Omaha Public Power District

10 CFR 50.82(a)(4)

March 30, 2017
LIC-17-0033

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Fort Calhoun Station, Unit No. 1
Renewed Facility Operating License No. DPR-40
NRC Docket No. 50-285

Subject: Fort Calhoun Station, Unit No. 1, Post-Shutdown Decommissioning Activities Report

Reference:
1. OPPD Letter (T. Burke) to USNRC (Document Control Desk), "Certification of Permanent Cessation of Power Operations," dated August 25, 2016 (LIC-16-0067) (ML16242A127)

Pursuant to 10 CFR 50.82(a)(4)(i), Omaha Public Power District (OPPD) is submitting a post-shutdown decommissioning activities report (PSDAR) for Fort Calhoun Station (FCS). By letter dated August 25, 2016 (Reference 1), OPPD notified the NRC of its intention to permanently cease power operations at FCS on October 24, 2016.

The Enclosure to this letter provides the FCS PSDAR. The PSDAR has been developed consistent with Regulatory Guide 1.185, Revision 1, "Standard Format and Content for Post-Shutdown Decommissioning Activities Report." The FCS PSDAR includes a description of the planned decommissioning activities, a schedule for their accomplishments, a site specific decommissioning cost estimate and a discussion that provides a basis for concluding that the environmental impacts associated with site-specific decommissioning will be bounded by appropriate, previously issued, environmental impact statements. The PSDAR also includes a discussion of the schedule and costs associated with the management of spent fuel and site restoration. Funding for irradiated fuel management will be addresses in a separate submittal as an update to the Irradiated Fuel Management Plan pursuant to 10 CFR 50.54(bb).

In accordance with 10 CFR 50.82(a)(4)(i), a copy of the FCS PSADR is being provided to the States of Nebraska and Iowa by transmitting a copy of this letter and its attachments to the designated State Officials.

No commitments to the NRC are made in this letter.

If you should have any questions about the enclosed reports, please contact Mr. Bradley H. Blome at (402) 533-7270.

Respectfully,

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Senior Director Fort Calhoun Station Decommissioning

MJF/cac

Enclosure: Fort Calhoun Station, Unit No. 1, Post-Shutdown Decommissioning Activities Report

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POST-SHUTDOWN DECOMMISSIONING ACTIVITIES REPORT

for the

FORT CALHOUN STATION

prepared for

OMAHA PUBLIC POWER DISTRICT

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

March 2017

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Acronyms

AIF	Atomic Industrial Forum
ALARA	As Low As Reasonably Achievable
BMP	Best Management Practices
CFR	Code of Federal Regulations
DCE	Decommissioning Cost Estimate
DOE	Department of Energy
DSEIS	Draft Supplemental Environmental Impact Statement (NUREG-1437)
EPA	Environmental Protection Agency
FCS	Fort Calhoun Station
FSAR	Final Safety Analysis Report
GEIS	Generic Environmental Impact Statement (NUREG-0586)
GTCC	Greater than Class C
GW	Groundwater
ISFSI	Independent Spent Fuel Storage Installation
LLRW	Low-Level Radioactive Waste
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MWt	Megawatt-thermal
NEI	Nuclear Energy Institute
NESP	National Environmental Studies Project
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OPPD	Omaha Public Power District
PSDAR	Post-Shutdown Decommissioning Activities Report
PWR	Pressurized Water Reactor
SEIS	Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437), Supplement 12 "Regarding Fort Calhoun Station"
SFP	Spent Fuel Pool
SSCs	Structures, Systems and Components
UFSAR	Updated Final Safety Analysis Report

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

In accordance with the requirements of Title 10 of the Code of Federal Regulations (CFR) 50.82, "Termination of license," paragraph (a)(4)(i), this report constitutes the Post-Shutdown Decommissioning Activities Report (PSDAR) for the Fort Calhoun Station (FCS). This PSDAR contains the following:

1. A description of the planned decommissioning activities along with a schedule for their accomplishment.
2. A discussion that provides the reasons for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate previously issued environmental impact statements.
3. A site-specific decommissioning cost estimate (DCE), including the projected cost of managing irradiated fuel and the post-decommissioning site restoration cost.

