casks Shipped		
		Minimum	Maximum	Average
2020	400	41	41	41
2021	600	58	58	58
2022	1,200	114	114	114
2023	2,000	165	223	194
2024	3,000	230	429	329
Thereafter	3,000	230	429	329

5.2.4.2 4,500 MTU Acceptance Capacity

Case 4, 4,500 MTU, OFF Acceptance Priority

Under Case 4, which assumes an overall acceptance rate of 4,500 MTU per year, the acceptance of UNF initially ramps up to an overall rate of 3,000 MTU by the fifth year of waste acceptance. Additional acceptance capacity is assumed to be added to the system beginning in 2030, either at the same facility initially operational in 2020 or at a second CSF. This additional capacity adds 1,500 MTU of additional capacity by 2033 such that the maximum overall acceptance rate reaches 4,500 MTU per year by 2033. The additional 1,500 MTU of acceptance capacity could be used to transport UNF from plant sites with operating reactors when the reactors begin to reach the end of 60-year license terms, to transport UNF from new reactors, or to continue to transport UNF from existing reactors under 60-year (or possibly 80-year) license terms. Case 4 assumes that UNF will be transported from nuclear power plant sites based on the OFF priority ranking.

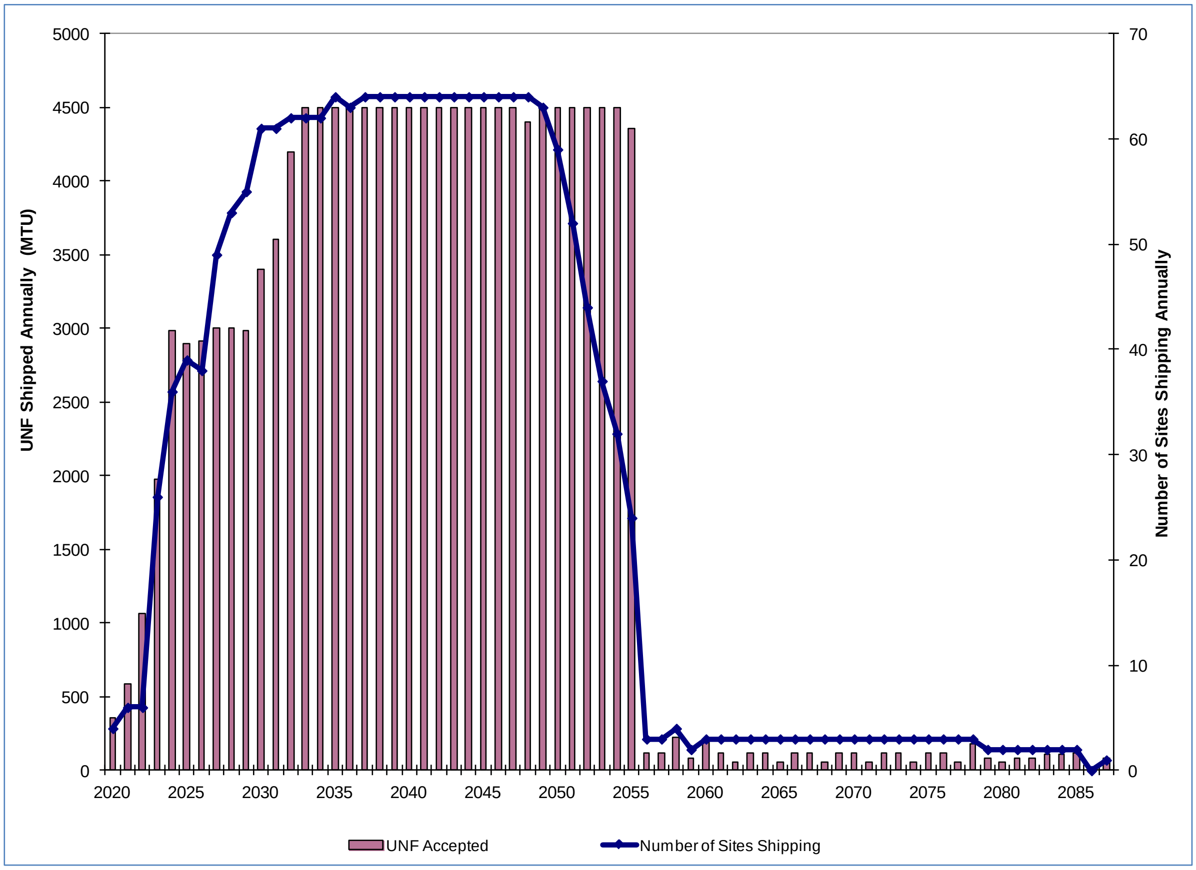
Under Case 4, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 4,500 MTU per year, UNF from currently operating plant sites would be accepted beginning from 2023 through approximately 2055, as shown in **Figure 5.2-7**. Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance. If existing reactors operated for more license terms of up to 80 years or additional new reactors begin operating, there would be additional capacity in the system after 2065 to accept UNF from these plants. UNF would remain at nuclear power plant sites for an average of 13 to 18 years after reactors reach the end of their extended 60-year license terms. Thus, compared to the Case 1 overall acceptance rate of 3,000 MTU, a 4,500-MTU annual acceptance rate that begins operating just as existing operating reactors begin to reach the end of their 60-year extended licenses reduces the number of years that UNF remains at plant sites by almost half (the average post-shutdown storage time was 25 to 30 years in Case 1).

During the years in which UNF is shipped at the 3,000 MTU steady-state rate (2024 through 2029), an average of 45 plant sites would ship UNF annually. The average amount of UNF accepted from each of these sites during the period 2024 to 2029 is approximately 69 MTU. During the years in which UNF is shipped at the 4,500 MTU steady-state rate (2032 to 2055), an average of 58 sites would ship UNF annually. The average number of sites that would ship UNF from 2024 to 2055 is approximately 55. The average amount of UNF accepted from each of these sites during the period 2032 to 2055 is approximately 85 MTU. That means if UNF is shipped in rail consists with five casks each, most sites would ship one to two full rail consists of five casks and another shipment with only one or two casks, depending upon the capacity of the casks used. This is not a significant difference compared to the results from Case 1 with an overall rate of 3,000 MTU.

The same assumptions for estimating the transport cask fleet size that were used in Case 1 were used for this case: a 10-week turnaround time, and cask sizes that include a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask.

As shown in **Table 5.2-9**, the 7-MTU cask is capable of shipping up to 36 MTU annually and the 13-MTU cask up to 68 MTU annually, assuming an efficient system. Since it is unlikely that one standard transport cask design can be used to transport the variety of dual purpose systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to transport the range of dual purpose canisters. Additional casks will also be needed to account for casks in maintenance, casks being prepared for service, tie-ups at plant sites or during transit, and the inefficiencies associated with OFF priority ranking (since many shipments could be fewer than five casks), etc. A 75 percent increase in the calculated minimum cask fleet size is assumed to provide for the previous considerations.

Figure 5.2-7
Case 4, 4,500 MTU Maximum Annual Acceptance Rate, OFF Acceptance Priority Ranking



This case assumes that 50 percent of the UNF may be shipped directly from SFPs. For the purposes of estimating transport cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 170 rail casks (the estimate was rounded up to be divisible by 5 cask consists). In addition, assuming that a CSF begins operation in 2020 while current reactors are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of 4 weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks, in addition to the rail casks. This brings the total number of casks to 188.

Table 5.2-9
Case 4, 4,500 MTU, OFF Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.75x50%
4,500	13	10	68	66	60
	7 (low)	10	36	125	110
Truck Cask Assumptions					(e)*1.5
Truck Casks	1-2	4	13	12	18
TOTAL					188

Table 5.2-10 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 4,500 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars.

Equipment required for truck transport would not be expected to change from that evaluated in Case 1, since only a limited number of sites would be expected to transport UNF directly from SFPs using truck casks. **Table 5.2-10** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-10
Case 4, 4,500 MTU, OFF Acceptance Priority, Transportation Equipment Requirements

Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	170	68	34	34	
Equipment Type	Truck Casks & Transport Skids	Trailers	Trucks	Equipment Truck	Escort Vehicle
Truck Equipment	18	18	18	6	18

Case 5, 4,500 MTU, Shutdown Reactor Priority

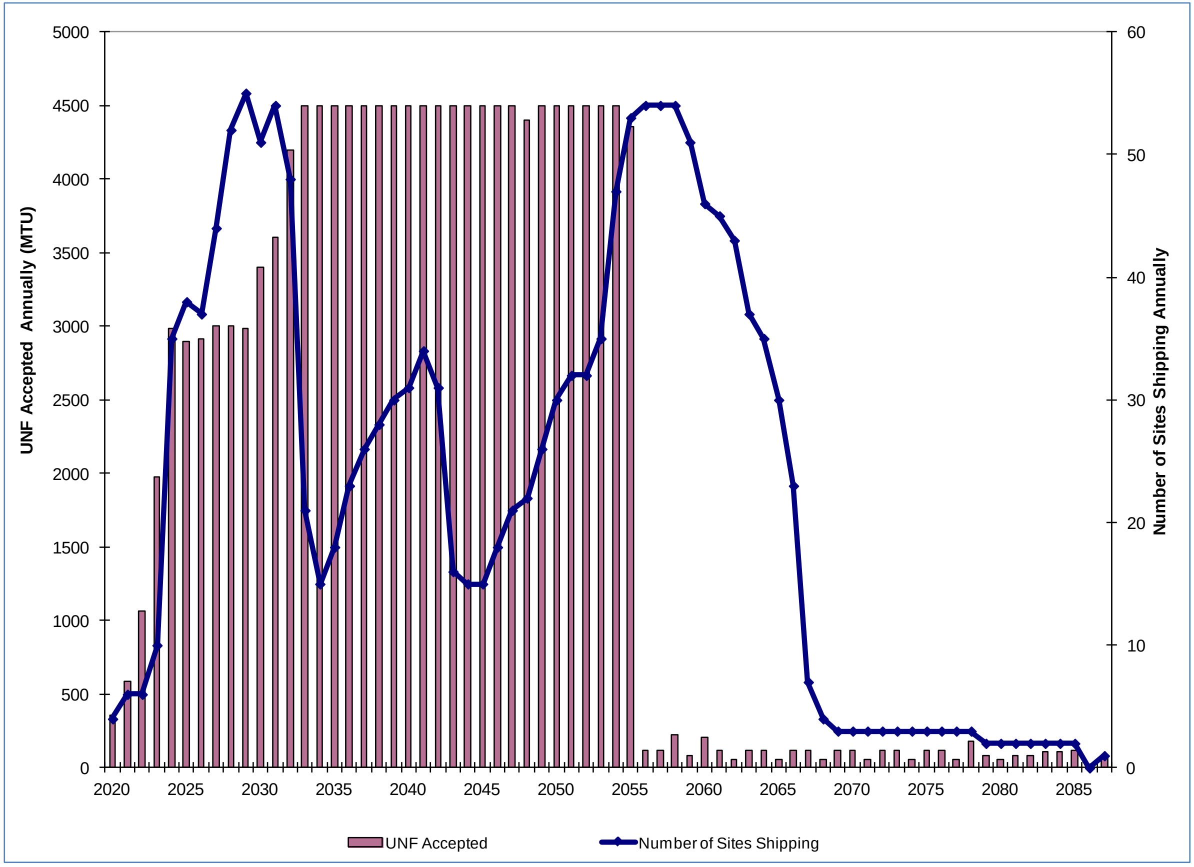
Case 5 assumes that UNF will be transported at the same overall acceptance rate assumed under Case 4, ramping up to 3,000 MTU by the fifth year of transport and then adding an additional 1,500 MTU of additional acceptance capacity by 2033, for an overall rate of 4,500 MTU accepted annually. Under Case 5, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 4,500 MTU per year, UNF from currently operating plant sites would be accepted from 2023 through approximately 2055, as shown in **Figure 5.2-8**. Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance.

UNF would remain at nuclear power plant sites for an estimated 9 to 13 years after reactors reach the end of their extended 60-year license terms. Thus, compared to the Case 2 overall acceptance rate of 3,000 MTU, a 4,500 MTU annual acceptance rate that begins operating just as existing nuclear power reactors begin to reach the end of their 60-year extended licenses reduces the number of years that UNF remains at plant sites by almost half (the average post-shutdown storage time was 22 to 27 years in Case 2). In addition, compared to Case 4, which has the same overall system capacity using an OFF priority ranking, UNF is removed from shutdown plant sites at a faster rate (13 to 18 years under Case 4).

As shown in **Figure 5.2-8**, during the period 2024 to 2029, when the maximum acceptance rate is 3,000 MTU, an average of 44 plant sites would ship each year. During this time period, only two or three plant sites become shutdown plant sites (i.e., all reactors on the site reach the end of their 60-year extended licenses). Thus, much of the UNF shipped comes from operating sites under an OFF priority. During the period of time when the maximum acceptance rate is 4,500 MTU per year (2033 to 2055), an average of 27 sites would ship UNF annually. Between 2024 and 2055, an average of 55 sites would ship UNF each year. Since the overall acceptance rate is higher during the time period when more reactors reach the end of their 60-year extended licenses, the Case 5 acceptance rate and shutdown reactor priority allow more UNF to be removed from shutdown plant sites at a faster rate. As more reactors begin to reach the end of their 60-year extended licenses in the late 2040s, the number of sites that would ship UNF annually again increases to more than 50 sites each year.

During the years in which UNF is shipped at the 3,000 MTU steady-state rate (2024 through 2029), the average amount of UNF accepted from each site is approximately 70 MTU. That means if UNF is shipped in rail consists with five casks each, most sites would ship one or two full rail consists of five casks, depending upon the capacity of the casks used. During the period that the overall rate is 4,500 MTU per year (2033 to 2055), the average amount of UNF accepted for sites is approximately 120 MTU. This means that sites would ship two to three full rail consists of five casks each annually, depending upon the capacity of the casks used.

Figure 5.2-8
Case 5, 4,500 MTU Maximum Annual Acceptance Rate, Shutdown Reactor Priority



Since Case 5 utilizes the same overall acceptance capacity as Case 4 and there is still the possibility of UNF being transported from more than 50 plant sites annually, this analysis assumes that the transport cask fleet and transportation equipment requirements identified in **Table 5.2-9** and **Table 5.2-10** would remain the same.

Case 6, 4,500 MTU, OFF-Plus Acceptance Priority

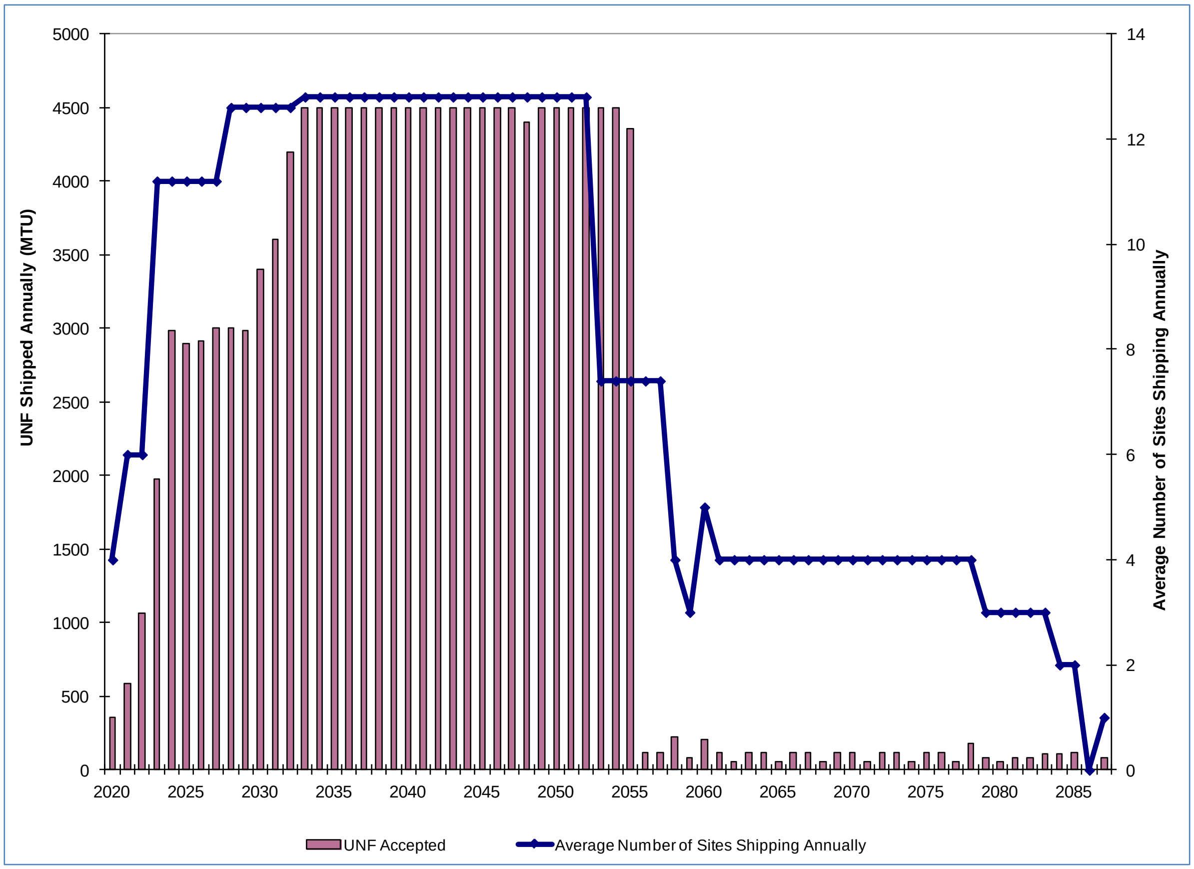
Case 6 assumes an overall acceptance rate that ramps up to 4,500 MTU per year, as described in Case 4, and the OFF-Plus priority ranking that was described under Case 3. As discussed earlier, the priority ranking for UNF would still be based on OFF; however, annual acceptance allocations could be grouped with the goal of having fewer shipping campaigns over a specified time period, while maintaining the total UNF accepted from any utility over that time period.

As shown in **Figure 5.2-9**, the steady-state rate of 3,000 MTU per year is assumed to be reached in the fifth year of transport. An additional 1,500 MTU of additional acceptance capacity is assumed to be added by 2033 for an overall rate of 4,500 MTU accepted annually. Under Case 6, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 4,500 MTU per year, UNF from currently operating plants would be accepted from 2023 through approximately 2055, as shown in **Figure 5.2-9**. UNF would remain at nuclear power plant sites for an average of 13 to 18 years after reactors reach the end of their extended 60-year license terms, although this post-shutdown time period could be reduced by up to 4 years depending upon which year in the 5-year OFF-Plus campaign period the final UNF is shipped from a site. Thus, compared to the Case 3 overall acceptance rate of 3,000 MTU, a 4,500 MTU annual acceptance rate that begins operating just as existing reactors begin to reach the end of their 60-year extended licenses reduces the number of years that UNF remains at plant sites by almost half (the average post-shutdown storage time was 25 to 30 years in Case 4).

During the years in which UNF is shipped at the 3,000 MTU steady-state rate (2024 through 2029) and when the steady state rate is 4,500 MTU annually (2033 to 2055), an average of 12 plant sites would ship UNF annually based on 5-year OFF-Plus shipping campaigns. This assumes that under a standard OFF priority, as many as 64 sites could be shipping annually. However, if each site shipped their UNF allocations in one shipping campaign over the 5-year allocation period, an average of 12 sites would ship UNF each year. Since many of the 5-year OFF allocations are several hundred MTU, particularly at multi-reactor sites, and since most operating plant sites do not have the resources or SFP and cask crane availability to load several hundred MTU into casks each year, it is likely that most sites would elect to have shipping campaigns in 2 or 3 years of the years in a 5-year period. Thus, for the purposes of this analysis, it is likely that between 24 and 36 sites would conduct one or more shipping campaigns annually. As reactors reach the end of their 60-year extended operating licenses, it is possible that sites could conduct larger annual campaigns rather than conducting shipping campaigns over several years.

The average amount of UNF in a 5-year acceptance allocation under OFF-Plus between 2024 and 2055 is approximately 325 MTU. At operating plant sites, it is likely that this type of 5-year allocation would be shipped over multiple campaigns over 3 years of the 5-year allocation period. If UNF is shipped in rail consists with five casks each, most sites would ship five to nine full rail consists of five casks over a 2- to 3-year period, depending upon the capacity of the casks used.

Figure 5.2-9
Case 6, 4,500 MTU Maximum Annual Acceptance Rate, OFF-Plus Acceptance Priority



Case 6 uses the same assumptions for estimating the cask fleet size as were used in Case 4: a 10-week turnaround time, and cask sizes that include a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask.

While Case 6 utilizes the same overall acceptance capacity as Cases 4 and 5, it is possible that UNF can be transported more efficiently under OFF-Plus than under a strict OFF acceptance priority. This would result in more shipping campaigns being conducted with a full five casks per rail consist. For the purpose of this analysis, it is assumed that the cask fleet would be used more efficiently than under the OFF or shutdown priority ranking in Case 4 and Case 5. As shown in **Table 5.2-11**, the same cask capacities were assumed, a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask. Since it is unlikely that one standard transport cask design can be used to transport the variety of dual purpose systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to transport the range of dual purpose canisters. Additional casks will also be needed to account for casks in maintenance, casks being prepared for service, and tie-ups at plant sites or during transit. Since there would be transport system efficiencies associated with OFF-Plus, a 50 percent increase in the cask fleet size is assumed to provide for the previous considerations (as compared to the 75 percent size increase assumed for the OFF and shutdown reactor acceptance priorities).

This assumes that 50 percent of the UNF may be shipped directly from SFPs. For the purposes of estimating transport cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 145 rail casks (the estimate was rounded up to be divisible by 5 cask consists). In addition, assuming that a CSF begins operation in 2020 while current reactors are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of 4 weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks, in addition to the rail casks. This brings the total number of casks to 163.

Table 5.2-11
Case 6, 4,500 MTU, OFF-Plus Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.50 *50%
4,500	13	10	68	66	50
	7 (low)	10	36	125	95
Truck Cask Assumptions					(e)x1.5
Truck Casks	1-2	4	13	12	18
TOTAL					163

Table 5.2-12 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 4,500 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars.

Equipment required for truck transport would not be expected to change from that evaluated in Case 1 since only a limited number of plant sites would be expected to transport UNF directly from SFPs using truck casks. For the purpose of this case, it is assumed that one equipment truck would be dispatched with every three casks to plant sites. **Table 5.2-12** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-12
Case 6, 4,500 MTU, OFF-Plus Priority, Transportation Equipment Requirements

Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	145	58	29	29	
Equipment Type	**Truck Casks & Transport Skids**	**Trailers**	**Trucks**	**Equipment Truck**	**Escort Vehicle**
Truck Equipment	18	18	18	6	18

4,500 MTU Acceptance Capacity: Estimated Casks Shipped Annually

Table 5.2-13 provides a summary of the estimated number of transport cask shipments for Cases 4 to 6, assuming an overall acceptance capacity of 4,500 MTU. During 2020 to 2022, the number of shipments is based on the acceptance of UNF from existing shutdown plant sites. Additional UNF is accepted from these shutdown sites in the period of 2023 to 2026; however, UNF is also accepted from operating plant sites beginning in 2023. The minimum and maximum numbers of shipments are based on the maximum acceptance rate in a given year divided by an assumed cask capacity (7 MTU or 13 MTU per cask). The average assumes that 50 percent of the UNF will be shipped in 7-MTU casks and 50 percent will be shipped in 13-MTU casks.

Table 5.2-13
Estimated Annual Cask Shipments for 4,500 MTU Capacity

Acceptance Year	MTU Accepted per Year	Number of Transport Casks Shipped		
		Minimum	Maximum	Average
2020	400	41	41	41
2021	600	58	58	58
2022	1,200	114	114	114
2023	2,000	165	223	194
2024–2029	3,000	230	429	329
2030	3,400	262	486	374
2031	3,600	277	514	396
2032	4,200	323	600	462
2033	4,500	346	643	495
Thereafter	4,500	346	643	495

5.2.4.3 6,000 MTU Acceptance Capacity

Case 7, 6,000 MTU, OFF Acceptance Priority

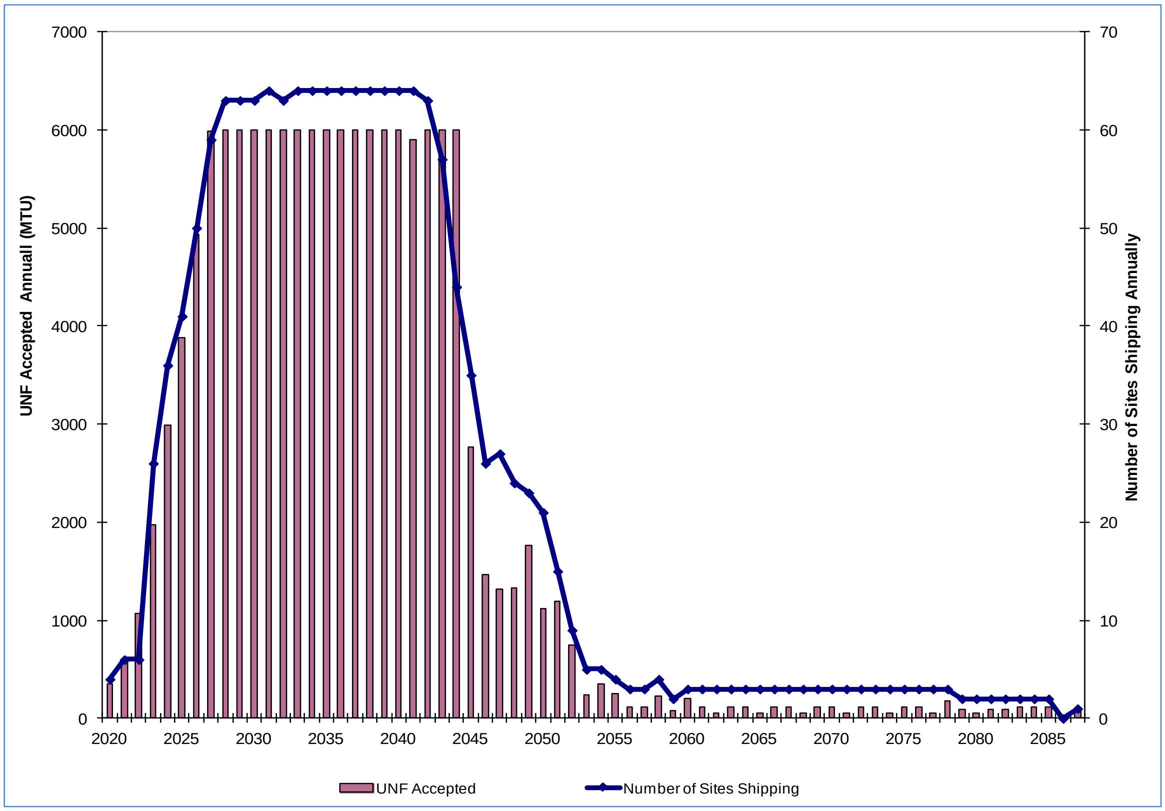
Under Case 7, the overall acceptance rate of 6,000 MTU is reached by the eighth year of waste acceptance and an OFF acceptance priority is assumed. The 6,000 MTU could be located at one or more CSF sites. Under Case 7, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. At an annual steady-state acceptance rate of 6,000 MTU per year, UNF from operating plant sites would be accepted from 2023 through approximately 2053, as shown in **Figure 5.2-10**. Thereafter, UNF from new reactors would continue to be accepted, although at much lower annual rates of acceptance. If existing plants operated for more license terms of up to 80 years or additional new reactors begin operating, there would be additional capacity in the system beginning by approximately 2045 to accept UNF from these plants. UNF would remain at nuclear power plant sites for between 5 to 12 years after reactors reach the end of their extended 60-year license terms. Thus, compared to the Case 1 overall acceptance rate of 3,000 MTU, a 6,000-MTU annual acceptance rate significantly reduces the number of years that UNF remains at plant sites (the average post-shutdown storage time was 25 to 30 years in Case 1). However, much of the acceptance and transport capacity in a 6,000-MTU acceptance alternative would sit idle after approximately 2044 (about 24 years of operation).

During the years in which UNF is shipped at the 6,000 MTU steady-state rate (2027 through 2044), an average of 61 plant sites would ship UNF annually. The average amount of UNF accepted from each of these sites during the period 2027 to 2044 is approximately 100 MTU, although some multi-reactor sites would have much higher allocations. That means if UNF is shipped in rail consists with five casks each, most sites would ship one to two full rail consists of five casks and another shipment with only two to four casks.

Case 7 makes the same assumptions for estimating the transport cask fleet size as were made in Case 1: a 10-week turnaround time, and cask sizes that include a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask.

As shown in **Table 5.2-14**, the 7-MTU cask is capable of shipping up to 36 MTU annually and the 13-MTU cask up to 68 MTU annually, assuming an efficient system. Since it is unlikely that one standard transport cask design can be used to transport the variety of dual purpose systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to transport the range of dual purpose canisters. Additional transport casks will also be needed to account for casks in maintenance, casks being prepared for service, tie-ups at plant sites or during transit, and the inefficiencies associated with OFF priority ranking (since many shipments could be fewer than five casks), etc. A 75 percent increase in the calculated minimum transport cask fleet size is assumed to provide for the previous considerations.

Figure 5.2-10
Case 7, 6,000 MTU Maximum Annual Acceptance Rate, OFF Acceptance Priority Ranking



This case assumes that 50 percent of the UNF may be shipped directly from SFPs. For the purposes of estimating transport cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 230 rail casks (the estimate was rounded up to be divisible by 5 cask consists). In addition, assuming that a CSF begins operation in 2020 while current reactors are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of 4 weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks, in addition to the rail casks. This brings the total number of casks to 248.

Table 5.2-14
Case 7, 6,000 MTU, OFF Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.75x50%
6,000	13	10	68	88	80
	7 (low)	10	36	167	150
Truck Cask Assumptions					(e)x1.5
Truck Casks	1-2	4	13	12	18
TOTAL					248

Table 5.2-15 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 6,000 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars.

Equipment required for truck transport would not be expected to change from that evaluated in Case 1 since only a limited number of plant sites would be expected to transport UNF directly from SFPs using truck casks. **Table 5.2-15** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-15
Case 7, 6,000 MTU, OFF Acceptance Priority, Transportation Equipment Requirements

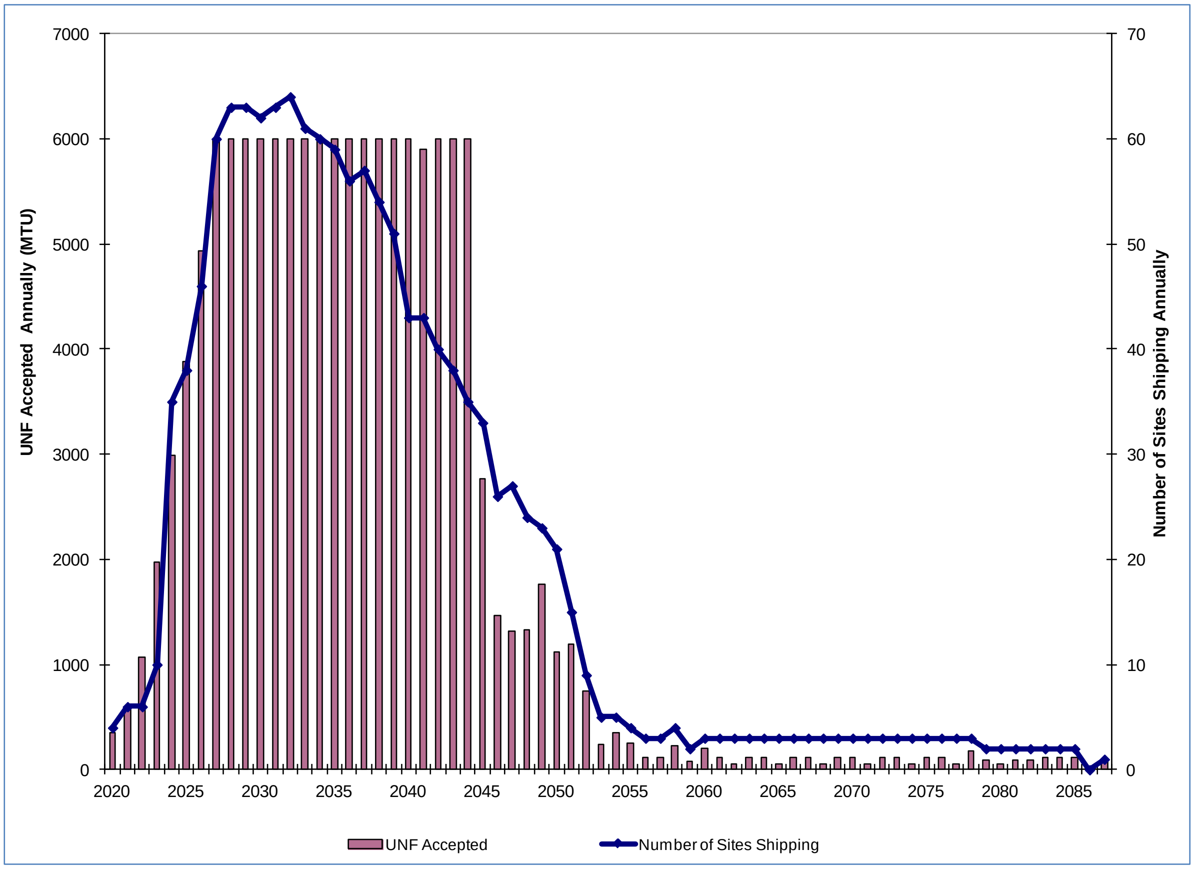
Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	230	92	46	46	
Equipment Type	**Truck Casks & Transport Skids**	**Trailers**	**Trucks**	**Equipment Truck**	**Escort Vehicle**
Truck Equipment	18	18	18	6	18

Case 8, 6,000 MTU, Shutdown Reactor Priority

Under Case 8, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. Case 8 assumes that the overall acceptance rate of 6,000 MTU per year is reached in the eighth year of acceptance and that priority will be provided for UNF from shutdown nuclear power plants. UNF would remain at nuclear power plant sites for between 5 and 7 years after reactors reach the end of their extended 60-year license terms. Thus, compared to the Case 2 overall acceptance rate of 3,000 MTU, a 6,000-MTU annual acceptance rate that begins operating just as existing reactors begin to reach the end of their 60-year extended licenses significantly reduces the number of years that UNF remains at plant sites (the average post-shutdown storage time was 22 to 27 years in Case 2). In addition, compared to Case 7, which has the same overall system capacity using an OFF priority ranking, UNF is removed from shutdown plant sites at a slightly faster rate (5 to 12 years under Case 7).

As shown in **Figure 5.2-11**, during the period 2027 to 2044, when 6,000 MTU of UNF are accepted annually, an average of 54 plant sites would ship UNF each year. During the years in which UNF is shipped at the 6,000-MTU steady-state rate (2027 through 2044), the average amount of UNF accepted from plant sites is approximately 115 MTU, although some multi-reactor sites would have much higher allocations. That means if UNF is shipped in rail consists with five casks each, most sites would ship one to three full rail consists of five casks and an additional shipment with two to four casks.

Figure 5.2-11
Case 8, 6,000 MTU Maximum Annual Acceptance Rate, Shutdown Reactor Priority



Since Case 8 utilizes the same overall acceptance capacity as Case 7, and since there is still the possibility of UNF being transported from more than 50 plant sites annually, this analysis assumes that the cask fleet and transportation equipment requirements identified in **Table 5.2-14** and **Table 5.2-15** would remain the same for Case 8.

Case 9, 6,000 MTU, OFF-Plus Acceptance Priority

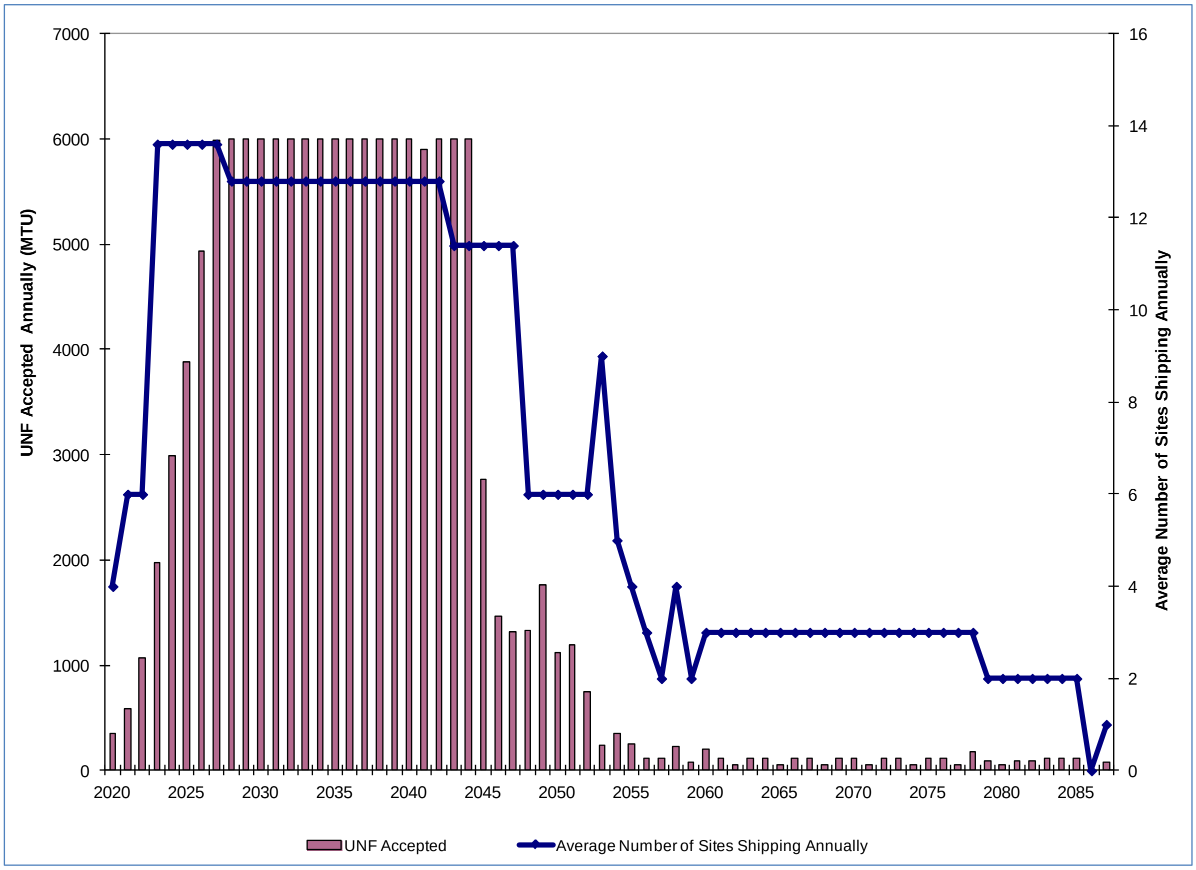
Under Case 9, UNF from existing shutdown plant sites is given priority and would be removed from these sites within the first 6 years of CSF operation. Under Case 9, which assumes an overall acceptance rate of 6,000 MTU per year, that acceptance rate is reached by the eighth year of waste acceptance. As discussed earlier, the priority ranking for UNF would still be based on OFF; however, annual acceptance allocations could be grouped with the goal of having fewer shipping campaigns over a specified time period, while maintaining the total UNF accepted from any utility over that time period.

As shown in **Figure 5.2-12**, the steady-state rate of 6,000 MTU per year is reached in the eighth year of transport. At an annual steady-state acceptance rate of 6,000 MTU per year, UNF from currently operating plants would be accepted through approximately 2053, as shown in **Figure 5.2-12**. UNF would remain at nuclear power plant sites for between 5 and 12 years after reactors reach the end of their extended 60-year license terms, although the 12-year post-shutdown time period could be reduced by up to 4 years depending upon which year in the 5-year OFF-Plus campaign period the final UNF is shipped from a site. Thus, compared to the Case 3 overall acceptance rate of 3,000 MTU, a 6,000-MTU annual acceptance rate significantly reduces the number of years that UNF remains at plant sites (the average post-shutdown storage time was 25 to 30 years in Case 3). However, much of the acceptance and transport capacity in a 6,000-MTU acceptance alternative would sit idle after approximately 2044 and 24 years of operation.

During the years in which UNF is shipped at the 6,000-MTU steady-state rate (2027 through 2044), an average of 13 plant sites would ship UNF annually, based on 5-year OFF-Plus shipping campaigns. This assumes that under a standard OFF priority, as many as 64 sites could be shipping annually. However, if each site shipped their UNF allocations in one shipping campaign over the 5-year allocation period (which is unlikely), an average of 13 sites would ship UNF each year. Since many of the 5-year OFF allocations are several hundred MTU and most operating plant sites do not have the resources or SFP and cask crane availability to load several hundred MTU into casks each year, it is likely that most sites would elect to have shipping campaigns in 3 to 4 years of the 5-year period. Thus, for the purposes of this analysis, it is likely that between 39 and 52 sites would conduct one or more shipping campaigns annually. As reactors reach the end of their 60-year extended operating licenses, it is possible that sites could conduct larger annual campaigns rather than conducting shipping campaigns over several years.

The average amount of UNF in a 5-year acceptance allocation under OFF-Plus between 2024 and 2055 is approximately 400 MTU. At operating plant sites, it is likely that this type of 5-year allocation would be shipped over multiple campaigns over 4 years of the 5-year allocation period. If UNF is shipped in rail consists with 5 casks each, most sites would ship 6 to 11 full rail consists of 5 casks over a 4-year period.

Figure 5.2-12
Case 9, 6,000 MTU Maximum Annual Acceptance Rate, OFF-Plus Priority



Case 9 uses the same assumptions for estimating the transport cask fleet size as were assumed in Case 7: a 10-week turnaround time, and cask sizes that include a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask.

While Case 9 utilizes the same overall acceptance capacity as Cases 7 and 8, it is possible that UNF can be transported more efficiently under OFF-Plus than under a strict OFF acceptance priority. This would result in more shipping campaigns being conducted with a full five casks per rail consist. For the purpose of this analysis, it is assumed that the cask fleet would be used more efficiently than under the OFF or shutdown priority ranking in Case 4 and Case 5. As shown in **Table 5.2-16**, the same cask capacities were assumed: a 13-MTU rail cask, a 7-MTU rail cask, and a 1- to 2-MTU truck cask. Since it is unlikely that one standard transport cask design can be used to transport the variety of dual purpose systems that are expected to be used for on-site storage at nuclear power plant sites, more transport casks will be needed in the cask fleet in order to transport the range of dual purpose canisters. Additional casks will also be needed to account for casks in maintenance, casks being prepared for service, and tie-ups at plant sites or during transit. Since there would be transport system efficiencies associated with OFF-Plus, a 50 percent increase in the cask fleet size is assumed to provide for the previous considerations (as compared to the 75 percent size increase assumed for the OFF and shutdown reactor acceptance priorities).

This case assumes that 50 percent of the UNF may be shipped directly from SFPs. For the purposes of estimating transport cask fleet size, it is assumed that 50 percent of the cask fleet would be the larger 13-MTU casks and 50 percent would be the smaller 7-MTU casks, resulting in 195 rail casks (the estimate was rounded up to be divisible by five cask consists). In addition, assuming that a CSF begins operation in 2020 while current plants are operating, a small fleet of truck casks may also be needed in order to accept UNF directly from SFPs at a small number of sites. Assuming that a small percentage of UNF would be transported by truck annually (i.e., 150 MTU), a cask turnaround time of four weeks, and applying a 50 percent increase in truck cask fleet size to account for system inefficiencies and maintenance, this would require approximately 18 truck casks in addition to the rail casks. This brings the total number of casks to 213.

Table 5.2-16
Case 9, 6,000 MTU, OFF Acceptance Priority, Transport Cask Fleet Assumptions

Annual UNF Shipped (MTU)	Cask Capacity (MTU)	Transport Cask Turn-Around Time (Weeks)	MTU Shipped Per Year by Cask (MTU/Year/Cask)	Nominal Casks Needed (# Casks)	Cask Fleet Estimate (# Casks)
(a)	(b)	(c)	(d) = [(b)x52 weeks]/(c)	(e) = [(a)/(d)]	(e)x1.50x50%
6,000	13	10	68	88	70
	7 (low)	10	36	167	125
Truck Cask Assumptions					(e)x1.5
Truck Casks	1-2	4	13	12	18
TOTAL					213

Table 5.2-17 presents the number of railcars, buffer cars, locomotives, and escort cars needed to transport UNF assuming that 6,000 MTU of UNF are transported annually. There will be two buffer cars, one locomotive, and one escort car for every five rail cask cars.

Equipment required for truck transport would not be expected to change from that evaluated in Case 1, since only a limited number of plant sites would be expected to transport UNF directly from SFPs using truck casks. For the purpose of this case, it is assumed that one equipment truck would be dispatched with every three casks to plant sites. **Table 5.2-17** shows the number of truck casks and transport skids, trailers, trucks, equipment trucks, and escort vehicles required for this case. If the loaded truck casks return from plant sites together, it is possible that the number of escort vehicles could be reduced.

Table 5.2-17
Case 9, 6,000 MTU, OFF-Plus Priority, Transportation Equipment Requirements

Equipment Type	Rail Cask Fleet and Railcars	Buffer Cars	Locomotives	Escort Cars	
Rail Equipment	195	78	39	39	
Equipment Type	**Truck Casks & Transport Skids**	**Trailers**	**Trucks**	**Equipment Truck**	**Escort Vehicle**
Truck Equipment	18	18	18	6	18

6,000 MTU Acceptance Capacity: Estimated Casks Shipped Annually

Table 5.2-18 provides a summary of the estimated number of transport cask shipments for Cases 7 to 9, assuming an overall acceptance capacity of 6,000 MTU. During 2020 to 2022, the number of shipments is based on the acceptance of UNF from existing shutdown plant sites. Additional UNF is accepted from these shutdown plant sites in the period of 2023 to 2026; however, UNF is also accepted from operating plant sites beginning in 2023. The minimum and maximum numbers of shipments are based on the maximum acceptance rate in a given year divided by an assumed cask capacity (7 MTU or 13 MTU per cask). The average assumes that 50 percent of the UNF will be shipped in 7-MTU casks and 50 percent will be shipped in 13-MTU casks.

Table 5.2-18
Estimated Annual Cask Shipments for 6,000-MTU Capacity

Acceptance Year	Maximum Rate 3,000 MTU	Number of Transport Casks Shipped		
		Minimum	Maximum	Average
2020	400	41	41	41
2021	600	58	58	58
2022	1,200	114	114	114
2023	2,000	165	223	194
2024–2029	3,000	230	429	329
2030	4,000	308	571	440
2031	5,000	385	714	550
2032	6,000	462	857	660
Thereafter	6,000	462	857	660

5.2.4.4 Summary and Recommendations Regarding Overall System Capacity and Acceptance Priority Alternatives

Summary of Results

Table 5.2-19 summarizes the results for the three alternative system capacity alternatives and the three acceptance priority alternatives evaluated in Cases 1 through 9.

Under Cases 1 through 3, which utilize an overall acceptance rate of 3,000 MTU per year, this maximum acceptance rate is utilized for approximately 44 years of waste acceptance. This means that during the period of waste acceptance from currently operating reactors, the transportation system has not been overbuilt. However, to the extent that existing reactors extend operating licenses to as much as 80 years, or additional new reactors are added to the system, a 3,000-MTU overall rate of acceptance does not provide additional flexibility in the system to move greater quantities of UNF until after 2067. The average number of sites that would ship UNF annually is the greatest under an OFF priority ranking at 54 sites per year, with a range of 21 to 62 sites during the time period that the maximum rate of 3,000 is utilized. The average number of sites that would ship UNF annually falls to 34 sites per year under shutdown priority, with a range of 7 to 55 sites during the time period that the maximum rate of 3,000 MTU is utilized. The average number of sites that would ship UNF annually under OFF-Plus is 12 sites per year, with a range of 21 to 62 sites during the time period that the maximum rate of 3,000 MTU is utilized. There is not a significant difference in the number of years of post-shutdown storage (at currently operating sites) for Cases 1 through 3. Under the OFF and OFF-Plus cases, UNF is projected to be stored for 25 to 30 years after currently operating reactors reach the end of their 60-year extended licenses. As noted in **Table 5.2-19**, under the OFF-Plus priority ranking, the post-shutdown storage period could be reduced by up to 4 years depending upon the year in which the final shipment is made in the 5-year allocation period. Under shutdown reactor priority, the number of years of post-shutdown storage is reduced to 22 to 27 years.

Under Cases 4 through 6, which utilize an overall acceptance rate of 4,500 MTU per year, the maximum acceptance rate (including the earlier period when the rate is only 3,000 MTU annually) is utilized for approximately 32 years of waste acceptance. A 32-year operating period is not an unreasonable time period over which to utilize the capital equipment procured for waste acceptance and transportation. In addition, once UNF is accepted from currently operating plant sites, the transportation system would have additional capacity beginning in 2055 to provide flexibility in the system to accept UNF from new reactors or from existing reactors that extend license terms beyond 60 years. The average number of sites that would ship UNF annually is the greatest under an OFF priority ranking at 55 sites per year, with a range of 24 to 64 sites during the time period that the maximum rate of 3,000 to 4,500 MTU per year is utilized. The average number of sites that would ship UNF annually falls to 32 sites per year under shutdown priority, with a range of 15 to 55 sites during the time period that the maximum rate of 3,000 to 4,500 MTU is utilized. The average number of sites that would ship UNF annually under OFF-Plus is 12 sites per year, with a range of 24 to 64 sites per year during the period of the maximum acceptance rate. There is not a significant difference in the number of years of post-shutdown storage (at currently operating sites) for Cases 4 through 6. Under the OFF and OFF-Plus cases, UNF is projected to be stored for 13 to 18 years after currently operating reactors reach the end of their 60-year extended licenses. As noted in **Table 5.2-19**, under OFF-Plus priority ranking, the post-shutdown storage period could be reduced by up to 4 years depending upon the year in which the final shipment is made in the 5-year allocation period. Under shutdown reactor priority, the number of years of post-shutdown storage is reduced to 9 to 13 years.

Under Cases 7 through 9, which utilize an overall acceptance rate of 6,000 MTU per year, this maximum acceptance rate is utilized for approximately 18 years of waste acceptance. This means that the system has a significant amount of excess capacity beginning in 2045 and that the transportation system has been overbuilt. However there would be flexibility in the system after 2045 to accept UNF from existing reactors that extend operating licenses beyond 60 years or as additional new reactors begin operation. The average number of sites that would ship UNF annually is the greatest under an OFF priority ranking at 61 sites per year, with a range of 44 to 64 sites during the time period that the maximum rate of 6,000 MTU per year is utilized. The average number of sites that would ship UNF annually falls to 54 sites per year under shutdown priority, with a range of 35 to 64 sites during the time period that the maximum rate of 6,000 MTU per year is utilized. The average number of sites that would ship UNF annually under OFF-Plus is 13 sites per year, with a range of 44 to 64 sites during the time period that the maximum rate of 6,000 MTU per year is utilized. There is not a significant difference in the number of years of post-shutdown storage (at currently operating sites) for Cases 7 through 9. Under the OFF and OFF-Plus cases, UNF is projected to be stored for 5 to 12 years after currently operating reactors reach the end of their 60-year extended licenses. As noted in **Table 5.2-19**, under OFF-Plus priority ranking, the post-shutdown storage period of 12 years could be reduced by up to 4 years depending upon the year in which the final shipment is made in the 5-year allocation period. Under shutdown reactor priority, the number of years of post-shutdown storage is reduced to 5 to 7 years.

Recommendations Regarding System Capacity and Acceptance Priority

System Capacity Recommendation

Based on the analyses regarding the three system capacity alternatives evaluated in Cases 1 through 9 and summarized in **Table 5.2-19**, the 4,500 MTU overall acceptance rate is the recommended alternative. This overall system capacity assumes that acceptance of UNF initially ramps up to an overall rate of 3,000 MTU by the fifth year of waste acceptance and that additional acceptance capacity is added to the system beginning in 2030, either at the same facility initially operational in 2020 or at a second CSF. This additional capacity adds 1,500 MTU of additional capacity by 2033 such that the maximum overall acceptance rate reaches 4,500 MTU per year by 2033. The additional 1,500 MTU of acceptance capacity could be used to transport UNF from current operating plants when they begin to reach the end of their 60-year license terms, to transport UNF from new reactors, or to continue to transport UNF from existing reactors under 60-year (or possibly 80-year) license terms. As shown in **Table 5.2-19** and the prior discussion, a capacity of 4,500 MTU that is brought online as existing reactors are beginning to reach the end of 60-year license terms has an impact of reducing the number of years of post-shutdown storage by 50 percent (from 25–30 years under the 3,000-MTU rate to 13–18 years under the 4,500 MTU rate). In addition, overall system capacity is utilized for more than 30 years, such that the system is not overbuilt.

An overall acceptance rate of 3,000 MTU per year results in UNF remaining at plant sites for almost three decades after reactors reach the end of their 60-year license terms. If one of the goals of a CSF is to remove UNF from *all* plant sites when all reactors on the site have shut down permanently (not just the nine existing shutdown sites) a 3,000-MTU scenario does not accomplish this goal in a timely manner. While a 6,000-MTU overall acceptance rate would remove UNF from shutdown plant sites relatively rapidly, the maximum system capacity is only utilized for 18 years of acceptance, indicating that the transportation system has been overbuilt. The 4,500-MTU scenario offers an approach that maximizes system capacity while also removing UNF from shutdown plant sites on a timely basis.

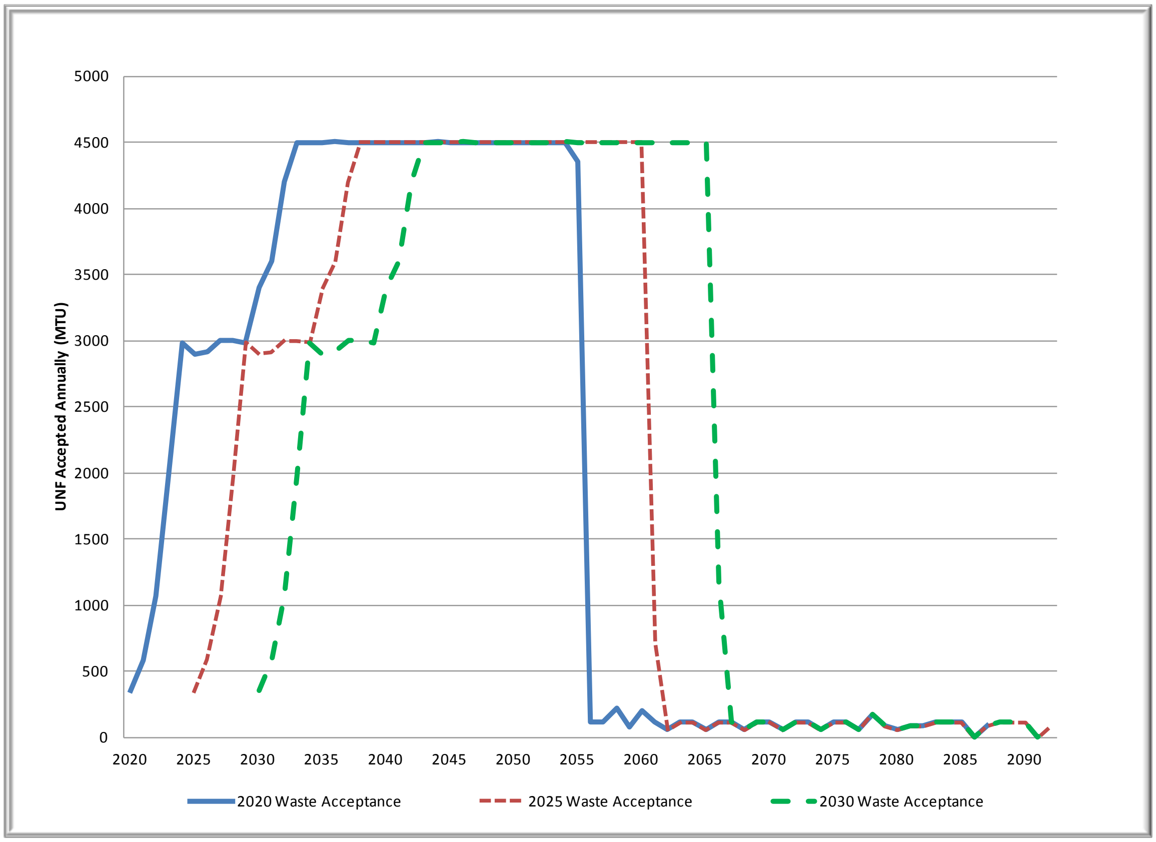
Table 5.2-19
Key Parameters Associated with System Capacity and Acceptance Priority Alternatives

Case #	Maximum Annual Acceptance Rate (MTU)	Priority Ranking Methodology	# Years Max Rate Utilized	# Sites Shipping/Year During Period of Maximum Acceptance Rate Range	# Sites Shipping/Year Average	# Years Post-Shutdown Storage
Case 1	3,000	OFF	44	21–62	54	25-30
Case 2	3,000	Shutdown	44	7–55	34	22-27
Case 3	3,000	OFF-Plus	44	21–62	12	25-30*
Case 4	4,500	OFF	32	24–64	55	13-18
Case 5	4,500	Shutdown	32	15–55	32	9-13
Case 6	4,500	OFF-Plus	32	24–64	12	13-18*
Case 7	6,000	OFF	18	44–64	61	5-12
Case 8	6,000	Shutdown	18	35–64	54	5-7
Case 9	6,000	OFF-Plus	18	44–64	13	

** # Year Post Shutdown Storage under OFF-Plus priority ranking could be reduced by up to 4 years depending upon what year the last shipment is made during the 5-year allocation period.*

The analyses discussed above regarding the comparison of the overall acceptance rates analyzed herein assume that waste acceptance begins in 2020. Assuming that the overall maximum annual rate of waste acceptance does not change (i.e., 3,000 MTU, 4,500 MTU, or 6,000 MTU) for each year that waste acceptance is delayed beyond 2020, there will be a subsequent delay in UNF acceptance both on the “front-end” and “back-end” of the waste acceptance schedule, until the cumulative amount of UNF accepted catches up with the backlog of UNF discharged. This is shown in the comparison in **Figure 5.2-13** in which an overall rate of 4,500 MTU is modeled assuming that waste acceptance begins in 2020, 2025, and 2030. There is a subsequent 5-year and 10-year delay in the start of overall waste acceptance for the 2025 and 2030 start dates as well as a 5-year and 10-year delay in working off the backlog of UNF discharged. By approximately 2068, all three scenarios would accept the same UNF (which is associated with UNF from new plants), and all three scenarios would result in waste acceptance being completed by the early 2090s. A similar number of plant sites would ship UNF annually for the alternative priority ranking cases. The overall rate could also be ramped up to 4,500 MTU earlier in the 2025 and 2030 scenarios to make up for the delay in waste acceptance.

Figure 5.2-13
Comparison of Annual UNF Acceptance Rate Associated with Waste Acceptance Start in 2020, 2025 and 2030 for a 4,500 MTU Overall Rate



Acceptance Priority Recommendation

Based on the analyses regarding the three priority ranking alternatives evaluated in Cases 1 through 9 and summarized in **Table 5.2-19**, the OFF-Plus acceptance priority is the recommended alternative. The "OFF-Plus" acceptance priority alternative assumes that UNF will be shipped in dedicated shipping campaigns. That is, the priority ranking for UNF would still be based on the OFF methodology; however, annual acceptance allocations could be grouped with the goal of having fewer shipping campaigns over a specified time period, while maintaining the total UNF accepted from any utility over that time period. OFF-Plus can benefit the utilities in that they would have more flexibility to schedule cask loading campaigns to avoid refueling outages and other activities that utilize the cask crane and spent fuel storage pool. OFF-Plus would also benefit the transport system by reducing the number of plant sites conducting shipments each year, as shown in **Table 5.2-19**. For example, under the recommended 4,500-MTU system capacity, an estimated 24 to 64 sites would ship UNF annually under an OFF priority ranking. If the allocations are grouped over a 5-year period, an average of 12 sites would ship annually. However, multi-reactor sites that have larger allocations may elect to have multiple shipping campaigns over several years of the 5-year period, depending upon the total allocation. Thus the number of sites shipping annually would most likely range from 24 to 36 sites over a 5-year period if UNF were shipped in campaigns under OFF-Plus. Logistically, this is preferable to arranging multiple small shipments from as many as 64 sites per year. Another benefit of OFF-Plus is that it does not alter the fundamental structure of the OFF priority ranking methodology provided in the Standard Contact. The scheduling process in the Standard Contract would be revised to reflect how the 5-year campaigns would be carried out.

5.2.5 Transport Cask Design, Certification, and Manufacture

If new transport casks need to be designed and certified, such as a smaller-capacity cask to accept high-heat load UNF from SFPs as discussed previously, a lead time of 4 to 8 years would be needed in order to design, certify, and fabricate the new cask design. Amendments to existing certified casks would require a lead time of 4 to 6 years. A more detailed discussion of the cask design and certification process can be found in a report developed for the BRC titled, “Overview of High-Level Nuclear Waste Materials Transportation: Processes, Regulations, Experience and Outlook in the U.S.”, ERI-2030-1101 (January 2011, p. 28 et seq.).

New cask designs would be expected to take 1 to 2 years for development of safety analysis reports and to perform required materials and cask component testing. The NRC certification process would be expected to take from 1 to 3 years, based on historical certification periods, although new designs that utilize new materials or new methodology may take longer to receive certification. Manufacturing of a new transport cask design and support equipment would take 2 to 3 years following certification, although this time period could be shortened if the manufacturing process began in advance of certification for the procurement of long-lead-time materials. This results in a 4- to 8-year duration for deployment of new transport cask designs.

Development of the safety analysis for amending an existing design would be expected to take up to 1 year. Amendments to certified cask designs generally take from 1 to 2 years, depending upon the complexity of the amendment. Amendments that utilize new methodology or make significant changes to the cask contents may take several years for NRC approval. Manufacturing of a new design would take 2 to 3 years following certification, although this time period could be shortened as noted previously. This results in a 4- to 5-year duration for deployment of amended transport cask designs.

For transport of UNF from existing shutdown sites, the cask designs and contents have been certified by NRC, or are expected to be certified by 2020. Thus, there would be a fabrication lead time of 2 to 3 years prior to the start of system operation for fabrication of the needed transport cask systems.

5.2.6 Alternatives for Accepting UNF with High Decay Heat

As noted in Section 5.2.2.3, it is likely that companies with operating nuclear power plants will prefer to ship UNF directly from SFPs during the initial years of UNF acceptance rather than to ship already-loaded dual purpose canisters from their at-reactor dry storage facilities. This would allow sites to begin to make space in SFPs, such that they no longer need to transfer UNF from SFPs to dry storage. It is estimated that under the UNF acceptance scenarios evaluated in this report, after 10 to 15 years of waste acceptance (depending upon the overall acceptance rate), UNF could be accepted either from SFPs or from previously loaded dual purpose canisters. Both Oyster Creek and Kewaunee, which will shut down prior to 2020, will have some amount of UNF with high decay heat in SFP storage at the time of shutdown. This UNF will either have to be cooled for longer time periods in on-site dry storage prior to transport to a CSF, or be packaged in smaller-capacity transport casks, as discussed later in this section.

The discussion in this section is for illustrative purposes to show the impact of fuel assembly burnup and decay heat on cask capacity.

Current PWR average discharge burnups are approximately 48 GWd/MTU and current BWR average discharge burnups are approximately 43 GWd/MTU. Discharge burnups are expected to gradually increase to approximately 55 GWd/MTU for PWRs and 48 GWd/MTU for BWRs.[22] At sites that have been storing UNF in dry storage casks for 10 years or longer, lower burnup, low-decay-heat UNF may have been transferred to dry storage in the early years of ISFSI operation. Therefore, if UNF is accepted from SFPs for transport to the CSF, it will be necessary to be able to ship UNF with short cooling times (5 to 8 years) and high decay heat. While current dry storage systems are capable of storing UNF with short cooling times and high decay heat through both uniform and regional loading schemes, longer cooling times and lower decay heat are generally required in order to transport the same UNF assemblies in the same configuration. For example, a dual purpose canister system may have a total package decay heat of 34 kW for storage, but that same dual purpose canister must have a lower decay heat of 20 kW and additional years of cooling in order to be suitable for transport. This is particularly true for dual purpose storage systems that have been approved to store high-burnup (i.e., greater than 45 GWd/MTU burnup) UNF because higher burnup UNF has higher decay heat and a higher source term for a given cooling time. Unlike storage casks, transport casks have dose rate limits for the outside of the package. **Figure 5.2-14** provides a summary of the decay heat for storage and transport for several dual purpose systems that have been certified under both 10 CFR Part 71 and 10 CFR Part 72.

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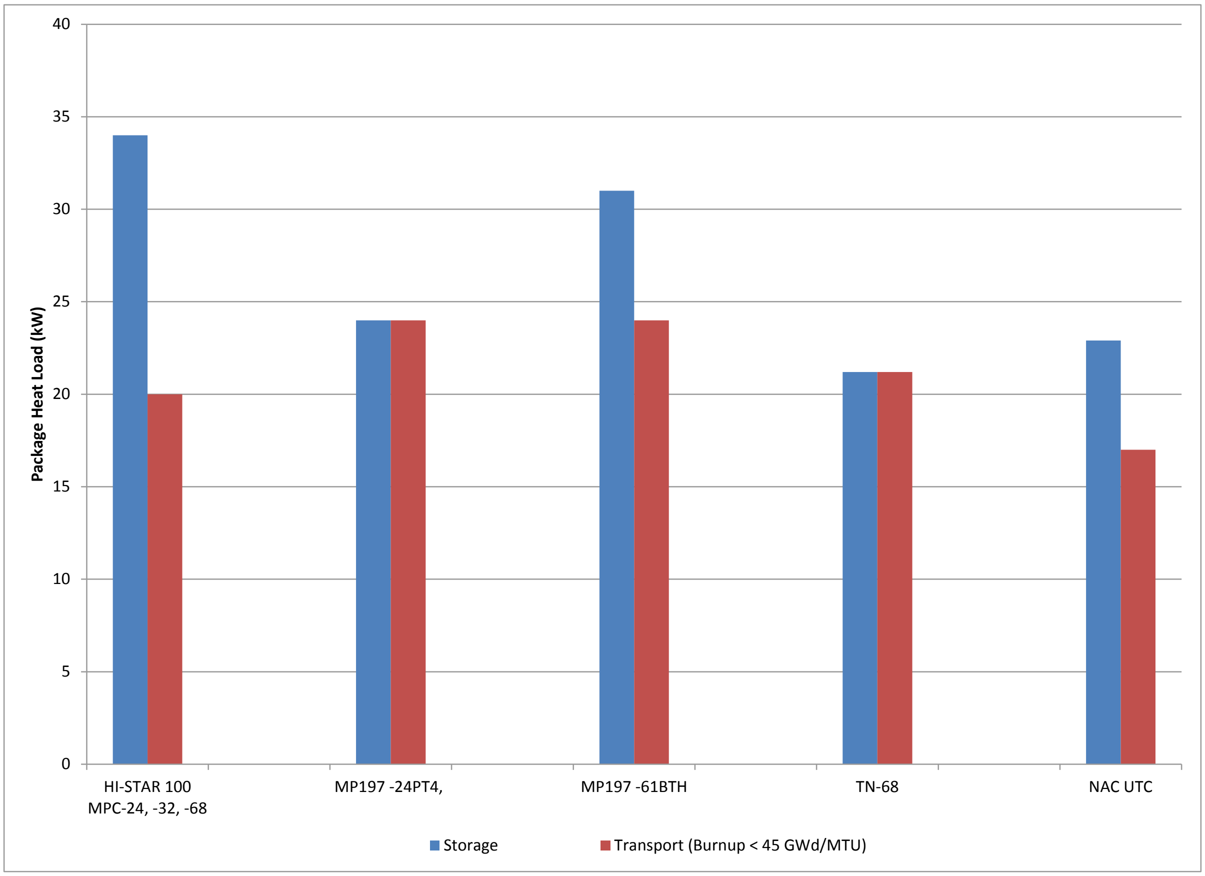
[22] Electric Power Research Institute, 2012. *Impacts Associated with Transfer of Spent Nuclear Fuel from Spent Fuel Storage Pools to Dry Storage After Five Years of Cooling*, Revision 1, Final Report, #1025206, August.

While the NAC UTC transport cask is certified to transport UNF from Maine Yankee that has burnups up to 49.5 GWd/MTU, this is the only dual purpose cask that is currently approved to transport even modestly high-burnup UNF. The 10 CFR Part 71 CoC specifically limits the NAC UMS to allow storage subsequent to transport of the existing high-burnup assemblies from Maine Yankee. No other dual purpose transport package design has been certified to transport high-burnup UNF, but the related storage systems have been certified to store high-burnup UNF. NRC certification of packages to transport high-burnup UNF well over 50 GWd/MTU is an issue that must be resolved in order to accept and transport much of the UNF that is now being stored in SFPs and dry storage facilities at nuclear power plant sites.

For packages that are approved to store and transport UNF with burnups less than 45 GWd/MTU, there is generally not a difference between the package decay heat for storage versus the decay heat for transport, as shown in **Figure 5.2-14**, for the TN-68 dual purpose cask. Based on a review of NRC 10 CFR Part 71 CoCs, it is possible to certify a transport cask with a decay heat of 20 to 24 kW, as shown in **Figure 5.2-14**. **Table 5.2-20** provides a summary of decay heat for PWR UNF assemblies with burnups of 45 to 55 GWd/MTU and cooling times of 5 years and 10 years; and for BWR assemblies with burnups of 40 to 50 GWd/MTU and cooling times of 5 years and 10 years. Assuming a transport package decay heat of 24 kW, it is possible to calculate a package capacity that would allow the transport of fuel assemblies with the various decay heat and cooling times, assuming uniform loading of UNF (that is, all assemblies have similar burnup and cooling times). While this allows an estimation of package capacity, there would be additional flexibility to load both higher and lower decay heat assemblies using regional loading as long as the total package heat did not exceed 24 kW, for this example.

Figure 5.2-14
Existing Package Decay Heat for Storage vs. Transport of UNF with Discharge Burnup < 45 GWd/MTU



Thus, 5-year cooled PWR assemblies with burnups of 45 GWd/MTU and a decay heat of 1,200 watts could be transported in a 20-assembly cask. If the UNF were cooled for 10 years, a 30-assembly cask could be used, as shown in **Table 5.2-20**. For 5-year cooled PWR assemblies with burnups of 55 GWd/MTU, the 24-kW cask capacity would be reduced to 16 assemblies (approximately 7 MTU). If this fuel were cooled for 10 years, a 24-kW cask could transport 24 assemblies. For BWR assemblies with burnups of 40 GWd/MTU and 5 years cooling, a 24-kW cask would have a capacity of approximately 66 assemblies. If this 40 GWd/MTU fuel were cooled for 10 years, there would likely not be a capacity restriction for transport of current BWR dual purpose systems with capacities from 61 to 89 BWR UNF assemblies, since the calculated capacity is 96 assemblies. For BWR assemblies with burnups of 50 GWd/MTU and 5 years of cooling, a 24-kW cask would have a capacity of 46 assemblies (approximately 8 MTU). If this fuel were cooled for 10 years, a 24-kW cask could transport 68 assemblies. In addition to decay heat, cask capacity must also consider shielding for higher burnup UNF, which will have higher source terms in addition to higher decay heat. Thus, actual cask capacities may differ from the values shown in **Table 5.2-20**, but the capacities provide a first approximation absent detailed cask design information.

Table 5.2-20
Assembly Decay Heat and Package Capacities for a 24 kW Cask

Burnup (GWd/MTU)	PWR Decay Heat (Watts/Assembly)		Burnup (GWd/MTU	BWR Decay Heat (Watts/Assembly)	
	5-Year Cooled	10-Year Cooled		5-Year Cooled	10-Year Cooled
45	1,200	800	40	360	250
50	1,350	900	45	400	290
55	1,500	1,000	50	520	350
Part 71 Cask Capacity – To Meet 24 kW Limit (No. of assemblies & MTU)*					
45	20 9 MTU	30 14 MTU	40	66 12 MTU	96 17 MTU
50	18 8 MTU	27 12 MTU	45	60 11 MTU	82 15 MTU
55	16 7 MTU	24 11 MTU	50	46 8 MTU	68 12 MTU

**Assumes 450 kg/PWR assembly & 180 kg/BWR assembly.*

High-capacity transport cask designs for high-burnup, high heat load UNF face two major obstacles: (1) package dose rate limits and (2) package heat dissipation capability. There are several alternatives for the transport of high-burnup, high decay heat UNF from SFPs. These include the following:

- A smaller-capacity transport package can be developed to transport high-burnup, high decay heat UNF with capacities of 16 to 18 PWR assemblies or 46 to 60 BWR assemblies, as described in **Table 5.2-20**. This could be a bare fuel cask or a canister-based system:
  - If the CSF does not have initial capability to unload bare fuel assemblies, this can be a canister-based dual purpose system.
  - If at a later time, it is useful to accept and transport bare, uncanistered fuel assemblies, this smaller capacity transport package could be amended to include removable BWR and PWR fuel assembly baskets, instead of canisters.
  - The lead time associated with development of new transport package design is 4 to 8 years for design, certification, and fabrication, as discussed in Section 5.2.5.
- Existing dual purpose canister designs could be amended to allow canisters to be short-loaded (that is, fewer assemblies than the maximum capacity are loaded). A number of existing dual purpose system designs already include approved contents in

which the canister is not fully loaded, such as only 20 out of 24 positions are loaded with UNF.

  - The lead time to amend existing certified transport packages is 4 to 6 years for design, certification, and fabrication, as discussed in Section 5.2.5.
  - Short-loading existing dual purpose canister designs in order to transport UNF to a CSF would likely result in higher costs for storage of those short-loaded canisters compared to storing a smaller-capacity canister.

5.2.7 UNF Transportation Technical Issues

There are a number of technical issues that must be addressed before embarking on a nationwide program to transport UNF from commercial nuclear power plant sites to a CSF. Technical issues that may need to be addressed in order to transport this UNF include resolution of regulatory issues associated with the transport of high-burnup UNF (i.e., burnups in excess of 45 GWd/MTU); approval and implementation of full burnup credit to support the criticality safety analyses for transport casks; confirmation of the condition of the UNF after extended storage; and consideration of the need for a transport cask testing program to support public acceptance of a nationwide program to transport UNF.

5.2.7.1 Burnup Credit

The criticality safety analyses that support UNF transport cask certification have historically assumed that the UNF is un-irradiated, referred to as a “fresh fuel” assumption. If the criticality safety analyses can take credit for the reactivity reduction associated with depletion of uranium and the buildup of neutron poisons in the UNF, criticality safety can be more readily demonstrated for high-capacity UNF transport casks, such as 32-PWR capacity dual purpose systems being loaded today for at-reactor storage and the 37-PWR canisters licensed and poised to be loaded in the near future.[23] A recent revision of NRC Interim Staff Guidance (ISG) on burnup credit, ISG-8, Rev. 3, includes two major changes in the recommendations to NRC staff regarding reviewing burnup credit applications for transportation and storage systems: (1) optional credit for fission product and minor actinide neutron absorbing isotopes in the UNF composition, and (2) misload analyses and additional administrative procedures in lieu of a burnup measurement at the time of loading. This ISG revision also includes an increase in the maximum assembly average burnup recommended for burnup credit.[24] This is significant progress. It will be important to understand how NRC

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[23] Wagner, John C., Cecil V. Parks, Don E. Mueller, and Ian Gauld, 2009. *Review of Technical Studies in the United States in Support of Burnup Credit Regulatory Guidance,* presented at the International Workshop on Advances in Applications of Burnup Credit for Spent Fuel Storage, Transport, Reprocessing, and Disposition, Cordoba, Spain, October 27–30.

[24] U.S. NRC, Spent Fuel Project Office, 2012. *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks,* Interim Staff Guidance - 8, Revision 3, September 26.

staff will implement this guidance in the review of applications for transport cask certification that rely on burnup credit.

5.2.7.2 Transport of High-burnup UNF

NRC ISG-11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," was issued in November 2003.[25] In that guidance document, NRC staff noted that it was "reevaluating the technical basis for the transportation of spent fuel including assemblies with average assembly burnups exceeding 45 GWd/MTU. The staff is reviewing data and technical reports to further understand the mechanical and fracture toughness properties of spent fuel cladding in relation to the transportation of high-burnup fuel under 10 CFR 71.55. Therefore, until further guidance is developed, the transportation of high-burnup commercial spent fuel will be handled on a case-by-case basis using the criteria given in 10 CFR 71.55, 10 CFR 71.43(f), and 10 CFR 71.51." Thus, until further NRC guidance is issued on this topic, there is not a generic approach for approval to transport UNF with burnups in excess of 45 GWd/MTU.

R&D that addresses research to be performed to qualify high-burnup fuel for transportation is discussed in Section 6.2 of this report.

5.2.7.3 Transport of UNF Following Extended Storage

Recognizing the likelihood that UNF will have to be stored at nuclear power plant sites for many decades, the Electric Power Research Institute (EPRI) has embarked on an extended storage collaborative research program to define the research and analysis needed to ensure very-long-term, safe storage, transportation, and monitoring. EPRI held a workshop in November 2009 that brought together representatives from EPRI, nuclear operating companies, the regulatory community, government agencies, UNF storage vendors, and other stakeholders that began to define critical gaps and research needs.[26]

Similarly, NRC staff has embarked on a review of NRC's regulatory programs for UNF storage and transportation to identify regulatory gaps in these regulations associated with very-long-term storage. NRC staff is examining the technical needs and potential changes to the regulatory framework that may be needed to continue licensing of UNF storage over periods beyond 120 years. In 2012, NRC issued a draft report regarding the results of NRC staff evaluation of the technical information needs for continued extended dry storage and for the subsequent transportation of UNF following long-term storage. The evaluation focuses

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[25] U.S. NRC, Spent Fuel Project Office, 2003. *Cladding Considerations for the Transportation and Storage of Spent Fuel*, Interim Staff Guidance-11, Revision 3, November 17.

[26] Electric Power Research Institute, 2010. *Used Fuel and HLW Extended Storage Collaboration Program: November 2009 Workshop Proceedings*, #1020780, February.

on the degradation phenomena that may affect dry storage systems, and how these phenomena may affect the ability of the systems to fulfill their regulatory functions.[27]

Prior to transport of UNF from reactor sites to a CSF, it will be necessary to demonstrate that the UNF can be transported safely in accordance with NRC regulations. Dry storage safety-related functions must be maintained during extended storage to ensure that UNF can be transported later. These safety functions include UNF thermal performance, radiological protection, confinement, sub-criticality, and ready retrievability.

Section 6.3 of this report discusses testing to support long-term storage of UNF; the development of monitoring devices for this testing is discussed in Section 6.4.

Potential issues include the following:

- Condition of the fuel in dry casks and of the fuel baskets in sealed canisters
- Environmental and handling conditions that could compel repackaging
- Repackaging at sites where reactor decommissioning has taken place (loss of wet pool storage, requirements for dry transfer)
- Long-term lead cask testing of high-burnup fuel
- Long-term monitoring requirements
- Effect of long-term storage on transportability

5.2.7.4 Transport Cask Testing

In February 2003, NRC staff released NUREG-1768 for public comment, "*U.S. Nuclear Regulatory Commission Package Performance Study Test Protocols*" (PPS Test Protocol).[28] In February 2004, NRC staff presented options to the NRC Commissioners for full-scale testing of UNF transport casks.[29] In May 2004, the Commission approved testing of a full-scale, NRC-certified rail transport cask and authorized NRC staff to purchase a single rail cask, develop a realistically conservative test that includes sufficient instrumentation to collect data to validate analytical methods including scaling, and include a fully engulfing fire as part of the test. NRC staff was instructed to develop a test plan for Commission approval, for a realistically conservative demonstration test.[30] NRC staff submitted a plan to

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[27] U.S. NRC, 2012. *Identification and Prioritization of the Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation of Spent Nuclear Fuel*, May.

[28] U.S. NRC, 2003. *U.S. Nuclear Regulatory Commission Package Performance Study Test Protocols*, Draft Report for Comment, NUREG-1768, February.

[29] U.S. NRC, 2004. *Options for Full-Scale Spent Nuclear Fuel Transportation Cask Testing Under the Package Performance Study*, SECY-04-0029, February 23.

[30] U.S. NRC, 2004. *Options for Full-Scale Spent Nuclear Fuel Transportation Cask Testing Under the Package Performance Study—Staff Requirements*, SECY-04-0029, May 11.

the Commission in 2005 for a cask demonstration test that would utilize a full-scale cask tied to and supported on a carrier railcar that would be impacted by a train approaching from a 90-degree angle at a simulated rail crossing. This would be considered an "extra-regulatory" test since it would be a test that is not required by 10 CFR Part 71 for package certification.[31] The Commission directed the staff to include a fire test scenario in the demonstration test plan in which the same rail cask used for the impact test would be subjected to a fully engulfing, optically dense, hydrocarbon fire for a duration of one-half hour, post-collision.[32]

While the Package Performance Study never proceeded, consideration should be given to whether a UNF cask testing program of some nature should be performed prior to embarking on a long-term, nationwide program to transport UNF. There may be a continued benefit to collecting data through testing to validate analytical methods used in cask safety analyses. In addition, a cask testing program could have an additional benefit of boosting public confidence in transport cask safety.

5.3 Transportation System

A transportation system to support consolidated storage would include the acquisition of casks and ancillary equipment for truck and rail shipments, specialty railcars, any maintenance facilities necessary to maintain the casks, intermodal transfer equipment, monitoring and maintenance equipment, and an operations center. Barges and/or heavy-haul trucks may be used for short-distance transport of UNF from those sites lacking direct access to a rail line.

Components of the rolling stock would include the following specifically designed railcars: cask cars, buffer cars, and escort cars. Standard locomotives will be used (and provided by the rail carriers). The cask car will carry the cask and cask cradle. The buffer car will act as a spacer between the cask car(s) and the security escort car, as well as between the cask car(s) and the locomotive(s). The security escort car will be used by security force personnel. In addition, equipment needed to load casks, including lift yokes, slings, and other ancillary equipment (such as vacuum drying or forced helium dehydration equipment, welding equipment for canister-based systems, helium backfill equipment, tools, etc.) could be transported in the escort car. If there is sufficient room on a buffer car, the equipment could be added to the train, or it could be shipped via general freight to the plant sites.

The truck cask equipment consists of the sleeper tractor, cask trailer, ancillary cask equipment, and the escort vehicle. The DOE cannot use rail transport exclusively because

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[31] U.S. NRC, 2005. *Details and Projected Cost of a Demonstration Test of a Full-Scale Spent Nuclear Fuel Rail Transportation Cask Under the Package Performance Study*, SECY-05-0051, March 28.
[32] U.S. NRC, 2005. *Details and Projected Cost of a Demonstration Test of a Full-Scale Spent Nuclear Fuel Rail Transportation Cask Under the Package Performance Study—Staff Requirements*, SECY-05-0051, June 9.

some commercial nuclear-generating sites may not have the ability to load large-capacity rail shipping casks. Those sites would use legal-weight or overweight trucks to ship material to the CSF or to an intermodal transfer site for railcar loading. Overweight trucks would be subject to permitting requirements in each state through which they travel. Commercial sites that could load the rail shipping casks but lack rail access could use heavy-haul trucks or barges to ship spent nuclear fuel to the nearest rail line as follows:

- Intermodal with Heavy-haul Truck—The CSF management entity could ship the casks to nearby railheads by heavy-haul truck. The viability of this approach is illustrated by the approximately 200 heavy-haul shipments of UNF that are conducted in France each year. Heavy-haul trucks would have gross vehicle weights of as much as 500,000 pounds. This option is site-specific and will be addressed on a case-by-case basis as site servicing and campaign plans are developed.
- Intermodal with Barge—Barge shipments of rail casks containing UNF could be considered from commercial sites that are on or near navigable waterways. Barge transport would be done to another facility where rail access is accessible. This option is site-specific and will be addressed on a case-by-case basis as site servicing and campaign plans are developed.

Since these are specialty services that would be highly dependent on local requirements, a CSF would likely procure services for barge, legal, and overweight and heavy-haul truck shipments rather than procuring all the equipment and personnel resources to provide such services at many different sites.

5.3.1 Rail Transportation

5.3.1.1 AAR Standards and Railcar Design Implications

The Association of American Railroads (AAR) is an industry organization representing the interests of commercial railroads in the U.S., Canada and Mexico. AAR's two principal functions are working with lawmakers and regulators to address critical rail-related issues and improving the efficiency, safety, and service of the overall railroad industry.

AAR standards are recommended practices to ensure interoperability among member railroads, but are not enforceable in the manner of federal regulations. The Federal Railroad Administration (FRA) does participate in AAR's development of standards. Collaboration with the AAR enables the FRA to address issues that affect all railroads via a single body, and to contribute to industry governance and regulation outside the rule-making process. The FRA may also adopt AAR standards by incorporating them into regulations.

AAR High Level Radioactive Material (HLRM) Standard S-2043, "Performance Specification for Trains Used to Carry High-Level Radioactive Material," effective May 1, 2003, is a performance standard for design, construction, and testing requirements for rolling stock used in the transportation of high-level radioactive material. It updates and complements sections of AAR's Manual of Standards and Recommended Practices (MSRP) applicable to freight car design and construction, and applies equally to the passenger and buffer cars specified for radioactive waste transported via rail.

AAR HLRM Standard S-2043 states that its objective is to "use the best available technology to minimize the chances of derailment of trains carrying radioactive waste in transportation." This standard requires new railcars to have increased structural integrity, increased strength and stability, an enhanced braking system, and real-time monitoring of railcar systems. For the escort car, the structure will be even more complex because of security features and capabilities. These requirements translate to an increased lead time for procurement of the rail rolling stock. The AAR standard requires all of these cars to be tested as a "consist," or complete train, to ensure the overall train dynamics meet the performance stability requirements. The train consist will include the locomotive, followed by a buffer car, followed by all of the cask cars, followed by another buffer car, and then the escort car.

The AAR standard requires certification of prototype cars. Prototype cars will be delivered in time to meet testing schedules. Once sufficient testing has been completed, production cars will be fabricated. While UNF shipping requirements may require relatively few cars to be available during the period of initial startup and operations, it may not be viable or economic to procure railcars in these small quantities due to the production facilities employed in the rail industry. Manufacturers of specialty railcars generally configure their facilities to fabricate large numbers of railcars (such as tank cars or passenger cars) in a continuous production run. Therefore, it may be advisable to procure orders for more railcars than will be initially needed and store them until they are needed. In order to supply the full quantity of railcars required for shipping at least 3,000 MTU or up to 4,500 MTU in a single year, it will be necessary to optimize delivery rates to satisfy program requirements and production capabilities regarding economies of scale.

Recommendations to meet AAR S-2034 regarding the design and procurement of railcars include the following:

- Design efforts that are adjusted based on the realization that AAR S-2043 compliant railcars could be launched from existing railcar designs so the initial design costs will be reduced.
- Lower costs for prototypes may be achievable based on using existing railcar designs.

- Transportation Technology Center, Inc. (TTCI) simulations confirmed existing “premium trucks” could be “tweaked” to meet the performance requirements of S-2043.
- Escort car development and production costs could be significantly reduced by collaborating design efforts and sharing costs with the U.S. Navy (associated with continuing work that the U.S. Navy is doing to develop an escort car to support naval reactor UNF transport).
- While no existing railcar or consist has yet completed the entire testing regimen prescribed by AAR S-2043, the performance requirements for individual components have been validated by physically testing available products.

5.3.1.2 Railcars

During procurement planning for rolling stock to support the proposed Yucca Mountain repository transportation system, the DOE developed specifications for the buffer car, cask car, and the escort car. However, the DOE did not initiate the preliminary/final design process within the railcar manufacturing industry. The DOE and Navy Nuclear Propulsion Program (NNPP) began a joint escort car development project in 2007. The NNPP has continued forward with the development of this escort railcar. It is recommended that efforts to develop rolling stock to support transport of UNF to a CSF should reconstitute discussions with the NNPP in pursuing the development of the escort car.

The specifications that were previously developed by the DOE for buffer cars, cask cars, and escort cars should be considered as a starting point for procurement planning for a transportation system to support a CSF facility. It is expected, although not required, that the cask car will be a depressed center flat car with approximately 50 percent low deck height, 8 axles, no bulkheads, 4 trucks, and 2 span bolsters. **Table 5.3-1** lists the basic dimensional specifications for the cask car.

Table 5.3-1
Basic Cask Car Weights and Dimensions

Weight of largest cask, fully loaded	150 tons
Weight of largest cask, empty	105 tons
Estimated cradle weight	20 tons
Largest cask length	25 ft. 8 in.
Largest cask largest outside diameter	12 ft.
Nominal Data, Car Dimensions, Clearances	
Maximum nominal speed	70 mph
Weight equalization between trucks	1%
Weight fully loaded ready to run	71–85 tons (range)
Weight per axle	8.9–10.6 tons (range)
AAR Clearance plate	Plate C; routes to be negotiated with railroad clearance engineers
Minimum curve radius	300 ft.
Minimum curve radius coupled units	300 ft.
Clearance above Top of Rail (TOR), fully worn wheels, defective springs.	2 ¾” worst case
Deck Width	[Car builder advise]
Deck Length (low deck)	[Car builder advise]
Deck Height (low deck)	[Car builder advise]
Length Between Pulling Faces	81’8”–86’8” (range)
Truck Centers at each end	12’ (approx.)
Truck Centers at span bolsters	51’4”–56’4” (range)
Truck Wheel Base	5’10” (110-ton service) or 6’0” (120-ton service)
AAR Coupler Height	34.5”

5.3.1.3 Locomotives

It is recommended that the CSF project not purchase its own road-haul locomotives for the dedicated UNF trains. The project should use commercial-railroad-supplied engines for the train consist, as the established rates for UNF transport with carriers include the costs of the locomotives, fuel, routine maintenance of railroad-provided equipment, and qualified crewmen (engineer and conductor) to safely operate the dedicated trains. By not purchasing locomotives, the CSF project would save approximately $100 million in acquisition costs plus the added fuel cost savings and routine maintenance and replacement costs associated with this equipment. The railroad rate for dedicated trains would not be reduced if the project were to provide shipper-owned/leased locomotives for the dedicated train consists.

The recommendation to use railroad-supplied locomotives is based on the premise that the railroads have 8 years to continue purchasing electronically controlled pneumatic (ECP) brake-equipped locomotives and build up their fleet numbers. The AAR S-2043 standard for the dedicated UNF trains requires that each railcar (cask, buffer, and escort) be equipped with ECP brakes. To operate these dedicated UNF trains, the locomotives must also be equipped with ECP brakes. At this time, not all locomotives in the current rail fleet (Class I's) are equipped with ECP brakes but locomotive manufacturers are moving in the direction of making ECP brakes a standard feature within the industry. By 2017, if there aren't enough ECP brake-equipped locomotives on the Class I railroads, then a decision will need to be made to either purchase 30 new ECP brake-equipped locomotives or lease 30 existing railroad locomotives for dedicated train service to DOE and retrofit these locomotives with the ECP control box. The retrofit cost to equip a locomotive with the ECP braking system is a minimum of $70,000.

The CSF project should consider purchasing two or three hybrid yard locomotives (a 31–35 percent fuel savings over conventional yard switching engines) to build the UNF train consists within the repository/interim storage rail yard and for the spotting/pulling of railcars at the CMF and FMF. The CSF project should also give serious consideration to purchasing hybrid yard locomotives for operations in the regional marshaling yards. The cost for these smaller yard switching units would be approximately $750,000 per locomotive.

5.3.1.4 Rail Equipment Cost

Assuming unit costs of $3.4 million, $670,000, and $510,000 for escort cars, cask cars, and buffer cars, respectively, as detailed later in this section, the preliminary cost range for rolling stock acquisition for the recommended 4,500-MTU maximum shipping rate with OFF-Plus priority is $320–340 million, as detailed below:

- 29 Escort Cars
  - Design Phase (preliminary & final): $2,950,000
  - Prototype
    - Fabrication: $17,000,000
    - Testing and Inspection: $1,700,000
  - Production Run
    - Final Design Package: $3,400,000
    - Production: $98,600,000
    - Final Testing and Inspection: $2,050,000

        - Contingency (extra cars, spare parts): $3,400,000
    - Other
        - TTCI Car Prototype & Consist Testing: $2,290,000
        - Special Tools and Equipment: $1,025,000
        - Training and Manuals: $2,500,000
        - Additional Equipment and Systems: $34,000,000
- 145 Cask Cars
    - Design Phase (preliminary and final): $1,150,000
    - Prototype
        - Fabrication: $2,900,000
        - Testing and Inspection: $170,000
    - Production Run
        - Final Design Package: $1,990,000
        - Production: $97,150,000
        - Final Testing and Inspection: $1,250,000
        - Contingency (extra cars, spare parts): $5,100,000
    - Other
        - TTCI Car Prototype and Consist Testing: $2,220,000
        - Special Tools and Equipment: $510,000
        - Training and Manuals: $1,535,000
        - Additional Equipment and Systems: $685,000
- 58 Buffer Cars
    - Design Phase (preliminary and final): $1,000,000
    - Prototype
        - Fabrication: $2,415,000
        - Testing and Inspection: $170,000
    - Production Run

    - Final Design Package: $1,365,000
    - Production: $29,600,000
    - Final Testing and Inspection: $1,140,000
    - Contingency (extra cars, spare parts): $3,640,000
  - Other
    - TTCI Car Prototype and Consist Testing: $2,220,000
    - Special Tools and Equipment: $510,000
    - Training and Manuals: $1,250,000
    - Additional Equipment and Systems: $0

5.3.1.5 Rolling Stock Issues

There are a number of issues associated with design, fabrication, and maintenance of rolling stock that may present challenges and must be addressed early in the process to ensure availability of rolling stock to support the start of operations at a CSF. These issues include the following:

- Assuming that a CSF is authorized and able to begin operation by 2020, no railcars that meet the AAR HLRM S-2043 standard will be readily available. Thus, a design and fabrication program will be required.
- It will be necessary to decide whether it is more cost effective or efficient to build a railcar FMF or to buy railcar maintenance services.
- It will be important to continue to interface with NNPP on development of the escort car.

Regarding the need to design and manufacture railcars that meet the AAR S-2043 standard, it is likely that railcar manufacturers will not find this to be an attractive contract for the following reasons:

- Depending upon what organization will be responsible for development of the CSF and transport system (i.e., the DOE, a FedCorp, or private industry), most railcar manufacturers do not have experience with government contracts and may be hesitant regarding the impact of federal appropriations on the order, federal procurement rules, etc.
- The number of railcars to be ordered, even to support an annual acceptance rate of 4,500 MTU per year, is a relatively small order quantity compared to the cars that are

manufactured for other customers. Railcar manufacturers will be reluctant to tie up their manufacturing capacity for one prototype cask car and buffer car that are needed for testing and then wait for 1 to 2 years before the start of production on the rolling stock fleet.

- Railcar manufacturers are not familiar with the AAR S-2043 Standard, as no manufacturer has built and tested cars to this standard. Therefore, there will be uncertainty regarding implementation of this standard for the first time.
- The engineering resources at most manufacturers are small and they are usually busy with current, large client orders. Therefore, they may be unwilling to tie up their engineering resources for a relatively small order.
- The AAR S-2043 prototype testing period will take approximately 3 years and will tie up scarce technical resources at the railcar manufacturers.

It is recommended that the CSF program managers initiate negotiations with AAR and commercial rail carriers to revise the speed regulation for UNF trains (“key trains”[33])from 50 mph to 70 mph on Class I railroads. UNF-dedicated trains are designated key trains by the FRA, have a maximum operating speed limit of 50 mph, and have other handling restrictions. Allowing UNF-dedicated trains to travel at 70 mph would reduce the travel time for the train and remove the operational problems created with a dedicated train operating at different speeds from other trains. The rationale behind such a request is the enhanced robustness in the design of all rolling stock equipment for UNF-dedicated trains and the enhanced safety equipment, which will be the standard for these new production railcars (i.e., redundant electronically controlled pneumatic (ECP) brakes and standard air-hose braking systems, “premium trucks”, GPS monitoring equipment, etc.). If UNF-dedicated trains operate with the 50 mph speed restriction, these trains will be the slowest trains in every rail corridor and will be an additional “bottleneck” on already-congested routes on their journey to the CSF.

Procurement of all rolling stock should also be initiated as soon as practicable to confirm positioning within the manufacturer’s development queue for the building of the UNF railcars to support transport to a CSF.

5.3.1.6 Procurement and Fabrication Duration for Rolling Stock

The best-case projection for the delivery lead time of the certified AAR S-2043 rolling stock equipment is that these railcars could be available for transporting UNF within 3 to 5 years (late 2017 to 2018 timeframe). Typical development could take as much as 7 to 9 years.

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[33] Key trains as defined in the AAR S-2043 standard include those transporting UNF and can operate at a maximum speed limit of 50 miles per hour (mph).

However, using the following recommendations, the DOE can shorten this timeline, saving 3 to 4 years in the "Initial Design to Production Run" delivery schedule of the rail equipment (assuming the DOE issues the contract to proceed with the CSF project by July 2013):

- Final Design—Railcars
  - Purchase the rights to the Private Fuel Storage (PFS) rail cask car design immediately (July 2013).
  - Use current industry flat car design for the buffer car (or depressed center, lowboy flat car) and modify to AAR S-2043 standard (i.e., electronically controlled pneumatic [ECP] braking system, GPS tracking system, etc.).
  - Re-partner with the NNPP for the escort car design.
- Place the order with the railcar manufacturer for the full contingent of railcars (cask, buffer, and escort) required for transport by the program (September 2013).
  - Assume there will be an 8–14 month queue before production can begin on the DOE specialty railcars (June 2014 through December 2014).
  - Take the first five cask cars, three buffer cars, and escort car off the production line (6–12 months) and deliver to TTCI for prototype and consist testing (December 2014 through December 2015).
- Initiate the prototype (buffer and escort car) TTCI testing schedule (January 2015 through January 2016, 6–12 months)
  - Full consist testing to be performed on Class I mainlines (AAR's 100,000 mile evaluation period), 8–12 months
  - Perform TTCI certification of train consist for AAR's Equipment Engineering Committee approval (March 2016 through January 2018)
- Move railcars to designated staging area(s) to begin UNF transport (September 2016 through June 2018).

This is an aggressive, but achievable, timeline without any contingency built into the schedule from the development through the delivery of the AAR S-2043 railcars. The above-stated recommendations will reduce the schedule by the following:

- Removing 12 months from the "Initial/Final Design" stage for the rolling stock by using existing designs.

- Placing the full order for the railcars with the railcar manufacturers rather than requesting a prototype testing/multiple production runs for each type of car, saving 2 to 3 years of start/stop retooling production runs and railcar manufacturing waiting queues.
- Instead of utilizing prototype models for S-2043 testing, take the first railcars off the production run to initiate TTCI prototype and full consist testing for AAR certification. Testing will occur simultaneously with continuing production, rather than in sequence based on previous DOE project management schedules for rolling stock acquisition.
- Take 12 months off the TTCI testing/certification schedule, as the cask car prototype (PFS design) has already been completed.

In pursuing this expedited schedule, there are some inherent risks involved, which can be mitigated by the DOE, to reap beneficial cost and time savings for the project. Some rolling stock schedule risks, along with associated mitigating actions, include the following:

- S-2043 design modifications are identified during/after prototype testing at TTCI
    - A change to design needs to be incorporated into the railcars during/after the production run
        - The PFS cask car design has already been vetted by TTCI pertaining to the AAR S-2043 standards
        - S-2043 compliant components (i.e. “premium trucks”, ECP braking systems, etc.) have already been tested and certified within the industry
    - Modifying existing railcar designs will ensure that any modification identified by TTCI will result in relatively simple changes during/after the manufacturing process
- Lack of contingency built into the current schedule
    - Any unexpected delays in the manufacturing process of the railcars could be mitigated by the DOE based on the number of railcars required for the first year of transport operations (40 cask car shipments in 2020), which averages to less than 4 cask railcar shipments per month
    - Placing the full order for the production of the railcars in 2013

        - By placing this order, the DOE will receive economies of scale and enable the lowering of manufacturing costs in a single procurement order
        - By placing this order, the DOE will remove from the schedule multiple potential manufacturing “wait” queues if production were to be performed in batches

To meet this delivery schedule, the DOE will need to initiate all the required actions concurrently, not in sequential order. Some of the current unknowns include the following:

- The length of time associated with the current “wait” queue for the railcar manufacturing contractor awarded this potential contract
- The specific railcar manufacturing contractors who will bid on this project
    - It is assumed there will be two separate contracts awarded for the rolling stock:
        - Cask and buffer car manufacturer (freight car industry)
        - Escort car manufacturer (passenger rail/transit car industry)
- TTCI testing schedule (timeline and “wait” queue)

5.3.1.7 Rail Shipping Costs

In order to estimate representative shipping costs, as the specific location of the CSF site(s) is not known at this time, the routes/mileage were estimated for an assumed location in New Mexico.

Assumptions:

- Railroad Negotiated UNF Rate (DOE/Class I RR’s)
    - Empty = $9.81 per dedicated train mile/cask car
        - Dedicated train consist rate (empty) = $57.69/mile[34]
    - Loaded = $19.17 per dedicated train mile/cask car
        - Dedicated train consist rate (loaded) = $112.71**Error! Bookmark not efined.**
- All heavy-haul truck (HHT) and barge casks transloaded to rail

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[34] Train consist includes five cask cars, two buffer cars, and the escort rail car.

- Six security escort personnel
- Average RT mileage/train = 2,850
    - Estimated total train miles = 9,100,000

Estimated number of Trains: 3,200 (15 percent contingency, non-5-cask train consists)

Estimated Number of Casks: 13,850[35]

Rail Transportation Costs: $776,000,000

5.3.2 Truck and Barge Transportation

At plant sites without the capacity to handle rail casks, a conventional LWT or an overweight truck (OWT) will be used to deliver one small-capacity cask. LWTs must not exceed 34,000 pounds per dual axle or 17,000 pounds per single axle considering full fuel load, two drivers, the loaded cask, and any additional road, tracking, or disabling equipment. After loading and preparation, the cask is picked up and delivered directly to the CSF using the public highway network, or in some cases, such as in the transport of OWT casks, is loaded onto a railcar at an intermodal transfer (IMT) site.

Although truck casks have substantially less capacity than a rail cask, for some plant sites, truck shipments may be the only option. These sites may lack sufficiently large entry points or cask handling cranes, or other equipment needed to load rail casks. Shipment by truck may also be more effective than rail casks in rare cases, such as near the completion of a campaign, when a partial cask load is all that remains at a plant site.

A truck convoy includes the cask trailer, a transport tractor (semi-truck cab), and a shipment security escort vehicle. Multiple truck shipments to or from a single origin site may be arranged as a convoy, or arranged sequentially to improve shipment schedules. Similar to rail shipments, the Transportation Security Force (TSF) accompanying a truck shipment maintains continuous surveillance of casks and communicates shipment progress to Transportation Operations Center personnel. One equipment truck is assumed to be used for shipment of ancillary cask handling equipment for every three casks.

At plant sites lacking direct rail service, large-capacity rail casks would be delivered by rail to a nearby IMT site, then removed and placed on a specialized HHT for transport to and from the plant site via local highways. Once casks are loaded, they return to the same IMT site via HHT, are transferred to railcars, and then transported to the CSF. The TSF accompanying HHT shipments would maintain continuous surveillance of casks and

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[35] Total MTU shipped is 140,000 (Section 5.2.2.1). MTU by truck is 1,500 (Section 5.2.4). 138,500 MTU by rail at an average of 10 MTU per cask equals 13,850 casks.

communicate shipment progress to Transportation Operations Center personnel. Trucks will travel by interstate highways or other approved routes.

Casks weighing from 20 to 40 tons (gross weight) can be transported by truck over public roads with annual permits and minimal restrictions. Standard trailers support these shipments. OWT casks would require special permits from states through which they are transported by road. Transport of OWTs via road could be limited by using IMT to transfer loaded OWT casks from road transport to rail at an IMT site. Truck trailers used to transport rail casks that require heavy-haul to the nearest rail line are custom-built for specific cask models and may accommodate intermodal (trailer-on-flat-car) rail shipment as necessary. HHT shipments require a permit for each shipment by each state.

For truck shipments, specialized commercial trucking firms that are certified under the DOE Motor Carrier Evaluation Program would be utilized and would provide USDOT-certified drivers qualified for UNF shipments. Special arrangements will be made for HHT carriers and barge operators.

The Transportation Operations Center would coordinate preshipment inspections by federal or state agencies, including FRA inspection and truck inspections conforming to Commercial Vehicle Safety Alliance enhanced inspection standards.

At plant sites that lack direct rail service but can be accessed by barge, an HHT (depending on the cask handling capacity of the plant site) moves casks from the rail IMT site to a dock where the HHT with a cask is transferred to a barge. The barge is delivered to a dock at a location near the plant site and an HHT delivers the cask for loading to the plant site. After loading the cask, the reverse process is used to return the loaded cask from the origin site to the rail IMT site. As with all other shipments, the TSF will provide security for the barge portion of a shipment, in coordination with the U.S. Coast Guard (USCG) and states.

Ancillary cask equipment shipped in the equipment trucks may include cask-unique lifting yokes, bolting operators, leak-testing equipment, testing and measuring instruments and fixtures for each cask system, packaging for surface contaminated ancillary equipment, and transfer casks (used with canister-based systems). Other initial spare parts and consumables that would be shipped in the equipment trucks may include fasteners, containment seal rings (gaskets), service fittings, valves, and unique lubricants.

5.3.2.1 Truck, Heavy-Haul, and Barge Costs

There are three options on how to transport UNF using LWT/OWT casks:

1. The DOE purchases the 18 tractors and trailers, 18 escort vehicles, and 6 equipment trucks, and hires 66 government drivers (2 per truck, 1 per escort vehicle).

2. The DOE utilizes a contactor to perform the work. The DOE owns the trailers, while the contractor supplies the tractors. The USDOT certifies tractor drivers and the escort vehicle drivers[36]. The casks would be transported by truck to the CSF.
3. Option 3 is the same as option 2 except that the contractor would short-haul the trailers to the closest rail “trailer on flat car” (TOFC) piggy-back facility for loading/transport within a dedicated DOE train consist to the CSF.

Option 2 is recommended.

Truck Costs

Equipment Costs

Sleeper tractors: $105,000–$125,000	Subtotal cost = $2,070,000 (unit price = $115,000)
*Trailers: $40,000–$50,000	Subtotal cost = $810,000 (unit price = $45,000)
Equipment trucks: $150,000 (18 wheeler)	Subtotal cost = $910,000
*Escort vehicles: $15,000–$25,000	Subtotal cost = $360,000 (unit price = $20,000)
*Miscellaneous ancillary equipment	Subtotal cost = $414,000

- Total truck equip. procurement costs:
    - Option 1 (above) = $4,564,000
    - Option 2 = $1,584,000

Truck Shipping/Maintenance Costs

Total shipments	1,000 casks
Shipping costs	$60,000–$100,000 per shipment

- Includes fuel, state-use fees and permits, driver per diem, driver “safe driving” bonus, and subcontractor performance of preventive maintenance on DOE trailers.

Total LWT/OWT Truck Shipping Costs: $60,000,000–$100,000,000

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[36] This is how the Waste Isolation Pilot Plant contract is structured.

Heavy-Haul Shipping Costs

Heavy-haul trucks may be used for short-distance transport of UNF from those sites lacking access to nearby railroads. The estimated costs below are based on procuring services for heavy-haul truck shipments rather than procuring equipment.

- Intermodal with heavy-haul truck—The DOE could ship the casks to nearby railheads by heavy-haul truck. This option is site-specific and will be addressed on a case-by-case basis as site servicing and campaign plans are developed.

The following data are used to determine the HHT costs:

- Tractor/trailer: $250/hour
- Truck driver: $95/hour
- Escort driver: $60/hour (2 required for front and rear escort vehicles)

The total cost of HHT is $465/hour. **Table 5.3-2** lists the plants expected to use HHT and associated data.

Table 5.3-2
HHT Plant Data

Site	Distance[37]	Travel Time	Trip Costs[38]
Big Rock Point, MI	12.4 miles	1 hour	$1,395
Callaway, MO	11.5 miles	1 hour	$1,395
Fort Calhoun, NE	3.8 miles	1 hour	$1,395
Ginna, NY	21.8 miles	1 hour	$1,395
Oconee, SC	10.9 miles	1 hour	$1,395
Peach Bottom, PA	36.6 miles	2 hours	$1,860
Yankee Rowe, MA	6.3 miles	1 hour	$1,395

HHT empty returns (back-hauls) are not included in the trip costs.

It is estimated that 1,032 HHT trips would be required. Assuming a 25 mph HHT speed results in an estimated total HHT cost of $1,600,995, considering the various travel times from the plants in **Table 5.3-2**.

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[37] One-way distance taken from the Yucca Mountain FEIS, DOE/EIS-0250F.

[38] This figure includes 1 hour loading time and 1 hour unloading time per cask. After the crane has lifted the cask from the heavy-haul trailer at the IMT site, the heavy-haul truck can return to the utility shipping site to pick-up the next UNF cask.

Barge Shipping Costs

Barges may be used for short-distance transport of UNF from those sites lacking access to nearby railroads. The costs below are based on procuring services for barge and the related legal and overweight truck and heavy-haul truck shipments rather than procuring hardware.

- Intermodal with barge—Barge shipments of rail casks containing UNF could be considered from commercial sites that are on or near navigable waterways. Barge transport would be done to another facility where rail access is accessible. This option is site-specific and will be addressed on a case-by-case basis as site servicing and campaign plans are developed.

The assumed barge speed is 5 mph (industry average). The standard barge is 195 feet long, 35 feet wide, with a double hull for safety. Barges typically operate with a 9-foot draft. The barge capacity is 1,500 tons and thus can accommodate a 300- to 750-ton payload (2 to 5 casks) for the DOE deck barge shipments. The following data are used to develop the barge transport costs:

- Tug/Barge: $1,000/hour, fuel consumption = 125 gallons/hour (8 hour minimum)
- Pilot: $125/hour
- Laborer: $80/hour (4 required)

The total cost of transport is $1,445/hour. **Table 5.3-3** lists the plants expected to use barge transportation and associated data.

Table 5.3-3
Barge Transportation Plant Data

Plant	Distance[39]	Travel Time	Trip Costs
Browns Ferry, AL	57 miles	12 hours	$17,340
Calvert Cliffs, MD	99 miles	20 hours	$28,900
Cooper, NE	117 miles	24 hours	$34,680
Diablo Canyon, CA	143 miles	29 hours	$41,905
Grand Gulf, MS	51 miles	10 hours	$14,450
Haddam Neck, CT	99 miles	20 hours	$28,900
Hope Creek, NJ	30 miles	6 hours	$11,560
Indian Point, NY	68 miles	14 hours	$20,230
Kewaunee, WI	177 miles	36 hours	$52,020
Oyster Creek, NJ	130 miles	26 hours	$37,570

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[39] One-way distance taken from the Yucca Mountain FEIS, DOE/EIS-0250F.

Plant	Distance[39]	Travel Time	Trip Costs
Palisades, MI	256 miles	51.5 hours	$74,418
Pilgrim, MA	74 miles	15 hours	$21,675
Point Beach, WI	169 miles	34 hours	$49,130
Salem, NJ	34 miles	7 hours	$11,560
St. Lucie, FL	140 miles	28 hours	$40,460
Surry, VA	71 miles	14.5 hours	$20,953
Turkey Point, FL	54 miles	11 hours	$15,895

Trip costs are one-way; empty or back-haul costs are not estimated nor included in **Table 5.3-3**.

Today's towboats range in size from about 117 feet long by 30 feet wide to more than 200 feet long by 45 feet wide and have diesel engines that can produce up to 10,000 horsepower. DOE towboat requirements for a single barge shipment would be in a lighter and smaller range of 2,500 to 3,000 horsepower. Large, slow turning diesels of the kind used in commercial towboats will burn approximately 1 gallon per hour per 20 horsepower delivered. Assuming a 2,500-horepower towboat is used for UNF shipments, fuel consumption would be 125 gallons/hour.

It is estimated that 641 barge shipments would be required, resulting in an estimated total barge cost of $18,209,923, considering the travel times from the plants in **Table 5.3-3**.

5.3.3 Transportation System Operations

In April 2006, OCRWM issued its Transportation System Concept of Operations (DOE/RW-0584, Rev. 0), which outlined major stages for the transportation operational cycle. The major stages identified in that document represent a reasonable starting approach for planning and operation of transportation logistics to support a CSF. The discussion later in this section is an adaptation of these stages for shipment to one or more CSFs, with a brief explanation of each stage in the cycle.

Transportation Logistics Operational Cycle	
1.	Shipment planning and management
2.	Assembly and dispatch from cask/fleet management facility
3.	Delivery to plant site (with intermodal transfers as necessary)
4.	Cask handling and loading at plant site
5.	Transport of loaded casks to CSF (via intermodal transfers or marshaling yards as needed
6.	Retrieving unloaded casks from the CSF

7.	Maintenance and preparation for shipment

Each stage consists of discrete functions or activities, processes, and interfaces among different involved entities.

5.3.3.1 Shipment Planning and Management

Shipment planning and management includes defining and understanding the transportation capabilities necessary to safely, securely, and efficiently transport UNF and GTCC waste from plant sites to a CSF. Transportation campaign plans must be developed that will maximize the usefulness and efficiency of transportation assets. Those plans will be developed in cooperation with the plant sites, the CSF operations team, and corridor jurisdictions to ensure efficient and effective allocation of staff and resources among sites and corridors that may be shipping simultaneously. When shipments commence, the Transportation Operations Center will develop periodic and rolling schedules for carrier and cask movements, track ongoing shipments, and serve as a communications hub in the event of schedule or route changes, or unexpected events.

***Functions and Activities*—**Shipment planning includes the development of shipment schedules and assignment of needed personnel and equipment. Shipment planning and management will rely on information provided by originating sites via the Final Delivery Schedules (FDSs) process outlined in the Standard Contract or by another process mutually agreed to between the originating sites and the CSF operations team.[40] Physical protection, security assessments, and emergency response guidelines will also be specified in plans. Data received from UNF origin sites via the FDSs will be used to develop an Annual Shipment Plan (or a Multi-Year Shipment Plan if OFF-Plus is utilized) and Site Campaign Plans for each plant site. A Site Campaign Plan correlates the unique logistics requirements at each plant site with transportation system capabilities (i.e., specific casks, equipment, and transportation modes) available.

Each Site Campaign Plan will describe specific logistical arrangements for transporters, including assignments of equipment and personnel; specifications for transport casks and equipment; schedules of arrivals and departures; special requirements; inspections; and time allocations for work activities, as well as specific security and emergency response requirements for a shipping campaign. Site Campaign Plan formats are described in DOE Order 460.1, “Packaging and Transportation Safety,” and will rely on DOE M 460.2-1A, “Radioactive Material Transportation Practices Manual.”

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[40] For the purpose of this analysis, the FDS process in the Standard Contract will be referenced throughout this discussion. However, it is recognized that planning beyond than the 12 months specified in the FDS process would likely be needed in order to provide efficient long-term planning. In addition, if an OFF-Plus priority ranking is utilized as recommended in Section 5.2.4.4, the planning processes would need to be revised by mutual agreement of the parties in order to implement a multi-year campaign schedules.

In these Site Campaign Plans, the CSF operations center will integrate the plant site requirements with the transportation system capabilities, including the availability of equipment from cask and fleet maintenance facilities and the current and forecasted acceptance rates at the CSF. Prior to dispatch of loaded casks from plant sites, the operations center will pre-notify affected jurisdictions of final route determinations and scheduling adjustments.

The CSF operations center will select modes of transportation based on shipment safety, security, and efficiency, while taking into consideration the availability of services, equipment, and infrastructure at origin sites. Routes will be determined in consultation with corridor jurisdictions based on shipment safety, security and efficiency, and will be guided by the experience and requirements of federal agencies such as USDOT, DHS, U.S. Department of Commerce (DOC), NRC, FRA, the Federal Motor Carrier Safety Administration (FMCSA), and, as appropriate, the USCG. Truck shipments of UNF will follow routing requirements in 49 CFR 397, Subpart D, "Routing of Class 7 (Radioactive) Materials." Rail shipment routes will be examined using USDOT's Rail Corridor Risk Management System[41], which was developed to analyze safety and security routing requirements specified in a 2008 rulemaking. During shipment, carriers will be tracked to ensure compliance with regulatory requirements and plans.

The CSF operations center will communicate with federal agencies; commercial carriers; origin sites; affected state, local, and Native American tribal officials; and stakeholder representatives to optimize services and minimize risks during shipments. The operations center will also be responsible for managing internal interfaces among the CSF and carriers.

5.3.3.2 Assembly and Dispatch from Cask/Fleet Management Facility

***Functions and Activities*—**Preparations for shipping UNF will originate with the assembly of casks and rolling stock in a train consist and will terminate with transporter dispatch. As specified in the Site Campaign Plan, the CSF operations center will identify and direct the CMF to release specific casks from inventory with current 10 CFR Part 71 CoC and associated transport equipment configured for the designated shipping facilities. In the case of both rail and truck shipments, cask types will be matched to plant site waste and transporter specifications. Security personnel will be dispatched to accompany each shipment.

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[41] Using funding from the Department of Homeland Security, the Railroad Research Foundation developed a risk management tool that assists rail carriers in performing the safety and security analyses mandated by the Rail Safety Improvement Act of 2008. The Rail Corridor Risk Management System is a web-based interactive tool that enables rail carriers to identify route characteristics using the 27 risk factors and to weigh safety and security impacts in the routing of hazmat shipments to meet federal requirements. This tool provides a standardized, consistent approach to selecting the rail routes posing the lowest overall safety and security risks for security-sensitive hazardous materials developed in partnership with the Federal Railroad Administration, Federal Emergency Management Agency, Transportation Security Administration, and the Pipeline and Hazardous Materials Safety Administration.

For a rail shipment, a train will be configured at the CMF with one or more unloaded casks and delivered to the interlining commercial rail carrier. As discussed previously, the train consist will include cask cars, buffer cars, and a security escort car. Locomotives will be provided by the rail carriers. Typically, a train consist will be expected to have five rail cask cars with casks affixed.

A truck shipment will have two drivers who move an unloaded cask on public highways from the CMF to the plant site. Truck shipment cask trailers and commercial carrier tractors will be matched to accommodate plant site limitations for cask loading. If multiple truck casks service a plant site, several trucks may be dispatched in a convoy and moved to the shipping facility in the same fashion as a single truck.

Principal interfaces during assembly and dispatch will involve the CSF, CMF, commercial carriers contracted to transport shipments, and security personnel.

5.3.3.3 Delivery to Plant Site (with intermodal transfers as needed)

Functions and Activities**—**The CSF operations center will oversee the variety of activities performed by commercial carriers and handlers who transport casks from the CMF to plant sites either through direct rail service or an IMT site. The operations center will coordinate with commercial carriers as necessary to complete each shipment. For example, contracts with Class 1 railroads and over-the-road trucking firms will ensure cross-country hauling of loaded and unloaded casks. Short-line railroads serving plant sites will move casks and equipment between some reactor sites and Class 1 railroads. Barge and heavy-haul truck operators would be engaged to transfer casks and equipment at pre-arranged private or public IMT sites to accommodate plant sites without rail access.

Significant interfaces during transport involve commercial transportation carriers, transfer facility or marshaling yard operations personnel, and the CSF operations center. The center will have continuous communication links with federal agencies to monitor conditions nationwide that may affect shipment progress and to deploy resources as necessary.

5.3.3.4 Cask Handling and Loading at Plant Site

Functions and Activities**—**When the unloaded casks arrive at plant sites, the commercial carrier will transfer possession of the unloaded casks to facility operations personnel for handling, loading, sealing, and secure placement on transporters.

During cask loading, rolling stock and the security car would typically remain at the plant site or at a nearby, secured, local train yard. Upon delivery, the plant site manager will supervise cask-loading operations with on-site assistance from CSF personnel. The plant site will ensure that cask loading strictly adheres to procedures, including manuals on cask operations, fuel assembly accountability, safety instructions, and federal regulations. Plant site personnel will load UNF and operate cask systems using site-specific procedures,[42] tools, fittings, fasteners, and components supplied by the CSF. Different casks and loading procedures will conform to the specific requirements and needs of particular sites and waste forms. When approved by on-site CSF personnel, the CSF operations center will direct the commercial carrier to begin shipment of loaded casks to the CSF in accordance with the DOE national transportation plan and the individual plant Site Campaign Plan.

5.3.3.5 Transport of Loaded Casks to the CSF (via intermodal transfers or marshaling yards as needed)

Functions and Activities**—**After CSF personnel certify that the loaded casks are ready to be shipped, that transporters have been inspection, and that transfer to CSF's commercial carrier is complete, transport operations will commence from the plant site to the CSF.

When carriers accept loaded casks for shipment, they will be required to meet specific inspection protocols prior to shipment. For example, tractor trailer and truck inspections comply with Commercial Vehicle Safety Alliance Level VI, while rail shipment inspections follow 49 CFR 174.92 and the FRA *High-Level Nuclear Waste Rail Transportation Inspection Policy*. Barge transport is regulated by the USCG under 33 CFR 1-199. Following inspection and cask acceptance for transport, the CSF operations center would direct the commercial carrier to transport loaded cask shipments from the plant site. Subsequent en route inspections, if necessary, would be coordinated to coincide with other mandatory shipment stops.

Where plant sites have direct rail access, the entire shipment will be completed using rail, consistent with the DOE's "mostly rail" policy determination. If only one cask railcar can be accommodated on the site at any given time (due to space or other constraints), the CSF may make arrangements with the servicing railroad for use of a nearby rail yard, where the train consist can be assembled for dispatch onto interlining railroads and then in a consist to the CSF.

Physical constraints at some plant sites may require rail casks to be transferred via barge or heavy-haul truck to an IMT site for transfer to a rail line. In such cases, a qualified hauling and rigging company would deliver the cask to a loading dock, where it is driven onto a barge, transported to a receiving location, and then moved to the loading location at the plant site. Once loaded, the process would be reversed, and the cask transferred back to a railcar on an outbound train consist.

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[42] Site-specific procedures for cask receipt, cask handling and loading operations, and other operations would be developed in advance of cask delivery and would be consistent with procedures specified in the cask 10 CFR 71 CoC, Safety Analysis Report and associated documentation.

Rail transport carriers will assign crews and maintain communications with their respective dispatchers (with the possible exception of a dedicated security force that could be provided by the CSF directly or through arrangements with law enforcement). The CSF operations center will communicate to railroad contacts, who would then issue instructions to crew members through their dispatchers (direct communications between escort personnel and train crews will also be available in case of an incident). Rail shipments will use dedicated trains (trains only carrying UNF and related equipment, not general freight service). Dedicated train service, following special arrangements made beforehand, will allow railroads to bypass scheduled train stops to expedite shipments through their systems. Thus, while some prescheduled refueling, crew changes, safety inspections, and in-transit repair stops may be mandatory, rail transport is expected to take place on an expedited basis; however, special operating rules and contractual arrangements may be needed to accomplish this.