The PSDAR has been developed consistent with Regulatory Guide 1.185, "Standard Format and Content for Post-Shutdown Decommissioning Activities Report," (Reference 1). This report is based on currently available information and the plans discussed herein may be modified as additional information becomes available or conditions change. As required by 10 CFR 50.82(a)(7), Omaha Public Power District (OPPD) will notify the Nuclear Regulatory Commission (NRC) in writing, with copies sent to the affected State(s), before performing any decommissioning activity inconsistent with, or making any significant schedule change from, those actions and schedules described in the PSDAR, including changes that significantly increase the decommissioning cost.

1.2 Background

The FCS site is approximately 660 acres in size and is located on the Missouri River, 19 miles north of Omaha, Nebraska. FCS employs a Combustion Engineering pressurized water reactor nuclear steam supply system licensed to generate 1,500 megawatts - thermal (Mwth). The facility ceased operating on October 24, 2016. The principal structures at FCS site include:

Containment Building – Constructed of pre-stressed steel reinforced concrete with walls almost four feet thick, with an interior one-quarter inch thick steel liner for leak tightness. The containment building contains the reactor and nuclear steam supply system.

Auxiliary Building – Houses the reactor auxiliary systems, including waste-treatment facilities, certain safety components, the control room, emergency diesel generators, and fuel handling and storage facilities. The Auxiliary Building is a heavily reinforced concrete structure that forms a "U" around the Containment Building.

Turbine Building – Houses the turbine generator, condensers, condensate and feedwater pumps, feedwater heaters and other turbine heat cycle components. The structural steel superstructure is enclosed with resin wall paneling, it has a reinforced concrete basement.

Service Building – Office space attached to, and of the same construction as, the Turbine Building.

Intake Structure – Houses the equipment that pumps cool river water into the plant for use in condensing the steam leaving the turbine. The building consists of a structural steel frame enclosed by resin wall panels. The intake structure is made of heavily reinforced concrete below the 1,014 foot elevation and extends over the Missouri River.

Security Access Facility – Serves as the main entrance to the plant.

Switchyard – Houses electrical transmission equipment that is connected to the main generator at the FCS.

Administration Building – Houses offices for management and engineering functions and NRC personnel, associated conference rooms and facilities, a fitness for duty laboratory, a radiological health area and a cafeteria.

Training Center – Includes an auditorium, laboratories and control room simulator.

Radioactive Waste Processing Building – Used to sort, compact, decontaminate and store (short-term) low-level solid and liquid radioactive waste. In this building, radioactively contaminated equipment and objects can be decontaminated. The building has a ridged steel framework to support a precast concrete exterior panel siding.

Chemistry and Radiation Protection Building – Houses chemistry and radiological laboratories, a cafeteria, offices, locker and shower room.

Warehouse – A 40,000 square-foot building used for receiving deliveries and storage of spare parts and equipment.

A brief history of the major milestones related to FCS construction and operational history is as follows:

- Construction Permit Issued: June 7, 1968
- Operating License Issued: August 9, 1973
- Commercial Operation: September 26, 1973
- Major Plant Refurbishment: 2006
- Original License Expiration: August 8, 2013
- Renewed License Expiration: August 9, 2033

By letter dated June 24, 2016 (Reference 2), OPPD notified the NRC that it intended to permanently cease power operations of FCS at the end of October 2016. An August 25, 2016 supplement to this letter certified that operations would cease on October 24, 2016 (Reference 2), in accordance with 10 CFR 50.82(a)(1)(i) and 10 CFR 50.4(b)(8). By letter dated November 13, 2016 (Reference 3) OPPD provided the certifications required by 10 CFR 50.82(a)(1)(i) and 10 CFR 50.82(a)(1)(ii), pursuant to 10 CFR 50.82(a)(2), that all fuel had been permanently removed from the FCS reactor vessel and placed in the FCS spent fuel pool. As such, the 10 CFR Part 50 license for FCS no longer authorizes operation of the reactor or emplacement or retention of fuel in the reactor vessel.