Truck casks may be shipped from a single plant site one at a time, as they are made ready for transport; or they may be shipped in multiples as part of a convoy, if several casks are ready simultaneously. A security escort vehicle would accompany the truck shipment from the moment it departs the plant site until it arrives at the CSF. Generally, truck cask shipments would follow USDOT-approved and NRC-reviewed routes as designated in the Site Campaign Plan, moving directly from the origin facility to the CSF. Depending on the specific circumstances (such as truck casks from different sites being made ready for transport simultaneously), truck carriers may transfer casks onto railcars at IMT sites. Sequential pickup of such casks is referred to as a “milk run.” As would be the case for rail, procedures for refueling, required equipment safety inspections, emergency repairs, driver change-outs, and personal needs stops along the highway will be preapproved by the CSF operations center and kept to a minimum.

Prior to each shipment, the CSF operations center would make necessary pre-notifications and conduct briefings on the Site Campaign Plan with affected carriers and security personnel. The operations center will communicate with federal agencies and state, local, and Native American tribal representatives as needed and consistent with security requirements.

Intermodal Transportation—Intermodal transportation (IMT) is the process of lifting and transferring loads from one type of transportation mode, such as railcars or barges, to one or more alternative transportation modes, such as regular or modified trucks, barges, railcars, or other conveyances, to ship the load to its destination. IMT is also commonly used where certain types of on-site transportation capabilities may be limited or unavailable, particularly when the item to be moved is over-dimension or overweight. Specialized lifting and transfer equipment (such as high-capacity cranes or jacking systems), transporters (such as trailers or barges), and heavy-duty prime-movers (such as tractors or tug boats), may be required.

Intermodal transportation is used for transferring UNF casks to, from, and around reactor sites as required for fuel management purposes.

Since UNF transport to a CSF is done predominantly using rail, a combination of transportation modes will be needed, including rail, truck, and possibly barge, to make efficient use of the rail system. Where direct rail service to a plant site is not available, IMT will be needed to transfer UNF casks to a rail line. Therefore, sites lacking direct rail access or with inadequate rail infrastructure would be served by using IMT, including a combination of heavy-haul (highway) trucks and barges to transfer casks to and from plant sites and a rail line.

Overall, about 30 percent of commercial UNF rail shipments would be expected to involve off-site intermodal operations.[43] As of 2012, 26 of 75 commercial origin sites lack direct railroad service and would be expected to need IMT in order to move casks to and from their railcars. Of the 49 plant sites served by rail, 30 (61 percent) would be expected to use on-site intermodal lifting, transferring, and moving to place casks for UNF canister loading, due to the fact that rail does not extend directly into the cask handling area.

By approximately 2020, almost all nuclear power plant sites are expected to implement dry storage. There are 62 sites currently using dry storage. On-site intermodal transfer operations would be needed to transfer previously loaded dual purpose canisters from dry storage to transport casks. At operating sites, these canisters would be transferred using existing transfer casks and transfer equipment.

Depending upon the acceptance rate of UNF from currently operating plant sites, and the amount of time that UNF remains at these sites after they reach the end of extended operating licenses, it is possible that the types of intermodal operations needed at plant sites could change over time. For example, if the overall acceptance rate of UNF results in storage of UNF at sites for several decades after currently operating plants reach the end of their operating licenses, it is possible that companies would transfer the remaining UNF inventories to on-site dry storage and dismantle spent fuel storage pools and cask cranes. Thus, additional intermodal operations and equipment, such as mobile cranes and transfer casks, would be needed at these sites in order to transfer loaded dual purpose canisters from dry storage to casks for transport off site.

In addition, intermodal lifting and transfer operations would also be conducted at a transfer location where empty casks would be delivered to plant sites; this process would essentially be reversed to return loaded casks to their railcars. To avoid repeating site preparation and

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[43] Based on data provided in the Facility Interface Data Sheets submitted by commercial nuclear operators. A larger number of utilities—possibly 70 percent—will be using some type of IMT for on-site operations.

equipment setup, intermodal lifting and transfer equipment (i.e., cranes) would usually remain at the transfer location until all the casks slated for near-term delivery are loaded and shipped, moving casks one at a time.

The logistical information regarding plant site rail and barge access, heavy-haul distances, and cask handling capability (rail cask versus truck cask) is based on best available information at this time (the Yucca Mountain Final Environmental Impact Statement, DOE/EIS-0250F, the Facility Interface Capability Assessment Project Report, and the team's knowledge of cask handling capability at plant sites). This information has been used to estimate intermodal transfer requirements, including equipment for heavy-haul and barge shipment, and intermodal lifting and transfer operations at plant sites and at IMT sites. Since rail and road access to sites may change over time, during the planning phase for transport of UNF to a CSF, it will be necessary to confirm site-specific transportation interfaces, near-site transportation infrastructure conditions, and special equipment needs for intermodal transfers both at an intermodal transfer facility and on site. This would include the following actions:

- Perform a site survey to confirm site-specific transportation interfaces such as condition of on-site rail facilities, on-site barge facilities, and proximity of on-site rail or barge facilities to cask handling equipment.
- Identify existing site equipment that can be used for on-site intermodal transfers such as transfer casks, cask crane, cask movers, etc.
- Identify additional equipment needed for on-site intermodal transfers, such as portable cranes, cask movers, etc.
- Perform a near-site survey to confirm road conditions for heavy-haul transport and proximity of nearest rail line or barge facilities to plant sites, etc.
- Identify IMT sites to transfer rail casks to/from a rail line, to/from barge facilities, and to/from heavy-haul vehicles.
- Identify equipment needed for intermodal transfer, including mobile cranes.
- Identify any special equipment needs such as equipment needed to allow canister transfer via a "stack-up" operation at a shutdown nuclear power plant.

To initiate IMT operations, some of the remaining technical issues and actions necessary that will need to be addressed before final transportation plans for shipment of UNF to a CSF can be approved and implemented are as follows:

- Rail Carriers
    - Identify intermodal transfer facility/location

  - Coordinate shipment and inspection scheduling
  - Inspect railcars, accept and assemble shipments
- Plant Site
  - Safety and security organizations
  - Operations
  - Engineering
- Intermodal Rigging, Hauling, and Logistics Contractors
  - Provide equipment and personnel resources
  - Provide shipment planning and engineering including routes and permitting
  - Coordinate plant site and rail transfer interfaces
- State, Tribal, and Local Government
  - Preferred transportation modes
  - Routes and shipment planning and scheduling
  - Infrastructure protection measures
  - Public information coordination
  - Public safety operations, briefings, and training
  - Physical security/escort coordination and notification

It is recommended that the CSF transportation system operator make maximum use of the substantial experience and capability among U.S.-based specialized carriers and riggers to ensure that intermodal transport of UNF will be conducted safely, securely, efficiently, and at a reasonable cost. The Specialized Carriers and Riggers Association[44] lists over 1,200 worldwide members who have the qualifications and capabilities to lift, transfer, and move specialized over-dimension and overweight loads and consists (i.e. cask skids).

Intermodal Operations Cost

IMT costs are the direct costs associated with trans-loading the UNF casks from barge and heavy-haul shipments loaded at the plant site to railcars at the designated rail head (intermodal site). Costs incurred by the UNF owner to load the UNF transport cask onto the HHT or barge are the sole responsibility of the owner, not the DOE. IMT total costs are to

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[44] Website at http://www.scranet.org/.

load 4,190 casks onto 851 dedicated DOE trains for transport to the CSF and are developed using the following data and assumptions:

- Crane: $365/hour for a 200-ton lifting capacity (4-hour minimum)
- Crane operator: $95/hour
- Foreman: $95/hour
- Flagmen/laborer: $80/hour (four required)
- Time to load and secure 1 cask is 2 hours; 10 hours to load 5 casks onto railcars

Based on a cost of loading operations of $875/hour, the estimated total IMT costs are $7,446,250 (total casks trans-loaded = 4,190 for 851 shipments).

5.3.3.6 Retrieving Unloaded Casks from the CSF

***Functions and Activities*—**When a shipment arrives at the CSF either via rail or truck, it will first be processed through a secured arrival yard at the CSF, inspected, and prepared for cask unloading. After that, the key activities include retrieval of unloaded casks, maintenance, and reassembly of shipping casks and equipment for dispatch as safely and expeditiously as possible.

From an operational standpoint, the buffer and security cars would be uncoupled at the CSF arrival yard and the cask railcars delivered to the CSF using a switch engine. Following a security inspection of the cars, the switch engine would couple to the loaded cask railcars and bring them into the CSF for processing. After the casks are unloaded, decontaminated (if needed), and certified for transportation in-commerce, the unloaded transport casks will be placed on a matching railcar and returned to the arrival yard. Minor repairs or maintenance (such as wheel truing and brake shoe replacement) would be performed at a small FMF. Heavy repairs and maintenance would be performed off site by a railroad maintenance facility (following a radiological survey and release of the equipment). At the CMF, repaired and inspected cask railcars will be matched to casks and skids and prepared for re-deployment to the field.

5.3.3.7 Maintenance and Preparation for Shipment

Functions and Activities—After post-operational maintenance, inspection, reconstitution, and re-supply of transportation vehicles and equipment occurs, they would be prepared for redeployment based on system and schedule requirements.

The CMF and FMF will need to perform two separate, consistently reliable, and efficient maintenance programs. The first will be to perform routine and minor transportation fleet maintenance and repairs at radiologically clean premises. The second will involve cask maintenance at a facility capable of handling low-level radiologically contaminated casks and equipment. Repair, reassembly, and final inspection of transporters, equipment, and supplies would constitute the final stage of the transportation cycle. End-stage fleet management functions include maintenance operations; minor repair of railcars, trucks, and ancillary equipment; replenishment of parts; equipment storage; status tracking of all transport equipment; and records management.

The CSF operations center will monitor and track equipment and personnel reassembly and preparation processes, and will issue schedules and directives for integrating transport operations with cask returns from the CSF, projections of future logistics needs, and plant site schedules. After each shipment, an operational review will provide feedback on best practices and lessons learned to be incorporated into future campaigns and plans.

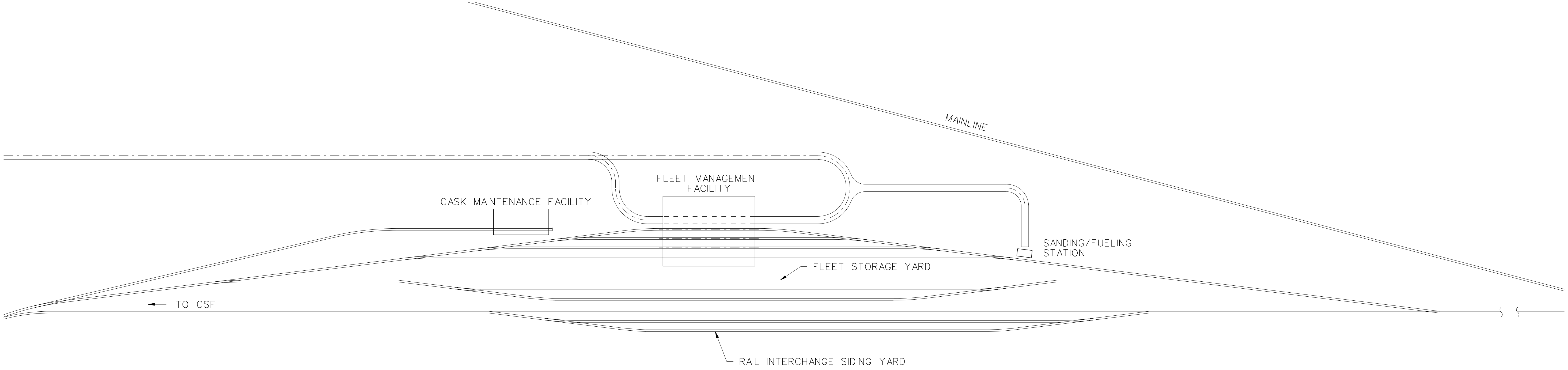
The FMF will also supply “campaign kits” for scheduled shipments, containing equipment for cask loading at plant sites. This equipment will be inspected, calibrated, and assembled, and will include cask-specific lifting yokes, hook adapters, gaskets, seals and leak testing equipment, helium backfill equipment, drying vacuums, and monitoring devices unique to a cask deployed to sites as described in the requisite Site Campaign Plan. If canister-based systems are provided to plant sites, equipment needed for canister welding would be provided. Kits will be sent by commercial carrier to an origin site in advance of the initial shipment to ensure that the plant site is properly equipped, and has examined fit-up of adapters and other cask handling equipment, before the casks arrive for loading. When a campaign is complete, or when kit components require servicing or routine maintenance, kit equipment will be returned to the FMF for reassignment or decommissioning as appropriate.

5.4 Fleet Management Site

The Fleet Management Site will consist of a Fleet Management Facility (FMF), a Cask Maintenance Facility (CMF), and outdoor storage areas for rolling stock, truck cask trailers, and 15 rail and 15 truck transport casks as shown on **Figure 5.4-1**. This figure shows the entire rail yard that would be necessary for development of the CSF with additional rail yard storage, sidings for mainline rail to CSF transfer operations, and links to the mainline rail and CSF. The Fleet Management Site also contains truck access and staging for any freight truck operations. Space for parking lots and training facilities is available at this site, but is not shown.

The railcars and the transport casks will require regular inspection and maintenance. Unloaded casks and transporters would depart from the FMF for prearranged plant sites where they would be loaded, shipped to the CSF, unloaded, and then returned to the CMF and FMF for maintenance, reassembly, inventory, inspection, and preparation for a new shipment.

Two consistently reliable and effective maintenance programs will be implemented at the FMF and CMF. The first focuses on transportation *fleet* equipment maintenance operations at nonradiological premises. The second focuses on *cask* testing, routine maintenance, and repair, which is to be performed at the CMF. Repair, reassembly, and final inspection of transporters, equipment, and supplies conducted at the FMF will complete the final stage of the shipment cycle, as discussed in Section 5.3.3. These functions include: maintenance operations; minor repair of railcars, truck trailers, and government-owned and ancillary equipment; replenishment of parts; equipment storage; status tracking of all transport equipment; and records management.



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FLEET MANAGEMENT SITE

FIGURE 5.4-1, FLEET MANAGEMENT SITE LAYOUT

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The FMF will determine the availability of equipment for the Site Campaign Plans. Preparations for shipping UNF and GTCC waste would originate with assembly of the shipping consist and terminate with dispatch of the consist at the FMF. Under the concept proposed herein, for a rail shipment, a train would be configured at the FMF with unloaded casks, buffers, cask equipment, and security escort railcars and the locomotives, and then the train would be dispatched from the FMF. Typically, the train consist is expected to have five cask railcars with casks affixed.

After a loaded UNF train consist arrives at the CSF rail yard, it would be uncoupled and the buffer cars, security escort car, and any accompanying auxiliary equipment returned to the FMF for inspection, maintenance, and necessary repairs in preparation for subsequent shipments. Casks would be unloaded, decontaminated, and certified for public transportation, and then placed onto railcars or truck trailers and sent to the CMF and FMF to be prepared for outbound shipment. To preserve operational effectiveness throughout the unloading stage, casks and equipment need to be placed back in service expeditiously. Each return will be identified as ready for in-commerce shipment or as needing maintenance and repair.

5.4.1 Fleet Management Facility

The FMF would be the primary equipment storage, maintenance, repair and test, inspection, assembly, staging, and dispatch facility for the transportation system. In general, minor repairs and maintenance of rolling stock and cask trailers would be completed at the FMF. Major refurbishment or rebuilding of rolling stock and cask trailers would be performed at off-site vendor establishments. The decision whether to repair equipment at the FMF would be made on a case-by-case basis.

There are two basic concepts and cost estimates for the rolling stock part of the FMF, a “Minimum Service Facility” and a “Full Service Facility,” based on the unique attributes of the rolling stock equipment, fleet size, and characteristics of the service provided. The Minimum Service Facility concept excludes provisions for component rebuilding such as truck overhaul, main engine or traction motor rebuilds for the yard locomotives, turbo rebuilds, etc. The maintenance program calls for removal/replacement of the broken or worn-out components and sends them to a commercial shop or to the original equipment manufacturer for refurbishment or replacement. In contrast, the Full Service Facility concept would provide workspace for these refurbishment and replacement activities. Both concepts include office space for administrative functions, yard control provisions, employee conveniences, and basic shop requirements (i.e., spare parts storage, welding shop, and machine shop).

Rolling stock inspection and corrective and heavy maintenance activities would be accomplished on through tracks, accessed via ladder tracks at either end of the facility. The

FMF design would consist of 4 tracks on 20- to 25-foot centers with a fifth track for washing, blow down, fueling, and sanding. The work pit tracks would have multi-level work ramps, with pit lighting and service items.

Minimum Service Facility

The functional requirements for design and operation of a Minimum Service Facility would include the following:

- *Scheduled Maintenance*—Scheduled maintenance is the performance of all periodic planned maintenance performed in accordance with FRA standards and guidelines, and preventive maintenance activities based on time or mileage. Typical inspection activities include verifying the structural integrity of the rolling stock, checking mounting of equipment, a thorough inspection of safety systems (i.e., doors, brakes, sanding systems, and propulsion and auxiliary systems).
- *Corrective Maintenance*—Corrective maintenance activities include troubleshooting and repair of rolling stock equipment or system failures noted while in service or during preventive maintenance inspection. Typical corrective maintenance activities include fault troubleshooting of propulsion, auxiliary, trucks, and braking systems, and testing and unit exchange.
- *Subsystem and Component Removal and Replacement*—The FMF design includes features to facilitate the removal and replacement of all rolling stock subsystems and components as unit replacements.
- *Cleaning*—The FMF design includes features for interior and exterior cleaning of all rolling stock.
- *Fueling*—Provisions for diesel fuel storage with tank capacity sufficient to support demand. The diesel fuel handling system would be designed in accordance with U.L. fire protection requirements and all applicable codes.
- *Sanding*—Sanding would occur in the yard at a permanent dispensing station or via mobile carts with sand pumping equipment in the storage tracks. A sand silo is necessary for storing bulk purchases of sand and to keep the sand dry.
- *Blow Down Shop*—Blow down or steam cleaning of equipment would typically be performed prior to maintenance activities.
- *Materials Management*—The FMF design would include provisions for materials management for parts distribution and storage.
- *Wheel Truing*—This is a mandatory activity that could be performed either by in-house staff or by a subcontractor. It is recommended that a wheel-truing machine be

procured in order to eliminate transportation and scheduling issues associated with whether the correct AAR wheel tolerances are being met.

- *Accident Repair/Painting*—It is recommended that accident repair or painting be conducted by an outside contractor, as the system does not justify the expense of a paint booth and body shop.
- Other Facility Workspace Requirements, including:
    - Administration
    - Motor Vehicle Access and Parking
    - Security
    - Rail Storage Yard
    - Transportation Operations Control Center (yard only)
    - Transportation Operations Control Center (OCC)—Typically the Transportation OCC and administrative offices are located within the confines of the FMF (break room, training room, control room, with space for computer and communications equipment). The OCC would contain the necessary equipment to monitor and control all mainline and yard train movement and to communicate with field personnel. The administrative area adjacent to the OCC shall contain offices for the operating and training personnel.

Figure 5.4-2 depicts the general arrangement for a FMF Minimum Service Facility. The areas are identified to show the space required and basic concepts.

Full Service Facility

The functional requirements for design and operation of a Full Service Facility would include the following functions:

- All activities listed above under Minimum Service Facility.
- *Heavy Maintenance*—Heavy maintenance activities include repair or overhaul of major components (i.e., HVAC equipment, traction motors, trucks, axles, and electronic equipment). The Full Service Facility is intended to be self-supporting or have the ability to perform all maintenance activities internally, with the exception of painting and accident damage, which will be contracted out.

Figure 5.4-3 depicts the general arrangement for a FMF Full Service Facility layout.

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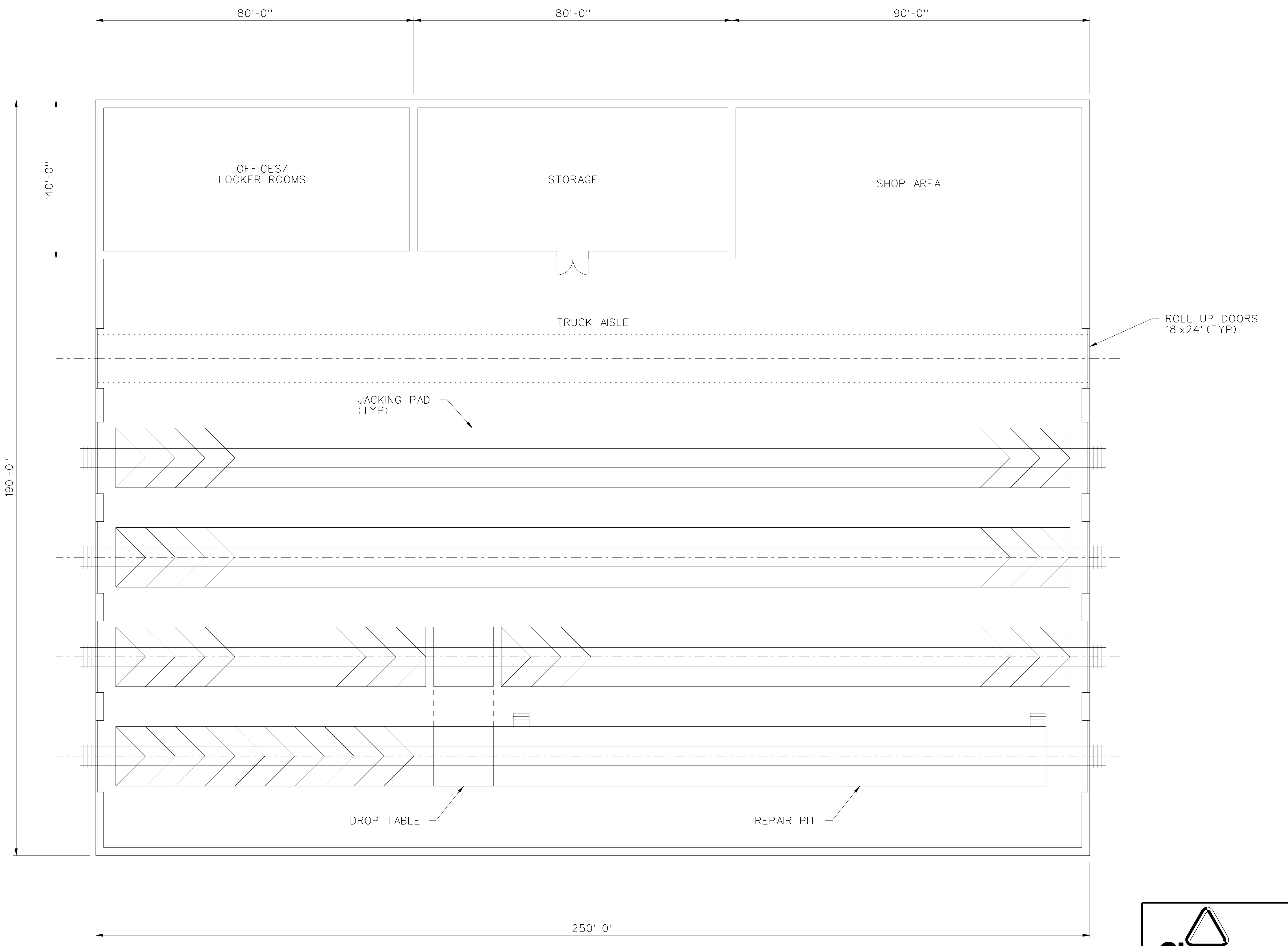

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FLEET MANAGEMENT FACILITY

FIGURE 5.4-2, MINIMUM SERVICE FLEET MANAGEMENT FACILITY LAYOUT

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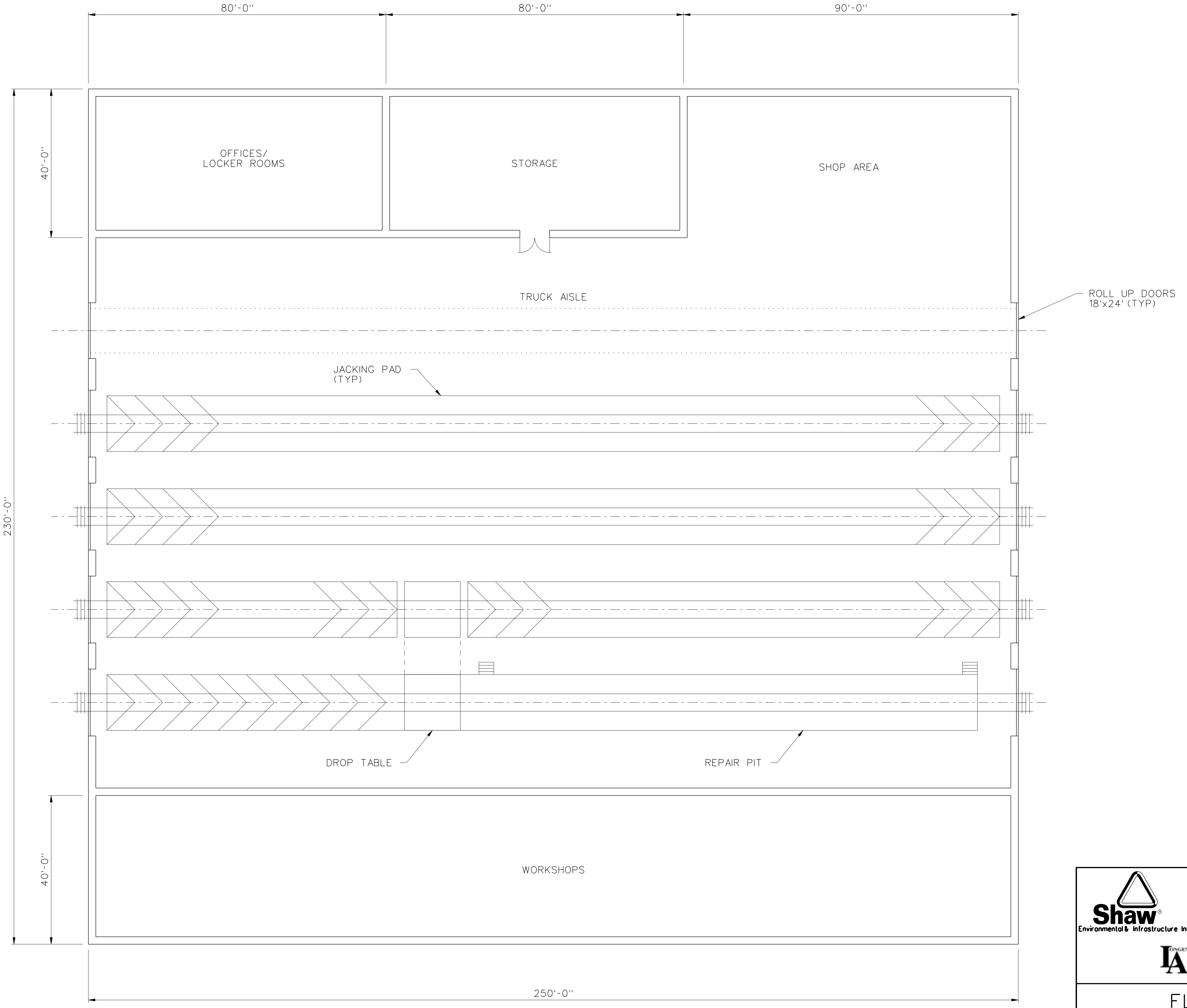

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FLEET MANAGEMENT FACILITY

FIGURE 5.4-3, FULL SERVICE FLEET MANAGEMENT FACILITY LAYOUT

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Recommendation Regarding FMF

It is recommended that a Minimum Service Facility be developed for a CSF. Assumptions that support this recommendation and that would ensure complete service to the rolling stock fleet for a CSF include the following:

- A CSF rail fleet will travel a relatively low annual mileage. (Estimated at less than 260,000 miles per year over the life of the shipping campaigns.)
- A CSF rail fleet will be a small fleet of cars, including cask cars (~145), buffer cars (~58), and escort cars (~29), a total fleet size of 232 cars assuming the use of OFF-Plus acceptance priority for a system with a maximum capacity to accept 4,500 MTU of UNF annually. As a point of comparison, the total fleet size assuming the same system capacity but an OFF acceptance priority would increase the total fleet size to 272 cars.
- Adequate rail service centers for heavy maintenance already exist within geographical regions throughout the U.S. to support maintenance and overhaul activities on an as-needed basis (i.e., Western-based companies include CATX, GATX, GM EMD, Progress Rail, Rescar, Trinity Rail, TTX, and Union Pacific based in Arizona, California, Colorado, Indiana, Kansas, Montana, Oregon, Texas, Washington, and Wyoming).

It is recommended that a plan be developed for facility and fleet maintenance that provides regular routine, or running, maintenance. Minimal downtime for the fleet of cars and yard locomotives can be achieved by maintaining adequate inventories of spare equipment and systems. Spare equipment and systems that should be maintained as inventory include the following:

- Complete rail trucks
- Matched axle sets
- Brake systems and pads
- Brake control units
- HVAC systems
- Toilet systems
- Power generators

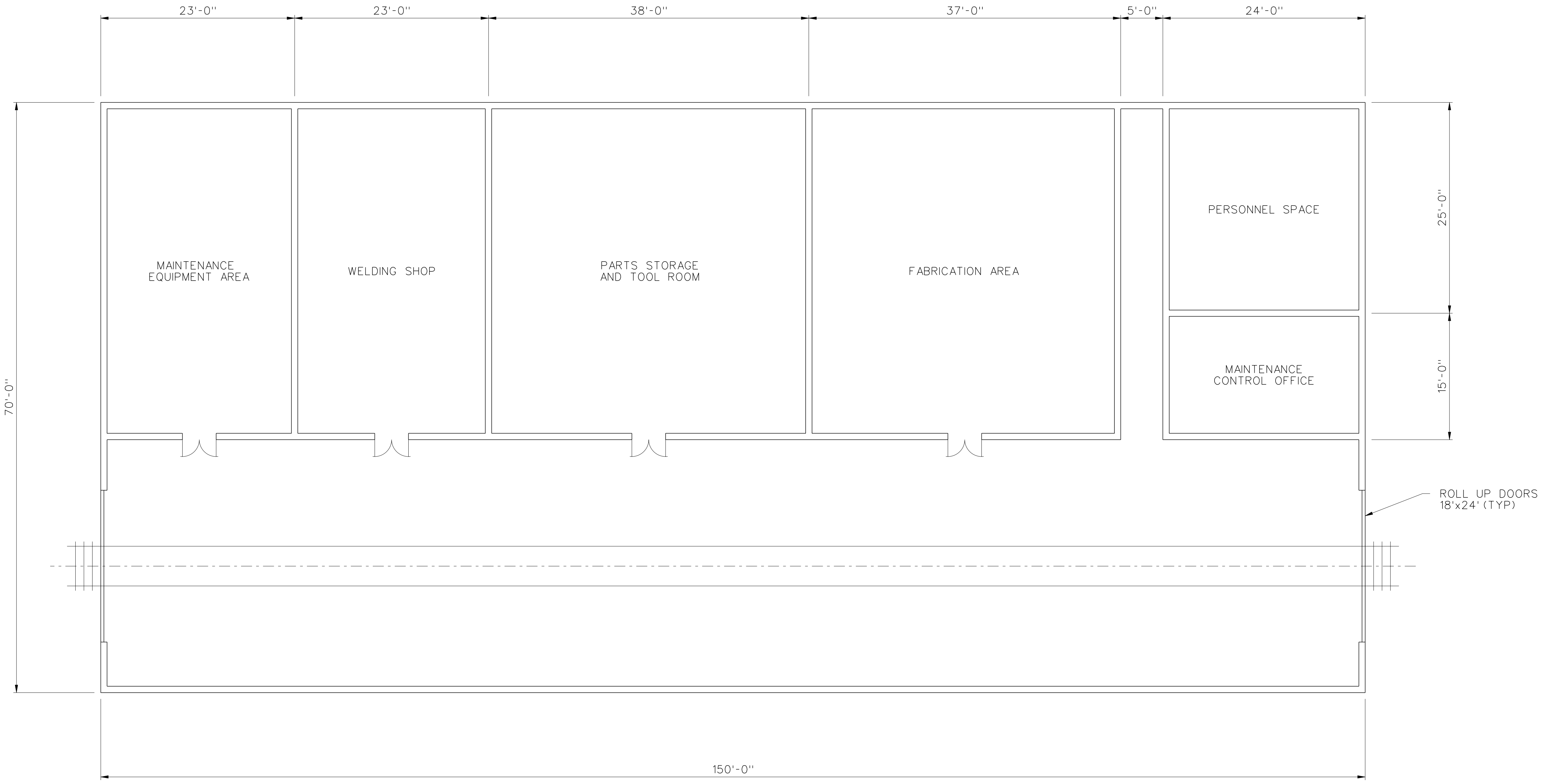
5.4.2 Cask Maintenance Facility

The mission of the CMF is to maintain casks as required to retain the CoC for each cask in accordance with 10 CFR Part 71, “Packaging and Transportation of Radioactive Material”, and 49 CFR Part 173, “General Requirements for Shipments and Packaging - Authorized Packaging - Fissile Materials.” The functional requirements necessary to accomplish this and related tasks include the following:

- Performing routine cask system maintenance such as seal and valve replacement
- Confirming and documenting continued conformance of the cask with its CoC
- Providing for replacement, storage, cleaning, and other maintenance of cask components in order to prepare a cask for its next payload
- Cleaning casks to meet regulatory requirements and/or to facilitate component replacement, repairs, testing, or maintenance
- Reworking, repairing, or modifying cask system components for improved performance, or to comply with a regulatory agency request
- Maintaining record documentation; including the CoC, design drawings and specifications, manuals, and procedures
- Preparing cask system components for decommissioning and disposal
- Preparing cask railcars and truck trailers for off-site maintenance
- Providing storage for spare and temporarily out-of-service cask system components
- Participating in the resolution of special situations, which will periodically occur off site

The CMF building layout is presented in **Figure 5.4-4**.

The CMF will house all the cask servicing and testing operations as well as the waste processing, shop support, and administration facilities. Work stations will include cask unloading/loading, cask external cleaning, cask testing and maintenance, and auxiliary equipment maintenance and repairs. Transport cask storage would be available in the operational areas of the CMF. Cask system auxiliary equipment, such as lifting yokes, may arrive via separate transport and would be stored, maintained, and inspected in the CMF. A separate loading dock would be provided to prevent auxiliary equipment operations from interfering with cask operations.



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CASK MAINTENANCE FACILITY

FIGURE 5.4-4, CASK MAINTENANCE FACILITY LAYOUT

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Cask cars and truck trailers with unloaded casks arriving at the CMF will be moved to the process building following a security inspection and a radiological survey. Casks will be removed in the unloading/loading bay and the empty vehicle will then be cleaned in one of the vehicle cleaning bays. The vehicle will then be moved to storage or to the FMF for inspection and maintenance. Meanwhile, unloaded casks will be moved to one of the three process stations in the central corridor for external cleaning, maintenance, and testing. Cask storage and an area for maintenance and testing of auxiliary cask system equipment (such as lifting yokes) will also be located in the corridor. The expected processing time for loading and unloading casks is 18 to 23 hours and is determined from the handling times at existing facilities.

5.4.3 Recommendations Regarding Siting for the CMF and FMF

Depending upon whether one or more CSFs are planned, it will be necessary to decide whether to colocate the CMF and FMF at one site or to locate the facilities at more than one site.

Single CSF Site

If the decision is made to construct and operate one CSF, it is recommended that the CMF and FMF be located near the CSF site. In addition, it is recommended that the CMF and FMF be constructed as separate facilities in case of a minor nuclear contamination incident at one or the other facilities. It is also recommended that the OCC be located within the FMF since the FMF will generally not include the handling of radioactive material or contaminants.

Multiple CSF Sites

If the decision is made to construct and operate multiple CSFs, it will be necessary to decide if the CMF and FMF should be colocated or located separately. Considerations associated with such a decision include the following:

- Option 1—Within the region that has the most traffic.
- Option 2—Within the region that is most geographically isolated.
- Option 3—Split the FMF and CMF locations, one at each CSF site.
- Option 4—Site the CMF and FMF in a centralized location, neutral to the CSF sites.
- Option 5—Site the FMF in a central location (Option 1 or 2) and provide a CMF at each CSF site.

5.5 Transportation Recommendations

The following is a summary of the recommendations for transportation:

- Development and periodic updating of the shipment schedule is a critically important step. Scheduling shipments should be performed by the CSF staff, while allowing sufficient time and flexibility to ensure there is formal involvement and input from the plant sites, as well as the carriers, corridor jurisdictions, et al. There may be events or operations of which the CSF may not be aware.

- Detailed site-by-site transportation plans should be developed to include not only the shipping schedule, but roles and responsibilities, procedures to be followed for off-normal events, and to formally track all commitments related to transportation that have been made by the CSF or its agents.

- Logistics professionals may come from various disciplines and be called upon to perform a wide variety of tasks (i.e., an engineer may be needed to lead operational training or conduct public briefings). CSF staffing requirements should provide for staff rotations and cross-training among different functions.

- Plans, equipment, and procedures will need to be extensively pilot-tested, especially for new procedures or for equipment that has not been placed into service. The CSF baseline should ensure sufficient resources and time are allotted for pilot testing and drills.

- Rolling stock and other equipment that is mission-critical and is designed for a specific use (such as a cask) should be owned and maintained by the CSF management entity. Other equipment and maintenance services (such as railcar heavy maintenance or use of locomotives or tractor-trailers) should be outsourced.

- Safety is a responsibility that is shared among shippers, carriers, and federal, state, tribal, and local authorities, and should be the basis for working relationships with stakeholders.

- If the CSF will not be limited to just fuel from shutdown plant sites, the CSF should begin accepting fuel first from shutdown plant sites, but also begin acceptance from operating plant sites before all fuel is removed from the shutdown plant sites. This will provide for greater operational and scheduling flexibility.

- The shipping queue (and the contracts with the utilities) should be modified to give priority to shutdown plant sites, and then to an “OFF-Plus” priority ranking that changes from annual allocations to multi-year allocations. This will greatly simplify logistics requirements while ensuring performance and preserving rights and obligations under the Standard Contract.

- The DOE (or any other entity designated to construct a CSF facility) should be prepared to begin the fabrication of certified cask designs needed for transportation of

UNF from shutdown plant sites no later than 3 years before the first shipments to the CSF are planned from these sites.

- The DOE (or any other entity designated to construct a CSF facility) should be prepared to begin the procurement process for new cask design and fabrication, ancillary equipment, testing, and verification no later than 7 years before the first shipments to the CSF are planned.
- The DOE (or any other entity designated to construct a CSF facility) should be prepared to begin providing technical assistance and funding to corridor jurisdictions to prepare for shipments well before the first shipment to the CSF is planned to arrive. CSF operators should assume that the activities contemplated in Section 180(c) are minimum requirements (more may be needed, based on the experience of successful campaigns).
- The CSF design should allow for an eventual throughput capacity of 4,500 MTU/year. Waste acceptance should be based on an "OFF-Plus" approach that will keep the numbers of plant sites shipping at any one time to a manageable size, yet ensure that the cask and rolling stock fleet is utilized efficiently (i.e., not overbuilt).
- The operator of a CSF should ensure that rolling stock will meet all of the requirements of AAR Standard S-2043, and that the train consist will be tested as a system (with the exception of locomotives, which will be supplied by the railroads).
- There may be a need to revise the railroads' current speed limit of 50 mph over "key routes" to avoid the potential for system bottlenecks or delays. Given the increased robustness and safety features of equipment fabricated and tested in accordance with AAR standard S-2043, this should be able to be negotiated readily.
- The operator of a CSF should engage NNPP on joint development of an escort car.
- The rights to the PFS rail cask design should be purchased immediately and procurement of all rolling stock should be initiated as soon as practicable to confirm positioning within the manufacturer's development queue for the building of the UNF railcars to support transport to a CSF.
- The CSF should include a minimum service FMF capable of performing minor repairs and maintenance; major repairs to rolling stock should be outsourced to railcar maintenance shops.
- The CSF should have a CMF in proximity to the storage site itself but outside the NRC-licensed area.

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6.0 RESEARCH AND DEVELOPMENT

6.1 Introduction

The R&D needs for the CSF program cover a broad range of subjects, many of which are related to the recommendations of the BRC. Most of these needs are related to providing dry storage of UNF for a long period of time. These needs require the following actions:

- To qualify the UNF for long-term storage
- To develop and implement cask monitoring devices
- To evaluate canister designs to permit a move toward standardization
- To develop and implement techniques for opening and sealing welded canisters
- To study the economics of rod consolidation

One other area, discussed first below, is the need to qualify high-burnup UNF for transportation and long-term storage. This is a near-term activity to be initiated shortly after funding for the contract is provided. In addition to the subjects above, the DOE is interested in rod consolidation. The history and recommended actions in this area are given in Section 6.7. Note that all of the collected R&D data will be utilized as inputs to predictive models of long-term performance of the cask/canister systems. Section 5.2.7 of this report discusses transportation technical issues that need to be addressed before embarking on a nationwide program to transport UNF from commercial nuclear power plant sites to a CSF, and identifies R&D and/or additional engineering and design needed to improve the efficiency of UNF transportation.

6.2 Qualify High-Burnup Fuel for Transportation

6.2.1 Introduction and Approach

The NRC currently licenses the storage and transportation of UNF with burnups up to 45 GWd/MTU. However, nuclear utilities are extending the burnups of the fuel toward at least 60 GWd/MTU. Thus, there is a vital need to be able to store and/or transport this UNF to either an off-site ISFSI or to the CSF. This requires the NRC to license such operations, either by a one-time exemption or through a licensing process.

Two approaches for obtaining high-burnup UNF for testing and qualification were discussed in the report, “A Plan for Testing and Evaluating Long-Term Behavior of Stored Used Nuclear Fuel”, Task Order No. 7, Shaw Environmental & Infrastructure, Inc., January 19, 2012 (Task Order 7 report). The first involves the use of high-burnup UNF already in storage. However, the UNF currently in dry storage is only slightly above the 45 GWd/MTU threshold that defines high-burnup UNF. In addition, there were no sibling rods taken from these dry storage casks that could be utilized as a baseline. However, high-burnup UNF that meets the requirements of this effort is currently being stored in reactor SFPs. Thus, the second and preferred approach for this test program is to sample high-burnup rods prior to the assemblies being removed from the SFPs and placed into transportable dry storage casks.

As part of the Task Order 7 report, nuclear utilities were surveyed to determine which reactors and storage systems would be best suited for a test program involving dry storage casks. Twenty-four plants that possessed dry storage systems designed and licensed for high-burnup UNF were selected, and the associated stored UNF was evaluated in detail. The plants selected were both PWRs and BWRs with a variety of storage systems. From the 24 plants, the Prairie Island and Peach Bottom plants were selected and have agreed to participate in this program. The characteristics of the UNF are shown in **Table 6.2-1**. Note that the recommended option utilizes the TN-40 and TN-68 casks.

Table 6.2-1
Recommended Suppliers of High-Burnup UNF (Dual Purpose Systems)

Source Facility	Dry Storage System	UNF Type	Cladding Types	High-Burnup Range
Prairie Island	TN-40 cask	WE 14x14	Zircaloy-4, Zirlo™	50-60 GWd/MTU
Peach Bottom	TN-68 cask	GE BWR/4-6	Zircaloy-2	48-50 GWd/MTU

GWd/MTU denotes gigawatt-days per metric ton of uranium metal.

Fuel assemblies from the Prairie Island and Peach Bottom plants would be loaded into TN-40 and TN-68 test casks. The benefits of these selected plants are taken from the Task Order 7 report. Prairie Island has burned a variety of Westinghouse 14 by 14 fuel assembly fuel types. Currently, their spent fuel storage inventory includes both assemblies using Zirlo^{TM} cladding (one 69 GWd/MTU, one 59 GWd/MTU, and approximately 40 with 56–57 GWd/MTU), and assemblies using Zircaloy-4 cladding (four over 55 GWd/MTU and approximately 45 with 50–55 GWd/MTU). Within each TN-40 cask, there can be up to 40 PWR assemblies, each with 179 rods. Likewise, Peach Bottom has burned a variety of General Electric BWR/4-6 assembly fuel types with 7x7 and 8x8 arrays with Zircaloy-2 cladding. Within each TN-68 cask, there can be up to 68 BWR assemblies, each with 49 to 62 rods. This provides a wealth of potential fuel types that could be employed for testing. In addition to burnup, these assemblies also represent various cooling times, different fuel enrichments, and placement locations in the reactor core. The test casks can be strategically loaded to incorporate several of these fuel conditions. (It is proposed that only intact fuel rods be loaded into the casks.) Obviously, the more rods that are examined, the better the statistical reliability will be from the results. It is estimated that testing two rods per assembly of interest would achieve a high degree of test reliability.

6.2.2 UNF Testing

As noted above, two rods per assembly of interest would be chosen to achieve a high degree of test reliability from each of the two types of casks selected. However, it is recommended that at least two casks for each UNF type (one primary and one backup of a PWR and BWR) be utilized to accommodate any single failure event that could render a cask and its contents unusable as a test source. The rods from the assemblies of interest would be sent to a hot cell laboratory and examined both non-destructively and destructively. The casks would then be placed in long-term dry storage at the utility. It is assumed that this program would begin quickly to provide data for confirmation of NRC licensing requirements. At the end of the first 10 years of storage, the casks would be transported to the CSF for follow-up examinations. This is preferred since it would permit greater opportunities to follow the performance of the casks and their contents, along with the other casks placed there, after selected intervals of time (i.e. every 10 or 20 years). In addition to the fuel rods, testing could include all of the subject components, which include the cask, basket, neutron poisons, neutron shields, and storage pad at the storage facility.

Another option would be the use of the Idaho National Laboratory (INL) for the near-term storage of the high-burnup UNF assemblies and casks. The INL has a concrete pad (2707) that already has casks in storage as part of the DOE dry storage demonstration program. The pad has room for approximately 12 additional casks. The potential drawback with this option is the need for the INL to receive a waiver from the State of Idaho, since under their current agreement with the State, they are currently limited to receive only about 0.5 tons of fuel. In addition, the facility would require some upgrades to permit the handling and opening of these casks, including the addition of an outside gantry crane required for up-ending and off-loading the truck or railcar. At the August 22–23, 2012, workshop in Idaho Falls on a high-burnup fuel demonstration, INL Laboratory Director Admiral John Grossenbacher stated that he expects to obtain approval for a long-term storage program. This is based on a positive outcome from the Leadership in Nuclear Energy Commission report to the Governor of Idaho that is due in January 2013. If a waiver is not likely in the near term, it may be possible to utilize the Engine Maintenance and Disassembly (EMAD) facility at the Nevada National Security Site (NNSS). However, the EMAD requires extensive refurbishment and does not possess rail access. The INL and EMAD options would require the expenditure of perhaps $25 to $30 million. In addition, these modifications could take several years to accomplish. Thus, it seems prudent to store the initial confirmatory data casks at the utility site.

For the Task Order 7 report, the hot cell facility options in the U.S., both at national laboratories and commercial facilities that could perform both the nondestructive examination (NDE) and the destructive examination (DE), were evaluated. This evaluation took advantage of two existing surveys, which were updated by telephone interviews. The latest survey was performed in fiscal year 2011. A report on this effort, "Capabilities of Existing Hot Cell Facilities for the Examination of Used Fuel Summary Report", FCRD-USED-2011-000094, April 2011, includes highly detailed descriptions of the facilities at each site. This survey, which was prepared for the DOE's Used Fuel Disposition Campaign, built upon and updated an August 2003 report prepared by the Pacific Northwest National Laboratory, PNNL-14390, titled, "Dry Storage Demonstration for High-Burnup Spent Nuclear Fuel Feasibility Study."

The review documented in the Task Order 7 report determined which facilities could handle the testing of individual rods versus whole assemblies and full-sized casks, and included national laboratories and commercial hot cell facilities. The national laboratories surveyed included Argonne, Idaho, Oak Ridge, Pacific Northwest, and Savannah River. Also included was the EMAD facility at the NNSS. The commercial facilities included the B&W Lynchburg Technical Center, the GE-Hitachi Vallecitos Nuclear Center, and the Westinghouse Churchill Hot Cell Facility. It became apparent that only a limited number of facilities could handle either assemblies or full-sized casks. It was also apparent that some laboratories specialized in some aspect of cladding behavior. Thus, it was prudent to assume that rods or rod segments would be shipped to these other facilities for those specialized examinations. Since the data to support an amendment to a cask CoC for transporting high-burnup fuel are needed quickly, near-term reliance must be placed on existing facilities, not the CSF. Data are also needed to provide confirmatory long-term storage data to the NRC in light of the June 2012 remand by the U.S. Court of Appeals for the D.C. Circuit to the Waste Confidence Rule. The later examination of the status of the UNF in storage would be initiated at the CSF, especially the NDE portion. However, the location of the CSF and its proximity to existing hot cell facilities may determine whether the testing equipment would be duplicated in the CSF. For the data needed for the high-burnup fuel, the rods would be sent to a hot cell facility. The facility chosen would be based on its ability to perform the examinations in a timely and economical manner. The capabilities of each facility are shown in **Table 6.2-2**.

Table 6.2-2
Capabilities of the Hot Cell Facilities

Action	ANL	B&W LTC	EMAD	GEH VNC	INL	ORNL	PNNL	SRNL	W
Receive Loaded Casks			X		X				
Receive Fuel Assemblies			X		X				

Action	ANL	B&W LTC	EMAD	GEH VNC	INL	ORNL	PNNL	SRNL	W
Remove Fuel Rods		X	X	X	X	X	X	X	
Perform NDE		X		X	X	X	X	X	
Perform DE		X		X	X	X	X	X	
Perform Cladding Tests	X			X	X	X	X	X	X

In regard to analyses of data needed to establish the technical basis for the long-term storage of high-burnup fuel, advantage was taken of a report titled, "Gap Analysis to Support Extended Storage of Used Nuclear Fuel", June 30, 2011, which was prepared by the national laboratories for the Used Fuel Disposition Campaign. (An update to this report is currently in process.) This gap analysis report was also built on many earlier reports prepared by the DOE, EPRI, and the NRC. A recent NRC report provides their analysis of information needs.[45] These and other reports regarding the gaps in the information base will be utilized to better define the testing program when that activity is initiated. In addition, benefit will be taken from the information gained from the August 22–23, 2012, workshop in Idaho Falls, hosted by INL, on High-Burnup Used Fuel Demonstration. The "must have" data needs developed at this workshop are almost identical to those defined in the gap analysis report cited above. In all of these reports, the changes to the properties of the cladding as a result of the high-burnup and the subsequent storage continued to be identified as the most important need. Need was also identified for the analysis of the content of the gas phase within the canister or cask, particularly for hydrogen, oxygen, xenon, krypton, and moisture content. See Section 6.4 for further details.

As noted previously, a basic set of NDE and DE tests will be performed. For NDE, visual inspection, dimensional analysis (profilometry), gamma scanning, eddy current analysis, and possibly neutron radiography, would be performed. The DEs would include fission gas puncturing and analysis, rod sectioning, fuel morphology, cladding morphology, hydrogen content analysis, hydride distribution, and testing the cladding's mechanical properties. Mechanical property tests will likely include standard tensile tests and ring and plug tests developed by Argonne and Oak Ridge National Laboratories, respectively. All of these tests would compare the results obtained with available data for the up-to 45 GWd/MTU UNF. The emphasis for high-burnup fuel would be placed on hydride effects, especially hydride reorientation. This impacts the ductility of the cladding and its resistance to internal pressure,

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[45] U.S. NRC, 2012. *Identification and Prioritization of the Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation of Spent Nuclear Fuel*, May.

which gives rise to radial stresses. In addition to the effect of the long-term storage in the dry storage casks, the hydride morphology is also influenced by the cask drying procedure utilized when the fuel assemblies are taken from pool storage after a suitable cooling period and placed into the dry storage canister/cask systems.

One way to quantify the embrittling effects of hydride reorientation is to determine the ductile-to-brittle transition temperature (DBTT) for the types of cladding in service by performing stress-strain tests over a range of temperatures. The DBTT marks the transition of the cladding from a brittle to ductile state. This change in DBTT is due mainly to the reorientation of circumferentially oriented hydrides to radially oriented hydrides. Obviously, one would prefer to handle or transport fuel when its temperature is above the DBTT since, in the ductile state, the cladding is not amenable to failure. A summary slide on this effect was shown by Michael Waters of the NRC at the June 2012 ANS Meeting in Chicago. He showed some of the data collected by Dr. Michael Billone of the ANL that illustrated how the DBTT was reduced by at least 50ºC as a result of simulated drying conditions utilizing one particular cladding. Such data would be very useful for all of the cladding types, both for simulated and actual thermal conditions.

Another approach to investigate the hydride effect would be to evaluate the distribution of hydrides as a function of drying cycles and thermal profiles during long-term storage. These evaluations would be performed with the sibling rods. If the initial drying cycle placed most of the hydrogen in solution as opposed to hydrides, this could be taken advantage of by keeping the fuel as hot as possible for as long as possible. One suggestion would be to replace at the 10-year (or longer) examination period the helium gas in the cask or canister with nitrogen, which has a much lower thermal conductivity. This would be done if the fuel temperature has dropped significantly. If the drying cycle causes the hydrogen to precipitate as circumferentially oriented hydrides, it may be prudent to keep the hydrogen in these hydrides rather than allowing them to go back into solution and precipitate radially upon cooling under stress. With either or both of these options, the tests would be conducted in parallel with the initial 10-year storage period so that an action plan for the post-storage examination of the fuel rods could be developed.

6.3 Test UNF to Support Long-Term Storage

The BRC and others have argued that the UNF at plant sites should be moved to one or more CSF facilities where the performance of the UNF and their casks could be followed as a function of time. Also, it has been argued, for example in a Brattle Group report, “Centralized Dry Storage of Nuclear Fuel, Lessons for U.S. Policy from Industry Experience and Fukushima,” Graves et al, August 2012, that such a facility would reduce the potential for proliferation as well as other safety and security concerns. This is particularly true for stranded fuel. In addition, the June 2012 ruling by the U.S. Court of Appeals for the D.C. Circuit that the Waste Confidence Rule by the NRC lacks long-term data to support storage for 60 years and beyond adds emphasis to the need for this action.

In Section 3.3.1 of this report, the issue of whether a central CSF or several regional CSF facilities would be built is discussed. The resolution of this issue will have some bearing on the content of the capabilities to be included in the hot cell of the CSF. If the CSF is in proximity to a National Laboratory or commercial facility that possesses the equipment to perform the UNF testing, particularly the DEs, it would be uneconomical to duplicate these capabilities at the CSF. In this case, the CSF would have the capability to open and reseal the casks, and open and reseal the canisters after retrieving rods and/or assemblies for examination over the time intervals needed. See the discussion below on the suggested design changes that would permit opening and resealing operations. At the CSF, these rods and/or assemblies would be examined, at least visually. The other NDE needed could then be performed there or at the nearby national laboratory facility prior to DE.

If there is no national or commercial laboratory nearby, the CSF must include equipment needed for at least all of the NDE. The trade-off on whether or not to include the equipment to perform the destructive analysis must weigh the cost and upkeep of the equipment needed plus the floor space required versus the transportation cost of moving the rods to one or more other facilities for the DE. In addition, the hot cell space needed for the DE must be partially inerted to maintain the condition of the sectioned fuel and cladding during the examination process. These are not trivial costs. The cost of the equipment and partially inerted hot cell space needed for the DE is likely to be \$0.5–\$1 billion. This compares to the cost of transportation of rods to the nearest national or commercial laboratory that could accept them (and the return of the UNF to the CSF), which is likely to be about \$3 to \$4 million per campaign.

It may be necessary that some portion of the CSF have inert gas capability if there is any indication, using the external or internal sensors, that one of more fuel assemblies have failed in storage. However, the UNF in storage is likely to have decayed for a sufficient time such that fuel oxidation will not be a problem. In the latest NRC Interim Staff Guidance, SFST-ISG-22 dealing with potential rod splitting, NRC argues that exposure to dry air for up to 100 hours is not of concern if the fuel is below 290ºC. Thus, inerting may not be required. Even in instances where longer exposure times were required due to unexpected conditions, it would be possible to flood the cask with nitrogen rather than relying on inerting the entire cell.

On the basis of this rough cost analysis, it appears that it would be cost effective to conduct the detailed DE at an appropriate national or commercial laboratory. Even if that laboratory does not have all of the equipment needed, such as for the specialized mechanical tests that are likely to be required, the additional transportation of rod segments to those laboratories that have the specialized equipment would be cost effective. The capabilities of each of the national laboratories and the commercial hot cells were reviewed in the Task Order 7 report and will not be repeated here. However, it is important to note that each facility has special capabilities that would make it an important part of the DE campaign for each set of rods. For example, as noted in **Table 6.2-2**, Argonne and Oak Ridge have special capabilities regarding the mechanical testing and evaluation of small cladding samples. Also, only small rod sections are needed for these tests. Hence, small casks could be employed for this transport, which would greatly reduce transportation costs.

The timing of the examinations has been noted above and in the Task Order 7 report. It has been assumed that the casks would be sampled at 10- to 20-year intervals. Later in life, the interval could be extended if the UNF and cask conditions are not changing. As noted above, each time the cask is opened provides an opportunity to examine cask components for potential degradation. In addition to the casks, the basket, neutron poisons, and neutron shields could also be evaluated. As part of routine maintenance and security operations, the storage pads and external conditions of the casks would be observed frequently.

The schedule for the operation of the CSF is shown elsewhere in this report, as is the rate at which casks currently at plant sites would be transported to the CSF. However, it is assumed that the early examinations of the fleet of storage casks at the ISFSI sites (that provide a baseline for long-term dry storage, particularly for the high-burnup UNF) would not be performed at the CSF unless it is ready for operation. It is likely that it would be initiated at the INL, since it is the only facility that can receive full-sized casks. Techniques would need to be developed to open and reseal the canisters. The INL facility could be utilized to perform the NDE and much of the DE needed. However, a waiver or change to the agreement with the State of Idaho would be required. As noted above, the use of the EMAD facility is a potential backup to the INL. For both options, significant upgrades to each facility would be required. For the EMAD facility, the likely scenario would include the removal of the assemblies from the casks for the initial NDE, with the detailed NDE and DE performed elsewhere. Thereafter, rods or rod segments could then be shipped to other laboratories for specialized testing.

Several casks would be selected from the entire inventory of casks located at utility sites to provide some of the needed confirmatory data to extend the time permitted in dry storage, which is the function of this activity. These casks would be shipped to the INL and the same process utilized as described above. Preference would probably be given to those casks with bolted lids and bare UNF and bolted lids with canistered UNF. Obviously, access to casks with bare UNF would permit easy access. In the latter case, the canisters would need to be cut open to permit access to the interior. This process is discussed in Section 6.6. The casks (or canisters) would be re-inerted and sealed. The casks would remain at the INL (or the EMAD facility) until the CSF is available and then shipped there.

The testing to be performed to determine the long-term performance of UNF in storage will be similar to that noted above for the high-burnup UNF. The basic set of tests will include the same suite of tests for NDEs and DEs. For NDEs, visual inspection, dimensional analysis (profilometry), gamma scanning, eddy current, and possibly neutron radiography would be performed. For the DE, fission gas puncturing and analysis, rod sectioning, fuel morphology, cladding morphology, hydrogen content, hydride distribution, and cladding mechanical property testing would be performed. Mechanical property tests will likely include standard tensile tests and ring and plug tests developed by Argonne and Oak Ridge National Laboratories, respectively. All of these tests would compare the results obtained with the available data set for the up-to 45 GWd/MTU UNF. The emphasis here and for the high-burnup fuel would be on the hydride effects, especially hydride re-orientation. This impacts the ductility of the cladding and its resistance to internal pressure, which gives rise to radial stresses.

6.4 Develop and Implement Monitoring Devices

When dry storage of UNF was initially evaluated as an alternative to pool storage, a demonstration program was conducted at the INL. This program was supported by the DOE, NRC, and the Electric Power Research Institute (EPRI). Several types of casks with several internal atmospheres were evaluated to better understand the thermal environment as a function of time. For these casks, thermal sensors were added internally to both the casks and canisters, which enabled thermal models to be developed that could be used as a predictive methodology. However, once these casks were certified for use by the utilities for dry storage, there was no requirement for internal or external thermal sensors. Pressure sensors were utilized in the demonstration program to determine the integrity of the cask seals as a function of time. These sensors sensed the pressure between the cask inner and outer lids in a bolted design or between the cask and canister in a welded design. A pressure increase might be indicative of a canister leak, while a pressure decrease might be indicative of a cask lid leak. For casks with internal canisters stored at an ISFSI under a general license, radiation monitoring is performed in accordance with 10 CFR Part 50 environmental monitoring requirements. For casks with bare fuel and bolted lid(s), the lid design incorporates either a double lid or a single lid with pressure sensors between the two set of O-rings. Under this R&D program, the long-term performance of O-ring seals will be quantified. This will be part of the Aging Management Plan. See further discussion on O-ring seals in Section 6.6.

In order to better understand the long-term thermal behavior of UNF in long-term storage, sensors would be installed in selected casks and/or canisters at the CSF. In addition to thermal performance, it would be useful to follow any deterioration of the canisters and/or casks utilizing corrosion-sensing devices. Such devices have been used to evaluate pipeline corrosion and rely on small sensors that measure the electrochemical impedance or resistance between two points on the metal surface. Alternately, it might be feasible to periodically examine the surface condition of the canisters through the available cask vents.

In this regard, it would be very useful to build upon the program described at the June 2012 Used Fuel Disposition meeting in Las Vegas. This program is being run with support from the DOE and EPRI, and includes investigation of TMI fuel at the INL and commercial fuel in dry storage at several reactor sites. The equipment needed for the TMI investigation has been obtained and tested with an un-irradiated prototype. This investigation includes the examination of the internal cask and external canister condition for the Calvert Cliffs NUHOMS system. Both hot and cold modules were selected for evaluation. The modules were identified as HSM-15 and HSM-1, which were loaded in June 1996 and June 1993, respectively. They contain stainless steel canisters identified as DSC-6 and DSC-11, respectively.

Two reports are now available that describe the results of the Calvert Cliffs investigation. The first is a Sandia National Laboratory summary of observations report from David Enos to Ken Sorenson, "Summary of Observations from Calvert Cliffs ISFSI Inspection," dated July 12, 2012. The report describes the view from a pan-tilt-zoom camera that was inserted into the NUHOMS casks through the rear exhaust vent. The report states that there was some light discoloration “here and there” on the surface of the container, but for the most part the welds looked pristine (“both the closure weld as well as the circumferential and longitudinal construction welds we were able to view”). However, there was some surface staining, probably due to weather-driven water seepage. There was dust or particulate covering the horizontal surfaces and some samples were taken for analysis after the front door of the cold HSM-1 cask was backed away a short distance to permit a collection tool to enter. A salinity measurement was also made using a SaltSmart^{TM} tool. The results of these samples will be reported by EPRI when they become available.

The second report is titled, “Calvert Cliffs Independent Spent Fuel Storage Installation Lead and Supplemental Canister Inspection Report,” from Calvert Cliffs to the NRC, dated July 27, 2012. The report provided further detail on their observations and included several photographs of the surfaces of the canister and the internals of the storage module. It noted that a few rust spots were observed on the shell body of DSC-6, but otherwise the surfaces looked fairly good. The report noted that some minor deterioration of the coating of the rail was observed with some resultant corrosion of the underlying carbon steel. This condition will be tracked in follow-up observations in the future. The report also showed some concrete stalactites on the roof of the modules near the rear outlet vent, again probably due to weather-driven seepage through the concrete. There was no evidence of rusting on the internal reinforcement bars.

If these and the other tests performed at Calvert Cliffs and at the INL show that non-destructive remote examination is possible and useful, then corrosion sensors may not be needed. This would be of benefit since the long-term viability of these corrosion sensors in a radiation environment has not been established.

During the High-Burnup Used Fuel Demonstration Workshop, the need to determine internal gas content was identified as an important need. Gases include hydrogen, oxygen, xenon and krypton, and moisture (H_2O). These could be measured either intermittently by grab samples or continuously. To perform a grab sample, the lid of the cask or canister would need to be modified to provide this access. It may be possible to utilize the existing vent ports that usually have quick-disconnect couplings with O-ring-sealed cover plates. The national laboratories and others have explored continuous monitoring devices. Such a device has been developed by Philip Winston of the INL. It utilizes a small pump that brings a small volume of gas past various detectors. This approach should be further explored.

At the workshop, members of the Shaw team met with utility representatives and cask vendors. Since Shaw recommends herein and in the Task Order 7 report that TN casks be utilized, the emphasis in these meetings was on modifications to the casks to permit additional temperature sensors. This exchange suggested that this was best accomplished by adding additional ports in the lid, some on the periphery, and at least one in or near the center of the casks. These changes may be accommodated within the current cask storage CoC in accordance with 10 CFR 72.48. This provision is not available in 10 CFR Part 71. However, any new port would be sealed with O-ring seals prior to transport in the same manner as the original ports. In any case, the first step would be to meet with the NRC to discuss the appropriate path forward.

6.5 Develop a Standardized Canister Program

In the 1980s, the DOE initiated the multi-purpose canister (MPC) program. The MPC would be capable and licensed for storage, transportation, and disposal of UNF. Its aim was to develop a standard canister that could be used by most utilities to simplify handling operations by not requiring the opening of the canister after it had been loaded at the plant site. Both large and small size canisters were designed. The design initially focused on storage and transportation, not disposal. The design effort was cancelled when funding was cut in 1996. The DOE revived this multi-purpose approach with the Transportation, Aging, and Disposal (TAD) canister program in the 2000s, but with the cancellation of the Yucca

Mountain Project, the project did not progress. There are current indications that the DOE may again make an effort to revive this cooperative program. This new program is the Standardized Transportation, Aging, and Disposal (STAD) canister program.

In order for such a standardized canister program to be successful, a team needs to be established that would consider the needs of each of the functions—storage, transportation, and disposal—along with the needs of the suppliers and utilities. The needs on the storage and transportation sides are fairly well known and the suppliers of existing canisters have met the NRC requirements of 10 CFR Parts 72 and 71. More work is required on the disposal side, where long-term requirements have been detailed in 10 CFR Part 63, for a Yucca Mountain repository, and in 10 CFR Part 60 for a generic repository.

The standardized canister effort must also take into account the various sizes of canisters that are currently in service. For example, PWR canisters exist that contain at least 24, 32, and 37 assemblies. A similar situation also exists for BWR assemblies. Thus, a minimum of six designs would have to be considered. However, this could be reduced if all parties—the suppliers, utilities, and the DOE—can agree on which designs would be standard.

For disposal, two aspects of canister design are key: the mechanical integrity of the internal structure and the long-term performance of the criticality control materials. Some progress has been made on both of these aspects. Note that flux trap approaches to criticality control are not permitted for disposal due to the potential for assembly compaction. For the criticality control material, long-term performance data need to be obtained. Testing was initiated on various boron-containing materials as part of the Yucca Mountain Project; however, follow-up testing after the initial tests were performed was not carried out. It is unclear whether a complete analysis of the early tests was performed. One issue is the sensitization of the materials due to the thermal history of the canister, both during loading and drying and in storage and disposal, and its effect on the mechanical stability and corrosion resistance of the boron-containing plates and any re-location of the boron itself. These effects must be addressed in order for an acceptable design to be developed and tested. While the Yucca Mountain Project was able to narrow the potential pH exposure range of waters that might contact the waste package and its internals, this would have to be re-examined for a repository in other geologic media. For example, aluminum that contains boron would not have performed well in the pH range for the Yucca Mountain Project, but it may be suitable for other systems where the pH is closer to the stability range of aluminum.

For long-term storage, the design of a standardized canister should also consider the ease of opening and resealing the canister to enable the long-term but routine examination of the internals during the storage period. See Section 6.6 on opening and sealing of canisters.

6.6 Opening and Sealing Canisters and Storage Overpacks

It is hoped that most storage overpacks in the future will rely on bolted lids, rather than welded lids, since bolted lids would provide easy access to the canisters for determination of possible degradation over time. Most vendors of DFSSs offer designs that utilize bolted lids. For long-term storage, the integrity of any O-ring or other seal would need to be confirmed. However, in many designs, the closure provides radiation shielding and physical protection of the canister and not confinement since the overpack is ventilated. If O-ring seals are required, they should be evaluated with a small R&D effort utilizing pressure sensors as noted in Section 6.4. The pressure sensors would provide indications of lid failure and would allow O-rings and other sealing components to be replaced and internal atmospheres re-established. The German effort on reliability of O-rings was reported by Dr. Holger Voelzke of BAM at a June 7–9, 2011, ESCP meeting in Berlin. He noted that the O-rings examined were in good condition after 10 years of service. The DOE should initiate an R&D effort on the long-term behavior of O-ring seals if one is not already ongoing. This could be done as part of the CSF program to ensure that the lid seals, particularly for casks containing bare fuel, are performing as required. In the High-Burnup Used Fuel Demonstration Workshop, the Shaw team met with some utility personnel with experience in bolted lids. They claimed that no problems have been found for lids thus far after 10 years of exposure.

Canisters, however, will need to be welded, not bolted, particularly if they function in the disposal mode. However, there are design changes that could accommodate both short-term (10- to 20-year) access and long-term closure requirements. Recall that access is required in order to retrieve fuel assemblies and/or rods for examination as noted in Sections 6.2 and 6.3. Most canisters could be cut open and resealed, but some designs make this operation more difficult than others. One solution would be to design a central port that is easily opened and is configured such that short-term access would be possible utilizing O-ring seals on the canister opening and the vent ports. Another would be to redesign the seal weld so that opening and resealing the canister would be simplified. Some canister designs contain a shield plug that would have to be modified to create an internal plug with a flange that could be removed once the port was opened. All designs include vent ports that must be utilized to re-establish the appropriate atmosphere within the canister. One way to achieve this would be to move the vent port from the edge, where it is located in most designs, to the central resealable port. After sealing the port ring and re-establishing the internal atmosphere, the vent port would be sealed with a small cover plate.

There is some past experience in remote opening and resealing of canisters and casks. For example, the Climax Mine experiment, conducted in the 1980s as part of the Yucca Mountain Project, opened a cask containing PWR fuel from Turkey Point in the EMAD facility and inserted that fuel into small canisters. The canisters were held stationary while the welder rotated around the circumference of the canister. These canisters were transported to the Climax Mine site and remotely placed in vertical boreholes in a tunnel within the Climax Mine. At that time, the Yucca Mountain Project was focusing on vertical boreholes for direct disposal of UNF. After the test, the canisters were remotely transported back to the EMAD facility. The lids of the canisters were cut open using a circumferential cutting tool. The fuel assemblies were removed from the canisters and placed into the transport cask for shipment to the INL.

In the mid 2000s, the INL developed remote techniques for welding, NDE testing, and opening DOE standardized canisters. These canisters were either 18 or 24 inches in diameter and 10 or 15 feet long, made of Type 316L stainless steel. NDE included visual, eddy current, and ultrasonic inspection.

In 2008–2009, the INL investigated remote welding of a full-scale Yucca Mountain Project waste package. The project was also tasked to examine opening operations, but only the closing and sealing of a waste package was demonstrated before the project was shut down. Details can be found in a November 2011 Nuclear Technology article ("A Fruit of Yucca Mountain: The Remote Waste Package Closure System," *Nuclear Technology*, Volume 176, Number 2, November 2011, Pages 296–308, Kevin Skinner, Greg Housley, Colleen Shelton-Davis). The system was designed and built by the INL and included evacuation, inerting, and remote sealing of the full-scale waste package prototype, as well as demonstrating four techniques for NDE of the weld. Techniques for weld-stress mitigation, such as ball burnishing, were also evaluated.

From the canister designs available in the literature, it appears that the opening and resealing of canisters are possible with minor design changes to the canister lid. This would permit the access needed to remove fuel assemblies for examination. Such a design change could be a requirement on the standardized canister discussed in Section 6.5. As noted in that section, the canister lid could contain a special resealable port through which a small, central set of fuel assemblies could be accessed. This port would also permit the evacuation and re-inerting of the interior of the canister. Some minor modification would need to be made to the shield plug for those designs that utilize them. The design must also take into consideration the clearance space between the canister and the cask lid. Alternately, only a small fraction of the canisters could be designed for this operation. This might ease the requirements on the utility site during the loading process. In either event, the design changes would need to be licensed by the NRC. As noted above, for addition of new openings to allow monitoring, a pre-meeting with the NRC would be very useful.

6.7 Rod Consolidation

UNF rod consolidation was explored in the early 1980s as another option to increase pool storage space. It was also considered by the DOE and the Yucca Mountain Project as a way to increase the density of UNF in canisters and waste packages. The objective was to achieve a two-to-one reduction in space occupied by the fuel rods.

International experience is summarized in an IAEA report[46]. The early U.S. experience was summarized in a 1985 Pacific Northwest Laboratory (PNL) report[47] and a 1988 paper[48]. The PNL report noted that the first U.S. consolidation of irradiated fuel was successfully demonstrated with four PWR assemblies at the Oconee Nuclear Station in October/November 1982 and one PWR fuel assembly at Maine Yankee in August 1983. The 1988 paper noted that four demonstrations were conducted, one at West Valley and three by utilities. These utility demonstrations involved the Rochester Gas & Electric Ginna plant[49], the Northeast Utilities Millstone Unit 2 plant[50], and the Northern States Power Prairie Island plant [51]. The equipment was designed and built by U.S. Tool & Die, Combustion Engineering, and Westinghouse, respectively. As required by the NRC, each of the utilities conducted criticality analyses to confirm subcriticality of the consolidated fuel. The Ginna effort was conducted in the pool at Battelle's nuclear facility outside Columbus, Ohio[52], while the others were conducted at the utility's spent fuel pools. The largest of these demonstrations was that at Prairie Island where 36 fuel assemblies were dismantled and the fuel placed into 18 canisters, each one the size of a single fuel assembly. Additional canisters would be needed to contain the top and bottom nozzles and the fuel spacer grids. In the process of removing the rods from the original assemblies, a cloud of crud was released into the pool that needed to be removed by the pool's filtration system.

In the 1980s, the DOE began a series of cooperative demonstration projects for fuel rod consolidation that were focused on in-cell, rather than poolside, operation[53]. The first was conducted by the INL in 1981 with support from the DOE and the Yucca Mountain Project

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[46] IAEA, 1992. *Consolidation of Spent Fuel Rods for LWRs*, AIEA-TECDOC-679.

[47] Bailey, W.J., 1985. *Status of Rod Consolidation*, PNL-5122, April.

[48] Matheson, J.E. and T. Tucoulat, 1988. *A Simple Approach to Fuel Consolidation*, presented at the Waste Management Symposium, V2, No. 76.

[49] Wachter, W.J., 1987. *Performance of the UST&D Consolidation System at Battelle*, presented at the INMM Spent Fuel Management Seminar IV, January.

[50] Isakson, R.A., 1988. *The Role of Consolidation in Northeast Utilities' Spent Fuel Management Plans*, presented at the INMM Spent Fuel Management Seminar V, January.

[51] Gerstberger, C.R., 1988. *Consolidation of Spent Fuel at Prairie Island*, presented at the INMM Spent Fuel Management Seminar V, January.

[52] Stahl, D. et al., 1987. *Final Report on Ginna Fuel Rod Consolidation Program*, Battelle Columbus Division Report, March.

[53] DOE, 1987. *Cooperative Demonstration Projects for Spent Nuclear Fuel*, OCRWM Backgrounder, DOE/RW-0138, April.

and was initiated with dummy assemblies. The final report[54] summarizes the work performed and states, "Twenty-four fuel assemblies were procured for the project. Most of the fuel was manufactured by the original vendors to simulate operational fuel assemblies, including postulated failure modes." The project involved the design, building and testing of the equipment, which was performed by the NUS Corporation. The demonstration involved the horizontal removal of each rod and essentially rolling them into a square holder the size of a fuel assembly. The project was terminated after the completion of the cold checkout phase. The unused assemblies were provided to DOE programs for research and public relations. The remaining assemblies, spare parts, and special tools were stored at the INL. The equipment itself was shipped to the UNLV Robotics Laboratory. The reason that the project was terminated was likely an economic one. A Yucca Mountain report[55] notes that a preliminary economic assessment indicated that the disposal of intact fuel assemblies was favored over rod consolidation. However, this analysis should be repeated given the increased costs of waste packages and disposal.

A later project at the INL in 1987 resumed in-cell consolidation and built upon the earlier demonstration noted above. This project involved the successful consolidation of fuel rods from a Westinghouse PWR. A discussion of this project[56] states, "The consolidation equipment was operated at an existing hot cell complex at the INL. The equipment was specifically designed to interface with the existing fuel handling and operational capabilities and was instrumented to provide data collection for process technology research. Equipment performance was recorded and data measurements were compiled on crud and contamination generated and spread. Fuel assembly skeletons were gamma scanned and analyzed for isotopic content and profile. The loaded consolidation fuel canisters were utilized for a test of the Transnuclear, Inc. TN-24P dry storage cask with consolidated fuel."

There appears to be no current activity in rod consolidation. However, vendors still offer the equipment and services for sale. The cause for this lack of activity may be due to the shift to dry storage at most utilities and the fact that the in-pool equipment takes up vital pool operating space. This does not preclude the use of rod consolidation at the CSF. An important study would be the determination of the cost effectiveness of the process compared to the direct storage of canisters received from the utilities. This approach might be beneficial if a large amount of fuel needs to be repackaged, either as a result of leaking canisters or ones that do not meet to be established disposal requirements. New canisters would need to be designed and built to contain this compacted fuel.

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[54] Gili, J.A. and V.K. Poston, 1993. *Prototypical Consolidation Demonstration Project Final Report*, EGG-WM-10955, November.

[55] SAIC, 1985. *Nevada Nuclear Waste Storage Investigations Project, Quarterly Report, October–December 1984,* NVO-196-47, December.

[56] Mullen, C.K. et al., 1988. *Dry Rod Consolidation Technology Project Results*, Waste Management Symposium, V2, No. 138.

It should be recalled that the early fuel rod consolidation effort was conducted on low to moderate fuel burnup fuel rods. Utilizing similar processes with higher burnup rods could lead to some difficulties. For example, the rods could have experienced significant deformation or embrittlement. These processes could make removal of the rods from the assemblies difficult and could lead to rod cladding failure and fuel pellet release. Even without failure, deformation will reduce the potential for a two-to-one reduction in cross section. These issues must be considered when examining the economics of the process.

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7.0 PROJECT PLANNING

7.1 Long-Range Planning Schedule

The long-range planning schedule covers a 100-year operating life for the CSF and identifies schedule milestones required to support the four CSF operational phases described in Section 3.0. These operational phases are as follows:

- CSF Phase 1—Stranded UNF at Shutdown Plant Sites
- CSF Phase 2—Transportable Canisters
- CSF Phase 3—Dual purpose Casks and Bare Fuel
- CSF Phase 4—Non-Transportable Dry Canister Storage Systems

The summary schedule shown in **Figure 7.1-1** shows the three CSF Construction Stages and the four Operational Phases and includes the major activities to support the receipt of stranded UNF from shutdown plant sites. The three construction stages are coordinated with the four-phased operational strategy and provide the operational flexibility to ramp up to the 4,500 MTU per year goal for UNF receipt by 2035. The flexible CSF design allows for the simultaneous receipt of dual purpose canisters (DPCs) and bare fuel assemblies. The PWR and BWR wet storage pools allow wet-to-wet transfer of UNF with sufficient surge capacity to decouple UNF receipt operations from downstream dry storage or UNF closed-cycle processing. The summary schedule also includes R&D on UNF and UNF storage systems to support the CSF Aging Management Program under 10 CFR Part 72. The acquisition of all rolling stock is expected to take place during the first construction stage. This acquisition of all CSF rolling stock is a very small order for a railroad car fabricator. Attempting to procure a reduced quantity of rolling stock would result in a significant premium and, based on our informal discussions, most fabricators would not submit a bid for a small rolling stock fabrication contract.

The staged construction of the CSF is further described in Section 7.2. This construction approach starts with a pilot plant (Construction Stage 1), which provides flexibility to adjust the future plan to build out the CSF dry and wet storage systems while addressing DFSS remediation capability and UNF testing.

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CSF - Summary Schedule | Detail Bar Chart | 18-Jan-13 12:08

Activity Name	Start	Finish
CSF - Summary Schedule	01-Jan-13	01-Jun-99
Site Acquisition / Expl / Permits	01-Jan-13	31-Dec-18
R&D - UNF / Cannisters	01-Jun-13	01-Jun-99
Conceptual Design	01-Jul-13	30-Jun-14
Preliminary Design	01-Jul-14	31-Dec-15
Final Design	01-Jan-16	30-Jun-17
ER / SAR / Prep	01-Jul-14	30-Jun-15
NCR License / Stage 1	01-Jul-15	31-Dec-18
Stage 1 Construction	01-Jan-19	31-Dec-20
Stage 2 Construction	02-Apr-22	30-Jun-26
Hot Cell & Fuel Pool Facilities - Prel / Final Design	01-Jan-26	31-Dec-28
Stage 3 Constr.	01-Jul-29*	31-Dec-32
Rolling Stock Des / Cert / Fab	01-Jan-13	29-Jun-18
Trans Cask & Equip Des / Cert / Fab - Stage 1	01-Jan-15	29-Jun-18
Transfer to CSF / Stranded Sites (I)	01-Jan-21	31-Dec-26
Transfer / Transportable Canisters (II)	01-Jul-26	17-Jul-56
Transfer / DPCs / Bare Fuel (III)	01-Jan-33	31-Jul-56
Transfer Non-Transportable (IV)	01-Jan-35	31-Jul-56

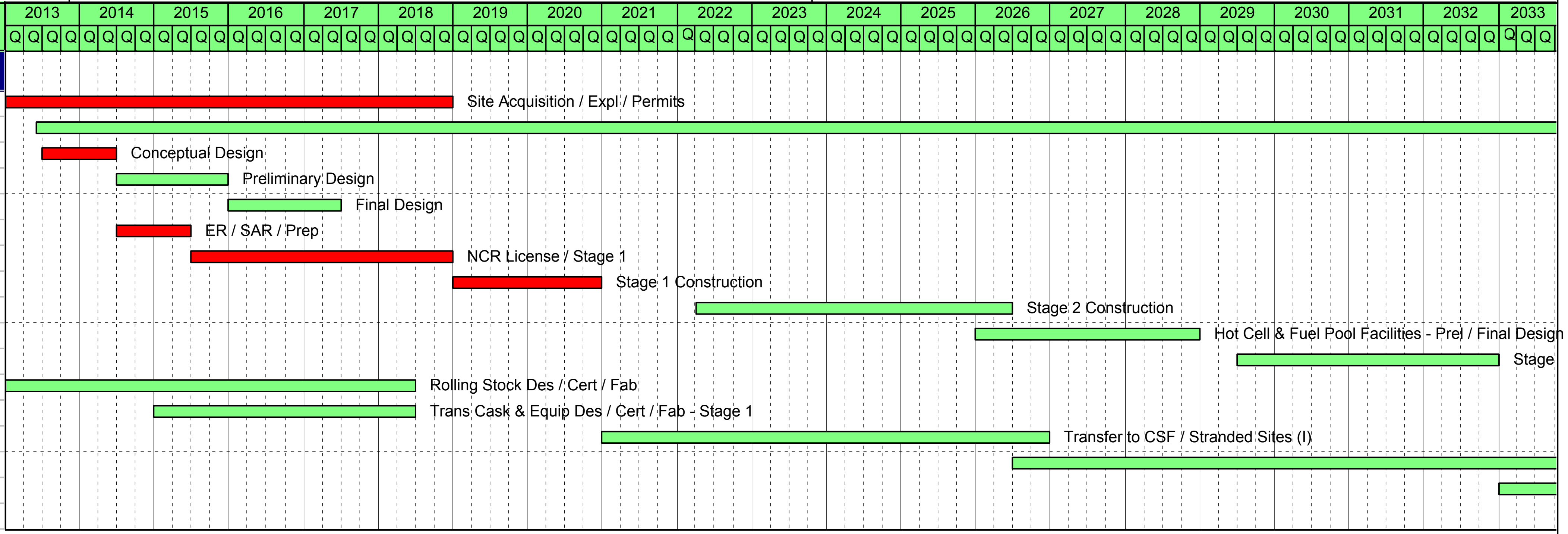

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Figure 7.1-1 - CSF - Summary Schedule

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CSF - Summary Schedule | Detail Bar Chart | 18-Jan-13 12:08

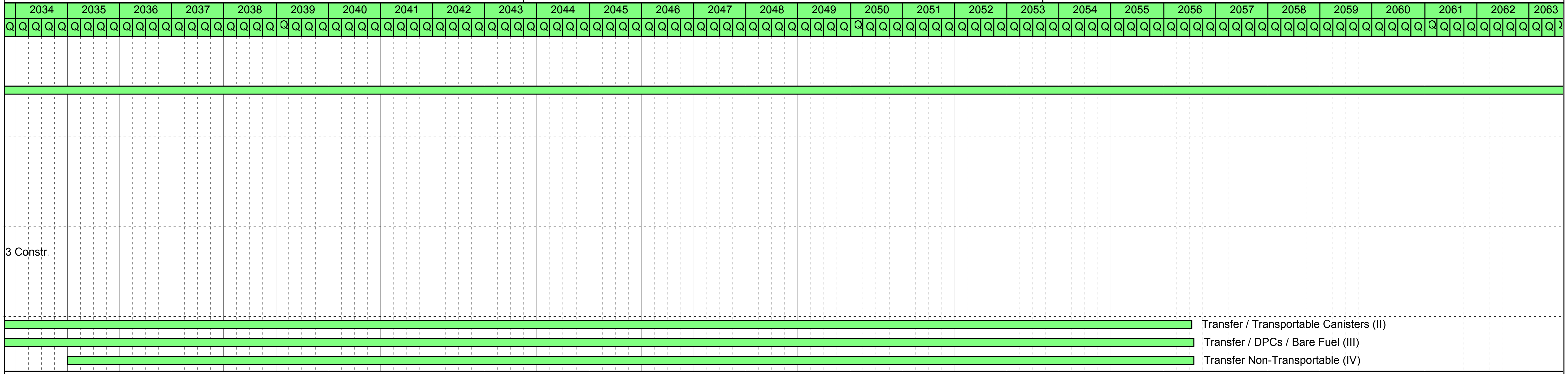

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Figure 7.1-1 - CSF - Summary Schedule

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7.2 Staged Approach to Facility Development

The Summary Schedule, **Figure 7.1-1**, shows a three-stage approach for constructing the CSF. The construction plan of the CSF has been coordinated with the Shaw Team's prioritized approach for removing UNF from its current storage, starting with stranded fuel as described in Section 3.1.

Figure 7.2-1 shows Construction Stage 1 of the CSF. During this first stage, on-site and off-site rail systems will be constructed along with a FMF to support the full fleet of rolling stock being fabricated during Construction Stage 1. The layout also includes eight storage pads for vertical, above-grade storage and three pads for horizontal modules sized to receive all the fuel from stranded sites. A Cask Handling Building (CHB) is provided for the unloading of the railcars and the transfer of canisters to dry storage during Phase 1 Operations. Construction Stage 1 also provides all necessary security features, including an entry control facility, central alarm station (CAS), secondary alarm station (SAS), and a perimeter intrusion detection and alarm system.

The schedule for Construction Stage 1 of the CSF is shown in **Figure 7.2-2**. This schedule shows an operational date of December 2020. The critical path for achieving this milestone is primarily through the licensing of the CSF. This schedule assumes the commencement of design in June 2013 and that site selection can be achieved by June 2014. Completion of these two activities will allow site exploration activities and environmental and safety analysis report preparation to begin starting in June 2014. During this period (between June 2013 and June 2014), pre-application meetings will be held with the NRC to determine the specific plan to license the CSF. A period of 18 months is provided to prepare the license application for submittal to the NRC. The Environmental Report will cover all three stages of CSF construction and the planned 100-year operating life. The Safety Analysis Report will cover just Construction Stage 1 and the receipt of stranded fuel. Duration of 3.5 years has been allowed for the licensing process, including three rounds of Requests for Additional Information (RAIs), Safety Evaluation Report (SER) preparation, Environmental Impact Statement (EIS) preparation and public hearings.

Upon completion of the SER and the Final EIS, early site preparation will commence while public hearings get underway. Early site preparation activities will include site clearing, grading, roadways, site utilities, an on-site concrete batch plant erection, and mobilization of construction equipment and facilities. Since this is a consent based site, 6 months of public hearings is assumed.

A 2-year construction schedule is planned. The facility concept will permit parallel construction activities for nearly all buildings, pads, and facilities, making a 2-year Construction Stage 1 schedule achievable.

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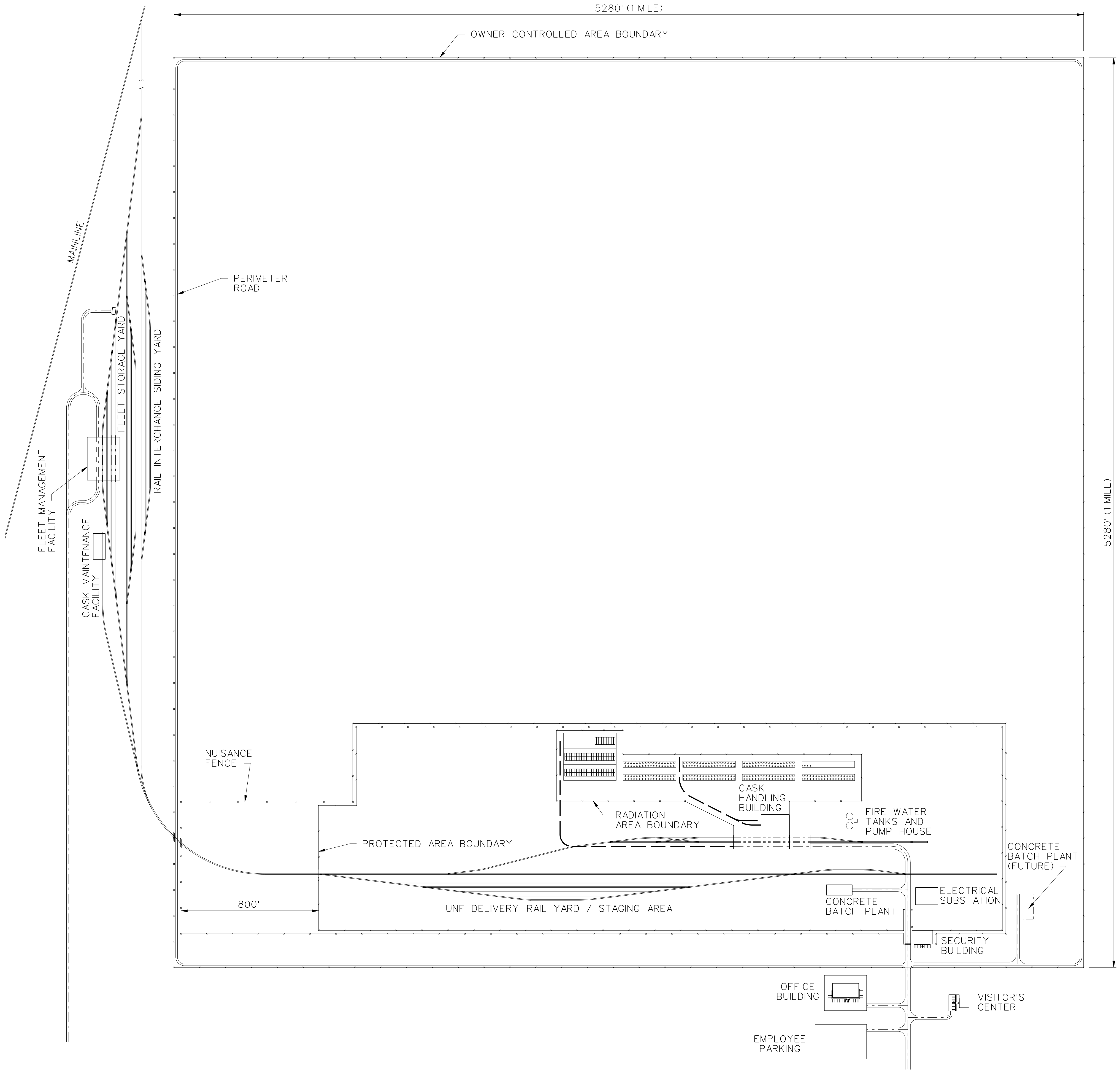

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CONSOLIDATED STORAGE FACILITY LAYOUT

FIGURE 7.2-1, STAGE 1 OVERALL CSF SITE LAYOUT

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CSF - Stage 1 Construction | Detail Bar Chart | 30-Jan-13 15:04

Activity Name	Start	Finish
CSF - Stage 1 Construction	01-Jan-13	31-Dec-20
Milestones	30-Jun-13	30-Dec-20
CD-0 Mission Approval	30-Jun-13*	
CD-1 Alternative Analysis Complete	30-Jun-14*	
CD-2 Baseline Approved	01-Jan-16*	
CD-3 Approval to Start Construction	30-Jun-17*	
CD-4 Start Operations- Receive UNF	30-Dec-20*	
Application Docketed	30-Sep-15*	
Issue NRC License Stage 1		30-Jun-18*
Begin Stranded UNF Shipments	30-Dec-20*	
Construction	01-Jan-13	31-Dec-20
DOE Bid and Award Design Contact	01-Jan-13	30-Jun-13
CSF Conceptual Design	01-Jul-13	30-Jun-14
Preliminary Design	01-Jul-14	01-Jan-16
Final Design & Construction Packages	02-Jan-16	30-Jun-17
Bid & Award Construction Contract	01-Jul-17	31-Dec-17
Hold for Licensing Completion	01-Jan-18	01-Jan-18
Early Site Preparation	01-Jul-18	31-Dec-18
CFS Stage 1 Construction	01-Jan-19	31-Dec-20
Site Selection	01-Jan-13	31-Dec-13
Geo-tech / ENV Investigations	01-Jan-14	30-Jun-14
ER/SAR Prep	01-Jul-14	30-Jun-15
License Application / NRC Initial Reviews	01-Jul-15	30-Sep-15
NRC Review & 3 Rounds RAI's	01-Oct-15	30-Jun-17
Public Hearings	01-Jul-17	01-Jan-18
NRC Complete ER Review and Draft EIS	01-Jul-17	01-Jan-18
EIS Public Review / Draft SER	02-Jan-18	31-Mar-18
FEIS / SER	01-Apr-18	30-Jun-18
Public Hearings / CSF License	01-Jul-18	31-Dec-18
Purchase PFS Rail Car Rights	01-Jan-13	30-Jun-13
Modify Industry Flat Car AAR-S-2043	01-Jan-13	30-Jun-13
Bid And Award Rail Rolling stock Contract	01-Jul-13	31-Dec-13
Fabrication Queue	01-Jan-14	31-Dec-14
Retooling for Fabrication	01-Jan-15	31-Dec-15
Buffer & Escort Prototype Car Tests	01-Jan-16	30-Dec-16
Fab and Eliver 5 Cask Cars	01-Jan-16	28-Dec-16
Consist Test (100,000 Mile)	31-Dec-16	28-Dec-17
AAR Review & Certify Rolling Stock	29-Dec-17	26-Jun-18
Transfer Cask & Equipment - Design Certify & Fabricate	01-Jan-15*	29-Jun-18

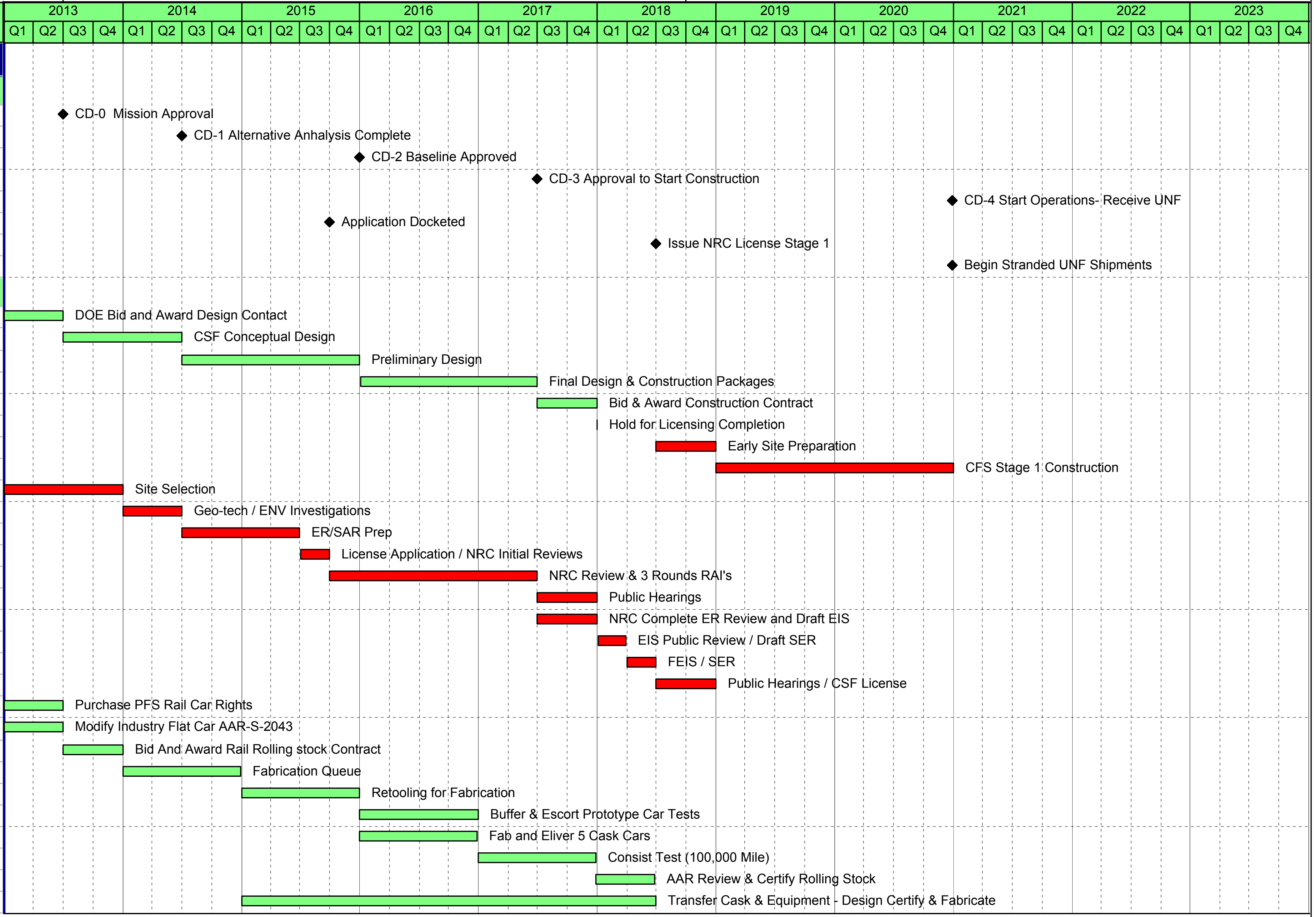

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Figure 7.2-2 CSF - Stage 1 Construction

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The schedule for the design, fabrication, and certification of the rolling stock assumes the procurement of the rail cask car rights owned by Private Fuel Storage. Based on the most optimistic scenario, if the rights are acquired by July 2013 and a fabrication award is made by December 2013, certified rail cask cars could be available by June 2018. This somewhat optimistic schedule includes 18 months of schedule slack, to resolve unforeseen problems.

The design, certification, and fabrication of the transportation casks, transfer casks, and handling equipment can be completed over a 3.5-year period. One and half years of schedule slack is also included in this schedule for unforeseen problems.

The capital costs associated with Construction Stage 1 of the CSF are shown in **Table 7.2-1**. These capital costs cover all the features shown in **Figure 7.2-1** and all schedule activities shown on **Figure 7.2-2**. The cost estimate assumes the storage pads and the Cask Handling Building (CHB) will be ITS structures, which will be designed and constructed in accordance with ASME NQA-1 requirements, applicable national standards, and state and local codes. All other structures are assumed to be not ITS and will be designed and constructed in accordance with applicable national standards and state and local codes.

Table 7.2-1
Design and Construction Costs, Stage 1 Development

Description	Stage 1 Costs
Land & Land Rights	$2,460,000
Permits & Licensing	$12,500,000
Research and Development	$40,000,000
Conceptual, Preliminary and Final Design	$78,800,000
Other Pre-construction Costs	$18,100,000
General Site Work	$17,836,378
Perimeter Fencing & Controls	$1,208,600
Site Lighting	$700,000
Site Utilities (on site, offsite, landscaping)	$6,140,250
Protected Area (PIDAS)	$13,440,000
On and off-site rail Development	$58,752,800
On and off-site Road Development	$18,212,737
Visitor Center	$627,200
Office/Administration Building	$2,749,435
Cask Handling Building	$27,742,732
Cask Maintenance Facility	$7,862,111
Fleet Maintenance Facility	$9,776,815

Description	Stage 1 Costs
Dry Storage Pads	$10,098,000
Control Room	$595,042
Security Building	$2,500,000
Electrical Substation	$14,850,000
Cask Transporters	$8,000,000
Other Site Equipment	$30,000,000
Rail Rolling Stock/Truck Equipment	$341,845,000
Transport Rail Casks and Truck Casks	$113,900,000
Hoisting Equipment	$10,000,000
Construction Indirect & CM costs	$71,370,000
Contractor Fees	$92,006,710
Total Stage 1 Development	$1,012,073,809

The Construction Stage 1 Cost Estimate also includes an allowance for the addition of canister instrumentation and monitoring as part of the Aging Management Program. Should this requirement become necessary, the implementation schedule and scope will be defined during the design and licensing process with support from the UNF R&D program.

Construction Stage 2 expands the number of horizontal and vertical storage to 92 pads and 162 pads, respectively. **Figure 7.2-3** shows the CSF after Construction Stage 2 is complete. The construction of the additional storage pads will take place outside of the Construction Stage 1 PA boundary. Upon construction completion of the storage pads, the PIDAS will be reconfigured to encompass the additional storage pads. This reconfiguration includes security cameras and expanded yard lighting. An additional concrete batch plant, located outside of the final CSF PA, will be installed to support Construction Stage 2 and Stage 3 activities. The concrete batch plant provided during Construction Stage 1 is located inside of the PA and will be primarily used to fabricate overpacks for the DFSSs after Construction Stage 1 is complete.

The Construction Stage 2 schedule is shown below in **Figure 7.2-4**. The design for the Construction Stage 2 expansion is included in the Construction Stage 1 design scope. A license amendment request for Construction Stage 2 and Phase 2 operations will be prepared by the design team as Construction Stage 1 is being completed. Since the scope of construction only involves the addition of storage pads already approved by the NRC for Construction Stage 1 and Phase 2 operations are essentially a continuation of handling and storing DPCs that were assessed in Phase 1, the approval of the CSF license amendment should be quickly completed by the NRC. The Final EIS issued during Construction Stage 1 covers all stages of CSF expansion.

Additional transportation casks will be fabricated and delivered during Construction Stage 2 to support the increase in UNF transport during Phase 2 operations.

Logistics planning, including storage site contracts, site planning, emergency planning, transportation contracts, transportation plans and permits, and intermodal transportation modifications, are considered to be transportation costs, even though these activities will occur during all three stages of construction and will continue throughout CSF operations.

The Construction Stage 2 Capital Cost Estimate is shown in **Table 7.2-2** below. The number of horizontal and vertical pads constructed during Construction Stage 2 could be easily adjusted based on Phase 1 operating experience and other factors that could influence the rate of CSF expansion. There are no significant technical or licensing challenges associated with adjusting the number of CSF storage pads.

Table 7.2-2
Design and Construction Costs, Stage 2 Development

Description	Stage 2 Costs
Permits and Licensing	$7,500,000
Other Pre-construction Costs	$3,620,000
Protected Area (PIDAS)	$16,128,000
Dry Storage Pads	$223,074,000
Transport Rail Casks and Truck Casks	$573,000,000
Construction Indirect & CM Costs	$42,822,000
Contractor Fees	$86,614,400.00
Total Stage 2 Construction	$952,758,400

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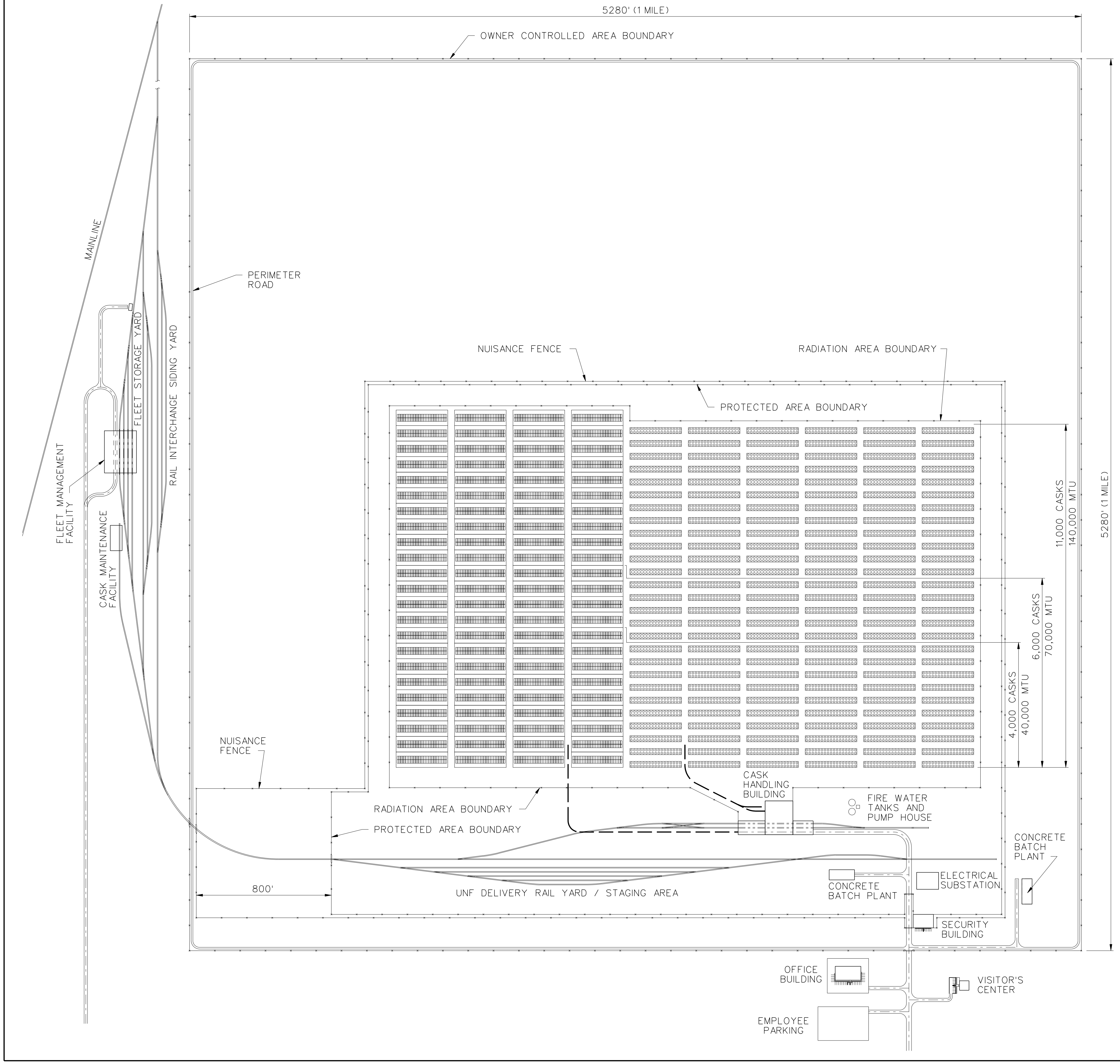

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FIGURE 7.2-3, STAGE 2 OVERALL CSF SITE LAYOUT

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CSF - Stage 2 Construction | Detail Bar Chart | 30-Jan-13 15:00

Activity Name	Start	Finish
CSF - Stage 2 Construction	30-Jun-20	30-Jun-26
Milestones	30-Jun-20	30-Jun-26
Critical Decision (CD) 2	30-Jun-20*	
Critical Decision (CD) 3	01-Apr-22*	
NRC License Amendment Request Submitted	01-Jan-21*	
License Amendment Issued (Stage 2)	31-Mar-22*	
Stage 2 Copnstruction Completed	30-Jun-26*	
Start Accepting UNF in Stage 2 Facilities	30-Jun-26*	
Construction	30-Jun-20	30-Jun-26
Prepare License and SAR Amendment	30-Jun-20	31-Dec-20
NRC Review	01-Jan-21	31-Mar-21
NRC Review / RAI's	01-Apr-21	31-Mar-22
Stage 2 Construction (Storage Pads and PIDAS Expansion)	01-Apr-22	30-Jun-26
Transportation Casks-Design & Certify	30-Jun-20	31-Dec-22
Transportation Casks - Fab & Deliver	01-Jan-23	31-Dec-24

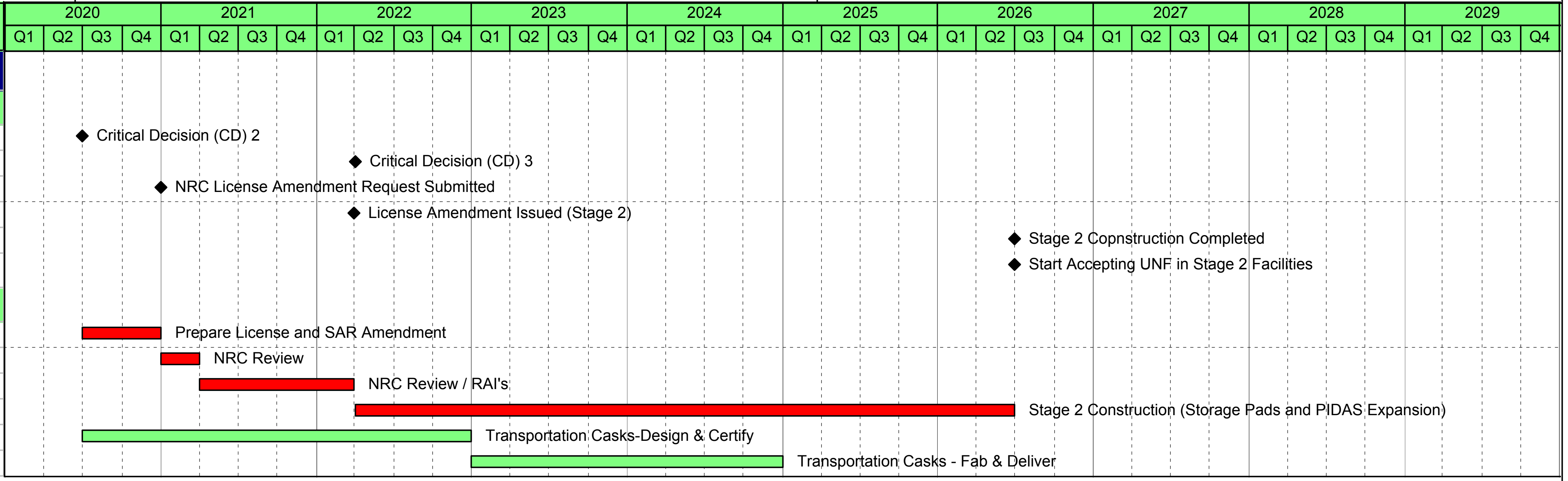

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Figure 7.2-4 CSF - Stage 2 Construction

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During Construction Stage 3, the remaining storage pads will be constructed, PWR and BWR pool storage will be added, and a Hot Cell Facility will be added to the CSF as shown in **Figure 7.2-5**. The design of the Construction Stage 1 CHB will include design features that permit the later construction of the PWR and BWR storage pools and associated structures and systems without impacting operations.

The on-site Hot Cell Facility will support the ongoing UNF R&D program. The Hot Cell Facility includes a large cask cell capable of receiving UNF canisters from CSF storage, opening welded or bolted canisters, and removing UNF assemblies or rods for testing. The Hot Cell Facility will be designed to repackage UNF assemblies or rods for off-site testing. The Hot Cell Facility will be also designed for the dry transfer all UNF from an old canister to a new canister. The Hot Cell Facility will include four smaller laboratory hot cells for on-site testing of UNF in support of the Aging Management Program.

The schedule for Construction Stage 3 is shown in **Figure 7.2-6**. During Construction Stage 1, the conceptual design and some preliminary design of PWR and BWR storage pools and associated cooling, purification, and handling systems will be performed. This delay in completing the final design until just prior to construction will help avoid obsolescence. Similarly, the large UNF cask hot cell and the four laboratory hot cells located in the Hot Cell Facility will also have their preliminary and final design completed during Construction Stage 3.

The design team will prepare a license amendment request for Construction Stage 3 and Phase 3 operations. An estimated 2.5 years have been allowed for the licensing process after submittal of the license amendment request. This will support a construction start date of June 2029. The Hot Cell Facility, UNF pools, and the additional storage pads are considered ITS and will be designed and constructed in accordance ASME NQA-1 requirements, applicable national standards, and state and local codes. A 3.5-year construction schedule is projected.

Additional transportation casks will be required to support the transport of DPCs, non-DPCs, and bare UNF during Phase 3 and Phase 4 operations. A 3.5-year activity to deliver approximately 100 certified transportation casks is included during Construction Stage 3. The wet to wet transfer of UNF during phase 3 operations provides buffer storage of UNF prior to transfer to disposal canister (open system solution) or downstream reprocessing (closed system solution).

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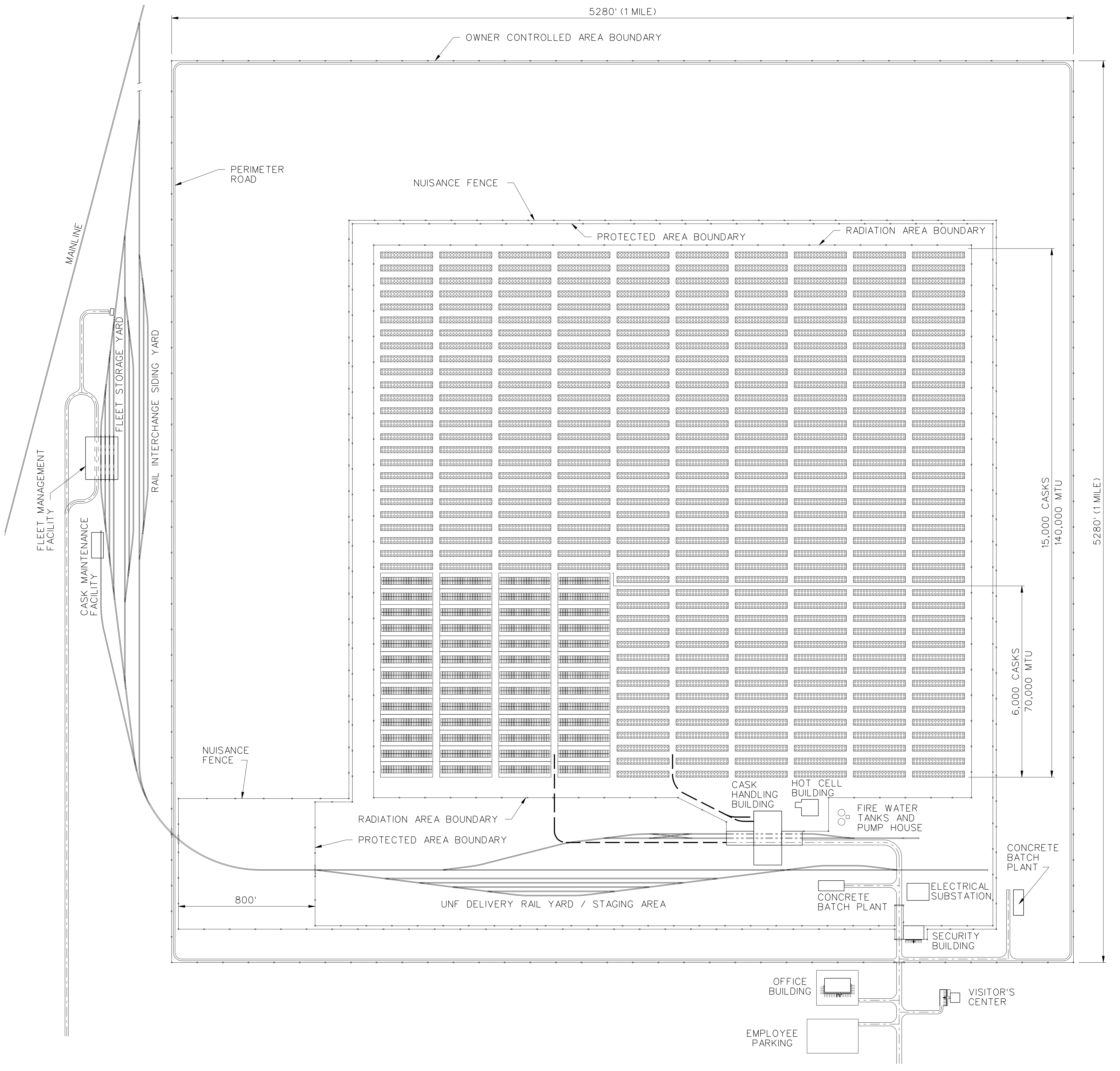

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FIGURE 7.2-5, STAGE 3 OVERALL CSF SITE LAYOUT

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CSF - Stage 3 Construction | Detail Bar Chart | 30-Jan-13 15:01

Activity Name	Start	Finish
CSF - Stage 3 Construction	01-Jan-26	01-Jan-33
Milestones	01-Jan-26	01-Jan-33
Start Stage 3 Design	01-Jan-26*	
Critical Decision (CD) 2	01-Jan-27*	
NRC License Amendment for Stage 3 Issued		30-Jun-29*
Complete Stage 3 Design	01-Jan-29	
Critical Decision (CD) 3		30-Jun-29
Start Stage 3 Construction	01-Jul-29	
Critical Decision (CD) 4 - Start Operations	01-Jan-33*	
Construction	01-Jan-26	31-Dec-32
Stage 3 Preliminary Design	01-Jan-26*	31-Dec-26
Stage 3 Complete Detailed Design & Construction Package	01-Jan-27	31-Dec-28
Bid and Award Stage 3 Construction	01-Jan-29	30-Jun-29
Construct UNF Pools, Hot cells, Hot labs, DFSS Pads	01-Jul-29	31-Dec-32
Prepare License Amendment Application	01-Jan-26*	31-Dec-26
NRC Initial Review	01-Jan-27	31-Mar-27
NRC Review and Requests for Additional Information	01-Apr-27	30-Sep-28
Post Notice of Hearings	17-Sep-28	01-Oct-28
Public Hearings	01-Oct-28	30-Jun-29
Design / Certify / Fab Transportation Casks	01-Jan-27	31-Dec-31

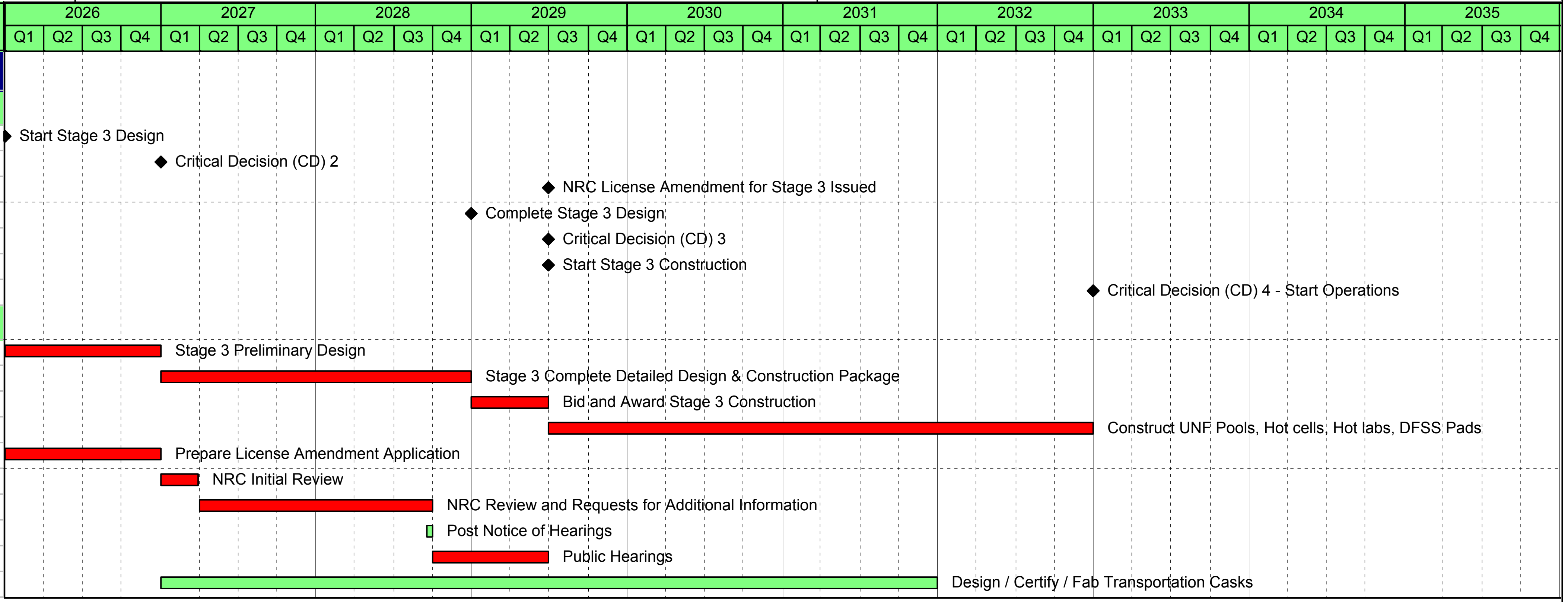

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Figure 7.2-6 CSF - Stage 3 Construction

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Table 7.2-3 provides a breakdown of the capital costs for Construction Stage 3. Logistics planning and coordination costs are considered transportation costs and are not included in the capital cost estimate for the CSF.