Pursuant to 10 CFR 50.51(b), "Continuation of license," the license for a facility that has permanently ceased operations continues in effect beyond the expiration date to authorize ownership and possession of the utilization facility until the Commission notifies the licensee in writing that the license has been terminated.

During the period that the license remains in effect, 10 CFR 50.51(b) requires that OPPD:

- Take actions necessary to decommission and decontaminate the facility and continue to maintain the facility including storage, control, and maintenance of the spent fuel in a safe condition.

- Conduct activities in accordance with all other restrictions applicable to the facility in accordance with NRC regulations and the 10 CFR 50 facility license.

10 CFR 50.82(a)(9) states that power reactor licensees must submit an application for termination of the license at least two years prior to the license termination date and that the application must be accompanied or preceded by a license termination plan to be submitted for NRC approval.

1.3 Summary of Decommissioning Alternatives

The NRC has evaluated the environmental impacts of three general methods for decommissioning power reactor facilities in NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors," (GEIS) (Reference 4). The three general methods evaluated are summarized as follows:

- DECON: The equipment, structures and portions of the facility and site that contain radioactive contaminants are promptly removed or decontaminated to a level that permits termination of the license shortly after cessation of operations.
- SAFSTOR: After the plant is shut down and defueled, the facility is placed in a safe, stable condition and maintained in that state (safe storage). The facility is decontaminated and dismantled at the end of the storage period to levels that permit license termination. During SAFSTOR, a facility is left intact or may be partially dismantled, but the fuel is removed from the reactor vessel and radioactive liquids are drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thereby lowering the level of contamination and radioactivity that must be disposed of during decontamination and dismantlement.
- ENTOMB: Radioactive structures, systems and components (SSCs) are encased in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

The decommissioning approach that has been selected by OPPD for FCS is the SAFSTOR method. The primary objectives of the FCS decommissioning project are to remove the facility from service, reduce residual radioactivity to levels permitting unrestricted release, restore the site, perform this work safely, and complete the work in a cost effective manner. The selection of a preferred decommissioning alternative is influenced by a number of factors at the time of plant shutdown. These factors include the cost of each decommissioning alternative, minimization of occupational radiation exposure, availability of a high-level waste (spent fuel) repository or a Department of Energy (DOE) interim storage facility, regulatory requirements, and public concerns. In addition, 10 CFR 50.82(a)(3) requires decommissioning to be completed within 60 years of permanent cessation of operations.

Under the SAFSTOR methodology, the facility is placed in a safe and stable condition and maintained in that state allowing levels of radioactivity to decrease through radioactive decay, followed by decontamination and dismantlement. After the safe storage period, the facility will be decontaminated and dismantled to levels that permit license termination. In accordance with 10 CFR 50.82(a)(9), a license termination plan will be developed and submitted for NRC approval at least two years prior to termination of the license.

The decommissioning approach for FCS is described in the following sections.

- Section 2.0 describes the planned decommissioning activities and the general timing of their implementation.
- Section 3.0 describes the overall decommissioning schedule, including the spent fuel management activities.
- Section 4.0 provides an analysis of expected decommissioning costs, including the costs associated with spent fuel management and site restoration.
- Section 5.0 describes the basis for concluding that the environmental impacts associated with decommissioning FCS are bounded by the NRC generic environmental impact statement related to decommissioning.
- Section 6.0 is a list of references.

2.0 DESCRIPTION OF PLANNED DECOMMISSIONING ACTIVITIES

OPPD is currently planning to decommission FCS using a SAFSTOR method. SAFSTOR is broadly defined in Section 1.3 of this report. Use of the SAFSTOR method will require the management of spent fuel because of the DOE's failure to perform its spent fuel removal obligations under its contract with OPPD. To explain the basis for projecting the cost of managing spent nuclear fuel (SNF), a discussion of spent fuel management activities for the site is included herein.

The initial decommissioning activities to be performed after plant shutdown will entail preparing the plant for a period of safe-storage (also referred to as dormancy). This will entail de-fueling the reactor and transferring the fuel into the spent fuel pool, draining of fluids and de-energizing systems, reconfiguring the electrical distribution, ventilation, heating, and fire protection systems, and minor deconstruction activities. Systems temporarily needed for continued operation of the spent fuel pool may be reconfigured for operational efficiency.

During dormancy the FCS will be staffed with personnel that will monitor, maintain and provide security for the Independent Spent Fuel Storage Installation (ISFSI) and plant facilities. Staffing and configuration requirements are expected to change during the period of dormancy, principally dependent upon the status of the spent fuel being stored on-site. This can be characterized as one of two spent fuel conditions, as follows:

- Wet and dry storage of spent fuel
- On-site dry storage of all spent fuel

Spent fuel will remain in the spent fuel pool (SFP) until it meets the criteria for transfer, and the spent fuel can be transferred in an efficient manner to the ISFSI. After all fuel has been transferred to the ISFSI, the pool and supporting systems will be in a drained and de-energized condition for the remainder of the dormancy period. The spent fuel will be stored in the ISFSI until transfer to the Department of Energy (DOE).

After the final spent fuel transfer to the ISFSI, the station begins dismantling and decontamination (D&D) activities. D&D activities will be scheduled to commence to enable the license to be terminated within 60 years after permanent cessation of operations. Following completion of the D&D activities and termination of the NRC license, site restoration will be performed, to a to-be-determined condition, such that the site may be re-used for beneficial purposes.

For the purposes of a current decommissioning cost estimate, it is assumed that remaining structures are to be demolished to three-feet below grade and the excavations backfilled with suitable material and erosion controls emplaced.

Decommissioning activities will be performed in accordance with written, reviewed and approved site procedures. There are no identified or anticipated decommissioning activities that are unique to the FCS site outside the bounds considered in the GEIS.

Radiological and environmental programs will be maintained throughout the decommissioning process to ensure occupational, public health and safety, and environmental compliance. Radiological programs will be conducted in accordance with the facility's revised Technical Specifications, Operating License, Updated Safety Analysis Report (USAR), Radiological Environmental Monitoring Program, and the Offsite Dose Calculation Manual. Non-radiological Environmental Programs will be conducted in accordance with applicable requirements and permits.

Tables 2-1 and 2-2 provide summaries of the schedule / plant status and costs for decommissioning FCS. The major decommissioning activities and the general sequence of activities are discussed in more detail in the sections that follow.

Table 2.1
Decommissioning Schedule and Plant Status Summary

Decommissioning Activities / Plant Status	Start	End	Approximate Duration (years)
Pre-Shutdown Planning	2016	Oct 2016	-------
Transition from Operations			
Plant Shutdown	24 Oct 2016	-------	-------
Preparations for SAFSTOR Dormancy	24 Oct 2016	01 Jul 2018	1.68
SAFSTOR Dormancy			
Dormancy w/Wet Fuel Storage	2018	2022	4.51
Dormancy w/Dry Fuel Storage	2023	2058	36.02
Decommissioning Preparations			
Preparations for D&D	2059	2060	1.49
Dismantling & Decontamination			
Large Component Removal	2060	2061	1.10
Plant Systems Removal and Building Decontamination	2061	2064	3.11
License Termination	2064	2065	0.75
Site Restoration			
Site Restoration	2065	2066	1.50
Total from Shutdown to Completion of License Termination	-------	-------	50.16

Table 2.2
Decommissioning Cost Summary
(Thousands of 2016 dollars)

Decommissioning Periods	License Termination	Spent Fuel Management	Site Restoration
Pre-shutdown Planning	1,482	-	-
Planning and Preparations	182,134	38,401	-
Dormancy w/Wet Fuel Storage	101,964	175,296	-
Dormancy w/Dry Fuel Storage	194,080	191,846	-
Site Reactivation	50,075	-	626
Decommissioning Preparation	26,644	-	821
Large Component Removal	141,440	-	1,037
Plant Systems Removal and Building Remediation	208,777	-	7,641
License Termination	25,174		
Site Restoration	205	-	35,733
Total [a]	931,973	405,543	45,857

[a] Columns may not add due to rounding

2.1 Discussion of Decommissioning Activities

The following narrative describes the basic activities associated with decommissioning the FCS. The site specific DCE (detailed in Attachment 1) is divided into phases or periods based upon major milestones within the project or significant changes in the annual projected expenditures. The following sub-sections correspond to the five major decommissioning periods within the estimate.