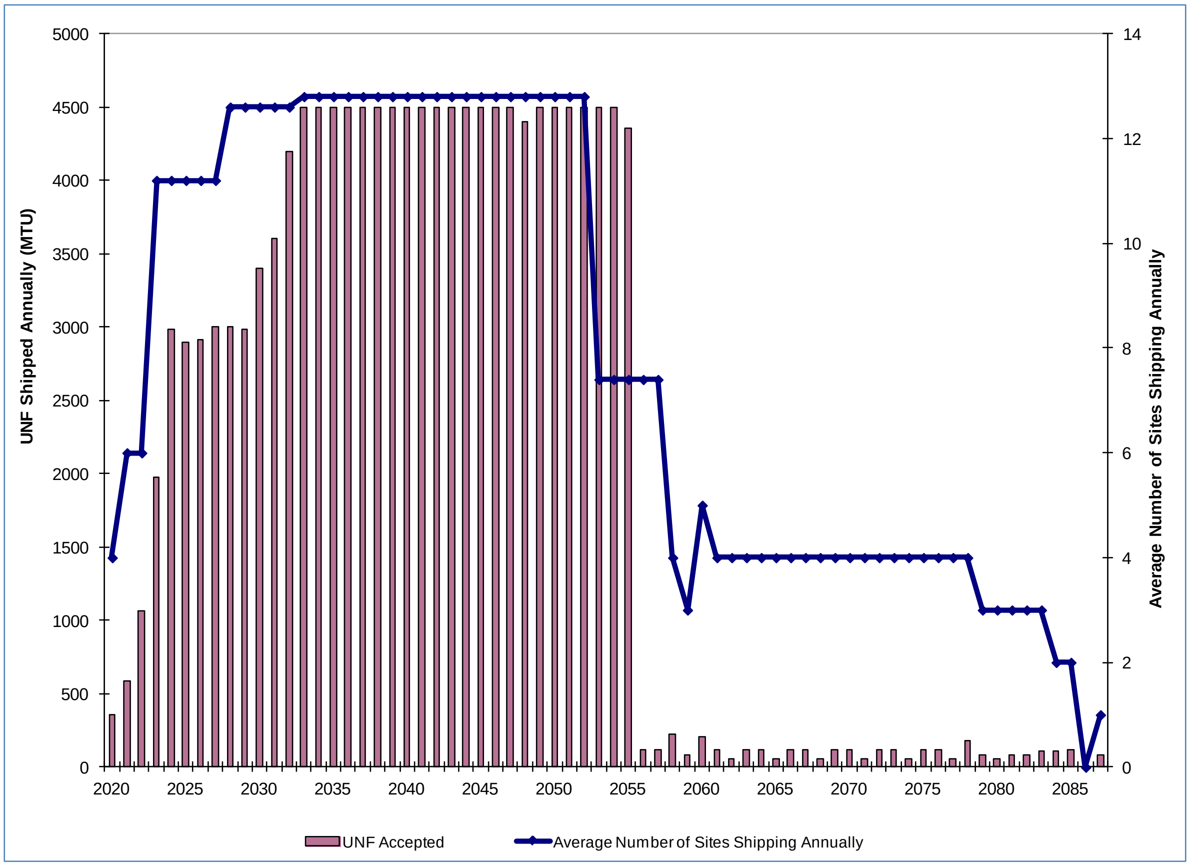
Table 7.2-3
Design and Construction Costs, Stage 3 Development

Description	Stage 3 Costs
Permits & Licensing	$30,000,000
Conceptual, Preliminary, and Final Design	$78,800,000
Other Pre-construction Costs	$14,480,000
Protected Area (PIDAS)	$24,192,000
Dry Storage Pads	$132,393,000
Pool Storage at Cask Handling Building	$88,715,913
Hot Cell	$402,735,063
Pool Storage Equipment	$148,000,000
Heat Rejection Equipment	$39,500,000
Hot Cell Equipment	$50,000,000
Laboratory Equipment	$40,000,000
Cask Transporters	$4,000,000
Transport Rail Casks and Truck Casks	$140,600,000
Construction Indirect & CM costs	$171,288,000
Contractor Fees	$130,530,398
Total Stage 3 Development	$1,495,234,374

7.3 Projected Annual Acceptance Rates

As described in Section 5.0, the recommended transportation plan is the 4,500-MTU maximum annual acceptance rate assuming an “OFF-Plus” acceptance priority. The projected acceptance rates are shown in **Figure 7.3-1**.

Figure 7.3-1
Projected CSF Acceptance Rates



7.4 Projected Transportation Fleet Needs

The transportation fleet required to support the 4,500-MTU maximum annual acceptance rate at the CSF is described in Section 5.0. The rolling stock required for this acceptance rate is as follows:

- 145 cask cars
- 58 buffer cars
- 29 locomotives (leased)
- 29 escort cars
- 18 trucks
- 18 trailers
- 6 equipment trucks
- 18 escort vehicles

- 18 truck casks and transport skids

7.5 New or Additional Equipment to Support Out-Year Campaigns

The intent of this plan is to procure essentially all rolling stock during Construction Stage 1 of the project. This procurement of all rolling stock in one order is recommended due to the relatively small size of the order. During Construction Stages 2 and 3 (out-year campaigns), additional transport casks and handling equipment for DFSSs will be acquired. The following is an estimate of the additional equipment to support these later stages:

- Transport Casks—145 rail casks, 18 truck casks
- Handling Equipment—None
- DFSSs—9,000 (TAD systems)

Spare parts for transportation equipment will be required throughout the operating life of the facility to support a continuous on-site maintenance program. With regular maintenance, the transportation fleet procured during Construction Stage 1 will support the 100-year life of the CSF. The estimated transport cask requirement assumes that there will not be significant changes to the IAEA/NRC transport safety regulations. If there are regulatory changes, it is possible that the cask fleet will have to be replaced after 40–50 years of use. CSF transportation spare parts requirements are described in Section 5.3.

Handling equipment purchased during Stage 1 should be sufficient to support out-year campaigns. Any replacement equipment required after 50 years of operation is not expected to be significant and could be leased, if required.

The staged construction of the CSF, including the flexibility to expand wet and dry storage systems and a hot cell and laboratory facility, will be required to support out-year campaigns. The base case for CSF construction during out-years assumes the following:

- 1 PWR fuel pool (1,750 assemblies)
- 1 BWR fuel pool (2,025 assemblies)
- 110 concrete storage pads (horizontal DFSS)
- 256 concrete storage pads (vertical DFSS)
- 1 hot cell and laboratory facility

7.6 Resource Needs

The breakdown of operating staff and transportation staff required from 2021 through 2055 is as follows:

Operating Staff

Category	FTE
O&M	20
Management	10
Fuel Shipment/Handling	60
Engineering	5
Licensing	3
Research	3
Monitoring and Analysis	2
Security	126

Transportation Staff

Category	FTE
Transportation Security	50
Logistics Coordination	5
Transportation Planning	23
Transportation Management	28
Notifications and Communications	8
Security Planning & Management	8

8.0 COSTS

The cost estimate for the CSF design concept study followed the guidelines from DOE O413.3B, DOE Guide 413.3-21, and AACE International guidelines for a Class 4 Estimate. This Class 4 Estimate, as defined by AACE, is based on a maximum CSF receipt rate of 4,500 MTU per year with an estimated accuracy of -30 percent to +50 percent. Level 2 and Level 3 Work Breakdown Cost Estimates covering the capital cost are show in Appendices E and F. The operational cost, transportation cost, life cycle cost, and decontamination and decommissioning costs are provided in **Appendix A** to this report. Basis of Estimates down to WBS Level 2 and 3 are provided in **Appendix G** to this report.

8.1 Capital Costs

The capital cost cash flow covering all three construction stages is provided in **Appendix A**. The cost elements associated with each construction stage are listed in Section 7.2.

The capital cost for Construction Stage 1 to support the receipt of stranded fuel is approximately $1,012M (2012 Dollars). This capital cost includes the procurement and fabrication of 21 transportation casks to support the delivery of UNF from stranded sites (Phase 1 operations). These rail transportation casks are estimated to cost $4.9M each. In addition, 11 sets of transportation equipment (impact limiters, rail skids, etc) at a cost of $1M each, will be procured for the existing transportation casks that will be acquired during Construction Stage 1 to support Phase 1 operations (six HI-STAR HB casks from Humboldt Bay, 1 MP-187 cask for Rancho Seco, and 7 HI-STAR 100 casks from Dresden 1 and Hatch). The Construction Stage 1 estimate also includes the total cost of all rolling stock required to transport UNF to the CSF for all operational phases. The Construction Stage 1capital cost estimate covers site acquisition, permits, Conceptual, Preliminary and Final Design, NRC licensing, CSF construction, and equipment procurement.

The capital cost estimate for the Construction Stage 1 includes approximately $342M for the acquisition of the rolling stock for all operational phases because this method results in the lowest per unit cost vs. multiple smaller purchases over time. The cost of acquiring just the minimum rolling stock fleet to support rolling stock certification and stranded fuel shipments (Phase 1 operations) is estimated to be $61M. This estimate does not include an additional premium that would likely be applied due to the very small fabrication order. The minimum rolling stock order to support rolling stock certification and delivery of all stranded fuel to the CSF over a 6-year period is as follows:

- 32 Cask Cars
- 18 Buffer Cars

- 9 Escort Cars

An allowance for R&D, up to the commencement of Phase 1 operations, shipment of stranded fuel, is also included in the Construction Stage 1 Capital Cost estimate. The Construction Stage 1 R&D estimate of $40M assumes rods are extracted from assemblies in the utility SFPs and shipped to laboratories for testing as described in Section 6.0 of this report. The R&D program is integral to the Aging Management Program and is expected to support the development of monitoring and surveillance features into the design of the facility to maintain long-term safe storage. After commencement of Phase 1 operations, the ongoing R&D program is included as an operating expense. The R&D program will continue throughout the life of the facility.

During Construction Stage 2, 243 additional storage pads will be constructed to support the receipt of canisters from dry storage at plant sites. The construction of these additional pads is estimated to cost $223M. The acquisition of additional transportation casks to support this second operational phase is estimated to cost $573M. The design and licensing costs for Construction Stage 2 are projected to be minimal and are captured in the Permit and Licensing estimate. The Environmental Report, prepared during Construction Stage 1 covers all three construction stages. The Construction Stage 2 estimate for storage pads includes an allowance of about $43M for the potential addition of DFSS monitoring instrumentation at the CSF. The total capital cost for Construction Stage 2 is estimated at $953M.

During Construction Stage 3, the PWR and BWR UNF pools and a hot cell facility will be constructed. In addition, 144 concrete pads for horizontal and vertical DFSSs will be constructed outside of the PIDAS. Upon completion of these Construction Stage 3 storage pads and facilities, the PIDAS will be reconfigured to encompass the expanded operating area. This study includes a hot cell facility capable of supporting the on-site testing and evaluation of UNF at the CSF. The hot cell facility includes one large bay designed to receive casks and canisters and to open and retrieve UNF. The large hot cell will permit the testing and evaluation of UNF as well as dry remediation of storage confinement systems. Four smaller hot cell laboratories are also included in the hot cell facility to support UNF R&D at the CSF. The hot cell facility and associated equipment is estimated at $493M.

The PWR and BWR UNF pools include cask areas that will be serviced by the same cask handling crane used to off-load the cask transportation cars. Separate fuel handling cranes are provided over the storage areas of each pool. The design of the important to safety CHB, constructed during Construction Stage 1, will include design features that will permit the addition of the important to safety wet storage facility during Construction Stage 3 without impacting CHB operations. The wet storage facility and associated equipment is estimated at $276M.

8.2 Operations Costs

Appendix B provides a breakdown of the estimated operating costs for the CSF for the 100-year operating life of the facility. During the first years of operation, UNF from shutdown plant sites will be transported to the CSF. The estimated operating cost during this 6-year phase is $282M. The operating costs during Phase 3 Operations (wet to wet transfer) include the procurement of 9,000 disposable canisters with overpacks, based on the Yucca Mountain Project Transportation, Aging and Disposal (TAD) canister. The estimated cost of 9,000 TADs is $11.5B (2012 Dollars). The total 100-year operating estimate in 2012 Dollars is approximately $19B. D&D costs are estimated separately at $3.75B.

Operational costs commence after Construction Stage 1 and continue through the 100-year operating life of the CSF. In addition to the estimate for CSF staff, the procurement of 9,000 TADs is included in the operations estimate. NRC licensing fees, spare parts and R&D is also included in the operations estimate. Transportation-related costs have been estimated separately.

8.3 Transportation Costs

Transportation costs assume that the UNF owner is responsible for all costs associated with loading canisters into the transportation cask and loading the transportation cask onto intermodal transportation. After the transportation cask leaves the plant site boundary, DOE will assume responsibility for the remaining logistics costs to deliver the transportation cask to the CSF. The unloading of cask rail cars and truck trailers at the CSF is an operational cost and is included in the operations estimate. Procurement of the complete suite of rolling stock is included in the Construction Stage 1 capital cost estimate for the CSF. If a minimum procurement of rolling stock is elected for Construction Stage 1, an approximate $250M reduction in Construction Stage 1 capital costs is possible. As shown in **Appendix C**, the transportation cost includes an allowance for infrastructure construction associated with the intermodal transportation of casks outside of the plant site boundary.

All logistics planning, coordination, contracts, and permits necessary to facilitate transportation of the UNF to the CSF is included in the transportation estimate. The annual resources have been estimated based on the quantity of UNF projected for the 4,500MTU per year (OFF-plus) scenario. Maintenance of the transportation fleet, including on-site transportation equipment, is captured in the transportation estimate. The total transportation estimate is $2.2B (2012 Dollars).

8.4 Life Cycle Costs

The life cycle costs for the facility include assumes a 100-year operating life for the CSF and an average forward inflation rate of 2 percent. The WBS and the associated cost estimates are provided in **Appendix A**. The life cycle cost is as follows:

- Total Capital Cost—$3.4 B
- Operation Cost—$19.0B
- Transportation—$2.2B
- Decontamination and Decommissioning Cost—$3.8B
- Life Cycle Cost—$28.4B (2012 Dollars)

Applying an annual 2 percent forward escalation rate over the 100-year operating life of the plant, the total project cost is $52.5B.

8.5 Decontamination and Decommissioning

The cost of decontamination and decommissioning (D&D) of the CSF has been broken down into the following four categories:

1. DFSSs including storage pads
2. On-site hot cell—$34M (May 2007 cost)
3. CHB and UNF pools
4. Other on-site utilities and facilities

Dry Cask Storage Systems Including Storage Pads

Based on a study performed by Shaw in 2009 for a utility customer, in 2009, the average D&D cost per UNF assembly was $13,628. **Table 8.4-1** provides a summary of the D&D costs for the DFSSs, including storage pads.

Table 8.5-1
Dry Cask Storage System Decommissioning Summary

Description	Total Estimated Decommissioning Cost (2009 Dollars)	Total Decommissioning Cost per UNF Assembly (2009 Dollars)
Arrangement 1—65 Storage Units (65 TN-40 and/or TN-40HT Casks)	$32,562,100	$12,524
Arrangement 2—74 Storage Units (29 TN-40 Casks/45 NUHOMS 32PTH Modules)	$36,677,900	$14,107
Arrangement 3—89 Storage Units (29 TN-	$40,312,400	$15,505

Description	Total Estimated Decommissioning Cost (2009 Dollars)	Total Decommissioning Cost per UNF Assembly (2009 Dollars)
40 Casks/60 NUHOMS 24PTH Modules)		
Arrangement 4—69 Storage Units (48 TN-40 Casks/21 NUHOMS 32PTH Modules)	$34,595,900	$13,347
Arrangement 5—99 Storage Units (65 TN-40 and/or TN-40HT Casks)	$49,510,800	$12,503

This estimate includes credit for metal redemption and includes the costs associated with loading a TAD canister. The cost of the TAD canister is not included. Assuming all 500,000 UNF assemblies (the estimated total number of assemblies that comprise the 140,000 MTU of UNF stored at the CSF) are ultimately placed in a DFSS and are either repackaged in a disposable canister (open cycle solution) or transferred to a fuel processing facility (closed cycle solution), approximately $6.8B (2009 Dollars) will be required for D&D of the DFSSs and associated storage pads. Assuming that the final disposition of the UNF is determined within the next 20 years, about 50 percent of the UNF will be stored in DFSSs that require D&D. This assumption results in an estimated cost of $3.4B (2009 Dollars) to D&D the DFSSs and associated storage pads.

The D&D estimate for the hot cell facility, CHB (including the UNF pools and other on-site systems and structures) is estimated at $200–$270M based on D&D estimates from other nuclear facilities. Since the decontamination for this facility is estimated to be less significant than most nuclear facilities, a $200M estimate (2012 Dollars) is assumed. The total D&D estimate is $3.75B.

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9.0 WASTE

The CSF is expected to generate very small volumes of LLRW in the early years of operation during Phases 1 and 2. During these phases, the UNF and GTCC waste will be received in welded DPCs, which will not need to be opened in order to store the waste on the storage pads. The DPCs will be transferred from the transport casks to the storage overpacks or modules without having to inspect or handle the individual UNF assemblies or GTCC waste.

In Phases 3 and 4, some of the UNF will arrive in bare fuel transport casks, requiring UNF pools to repackage the UNF into canisters for interim storage at the CSF. This will permit the empty bare fuel transport casks to be shipped back to the plant sites for reuse. Operation of the UNF pools at the CSF will result in the generation of additional LLRW types and volume. Later in the life of the facility, a hot cell may be used to perform R&D activities, potentially creating additional types of LLRW and GTCC waste.

9.1 Contaminated Waste Generated

9.1.1 Phase 1 and Phase 2

During operational Phases 1 and 2, the waste received at the CSF will arrive in DPCs inside transport casks. Except for the Humboldt Bay casks, the DPCs destined for storage in the vertical orientation will be transferred directly into storage overpacks in the CHB and the loaded overpacks moved to the storage pad using a vertical cask transporter. The Humboldt Bay dual purpose overpacks are uniquely designed for storage and transportation of the short Humboldt Bay UNF and cannot be reused with other DPCs. Thus, the loaded HI-STAR HB casks with the DPCs inside will be moved directly to the storage pad from the railcar using a vertical cask transporter. The DPCs destined for storage in horizontal modules will remain inside their transport casks and moved to the storage pads on a transfer trailer. These DPCs will be inserted directly into the HSMs from the transport casks using a hydraulic ram system.

The DPCs are submerged in the SFPs at the plant sites to permit loading the UNF assemblies. Depending on the DPC design, some of the DPC lids will have been directly exposed to contaminated plant SFP water. In all cases, the potential exists for the external canister wall to be exposed to some contaminated SFP water, despite design features (i.e., annulus seals) intended to prevent SFP water from reaching the annulus between the DPC and the transfer cask during UNF loading operations. Accessible portions of the DPCs (i.e., the top lid and the top portion of the shell) will be decontaminated as part of loading operations.

The accessible portions of the DPC will be swiped for contamination at the CSF before being placed into storage. Likewise, the empty transport casks will be swiped for contamination before being shipped back to the plants for reuse. The DPCs and transport casks may require additional decontamination at the CSF site based on the results of the swipes. These swiping and decontamination activities will be performed by personnel dressed in anticontamination clothing. The swipes, personnel clothing, rags, and resins used to process waste water used for decontamination may all become LLRW requiring disposal during Phases 1 and 2.

It is also possible that any filters in the HVAC system serving the CSF radiation area could become slightly contaminated over time. These filters would also become LLRW requiring disposal.

It is expected that the waste streams during Phases 1 and 2 will be of low volume and low activity because the activities generating the waste do not involve handling of individual fuel assemblies. This avoids the potential for fuel activation products on the outside of the fuel cladding (i.e., “crud”) to make their way into the waste stream.

9.1.2 Phase 3 and Phase 4

The CSF will include UNF pools and, eventually, potentially a hot cell. The UNF pools will be used to unload bare fuel transport casks of their individual UNF assemblies and place them into storage racks to await repackaging for further disposition. The UNF assemblies will release crud into the UNF pool water, making it a source of contamination. The bare fuel transport casks will require decontamination prior to being shipped back to the power plants, which creates a liquid waste stream that will be processed by a resin-based LLRW processing system.

The UNF pools will require cooling systems that include piping, pumps, heat exchangers, valves, instrumentation, filters, and demineralizers. This equipment will become contaminated by coming into contact with the UNF pool water. The filters and the resins in the demineralizers will require periodic replacement, creating a waste stream to be managed during these phases of CSF operation. The metal components will become LLRW when they are replaced via maintenance or at the end of facility life if they cannot be sufficiently decontaminated to a level below concern.

The operation of UNF pool cooling systems will also require periodic maintenance of the systems, which will generate radwaste in the form of consumables, such as pump seals, valve packing, flange gaskets, and rags, as well as contaminated personnel clothing and protective breathing equipment. Having UNF pools also means that the contaminated HVAC filters serving the area could require more frequent replacement. The amount of waste would depend on the number of UNF pools and the number of UNF assemblies stored in the UNF pools. The spent fuel racks would eventually become waste that would require decontamination and processing, usually involving cutting the racks into small pieces.

A hot cell creates the possibility for crud on the UNF assembly cladding to become airborne when the assemblies are lifted and moved around. In addition, the UNF assemblies will likely be disassembled and the fuel cladding cut open in the hot cell for research purposes. This would create GTCC waste in the form of empty fuel assembly cladding and structural components, such as grid straps, inserts, control rods, top and bottom nozzles, and spacer plates. It would also expose the fuel pellets and likely add microscopic pieces of fuel to the liquid and airborne waste streams serving the hot cell. Dedicated waste processing equipment would be required to manage this potentially high-activity waste stream. The amount of waste would depend on the capacity of the hot cell and the frequency of use.

All of these Phase 3 and 4 wastes would be in addition to the wastes described for Phases 1 and 2.

9.2 Disposition Pathways

The DOE, as the CSF licensee, would be responsible for storing and ultimately arranging for the disposal of the LLRW created by facility operation. Most of the LLRW generated by the CSF will be in the form of used clothing, rags, HVAC filters, resins, UNF Pool Cooling System filters, and small consumables. Except for the resins and the UNF Pool Cooling System filters, and possibly the HVAC filters, this type of waste would be compacted and placed in barrels for eventual transport to a licensed LLRW facility in a large-volume NRC-certified transportation package, such as a C-VAN. The resins used to process UNF pool water and water used for decontamination activities would be de-watered, the UNF Pool Cooling System filters appropriately treated, and both transferred to a high-integrity container (HIC) for shipment to a LLRW site inside an NRC-certified transportation package. HVAC filters may also be of high enough activity to require transportation to the disposal facility in a HIC.

After processing via resins, the water used for decontamination would eventually be of such low activity level that it could be discharged as normal waste water either with or without dilution, depending on the actual activity level.

At the end of facility life, the contaminated metal components may be able to be decontaminated to a level permitting disposal as nonradioactive waste. Otherwise, it could be processed into as small a volume as possible via cutting and disposed of at a licensed LLRW facility.

9.3 Estimated LLRW Volume

The annual dry LLRW volumes estimated for the CSF are shown in **Table 9.3-1**. The basis for these values is Table 1.4.5-1 of the Yucca Mountain (YM) Repository SAR. Estimated LLRW volumes from the YM Repository SAR have been appropriately adjusted for the differences in waste types and the higher UNF receipt rate at the CSF compared to the YM Repository. Specifically, the YM Repository was designed to receive and dispose of commercial UNF and high-level waste at a rate of 3,000 MTU per year. The midrange of the CSF UNF receipt rate evaluated in this report, 4,500 MTU, is used for estimating the LLRW generated annually by CSF operations. The waste volumes shown in **Table 9.3-1** are higher than the YM values in proportion to these relative MTU receipt values.

Liquid waste is not included for the CSF because any liquid waste is assumed to be able to be filtered to very low concentrations and released from the facility or reused. The facility names below have been modified to match the terminology used in this report for the CSF. Filter wastes from the CSF UNF pools will not occur until Phase 3 and later. Hot cell low-level wastes will not occur until Phase 3. Fuel-assembly-related waste from the hot cell is not included because it is anticipated that this type of waste will be stored on site throughout CSF operation.

Table 9.3-1
Annual Estimated CSF LLRW

Facility	Dry Activated Waste (ft^3)	Resin (ft^3)	Pool Filters (ft^3)	Prefilters and HEPA Filters (ft^3)
CHB Cask Receipt and Handling Area[1]	1,950	NA	NA	2,400
CHB Canister Transfer Area	3,900	300[3]	NA	10,500
Cask Storage Facility	390[2]	NA	NA	NA
Liquid Waste Processing Facility	920	300[3]	2,600[3]	540
Phase 1 and 2 Totals	7,160	600	0	13,440
UNF Pools	9,100	300	2,600	1,000
Phase 3 Totals	16,260	900	2,600	14,440
Hot Cell	1,300[4]	300[3]	NA	3,500[4]
Phase 4 and Later Totals	17,560	1,200	2,600	17,940

[1] *Value for YM receipt facility multiplied by 4,500/3,000.*

[2] *Value from YM aging facility multiplied by 4,500/3,000.*

[3] *Assumes liquids from decontamination activities and liquid waste processing facility are processed using resin-based cleanup systems, similar to spent fuel pools.*

[4] *Values taken from a single YM Canister Receipt and Closure Facility.*

Appendix A
100-Year Cash Flow and Escalation

100-Year Cash Flow and Escalation

		1	2	3	4	5	6	7	8
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
		2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Escalation Rate: 2.00%	**Total**	**Start Design**					**Start Ph1 Const**		**Start Ops**
Design Costs/ Precon Costs	**286,260,000**	50,000,000	40,000,000	40,000,000	40,000,000	26,700,000	10,000,000	10,000,000	10,000,000
Capital Costs (Const & Rolling Stock)	**3,143,206,583**				150,000,000	216,784,105	250,000,000	300,000,000	300,000,000
Transportation Costs & Equipment	**2,191,106,273**								
Operations Costs & Equipment	**18,999,454,664**								
Decommissioning Costs	**3,750,000,000**								
Total Unescalated Cost	**28,370,027,520**								
Total Project Costs - 2012 Dollars		50,000,000	40,000,000	40,000,000	190,000,000	243,484,105	260,000,000	310,000,000	310,000,000
Escalation Factor		1,000,000	1,600,000	2,400,000	15,200,000	24,348,411	31,200,000	43,400,000	49,600,000
Escalated Annual Cost		51,000,000	41,600,000	42,400,000	205,200,000	267,832,516	291,200,000	353,400,000	359,600,000

Total Design and R&D Costs:	**Capital Costs:**
286,260,000	$3,429,466,583
Total Construction Costs:	
3,143,206,583	
Total Transportation Costs-100 Years:	
2,191,106,273	
Total Operational Costs-100 Years:	
18,999,454,664	
Total Decommissioning Costs:	
3,750,000,000	
Total Escalation Costs-108 Years:	
24,121,000,390	
Total Project Costs-108 Years:	
52,491,027,910	
Cost/Metric Ton-140,000/MT:	
$374,935.91	

100-Year Cash Flow and Escalation

	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
	Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Escalation Rate: 2.00%		**Start PH2 Const**								**Start PH3 Const**
Design Costs/ Precon Costs	6,310,882	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Capital Costs (Const & Rolling Stock)	50,000,000	50,000,000	150,000,000	250,000,000	300,000,000	300,000,000	100,000,000	70,000,000	20,000,000	200,000,000
Transportation Costs & Equipment	18,572,593	23,956,790	29,340,988	34,725,185	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383
Operations Costs & Equipment	36,461,728	43,594,430	46,662,688	49,730,945	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203
Decommissioning Costs										
Total Unescalated Cost										
Total Project Costs - 2012 Dollars	111,345,202	122,551,220	231,003,675	339,456,130	397,908,585	397,908,585	197,908,585	167,908,585	117,908,585	297,908,585
Escalation Factor	20,042,136	24,510,244	50,820,809	81,469,471	103,456,232	111,414,404	59,372,576	53,730,747	40,088,919	107,247,091
Escalated Annual Cost	131,387,338	147,061,464	281,824,484	420,925,601	501,364,817	509,322,989	257,281,161	221,639,332	157,997,504	405,155,676

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	19	20	21	22	23	24	25	26	27	28	29	30
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Escalation Rate: 2.00%												
Design Costs/ Precon Costs	5,000,000	3,249,118										
Capital Costs (Const & Rolling Stock)	300,000,000	136,422,478										
Transportation Costs & Equipment	40,109,383	40,109,383	40,109,383	40,109,383	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975
Operations Costs & Equipment	52,799,203	52,799,203	685,299,203	685,299,203	694,503,975	694,503,975	694,503,975	694,503,975	691,771,575	691,771,575	691,771,575	691,771,575
Decommissioning Costs												
Total Unescalated Cost												
Total Project Costs - 2012 Dollars	397,908,585	232,580,181	725,408,585	725,408,585	750,765,950	750,765,950	750,765,950	750,765,950	748,033,550	748,033,550	748,033,550	748,033,550
Escalation Factor	151,205,262	93,032,072	304,671,606	319,179,777	345,352,337	360,367,656	375,382,975	390,398,294	403,938,117	418,898,788	433,859,459	448,820,130
Escalated Annual Cost	549,113,847	325,612,253	1,030,080,191	1,044,588,362	1,096,118,287	1,111,133,606	1,126,148,925	1,141,164,244	1,151,971,667	1,166,932,338	1,181,893,009	1,196,853,680

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	31	32	33	34	35	36	37	38	39	40	41	42
	Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	2043	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**
Escalation Rate: 2.00%												
Design Costs/ Precon Costs												
Capital Costs (Const & Rolling Stock)												
Transportation Costs & Equipment	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	53,841,975	53,841,975
Operations Costs & Equipment	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575
Decommissioning Costs												
Total Unescalated Cost												
Total Project Costs - 2012 Dollars	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	748,033,550	745,613,550	745,613,550
Escalation Factor	463,780,801	478,741,472	493,702,143	508,662,814	523,623,485	538,584,156	553,544,827	568,505,498	583,466,169	598,426,840	611,403,111	626,315,382
Escalated Annual Cost	1,211,814,351	1,226,775,022	1,241,735,693	1,256,696,364	1,271,657,035	1,286,617,706	1,301,578,377	1,316,539,048	1,331,499,719	1,346,460,390	1,357,016,661	1,371,928,932

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	43	44	45	46	47	48	49	50	51	52	53	54	55
	Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	2055	**2056**	**2057**	**2058**	**2059**	**2060**	**2061**	**2062**	**2063**	**2064**	**2065**	**2066**	**2067**
Escalation Rate: 2.00%													
Design Costs/ Precon Costs													
Capital Costs (Const & Rolling Stock)													
Transportation Costs & Equipment	53,841,975	48,457,778	36,857,411	32,250,235	27,643,058	23,035,882	18,428,706	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117
Operations Costs & Equipment	691,771,575	56,203,318	53,135,060	50,066,803	46,998,545	43,930,288	40,862,030	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901
Decommissioning Costs													
Total Unescalated Cost													
Total Project Costs - 2012 Dollars	745,613,550	104,661,095	89,992,471	82,317,037	74,641,603	66,966,170	59,290,736	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019
Escalation Factor	641,227,653	92,101,764	80,993,224	75,731,674	70,163,107	64,287,523	58,104,921	55,453,019	56,562,079	57,671,139	58,780,200	59,889,260	60,998,321
Escalated Annual Cost	1,386,841,203	196,762,859	170,985,695	158,048,712	144,804,711	131,253,692	117,395,657	110,906,037	112,015,098	113,124,158	114,233,218	115,342,279	116,451,339

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	56	57	58	59	60	61	62	63	64	65	66	67	68
	Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	2068	**2069**	**2070**	**2071**	**2072**	**2073**	**2074**	**2075**	**2076**	**2077**	**2078**	**2079**	**2080**
Escalation Rate: 2.00%													
Design Costs/ Precon Costs													
Capital Costs (Const & Rolling Stock)													
Transportation Costs & Equipment	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117
Operations Costs & Equipment	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901
Decommissioning Costs													
Total Unescalated Cost													
Total Project Costs - 2012 Dollars	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019	55,453,019
Escalation Factor	62,107,381	63,216,441	64,325,502	65,434,562	66,543,622	67,652,683	68,761,743	69,870,804	70,979,864	72,088,924	73,197,985	74,307,045	75,416,105
Escalated Annual Cost	117,560,400	118,669,460	119,778,520	120,887,581	121,996,641	123,105,701	124,214,762	125,323,822	126,432,883	127,541,943	128,651,003	129,760,064	130,869,124

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	69	70	71	72	73	74	75	76	77	78	79	80	81	82
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094
Escalation Rate: 2.00%														
Design Costs/ Precon Costs														
Capital Costs (Const & Rolling Stock)														
Transportation Costs & Equipment	16,125,117	0	0	0	0	0	0	0	0	0	0	0	0	0
Operations Costs & Equipment	39,327,901	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Decommissioning Costs														
Total Unescalated Cost														
Total Project Costs - 2012 Dollars	55,453,019	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Escalation Factor	76,525,166	50,763,501	51,488,694	52,213,887	52,939,080	53,664,273	54,389,466	55,114,659	55,839,851	56,565,044	57,290,237	58,015,430	58,740,623	59,465,816
Escalated Annual Cost	131,978,184	87,023,145	87,748,338	88,473,531	89,198,724	89,923,917	90,649,109	91,374,302	92,099,495	92,824,688	93,549,881	94,275,074	95,000,267	95,725,460

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	83	84	85	86	87	88	89	90	91	92	93	94	95	96
	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108
Escalation Rate: 2.00%														
Design Costs/ Precon Costs														
Capital Costs (Const & Rolling Stock)														
Transportation Costs & Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operations Costs & Equipment	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Decommissioning Costs														
Total Unescalated Cost														
Total Project Costs - 2012 Dollars	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Escalation Factor	60,191,009	60,916,202	61,641,394	62,366,587	63,091,780	63,816,973	64,542,166	65,267,359	65,992,552	66,717,745	67,442,937	68,168,130	68,893,323	69,618,516
Escalated Annual Cost	96,450,652	97,175,845	97,901,038	98,626,231	99,351,424	100,076,617	100,801,810	101,527,003	102,252,195	102,977,388	103,702,581	104,427,774	105,152,967	105,878,160

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	97	98	99	100	101	102	103	104	105	106	107
	Year	Year	Year	Year							
	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119
Escalation Rate: 2.00%											
Design Costs/ Precon Costs											
Capital Costs (Const & Rolling Stock)											
Transportation Costs & Equipment	0	0	0	0	0	0	0	0	0	0	0
Operations Costs & Equipment	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Decommissioning Costs						1,000,000,000	1,000,000,000	500,000,000	500,000,000	500,000,000	165,000,000
Total Unescalated Cost											
Total Project Costs - 2012 Dollars	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	1,036,259,644	1,036,259,644	536,259,644	536,259,644	536,259,644	201,259,644
Escalation Factor	70,343,709	71,068,902	71,794,095	72,519,288	73,244,480	2,113,969,673	2,134,694,866	1,115,420,059	1,126,145,252	1,136,870,445	430,695,638
Escalated Annual Cost	106,603,353	107,328,546	108,053,738	108,778,931	109,504,124	3,150,229,317	3,170,954,510	1,651,679,703	1,662,404,896	1,673,130,089	631,955,281

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

100-Year Cash Flow and Escalation

	108
	2120
Escalation Rate: 2.00%	(Complete 100 Years OPS)
Design Costs/ Precon Costs	
Capital Costs (Const & Rolling Stock)	
Transportation Costs & Equipment	0
Operations Costs & Equipment	36,259,644
Decommissioning Costs	85,000,000
Total Unescalated Cost	
Total Project Costs - 2012 Dollars	121,259,644
Escalation Factor	261,920,831
Escalated Annual Cost	383,180,474

Total Design and R&D Costs:
286,260,000
Total Construction Costs:
3,143,206,583
Total Transportation Costs-100 Years:
2,191,106,273
Total Operational Costs-100 Years:
18,999,454,664
Total Decommissioning Costs:
3,750,000,000
Total Escalation Costs-108 Years:
24,121,000,390
Total Project Costs-108 Years:
52,491,027,910
Cost/Metric Ton-140,000/MT:
$374,935.91

Appendix B
Operational Costs

Annual Operations Costs

Escalation Rate: **2.00%**

		Percent of Max	**30.00%**	**40.00%**	**50.00%**	**60.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**	**70.00%**
		Year	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
		FTE Rate	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**2012 cost**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
O&M Staff	20	100,000	600,000	800,000	1,000,000	1,200,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
Management Staff	10	200,000	600,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	150,000	2,700,000	3,600,000	4,500,000	5,400,000	6,300,000	6,300,000	6,300,000	6,300,000	6,300,000	6,300,000	6,300,000	6,300,000	6,300,000
Engineering	5	200,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Licensing	3	200,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Researchers	4	200,000	240,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	100,000	180,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	150,000	90,000	120,000	150,000	180,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
Security Costs	126	100,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%		6,513,500	7,742,000	8,137,500	8,533,000	8,928,500	8,928,500	8,928,500	8,928,500	8,928,500	8,928,500	8,928,500	8,928,500	8,928,500
Operations Materials		5,000,000	1,500,000	2,000,000	2,500,000	3,000,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Spare Parts		2,500,000	750,000	1,000,000	1,250,000	1,500,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000
9,000 DFSS- Canisters/Overpacks		500,000,000	0	0	0	0	0	0	0	0	0	0	0	0	500,000,000
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL		0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		1,500,000	450,000	600,000	750,000	900,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000
Contingency on Annual O&M Costs	15.00%		4,323,525	5,169,300	5,533,125	5,896,950	6,260,775	6,260,775	6,260,775	6,260,775	6,260,775	6,260,775	6,260,775	6,260,775	81,260,775
Contractor Fees		10.00%	3,314,703	3,963,130	4,242,063	4,520,995	4,799,928	4,799,928	4,799,928	4,799,928	4,799,928	4,799,928	4,799,928	4,799,928	62,299,928
Annual Operations Costs			36,461,728	43,594,430	46,662,688	49,730,945	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203	52,799,203	685,299,203
Escalation Factor			6,563,111	8,718,886	10,265,791	11,935,427	13,727,793	14,783,777	15,839,761	16,895,745	17,951,729	19,007,713	20,063,697	21,119,681	287,825,665
Escalated Annual Operating Cost			43,024,838	52,313,316	56,928,479	61,666,372	66,526,995	67,582,979	68,638,963	69,694,947	70,750,931	71,806,915	72,862,899	73,918,884	973,124,868

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		70.00%	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
O&M Staff	20	1,400,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	6,300,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000
Engineering	5	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000							
Licensing	3	600,000	600,000	600,000	600,000	600,000							
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	210,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	8,928,500	10,115,000	10,115,000	10,115,000	10,115,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000
Operations Materials		3,500,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Spare Parts		1,750,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
9,000 DFSS- Canisters/Overpacks		500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		1,050,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Contingency on Annual O&M Costs	15.00%	81,260,775	82,352,250	82,352,250	82,352,250	82,352,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250
Contractor Fees		62,299,928	63,136,725	63,136,725	63,136,725	63,136,725	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325
Annual Operations Costs		685,299,203	694,503,975	694,503,975	694,503,975	694,503,975	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575
Escalation Factor		301,531,649	319,471,829	333,361,908	347,251,988	361,142,067	373,556,651	387,392,082	401,227,514	415,062,945	428,898,377	442,733,808	456,569,240
Escalated Annual Operating Cost		986,830,852	1,013,975,804	1,027,865,883	1,041,755,963	1,055,646,042	1,065,328,226	1,079,163,657	1,092,999,089	1,106,834,520	1,120,669,952	1,134,505,383	1,148,340,815

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		100.00%	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**90.00%**	**80.00%**	**70.00%**
		2046	**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**
O&M Staff	20	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	1,800,000	1,600,000	1,400,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	8,100,000	7,200,000	6,300,000
Engineering	5													
Licensing	3													
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	270,000	240,000	210,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,555,000	9,159,500	8,764,000	8,368,500
Operations Materials		5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	4,500,000	4,000,000	3,500,000
Spare Parts		2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,250,000	2,000,000	1,750,000
9,000 DFSS- Canisters/Overpacks		500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	500,000,000	0	0	0
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,350,000	1,200,000	1,050,000
Contingency on Annual O&M Costs	15.00%	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	82,028,250	6,664,425	6,300,600	5,936,775
Contractor Fees		62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	62,888,325	5,109,393	4,830,460	4,551,528
Annual Operations Costs		691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	691,771,575	56,203,318	53,135,060	50,066,803
Escalation Factor		470,404,671	484,240,103	498,075,534	511,910,966	525,746,397	539,581,829	553,417,260	567,252,692	581,088,123	594,923,555	49,458,919	47,821,554	46,061,458
Escalated Annual Operating Cost		1,162,176,246	1,176,011,678	1,189,847,109	1,203,682,541	1,217,517,972	1,231,353,404	1,245,188,835	1,259,024,267	1,272,859,698	1,286,695,130	105,662,237	100,956,614	96,128,261

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		60.00%	**50.00%**	**40.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**
		2059	**2060**	**2061**	**2062**	**2063**	**2064**	**2065**	**2066**	**2067**	**2068**	**2069**	**2070**	**2071**	**2072**	**2073**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**
O&M Staff	20	1,200,000	1,000,000	800,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	5,400,000	4,500,000	3,600,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000
Engineering	5															
Licensing	3															
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	180,000	150,000	120,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	7,973,000	7,577,500	7,182,000	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250
Operations Materials		3,000,000	2,500,000	2,000,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000
Spare Parts		1,500,000	1,250,000	1,000,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000
9,000 DFSS- Canisters/Overpacks		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		900,000	750,000	600,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000
Contingency on Annual O&M Costs	15.00%	5,572,950	5,209,125	4,845,300	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388
Contractor Fees		4,272,595	3,993,663	3,714,730	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264
Annual Operations Costs		46,998,545	43,930,288	40,862,030	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901
Escalation Factor		44,178,632	42,173,076	40,044,789	39,327,901	40,114,459	40,901,017	41,687,575	42,474,133	43,260,691	44,047,249	44,833,807	45,620,365	46,406,923	47,193,482	47,980,040
Escalated Annual Operating Cost		91,177,177	86,103,364	80,906,819	78,655,803	79,442,361	80,228,919	81,015,477	81,802,035	82,588,593	83,375,151	84,161,709	84,948,267	85,734,825	86,521,383	87,307,941

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: 2.00%

		35.00%	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**35.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**
		2074	**2075**	**2076**	**2077**	**2078**	**2079**	**2080**	**2081**	**2082**	**2083**	**2084**	**2085**	**2086**	**2087**	**2088**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**
O&M Staff	20	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000
Engineering	5															
Licensing	3															
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,984,250	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750
Operations Materials		1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Spare Parts		875,000	875,000	875,000	875,000	875,000	875,000	875,000	875,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000
9,000 DFSS- Canisters/Overpacks		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000
Contingency on Annual O&M Costs	15.00%	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,663,388	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563
Contractor Fees		3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,575,264	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331
Annual Operations Costs		39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	39,327,901	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Escalation Factor		48,766,598	49,553,156	50,339,714	51,126,272	51,912,830	52,699,388	53,485,946	54,272,504	50,763,501	51,488,694	52,213,887	52,939,080	53,664,273	54,389,466	55,114,659
Escalated Annual Operating Cost		88,094,499	88,881,057	89,667,615	90,454,173	91,240,731	92,027,289	92,813,847	93,600,405	87,023,145	87,748,338	88,473,531	89,198,724	89,923,917	90,649,109	91,374,302

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		25.00%	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**
		2089	**2090**	**2091**	**2092**	**2093**	**2094**	**2095**	**2096**	**2097**	**2098**	**2099**	**2100**	**2101**	**2102**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
O&M Staff	20	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000
Engineering	5														
Licensing	3														
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750
Operations Materials		1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Spare Parts		625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000
9,000 DFSS- Canisters/Overpacks		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000
Contingency on Annual O&M Costs	15.00%	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563
Contractor Fees		3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331
Annual Operations Costs		36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Escalation Factor		55,839,851	56,565,044	57,290,237	58,015,430	58,740,623	59,465,816	60,191,009	60,916,202	61,641,394	62,366,587	63,091,780	63,816,973	64,542,166	65,267,359
Escalated Annual Operating Cost		92,099,495	92,824,688	93,549,881	94,275,074	95,000,267	95,725,460	96,450,652	97,175,845	97,901,038	98,626,231	99,351,424	100,076,617	100,801,810	101,527,003

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		25.00%	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**	**25.00%**
		2103	**2104**	**2105**	**2106**	**2107**	**2108**	**2109**	**2110**	**2111**	**2112**	**2113**	**2114**	**2115**	**2116**
		Year	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**
O&M Staff	20	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Fuel Shipment/Handling Costs	60	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000
Engineering	5														
Licensing	3														
Researchers	4	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Research Technicians	6	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Monitoring and Analysis	2	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
Salary Related Costs	35.00%	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750	6,588,750
Operations Materials		1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Spare Parts		625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000	625,000
9,000 DFSS- Canisters/Overpacks		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000	375,000
Contingency on Annual O&M Costs	15.00%	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563	4,299,563
Contractor Fees		3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331	3,296,331
Annual Operations Costs		36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644	36,259,644
Escalation Factor		65,992,552	66,717,745	67,442,937	68,168,130	68,893,323	69,618,516	70,343,709	71,068,902	71,794,095	72,519,288	73,244,480	73,969,673	74,694,866	75,420,059
Escalated Annual Operating Cost		102,252,195	102,977,388	103,702,581	104,427,774	105,152,967	105,878,160	106,603,353	107,328,546	108,053,738	108,778,931	109,504,124	110,229,317	110,954,510	111,679,703

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Annual Operations Costs

Escalation Rate: **2.00%**

		25.00%	**25.00%**	**25.00%**	**25.00%**	**Total**
		2117	**2118**	**2119**	**2120**	
		Year	**Year**	**Year**	**Year**	
	FTE	**105**	**106**	**107**	**108**	
O&M Staff	20	500,000	500,000	500,000	500,000	100,900,000
Management Staff	10	2,000,000	2,000,000	2,000,000	2,000,000	198,600,000
Fuel Shipment/Handling Costs	60	2,250,000	2,250,000	2,250,000	2,250,000	454,050,000
Engineering	5					18,000,000
Licensing	3					10,800,000
Researchers	4	800,000	800,000	800,000	800,000	79,440,000
Research Technicians	6	600,000	600,000	600,000	600,000	59,580,000
Monitoring and Analysis	2	75,000	75,000	75,000	75,000	15,135,000
Security Costs	126	12,600,000	12,600,000	12,600,000	12,600,000	1,260,000,000
Salary Related Costs	35.00%	6,588,750	6,588,750	6,588,750	6,588,750	768,776,750
Operations Materials		1,250,000	1,250,000	1,250,000	1,250,000	252,250,000
Spare Parts		625,000	625,000	625,000	625,000	126,125,000
9,000 DFSS- Canisters/Overpacks		0	0	0	0	11,500,000,000
Utilities/Supplies/Consumable		1,000,000	1,000,000	1,000,000	1,000,000	100,000,000
Capital Plant upgrades	EXCL	0	0	0	0	0
Taxes and Insurance		375,000	375,000	375,000	375,000	75,675,000
Contingency on Annual O&M Costs	15.00%	4,299,563	4,299,563	4,299,563	4,299,563	2,252,899,763
Contractor Fees		3,296,331	3,296,331	3,296,331	3,296,331	1,727,223,151
Annual Operations Costs		36,259,644	36,259,644	36,259,644	36,259,644	18,999,454,664
Escalation Factor		76,145,252	76,870,445	77,595,638	78,320,831	14,082,426,906
Escalated Annual Operating Cost		112,404,896	113,130,089	113,855,281	114,580,474	33,081,881,569

Total Operational Costs (2012 Dollars):
18,999,454,664
Total Escalation Costs:
14,082,426,906
Total Operational Costs with Escalation:
33,081,881,569

Cost Per Metric Ton/100 Years	$236,299

Appendix C
Transportation Costs

Annual Transportation Costs

		Percent of Max	30.00%	40.00%	50.00%	60.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%	70.00%
Escalation Rate:	**2.00%**		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
	FTE	**FTE Rate 2012 cost**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**
Transport Security	50	100,000	1,500,000	2,000,000	2,500,000	3,000,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Logistics Coordination	5	100,000	150,000	200,000	250,000	300,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000	350,000
Transportation Planning	23	100,000	690,000	920,000	1,150,000	1,380,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000
Transportation Management	28	150,000	1,260,000	1,680,000	2,100,000	2,520,000	2,940,000	2,940,000	2,940,000	2,940,000	2,940,000	2,940,000	2,940,000	2,940,000	2,940,000
Shipment Tracking	6	75,000	135,000	180,000	225,000	270,000	315,000	315,000	315,000	315,000	315,000	315,000	315,000	315,000	315,000
Notifications & Comm.	8	75,000	180,000	240,000	300,000	360,000	420,000	420,000	420,000	420,000	420,000	420,000	420,000	420,000	420,000
Security Planning & Mgnt.	8	100,000	240,000	320,000	400,000	480,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000	560,000
Salary Related Costs	35.00%		1,454,250	1,939,000	2,423,750	2,908,500	3,393,250	3,393,250	3,393,250	3,393,250	3,393,250	3,393,250	3,393,250	3,393,250	3,393,250
Rail Road Shipping Costs		18,600,000	5,580,000	7,440,000	9,300,000	11,160,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000	13,020,000
Funding to States and Tribes		2,250,000	675,000	900,000	1,125,000	1,350,000	1,575,000	1,575,000	1,575,000	1,575,000	1,575,000	1,575,000	1,575,000	1,575,000	1,575,000
Plant Site - Modifications		2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Truck/Heavy Haul/Barge		3,150,000	945,000	1,260,000	1,575,000	1,890,000	2,205,000	2,205,000	2,205,000	2,205,000	2,205,000	2,205,000	2,205,000	2,205,000	2,205,000
Emergency Planning/Training		300,000	90,000	120,000	150,000	180,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
Taxes and Insurance		1,500,000	450,000	600,000	750,000	900,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000	1,050,000
Contingency on Annual Transport Costs	10.00%		1,534,925	1,979,900	2,424,875	2,869,850	3,314,825	3,314,825	3,314,825	3,314,825	3,314,825	3,314,825	3,314,825	3,314,825	3,314,825
Contractor Fee		10.00%	1,688,418	2,177,890	2,667,363	3,156,835	3,646,308	3,646,308	3,646,308	3,646,308	3,646,308	3,646,308	3,646,308	3,646,308	3,646,308

Annual Transportation Costs	18,572,593	23,956,790	29,340,988	34,725,185	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383	40,109,383
Escalation Factor	3,343,067	4,791,358	6,455,017	8,334,044	10,428,439	11,230,627	12,032,815	12,835,002	13,637,190	14,439,378	15,241,565	16,043,753	16,845,941
Escalated Annual Transportation Cost	21,915,659	28,748,148	35,796,005	43,059,229	50,537,822	51,340,010	52,142,197	52,944,385	53,746,573	54,548,760	55,350,948	56,153,136	56,955,323

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Phase 1 Operation
186,814,320

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

		Percent of Max	**70.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Escalation Rate:	**2.00%**		**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**
		FTE Rate	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**2012 cost**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Transport Security	50	100,000	3,500,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Logistics Coordination	5	100,000	350,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Transportation Planning	23	100,000	1,610,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000
Transportation Management	28	150,000	2,940,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000
Shipment Tracking	6	75,000	315,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000
Notifications & Comm.	8	75,000	420,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Security Planning & Mgnt.	8	100,000	560,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Salary Related Costs	35.00%		3,393,250	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500
Rail Road Shipping Costs		18,600,000	13,020,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000
Funding to States and Tribes		2,250,000	1,575,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000
Plant Site - Modifications		2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Truck/Heavy Haul/Barge		3,150,000	2,205,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000
Emergency Planning/Training		300,000	210,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Taxes and Insurance		1,500,000	1,050,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Contingency on Annual Transport Costs	10.00%		3,314,825	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750
Contractor Fee		10.00%	3,646,308	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725

Annual Transportation Costs	40,109,383	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975
Escalation Factor	17,648,128	25,880,509	27,005,748	28,130,988	29,256,227	30,381,467	31,506,706	32,631,946	33,757,185	34,882,425	36,007,664	37,132,904	38,258,143
Escalated Annual Transportation Cost	57,757,511	82,142,484	83,267,723	84,392,963	85,518,202	86,643,442	87,768,681	88,893,921	90,019,160	91,144,400	92,269,639	93,394,879	94,520,118

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

		Percent of Max	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	90.00%	80.00%	70.00%	60.00%
Escalation Rate:	**2.00%**		**2047**	**2048**	**2049**	**2050**	**2051**	**2052**	**2053**	**2054**	**2055**	**2056**	**2057**	**2058**	**2059**
		FTE Rate	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**2012 cost**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**
Transport Security	50	100,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	4,500,000	4,000,000	3,500,000	3,000,000
Logistics Coordination	5	100,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	450,000	400,000	350,000	300,000
Transportation Planning	23	100,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,300,000	2,070,000	1,840,000	1,610,000	1,380,000
Transportation Management	28	150,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	4,200,000	3,780,000	3,360,000	2,940,000	2,520,000
Shipment Tracking	6	75,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	405,000	360,000	315,000	270,000
Notifications & Comm.	8	75,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	540,000	480,000	420,000	360,000
Security Planning & Mgnt.	8	100,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	720,000	640,000	560,000	480,000
Salary Related Costs	35.00%		4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,847,500	4,362,750	969,500	848,313	727,125
Rail Road Shipping Costs		18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	18,600,000	16,740,000	14,880,000	13,020,000	11,160,000
Funding to States and Tribes		2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,025,000	1,800,000	1,575,000	1,350,000
Plant Site - Modifications		2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	0	0	0	0	0	0	0
Truck/Heavy Haul/Barge		3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	3,150,000	2,835,000	2,520,000	2,205,000	1,890,000
Emergency Planning/Training		300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	270,000	240,000	210,000	180,000
Taxes and Insurance		1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,350,000	1,200,000	1,050,000	900,000
Contingency on Annual Transport Costs	10.00%		4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,649,750	4,449,750	4,449,750	4,449,750	4,004,775	817,238	715,083	612,928
Contractor Fee		10.00%	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	5,114,725	4,894,725	4,894,725	4,894,725	4,405,253	3,350,674	2,931,840	2,513,005

Annual Transportation Costs	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	56,261,975	53,841,975	53,841,975	53,841,975	48,457,778	36,857,411	32,250,235	27,643,058
Escalation Factor	39,383,383	40,508,622	41,633,862	42,759,101	43,884,341	45,009,580	44,150,420	45,227,259	46,304,099	42,642,844	33,171,670	29,670,216	25,984,475
Escalated Annual Transportation Cost	95,645,358	96,770,597	97,895,837	99,021,076	100,146,316	101,271,555	97,992,395	99,069,234	100,146,074	91,100,622	70,029,081	61,920,451	53,627,533

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

		Percent of Max	50.00%	40.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%
Escalation Rate:	**2.00%**		**2060**	**2061**	**2062**	**2063**	**2064**	**2065**	**2066**	**2067**	**2068**	**2069**	**2070**	**2071**	**2072**
	FTE	**FTE Rate 2012 cost**	**Year 48**	**Year 49**	**Year 50**	**Year 51**	**Year 52**	**Year 53**	**Year 54**	**Year 55**	**Year 56**	**Year 57**	**Year 58**	**Year 59**	**Year 60**
Transport Security	50	100,000	2,500,000	2,000,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000
Logistics Coordination	5	100,000	250,000	200,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000
Transportation Planning	23	100,000	1,150,000	920,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000
Transportation Management	28	150,000	2,100,000	1,680,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000
Shipment Tracking	6	75,000	225,000	180,000	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500
Notifications & Comm.	8	75,000	300,000	240,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
Security Planning & Mgnt.	8	100,000	400,000	320,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000
Salary Related Costs	35.00%		605,938	484,750	424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156
Rail Road Shipping Costs		18,600,000	9,300,000	7,440,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000
Funding to States and Tribes		2,250,000	1,125,000	900,000	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500
Plant Site - Modifications		2,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Truck/Heavy Haul/Barge		3,150,000	1,575,000	1,260,000	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500
Emergency Planning/Training		300,000	150,000	120,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000
Taxes and Insurance		1,500,000	750,000	600,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000
Contingency on Annual Transport Costs	10.00%		510,773	408,619	357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541
Contractor Fee		10.00%	2,094,171	1,675,337	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920

	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072
Annual Transportation Costs	23,035,882	18,428,706	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117
Escalation Factor	22,114,447	18,060,132	16,125,117	16,447,620	16,770,122	17,092,624	17,415,127	17,737,629	18,060,132	18,382,634	18,705,136	19,027,639	19,350,141
Escalated Annual Transportation Cost	45,150,329	36,488,837	32,250,235	32,572,737	32,895,240	33,217,742	33,540,244	33,862,747	34,185,249	34,507,751	34,830,254	35,152,756	35,475,258

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

Percent of Max			35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	35.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Escalation Rate:	**2.00%**		**2073**	**2074**	**2075**	**2076**	**2077**	**2078**	**2079**	**2080**	**2081**	**2082**	**2083**	**2084**	**2085**	**2086**	**2087**	**2088**	**2089**
		FTE Rate	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**	**Year**
	FTE	**2012 cost**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**
Transport Security	50	100,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	1,750,000	0	0	0	0	0	0	0	0
Logistics Coordination	5	100,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	0	0	0	0	0	0	0	0
Transportation Planning	23	100,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	805,000	0	0	0	0	0	0	0	0
Transportation Management	28	150,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000	0	0	0	0	0	0	0	0
Shipment Tracking	6	75,000	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500	157,500	0	0	0	0	0	0	0	0
Notifications & Comm.	8	75,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	0	0	0	0	0	0	0	0
Security Planning & Mgnt.	8	100,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	0	0	0	0	0	0	0	0
Salary Related Costs	35.00%		424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156	424,156	0	0	0	0	0	0	0	0
Rail Road Shipping Costs		18,600,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	6,510,000	0	0	0	0	0	0	0	0
Funding to States and Tribes		2,250,000	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500	787,500	0	0	0	0	0	0	0	0
Plant Site - Modifications		2,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Truck/Heavy Haul/Barge		3,150,000	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	1,102,500	0	0	0	0	0	0	0	0
Emergency Planning/Training		300,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	0	0	0	0	0	0	0	0
Taxes and Insurance		1,500,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	0	0	0	0	0	0	0	0
Contingency on Annual Transport Costs	10.00%		357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541	357,541	0	0	0	0	0	0	0	0
Contractor Fee		10.00%	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	1,465,920	0	0	0	0	0	0	0	0

	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089
Annual Transportation Costs	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	16,125,117	0	0	0	0	0	0	0	0
Escalation Factor	19,672,643	19,995,146	20,317,648	20,640,150	20,962,653	21,285,155	21,607,657	21,930,160	22,252,662	0	0	0	0	0	0	0	0
Escalated Annual Transportation Cost	35,797,761	36,120,263	36,442,765	36,765,268	37,087,770	37,410,272	37,732,775	38,055,277	38,377,779	0	0	0	0	0	0	0	0

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

		Percent of Max	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Escalation Rate:	**2.00%**		**2090**	**2091**	**2092**	**2093**	**2094**	**2095**	**2096**	**2097**	**2098**	**2099**	**2100**	**2101**	**2102**	**2103**	**2104**	**2105**	**2106**	**2107**	**2108**	**2109**	**2110**	**2111**
	FTE	**FTE Rate 2012 cost**	**Year 78**	**Year 79**	**Year 80**	**Year 81**	**Year 82**	**Year 83**	**Year 84**	**Year 85**	**Year 86**	**Year 87**	**Year 88**	**Year 89**	**Year 90**	**Year 91**	**Year 92**	**Year 93**	**Year 94**	**Year 95**	**Year 96**	**Year 97**	**Year 98**	**Year 99**
Transport Security	50	100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Logistics Coordination	5	100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Planning	23	100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Management	28	150,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shipment Tracking	6	75,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Notifications & Comm.	8	75,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Security Planning & Mgnt.	8	100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salary Related Costs	35.00%		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rail Road Shipping Costs		18,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Funding to States and Tribes		2,250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plant Site - Modifications		2,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Truck/Heavy Haul/Barge		3,150,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Planning/Training		300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes and Insurance		1,500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency on Annual Transport Costs	10.00%		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contractor Fee		10.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annual Transportation Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Escalation Factor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Escalated Annual Transportation Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

Annual Transportation Costs

		Percent of Max	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Escalation Rate:	**2.00%**		**2112**	**2113**	**2114**	**2115**	**2116**	**2117**	**2118**	**2119**	**2120**	
	FTE	**FTE Rate 2012 cost**	**Year 100**	**Year 101**	**Year 102**	**Year 103**	**Year 104**	**Year 105**	**Year 106**	**Year 107**	**Year 108**	**Total**
Transport Security	50	100,000	0	0	0	0	0	0	0	0	0	203,500,000
Logistics Coordination	5	100,000	0	0	0	0	0	0	0	0	0	20,350,000
Transportation Planning	23	100,000	0	0	0	0	0	0	0	0	0	93,610,000
Transportation Management	28	150,000	0	0	0	0	0	0	0	0	0	170,940,000
Shipment Tracking	6	75,000	0	0	0	0	0	0	0	0	0	18,315,000
Notifications & Comm.	8	75,000	0	0	0	0	0	0	0	0	0	24,420,000
Security Planning & Mgnt.	8	100,000	0	0	0	0	0	0	0	0	0	32,560,000
Salary Related Costs	35.00%		0	0	0	0	0	0	0	0	0	160,937,000
Rail Road Shipping Costs		18,600,000	0	0	0	0	0	0	0	0	0	757,020,000
Funding to States and Tribes		2,250,000	0	0	0	0	0	0	0	0	0	91,575,000
Plant Site - Modifications		2,000,000	0	0	0	0	0	0	0	0	0	64,000,000
Truck/Heavy Haul/Barge		3,150,000	0	0	0	0	0	0	0	0	0	128,205,000
Emergency Planning/Training		300,000	0	0	0	0	0	0	0	0	0	12,210,000
Taxes and Insurance		1,500,000	0	0	0	0	0	0	0	0	0	61,050,000
Contingency on Annual Transport Costs	10.00%		0	0	0	0	0	0	0	0	0	153,222,794
Contractor Fee		10.00%	0	0	0	0	0	0	0	0	0	199,191,479

Annual Transportation Costs	0	0	0	0	0	0	0	0	0	2,191,106,273
Escalation Factor	0	0	0	0	0	0	0	0	0	1,492,420,477
Escalated Annual Transportation Cost	0	0	0	0	0	0	0	0	0	3,683,526,750

Total Transportation Costs (2012 Dollars)
2,191,106,273
Total Escalation Costs
1,492,420,477
Total Transportation Costs with Escalation
3,683,526,750