2.1.1 Preparations for Dormancy:

The NRC defines SAFSTOR as, "A method of decommissioning in which a nuclear facility is placed and maintained in a condition that allows the facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use." The facility is left intact (during the dormancy period), with structures maintained in a stable condition. Systems that are not required to support the spent fuel, HVAC, Emergency Plan or site security are drained, de-energized, and secured. Some cleaning/removal of loose contamination and or fixation and sealing of remaining contamination is performed. Access to contaminated areas is maintained secure to provide controlled access for inspection and maintenance.

The process of placing the plant in safe-storage will include, but is not limited to, the following activities:

- Creation of an organizational structure to support the decommissioning plan and evolving emergency planning and site security requirements.
- Revision of technical specifications, plans and operating procedures appropriate to the operating conditions and requirements.
- Characterization of the facility and major components as may be necessary to plan and prepare for the dormancy phase.
- Management of the spent fuel pool and reconfiguring fuel pool support systems so that draining and de-energizing may commence in other areas of the plant.
- Deactivation (de-energizing and or draining) of systems that are no longer required during the dormancy period.
- Processing and disposal of water and water filter and treatment media not required to support dormancy operation.
- Disposition of incidental waste that may be present prior to the start of the dormancy period, such as excess tools and equipment and waste produced while deactivating systems and preparing the facility for dormancy.
- Reconfiguration of power, lighting, heating, ventilation, fire protection, and any other services needed to support long-term storage and periodic plant surveillance and maintenance.
- Stabilization by fixing or removing loose incidental surface contamination to facilitate future building access and plant maintenance. Decontamination of high-dose areas is not anticipated.
- Performance of interim radiation surveys of the plant, posting caution signs and establishing access requirements, where appropriate.
- Maintenance of appropriate barriers for contaminated and radiation areas.
- Reconfiguration of security boundaries and surveillance systems, as needed to support efficiency during the dormancy period.

The following is a general discussion of the planned reconfiguration expected after plant shutdown.

Electrical Systems

The electrical system will undergo a series of reconfigurations between shutdown and the time all spent fuel has been transferred to dry storage. The reconfigurations will be performed to reduce operating and maintenance expenses, while maintaining adequate power for station loads, and backup power for Spent Fuel Pool-related systems and critical security equipment.

Mechanical Systems

Following shutdown, as applicable, fluid filled systems will be drained and abandoned, and resins removed based on an evaluation of system category, functionality, and plant configuration. The plant configuration and functionality of each system within the plant configuration as it evolves will determine when a system can be drained and abandoned.

Ventilation and Heating Systems

Ventilation will be reconfigured to support remaining systems and habitability. Fluid filled systems will either be drained or freeze protection installed, and the heating steam secured. The ventilation system will be reconfigured to maintain building temperature to support habitability and the functioning of Fuel Pool Cooling systems, Fire Protection systems, and Dry Fuel Storage systems as needed.

Fire Protection Systems

Fire Protection (FP) systems will be reconfigured based on a fire hazards analysis. The fire hazards analysis provides a comprehensive evaluation of the facility's fire hazards, the fire protection capability relative to the identified hazards, and the ability to protect spent fuel and other radioactive materials from potential fire-induced releases. The fire hazards analysis will be reevaluated and revised as necessary to reflect the unique or different fire protection issues and strategies associated with decommissioning. It is expected that as the plant's systems are drained and the combustible loading footprint shrinks, the FP requirements will be reduced.

Maintenance of Systems Critical to Decommissioning

There are no mechanical systems that will be critical to the final decommissioning process. As such, mechanical systems will be abandoned after all spent fuel has been transferred to Dry Fuel Storage, with the exception of systems required to maintain habitability during dormancy. The site power distribution system will be abandoned with the possible exception of Motor Control Centers that are required to support ventilation and lighting.