Cost Per Metric Ton/100 Years	$26,311

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Appendix D
Basic Cost Data

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
	$286,260,000	**1F10**	**Capitalized Pre Construction Costs**										
		$2,460,000	1F11	Land and Land Rights									$0
			$960,000	1F111	Land Purchase					640	Acres	$1,500.00	$960,000
			$1,500,000	1F112	15 mile Access Right of Way (Annual land Lease)					15	Miles	$100,000.00	$1,500,000
			$0	1F113									$0
			$0	1F114									$0
			$0	1F115									$0
			$0	1F116									$0
			$0	1F117									$0
		$11,000,000	1F12	Site Permits									$0
			$2,000,000	1F121	Federal Government/Agency Permits					1	LS	$2,000,000.00	$2,000,000
			$2,000,000	1F122	State Government Permits					1	LS	$2,000,000.00	$2,000,000
			$2,000,000	1F123	Local Government Permits					1	LS	$2,000,000.00	$2,000,000
			$5,000,000	1F124	Environmental Impact Statement/NEPA					1	LS	$5,000,000.00	$5,000,000
			$0	1F125									$0
			$0	1F126									$0
			$0	1F127									$0
			$0	1F128									$0
		$33,000,000	1F13	Plant Licensing									$0
			$18,000,000	1F131	NRC					6	Years	$3,000,000.00	$18,000,000
			$6,000,000	1F132	State Government					6	Years	$1,000,000.00	$6,000,000
			$9,000,000	1F133	DOT Licensing					6	years	$1,500,000.00	$9,000,000
			$0	1F134									$0
			$0	1F135									$0
			$0	1F136									$0
			$0	1F137									$0
			$0	1F137									$0
			$0	1F139									$0
		$6,000,000	1F14	Plant Permits									$0
			$1,000,000	1F141	Federal Government/Agency Permits					1	LS	$1,000,000.00	$1,000,000
			$2,500,000	1F142	State Government Permits					1	LS	$2,500,000.00	$2,500,000
			$2,500,000	1F143	Local Government Permits					1	LS	$2,500,000.00	$2,500,000
			$0	1F144									$0
			$0	1F145									$0
			$0	1F146									$0
			$0	1F147									$0
			$0	1F148									$0
		$0	1F15	Planning Studies & Alternatives Analysis			INCLUDED in DESIGN SCOPE of 1F18						$0
			$0	1F151	Environmental								$0
					1F151.1	Siting Analysis					LS	$500,000.00	$0
					1F151.2	Environmental Impact Study/NEPA (See Site Permits)					LS		$0
					1F151,3	Applications Studies					LS	$500,000.00	$0
					1F151.4	Geotechnical Data					LS	$750,000.00	$0
					1F151.5	Transportation Studies					LS	$1,000,000.00	$0
					1F151						LS		$0
					1F151								$0
					1F151								$0
					1F151								$0
					1F151								$0
					1F151								$0
					1F151								$0
			$0	1F152	Nuclear System Studies								$0
					1F152.1	**Top Level Requirements Studies**					LS	$500,000.00	$0
					1F152.2	**Seismic Hazards analysis**					LS	$500,000.00	$0
					1F152.3	**Major Equipment Transport/Field Fabrication Study**					LS	$250,000.00	$0
					1F152.4						LS		$0
					1F152.5						LS		$0
					1F152.6						LS		$0
					1F152						LS		$0
					1F152						LS		$0
					1F152						LS		$0
					1F152						LS		$0
					1F152						LS		$0
					1F152								$0
					1F152								$0
					1F152								$0
					1F152								$0
					1F152								$0
					1F152								$0
					1F152								$0
			$0	1F153	Building Studies								$0
					1F153.1	**Hot Cell**					LS	$500,000.00	$0
					1F153.2	**Cask Handling/Off Loading**					LS	$500,000.00	$0
					1F153.3	**Value Engineering Study**					LS	$500,000.00	$0
					1F153.4	**Fuel Examination/Testing Rqmts**					LS	$250,000.00	$0
					1F153.5	**Cyber Security Study**					LS	$250,000.00	$0
					1F153.6						LS		$0
					1F153						LS		$0
					1F153						LS		$0
					1F153						LS		$0
					1F153								$0
					1F153								$0
					1F153								$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
					1F153								$0
					1F153								$0
			$0	1F154							LS		$0
					1F154								$0
			$0	1F155	Transportation Studies						LS	$2,500,000.00	$0
			$0	1F156	Cask Design Studies						LS	$1,500,000.00	$0
			$0	1F157	Package Performance Studies & Testing						LS	$5,000,000.00	$0
			$0	1F158	Routing Studies for Risk Assessment						LS	$5,000,000.00	$0
		$40,000,000	1F16	Research and Development (8 years during design/construction)									$0
			$40,000,000							8	LS	$5,000,000.00	$40,000,000
		$26,200,000	1F17	Other Preconstruction Costs									$0
			$6,000,000	1F171	DOE Administration					6	Years	$1,000,000.00	$6,000,000
			$7,200,000	1F172	Contractor Administration					6	Years	$1,200,000.00	$7,200,000
			$3,000,000	1F173	Legal					6	Years	$500,000.00	$3,000,000
			$3,000,000	1F174	NRC meetings/interaction					6	years	$500,000.00	$3,000,000
			$1,000,000	1F175	Independent Reviews (EIR and others)					1	LS	$1,000,000.00	$1,000,000
			$6,000,000	1F176	Contractor Support to DOE					6	Years	$1,000,000.00	$6,000,000
			$0	1F177									$0
			$0	1F178									$0
			$0	1F179									$0
		$157,600,000	1F18	Conceptual Preliminary and Final Design									$0
			$10,800,000	1F181	Conceptual Design					45	Man Years	$240,000.00	$10,800,000
					1F181.1						Man Years	$240,000.00	$0
					1F181.2						Man Years	$240,000.00	$0
					1F181.3						Man Years	$240,000.00	$0
					1F181.4						Man Years	$240,000.00	$0
					1F181.9								$0
			$21,600,000	1F182	Preliminary Design CSF (Excluding Pools & Hot Cells)					90	Man Years	$240,000.00	$21,600,000
					1F182.1						Man Years	$240,000.00	$0
					1F182.2						Man Years	$240,000.00	$0
					1F182.3						Man Years	$240,000.00	$0
					1F182.4						Man Years	$240,000.00	$0
			$28,800,000	1F183	Final Design CSF (Excluding Pools and Hot Cells)					120	Man Years	$240,000.00	$28,800,000
					1F183.1						Man Years	$240,000.00	$0
					1F183.2						Man Years	$240,000.00	$0
					1F183.3						Man Years	$240,000.00	$0
					1F183.4						Man Years	$240,000.00	$0
			$57,600,000	1F184	Preliminary Design Storage pools and Hot Cell					120	Man Years	$240,000.00	$28,800,000
					1F184.1						Man Years	$240,000.00	$0
					1F184.2						Man Years	$240,000.00	$0
					1F184.3						Man Years	$240,000.00	$0
					1F184.4						Man Years	$240,000.00	$0
			$28,800,000	1F185	Final Design Storage Pools and Hot Cell					120	Man Years	$240,000.00	$28,800,000
					1F185.1						Man Years	$240,000.00	$0
					1F185.2						Man Years	$240,000.00	$0
					1F185.3						Man Years	$240,000.00	$0
					1F185.4						Man Years	$240,000.00	$0
			$10,000,000	1F189	Contingency (Design Work/Const Documents)					1	LS	$10,000,000.00	$10,000,000
													$0
													$0
		$10,000,000	1F19	Contingency on Pre Construction Costs									$0
			$2,500,000	1F191	Studies					1	LS	$2,500,000.00	$2,500,000
			$2,500,000	1F192	Licensing					1	LS	$2,500,000.00	$2,500,000
			$2,500,000	1F193	Title I & Title II Design					1	LS	$2,500,000.00	$2,500,000
			$2,500,000	1F194	Time Related Costs					1	LS	$2,500,000.00	$2,500,000
			$0	1F195									$0
			$0	1F196									$0
			$0	1F197									$0
			$0	1F198									$0
			$0	1F199									$0
													$0
	$2,548,575,075	**1F20**	**Capitalized Direct Costs**										$0
		$1,065,480,075	1F21	Structures and improvements									$0
			$79,645,228	1F211	Site Preparation/Yard Work								$0
				$17,836,378	1F211.1	Earthwork							$0
					$75,000	1F211.11	Survey and Staking			30	Crew Days	$2,500.00	$75,000
					$17,761,378	1F211.12	Earthwork						$0
						$640,000	1F211.121	Clear and Grub		640	Acres	$1,000.00	$640,000
						$8,260,267	1F211.122	Mass Excavation (Cut Fill site)		1,032,533	CY	$8.00	$8,260,267
						$111,111	1F211.123	Building Site Excavation					$0
								211.123.1	Building Pads (100,000 SF)	7,407	CY	$15.00	$111,111
								211.123.2			CY		$0
								211.123.3					$0
								211.123.4			LS		$0
								211.123.5			CY		$0
								211.123.7			Gal		$0
								211.123.8			Crew Days		$0
								211.123.9					$0
						$8,750,000	1F211.124	Crush and Prep Site Materials					$0
								211.124.1			LS		$0
								211.124.2	Crushed Gravel	250,000	CY	$35.00	$8,750,000
								211.124.3			CY		$0
								211.124.3					$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
								211.124.4					$0
								211.124.5					$0
								211.124.6					$0
								211.124.7					$0
						$0	1F211.125	Backfill and Recompaction (Neat in the Hole)			CY		$0
								211.125.1					$0
								211.125.2					$0
								211.125.3					$0
								211.125.4			Crew Days		$0
								211.125.5			Crew Days		$0
								211.125.6					$0
						$0	1F211.126	Building Pad Construction					$0
								211.126.1			SF		$0
								211.126.2			CY		$0
								211.126.3			LS		$0
								211.126.4			LS		$0
						$0	1F211.127						$0
													$0
						$0	1F211.129	Contingency Earthwork			LS		$0
					$0	1F211.13							$0
					$0	1F211.14							$0
					$0	1F211.15							$0
					$0	1F211.16							$0
				$55,668,600	1F211.2	Perimeter Controls							$0
					$1,058,600	1F211.21	Perimeter Fencing						$0
							8 Foot Fence			21,120	LF	$15.00	$316,800
							Razor Wire Top (One Loop)			21,120	LF	$15.00	$316,800
							Continuous Concrete Bottom - 2 Feet Deep 6" wide			1,000	CY	$250.00	$250,000
							Guard Shack			1	LS	$75,000.00	$75,000
							Auto Control Devices			2	Each	$50,000.00	$100,000
													$0
					$0	1F211.22	Protected Area Double Fence						$0
							8 Foot Fencing (Double fence 100 feet apart)				LF		$0
							Razor Wire Top (Three Loop on each fence)				LF		$0
							Continuous concrete bottom - 3 feet deep x 1 foot wide				CY		$0
							Vital Area Fence				LF		$0
							Razor Wire Top (Three Loop on each fence)				LF		$0
							Concrete Bottom (5 ft deep by 1 foot wide)				CY		$0
							Inner Guard Station				LS		$0
							Auto Control Devices				Each		$0
													$0
							QA/QC				LS		$0
													$0
					$700,000	1F211.23	Site Lighting						$0
							1F211.231	Vital Area Lighting (Pole Every 100 LF)			Poles		$0
							1F211.232	Protected Area Lighting (Pole Every 100 LF)		100	Poles	$2,500.00	$250,000
							1F211.233	Perimeter Lighting (Pole Every 200 Ft)		100	Poles	$2,500.00	$250,000
							1F211.233	Light Power Distribution (Trench/Backfill/Wire)		40,000	LF	$5.00	$200,000
					$53,760,000	1F211.24	Site Monitoring/Intrusion Detection						$0
							1F211.241	PIDAS		15,000	LF	$3,500.00	$52,500,000
							1F211.242	Lighting Cask Storage Area		200	Poles	$2,500.00	$500,000
							1F211.243	Cameras Perimeter (Every 500 LF)		40	Each	$2,500.00	$100,000
							1F211.243	Cameras Double Fenced Area (Every 250 lf)			Each		$0
							1F211.243	Cameras Vital Area Fence (Every 250 LF)			Each		$0
							1F211.243	Power for intrusion Detection		15,000	LF	$10.00	$150,000
							1F211.243	Data collection Cameras		25,000	LF	$7.00	$175,000
							1F211.243	Data Collection Intrusion Detection Systems		25,000	LF	$10.00	$250,000
							1F211.243	Internet Access		1	LS	$10,000.00	$10,000
							1F211.243	QA/QC Electrical Work		1	LS	$75,000.00	$75,000
					$150,000	1F211.25	Access Gates/Controls						$0
							1F211.251	Perimeter Gate and Control		2	Entrances	$25,000.00	$50,000
							1F211.242	Protected Area Double Gate and Control		2	Entrances	$50,000.00	$100,000
							1F211.253	Vital Area Double Gate and control			Entrances		$0
					$0	1F211.26							$0
					$0	1F211.27							$0
					$0	1F211.28							$0
					$0	1F211.29	Contingency for Perimeter Security Systems				LS		$0
					$0	1F211.							$0
													$0
				$0	1F211.3	Site Access (Roads and Rail) See 1F218X and 1F218Y							$0
					$0	1F211.31	Off-Site Road (20 Miles, 24 Ft Wide) SEE 1F218Y						$0
					$0	1F211.32	Off- Site Rail (Single Rail w/Two Sidings) See 1F218X						$0
					$0	1F211.33	On Site Roads (Dependent on size of Site) SEE 1F218Y				LF		$0
					$0	1F211.34	On Site Rail (Dependent on size of Site) See 1F218X				LF		$0
						1F211.35							$0
				$5,808,000	1F211.4	Utilities (Off Site)							$0
						1F211.41	Site Water lines			105,600	LF	$15.00	$1,584,000
						1F211.42	Site Sewer/Septic Systems						$0
						1F211.43	Site Electrical (Feed from utility)			105,600	LF	$20.00	$2,112,000
						1F211.45	Site Gas			105,600	LF	$10.00	$1,056,000
						1F211.46	Site Phone/Telecommunications			105,600	LF	$10.00	$1,056,000
						1F211.47							$0
						1F211.48							$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
				$57,250	1F211.5	Landscaping							$0
					$30,000	1F211.51	Rain Water Collection/Storage			15,000	gal	$2.00	$30,000
					$20,000	1F211.52	Irrigation			1	LS	$20,000.00	$20,000
					$6,250	1F211.53	Plantings			250	Each	$25.00	$6,250
						1F211.54	Miscellaneous			1	LS	$1,000.00	$1,000
				$275,000	1F211.6	Utilities (On Site)							$0
						1F211.61	Site Water lines			5,000	lf	$15.00	$75,000
						1F211.62	Site Sewer/Septic Systems			1,000	LF		$0
						1F211.63	Site Electrical			5,000	LF	$20.00	$100,000
						1F211.64	Site Gas			5,000	LF	$10.00	$50,000
						1F211.65	Site Phone/Telecommunications			5,000		$10.00	$50,000
						1F211.66							$0
						1F211.67							$0
				$0	1F211.7								$0
				$0	1F211.8								$0
													$0
			$0	1F212	Cask Storage Site Improvements (Public Domain)				INCLUDED IN OPERATIONAL COSTS				$0
						# of Sites	0.00						$0
				$0	1F212.1	Concrete							$0
					$0	1F212.11	General Concrete Work			0	Each	$250,000.00	$0
					$0	1F212.12	Cast in place Perimeter Walls						$0
					$0	1F212.13	Internal Divider Walls						$0
					$0	1F212.16	Main Floor At Grade						$0
					$0	1F212.17	Access Plugs						$0
					$0	1F212.18	Building Super Structure						$0
					$0	1F212.18	Building Roof Structure						$0
					$0	1F212.19	Miscellaneous Facility Concrete						$0
					$0	1F212.19	Cell Walls (Local Fuel Storage & Circulation Cells)						$0
											LS		$0
				$0	1F212.2	Structural Steel							$0
						1F212.21	General Structural Steel Work			0	Each	$100,000.00	$0
						1F212.22	Equipment Support Steel				LS		$0
						1F212.23	Bridge Crane Support Steel/Rail				LF		$0
						1F212.24	Stairs and Handrails				Flights		$0
						1F212.25	Piping support steel				LS		$0
						1F212.26	Miscellaneous steel (Ladders, rails, angles, bollards, etc.)				SF		$0
						1F212.27							$0
						1F212.28							$0
						1F212.29	QA/QC for Structural Steel				LS		$0
				$0	1F212.3	Architectural							$0
						1F212.31	General Architectural Work			0	Each	$25,000.00	$0
						1F212.32	Thermal and Moisture protection/Caulking				SF		$0
						1F212.33	Metal Stud and Drywall						$0
						1F212.34	Painting/Epoxy Coatings				SF		$0
						1F212.34	Epoxy Coatings Floors				SF		$0
						1F212.35	Doors and Hardware				Each		$0
						1F212.36	Insulation				SF		$0
						1F212.37	Accessories				LS		$0
						1F212.38	Expansion Joint Materials				LF		$0
						1F212.39							$0
				$0	1F212.4	Mechanical							$0
					$0	1F212.41	General Mechanical			0	Each	$75,000.00	$0
					$0	1F212.42	Building HVAC (Chilled water from Central Plant)				Tons		$0
					$0	1F212.43	Misc. Sheet metal and Ducting						$0
					$0	1F212.44	Exhaust to filtering systems				Each		$0
						1F212.45	Fire Sprinkler				SF		$0
						1F212.46							$0
				$0	1F212.5	Plumbing							$0
						1F212.51	General Plumbing			0	Each	$15,000.00	$0
						1F212.52	Demineralized Water				LS		$0
						1F212.53	Compressed Air				LS		$0
						1F212.54	Specialty Gasses				LS		$0
						1F212.55	Sanitary Waste				SF		$0
						1F212.56	Storm water systems				SF		$0
						1F212.57	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)				Each		$0
						1F212.58							$0
				$0	1F212.6	Electrical							$0
						1F212.61	General Building Power			0	Each	$25,000.00	$0
						1F212.62	High Bay Lighting				Each		$0
						1F212.63	Below Grade Power Distribution				SF		$0
						1F212.64	Emergency lighting				SF		$0
						1F212.65	Emergency Power Generator				Each		$0
						1F212.66	Bridge Crane Electrical				LS		$0
						1F212.67							$0
				$0	1F212.7	Controls							$0
						1F212.71	General Controls and Monitoring			0	Each	$15,000.00	$0
						1F212.72	Access Controls				Doors		$0
						1F212.73	Security and Monitoring Systems				Cameras		$0
						1F212.74					LS		$0
						1F212.75	Mechanical Controls				SF		$0
						1F212.76	Lighting Controls				SF		$0
						1F212.77	Bridge Crane Controls				LS		$0
						1F212.78							$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F212.79	Contingency Controls				LS		$0
				$0	1F212.8	Miscellaneous							$0
						1F212.81	General Work			0	Each	$25,000.00	$0
						1F212.82							$0
						1F212.83							$0
						1F212.84							$0
						1F212.85							$0
				$0	1F212.9	Contingency				0	Each	$50,000.00	$0
													$0
			$365,565,000	1F213	Storage Pads								$0
						Total SF	6,750,000	SF	450 Pads @ 32 Casks Each @15,000 SF Each				$0
				$270,565,000	1F213.1	Concrete							$0
					$270,565,000	1F213.11	Mat Foundation						$0
							1F213.11.1		Temporary Formwork (100x150)	450,000	SF	$5.00	$2,250,000
							1F213.11.2		Permanent Formwork		SF		$0
							1F213.11.3		Rebar (Top/Bottom Double Mats)	135,000,000	LBS	$0.65	$87,750,000
							1F213.11.4		Embedded Metals		LBS		$0
							1F213.11.5		Structural Concrete (2-3 Foot thick)	578,500	CY	$300.00	$173,550,000
							1F213.11.6		Gravel paths around pads	200,000	CY	$35.00	$7,000,000
							1F213.11.7		Pre-Cast Concrete		SF		$0
							1F213.11.8		Concrete Structural Modules		SF		$0
							1F213.11.9		QA/QC Review & Documentation	1	LS	$15,000.00	$15,000
				$0	1F213.2	Steel							$0
				$0	1F213.3	Architectural							$0
				$0	1F213.4	Mechanical							$0
				$0	1F213.5	Plumbing							$0
				$0	1F213.6	Electrical							$0
				$70,000,000	1F213.7	Controls (Monitoring)			Cask Monitoring	14,000	Each	$5,000.00	$70,000,000
				$0	1F213.8	Miscellaneous							$0
				$25,000,000	1F213.9	Contingency				1	LS	$25,000,000.00	$25,000,000
			$88,715,913	1F213A	Storage pool and structures								$0
						Building Size	33,000		Pool 40x40x40 - Two Each				$0
				$12,259,163	1F213A.1	Concrete							$0
					$876,467	1F213A.11	Mat Foundation				Ft		$0
							1F213A.11.1		Temporary Formwork	960	SF	$5.00	$4,800
							1F213A.11.2		Permanent Formwork/liner	1,600	SF	$25.00	$40,000
							1F213A.11.3		Rebar (Top/Bottom Double Mats)	900,000	LBS	$0.65	$585,000
							1F213A.11.4		Embedded Metals	20,000	LBS	$1.00	$20,000
							1F213A.11.5		Structural Concrete	556	CY	$300.00	$166,667
							1F213A.11.6		Fill Concrete		CY		$0
							1F213A.11.7		Pre-Cast Concrete		SF		$0
							1F213A.11.8		Concrete Structural Modules		SF		$0
							1F213A.11.9		QA/QC Review & Documentation	1	LS	$60,000.00	$60,000
					$2,759,733	1F213A.12	Cast in place Perimeter Walls						$0
							1F213A.12.1		Temporary Formwork	25,600	SF	$5.00	$128,000
							1F213A.12.2		Permanent Formwork/Liner	25,600	SF	$25.00	$640,000
							1F213A.12.3		Rebar	1,536,000	LBS	$0.65	$998,400
							1F213A.12.4		Embedded Metals	40,000	LBS	$1.00	$40,000
							1F213A.12.5		Structural Concrete	2,844	CY	$300.00	$853,333
							1F213A.12.6		Fill Concrete		CY		$0
							1F213A.12.7		Pre-Cast Concrete		SF		$0
							1F213A.12.8		Concrete Structural Modules		SF		$0
							1F213A.12.9		QA/QC Review & Documentation	1	LS	$100,000.00	$100,000
					$0	1F213A.13	Internal Divider Walls						$0
							1F213A.13.1		Temporary Formwork		SF		$0
							1F213A.13.2		Permanent Formwork (SS Liner)				$0
							1F213A.13.3		Rebar		LBS		$0
							1F213A.13.4		Embedded Metals		LBS		$0
							1F213A.13.5		Structural Concrete		CY		$0
							1F213A.13.6		Fill Concrete		CY		$0
							1F213A.13.7		Pre-Cast Concrete		SF		$0
							1F213A.13.8		Concrete Structural Modules		SF		$0
							1F213A.13.9		QA/QC Review & Documentation		LS		$0
					$660,000	1F213A.16	Main Floor At Grade						$0
							1F213A.16.1		Total SF	33,000	LS	$20.00	$660,000
							1F213A.16.2		Forming		SF		$0
							1F213A.16.3		Rebar (4 Mats #1 6"OCEW)		LBS		$0
							1F213A.16.3		Rebar Labor		LBS		$0
							1F213A.16.3		Vert Lacing Bars #6 @ 2ft OCEW		LBS		$0
							1F213A.16.3		Labor for Vert Lacing & J-Bars		LBS		$0
							1F213A.16.4		Rebar Mechanical Ties		Each		$0
							1F213A.16.4		Embedded Metals (Rails)		LBS		$0
							1F213A.16.5		Structural Concrete		CY		$0
							1F213A.16.6		Fill Concrete		CY		$0
							1F213A.16.7		Pre-Cast Concrete		SF		$0
							1F213A.16.8		Concrete Structural Modules		SF		$0
							1F213A.16.9		QA/QC Review & Documentation				$0
					$0	1F213A.17	Access Plugs						$0
							1F213A.17.1		Temporary Formwork		SF		$0
							1F213A.17.2		Permanent Formwork (SS Pans)		SF		$0
							1F213A.17.3		Rebar		LBS		$0
							1F213A.17.3		Rebar Labor		LBS		$0
							1F213A.17.4		Embedded Metals		LBS		$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
							1F213A.17.5		Structural Concrete		CY		$0
							1F213A.17.6		Fill Concrete		CY		$0
							1F213A.17.7		Pre-Cast Concrete		SF		$0
							1F213A.17.8		Concrete Structural Modules		SF		$0
							1F213A.199				LS		$0
					$3,544,074	1F213A.18	Building Super Structure (Hardened)						$0
							1F213A.18.1		Temporary Formwork	72,800	SF	$5.00	$364,000
							1F213A.18.2		Permanent Formwork/liners		SF		$0
							1F213A.18.3		Rebar	3,640,000	Lbs	$0.65	$2,366,000
							1F213A.18.4		Embedded Metals	40,000	LBS	$1.00	$40,000
							1F213A.18.5		Structural Concrete _CIP walls	2,696	CY	$250.00	$674,074
							1F213A.18.5		Structural Concrete-Integral Columns		CY		$0
							1F213A.18.9		QA/QC Review & Documentation	1	LS	$100,000.00	$100,000
					$2,716,111	1F213A.18	Building Roof Structure						$0
							1F213A.18.1		Temporary Formwork	33,000	SF	$10.00	$330,000
							1F213A.18.2		Permanent Formwork Pans	33,000	SF	$15.00	$495,000
							1F213A.18.3		Rebar	1,650,000	Lbs	$0.65	$1,072,500
							1F213A.18.4		Embedded Metals/Beams	20,000	LBS	$1.00	$20,000
							1F213A.18.5		Structural Concrete _CIP Roof	2,444	CY	$250.00	$611,111
							1F213A.18.5		Structural Concrete-Integral Beams	250	CY	$550.00	$137,500
							1F213A.18.9		QA/QC Review & Documentation	1	ls	$50,000.00	$50,000
					$1,702,778	1F213A.19							$0
						1F213A.19	Cell Walls (Local Fuel Storage & Circulation Cells)						$0
							1F213A.19.1		Temporary Formwork	30,000	SF	$5.00	$150,000
							1F213A.19.2		Permanent Formwork(Stainless Liners)		SF		$0
							1F213A.19.3		Rebar	1,500,000	LBS	$0.65	$975,000
							1F213A.19.4		Embedded Metals	20,000	LBS	$10.00	$200,000
							1F213A.19.5		Structural Concrete	1,111	CY	$250.00	$277,778
							1F213A.19.6		Fill Concrete		CY		$0
							1F213A.19.7		Pre-Cast Concrete		SF		$0
							1F213A.19.8		Concrete Structural Modules		SF		$0
							1F213A.19.9		QA/QC Review & Documentation	1	LS	$100,000.00	$100,000
				$667,500	1F213A.2		Structural Steel						$0
						1F213A.21	Superstructure Steel (PIP Concrete) SEE CONCRETE			33,000	SF	$10.00	$330,000
						1F213A.22	Equipment Support Steel			1	LS	$50,000.00	$50,000
						1F213A.23	Bridge Crane Support Steel/Rail			750	LF	$200.00	$150,000
						1F213A.24	Stairs and Handrails			10	Flights	$1,250.00	$12,500
						1F213A.25	Piping support steel			1	LS	$20,000.00	$20,000
						1F213A.26	Miscellaneous steel (Ladders, rails, angles, bollards, etc.)			10,000	SF	$3.00	$30,000
						1F213A.27							$0
						1F213A.28							$0
						1F213A.29	QA/QC for Structural Steel			1	LS	$75,000.00	$75,000
				$608,500	1F213A.3	Architectural							$0
						1F213A.31	Roofing			33,000	SF	$5.00	$165,000
						1F213A.32	Thermal and Moisture protection/Caulking			33,000	SF	$2.00	$66,000
						1F213A.33	Metal Stud and Drywall						$0
						1F213A.34	Painting/Epoxy Coatings			75,000	SF	$2.00	$150,000
						1F213A.34	Epoxy Coatings Floors			33,000	SF	$5.00	$165,000
						1F213A.35	Doors and Hardware			5	Each	$500.00	$2,500
						1F213A.36	Insulation				SF		$0
						1F213A.37	Accessories			1	LS	$50,000.00	$50,000
						1F213A.38	Expansion Joint Materials			1	LS	$10,000.00	$10,000
						1F213A.39							$0
				$5,582,500	1F213A.4	Mechanical							$0
					$0	1F213A.41	Storage Area cooling systems						$0
					$5,000,000	1F213A.42	Building HVAC			1,000	Tons	$5,000.00	$5,000,000
					$500,000	1F213A.43	Misc. Sheet metal and Ducting			1	LS	$500,000.00	$500,000
					$0	1F213A.44	Exhaust to filtering systems				Each		$0
						1F213A.45	Fire Sprinkler			33,000	SF	$2.50	$82,500
						1F213A.46							$0
				$25,100,000	1F213A.5	Plumbing							$0
						1F213A.51	Domestic Water			1	LS	$10,000.00	$10,000
						1F213A.52	Demineralized Water			1	LS	$15,000.00	$15,000
						1F213A.53	Compressed Air			1	LS	$15,000.00	$15,000
						1F213A.54	Specialty Gasses			1	LS	$15,000.00	$15,000
						1F213A.55	Sanitary Waste			1	SF	$10,000.00	$10,000
						1F213A.56	Storm water systems			1	SF	$15,000.00	$15,000
						1F213A.57	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			10	Each	$2,000.00	$20,000
						1F213A.58	Pool Cooling & Filtration			1,000,000	Gallons	$25.00	$25,000,000
				$1,088,250	1F213A.6	Electrical							$0
						1F213A.61	General Building Power			33,000	SF	$10.00	$330,000
						1F213A.62	High Bay Lighting			150	Each	$2,500.00	$375,000
						1F213A.63	Below Grade Power Distribution				SF		$0
						1F213A.64	Emergency lighting			33,000	SF	$0.25	$8,250
						1F213A.65	Emergency Power Generator W Fuel Day Tank			1	Each	$350,000.00	$350,000
						1F213A.66	Bridge Crane Electrical			1	LS	$25,000.00	$25,000
						1F213A.67							$0
				$80,000	1F213A.7	Controls							$0
						1F213A.71	System Controls			1	LS	$50,000.00	$50,000
						1F213A.72	Access Controls				Doors		$0
						1F213A.73	Security and Monitoring Systems				Cameras		$0
						1F213A.74					LS		$0
						1F213A.75	Mechanical Controls				SF		$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F213A.76	Lighting Controls				SF		$0
						1F213A.77	Bridge Crane Controls			1	LS	$15,000.00	$15,000
						1F213A.78							$0
						1F213A.79	Contingency Controls			1	LS	$15,000.00	$15,000
				$43,000,000	1F213A.8	Miscellaneous							$0
						1F213A.81	Bridge Crane			4	Each	$4,500,000.00	$18,000,000
						1F213A.82	Central Plant Capital Cost			1	LS	$25,000,000.00	$25,000,000
						1F213A.83							$0
						1F213A.84							$0
						1F213A.85							$0
				$330,000	1F213A.9	Contingency				33,000	SF	$10.00	$330,000
			$27,742,732	1F213B	Consolidated Storage Facility - Fuel & Cask Handling Building								$0
							33,000	33,000	Total Square Feet				$0
				$9,239,972	1F213B.1	Concrete							$0
					$2,075,417	1F213B.11	Mat Foundation				Ft		$0
							1F213B.11.1		Temporary Formwork	2,250	SF	$5.00	$11,250
							1F213B.11.2		Permanent Formwork		SF		$0
							1F213B.11.3		Rebar (Top/Bottom Double Mats)	1,650,000	LBS	$0.65	$1,072,500
							1F213B.11.4		Embedded Metals	25,000	LBS	$1.00	$25,000
							1F213B.11.5		Structural Concrete	3,667	CY	$250.00	$916,667
							1F213B.11.6		Fill Concrete		CY		$0
							1F213B.11.7		Pre-Cast Concrete		SF		$0
							1F213B.11.8		Concrete Structural Modules		SF		$0
							1F213B.11.9		QA/QC Review & Documentation	1	LS	$50,000.00	$50,000
					$3,152,778	1F213B.12	Cast in place Perimeter Walls						$0
							1F213B.12.1		Temporary Formwork	60,000	SF	$5.00	$300,000
							1F213B.12.2		Permanent Formwork		SF		$0
							1F213B.12.3		Rebar	3,000,000	LBS	$0.65	$1,950,000
							1F213B.12.4		Embedded Metals	50,000	LBS	$1.00	$50,000
							1F213B.12.5		Structural Concrete	2,222	CY	$350.00	$777,778
							1F213B.12.6		Fill Concrete		CY		$0
							1F213B.12.7		Pre-Cast Concrete		SF		$0
							1F213B.12.8		Concrete Structural Modules		SF		$0
							1F213B.12.9		QA/QC Review & Documentation	1	LS	$75,000.00	$75,000
					$0	1F213B.13	Internal Divider Walls						$0
							1F213B.13.1		Temporary Formwork		SF		$0
							1F213B.13.2		Permanent Formwork (SS Liner)				$0
							1F213B.13.3		Rebar		LBS		$0
							1F213B.13.4		Embedded Metals		LBS		$0
							1F213B.13.5		Structural Concrete		CY		$0
							1F213B.13.6		Fill Concrete		CY		$0
							1F213B.13.7		Pre-Cast Concrete		SF		$0
							1F213B.13.8		Concrete Structural Modules		SF		$0
							1F213B.13.9		QA/QC Review & Documentation		LS		$0
					$0	1F213B.16	Main Floor At Grade						$0
							1F213B.16.1		Total SF (less Silo Cover)				$0
							1F213B.16.2		Forming		SF		$0
							1F213B.16.3		Rebar (4 Mats #1 6"OCEW)		LBS		$0
							1F213B.16.3		Rebar Labor		LBS		$0
							1F213B.16.3		Vert Lacing Bars #6 @ 2ft OCEW		LBS		$0
							1F213B.16.3		Labor for Vert Lacing & J-Bars		LBS		$0
							1F213B.16.4		Rebar Mechanical Ties		Each		$0
							1F213B.16.4		Embedded Metals (Rails)		LBS		$0
							1F213B.16.5		Structural Concrete		CY		$0
							1F213B.16.6		Fill Concrete		CY		$0
							1F213B.16.7		Pre-Cast Concrete		SF		$0
							1F213B.16.8		Concrete Structural Modules		SF		$0
							1F213B.16.9		QA/QC Review & Documentation				$0
					$0	1F213B.17	Access Plugs						$0
							1F213B.17.1		Temporary Formwork		SF		$0
							1F213B.17.2		Permanent Formwork (SS Pans)		SF		$0
							1F213B.17.3		Rebar		LBS		$0
							1F213B.17.3		Rebar Labor		LBS		$0
							1F213B.17.4		Embedded Metals		LBS		$0
							1F213B.17.5		Structural Concrete		CY		$0
							1F213B.17.6		Fill Concrete		CY		$0
							1F213B.17.7		Pre-Cast Concrete		SF		$0
							1F213B.17.8		Concrete Structural Modules		SF		$0
							1F213B.199				LS		$0
					$0	1F213B.18	Building Super Structure						$0
							1F213B.18.1		Temporary Formwork		SF		$0
							1F213B.18.2		Permanent Formwork		SF		$0
							1F213B.18.3		Rebar				$0
							1F213B.18.4		Embedded Metals		LBS		$0
							1F213B.18.5		Structural Concrete _CIP walls		CY		$0
							1F213B.18.5		Structural Concrete-Integral Columns		CY		$0
							1F213B.18.9		QA/QC Review & Documentation		ls		$0
					$3,349,556	1F213B.18	Building Roof Structure						$0
							1F213B.18.1		Temporary Formwork	33,000	SF	$10.00	$330,000
							1F213B.18.2		Permanent Formwork Pans	33,000	SF	$15.00	$495,000
							1F213B.18.3		Rebar	2,310,000	Lbs	$0.65	$1,501,500
							1F213B.18.4		Embedded Metals/Beams	50,000	LBS	$0.65	$32,500
							1F213B.18.5		Structural Concrete _CIP Roof	2,444	CY	$350.00	$855,556

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
							1F213B.18.5		Structural Concrete-Integral Beams	100	CY	$350.00	$35,000
							1F213B.18.9		QA/QC Review & Documentation	1	ls	$100,000.00	$100,000
					$662,222	1F213B.19	Miscellaneous Facility Concrete						$0
						1F213B.19	Cell Walls (Local Fuel Storage & Circulation Cells)						$0
							1F213B.19.1		Temporary Formwork	12,000	SF		$0
							1F213B.19.2		Permanent Formwork(Stainless Liners)		SF		$0
							1F213B.19.3		Rebar	600,000	LBS	$0.65	$390,000
							1F213B.19.4		Embedded Metals		LBS		$0
							1F213B.19.5		Structural Concrete	889	CY	$250.00	$222,222
							1F213B.19.6		Fill Concrete		CY		$0
							1F213B.19.7		Pre-Cast Concrete		SF		$0
							1F213B.19.8		Concrete Structural Modules		SF		$0
							1F213B.19.9		QA/QC Review & Documentation	1	LS	$50,000.00	$50,000
				$589,500	1F213B.2								$0
						1F213B.21	Superstructure Steel (PIP Concrete) SEE CONCRETE			33,000	SF	$10.00	$330,000
						1F213B.22	Equipment Support Steel			1	LS	$50,000.00	$50,000
						1F213B.23	Bridge Crane Support Steel/Rail			400	LF	$150.00	$60,000
						1F213B.24	Stairs and Handrails			5	Flights	$1,250.00	$6,250
						1F213B.25	Piping support steel			1	LS	$100,000.00	$100,000
						1F213B.26	Miscellaneous steel (Ladders, rails, angles, bollards, etc.)			33,000	SF	$0.25	$8,250
						1F213B.27							$0
						1F213B.28							$0
						1F213B.29	QA/QC for Structural Steel			1	LS	$35,000.00	$35,000
				$512,508	1F213B.3	Architectural							$0
						1F213B.31	Roofing			33,001	SF	$7.50	$247,508
						1F213B.32	Thermal and Moisture protection/Caulking				SF		$0
						1F213B.33	Metal Stud and Drywall						$0
						1F213B.34	Painting/Epoxy Coatings			60,000	SF	$1.00	$60,000
						1F213B.34	Epoxy Coatings Floors			33,000	SF	$5.00	$165,000
						1F213B.35	Doors and Hardware				Each		$0
						1F213B.36	Insulation				SF		$0
						1F213B.37	Accessories			1	LS	$25,000.00	$25,000
						1F213B.38	Expansion Joint Materials			1	LF	$15,000.00	$15,000
						1F213B.39							$0
				$5,582,503	1F213B.4	Mechanical							$0
					$0	1F213B.41	Storage Area cooling systems				SF		$0
					$5,000,000	1F213B.42	Building HVAC			1,000	Tons	$5,000.00	$5,000,000
					$500,000	1F213B.43	Misc. Sheet metal and Ducting			1	LS	$500,000.00	$500,000
					$0	1F213B.44	Exhaust to filtering systems				Each		$0
						1F213B.45	Fire Sprinkler			33,001	SF	$2.50	$82,503
						1F213B.46							$0
				$320,000	1F213B.5	Plumbing							$0
						1F213B.51	Domestic Water			1	LS	$50,000.00	$50,000
						1F213B.52	Demineralized Water			1	LS	$50,000.00	$50,000
						1F213B.53	Compressed Air			1	LS	$50,000.00	$50,000
						1F213B.54	Specialty Gasses			1	LS	$50,000.00	$50,000
						1F213B.55	Sanitary Waste			1	SF	$50,000.00	$50,000
						1F213B.56	Storm water systems			1	SF	$50,000.00	$50,000
						1F213B.57	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			10	Each	$2,000.00	$20,000
						1F213B.58							$0
				$1,088,250	1F213B.6	Electrical							$0
						1F213B.61	General Building Power			33,000	SF	$10.00	$330,000
						1F213B.62	High Bay Lighting			150	Each	$2,500.00	$375,000
						1F213B.63	Below Grade Power Distribution				SF		$0
						1F213B.64	Emergency lighting			33,000	SF	$0.25	$8,250
						1F213B.65	Emergency Power Generator			1	Each	$350,000.00	$350,000
						1F213B.66	Bridge Crane Electrical			1	LS	$25,000.00	$25,000
						1F213B.67							$0
				$80,000	1F213B.7	Controls							$0
						1F213B.71	System Controls			1	LS	$50,000.00	$50,000
						1F213B.72	Access Controls				Doors		$0
						1F213B.73	Security and Monitoring Systems				Cameras		$0
						1F213B.74					LS		$0
						1F213B.75	Mechanical Controls				SF		$0
						1F213B.76	Lighting Controls				SF		$0
						1F213B.77	Bridge Crane Controls			1	LS	$15,000.00	$15,000
						1F213B.78							$0
						1F213B.79	Contingency Controls			1	LS	$15,000.00	$15,000
				$10,000,000	1F213B.8	Miscellaneous							$0
						1F213B.81	Bridge Crane			1	Each	$10,000,000.00	$10,000,000
						1F213B.82							$0
						1F213B.83							$0
						1F213B.84							$0
						1F213B.85							$0
				$330,000	1F213B.9	Contingency				33,000	SF	$10.00	$330,000
			$402,735,063	1F214	Hot Cell		NQA-1, Seismic 1, Physical Protection 1						$0
							25,000	25,000					$0
				$82,902,563	1F214.1	Concrete							$0
					$11,174,278	1F214.11	Mat Foundation				Ft		$0
							1F214.11.1		Temporary Formwork	1,800	SF	$5.00	$9,000
							1F214.11.2		Permanent Formwork - Floor Stainless Liner	22,500	SF	$100.00	$2,250,000
							1F214.11.3		Rebar (Top/Bottom Double Mats)	1,750,000	LBS	$0.65	$1,137,500
							1F214.11.4		Embedded Metals		LBS		$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
							1F214.11.5		Structural Concrete	2,778	CY	$1,000.00	$2,777,778
							1F214.11.6		Fill Concrete		CY		$0
							1F214.11.7		Pre-Cast Concrete		SF		$0
							1F214.11.8		Concrete Structural Modules		SF		$0
							1F214.11.9		QA/QC Review & Documentation	1	LS	$5,000,000.00	$5,000,000
					$0	1F214.12	Cast in place Perimeter Walls						$0
							1F214.12.1		Temporary Formwork		SF		$0
							1F214.12.2		Permanent Formwork		SF		$0
							1F214.12.3		Rebar		LBS		$0
							1F214.12.4		Embedded Metals		LBS		$0
							1F214.12.5		Structural Concrete		CY		$0
							1F214.12.6		Fill Concrete		CY		$0
							1F214.12.7		Pre-Cast Concrete		SF		$0
							1F214.12.8		Concrete Structural Modules		SF		$0
							1F214.12.9		QA/QC Review & Documentation		LS		$0
					$19,821,111	1F214.13	Internal Divider Walls						$0
							1F214.13.1		Temporary Formwork	50,000	SF	$10.00	$500,000
							1F214.13.2		Permanent Formwork (SS Liner)	50,000	SF	$75.00	$3,750,000
							1F214.13.3		Rebar	5,250,000	Lbs	$0.64	$3,360,000
							1F214.13.4		Embedded Metals	50,000	LBS	$2.00	$100,000
							1F214.13.5		Structural Concrete	7,111	CY	$1,000.00	$7,111,111
							1F214.13.6		Fill Concrete		CY		$0
							1F214.13.7		Pre-Cast Concrete	1	LS	$5,000,000.00	$5,000,000
							1F214.13.8		Concrete Structural Modules		SF		$0
							1F214.13.9		QA/QC Review & Documentation		LS		$0
					$11,265,278	1F214.16	Cast in Place Floors						$0
							1F214.16.1		Temp Forming	20,000	SF	$5.00	$100,000
							1F214.16.2		Permanent Forming	22,500	SF	$100.00	$2,250,000
							1F214.16.3		Rebar (4 Mats #1 6"OCEW)	1,750,000	LBS	$0.65	$1,137,500
							1F214.16.3		Rebar Labor		LBS		$0
							1F214.16.3		Structural Concrete	2,778	CY	$1,000.00	$2,777,778
							1F214.16.3		Fill Concrete		CY		$0
							1F214.16.4		Pre-Cast Concrete		SF		$0
							1F214.16.4		Concrete Structural Modules		SF		$0
							1F214.16.5		QA/QC Review & Documentation	1	LS	$5,000,000.00	$5,000,000
							1F214.16.6				CY		$0
							1F214.16.7				SF		$0
							1F214.16.8				SF		$0
							1F214.16.9						$0
					$0	1F214.17	Access Plugs						$0
							1F214.17.1		Temporary Formwork		SF		$0
							1F214.17.2		Permanent Formwork (SS Pans)		SF		$0
							1F214.17.3		Rebar		LBS		$0
							1F214.17.3		Rebar Labor		LBS		$0
							1F214.17.4		Embedded Metals		LBS		$0
							1F214.17.5		Structural Concrete		CY		$0
							1F214.17.6		Fill Concrete		CY		$0
							1F214.17.7		Pre-Cast Concrete		SF		$0
							1F214.17.8		Concrete Structural Modules		SF		$0
							1F214.199				LS		$0
					$20,056,711	1F214.18	Building Super Structure						$0
							1F214.18.1		Temporary Formwork	102,000	SF	$10.00	$1,020,000
							1F214.18.2		Permanent Formwork/Stainless Liner	48,000	SF	$75.00	$3,600,000
							1F214.18.3		Rebar	5,040,000	Lbs	$0.64	$3,225,600
							1F214.18.4		Embedded Metals	50,000	LBS	$2.00	$100,000
							1F214.18.5		Structural Concrete _CIP walls	7,111	CY	$1,000.00	$7,111,111
							1F214.18.5		Structural Concrete-Integral Columns		CY		$0
							1F214.18.9		QA/QC Review & Documentation	1	LS	$5,000,000.00	$5,000,000
					$10,585,185	1F214.18	Building Roof Structure						$0
							1F214.18.1		Temporary Formwork		SF		$0
							1F214.18.2		Permanent Formwork Pans	25,000	SF	$35.00	$875,000
							1F214.18.3		Rebar	2,625,000	Lbs	$1.00	$2,625,000
							1F214.18.4		Embedded Metals/Beams	50,000	LBS	$2.00	$100,000
							1F214.18.5		Structural Concrete _CIP Roof	3,704	CY	$500.00	$1,851,852
							1F214.18.5		Structural Concrete-Integral Beams	333	CY	$400.00	$133,333
									Labor for Integral Beams		CY		$0
									Pumps and Delivery Mechanism		CY		$0
									Testing (Slump 50CY, Breaks 100CY)		Each		$0
							1F214.18.9		QA/QC Review & Documentation	1	ls	$5,000,000.00	$5,000,000
					$10,000,000	1F214.19	Miscellaneous Facility Concrete						$0
						1F214.19	Cell Walls (Local Fuel Storage & Circulation Cells)			1	LS	$10,000,000.00	$10,000,000
							1F214.19.1		Temporary Formwork		SF		$0
							1F214.19.2		Permanent Formwork(Stainless Liners)		SF		$0
							1F214.19.3		Rebar		LBS		$0
							1F214.19.4		Embedded Metals		LBS		$0
							1F214.19.5		Structural Concrete		CY		$0
							1F214.19.6		Fill Concrete		CY		$0
							1F214.19.7		Pre-Cast Concrete		SF		$0
							1F214.19.8		Concrete Structural Modules		SF		$0
							1F214.19.9		QA/QC Review & Documentation		LS	$3,000,000.00	$0
				$8,857,500	1F214.2	Structural Steel							$0
						1F214.21	Superstructure Steel (PIP Concrete) SEE CONCRETE			25,000	SF	$10.00	$250,000
						1F214.22	Equipment Support Steel			1	LS	$3,000,000.00	$3,000,000

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F214.23	Bridge Crane Support Steel/Rail			300	LF	$150.00	$45,000
						1F214.24	Stairs and Handrails			10	Flights	$1,250.00	$12,500
						1F214.25	Piping support steel			1	LS	$2,000,000.00	$2,000,000
						1F214.26	Miscellaneous steel (Ladders, rails, angles, bollards, etc.)			25,000	SF	$2.00	$50,000
						1F214.27							$0
						1F214.28							$0
						1F214.29	QA/QC for Structural Steel			1	LS	$3,500,000.00	$3,500,000
				$182,905,000	1F214.3	Architectural							$0
						1F214.31	Roofing			25,000	SF	$10.00	$250,000
						1F214.32	Thermal and Moisture protection/Caulking			25,000	SF	$5.00	$125,000
						1F214.33	Metal Stud and Drywall						$0
						1F214.34	Painting/Epoxy Coatings			96,000	SF	$5.00	$480,000
						1F214.34	Leaded Cell Windows			20	Each	$1,500,000.00	$30,000,000
						1F214.35	Manipulators			40	Each	$2,500,000.00	$100,000,000
						1F214.36	Lab Windows and Manipulators			4	Each	$10,000,000.00	$40,000,000
						1F214.37	Accessories			1	LS	$50,000.00	$50,000
						1F214.38	Air Lock			1	LS	$10,000,000.00	$10,000,000
						1F214.39	Specialty Doors			4	Each	$500,000.00	$2,000,000
				$52,500,000	1F214.4	Mechanical							$0
						1F214.41	Storage Area cooling systems				SF		$0
						1F214.42	Building HVAC			1,000	Tons	$15,000.00	$15,000,000
						1F214.43	HEPA Filters			2	Stages	$15,000,000.00	$30,000,000
						1F214.44	Exhaust/ filtering system/Stack			1	LS	$5,000,000.00	$5,000,000
						1F214.45	HALON System			25,000	SF	$100.00	$2,500,000
						1F214.46							$0
				$320,000	1F214.5	Plumbing							$0
						1F214.51	Domestic Water			1	LS	$50,000.00	$50,000
						1F214.52	Demineralized Water			1	LS	$50,000.00	$50,000
						1F214.53	Compressed Air			1	LS	$50,000.00	$50,000
						1F214.54	Specialty Gasses			1	LS	$50,000.00	$50,000
						1F214.55	Sanitary Waste			1	SF	$50,000.00	$50,000
						1F214.56	Storm water systems			1	SF	$50,000.00	$50,000
						1F214.57	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			10	Each	$2,000.00	$20,000
						1F214.58							$0
				$2,775,000	1F214.6	Electrical							$0
						1F214.61	General Building Power			25,000	SF	$25.00	$625,000
						1F214.62	High Bay Lighting			150	Each	$2,500.00	$375,000
						1F214.63	Below Grade Power Distribution			25,000	SF	$5.00	$125,000
						1F214.64	Emergency lighting			25,000	SF	$5.00	$125,000
						1F214.65	Emergency Power Generator			1	Each	$1,500,000.00	$1,500,000
						1F214.66	Bridge Crane Electrical			1	LS	$25,000.00	$25,000
						1F214.67							$0
				$23,975,000	1F214.7	Controls							$0
						1F214.71	System Controls			1	LS	$2,000,000.00	$2,000,000
						1F214.72	Access Controls			1	LS	$1,000,000.00	$1,000,000
						1F214.73	Security and Monitoring Systems			1	LS	$500,000.00	$500,000
						1F214.74	Rad & Criticality Monitoring			1	LS	$20,000,000.00	$20,000,000
						1F214.75	Mechanical Controls			25,000	SF	$15.00	$375,000
						1F214.76	Lighting Controls				SF		$0
						1F214.77	Bridge Crane Controls			1	LS	$50,000.00	$50,000
						1F214.78							$0
						1F214.79	Contingency Controls			1	LS	$50,000.00	$50,000
				$43,500,000	1F214.8	Miscellaneous							$0
						1F214.81	Bridge Crane			1	Each	$10,000,000.00	$10,000,000
						1F214.82	Hot Cell Specialties			1	LS	$10,000,000.00	$10,000,000
						1F214.83	QA/QC throughout			1	LS	$3,500,000.00	$3,500,000
						1F214.84	Hot Cell Labs			4	Each	$5,000,000.00	$20,000,000
						1F214.85							$0
				$5,000,000	1F214.9	Contingency				25,000	SF	$200.00	$5,000,000
			$0	1F215	Transportation Equipment								$0
							See 1F22 - Equipment						$0
				$0	1F215.1	Rail Rolling Stock							$0
					$0	1F215.11	Cask Cars		See 1F22 Equipment	0	Each		$0
					$0	1F215.12	Escort Cars		See 1F22 Equipment	0	Each		$0
					$0	1F215.13	Buffer Cars		See 1F22 Equipment	0	Each		$0
					$0	1F215.16							$0
					$0	1F215.17							$0
				$0	1F215.2	Transportation Casks							$0
						1F215.21	Licensed Shipping Casks		See 1F22 Equipment	0	SF		$0
						1F215.22	Canisters		See 1F22 Equipment	0	LS		$0
						1F215.23					LF		$0
						1F215.24					Flights		$0
						1F215.25					LS		$0
						1F215.26					SF		$0
						1F215.27							$0
						1F215.28							$0
						1F215.29					LS		$0
				$0	1F215.3	Storage Casks and Over packs			See 1F22 Equipment				$0
						1F215.31	**Over pack are in Operational Materials Costs**				SF		$0
						1F215.32	Storage Casks are Originator's Responsibility				Each	$2,800,000.00	$0
						1F215.33							$0
						1F215.34					SF		$0
						1F215.34					SF		$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F215.35					Each		$0
						1F215.36					SF		$0
						1F215.37					LS		$0
						1F215.38					LF		$0
						1F215.39							$0
													$0
			$595,042	1F218A	Control Rooms/Space								$0
				$358,542	1F218.1	Concrete					SF		$0
						1F218.11	Mat Foundation						$0
							1F21811.1		Temporary Formwork	900	SF	$5.00	$4,500
							1F218.11.2		Permanent Formwork		SF		$0
							1F218.11.3		Rebar	0	LBS	$0.65	$0
							1F218.11.4		Embedded Metals	15,000	LBS	$1.00	$15,000
							1F218.11.5		Structural Concrete	0	CY	$250.00	$0
							1F218.11.6		Fill Concrete		CY		$0
							1F218.11.7		Pre-Cast Concrete		SF		$0
							1F218.11.8		Concrete Structural Modules		SF		$0
							1F218.11.9		QA/QC Review & Documentation	1	LS	$20,000.00	$20,000
						1F218.18	Miscellaneous Control Building Concrete/Superstructure						$0
							1F218.18.1		Temporary Formwork	9,000	SF	$5.00	$45,000
							1F218.18.2		Permanent Formwork		SF		$0
							1F218.18.3		Rebar	157,500	LBS	$0.65	$102,375
							1F218.18.4		Embedded Metals	20,000	LBS	$1.00	$20,000
							1F218.18.5		Structural Concrete	333	CY	$350.00	$116,667
							1F218.18.6		Fill Concrete		CY		$0
							1F218.18.7		Poured in place Concrete Roof Structure	0	SF	$30.00	$0
							1F218.18.8		Concrete Structural Modules		SF		$0
							1F218.18.9		QA/QC Review & Documentation	1	LS	$35,000.00	$35,000
				$0	1F218.2	Structural Steel							$0
						1F218.21	Superstructure Steel (Columns/Beams/Decking)						$0
						1F218.22	Equipment Support Steel				LS		$0
						1F218.23	Bridge Crane Support Steel						$0
						1F218.24	Stairs and Handrails				LS		$0
						1F218.25	Piping/Conduit support steel						$0
						1F218.26	Miscellaneous steel			0	SF	$5.00	$0
						1F218.27							$0
						1F218.28							$0
						1F218.29							$0
				$59,000	1F218.3	Architectural							$0
						1F218.31	Roofing			0	SF	$10.00	$0
						1F218.32	Thermal and Moisture protection			0	SF	$3.00	$0
						1F218.33	Metal Stud and Drywall			0	Offices	$15.00	$0
						1F218.34	Painting/Epoxy Coatings			18,000	SF	$0.50	$9,000
						1F218.35	Doors and Hardware			10	Each	$1,500.00	$15,000
						1F218.36	Tile/Stone Surfaces			0	SF	$10.00	$0
						1F218.37	Accessories			1	LS	$10,000.00	$10,000
						1F218.38	Control Cabinetry			1	LS	$25,000.00	$25,000
						1F218.39	Acoustic Ceilings			0	SF	$3.00	$0
				$75,000	1F218.4	Mechanical							$0
						1F218.41							$0
						1F218.42	Building HVAC			15	Tons	$5,000.00	$75,000
						1F218.43	Misc. Sheet metal and Ducting			0	SF	$5.00	$0
						1F218.44	Exhaust Systems			0	SF	$2.00	$0
						1F218.45	Halon System			0	SF	$15.00	$0
						1F218.46							$0
						1F218.47							$0
						1F218.48							$0
						1F218.49							$0
						1F218.4							$0
				$12,500	1F218.5	Plumbing							$0
						1F218.51							$0
						1F218.52	Domestic Water			0	SF	$5.00	$0
						1F218.53	Demineralized Water			0	SF	$3.00	$0
						1F218.54	Compressed Air			0	SF	$2.00	$0
						1F218.55	Specialty Gasses			0	SF	$5.00	$0
						1F218.56	Sanitary Waste			0	SF	$5.00	$0
						1F218.57	Storm water systems			0	SF	$5.00	$0
						1F218.58	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			10	Each	$1,250.00	$12,500
						1F218.59							$0
						1F218.5							$0
				$25,000	1F218.6	Electrical							$0
						1F218.61	General Building Power			0	SF	$15.00	$0
						1F218.62	High Bay Lighting				SF		$0
						1F218.63	Below Grade Power Distribution			0	SF	$5.00	$0
						1F218.64	Emergency lighting			0	SF	$2.50	$0
						1F218.65	Emergency Power			1	LS	$25,000.00	$25,000
						1F218.66							$0
						1F218.67							$0
						1F218.68							$0
						1F218.69							$0
				$65,000	1F218.7	Controls							$0
						1F218.71	Off Site Monitoring			1	LS	$10,000.00	$10,000
						1F218.72	Instrumentation - Control Panels			1	LS	$35,000.00	$35,000

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F218.73	Access Controls			5	Points	$1,500.00	$7,500
						1F218.74	Security and Monitoring Systems			5	Cameras	$2,500.00	$12,500
						1F218.75							$0
						1F218.76	Mechanical Controls			0	SF	$3.00	$0
						1F218.77	Lighting Controls			0	SF	$2.00	$0
						1F218.78							$0
						1F218.79	Contingency Controls				SF	$10.00	$0
				$0	1F218.8	Miscellaneous							$0
						1F218.81							$0
						1F218.82							$0
						1F218.83							$0
				$0	1F218.9	Contingency				0	LS	$10.00	$0
													$0
			$2,749,435	1F218B	Administration Building								$0
							20,000						$0
				$231,185	1F218B.1	Concrete							$0
						1F218B.11	Foundations and Slabs				SF		$0
							1F218B.11.1		Temporary Formwork	1,200	SF	$5.00	$6,000
							1F218B.11.2		Permanent Formwork		SF		$0
							1F218B.11.3		Rebar	20,000	SF	$1.25	$25,000
							1F218B.11.4		Embedded Metals		LBS		$0
							1F218B.11.5		Structural Concrete (IN place)	741	CY	$250.00	$185,185
							1F218B.11.6		Fill Concrete		CY		$0
							1F218B.11.7		Pre-Cast Concrete		SF		$0
							1F218B.11.8		Concrete Structural Modules		SF		$0
							1F218B.11.9		QA/QC Review & Documentation	1	LS	$15,000.00	$15,000
				$440,000	1F218B.2	Structural Steel							$0
						1F218b.21	Superstructure Steel (Columns/Beams/Decking)			20,000	SF	$20.00	$400,000
						1F218B.22	Equipment Support Steel						$0
						1F218B.23	Bridge Crane Support Steel						$0
						1F218B.24	Stairs and Handrails				SF		$0
						1F218B.25	Piping support steel						$0
						1F218B.26	Miscellaneous steel			20,000	SF	$2.00	$40,000
						1F212.27					SF		$0
						1F212.28							$0
						1F212.29							$0
				$928,250	1F218B.3	Architectural							$0
						1F218B.31	Roofing			20,000	SF	$10.00	$200,000
						1F218B.32	Thermal and Moisture protection			20,000	SF	$5.00	$100,000
						1F218B.33	Metal Stud and Drywall			20,000	SF	$10.00	$200,000
						1F218B.34	Painting/Epoxy Coatings			20,000	SF	$3.50	$70,000
						1F218B.34	Floor Coverings			20,000	SF	$7.00	$140,000
						1F218B.35	Doors and Hardware			25	Each	$750.00	$18,750
						1F218B.36	Tile/Stone Surfaces			5,000	SF	$10.00	$50,000
						1F218B.37	Accessories			1	LS	$1,000.00	$1,000
						1F218B.38	Building Skin			1	LS	$35,000.00	$35,000
							Windows			1	LS	$25,000.00	$25,000
							Appliances			1	LS	$1,000.00	$1,000
							Window Coverings			1	LS	$5,000.00	$5,000
							Landscaping			1	LS	$15,000.00	$15,000
							Sidewalks			1	LS	$5,000.00	$5,000
							Parking			25	Cars	$2,500.00	$62,500
													$0
													$0
													$0
				$150,000	1F218B.4	Mechanical							$0
						1F218B.41							$0
						1F218B.42	Building HVAC			40	Tons	$2,500.00	$100,000
						1F218B.43	Misc. Sheet metal and Ducting			20,000	SF	$2.50	$50,000
						1F218B.44	Halon System - Simulator				SF		$0
						1F218B.45							$0
				$390,000	1F218B.5	Plumbing							$0
						1F218B.51	Domestic Water			20,000	SF	$5.00	$100,000
						1F218B.52	Demineralized Water			20,000	SF	$0.00	$0
						1F218B.53	Compressed Air			20,000	SF	$0.00	$0
						1F218B.54	Specialty Gasses			20,000	SF	$0.00	$0
						1F218B.55	Sanitary Waste			20,000	SF	$3.00	$60,000
						1F218B.56	Storm water systems			20,000	SF	$5.00	$100,000
						1F218B.57	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			40	Each	$1,500.00	$60,000
						1F218B.58	Fire Protection			20,000	SF	$3.50	$70,000
						1F218B.59							$0
						1F218B.5							$0
				$410,000	1F218B.6	Electrical	General Building Power			20,000	SF	$10.00	$200,000
						1F218B.61	Building Lighting			20,000	SF	$5.00	$100,000
						1F218B.62	Below Grade Power Distribution			20,000	SF	$3.00	$60,000
						1F218B.63	Emergency lighting			20,000	SF	$2.00	$40,000
						1F218B.64	Emergency Power			1	LS	$10,000.00	$10,000
						1F218B.65							$0
						1F218B.66							$0
						1F218B.67							$0
						1F218B.68							$0
						1F218B.69							$0
				$0	1F218B.7	Controls							$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F218B.71	Off Site Monitoring						$0
						1F218B.72	instrumentation - Control Panels						$0
						1F218B.73	Access Controls				Points		$0
						1F218B.74	Security and Monitoring Systems				Cameras		$0
						1F218B.75							$0
						1F218B.76	Mechanical Controls				SF		$0
						1F218B.77	Lighting Controls				SF		$0
						1F218B.78							$0
						1F218B.79							$0
				$0	1F218B.8	Miscellaneous							$0
						1F218B.81							$0
						1F218B.82							$0
						1F218B.83							$0
				$200,000	1F218B.9	Contingency				20,000	LS	$10.00	$200,000
													$0
			$7,862,111	1F218C	Cask Maintenance Facility			10,500					$0
													$0
				$229,361	1F218C.1	Concrete							$0
						1F218C.11	Mat Foundation						$0
							1F218C.11		Temporary Formwork	8,000	SF	$5.00	$40,000
							1F218C.11		Permanent Formwork		SF		$0
							1F218C.11		Rebar	105,000	LBS	$0.65	$68,250
							1F218C.11		Embedded Metals		LBS		$0
							1F218C.11		Structural Concrete	370	CY	$300.00	$111,111
							1F218C.11		Fill Concrete		CY		$0
							1F218C.11		Pre-Cast Concrete		SF		$0
							1F218C.11		Concrete Structural Modules		SF		$0
							1F212.11		QA/QC Review & Documentation	1	LS	$10,000.00	$10,000
						1F218C.12	Walls						$0
							1F218C.12		Temporary Formwork		SF		$0
							1F218C.12		Permanent Formwork		SF		$0
							1F218C.12		Rebar		LBS		$0
							1F218C.12		Embedded Metals		LBS		$0
							1F218C.12		Structural Concrete		CY		$0
							1F218C.12		Fill Concrete		CY		$0
							1F218C.12		Pre-Cast Concrete		SF		$0
							1F218C.12		Concrete Structural Modules		SF		$0
							1F218C.12		QA/QC Review & Documentation		LS		$0
						1F218C.13	Hard Lids						$0
							1F218C.13		Temporary Formwork		SF		$0
							1F218C.13		Permanent Formwork		SF		$0
							1F218C.13		Rebar		LBS		$0
							1F218C.13		Embedded Metals		LBS		$0
							1F218C.13		Structural Concrete		CY		$0
							1F218C.13		Fill Concrete		CY		$0
							1F218C.13		Pre-Cast Concrete		SF		$0
							1F218C.13		Concrete Structural Modules		SF		$0
							1F218C.13		QA/QC Review & Documentation		LS		$0
				$525,000	1F218C.2	Structural Steel							$0
						1F218C.21	Superstructure Steel (Columns/Beams/Decking)			10,500	SF	$50.00	$525,000
						1F218C.22	Equipment Support Steel						$0
						1F218C.23	Bridge Crane Support Steel						$0
						1F218C.24	Stairs and Handrails						$0
						1F218C.25	Piping support steel						$0
						1F218C.26	Miscellaneous steel						$0
													$0
													$0
													$0
				$171,250	1F218C.3	Architectural							$0
						1F218C.31	Roofing			10,500	SF	$7.50	$78,750
						1F218C.32	Thermal and Moisture protection			10,500	SF	$2.00	$21,000
						1F218C.33	Metal Stud and Drywall						$0
						1F218C.34	Painting/Epoxy Coatings			10,500		$1.00	$10,500
						1F218C.35	Doors and Hardware			10	Each	$750.00	$7,500
						1F218C.36	Tile/Stone Surfaces						$0
						1F218C.37	Accessories			1	LS	$1,000.00	$1,000
							Epoxy Floors			10,500	SF	$5.00	$52,500
													$0
				$525,000	1F218C.4	Mechanical							$0
						1F218C.41							$0
						1F218C.42	Building HVAC			210	Tons	$2,500.00	$525,000
						1F218C.43	Misc. Sheet metal and Ducting				SF		$0
						1F218C.44							$0
				$229,500	1F218C.5	Plumbing							$0
						1F218C.5	Domestic Water			10,500	SF	$2.00	$21,000
						1F218C.5	Demineralized Water			10,500	SF	$3.00	$31,500
						1F218C.5	Compressed Air			10,500	SF	$3.00	$31,500
						1F218C.5	Specialty Gasses			10,500	SF	$3.00	$31,500
						1F218C.5	Sanitary Waste			10,500	SF	$2.00	$21,000
						1F218C.5	Storm water systems			10,500	SF	$3.00	$31,500
						1F218C.5	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			20	Each	$1,500.00	$30,000
						1F218C.5	Fire Protection			10,500	SF	$3.00	$31,500
						1F218C.5							$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F218C.5							$0
				$126,000	1F218C.6	Electrical	General Building Power			10,500	SF	$5.00	$52,500
						1F218C.6	Building Lighting			10,500	SF	$2.00	$21,000
						1F218C.6	Below Grade Power Distribution			10,500	SF	$2.00	$21,000
						1F218C.6	Emergency lighting			10,500	SF	$1.00	$10,500
						1F218C.6	Emergency Power			10,500	LS	$2.00	$21,000
						1F218C.6							$0
						1F218C.6							$0
						1F218C.6							$0
						1F218C.6							$0
						1F218C.6							$0
				$31,000	1F218C.7	Controls							$0
						1F218C.7	Off Site Monitoring						$0
						1F218C.7	instrumentation - Control Panels						$0
						1F218C.7	Access Controls			4	Points	$1,500.00	$6,000
						1F218C.7	Security and Monitoring Systems			10	Cameras	$2,500.00	$25,000
						1F218C.7							$0
						1F218C.7	Mechanical Controls				SF		$0
						1F218C.7	Lighting Controls				SF		$0
						1F218C.7							$0
						1F212.79							$0
				$5,500,000	1F218C.8	Miscellaneous							$0
						1F218C.8	Crane			1	LS	$5,000,000.00	$5,000,000
						1F218C.8	Testing/Service Equipment			1	LS	$500,000.00	$500,000
						1F218C.8							$0
				$525,000	1F218C.9	Contingency				10,500	LS	$50.00	$525,000
													$0
			$2,500,000	1F218D	Entry Control Building (80x120)					10,000	SF	$250.00	$2,500,000
			$627,200	1F218E	Visitor Center (56x56)					3,136	SF	$200.00	$627,200
			$9,776,815	1F218W	Fleet Management Facility								$0
							47,500	SF					$0
				$763,565	1F218W.1	Concrete							$0
						1F218W.11	Mat Foundation						$0
							1F218W.11		Temporary Formwork		SF		$0
							1F218W.11		Permanent Formwork		SF		$0
							1F218W.11		Rebar	475,000	LBS	$0.65	$308,750
							1F218W.11		Embedded Metals		LBS		$0
							1F218W.11		Structural Concrete	1,759	CY	$250.00	$439,815
							1F218W.11		Fill Concrete		CY		$0
							1F218W.11		Pre-Cast Concrete		SF		$0
							1F218W.11		Concrete Structural Modules		SF		$0
							1F212.11		QA/QC Review & Documentation	1	LS	$15,000.00	$15,000
						1F218W.12	Walls	Steel					$0
						1F218W.13	Hard Lids	Steel					$0
				$1,187,500	1F218W.2	Structural Steel							$0
						1F218W.21	Superstructure Steel (Columns/Beams/Decking/Walls)			47,500	SF	$25.00	$1,187,500
						1F218W.22	Equipment Support Steel						$0
						1F218W.23	Bridge Crane Support Steel						$0
						1F218W.24	Stairs and Handrails						$0
						1F218W.25	Piping support steel						$0
						1F218W.26	Miscellaneous steel						$0
													$0
													$0
													$0
				$961,000	1F218W.3	Architectural							$0
						1F218W.31	Roofing			47,500	SF	$7.50	$356,250
						1F218W.32	Thermal and Moisture protection			47,500	SF	$2.00	$95,000
						1F218W.33	Metal Stud and Drywall						$0
						1F218W.34	Painting/Epoxy Coatings						$0
						1F218W.34	Floor Epoxy			47,500	SF	$5.00	$237,500
						1F218W.35	Doors and Hardware			25	Each	$750.00	$18,750
						1F218W.36	Tile/Stone Surfaces						$0
						1F218W.37	Accessories			1	LS	$1,000.00	$1,000
						1F218W.38	Overhead Doors			6	Each	$2,500.00	$15,000
							Siding System			47,500	SF	$5.00	$237,500
				$2,470,000	1F218W.4	Mechanical							$0
						1F218W.41							$0
						1F218W.42	Building HVAC			950	Tons	$2,500.00	$2,375,000
						1F218W.43	Misc. Sheet metal and Ducting			47,500	SF	$2.00	$95,000
						1F218W.44							$0
													$0
				$561,250	1F218W.5	Plumbing							$0
						1F218W.5	Domestic Water			47,500	SF	$2.00	$95,000
						1F218W.5	Demineralized Water				SF		$0
						1F218W.5	Compressed Air			47,500	SF	$1.50	$71,250
						1F218W.5	Specialty Gasses				SF		$0
						1F218W.5	Sanitary Waste			47,500	SF	$2.00	$95,000
						1F218W.5	Storm water systems			47,500	SF	$3.00	$142,500
						1F218W.5	Plumbing Fixtures (Toilers, Lavs, Urinals, Water Fountains)			10	Each	$1,500.00	$15,000
						1F218W.5	Fire Protection			47,500	SF	$3.00	$142,500
						1F218W.5							$0
						1F218W.5							$0
				$522,500	1F218W.6	Electrical	General Building Power			47,500	SF	$5.00	$237,500

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F218W.6	Building Lighting			47,500	SF	$2.00	$95,000
						1F218W.6	Below Grade Power Distribution			47,500	SF	$2.00	$95,000
						1F218W.6	Emergency lighting			47,500	SF	$1.00	$47,500
						1F218W.6	Emergency Power			47,500	LS	$1.00	$47,500
						1F218W.6							$0
						1F218W.6							$0
						1F218W.6							$0
						1F218W.6							$0
						1F218W.6							$0
				$31,000	1F218W.7	Controls							$0
						1F218W.7	Off Site Monitoring						$0
						1F218W.7	instrumentation - Control Panels						$0
						1F218W.7	Access Controls			4	Points	$1,500.00	$6,000
						1F218W.7	Security and Monitoring Systems			10	Cameras	$2,500.00	$25,000
						1F218W.7							$0
						1F218W.7	Mechanical Controls				SF		$0
						1F218W.7	Lighting Controls				SF		$0
						1F218W.7							$0
						1F212.79							$0
				$1,780,000	1F218W.8	Miscellaneous							$0
						1F218W.8	Crane/Hoisting Equipment			1	LS	$1,250,000.00	$1,250,000
						1F218W.8	Warehouse Forklift			1	LS	$30,000.00	$30,000
						1F218W.8	Testing/Service equipment			1	LS	$500,000.00	$500,000
													$0
				$1,500,000	1F218W.9	Contingency				1	LS	$1,500,000.00	$1,500,000
			$58,752,800	1F218X	Railroad Tracks								$0
					$45,896,800	1F218X.32	Off- Site Rail (Single Rail w/Two Sidings)			0			$0
							1F218X.321	Excavation and Grading (Avg 3 Ft Excavation)		132,000	CY	$5.00	$660,000
							1F218X.322	Culverts and Water Controls		100	Each	$5,000.00	$500,000
							1F218X.323	Bed Preparation		132,000	SY	$5.00	$660,000
							1F218X.324	Rails/Ballast		79,200	LF	$450.00	$35,640,000
							1F218X.325	Signals/Communications		15	Miles	$10,000.00	$150,000
							1F218X.326	Switches & Sidings		15,840	LF	$450.00	$7,128,000
							1F218X.327	Tie in to Main Rail line		1	Each	$50,000.00	$50,000
							1F218X.328	Livestock Fencing		158,400	LF	$7.00	$1,108,800
					$12,856,000	1F218X.34	On Site Rail (Dependent on size of Site)						$0
							1F218X.341	Excavation and Grading		33,000	CY	$5.00	$165,000
							1F218X.342	Culverts and Water Controls		15	Each	$5,000.00	$75,000
							1F218X.343	Bed Preparation		33,000	SY	$4.00	$132,000
							1F218X.344	Rails/Ballast		26,400	LF	$450.00	$11,880,000
							1F218X.345	Signals/Communications		1	LS	$10,000.00	$10,000
							1F218X.346	Siding and Switches		1,320	LF	$450.00	$594,000
			$18,212,737	1F218Y	Roads and Paved Areas								$0
					$18,046,453	1A218Y1.1	Off-Site Road (20 Miles, 24 Ft Wide)			0		$1.00	$0
							1A218Y1.1	Excavation and Grading (Avg 3 Ft Excavation)		352,000	CY	$3.00	$1,056,000
							1A218Y1.1	Culverts and Water Controls		200	Each	$2,500.00	$500,000
							1A218Y1.1	Road Bed Preparation		328,533	SY	$3.00	$985,600
							1A218Y1.1	Paving (6 in AC over 10 Compacted ABC)		328,533	SY	$40.00	$13,141,333
							1A218Y1.1	Rip Rap		200	Each	$500.00	$100,000
							1A218Y1.1	Revegitation		1,056,000	SF	$0.75	$792,000
							1A218Y1.1	Barriers		10,000	LF	$35.00	$350,000
							1A218Y1.1	Striping and Signage		422,400	LF	$0.30	$126,720
							1A218Y1.1	Livestock Fencing		211,200	LF	$4.00	$844,800
							1A218Y1.1	Cattle Guards		60	Each	$2,500.00	$150,000
					$166,283	1A218Y.2	On Site Roads (Dependent on size of Site)			500	LF		$0
							1A218Y.2	Excavation and Grading		1,667	CY	$3.00	$5,000
							1A218Y.2	Culverts and Water Controls		20	Each	$2,500.00	$50,000
							1A218Y.2	Road Bed Preparation		1,667	SY	$3.00	$5,000
							1A218Y.2	Paving 6"AC on 10"ABC		1,333	SY	$40.00	$53,333
							1A218Y.2	Rip Rap		20	Each	$500.00	$10,000
							1A218Y.2	Revegitation		10,000	SF	$0.75	$7,500
							1A218Y.2	Barriers		1,000	LF	$35.00	$35,000
							1A218Y.2	Striping and Signage		1,500	LF	$0.30	$450
		$796,900,000	1F22	Equipment									$0
			$796,900,000	1F221	Cask Canisters & fuel Handling Equipment								$0
				$796,900,000	1F221.1	Fuel Transport Equipment							$0
						1F221.11	Transportation Casks			145	Each	$4,900,000.00	$710,500,000
						1F221.11	Transportation Truck Casks			18	Each	$4,800,000.00	$86,400,000
						1F221.11	Storage Casks		INCLUDED IN OPERATIONAL COSTS	0	Each	$3,052,000.00	$0
						1F221.12	Canisters		INCLUDED IN OPERATIONAL COSTS	0	Each	$800,000.00	$0
						1F221.13	Purchased Over packs		INCLUDED IN OPERATIONAL COSTS	0	Each	$300,000.00	$0
				$0	1F221.8	Contingency - Equipment					MWt		$0
		$614,845,000	1F22A	**Consolidated Storage Facility Equipment**									$0
				$0	1F22A.1	Casks					Each		$0
						1F22A.11	Casks		INCLUDED IN OPERATIONAL COSTS	0	Each	$3,052,000.00	$0
						1F22A.12	Over packs (Part of Operational Costs)						$0
						1F22A.13					Each		$0
				$0	1F22A.2	Canisters							$0
						1F22A.21	Canisters (Replacements for Leakers		INCLUDED IN OPERATIONAL COSTS	0	each	$800,000.00	$0
						1F22A.22					Each		$0
						1F22A.23					Each		$0
						1F22A.24					Each		$0
				$148,000,000	1F22A.3	Storage Racking systems/Pool Liners							$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
						1F22A.3	Rack Systems			2	Each	$42,000,000.00	$84,000,000
						1F22A.3	Pool Liners			2	Each	$32,000,000.00	$64,000,000
						1F22A.3							$0
				$0	1F221.2								$0
						1F221.21							$0
						1F221.22							$0
						1F221.23							$0
						1F221.24							$0
				$0	1F221.3	Storage Racking systems (By Originating Utility							$0
						1F221.3	Pool Racking Systems				Each		$0
						1F221.3							$0
						1F221.3							$0
				$10,000,000	1F221.4	Hoisting Equipment				1	LS	$10,000,000.00	$10,000,000
				$0	1F221.5						Each		$0
				$0	1F221.6						Each		$0
					1F221.7								$0
				$0	1F22A.4	Rail Equipment							$0
				$0	1F22A.5	Miscellaneous Equipment					Each		$0
				$0	1F22A.6						Each		$0
					1F22A.7								$0
				$0	1F22A.8	Contingency - Equipment					MWt		$0
			$90,000,000	1F223	Hot Cell Equipment								$0
				$50,000,000	1F223.1	Misc. Hot Cell Equipment				1	LS	$50,000,000.00	$50,000,000
				$40,000,000	1F223.2	Hot Cell Labs				4	Each	$10,000,000.00	$40,000,000
				$0	1F223.3								$0
				$0	1F223.4								$0
				$0	1F223.5								$0
				$0	1F223.6								$0
				$0	1F223.7								$0
				$0	1F223.8								$0
				$0	1F223.9								$0
				$0	1F223								$0
			$341,845,000	1F224	Rail Equipment								$0
				$145,725,000	1F224.1		Cask Cars			145	Each	$1,005,000.00	$145,725,000
				$44,370,000	1F224.2		Buffer Cars			58	Each	$765,000.00	$44,370,000
				$147,900,000	1F224.3		Escort Cars			29	Each	$5,100,000.00	$147,900,000
				$2,250,000	1F224.4		Yard Locomotives/Switchers			3	Each	$750,000.00	$2,250,000
				$1,600,000	1F224.5		Truck Equipment			1	LS	$1,600,000.00	$1,600,000
				$0	1F224.6								$0
				$0	1F224.7								$0
				$0	1F224.8								$0
				$0	1F224.9								$0
			$0	1F227									$0
			$0	1F228	Plant Maintenance Equipment								$0
			$25,000,000	1F229	Contingency Equipment					1	LS	$25,000,000.00	$25,000,000
		$14,850,000	**1F24**	**Electrical Equipment**									$0
			$3,375,000	1F241	Switchgear					1	LS	$3,375,000.00	$3,375,000
			$2,025,000	1F242	Sub-Station Service Equipment					1	LS	$2,025,000.00	$2,025,000
			$4,050,000	1F243	Transformers					1	LS	$4,050,000.00	$4,050,000
			$2,025,000	1F244	Protective Systems Equipment					1	LS	$2,025,000.00	$2,025,000
			$1,350,000	1F245	Electrical Raceway Systems					1	LS	$1,350,000.00	$1,350,000
			$2,025,000	1F246	Power and Control Cables and Wiring					1	LS	$2,025,000.00	$2,025,000
				1F247						1			$0
				1F248						1			$0
		$39,500,000	**1F25**	**Heat Rejection Equipment**									$0
			$15,000,000	1F251	Piping Systems					1	LS	$15,000,000.00	$15,000,000
			$20,000,000	1F252	Fuel Pool Cooling Systems					2	Each	$10,000,000.00	$20,000,000
			$4,500,000	1F253	Miscellaneous Equipment					1	L:S	$4,500,000.00	$4,500,000
			$0	1F254						0		$0.00	$0
			$0	1F255						0		$0.00	$0
			$0	1F256						0		$0.00	$0
			$0	1F257						0		$0.00	$0
			$0	1F258						0		$0.00	$0
				1F259						0			$0
		$17,000,000	**1F26**	**Miscellaneous Equipment**						0		$1.00	$0
			$1,000,000	1F261	Transportation and Lift Equipment					1	LS	$1,000,000.00	$1,000,000
			$2,500,000	1F262	Air Water Plant Fuel Oil and Steam Service Systems					1	LS	$2,500,000.00	$2,500,000
			$1,000,000	1F263	Communication Equipment					1	LS	$1,000,000.00	$1,000,000
			$500,000	1F264	Furnishings and Fixtures					1	LS	$500,000.00	$500,000
			$6,000,000	1F265	Cask Transporters					3	Each	$2,000,000.00	$6,000,000
			$6,000,000	1F266	NUHOMS Transporters					3	Each	$2,000,000.00	$6,000,000
			$0	1F267						0		$1.00	$0
			$0	1F268						0		$1.00	$0
		$0	**1F27**	**Special Materials**									$0
			$0	1F271									$0
			$0	1F272									$0
			$0	1F273									$0
			$0	1F274									$0
			$0	1F275									$0
			$0	1F276									$0
				1F277									$0
		$0	**1F28**	**Simulator**									$0
			$0	1F281							LS		$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	**Quantity**	**Unit**	**Unit Rate**	**Total**
			$0	1F282							LS		$0
			$0	1F283									$0
			$0	1F284									$0
			$0	1F285									$0
			$0	1F286									$0
			$0	1F287									$0
			$0	1F288									$0
				1F289									$0
		$0	1F29	**Contingency on Direct Costs**									$0
			$0	1F291							LS		$0
			$0	1F292							LS		$0
			$0	1F293							LS		$0
			$0	1F294							LS		$0
			$0	1F295							LS		$0
			$0	1F296							LS		$0
			$0	1F297							LS		$0
			$0	1F298							LS		$0
			$0	1F299									$0
													$0
													$0
Direct Construction Costs													$0
$2,806,035,075													$0
Construction Duration (months)	**$285,480,000**	1F30	Capitalized Field Indirect Services Costs			Three Separate Construction Phases 3 Years each							$0
		$65,160,000	1F31	Field Indirect Costs									$0
			$4,680,000	1F311	Temporary Facilities								$0
					1F311	Access Control/Guard Stations				120	Months	$1,000.00	$120,000
					1F311	Office Space				120	Months	$15,000.00	$1,800,000
					1F311	Warehouse/Storage				120	Months	$10,000.00	$1,200,000
					1F311	Temp Fencing				120	Months	$3,000.00	$360,000
					1F311	Break Facilities				120	Months	$10,000.00	$1,200,000
					1F311								$0
					1F311								$0
			$3,300,000	1F312	Temporary Utilities								$0
					1F312	Electricity				120	Months	$3,000.00	$360,000
					1F312	Water				120	Months	$2,000.00	$240,000
					1F312	Gas				120	Months	$2,000.00	$240,000
					1F312	Phone				120	Months	$3,500.00	$420,000
					1F312	Internet				120	Months	$2,000.00	$240,000
					1F312	Restroom Facilities				120	Months	$1,000.00	$120,000
					1F312	Chemical Toilets				120	Months	$2,000.00	$240,000
					1F312	Trash Removal/Dumpsters				120	Months	$3,500.00	$420,000
					1F312	Bottled Gasses				120	Months	$5,000.00	$600,000
					1F312	Drinking Water and Cups				120	Months	$3,500.00	$420,000
					1F312								$0
					1F312								$0
					1F312								$0
			$5,400,000	1F313	Vehicles								$0
					1F313	Superintendent				120	Months	$2,500.00	$300,000
					1F313	Field Engineers				600	Months	$2,500.00	$1,500,000
					1F313	General Motor Pool				120	Months	$5,000.00	$600,000
					1F313	Medical EMT				120	Months	$3,500.00	$420,000
					1F313	Gas and Oil				120	Months	$2,500.00	$300,000
					1F313	Maintenance/Repair				120	Months	$3,500.00	$420,000
					1F313	ATVs for on-site access				120	Months	$3,500.00	$420,000
					1F313	Vehicle insurance				120	Months	$2,000.00	$240,000
					1F313	Emergency Rescue Vehicles				120	Months	$5,000.00	$600,000
					1F313	Vehicle Cleaning				120	Months	$2,000.00	$240,000
					1F313	Fire Truck(s)				120	Months	$3,000.00	$360,000
			$9,660,000	1F314	Cleaning & Janitorial								$0
					1F314	Janitorial Service				120	Months	$3,500.00	$420,000
					1F314	Daily Cleanup Labor				600	M.Months	$7,500.00	$4,500,000
					1F314	Site Cleanup Labor				600	M.Months	$7,500.00	$4,500,000
					1F314	Cleaning Supplies				120	Months	$2,000.00	$240,000
					1F314								$0
					1F314								$0
					1F314								$0
					1F314								$0
			$3,300,000	1F315	Safety Services								$0
					1F316	Fire Extinguisher Service				120	Months	$1,000.00	$120,000
					1F316	Air Quality monitors				120	Months	$2,500.00	$300,000
					1F316	Firs Aid Kits				120	Months	$1,000.00	$120,000
					1F316	AED's (Defibrillators)				120	Months	$500.00	$60,000
					1F316	On Site Medical Station				120	Months	$10,000.00	$1,200,000
					1F316	Personal Safety Equipment				120	Months	$5,000.00	$600,000
					1F316	Safety Signage				120	Months	$2,500.00	$300,000
					1F316	Safety Education				120	Months	$5,000.00	$600,000
			$23,220,000	1F316	Security Services								$0
					1F316	Security Patrol				120	Months	$150,000.00	$18,000,000
					1F316	Armory				120	Months	$2,500.00	$300,000
					1F316	Security Vehicles				120	Months	$10,000.00	$1,200,000
					1F316	Surveillance Service				120	Months	$5,000.00	$600,000
					1F316	Name Tags				120	Months	$1,000.00	$120,000
					1F316	General Procedures Training				120	Months	$5,000.00	$600,000

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
					1F316	Access Controls				120	Months	$10,000.00	$1,200,000
					1F316	Security Force Training				120	Months	$10,000.00	$1,200,000
					1F316								$0
			$8,640,000	1F317	Material handling/Shipping & Receiving								$0
					1F317	Receipt inspection				120	Months	$10,000.00	$1,200,000
					1F317	Inventory Control				120	Months	$10,000.00	$1,200,000
					1F317	Procedures Development				120	Months	$15,000.00	$1,800,000
					1F317	Periodic Inspection and Cleaning				120	Months	$5,000.00	$600,000
					1F317	Documentation Controls for QC Records				120	Months	$2,000.00	$240,000
					1F317					120	Months	$30,000.00	$3,600,000
					1F317								$0
					1F317								$0
					1F317								$0
			$5,400,000	1F318	Equipment								$0
					1F318	Fork Lift				120	Months	$15,000.00	$1,800,000
					1F318	Crane				120	Months	$30,000.00	$3,600,000
					1F318								$0
					1F318								$0
					1F318								$0
					1F318								$0
					1F318								$0
			$1,560,000	1F319	Office Supplies								$0
					1F319	Furniture				120	Months	$5,000.00	$600,000
					1F319	Computers				120	Months	$5,000.00	$600,000
					1F319	Copiers				120	Months	$1,000.00	$120,000
					1F319	Paper				120	Months	$500.00	$60,000
					1F319	Postage/Courier				120	Months	$500.00	$60,000
					1F319	Coffee/Drinks/Snacks				120	Months	$500.00	$60,000
					1F319	Miscellaneous				120	Months	$500.00	$60,000
					1F319								$0
					1F319								$0
					1F319								$0
				1F319									$0
		$57,960,000	1F32	Construction Supervision			120	Months					$0
				1F321	Construction Management					360	M.Months	$20,833.33	$7,500,000
				1F322	Project Engineers					600	M.Months	$10,000.00	$6,000,000
				1F323	Document Control					600	M.Months	$7,500.00	$4,500,000
				1F324	Project Control Specialists					600	M.Months	$6,500.00	$3,900,000
				1F325	Testing Lab					120	Months	$10,000.00	$1,200,000
				1F326	Inspectors					600	M.Months	$15,000.00	$9,000,000
				1F327	Field QC					1,200	M.Months	$12,500.00	$15,000,000
				1F328	Design Liaison					600	M.Months	$12,500.00	$7,500,000
				1F329	Administrative Assistance					480	M.Months	$7,000.00	$3,360,000
				1F32		Total Personnel		43					$0
				1F32									$0
		$7,680,000	1F33	Commissioning and Start up Costs			12	Months					$0
				1F33	Management					24	M.Months	$20,000.00	$480,000
				1F33	Engineers					120	M.Months	$15,000.00	$1,800,000
				1F33	Operators (Included in Operational Costs)						M.Months	$10,000.00	$0
				1F33	NRC Interface					72	M.Months	$15,000.00	$1,080,000
				1F33	Security Force (Included in Operational Costs)						M.Months		$0
				1F33	Design Liaison					120	M.Months	$15,000.00	$1,800,000
				1F33	Updated Analyses					120	M.Months	$15,000.00	$1,800,000
				1F33	NRC Fee			41		36	Months	$20,000.00	$720,000
				1F33									$0
				1F33									$0
				1F33									$0
		$2,280,000	1F34	Demonstration Test Run			12	Months					$0
				1F34	Management					24	M.Months	$20,000.00	$480,000
				1F34	Engineers					120	M.Months	$15,000.00	$1,800,000
				1F34	Operators (Included in Operational Costs)						M.Months		$0
				1F34	Security Force (Included in Operational Costs)						M.Months		$0
								12					$0
		$38,400,000	1F35	Design Services Off Site			120	Months					$0
				1F35	Management					240	M.Months	$25,000.00	$6,000,000
				1F35	Engineering-Civil/Structural					1,200	M.Months	$15,000.00	$18,000,000
				1F35	Stress Analysis					480	M.Months	$15,000.00	$7,200,000
				1F35	Radiological					480	M.Months	$15,000.00	$7,200,000
				1F35				20					$0
		$22,800,000	1F36	PM/CM Services Off Site			120	Months					$0
				1F36	Management					240	M.Months	$25,000.00	$6,000,000
				1F36	Cost Controls					960	M.Months	$10,000.00	$9,600,000
				1F36	Scheduling					720	M.Months	$10,000.00	$7,200,000
				1F36									$0
				1F36				16					$0
				1F36									$0
		$60,000,000	1F37	Design Services On Site			120	Months					$0
				1F37	Management					240	Months	$25,000.00	$6,000,000
				1F37	Engineers					1,200	Months	$15,000.00	$18,000,000
				1F37	Stress Analysis					1,200	Months	$15,000.00	$18,000,000
				1F37	MPE					1,200	Months	$15,000.00	$18,000,000
				1F37				32					$0
				1F37									$0

Detailed Breakdown of Costs from COA in DOE Guidelines
Consolidated Interim Waste Storage Facility, Commercial Used Nuclear Fuel

Notes:
First-of-a-kind Plant Estimate
Spent Fuel Interim Storage Facility

									Description	Quantity	Unit	Unit Rate	Total
		$25,200,000	1F38	PM/CM Services On Site			120	Months					$0
				1F38	Cost Controls					240	Months	$15,000.00	$3,600,000
				1F38	Change Control					720	Months	$10,000.00	$7,200,000
				1F38	Schedule					720	Months	$10,000.00	$7,200,000
				1F38	Document Control					720	Months	$10,000.00	$7,200,000
				1F38									$0
				1F38				20					$0
		$6,000,000	1F39	Contingency on Indirect Services						120	Months	$50,000.00	$6,000,000
													$0
													$0
													$0
Base Construction Costs													$0
$3,091,515,075													$0
													$0
	$0	1F40	Capitalized Owner Costs										$0
		$0	1F41	Staff Recruitment and Training							Months		$0
		$0	1F42	Staff Housing							Months		$0
		$0	1F43	Staff Salary related Costs							Months		$0
		$0	1F44	Other Owner's capital Costs							Months		$0
		$0	1F45										$0
		$0	1F46										$0
		$0	1F47										$0
		$0	1F48										$0
		$0	1F49	Contingency on Owner's Costs							Months		$0
													$0
													$0
	$0	1F50	Decontamination and Decommissioning (DD&D)						INCLUDED IN OPERATIONAL COSTS				$0
		$0	1F51	Shipping and Transportation Costs							LS		$0
		$0	1F52	Spare Parts							LS		$0
		$0	1F53	Taxes							LS		$0
		$0	1F54	Insurance							Months		$0
		$0	1F55										$0
			$0	1F551									$0
					1F551.1						Mwt		$0
					1F551.2						Mwt		$0
					1F551.3						Mwt		$0
					1F551.4						Mwt		$0
					1F551.5						Mwt		$0
			$0	1F552									$0
					1F552.1						Mwt		$0
					1F552.2						Mwt		$0
					1F552.3						Mwt		$0
					1F552.4						Mwt		$0
					1F552.5						Mwt		$0
					1F552.6						Mwt		$0
					1F552.7						Mwt		$0
					1F552.8						Mwt		$0
		$0	1F56	Decontaminate Fuel Canisters and Casks - Salvage					INCLUDED IN OPERATIONAL COSTS	0	EACH	$13,500.00	$0
		$0	1F57	Decontamination & LLRW Disposal					INCLUDED IN OPERATIONAL COSTS	0	50	$100,000,000.00	$0
		$0	1F58	Decommissioning Costs					INCLUDED IN OPERATIONAL COSTS	0	LS	$200,000,000.00	$0
		$0	1F59	Contingency on Decommissioning costs					INCLUDED IN OPERATIONAL COSTS	0	LS	$20,000,000.00	$0
													$0
													$0
													$0
													$0
	$309,151,508	1F60	Capitalized Financial Costs										$0
		$0	1F61	Escalation	See Separate Escalation Tables for 100 Year Cash Flow					0	LS	$0.00	$0
		$309,151,508	1F62	Fees - Contractor OH&P						10.00%	Percent	$309,151,507.54	$309,151,508
		$0	1F69	Contingency on Financial Costs						0.00%	Percent	$0	$0
													$0
													$0
Total capital Investment Costs													$0
$3,429,466,583													$0

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Appendix E
Three-Digit Summary Level

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Breakdown of Costs from COA in DOE Guidelines

							Description	Total	Phase	Phase 1 Cost	Phase 2 Cost	Phase 3 Cost	Phase 4 Cost
		1F10	**Capitalized Pre Construction Costs**			**$286,260,000**							
			1F11	Land and Land Rights			$2,460,000						
				1F111	Land Purchase			$960,000	1	$960,000	$0	$0	$0
				1F112	20 Mile Access Right of Way-100 Years			$1,500,000	1	$1,500,000	$0	$0	$0
				1F113				$0		$0	$0	$0	$0
				1F117				$0		$0	$0	$0	$0
			1F12	Site Permits			$11,000,000			$0	$0	$0	$0
				1F121	Federal Government/Agency Permits			$2,000,000	1	$2,000,000	$0	$0	$0
				1F122	State Government Permits			$2,000,000	1	$2,000,000	$0	$0	$0
				1F123	Local Government Permits			$2,000,000	1	$2,000,000	$0	$0	$0
				1F124				$5,000,000		$0	$0	$0	$0
				1F128				$0		$0	$0	$0	$0
			1F13	Plant Licensing			$33,000,000			$0	$0	$0	$0
				1F131	NRC			$18,000,000	1	$18,000,000	$0	$0	$0
				1F132	State Government			$6,000,000	1	$6,000,000	$0	$0	$0
				1F133	DOT Licensing			$9,000,000	1	$9,000,000	$0	$0	$0
				1F134				$0		$0	$0	$0	$0
			1F14	Plant Permits			$6,000,000			$0	$0	$0	$0
				1F141	Federal Government/Agency Permits			$1,000,000	1	$1,000,000	$0	$0	$0
				1F142	State Government Permits			$2,500,000	1	$2,500,000	$0	$0	$0
				1F143	Local Government Permits			$2,500,000	1	$2,500,000	$0	$0	$0
				1F144				$0		$0	$0	$0	$0
				1F145				$0		$0	$0	$0	$0
			1F15	Planning Studies & Alternatives Analysis (With Design Costs)			$0			$0	$0	$0	$0
			1F16	Research and Development (20 Years)			$40,000,000	$40,000,000	2	$0	$40,000,000	$0	$0
			1F17	Other Preconstruction Costs			$26,200,000			$0	$0	$0	$0
				1F171	DOE Administration			$6,000,000	1	$6,000,000	$0	$0	$0
				1F172	Contractor Administration			$7,200,000	1	$7,200,000	$0	$0	$0
				1F173	Legal			$3,000,000	1	$3,000,000	$0	$0	$0
				1F174	NRC meetings/interaction			$3,000,000	1	$3,000,000	$0	$0	$0
				1F175	Independent Reviews (EIR and others)			$1,000,000	1	$1,000,000	$0	$0	$0
				1F176	Contractor Support to DOE			$6,000,000	1	$6,000,000	$0	$0	$0
				1F177				$0		$0	$0	$0	$0
				1F178				$0		$0	$0	$0	$0
				1F179				$0		$0	$0	$0	$0
			1F18	Conceptual Preliminary and Final Design			$157,600,000			$0	$0	$0	$0
										$0	$0	$0	$0
			1F19	Contingency on Pre Construction Costs			$10,000,000			$0	$0	$0	$0
				1F191	Studies			$2,500,000	1	$2,500,000	$0	$0	$0
				1F192	Licensing			$2,500,000	1	$2,500,000	$0	$0	$0
				1F193	Construction Documents			$2,500,000	1	$2,500,000	$0	$0	$0
				1F194	Time Related Costs			$2,500,000	1	$2,500,000	$0	$0	$0
				1F195				$0	1	$0	$0	$0	$0
										$0	$0	$0	$0

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Breakdown of Costs from COA in DOE Guidelines

							Description	Total	Phase	Phase 1 Cost	Phase 2 Cost	Phase 3 Cost	Phase 4 Cost
		1F10	**Capitalized Pre Construction Costs**			**$286,260,000**							
$2,548,575,075		**1F20**	**Capitalized Direct Costs**							$0	$0	$0	$0
			1F21	Structures and improvements		**$1,065,480,075**				$0	$0	$0	$0
				1F211	Site Preparation/Yard Work		$79,645,228			$0	$0	$0	$0
					1F211.1	Earthwork		$17,836,378	1	$17,836,378	$0	$0	$0
					1F211.2	Perimeter Controls		$55,668,600	1	$55,668,600	$0	$0	$0
					1F211.3	Site Access (Roads and Rail)		$0	1	$0	$0	$0	$0
					1F211.4	Utilities (Off Site)		$5,808,000	1	$5,808,000	$0	$0	$0
					1F211.5	Landscaping		$57,250	1	$57,250	$0	$0	$0
					1F211.6	Utilities (On Site)		$275,000	1	$275,000	$0	$0	$0
					1F211.7			$0		$0	$0	$0	$0
					1F211.8			$0		$0	$0	$0	$0
										$0	$0	$0	$0
				1F212	Cask Storage Site Improvements (Transportation Cost)					$0	$0	$0	$0
				1F213	Storage Pads					$0	$0	$0	$0
							$365,565,000.00			$0	$0	$0	$0
					1F213.1	Concrete		$270,565,000.00	2	$0	$270,565,000	$0	$0
					1F213.2	Steel		$0	2	$0	$0	$0	$0
					1F213.3	Architectural		$0	2	$0	$0	$0	$0
					1F213.4	Mechanical		$0	2	$0	$0	$0	$0
					1F213.5	Plumbing		$0	2	$0	$0	$0	$0
					1F213.6	Electrical		$0	2	$0	$0	$0	$0
					1F213.7	Controls (Monitoring)		$70,000,000	2	$0	$70,000,000	$0	$0
					1F213.8	Miscellaneous		$25,000,000	2	$0	$25,000,000	$0	$0
					1F213.9	Contingency				$0	$0	$0	$0
				1F213A	Storage pool and structures		$88,715,912.96			$0	$0	$0	$0
					1F213A.1	Concrete		$12,259,162.96	3	$0	$0	$12,259,163	$0
					1F213A.2	Steel		$667,500	3	$0	$0	$667,500	$0
					1F213A.3	Architectural		$608,500	3	$0	$0	$608,500	$0
					1F213A.4	Mechanical		$5,582,500	3	$0	$0	$5,582,500	$0
					1F213A.5	Plumbing		$25,100,000	3	$0	$0	$25,100,000	$0
					1F213A.6	Electrical		$1,088,250	3	$0	$0	$1,088,250	$0
					1F213A.7	Controls		$80,000	3	$0	$0	$80,000	$0
					1F213A.8	Miscellaneous		$43,000,000	3	$0	$0	$43,000,000	$0
					1F213A.9	Contingency		$330,000	3	$0	$0	$330,000	$0
				1F213B	Consolidated Storage Facility - Fuel & Cask Handling Building		$27,742,732.22			$0	$0	$0	$0
					1F213B.1	Concrete		$9,239,972.22	1	$9,239,972	$0	$0	$0
					1F213B.2	Steel		$589,500	1	$589,500	$0	$0	$0
					1F213B.3	Architectural		$512,508	1	$512,508	$0	$0	$0
					1F213B.4	Mechanical		$5,582,503	1	$5,582,503	$0	$0	$0
					1F213B.5	Plumbing		$320,000	1	$320,000	$0	$0	$0
					1F213B.6	Electrical		$1,088,250	1	$1,088,250	$0	$0	$0
					1F213B.7	Controls		$80,000	1	$80,000	$0	$0	$0
					1F213B.8	Miscellaneous		$10,000,000	1	$10,000,000	$0	$0	$0
					1F213B.9	Contingency		$330,000	1	$330,000	$0	$0	$0

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Breakdown of Costs from COA in DOE Guidelines

							Description	Total	Phase	Phase 1 Cost	Phase 2 Cost	Phase 3 Cost	Phase 4 Cost
		1F10	**Capitalized Pre Construction Costs**			**$286,260,000**							
				1F214	Hot Cell	NQA-1, Seismic 1, Physical Protection 1				$0	$0	$0	$0
							$402,735,062.96			$0	$0	$0	$0
					1F214.1	Concrete		$82,902,562.96	3	$0	$0	$82,902,563	$0
					1F214.2	Structural Steel		$8,857,500	3	$0	$0	$8,857,500	$0
					1F214.3	Architectural		$182,905,000	3	$0	$0	$182,905,000	$0
					1F214.4	Mechanical		$52,500,000	3	$0	$0	$52,500,000	$0
					1F214.5	Plumbing		$320,000	3	$0	$0	$320,000	$0
					1F214.6	Electrical		$2,775,000	3	$0	$0	$2,775,000	$0
					1F214.7	Controls		$23,975,000	3	$0	$0	$23,975,000	$0
					1F214.8	Miscellaneous		$43,500,000	3	$0	$0	$43,500,000	$0
					1F214.9	Contingency		$5,000,000	3	$0	$0	$5,000,000	$0
										$0	$0	$0	$0
				1F218A	Control Rooms/Space		$595,042			$0	$0	$0	$0
					1F218.1	Concrete		$358,542	3	$0	$0	$358,542	$0
					1F218.2	Structural Steel		$0	3	$0	$0	$0	$0
					1F218.3	Architectural		$59,000	3	$0	$0	$59,000	$0
					1F218.4	Mechanical		$75,000	3	$0	$0	$75,000	$0
					1F218.5	Plumbing		$12,500	3	$0	$0	$12,500	$0
					1F218.6	Electrical		$25,000	3	$0	$0	$25,000	$0
					1F218.7	Controls		$65,000	3	$0	$0	$65,000	$0
					1F218.8	Miscellaneous		$0	3	$0	$0	$0	$0
					1F218.9	Contingency		$0	3	$0	$0	$0	$0
										$0	$0	$0	$0
				1F218B	Administration Building		$2,749,435			$0	$0	$0	$0
					1F218B.1	Concrete		$231,185	1	$231,185	$0	$0	$0
					1F218B.2	Structural Steel		$440,000	1	$440,000	$0	$0	$0
					1F218B.3	Architectural		$928,250	1	$928,250	$0	$0	$0
					1F218B.4	Mechanical		$150,000	1	$150,000	$0	$0	$0
					1F218B.5	Plumbing		$390,000	1	$390,000	$0	$0	$0
					1F218B.6	Electrical		$410,000	1	$410,000	$0	$0	$0
					1F218B.7	Controls		$0	1	$0	$0	$0	$0
					1F218B.8	Miscellaneous		$0	1	$0	$0	$0	$0
					1F218B.9	Contingency		$200,000	1	$200,000	$0	$0	$0
									1	$0	$0	$0	$0
				1F218C	Cask Maintenance Facility		$7,862,111			$0	$0	$0	$0
					1F218C.1	Concrete		$229,361	1	$229,361	$0	$0	$0
					1F218C.2	Structural Steel		$525,000	1	$525,000	$0	$0	$0
					1F218C.3	Architectural		$171,250	1	$171,250	$0	$0	$0
					1F218C.4	Mechanical		$525,000	1	$525,000	$0	$0	$0
					1F218C.5	Plumbing		$229,500	1	$229,500	$0	$0	$0
					1F218C.6	Electrical		$126,000	1	$126,000	$0	$0	$0
					1F218C.7	Controls		$31,000	1	$31,000	$0	$0	$0
					1F218C.8	Miscellaneous		$5,500,000	1	$5,500,000	$0	$0	$0
					1F218C.9	Contingency		$525,000	1	$525,000	$0	$0	$0
				1F218D	Entry Control Building (80x120)		$2,500,000	$2,500,000	1	$2,500,000	$0	$0	$0
				1F218F	Visitor Center (56x56)		$627,200	$627,200		$0	$0	$0	$0
				1F218W	Fleet Management Facility		$9,776,815	$9,776,815	1	$9,776,815	$0	$0	$0
				1F218X	Railroad Tracks		$58,752,800	$58,752,800	1	$58,752,800	$0	$0	$0
				1F218Y	Roads and Paved Areas		$18,212,737	$18,212,737	1	$18,212,737	$0	$0	$0
										$0	$0	$0	$0
										$0	$0	$0	$0

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Breakdown of Costs from COA in DOE Guidelines

							Description	Total	Phase	Phase 1 Cost	Phase 2 Cost	Phase 3 Cost	Phase 4 Cost
		1F10	**Capitalized Pre Construction Costs**			**$286,260,000**							
			1F22	**Cask, Canister & Fuel Related Equipment**		**$796,900,000**				$0	$0	$0	$0
				1F22	Cask, Canister & Fuel Equipment			$796,900,000	3	$0	$0	$796,900,000	$0
			1F22A	**Consolidated Storage Facility Equipment**		**$614,845,000**				$0	$0	$0	$0
				1F223	CSF Facility Equipment			$158,000,000	3	$0	$0	$158,000,000	$0
				1F223	Hot Cell Equipment			$90,000,000	3	$0	$0	$90,000,000	$0
				1F223	Rail Equipment			$341,845,000	1	$341,845,000	$0	$0	$0
				1F224	Equipment Contingency			$25,000,000	3	$0	$0	$25,000,000	$0
			1F24	**Electrical Equipment**		**$14,850,000**				$0	$0	$0	$0
				1F241	Switchgear			$3,375,000	1	$3,375,000	$0	$0	$0
				1F242	Station Service Equipment			$2,025,000	1	$2,025,000	$0	$0	$0
				1F243	Switchboards			$4,050,000	1	$4,050,000	$0	$0	$0
				1F244	Protective Systems Equipment			$2,025,000	1	$2,025,000	$0	$0	$0
				1F245	Electrical Raceway Systems			$1,350,000	1	$1,350,000	$0	$0	$0
				1F246	Power and Control Cables and Wiring			$2,025,000	1	$2,025,000	$0	$0	$0
				1F247				$0		$0	$0	$0	$0
				1F248						$0	$0	$0	$0
			1F25	**Heat Rejection Equipment**		$39,500,000			2	$0	$0	$0	$0
				1F251	Piping Systems			$15,000,000	3	$0	$0	$15,000,000	$0
				1F252	Cooling Towers			$20,000,000	3	$0	$0	$20,000,000	$0
				1F253	Miscellaneous Equipment			$4,500,000	3	$0	$0	$4,500,000	$0
				1F254				$0	3	$0	$0	$0	$0
				1F255				$0	3	$0	$0	$0	$0
			1F26	**Miscellaneous Equipment**		$17,000,000				$0	$0	$0	$0
				1F261	Transportation and Lift Equipment			$1,000,000	1	$1,000,000	$0	$0	$0
				1F262	Air Water Plant Fuel Oil and Steam Service Systems			$2,500,000	1	$2,500,000	$0	$0	$0
				1F263	Communication Equipment			$1,000,000	1	$1,000,000	$0	$0	$0
				1F264	Furnishings and Fixtures			$500,000	1	$500,000	$0	$0	$0
				1F265	Cask Transporters			$6,000,000		$0	$0	$0	$0
				1F266	NUHOMES Transporters			$6,000,000		$0	$0	$0	$0
				1F267				$0		$0	$0	$0	$0
				1F268				$0		$0	$0	$0	$0
Direct Construction Costs										$0	$0	$0	$0
$2,834,835,075										$0	$0	$0	$0
		1F30	Capitalized Field Indirect Services Costs			**$285,480,000**				$0	$0	$0	$0
			1F31	Field Indirect Costs				$65,160,000	2	$0	$65,160,000	$0	$0
			1F32	Construction Supervision				$57,960,000	2	$0	$57,960,000	$0	$0
			1F33	Commissioning and Start up Costs				$7,680,000	2	$0	$7,680,000	$0	$0
			1F34	Demonstration Test Run				$2,280,000	2	$0	$2,280,000	$0	$0
										$0	$0	$0	$0
Total Field Costs										$0	$0	$0	$0
$285,480,000										$0	$0	$0	$0
			1F35	Design Services Off Site				$38,400,000	1	$38,400,000	$0	$0	$0
			1F36	PM/CM Services Off Site				$22,800,000	2	$0	$22,800,000	$0	$0
			1F37	Design Services On Site				$60,000,000	2	$0	$60,000,000	$0	$0
			1F38	PM/CM Services On Site				$25,200,000	2	$0	$25,200,000	$0	$0
			1F39	Contingency on Indirect Services				$6,000,000	2	$0	$6,000,000	$0	$0

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Breakdown of Costs from COA in DOE Guidelines

							Description	**Total**	**Phase**	**Phase 1 Cost**	**Phase 2 Cost**	**Phase 3 Cost**	**Phase 4 Cost**
		1F10	**Capitalized Pre Construction Costs**			**$286,260,000**							
		1F60	Capitalized Financial Costs			$309,151,508				$0	$0	$0	$0
			1F61	Escalation				$0		$0	$0	$0	$0
			1F62	Fees				$309,151,508	3	$0	$0	$309,151,508	$0
			1F63	Interest During Construction						$0	$0	$0	$0
			1F64							$0	$0	$0	$0
			1F69	Contingency on Financial Costs				$0		$0	$0	$0	$0
										$0	$0	$0	$0
										$0	$0	$0	$0
Total Capital Investment Costs										$0	$0	$0	$0
$3,429,466,583										$0	$0	$0	$0

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Incremental Capital Costs for a Second Regional Facility

							Description	**Total**	
		1F10	**Capitalized Pre Construction Costs**			**$89,460,000**			
			1F11	Land and Land Rights			$2,460,000		
				1F111	Land Purchase			$960,000	
				1F112	20 Mile Access Right of Way-100 Years			$1,500,000	
				1F113				$0	
				1F117				$0	
			1F12	Site Permits			$11,000,000		
				1F121	Federal Government/Agency Permits			$2,000,000	
				1F122	State Government Permits			$2,000,000	
				1F123	Local Government Permits			$2,000,000	
				1F124				$5,000,000	
				1F128				$0	
			1F13	Plant Licensing			$33,000,000		
				1F131	NRC			$18,000,000	
				1F132	State Government			$6,000,000	
				1F133	DOT Licensing			$9,000,000	
				1F134				$0	
			1F14	Plant Permits			$6,000,000		
				1F141	Federal Government/Agency Permits			$1,000,000	
				1F142	State Government Permits			$2,500,000	
				1F143	Local Government Permits			$2,500,000	
				1F144				$0	
				1F145				$0	
			1F15	Planning Studies & Alternatives Analysis (With Design Costs)			$0		
			1F16	Research and Development (20 Years)			$0	$0	
			1F17	Other Preconstruction Costs			$26,200,000		
				1F171	DOE Administration			$6,000,000	
				1F172	Contractor Administration			$7,200,000	
				1F173	Legal			$3,000,000	
				1F174	NRC meetings/interaction			$3,000,000	
				1F175	Independent Reviews (EIR and others)			$1,000,000	
				1F176	Contractor Support to DOE			$6,000,000	
				1F177				$0	
				1F178				$0	
				1F179				$0	
			1F18	Conceptual Preliminary and Final Design			$10,800,000		
				1F181	Conceptual Design			$10,800,000	
				1F182	Preliminary Design CSF (Excluding Pools & Hot Cells)			$0	
				1F183	Final Design CSF (Excluding Pools and Hot Cells)			$0	
				1F184	Preliminary Design Storage pools and Hot Cell			$0	
				1F185	Final Design Storage Pools and Hot Cell			$0	
				1F189	Contingency (Design Work/Const Documents)			$0	
			1F19	Contingency on Pre Construction Costs			$0		
				1F191	Studies			$0	
				1F192	Licensing			$0	
				1F193	Construction Documents			$0	
				1F194	Time Related Costs			$0	
				1F195				$0	
		1F20	**Capitalized Direct Costs**						
			1F21	Structures and improvements		**$831,372,216**			
				1F211	Site Preparation/Yard Work		$78,741,294		
					1F211.1	Earthwork		$16,932,444	
					1F211.2	Perimeter Controls		$55,668,600	
					1F211.3	Site Access (Roads and Rail)		$0	

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Incremental Capital Costs for a Second Regional Facility

							Description	Total	
					1F211.4	Utilities (Off Site)		$5,808,000	
					1F211.5	Landscaping		$57,250	
					1F211.6	Utilities (On Site)		$275,000	
					1F211.7			$0	
8559324562					1F211.8			$0	
				1F212	Cask Storage Site Improvements (Transportation Cost)				
				1F213	Storage Pads				
							$150,000,000.00		
					1F213.1	Concrete		$150,000,000.00	
					1F213.2	Steel		$0	
					1F213.3	Architectural		$0	
					1F213.4	Mechanical		$0	
					1F213.5	Plumbing		$0	
					1F213.6	Electrical		$0	
					1F213.7	Controls (Monitoring)		$0	
					1F213.8	Miscellaneous		$0	
					1F213.9	Contingency			
				1F213A	Storage pool and structures		$88,715,912.96		
					1F213A.1	Concrete		$12,259,162.96	
					1F213A.2	Steel		$667,500	
					1F213A.3	Architectural		$608,500	
					1F213A.4	Mechanical		$5,582,500	
					1F213A.5	Plumbing		$25,100,000	
					1F213A.6	Electrical		$1,088,250	
					1F213A.7	Controls		$80,000	
					1F213A.8	Miscellaneous		$43,000,000	
					1F213A.9	Contingency		$330,000	
				1F213B	Consolidated Storage Facility - Fuel & Cask Handling Building		$27,742,732.22		
					1F213B.1	Concrete		$9,239,972.22	
					1F213B.2	Steel		$589,500	
					1F213B.3	Architectural		$512,508	
					1F213B.4	Mechanical		$5,582,503	
					1F213B.5	Plumbing		$320,000	
					1F213B.6	Electrical		$1,088,250	
					1F213B.7	Controls		$80,000	
					1F213B.8	Miscellaneous		$10,000,000	
					1F213B.9	Contingency		$330,000	
				1F214	Hot Cell	NQA-1, Seismic 1, Physical Protection 1			
							$402,735,062.96		
					1F214.1	Concrete		$82,902,562.96	
					1F214.2	Structural Steel		$8,857,500	
					1F214.3	Architectural		$182,905,000	
					1F214.4	Mechanical		$52,500,000	
					1F214.5	Plumbing		$320,000	
					1F214.6	Electrical		$2,775,000	
					1F214.7	Controls		$23,975,000	
					1F214.8	Miscellaneous		$43,500,000	
					1F214.9	Contingency		$5,000,000	
				1F218A	Control Rooms/Space		$595,042		
					1F218.1	Concrete		$358,542	
					1F218.2	Structural Steel		$0	
					1F218.3	Architectural		$59,000	
					1F218.4	Mechanical		$75,000	
					1F218.5	Plumbing		$12,500	

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Incremental Capital Costs for a Second Regional Facility

							Description	Total	
					1F218.6	Electrical		$25,000	
					1F218.7	Controls		$65,000	
					1F218.8	Miscellaneous		$0	
					1F218.9	Contingency		$0	
				1F218B	Administration Building		$2,749,435		
					1F218B.1	Concrete		$231,185	
					1F218B.2	Structural Steel		$440,000	
					1F218B.3	Architectural		$928,250	
					1F218B.4	Mechanical		$150,000	
					1F218B.5	Plumbing		$390,000	
					1F218B.6	Electrical		$410,000	
					1F218B.7	Controls		$0	
					1F218B.8	Miscellaneous		$0	
					1F218B.9	Contingency		$200,000	
				1F218C	Cask Maintenance Facility		$0		**Cost Covered in First Facility**
					1F218C.1	Concrete			
					1F218C.2	Structural Steel			
					1F218C.3	Architectural			
					1F218C.4	Mechanical			
					1F218C.5	Plumbing			
					1F218C.6	Electrical			
					1F218C.7	Controls			
					1F218C.8	Miscellaneous			
					1F218C.9	Contingency			
				1F218D	Entry Control Building (80x120)		$2,500,000	$2,500,000	
				1F218F	Visitor Center (56x56)		$627,200	$627,200	
				1F218W	Fleet Management Facility		$0		**Cost Covered in First Facility**
				1F218X	Railroad Tracks		$58,752,800	$58,752,800	
				1F218Y	Roads and Paved Areas		$18,212,737	$18,212,737	
			1F22	**Cask, Canister & Fuel Related Equipment**		**$0**			
				1F22	Cask, Canister & Fuel Equipment			$0	**Cost Covered in First Facility**
			1F22A	**Consolidated Storage Facility Equipment**		**$248,000,000**			
				1F223	CSF Facility Equipment			$158,000,000	
				1F223	Hot Cell Equipment			$90,000,000	
				1F223	Rail Equipment			$0	**Cost Covered in First Facility**
				1F224	Equipment Contingency			$0	
			1F24	**Electrical Equipment**		**$14,850,000**			
				1F241	Switchgear			$3,375,000	
				1F242	Station Service Equipment			$2,025,000	
				1F243	Switchboards			$4,050,000	
				1F244	Protective Systems Equipment			$2,025,000	
				1F245	Electrical Raceway Systems			$1,350,000	
				1F246	Power and Control Cables and Wiring			$2,025,000	
				1F247				$0	
				1F248					
			1F25	**Heat Rejection Equipment**		$39,500,000			
				1F251	Piping Systems			$15,000,000	
				1F252	Cooling Towers			$20,000,000	
				1F253	Miscellaneous Equipment			$4,500,000	
				1F254				$0	
				1F255				$0	
			1F26	**Miscellaneous Equipment**		$17,000,000			
				1F261	Transportation and Lift Equipment			$1,000,000	
				1F262	Air Water Plant Fuel Oil and Steam Service Systems			$2,500,000	

Summary of Costs - Third Level WBS
Consolidated Storage Facility
Incremental Capital Costs for a Second Regional Facility

							Description	Total	
				1F263	Communication Equipment			$1,000,000	
				1F264	Furnishings and Fixtures			$500,000	
				1F265	Cask Transporters			$6,000,000	
				1F266	NUHOMES Transporters			$6,000,000	
				1F267				$0	
				1F268				$0	
		1F30	Capitalized Field Indirect Services Costs			**$285,480,000**			
			1F31	Field Indirect Costs				$65,160,000	
			1F32	Construction Supervision				$57,960,000	
			1F33	Commissioning and Start up Costs				$7,680,000	
			1F34	Demonstration Test Run				$2,280,000	
			1F35	Design Services Off Site				$38,400,000	
			1F36	PM/CM Services Off Site				$22,800,000	
			1F37	Design Services On Site				$60,000,000	
			1F38	PM/CM Services On Site				$25,200,000	
			1F39	Contingency on Indirect Services				$6,000,000	
		1F60	Capitalized Financial Costs			$152,566,222			
			1F61	Escalation				$0	
			1F62	Fees				$152,566,222	
			1F63	Interest During Construction					
			1F64						
			1F69	Contingency on Financial Costs				$0	
		Total Costs for Second Facility						$1,678,228,438	

Total Field Costs
285480000
Base Construction Costs
9096115444
Overnight Construction Costs
12846115444
Total Capital Investment Costs
13873804679

Appendix F
Two-Digit Summary Level

Summary of Costs - Second Level
Consolidated Storage Facility

							Total
	$286,260,000	**1F10**	**Capitalized Pre Construction Costs**				
			1F11	Land and Land Rights			$2,460,000
			1F12	Site Permits			$11,000,000
			1F13	Plant Licensing			$33,000,000
			1F14	Plant Permits			$6,000,000
			1F15	Planning Studies & Alternatives Analysis			$0
			1F16	Research and Development (20 Years)			$40,000,000
			1F17	Other Preconstruction Costs			$26,200,000
			1F18	Conceptual Preliminary and Final Design			$157,600,000
			1F19	Contingency on Pre Construction Costs			$10,000,000
	$2,548,575,075	**1F20**	**Capitalized Direct Costs**				
			1F21	Structures and improvements			$1,065,480,075
			1F22	Casks, Canisters, Fuel Equipment			$796,900,000
			1F22A	CSF Facility & Rail Equipment			$614,845,000
			1F24	Electrical Equipment			**$14,850,000**
			1F25	Heat Rejection Equipment			$39,500,000
			1F26	Miscellaneous Equipment			$17,000,000
Direct Construction Costs							
$2,834,835,075							
	$285,480,000	**1F30**	**Capitalized Field Indirect Services Costs**				
			1F31	Field Indirect Costs			$65,160,000
			1F32	Construction Supervision			$57,960,000
			1F33	Commissioning and Start up Costs			$7,680,000
			1F34	Demonstration Test Run			$2,280,000
Total Field Costs							
$285,480,000							
			1F35	Design Services Off Site			$38,400,000
			1F36	PM/CM Services Off Site			$22,800,000
			1F37	Design Services On Site			$60,000,000
			1F38	PM/CM Services On Site			$25,200,000
			1F39	Contingency on Indirect Services			$6,000,000
Base Construction Costs							
$3,120,315,075							
Overnight Construction Costs							
$3,120,315,075							
	$309,151,508	1F60	Capitalized Financial Costs				
			1F61	Escalation			$0
			1F62	Fees			$309,151,508
			1F63	Interest During Construction			$0
			1F64				$0
			1F69	Contingency on Financial Costs			$0
Total Capital Investment Costs							
$3,429,466,583							

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Appendix G
Basis of Estimate

Consolidated Storage Facility Basis of Estimate

PROJECT LEVEL BASIS OF ESTIMATE

The estimate for the CSF was developed following guidelines contained in DOE O 413.3B Program and Project Management for the Acquisition of Capital Assets, DOE G 413-3.21 Cost Estimating Guide, and GAO Guide GAO-09-3SP Cost Estimating and Assessment Guide (Best Practices for Developing and Managing Capitol Program Costs). Additional guides used in the preparation of this estimate included AACE International Skills and Knowledge of Cost Estimating and Gen IV International Forum’s Cost Estimating Guidelines for Generation IV Nuclear Energy Systems.