The organization responsible for the final dismantlement will be expected to establish temporary services, including electrical and cranes.

2.1.2 Dormancy

Activities required during the early dormancy period while spent fuel is stored in the fuel pool will be substantially different than those activities required during dry fuel storage.

Early activities include operating and maintaining the spent fuel pool and its associated systems, and transferring spent fuel from the pool to the ISFSI. Spent fuel transfer is expected to be complete by the end of 2022. After the fuel transfer is completed, the spent fuel pool and systems will be drained and de-energized for long-term storage.

Dormancy activities will include a 24-hour security force, preventive and corrective maintenance on security systems, area lighting, general building maintenance, freeze protection heating, ventilation of buildings for periodic habitability, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program.

Security during the dormancy period will be conducted primarily to safeguard the spent fuel on site and prevent unauthorized entry. A security barrier, sensors, alarms, and other surveillance equipment will be maintained as required to provide security.

An environmental surveillance program will be carried out during the dormancy period to monitor for radioactive material in the environment. Appropriate procedures will be established and initiated for potential releases that exceed prescribed limits. The environmental surveillance program will consist of a version of the program in effect during normal plant operations that will be modified to reflect the plant's conditions and risks at the time.

Late in the dormancy period, additional activities will include transferring the spent fuel from the ISFSI to the DOE. For planning purposes, OPPD's current spent fuel management plan for the Fort Calhoun spent fuel is based, in general, upon the following projections: 1) a 2030 start date for the DOE initiating transfer of commercial spent fuel to a federal facility, 2) a corresponding 2032 date for removal of spent fuel from the Fort Calhoun ISFSI, and 3) a 2058 completion date for removal of all Fort Calhoun spent fuel from the site. It is acknowledged that the plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance. The ISFSI pad and associated facilities will be decommissioned along with the power block structures during the deferred decontamination and dismantling phases.

2.1.3 Preparations for Decommissioning

Prior to the commencement of decommissioning operations, preparations will be undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a site characterization, and the assembly of a decommissioning management organization. This would likely include the development of work plans, specifications and procedures.

2.1.4 Decommissioning (Dismantling and Decontamination)

Following the preparations for decommissioning, physical decommissioning activities will take place. This includes the removal and disposal of contaminated and activated components and structures, leading to the termination of the 10 CFR 50 operating license. Although much of the radioactivity will decrease during the dormancy period due to decay of ^{60}Co and other short-lived radionuclides, the internal components of the reactor vessel will still exhibit radiation dose rates that will likely require remote sectioning under water due to the presence of long-lived radionuclides such as ^{94}Nb, ^{59}Ni, and ^{63}Ni. Portions of the biological shield wall may also be radioactive due to the presence of activated trace elements with longer half-lives (such as ^{152}Eu and ^{154}Eu). It is assumed that radioactive contamination on structures, systems, and component surfaces will not have decayed to levels that will permit unrestricted release. These surfaces will be surveyed and items dispositioned in accordance with the existing radioactive release criteria.

Significant decommissioning activities in this phase include:

- Reconfiguration and modification of site structures and facilities, as needed, to support decommissioning operations. Modifications may also be required to the reactor or other buildings to facilitate movement of equipment and materials, support the segmentation of the reactor vessel and reactor vessel internals, and for large component removal.
- Design and fabrication of temporary and longer-term shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.