While the development strategy for the CSF allows for the implementation of regional facilities, the significant additional costs associated with regional facilities, capital, and operational costs far outweigh the potential savings in transportation costs and thus have led us to recommend a consent-based single Consolidated Storage Facility (CSF).

The detailed assumptions that support the estimated capital and life cycle costs are contained in this Basis of Estimate.

Work Scope Summary

The attached estimate outlines the costs for development, implementation, and operation of a CSF to store and monitor used nuclear fuel (UNF) from our nation’s fleet of commercial nuclear reactors. The scope of the project will include all of the following elements:

- Land acquisition including the site of the CSF as well as access rights to the property
- Site and building permits at federal, state, and local levels
- NRC licensing activities
- All licensing activities associated with all levels of oversight including federal, state, and local
- Conceptual, preliminary, and final design effort for all facilities, transportation system, and storage systems
- Pre-construction costs associated with DOE and their support contactors
- Research and development tasks required to support shipment of high burn-up UNF and a CSF Aging Management Program

- Certification and fabrication of transportation casks and canisters for UNF
- Railway rolling stock design, fabrication, testing, and certification for shipment of UNF casks to the CSF
- Purchase of 7,000 Dry Cask Storage Systems (DCSSs) for fuel being transferred from wet storage to wet storage and then packaging into a DCSS
- Fabrication of Cask Handling Equipment required to be used at the existing storage sites as well as at the CSF
- Negotiation of contracts with rail lines for movement of UNF to the CSF
- Development of Emergency Action Plans (EAPs) for movement of UNF from the plant sites to the CSF
- Training of Emergency Response Teams in the implementation of the EAPs along the routes where UNF will be transported
- Planning and logistics for all UNF transportation to the CSF
- Development of conceptual, preliminary, and final design for the CSF
- Development of cask monitoring equipment and instrumentation
- Conducting pre-construction investigations (geotechnical, environmental); obtaining local approvals
- Preparing Environmental Report, securing NEPA permits
- Obtaining Site Permits (EIS, RCRA, Clean Air, Clean Water, NEPA, utility, etc.)
- SAR preparation and NRC Licensing of the CSF
- Development of rail and road access to the site
- Development of utilities to the site including electrical, phone, gas, potable water, fire water (stored on-site in tanks filled by potable water system), sanitary waste, communication
- Site preparations (civil works, construction facilities, batch plant, etc.)
- Construction of the CSF–Stage 1 (Cask Handling Building, DCSS Storage Pads, Cask Maintenance Facility, Administration Building, rail yard, Fleet Management Facility, Perimeter Intrusion Detection and Alarm System [PIDAS], Entry Control Building, Visitors Center, Central and Secondary Alarm Stations, Security Portals, Cask Monitoring System, off-site and on-site lighting and utilities, fire water tanks and fire suppression system, chillers, switch yard)

- Construction–Stage 2 (Additional Dry Storage Pad Construction, modify Stage 1 PIDAS)
- Final design of Cask Hot Cell, Hot Cell Laboratories, and Pool Storage Facilities
- Construction–Stage 3 (Hot Cell and Laboratory Facility, PWR and BWR fuel building pools, cooling and purification systems, chillers, emergency power supply)
- Operational costs for all cask handling and storage at the CSF including:
    1. Security
    2. Cask Handling Operations
    3. Maintenance
    4. Transportation Operations Center
    5. CSF Management and Administration
    6. Pool Storage Systems
    7. Hot Cell and laboratory facility operations and maintenance
    8. Operations and Transportation Quality Assurance
    9. Cask Maintenance
    10. Fleet Maintenance
    11. R&D required to effectively manage UNF long term at this facility
- Acquisition of operations equipment for the CSF facility
- Acquisition of transportation equipment and spare parts including railway rolling stock, rail transportation casks, trucks, and truck transportation casks
- UNF R&D support from the National Laboratories to support Aging Management Program requirements for the CSF
- Costs to transport 140,000 MTU of UNF to the CSF
- Cost of transportation contracts with the railroads and contracts for intermodal transport of the UNF from all plant sites to a rail loading location for rail transport to the CSF
- Decontamination of transportation casks and recycling of cask and transportation equipment (handling equipment, cradles, impact limiters, etc.) at the CSF site
- Decontamination and Decommissioning of the physical CSF facilities and the DCSSs

The work scope is laid out in accordance with the Work Breakdown Structure (WBS) as follows:

1F10 Capitalized Pre-Construction Costs:

- Land acquisition or lease
- Permits
- Licensing
- Contracting
- Plant studies and reports
- Conceptual, preliminary, and final design efforts
- Cask certification and recertification
- Canister re-certification
- Railroad equipment design and certification
- Fuel handling equipment design
- Fuel cask handling equipment design
- Public review process
- Federal, state, and local government reviews and approvals
- Research and development to support Aging Management Program
- EPA permits
- NRC licensing process including ER and SAR preparation
- DOE and DOE support contractor costs
- 413.3B Critical Decision process up through CD-3

1F20 Capitalized Direct Costs:

- Grading
- Excavation
- Drainage
- Utilities and lighting
- Roads
- Rail

- Perimeter Intrusion Detection and Alarm System (PIDAS)
- Cask Handling Building
- Surface storage pads
- Pool storage
- Hot Cell Facility
- Office Building
- Control Room/Space
- Off-site access improvements (road and rail)
- Off-site utilities
- Transportation equipment
- Fuel handling equipment
- Long-term monitoring systems
- Cask Maintenance Facility
- Fleet Management Facility
- Visitors Center
- Entry Control Building
- CSF electrical equipment
- CSF heat transfer equipment

1F30 Capitalized Indirect Field Services Costs:

- Project management
- Construction management
- Field engineering
- Temporary utilities
- Temporary facilities
- Contractor general conditions
- Contractor bonds, insurance, overhead, and fee
- Testing, commissioning, and startup
- Off-site services including Title III design and PM/CM services

1F40 Capitalized Owner Costs:

- DOE costs during construction
- Recruitment and training
- O&M contractor start-up costs

1F50 Capitalized Supplementary Costs:

- Shipping
- Spare parts
- Taxes
- Insurance
- Decontamination and Deconstruction

1F60 Capitalized Financial Costs:

- Escalation
- Financing costs (if any)
- Costs of restricted funding profile (if any)
- Contractor fee

1F70 Annualized Operations and Maintenance Costs

- Procurement of 7,000 DCCS canisters and overpacks
- Cask handling
- Storage system monitoring
- R&D
- Maintenance
- Security
- Program management
- Transportation

Exclusions

Exclusions from the Work Scope of this program include the following:

- The utility is responsible for the cost to transport the loaded transport cask to outside the utility's perimeter fence. DOE is responsible for the intermodal transportation costs from the utility's perimeter fence to the rail loading area and all subsequent transportation and handling costs.

- DOE will provide the transport casks and associated handling equipment.
- The costs associated with the ultimate disposal of the UNF either through reprocessing or geologic disposal are not included.
- Interest carry costs are excluded, as this project is to be funded by DOE.
- Examination and testing of UNF other than for purposes of safely storing the materials at the CSF.
- Significant litigation costs associated with licensing process are excluded since this is a consent-based site.

Assumptions

- The utility is responsible for loading Dual-purpose Canisters (DPCs) into transport casks and loading the transportation casks onto rail cars or intermodal transportation. DOE is responsible for transportation costs from outside the utility's property to the CSF.
- A single CSF location is developed for all 140,000 metric tons of UNF.
- CSF includes dry surface storage and wet storage for PWR and BWR assemblies.
- Long-term monitoring and maintenance of the stored fuel will require modifications to DCSSs.
- Construction Stage 1 will support the receipt of all stranded fuel from decommissioned reactor sites.
- Construction Stage 2 will be implemented to allow receipt of UNF in transportable canisters from operating sites.
- Construction Stage 3 will add PWR and BWR fuel pools to permit wet to wet transfer. This stage will also include a large Hot Cell for handling a loaded cask to support the R&D program along with four laboratory Hot Cells to support on-site R&D of UNF. The large Hot Cell will support dry re-packaging of fuel canisters.
- Off-site development is based on a nominal 15 miles of development from a defined access point to the CSF site.
- The site shall be assumed to be a one mile square geographic site.
- Construction will be in three stages: (1) to accept the initial stranded fuel from decommissioned reactor sites; (2) to accept DPCs from operating plants; and (3) to

transfer bare fuel from the utility's fuel pools to CSF storage pools, to receive transportable and non-transportable canisters from utility sites, to permit on-site R&D of UNF, and to remediate UNF storage systems.

- Plant operations of 100 years is assumed from the date the first shipments are received.
- All estimates are in 2012 Dollars.
- Escalation factors will be applied to out-year expenditures and incorporated as a single element into the overall cost estimate.
- Estimate assumes 2 percent annual escalation.
- Active operations include on-site transportation of casks, unloading casks from rail car or truck, loading canisters in transfer casks (as required), and transporting and loading canisters into storage.
- Active operations also include receipt of fuel for wet storage and cask handling operations in the cask area of the fuel pool. Fuel pool cooling and purification operation and maintenance. Cask handling, opening, and closing to support R&D and dry remediation are performed in the Hot Cell Facility.
- R&D on UNF and canister systems is performed in the Hot Cell Facility laboratories and National Laboratories. Prior to start of Hot Cell operations, all UNF testing and evaluation will be performed at National Laboratories.
- The storage capacity of the CSF is 140,000 MTU. All fuel transferred from the utilities in bare fuel casks will initially be stored in the CSF fuel pools. This fuel will then be transferred into DCSSs.
- This estimate assumes that 7,000 DCSS canisters and overpacks will be procured by the CSF to transfer UNF from wet storage to dry storage.
- The classification of the Estimate shall be a Class 4 Estimate in accordance with the guidelines of the AACE-International classification index.
- The range of accuracy of the estimate is intended to be +50% and -30%.
- The costs of any modifications at the plant sites to support the transport of loaded transportation casks from their existing storage location to the railroad UNF consist is included. These costs are associated only with any work in the public domain and the UNF owner is responsible for any modifications on their site.
- A logistics support center is included in the CSF to plan and coordinate the transport of UNF to the CSF.

- Formalized risk analysis is not included as part of the estimated costs.
- Capital costs are isolated from operating costs.
- Transportation costs are identified separate from capital costs and CSF operational costs.
- Cost of Decontamination and Decommissioning costs are included in the overall life cycle costs.
- Long-term operations are developed on a per year basis and are escalated to reflect the costs for the year of delivery in the out-years.

Source of Estimate Information

The intent of this estimating effort is the development of a Class 4 Estimate in accordance with AACE-I Classification system and DOE O 413.3-21 Estimating Guidelines. Basis of Estimate (BOE) documentation provides greater detail on all areas of this estimate. Information has been developed from the following sources:

- Where specialized nuclear construction data is available, it has been used as the source of the estimate information. For example: ISFSI data for storage of fuel canisters and casks at reactor locations provide reasonable historical data for pricing on-surface storage pads and cask handling equipment.
- Where prototype equipment has been developed, those costs have been used and extrapolated for the production runs. For example: Rail rolling stock.
- Where existing equipment is being used in this program, current cost data are being used in this estimate. For example: Canisters and casks.
- Where site development costs are required, estimators’ best professional judgment is being applied. For example: Grading, drainage, roads, rail, and utilities.
- Where specialized systems for nuclear facilities are required, current cost data are being applied. For example: PIDAS and Security.
- Where newly developed systems are required, estimators’ best professional judgment is applied.
- Where commercial fuel handling data is available, it has been applied. For example: Costs of handling canisters, casks, and fuel assemblies; cost of fuel storage pools.
- Where specialized nuclear facility construction is required, industry best practices and estimators’ best professional judgment have been applied. For example: Cost of Hot Cell construction.

All cost data in the estimate is presented in a “loaded” cost format incorporating any labor fringes, Corporate G&A, and Corporate Overhead (the cost DOE should expect to pay for each item). “Contractor Fee” is identified separately in WBS 1F60 for capital costs and in 1F70 as relates to Transportation and Operational costs.

Work Breakdown Structure (WBS) Detailed Basis of Estimate

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F11
Account Name: ....Land and Land Rights
Date:..January 10, 2013

Period of Performance: ....Jan 2013 through Jan 2015

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The land rights procurement may take one of several forms:

1. Land purchase of private property
2. Government set aside on a DOE site
3. Lease of either private or tribal lands

For purposes of this estimate, we have assumed a land purchase with the likely location in the American Southwest. Total land required for the development will be approximately 640 acres or an area one mile on a side. An exclusion zone surrounding the facility is not included in the cost estimate for the land rights. However, the assumption is that the property will be located in a remote area with few neighbors at a distance.

The land is undeveloped and the costs of all site development and off-site development are included in other WBS elements of the Estimated Costs.

Determination will be made in the early days of the project whether this project will be located on private, public, or tribal land.

The lease rights for a right-of-way access to the site is included for a 15-mile right-of-way access for life of the project.

Land is assumed to cost $1,500 per acre for site acquisition and the Access Rights are assumed to be $1,000 per mile per year for the assumed 15-mile access corridor.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F12
Account Name: ....Site Permits
Date:..January 10, 2013

Period of Performance: ....Jan 2014 through Jan 2020

Description of Work including:
1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The site permits for the Consolidated Storage Facility (CSF) will include but not be limited to the following:
- Grading and Drainage Permits
- Utility Permits
- DOT Permits
- Special Use Permits for storage of Nuclear materials
- Fire Prevention
- EPA
- RCRA Permit
- BLM if located on Public Land
- Off-Site Development Permits
- Access Permits
- Clean Air
- Clean Water
- SWPPP Permits

The effort under this work package will include all Labor Other Direct Costs for presentation, negotiation, coordination, and purchase of all site permits. Also included in this WBS element will be any business licenses required to perform the work of this effort within the municipal and state boundaries of the selected site.

It is probable that the site will be located in the southwestern United States and as such may be located on private land, public land, or tribal land. The final set of permits required for this CSF will be determined when a site is selected and secured.

Since there is no designated site, it is not possible to determine an exact list of permits or the costs for those permits. The cost included in this WBS are based on Estimator Best Judgment and represent approximately 0.3% of the total project costs.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F13
Account Name: ....Plant Licensing
Date:......................................January 10, 2013

Period of Performance: ....January 2015 through January 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This WBS element includes all licensing activities for the facility. Included are the following:

- WBS 1F131 – NRC Licensing
- WBS 1F132 – State Licensing
- WBS 1F133 – Department of Transportation Licensing

The NRC licensing will encompass all aspects of the project including site facilities design and operations, operational activities at the plant sites, licensing of transportation equipment (Casks, Canisters, etc.), rolling stock, operational plans, emergency response plans, and all other aspects of this project from the moment UNF is loaded at the plant site until the end of life disposition of the UNF at the CSF site.

The NRC licensing will be in three Stages consistent with the Staged construction approach for development of the CSF. Stage 1 Construction will include the site and off-site development, the cask handling facility, and all work required to accept stranded UNF from plant sites. Stage 2 construction will include additional storage pads and all work required to be able to accept UNF from operating plants. Stage 3 construction will include fuel storage pools, additional storage pads as well as Hot Cell facilities.

The costs included in this WBS element include all costs associated with achieving original licenses from the NRC to operate the program and the CSF site. Costs for ongoing licensing activities following issuance of initial licenses are contained in the operational costs WBS elements.

State licenses will depend on the nature of the location selected for the CSF site. Potential licenses include special use licenses for movement and storage of nuclear materials within the state, approvals of emergency planning efforts, environmental protection reviews and approvals, or other miscellaneous licenses or permits required by the hosting state. The requirements will be different if the facility is located on a tribal property or on a DOE reservation.

The estimated costs is based on the SME's estimated level of manpower to complete all licensing activities and is set at 22 FTE per year for 6 years or a total of 132 Man Years at a FTE loaded rate of $240,000 per Man Year.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F14
Account Name: ....Plant Permits
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2014 through Jan 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This effort includes all man hours and ODCs required to secure and maintain all plant-specific permits and licenses (other than the NRC license) for the startup and operation of this facility at the selected location. This scope is distinct from the site permits in that it refers to other requirements beyond site and access permits.

The costs included in this WBS include any special operating permits that are required beyond the NRC license that may be required by the specific site in question. This would include federal, state, and local environmental permits; site characterization requirements; and permits required for movement and storage of hazardous materials.

Since the site is undetermined, it is not possible to establish a definitive set of permits or their associated costs. This WBS together with the Site Permits WBS 1F12 represent approximately 0.5% of the total project Capital Cost.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F16
Account Name: ....Research and Development
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2013 through Jan 2033

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This effort includes all man hours and ODCs required to perform the necessary R&D to: qualify high-burn-up fuel for transport; initiate planning and conduct examinations to obtain confirmatory data for long-term storage; initiate development and perform testing of monitoring devices; initiate interactions with DOE and the utilities on standardized canisters, including the opening and sealing of canisters; and review available economic studies on rod consolidation, and update as needed.

The principal effort early in this time frame will be that involving high-burn-up fuel. Negotiations with cooperating utilities will be initiated quickly and specific plans will be developed for obtaining fuel rods from sibling assemblies being placed in dry storage. Services of transportation cask suppliers and post-irradiation Hot Cell facilities will be priced and selected. Interactions with the NRC will be conducted to assure that there are no issues regarding the shipment of this fuel to the selected Hot Cell. It is assumed that no new licensing will be required and that the selected fuel can be shipped during a timely operations window of the utility. Interactions with the appropriate DOE efforts will be required to confirm the specific details of the Hot Cell investigations, particularly in regard to filling the known high-priority data gaps identified in various joint DOE/NRC/Utility meetings.

Later effort in this time frame will focus on characterizing the long-term performance of used nuclear fuel in dry storage. To that end, negotiations with potential utilities will be conducted to identify and select specific rods for examination. The emphasis will be on those casks that have bolted lids with bare fuel to avoid opening canisters at this time. Services of transportation cask suppliers and post-irradiation Hot Cell facilities will again be priced and selected. It is expected that two campaigns will be performed during this time period.

This R&D effort is spread starts during in design and construction of the CSF and continues throughout over the entire operating life of the facility. The costs prior to completion of Construction Stage 1 and the subsequent shipment of stranded fuel are included in the Stage 1 Capital Cost estimate. Upon commencement of operations, the R&D costs have been included in the Operating cost estimate.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F17
Account Name: ....Other Pre-Construction Direct Costs
Date:.......................................January 10, 2013

Period of Performance:..........Jan 2013 through Jan 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

1F171	DOE Administration
1F172	Contractor Administration
1F173	Legal
1F174	NRC Meetings/Interaction
1F175	Independent Reviews (EIR and others)
1F176	Contractor Support to DOE

Included in this WBS element will be all other direct pre-construction costs not specifically related to design, permitting, and licensing of this facility. As shown above, these costs will fall into several categories. The first is the cost of the DOE efforts to manage and support the design, permitting, and licensing of the facility. This includes all DOE direct manpower and ODC costs from project initiation until start of construction.

The contractor selected for design, permitting, and licensing will have management and overhead costs associated with the performance of this contract. These costs including any direct manpower and ODC costs shall be included in this WBS.

Outside legal efforts will be required during the design, permitting, and licensing process, specifically related to public hearings, NRC hearings, and Congressional hearings related to this project. The costs associated with external legal efforts are included in this WBS.

The primary information for the design, permitting, and licensing of the CSF will be through the Prime Contractor. This WBS elements includes the costs of external Subject Matter Experts (SMEs) associated with presentations of information to Public, NRC, and Congressional hearings.

Also included in these costs are the Technical Support to DOE required for independent reviews of the contractors designs as well as External Independent Review required by the 413.3B process for major capital procurements. It is assumed that DOE will require SME support through the entire design, permitting, and licensing effort and concentrated efforts at key points in the decision process including CD-0 Definition and Affirmation of the Mission, CD-1 Evaluation of Alternatives and Selection of Final Concepts, CD-2 Definition of the Conceptual Design and Establishment of the Project Baseline, and CD-3 Approval for Start of Construction.

The costs were based on the following assessment of personnel requirements:

DOE Administration:......................5 FTE annually over 6 years or 30 Man Years
Contactor Administration: ....5 FTE annually over 6 years or 30 Man Years
Legal: ....2 FTE Annually over 6 years or 12 Man Years
NRC Meeting Coordination:...........2.5 FTE annually over 6 years or 15 Man Years
Independent Reviews:.....................Peer and EIR reviews totaling $1 million over 6 years
Contractor Support to DOE: ....4 FTE annually over 6 years or 24 Man Years

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F18
Account Name: ....Conceptual, Preliminary and Final Design
Date:.......................................December 27, 2012

Period of Performance: ....July 2014 through July 2033

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

WBS 1F18 encompasses the costs for all original design including conceptual, preliminary, and final design and development of the Construction Bid Packages. This WBS element includes work in lower-level WBS elements as follows:

1F181	Conceptual Design of CSF
1F182	Preliminary Design of CSF (Excluding pools and Hot Cell facilities)
1F183	Final Design CSF (Excluding pools and Hot Cell facilities
1F184	Preliminary Design of pools storage and Hot Cell facilities
1F185	Final Design of pool storage and Hot Cell facilities

1F181 Conceptual Design of CSF—The Conceptual Design of the CSF includes additional alternative studies and time and motion studies to establish the Design Concept (CD-1) for the entire CSF (all 3 construction stages). Design criteria will be completed to support licensing and the later design phases. Geotechnical and environmental exploration of the will be supported; seismic design criteria will be established. An Integrated Safety Management plan will be issued and a Preliminary Hazards analysis will be performed. An acquisition strategy will be produced and value engineering studies will be performed. CAD/CAE systems will be set up and conceptual design drawings and diagrams will be produced. A preliminary Vulnerability Analysis will be performed to support the integration of security into the concept. A formal design review will be performed and a Conceptual Design Report will be issued in support of Critical Decision 1. We will specify and coordinate the acquisition of all rolling stock and Stage 1 Transportation Casks (long lead procurements).

1F182 Preliminary Design of CSF—The Preliminary Design will establish the technical, cost, and schedule baselines for the project (CD-2). Project design criteria will be updated. System sizing calculations will be issued. General Arrangement Drawings, P&IDs, electrical 1-lines, control system architecture, and System Descriptions will be produced. The Hazards Analysis Report and Vulnerability Assessment Reports will be issued and the Earned Value Management System will be implemented. The Environmental Report and Safety Analysis Report will be produced and submitted to the NRC. The acquisition and certification of rolling stock and Transportation Casks will continue to be supported.

1F183 Final Design of the CSF (Except pool storage and Hot Cell facilities)—The final construction drawings and specifications and associated analysis will be completed. A set of procurement specifications will be produced to receive and integrate vendor design data into the final construction package. A construction cost estimate and project risk analysis will be produced in support of CD-3. The quality assurance program for construction will be updated and construction bid process and transition to construction will be supported. We will continue to support licensing and delivery of certified rolling stock and transportation casks.

1F184 Preliminary Design of Storage Pools and Hot Cell Facilities—Prior to Stage 3 Construction the Preliminary Design of the Storage Pool and Hot Cell Facilities will be completed. Technical, cost, and schedule baselines will be established in support of CD-2. A licensing amendment will be prepared and submitted to the NRC. Design products, including design criteria, sizing calculations, Hazards Analysis, Vulnerability Assessment, Shielding and Confinement Analysis, P&IDs, Electrical 1-lines, control system architecture, General Arrangement Drawings, System Descriptions, Seismic Response Spectra, and Foundation Design will be produced to support the detailed design of these facilities, which are included in the Conceptual Design Report. CAD/CAE systems and records management systems will be setup and managed for this project.

1F185 Final Design of Storage Pools and Hot Cell Facilities—Final analysis, drawings, and specifications will be completed for the Pool Storage Facility and Hot Cell Facility, along with a construction cost estimate, a final design report, and a risk analysis report to support the CD-3 process. Procurement specifications will be prepared and awards will be made to obtain engineering data and pricing (release for fabrication will be held provided until after CD-3). Licensing support will continue during final design.

The Total Design Effort is captured in the 1st and 3rd Construction Stages. All costs for design efforts associated with support to construction (Title III Design) are contained in 1F35 and 1F37 (Engineering support to Construction). The total FTEs for the Conceptual, Preliminary, and Final Design effort (including licensing support) is estimated at 495 Man Years with the average cost of $240,000 per Man Year.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F20
Account Name: ....Direct Capital Costs
Date:......................................January 10, 2013

Period of Performance: ....Jan 2013 through Jan 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This is a WBS Level 2 Control Account. Included in this WBS element are numerous elements of the project as defined in level 3 and below WBS elements. Specifically included in this WBS are the following:

1. 1F211 Site Preparation and Yard Work
2. 1F213 Consolidated Storage Facility (CSF) – All Stages
3. 1F214 Hot Cell at the CSF
4. 1F215 Transportation Equipment
5. 1F218A Control Room/Area
6. 1F218B Administration Building
7. 1F218C Cask Maintenance Facility
8. 1F218D Entry Control Building
9. 1F218E Visitor Center
10. 1F218X Rail Access to Facility
11. 1F218Y Road Access to Facility
12. 1F22 Engineered Equipment – Material Handling
13. 1F24 Electrical Equipment
14. 1F25 Heat Rejection Equipment
15. 1F26 Miscellaneous Equipment

The detailed scope of work and assumptions for development of the total costs are written in the lower level WBS Basis of Estimate (BOE).

This WBS element is intended to capture all costs related to the development of the CSF and related equipment during the construction and acquisition stage of the project.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F211
Account Name: ....Site Preparation and Yard Work
Date:......................................January 10, 2013

Period of Performance: ....January 2018 through January 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

All work related to preparation of the site to receive the CSF construction including Clear and Grub, Rough Grading, Excavation (Fuel Storage), Final Grading, Drainage Structures, Retention, Building Pad Construction, Surveying, Site Utilities (Sewer, Water, Gas, Electric, Data), Curbing and Sidewalks, Paving, Site Lighting, Perimeter Fencing (not specifically the PIDAS).

The site is assumed to be one mile on each side with a perimeter (non-PIDAS) fence surrounding all sides of the site. The CSF facilities are located in a centralized location to minimize the costs of utilities, roads, and other site developments to support the functioning of the CSF.

All earthwork for the site is included with an assumed average processing of one foot of soil over the entire site. Building pads and other structural earthwork efforts are included using approximately 7,500 CY of on-site material for building pad construction. Crushed gravel circulation around the Storage Pads is included using 250,000 CY of crushed gravel materials.

Site and off-site utilities are included in this WBS. The off-site utilities are assumed to be 15 miles of water, electrical, communications, gas; on-site utilities include sewer, water, gas, communications, and septic disposal.

Perimeter Fencing (non-PIDAS) is included assuming 21,120 LF of 8-foot fence with razor wire loop on fence top and concrete bottom 6 inches wide by 2 feet deep.

Site Lighting is included with the perimeter having light poles and bases every 200 LF, the Protected Area (PIDAS) perimeter lighting having one pole every 100 LF and the Dry Storage Area lighted with a grid of 200 light poles to achieve design luminosity within the storage areas.

A Perimeter Intrusion Detection and Surveillance System (PIDAS) is included for the assumed 15,000 LF perimeter of the protected area. It is assumed that the PIDAS will be initially installed for Stage 1 Construction and then expanded/relocated for Stages 2 and 3. Based on SME input, the unit cost per LF for the PIDAS has been set at $3,500 per LF.

Two Perimeter Fence access points with associated controls have been provided, as well as two protected area access points (excluding the security building access point) with controls.

Electrical distribution to all facilities and site lighting on the site has been included.

Heavy haul road, electrical, gas, water, and data are provided for on-site facilities. Sewer is intended to be on-site septic disposal.

Costs are based on standard commercial construction rates, except for the PIDAS costs which represent a special system for nuclear facilities and which have been reviewed by SMEs.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F213
Account Name: ....Consolidated Storage Facility – Storage Pads
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2026

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This WBS element includes all costs associated with the construction of the Consolidated Storage Facility storage pads.

The site and associated buildings will be constructed in three Stages. The first Stage will include all elements required to receive transportation casks by rail or truck and to transfer these into either vertical or horizontal dry storage systems while maintaining radiation doses to the CSF operators ALARA. Additionally all site development, office building, visitor center, Fleet Management Facility, and Cask Maintenance Facility will be constructed during this Stage. UNF received during this Stage will be transferred to dry storage and represents stranded fuel from shut down reactor plants.

The second Stage of the CSF facility will include and expansion of the dry storage pads and a relocation of the PIDAS to be able to accept UNF in DCSS from operating plants.

The third Stage of the CSF construction will include the fuel storage pools to accept fuels being shipped from operating nuclear plants, the Hot Cell and a final relocation of the PIDAS. There will be two storage pools, one for PWR assemblies and the other for BWR assemblies, which are intended to accept fuel assemblies that are shipped to the site in dual purpose casks. Fuels will be removed from the site cooling pools and transferred to the CSF cooling pools for continued decay heat removal and buffer storage. Assemblies stored in the CSF pools will ultimately be transferred to dry storage or reprocessing.

These first two stages will be constructed over a period of 2 years for each stage. The third and final stage will require a longer construction period of approximately 4 to 5 years. The CSF will be a seismically designed, hardened facility (where applicable) that complies with ASME NQA-1 requirements.

Storage Pads will be sufficient to store 140,000 MTU of UNF. Basis pad design is based on current commercial ISFSI storage facilities designed and constructed by Shaw. The typical storage pad will be 2 to 3 feet thick structural concrete with top and bottom reinforcing mats of #10–#11 rebar at 12 inches OCEW. The vertical storage pads (canister & concrete over-pack) will be approximately 15,000 SF each and support 32 storage canisters/over-packs each. The pads will be surrounded with crushed gravel circulation to allow transporters to place and retrieve any DCSS unit.

The pads for the horizontal storage systems (NUHOMS) will be of s similar size but will also have a poured-in-place apron to support placement and alignment of the horizontal storage systems.

Pads for the dry storage include approximately 585,500 CY of structural concrete and 135,000,000 pounds of reinforcing steel.

While it is not a specific requirement, an allowance of $70,000,000 for possible surveillance and monitoring of the DCSS systems has been included.

The Cask Handling Facility will be built in two stages. The first stage is to accommodate the early deliveries of stranded fuel from closed reactor facilities. The building is approximately 33,000 SF and is constructed of poured-in-place concrete including a concrete roof structure. It is designed as a safety-related structure and will meet the natural hazards criteria related to hurricanes, tornadoes, and earthquakes.

Storage Pads will be constructed in three stages. The first stage of construction will accept stranded UNF from closed plants. The second stage of pad construction will include a substantially expanded storage area and associated PIDAS to begin accepting UNF from operating plants. The third and final Stage of the pad construction will include the complete build-out of the storage pads and final configuration of the PIDAS to accept the balance of the planned 140,000 MTU of UNF.

The Storage Pads are approximately 6,750,000 SF and the total cost is approximately $54 per SF or $630 per CY of concrete.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F213A
Account Name: ....Consolidated Storage Facility – Pool Storage Systems
Date:.......................................January 10, 2013

Period of Performance: ....January 2029 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Cask Handling Facility will be built in two stages. The first stage is to accommodate the early deliveries of stranded fuel from closed reactor facilities and will encompass the basic Cask Handling Facility and Equipment. Operations in the CHF will begin with the earliest shipments. The third stage of site development will include the storage pools for direct wet to wet transfer of UNF from operating reactor sites.

The Pool Storage Facility will be located adjacent to the operating Cask Handling Facility and will involve deep excavations for the cooling pools. To eliminate disruption of the operations of the Cask Handling Facility, a deep foundation wall will be constructed as part of the Stage 1 Construction of the CHF, allowing adjacent excavation and construction without interruption of the CHF activities. The building is a poured-in-place concrete building of similar design to the CHF and will be a safety related design and construction.

The building footprint is 19,000 SF and it will contain two pools that are 40 feet by 40 feet by 40 feet, one for BWR fuel and one for PWR fuel. The main equipment in the pool storage areas are the storage racking systems and the pool liner systems. The costs for this equipment, along with the used fuel pool bridge cranes, were taken as an extrapolation of current pricing from the AP-1000 units being constructed by Shaw.

Pool Liners and Racking Systems are included in WBS 1F22A and 1F25 include the cost of Heat Rejection Equipment.

Concrete, steel, and MPE are estimated using current nuclear facility construction costs and the specialty items are taken from current pricing data from current and planned pool storage systems.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F213B
Account Name: ....Consolidated Storage Facility – Cask Handling Facility
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2026

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Cask Handling Facility (CHF) will be part of the initial stage of Construction. The CHF will need to be operational for the first shipments of stranded fuel.

The CHF will be a safety related facility and will be constructed of poured-in-place concrete. The footprint of the facility will be 33,000 square feet and will provide for rail access and cask transporter access. Lifting equipment to maneuver fully loaded casks and canister/over-pack will be included in the facility.

Building is assumed to be 40 feet tall with a concrete roof for protection from hurricane and tornado-generated missiles. Walls and roof are nominally 2-foot-thick poured-in-place concrete.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F214
Account Name: ....Hot Cell
Date:......................................January 10, 2013

Period of Performance: ....January 2029 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Hot Cell will be included in stage three of the construction program for the CSF. Following completion of all facilities required for accepting both stranded fuel from closed facilities and hot fuel from operating facilities, the Hot cell will be constructed. The Hot Cell will provide the capability of re-packaging canisters, packaging rods and assemblies for off-site testing, and testing and evaluating of fuel rods and assemblies in Hot Cell laboratories located on the CSF site.

Four Hot Labs will be developed within the Hot Cell Facility for R&D purposes.

The ongoing R&D program will use this facility to monitor confinement performance as part of the Aging Management Program.

Details of the estimate were developed from a conceptual approach assuming a footprint of 25,000 SF, fully poured-in-place structure with 2- to 4-foot-thick concrete, leaded glass Hot Cell view windows, and full remote operations within the cell(s). Intermediate levels were included along with added leaded windows and remote manipulators to be able to view and access the casks and fuel within the Hot Cell for the full height of the Hot Cell. Cost for the specialized equipment for use within the Hot Cell facility are captured in the equipment portion of the Estimate WBS 1F22.

The building is assumed to be 80 feet tall, is designed to be a safety-related structure, and will contain full HEPA filtration on the mechanical systems. It is designed to have a single cask on a rail car in the Hot Cell at any given time. Remote-controlled material handling is included in the estimated costs.

Costs for the structural elements were developed from similar structures presently being constructed in the commercial nuclear industry. Much of the specialty equipment is priced based on Estimators’ best professional opinion.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218A
Account Name: ....Control Room/Space
Date:......................................January 10, 2013

Period of Performance: ....Jan 2018 through Jan 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Control Room/Space work stations will be the single point where storage data and command and control data is tracked and monitored. This includes the remote backup of all control room functions. Control room functions will include tracking the location and data associated with all UNF received at the facility, the monitoring and operation of the fuel pool cooling and purification systems, the radiation monitoring system, utilities monitoring and operation, Hot Cell ventilation and area monitoring, CSF health physics data, closed-circuit TV monitoring of operations, and maintenance. This location will monitor and alarm all active cooling and safety related systems, including pool storage cooling and Hot Cell monitoring. An economic analysis will be conducted to determine if this control function must be incorporated into design of a hardened safety related structure, such as the Cask Handling Building, or if a room in the Administrative Building is sufficient, since safety-related events may evolve slowly and could be backed up by local control systems.. For planning purposes, we have assumed that this will be a hardened safety related space and will meet required seismic criteria as well as design basis physical event criteria including hurricane and tornado forces and wind-driven missiles.

The Control Room/Space is assumed to be 1,000 square feet and shall maintain monitoring of all fuel storage locations as well as active control of all pool storage locations requiring safety related active cooling.

The Control Room/Space will be required for initial acceptance of fuel at the CSF facility, with at least the monitoring capabilities full operational for the air cooled storage locations.

Construction methods are assumed to be a poured-in-place concrete superstructure to provide the protection of the safety-related systems contained therein. It is assumed that NQA-1 requirements will apply to the building as well as the monitoring and control systems contained therein.

Basis of Estimate: Consolidated Storage Facility

WBS Number:........................1F218B
Account Name: ....Office Building
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2018 through Jan 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Office Building will house CSF operations and maintenance management, R&D Management and Staff, NRC offices, DOE offices, records management, project controls, human resources, accounting, logistics management, engineering, licensing, medical, and health physics. The Administration Building is located outside of the Protected Area and will include a lunch room, rest rooms, a reception area, conference rooms, offices sufficient to support the various CSF support functions.

The footprint of the administration building is assumed to be 12,500 SF. Commercial construction methods will be employed for the construction of the Office Building.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218C
Account Name: ....Cask Maintenance Facility
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2018 through June 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This facility shall be located on site, outside of the Protected Area and is not be considered safety related. The total footprint is assumed to be approximately 10,500 SF.

This facility will provide for maintenance and repair of the transportation casks and other logistics and support for all activities on the CSF, but will not handle any radioactive materials. It will serve as the repository for all spares for the facility as well as staging area for all normal operations and maintenance functions. Construction methods are assumed to be standard commercial methods for a heavy steel building with a light steel skin. Rail access and large roll-up doors at either end will be included. A heavy lift crane will be included in the cost of this building.

Since this facility is not a safety-related facility, it shall be stand alone from any of the other buildings on site, including the fuel handling/cask handling, pool storage, Hot Cell, or control room.

Estimate data is taken from standard commercial construction cost data and represents Estimators’ best professional judgment.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218D
Account Name: ....Security Building
Date:......................................January 10, 2013

Period of Performance: ....Jan 2018 through June 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The Security Building will be constructed on the CSF site and will be the main point of access control to the storage locations, pools, Hot Cells, and all other areas where UNF will be stored on the site. The approximate size of the of the structure will be 80 feet by 120 feet. While the structure will not be safety related, it will be constructed to prevent intruder access and will be a poured-in-place structure including walls and roof. Access control equipment will be installed in the building to monitor and control all personnel access into the protected area.

This building will also contain the center for the security forces and serve as either the primary or secondary control point for the CSF facility.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218E
Account Name: ....Visitors Center
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2018 through June 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

A Visitors Center will be constructed on the CSF site and located outside the Protected Area. The approximate size of the visitor center will be 56 feet by 56 feet. Construction methods will be standard commercial construction methods and codes. Interior finished will be standard commercial level construction finishes.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218X
Account Name: ....Railroad Track Development
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

Development of the rail system both off site and on site will be essential for the start of operations of the CSF. Since a site has not been selected, a nominal 15 miles of rail line from existing facilities to the site will be assumed. The on-site rail development is assumed to be a total of 5 miles of railway. This shall be a single line with two sidings, allowing traffic in both directions without the cost of a dual-line installation. Construction methods will meet the requirements of all federal and state regulations for rail transportation.

It is assumed that the rail right-of-way will parallel the road access and utility right-of-ways and that all rights-of-way will be secured at the same time.

The on-site rail line will be assumed to be 5 miles total length including all parallel lines, switches, and sidings.

Included in the cost for the rail lines are the bed preparations, ties, ballast, rails, communications and signaling, switches, sidings, drainage crossings (no bridges assumed), road crossings, and associated signals and controls.

There will be a maintenance yard near the Fleet Management Facility to allow for maintenance of the DOE consist vehicles.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F218Y
Account Name: ....Paved Access – On Site and Off Site
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

Paved access to the site and around the site will be required prior to start of operations. The off-site road development is planned to parallel the rail and utility development for the site and is assumed to be 15 miles to the site location from developed roadways.

Clearing, grubbing, and earthwork for the roadway is included. Bed preparations, drainage, rip par, culverts, and other associated structures are included in the cost.

The roads will be a heavy-haul design section assuming as a minimum 6 inches AC on 10 inches base course. Depending upon the location of the site, subgrade preparations may be more or less extensive. For purposes of this estimate, we are assuming development of the site in the desert (Southwest) with low expansive soils, requiring a scarify and re-compact subgrade preparations following clear/grub and mass excavation. The road will be 24 feet wide with 3-foot shoulders on each side. Appropriate drainage crossings and protection barriers will be included in the costs of this element.

The cost of on-site roadways is also included in this WBS Element and shall provide interconnection of all facilities on the site for vehicular traffic.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F22
Account Name: ....Engineered Equipment
Date:......................................January 10, 2013

Period of Performance: ....2016 through 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

WBS 1F22 contains the costs for most of the specialized equipment to be used on the CSF project. These costs include the following:

- WBS 1F221—Transportation Equipment
- WBS 1F222—Consolidated Storage Facility Equipment
- WBS 1F223—Hot Cell Equipment

Transportation equipment includes all rolling stock used to form the transport consists including cask cars, buffer cars, and escort cars. 148 cask cars, 29 escort cars, and 58 buffer cars are included in the estimated costs. The number and unit costs for the rolling stock were developed by the transportation SMEs on the team using industry current cost data.

Additionally, the transportation equipment includes the costs for the Transport Casks for both the rail and truck transport of UNF. The cost estimate included 145 Rail Transport Casks and 18 Truck Transport Casks. The number and unit rates for the transport casks were developed by the transportation SMEs on the team using industry current cost data.

The equipment costs for the Consolidated Storage Facility include the consist yard locomotives (or tuggers), cask transporters, as well as racking systems and pool liner systems for pool storage of fuel elements within the two storage pools.

The Hot Cell will require miscellaneous specialized equipment to make the facility useful. Much of this will be specially designed remote operating equipment to facilitate the operations to be conducted in the Hot Cell facility. This does not include the lead windows, remote manipulators or remote hoists, which are included in the building costs in WBS 1F214 Hot Cell.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F24
Account Name: ....Site Electrical Equipment
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2033

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

WBS 1F24 will include all site electrical equipment required to serve this facility, including a substation, service entrance, switchboards, switching cabinets, transformers, and distribution duct banks required to serve the various facilities in the site.

Site lighting and electrical power distribution are included in other WBS elements.

Site lighting and electrical gear were priced prices using standard commercial pricing data. Electrical power distribution was priced as direct burial electrical and communications wiring.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F25
Account Name: ....Heat Transfer Equipment
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

WBS 1F25 covers the costs of heat transfer equipment and systems to reject heat from the active cooling systems on the site. Primarily, this involves independent, redundant safety-related air-cooled chillers for the PWR Storage Pool and two independent and redundant air-cooled chillers for the BWR Storage Pool. An assumed chiller capacity of 1 Kw/assembly (TBC) is assumed for each pool to reject heat from the PWR and BWR storage pools in the Consolidated Storage Facility.

Data on the heat removal equipment is extrapolated from the current pricing data for AP-1000 pool cooling systems currently being developed and constructed by Shaw.

HVAC systems within each of the buildings and facilities are included in the respective WBS element and are not included in this Heat Rejection Equipment account.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F26
Account Name: ....Miscellaneous Site Equipment
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2020

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

WBS 1F26 includes the costs of all miscellaneous equipment for the project not specifically noted in other WBS elements. Included here will be forklifts, special-use trucks, hoisting equipment, compressors, communications equipment, and furniture and fixtures for all the facilities on the project.

Also included in this WBS element will be the fire water storage tanks and fire pumps, which will serve as a reservoir for cooling the used fuel pools should there should be a loss of power and emergency power on the site.

The cask transporters and the NUHOMS overpack transporters are included in this WBS element.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F30
Account Name: ....Capitalized Field indirect Services
Date:......................................January 10, 2013

Period of Performance: ....January 2018 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This WBS elements is a Level 2 Cost Account to hold all costs associated with the indirect costs of construction for all Stages of construction. Included in this WBS element are the following:

General Conditions	120 Months	$543,500/Month
Project Management	120 Months	36 FTE
Construction Management	120 Months	43 FTE
Engineering Title III	120 Months	52 FTE
Test & Commissioning	12 Months	62 FTE

The details of the costs and assumption of these specific areas are contained in the Lower Level 3 BOEs specifically addressing each area.

We have assumed that the construction of the CSF will take place in three stages with the first stage to support initial operations and movement of stranded fuel from closed reactor sites. The first stage will include complete site clearing and development, perimeter fencing, site lighting, site electrical, initial PIDAS, primary and secondary monitoring stations, first stage storage pads, control space, Cask Maintenance Facility, Fleet Management Facility, Security Building, Concrete Batch Plant, Office Building, Visitors Center, and the Cask Handling Facility.

The off-site rail, road, and utility developments will be required for this initial stage as well.

The second stage will include a second stage of dry storage pad development and a PIDAS expansion/relocation. The final stage will include the Hot Cell, the balance of the dry storage pads, the pool storage capabilities, and a final expansion/relocation of the PIDAS.

These costs are time-staged over an extended period of time and the basic cost data is presented in 2012 Dollars. Escalation factors are added at the project level based on project cash flow and assumed escalation rates over the period of performance.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F31
Account Name: ....Field Indirect Costs
Date:......................................January 10, 2013

Period of Performance: ....Jan 2018 through Jan 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This WBS element includes all costs associated with temporary facilities, temporary utilities, cleaning services, office supplies, safety, security, material handling (construction materials only), and all other support services not directly related with Project Management, Construction Management, or Project Design Services, which are held in a separate WBS element.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding Stage. Services will not be continuous in between the Stages. It is likely the services contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of stranded fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require pool storage as well as pad storage. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the pool storage and Hot Cell operations.

Stage 1 is assumed to last 2 years. Stage 2 is assumed to last 2 years. Stage 3 is assumed to last 5 to 6 years. Details of the field indirect costs are shown in the estimate.

Temporary Facilities	120 Months	$39,000/Month
Temporary Utilities	120 Months	$27,500/Month
Vehicles	120 Months	$45,000/Month
Cleaning & Janitorial	120 Months	$80,500/month
Safety	120 Months	$27,500/Month
Security	120 Months	$193,500/Month
Material Handling	120 Months	$72,000/Month
Equipment/Rentals	120 Months	$45,000/Month
Office Supplies	120 Months	$13,000/Month

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F32
Account Name: ....Construction Supervision
Date:......................................January 10, 2013

Period of Performance: ....January 2018 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

This WBS element includes all manpower and support costs for management of construction activities for each of the three Stages of the construction for this program. Construction Management activities will include a Construction Manager, Field Engineers, Superintendents, and Foremen for the actual construction activities on the project. Administrative support for the Construction Management Team will also be included in this WBS element. Other required activities such as Project Management, Engineering, QA/QC, Health and Safety, or other support functions, whether on site or off site, will be captured in other WBS elements. Staffing levels will vary between the construction stages as will the level of overview required as Stages 2 and 3 contain much more safety-related construction than Stage 1.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding Stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of stranded fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require additional pad storage. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require used fuel storage pools and Hot Cell operations.

Stage 1 is assumed to last 2 years. Stage 2 is assumed to last 2 years. Stage 3 is assumed to last 5 to 6 years.

Construction Management	120 Months	3 FTE
Project Engineers	120 Months	5 FTE
Document Control	120 Months	5 FTE
Project Controls	120 Months	5 FTE
Testing	120 Months	1 FTE
Inspectors	120 Months	5 FTE
Field QC	120 Months	10 FTE
Tech Reps/Expediting	120 Months	5 FTE
Administrative Assistance	120 Months	4 FTE

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F33
Account Name: ....Commissioning and Startup Costs
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2020 through Jan 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The initial stage of the Commissioning and Startup Costs will be limited to storage of stranded fuel from closed reactors on air-cooled pads. This startup, testing, and commissioning effort will include the CHF cranes and cask handling equipment as well as all of the building systems for the Stage 1 Construction. Stage 2 Construction will be a limited testing and startup effort for the expansion of the storage pads and expanded/relocated PIDAS. Stage 3 Construction, however, will contain active safety related systems for the pool cooling and cask handling/re-packaging and the Hot Cell operations. These will require more intense startup and commissioning activities than Stage 1.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of Stranded Fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require expanded storage pads and PIDAS. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the used fuel storage pools and Hot Cell operations.

Startup Management	12 Months	4 FTE/Month
Startup Engineers	12 Months	20 FTE/Month
Operators (in Operations Costs)	12 Months	0 FTE/Month
Security (in Operations Costs)	12 Months	0 FTE/Month
NRC Interface	12 Months	6 FTE/Month

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F35
Account Name: ....Title III Design Services, Off Site
Date:......................................January 10, 2013

Period of Performance: ....Jan 2018 through Jan 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The project may be of sufficient size and import that a home office design effort will be required to support the construction in the field. This WBS element will cover the costs associated with all off-site Title III Design Services for the project.

Following the start of construction, continued design services are required to resolve questions, discrepancies, non-conformances, and respond to the need for alternate design concepts and details. Since the facility will be located in a remote, rural portion of the country, design capabilities will need to be maintained in the home office of the EPC contractor. We anticipate that this Title III design activity will be greater for the nuclear systems side of the CSF and far less for the standard commercial construction activities. Requirements will be established for the level of Title III design requirements during the initial requirements Stage of the design program.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of Stranded Fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require additional pad storage and PIDAS expansion. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the used fuel storage pools and Hot Cell operations.

Total Title III engineering and design staffing for off-site support is set at 20 FTE over the 10 years of construction.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F36
Account Name: ....Project Management/Construction Management, Off Site
Date:.......................................January 10, 2013

Period of Performance: ....Jan 2018 through Jan 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The project may be of sufficient size and import that home office management will be required to support the construction management staff in the field. This WBS element will cover the costs associated with all off-site Project and Construction Management for the prime contractor/designer's home office. This staff will also include the project controls efforts and the equipment procurement and expediting efforts.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of Stranded Fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require additional pad storage and PIDAS expansion. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the used fuel storage pools and Hot Cell operations.

Stage 1 is assumed to last 2 years. Stage 2 is assumed to last 2 years and Stage 3 is assumed to last 5 to 6 years.

Project & Construction Management	120 Months	2 FTE
Cost Controls	120 Months	8 FTE
Scheduling/Planning	120 Months	6 FTE

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F37
Account Name: ....Title III Design, On Site
Date:.......................................January 10, 2013

Period of Performance: ....January 2018 through January 2035

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

During the construction of each of the three Stages of the CSF Construction and especially during the Stage 2 construction of expanded storage pads and PIDAS and the Stage 3 construction of used fuel storage pools and Hot Cells, on-site engineering will be required to facilitate and support the construction. This engineering will either on-site or near-site to facilitate examination of conditions in the field to expedite the design evolution as construction proceeds. The on-site Engineering Team will work hand-in-hand with the home office engineering department to resolve any significant issues or perform any complex analyses required to support the continuation of construction.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of Stranded Fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require additional pad storage and PIDAS expansion. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the used fuel storage pools and Hot Cell operations.

Stage 1 is assumed to last 2 years. Stage 2 is assumed to last 2 years and Stage 3 is assumed to last 5 to 6 years.

The on-site engineering and engineering management is assumed to be 32 FTE over the 10 years of assumed construction.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F38
Account Name: ....PM/CM Services, On Site
Date:......................................January 10, 2013

Period of Performance: ....January 2018 through January 2035

Description of Work including:
1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The primary direct role for both project management and construction management will be on-site management and administrative support. This WBS element will include the costs of the on-site project management, construction manager, project controls, and other required personnel for procurement, business administration, accounting, and other required business functions.

This effort will include the staged construction efforts as envisioned in WBS-1F30. Since Stages 1, 2, and 3 of construction will be separated by a number of years, all of the field services and support costs will include de-mobilization and re-mobilization for each succeeding stage. Services will not be continuous in between the Stages. It is likely the construction contractors may not be the same for each of the Stages.

Stage 1 is required to support delivery of Stranded Fuel from closed reactors. Stage 2 will be required to accept fuel from operating reactors that will require additional pad storage and PIDAS expansion. Stage 3 will be for assessment of the long-term stability of the stored fuels and will require the used fuel storage pools and Hot Cell operations.

Stage 1 is assumed to last 2 years. Stage 2 is assumed to last 2 years and Stage 3 is assumed to last 5 to 6 years.

We have assumed a total of 20 FTE over the 10 years of the construction effort for on-site project management and construction management functions.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F60
Account Name: ....Capitalized Financial Costs
Date:.......................................January 10, 2013

Period of Performance: ....2013 through 2120

Description of Work including:
1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The following costs are to be captured in this WBS element:

- 1F61 Escalation
- 1F62 Fees
- 1F63 IDC

Under the assumed development scenario, the facility will be DOE-owned and DOE-funded. As such, there will not be any interest during construction (IDC) included in the calculation of the project costs.

Escalation costs will be determined on a time-phased funding requirement for the project and will be accumulated in this WBS element.

Escalation costs will be determined using the recommended escalation values in Government publication for the years in question. This estimate has used a nominal 2% compounded escalation rate over the life of the program.

The fee to be included will be based on the value of the EPC contract costs and the O&M contract costs over the life of the project. The contractor fee will be accumulated in this WBS element.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F70
Account Name: ....Annualized Operations and Maintenance Costs
Date:.......................................January 10, 2013

Period of Performance: ....2020 through 2120

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The annualized operating costs for the facility will be held in this WBS element. There will be two distinct Phases of the operational costs with Phase 1 being a combined shipment of fuel along with monitoring and maintenance of the fuel on site. The second Phase will be simply the monitoring and maintenance of the fuel on site after shipments from current and planned facilities have ceased. There are no costs associated with the shipment of fuel from this CSF to a final disposition location. The annualized costs are identified in the following lower level WBS elements:

- 1F71—O&M Staff
- 1F72—Management Staff
- 1F73—Salary Related Costs
- 1F74—Operations Materials
- 1F75—Spare Parts
- 1F76—Utilities, Supplies and consumables
- 1F77—Capitol Plant Upgrades
- 1F78—Taxes and Insurance
- 1F79—Fuel Shipment Costs
- 1F79A—Security Costs
- 1F79B—Contingency on Annualized O&M Costs

Certain materials costs have been included in the Operations costs, the most significant of which is the procurement of 9,000 DFSS canisters and associated overpacks. The total cost of these canisters and overpacks was determined by escalating latest pricing from the Yucca Mountain TAD design. Total cost included for TAD canisters and overpacks included in this WBS element is $11.5B. These DFSS canisters will be used over the life of the project to transfer UNF from the fuel cooling pools into dry storage on the storage pads.

Additionally, consumables for construction of the required overpacks for the DCSS are included in the Operations costs.

Operations costs are determined annually and an escalation factor is applied to the year of expenditure to determine costs plus escalation costs.

The full-strength staffing and operations costs are shown below, which are consistent with the maximum levels of fuel shipments (4,500 MTU per year). A ramp up and ramp down are provided for the earliest operations and for operations after 2055 when fuel shipments are substantially reduced.

Management	10 FTE
O&M Staff	20 FTE
Cask & Fuel Handling	60 FTE
Engineering	5 FTE
Licensing	3 FTE
Researchers	4 FTE
Research Technicians	6 FTE
Cask/Fuel Monitoring	2 FTE
Logistics Support	3 FTE
Security	126 FTE
DFSS & Overpack Procurement	$500 million (years 2033–2055)
Consumables/Taxes	$8.5 million
Contractor Fee	10%

During the later years of operations when fuel shipments have stopped and the O&M is essentially monitoring the stored fuel, the staffing and costs are substantially reduced as follows:

Management	10 FTE
O&M Staff	20 FTE
Cask & Fuel Handling	0 FTE
Engineering	0 FTE
Licensing	3 FTE
Researchers	4 FTE
Research technicians	6 FTE
Cask/Fuel Monitoring	2 FTE
Logistics Support	0 FTE
Security	126 FTE
Over-Pack Materials	$0
DCCS Procurement	$0
Consumables/Taxes	$5 million
Contractor Fee	10%

A cost for D&D is included at the end of the project. This cost may vary substantially as decisions are made on the final disposition of the UNF. We have assumed that at least half of the DCSS systems will need to be D&D along with all facilities on the site.

Basis of Estimate: Consolidated Storage Facility

WBS Number: 1F70
Account Name: ....Annualized Transportation Costs
Date:.......................................December 26, 2012

Period of Performance: ....2020 through 2120

Description of Work including:

1. Work Scope Summary
2. Assumptions
3. Source of Estimate information

The annualized operating costs associated with transportation of UNF will be held in this WBS element. There are four operational Phases of fuel shipment. Phase 1 will be stranded fuel form closed plants. Phase 2 will be fuel from operating facilities. Phase 3 will incorporate pool-to-pool transfers. Phase 4 will include fuel currently stored in non-transportable storage systems. The transportation effort will include logistics, planning, utility coordination, loading of fuel onto transport rail, intermodal transport from plant site to rail heads, railroad contracts, transport security, and all other costs associated with the transport of UNF from the plant sites to the CSF. Funding to states and Native American tribes to support planning and emergency response will be included in this WBS element. Fees assessed by certain states for shipment of UNF casks through the state have not been included in this WBS element. Since robust funding is included to provide states and tribes with support for planning and emergency response, there would not be a need for the states to assess separate fees or if states did assess separate fees, the funding provided to those states would be reduced by the amount of fees assessed. Additionally, the costs for required modifications at the reactor plant sites (public domain outside of site fences) have been incorporated as one-time costs within this transportation WBS element.

All capital costs associated with transportation, including rail rolling stock, casks, canisters, and intermodal transport equipment have been captured in other Capital Cost WBS elements. There are no costs associated with the shipment of fuel from this CSF to a final disposition location.

The annualized costs are identified in the following lower-level WBS elements. These represent the maximum funding levels that are incurred during the years of maximum fuel shipment levels of 4,500 MTU annually. Ramp up and ramp down adjustments have been made in early and later years of the fuel shipments.

Transport Labor	50 FTE
Transport Security	50 FTE
Logistics Coordination	5 FTE
Transportation Planning	23 FTE
Transportation Management	28 FTE
Shipment Tracking	6 FTE
Notifications & Communications	8 FTE

Security Planning & Management	8 FTE
Rail Contracts	$18.6 million annually
Funding to States and Tribes	$2.5 million annually
Miscellaneous	$7 million annually
Contractor Fee	10%

Appendix H
Total Program Cost

Total Program Costs

Total Program Costs	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction - all Stages - 2013 - 2032	3,429,466,583				168,748,411	3,598,214,993
Operations/Transport - Stranded Fuel 2021 - 2026		282,048,195	186,814,320		391,713,296	860,575,811
Operations/Transport - DCSS - 2027-2055		2,080,287,647	742,440,391		1,913,822,745	4,736,550,783
Operations/Transport - Pool to Pool 2033-2055		2,204,365,540	627,230,120		1,493,194,011	4,324,789,671
Canisters & Overpacks 2033-2055		11,500,000,000			7,789,874,599	19,289,874,599
Operations/Transport-Non Transportable 2033-2055		440,873,108	125,446,024		298,638,802	864,957,934
Post 2055 Operations/Transportation - 2056-2120		2,491,880,174	509,175,418		8,065,008,526	11,066,064,118
D&D Costs				$3,750,000,000	4,000,000,000	7,750,000,000
Totals	3,429,466,583	18,999,454,664	2,191,106,273	$3,750,000,000	24,121,000,390	52,491,027,910

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Appendix E
FCT Document Cover Sheet

Name/Title of Deliverable/Milestone	TA 11 Development of Consolidated Storage Facility Design Concepts
Work Package Title and Number	Subtask 07- Final Report
Work Package WBS Number	Subtask 07
Responsible Work Package Manager	Richard Berry/ Richard Berry

Date Submitted January 31, 2013

Quality Rigor Level for Deliverable/Milestone ☒ QRL-3 ☐ QRL-2 ☐ QRL-1 ☐ N/A* ☐ Nuclear Data

This deliverable was prepared in accordance with ______________________
(Participant/National Laboratory Name)

QA program which meets the requirements of
☐ DOE Order 414.1 ☐ NQA-1-2000 ☐ Other

This Deliverable was subjected to:

☒ Technical Review	☒ Peer Review
Technical Review (TR)	**Peer Review (PR)**
Review Documentation Provided	**Review Documentation Provided**
☐ Signed TR Report or,	☐ Signed PR Report or,
☐ Signed TR Concurrence Sheet or,	☐ Signed PR Concurrence Sheet or,
☒ Signature of TR Reviewer(s) below	☒ Signature of PR Reviewer(s) below

Name and Signature of Reviewers

Gary Vine (TR)/ Gary L Vine
Jack Clemmens (TR)/ J Clemmens
Charles Hess (PR) Charles Hess

***NOTE** *In some cases there may be a milestone where an item is being fabricated, maintenance is being performed on a facility, or a document is being issued through a formal document control process where it specifically calls out a formal review of the document. In these cases, documentation (e.g., inspection report, maintenance request, work planning package documentation or the documented review of the issued document through the document control process) of the completion of the activity along with the Document Cover Sheet is sufficient to demonstrate achieving the milestone. QRL for such milestones may also be marked N/A in the work package provided the work package clearly specifies the requirement to use the Document Cover Sheet and provide supporting documentation.*