- Procurement or leasing of shipping cask, cask liners, and industrial packages for the disposition of low-level radioactive waste.
- Decontamination of components and piping systems, as required, to control (minimize) worker exposure.
- Removal of piping and components no longer essential to support decommissioning operations.
- Removal of control rod drive housings and the head service structure from reactor vessel head. Segmentation of the vessel closure head.
- Removal and segmentation of the upper internals assemblies. Segmentation will maximize the loading of the shielded transport casks, i.e., by weight and activity. The operations are conducted under water using remotely operated tooling and contamination controls.
- Disassembly and segmentation of the remaining reactor internals, including the core former and lower core support assembly. Some material is expected to exceed Class C disposal requirements. As such, the segments will be packaged in modified fuel storage canisters for geologic disposal.
- Segmentation of the reactor vessel. A shielded platform is installed for segmentation as cutting operations are performed in-air using remotely operated equipment within a contamination control envelope. The water level is maintained just below the cut to minimize the working area dose rates. Segments are transferred in-air to containers that are stored under water, for example, in an isolated area of the refueling canal.
- Removal of the activated portions of the concrete biological shield and accessible contaminated concrete surfaces. If dictated by the steam generator and pressurizer removal scenarios, those portions of the associated cubicles necessary for access and component extraction are removed.
- Removal of the steam generators and pressurizer for material recovery and controlled disposal. The generators will be moved to an on-site processing center, the steam domes removed and the internal components segregated for recycling. The lower shell and tube bundle will be packaged for direct disposal. These components can serve as their own burial containers provided that all penetrations are properly sealed and the internal contaminants are stabilized, e.g., with grout.
- Remediation of contaminated surface soil or sub-surface media will be performed as necessary to meet the unrestricted use criteria in 10 CFR 20.1402.
- Underground piping (or similar items) and associated soil will be removed as necessary to meet license termination criteria.

At least two years prior to the anticipated date of license termination, a License Termination Plan (LTP) will be submitted to the NRC. That plan will include: a site characterization, description of the remaining dismantling / removal activities, plans for remediation of remaining radioactive materials, developed site-specific Derived Concentration Guideline Levels, plans for the final status (radiation) survey (FSS), designation of the end use of the site, an updated cost estimate to complete the decommissioning, and associated environmental concerns.

The FSS plan will identify the radiological surveys to be performed once the decontamination activities are completed and will be developed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)." This document incorporates statistical approaches to survey design and data evaluation. It also identifies commercially available instrumentation and procedures for conducting radiological surveys. Use of this guidance ensures that the surveys are conducted in a manner that provides a high degree of confidence that applicable NRC criteria are satisfied. Once the FSS is complete, the results will be submitted to the NRC, along with a request for termination of the NRC license.

OPPD may release unaffected portions of the site on a partial site release basis, as they become available, before all site decommissioning work has been completed.

2.1.5 Site Restoration

After the NRC terminates the license, site restoration activities will be performed, at the licensee's discretion. OPPD currently assumes that remaining structures will be removed to a nominal depth of three feet below the surrounding grade level. Affected area(s) would then be backfilled with suitable fill materials, graded, and appropriate erosion controls established.

Non-contaminated concrete rubble produced by the demolition activities may be used for backfilling subsurface voids or may be transported to an offsite area for appropriate disposal as construction debris.

2.2 General Decommissioning Considerations

2.2.1 Major Decommissioning Activities

As defined in 10 CFR 50.2, "definitions," a "major decommissioning activity" is "any activity that results in permanent removal of major radioactive components, permanently modifies the structure of the containment, or results in dismantling components for shipment containing greater than class C waste in accordance with § 61.55." The following discussion provides a summary of the major decommissioning activities currently planned for decommissioning of the FCS. These activities are envisioned to occur in the Dismantling and Decontamination Period. The schedule may be modified as conditions dictate.

Prior to starting a major decommissioning activity, the affected components will be surveyed and decontaminated, as required, in order to minimize worker exposure, and a plan will be developed for the activity. Shipping casks and other equipment necessary to conduct major decommissioning activities will be procured.

The initial major decommissioning activity inside the containment building will be the removal, packaging, and disposal of systems and components attached to the reactor, to provide access and allow it to be removed.

The reactor vessel internals will be removed from the reactor vessel and segmented, if necessary, for packaging, transport and disposal, or to separate greater than Class C (GTCC) waste. Internals classified as GTCC waste will be segmented and packaged into containers similar to spent fuel canisters for transfer to the DOE. Removal of the reactor vessel follows the removal of the reactor internals. Industry experience indicates that there may be several options available for the removal and disposal of the reactor vessel (i.e., segmentation or disposal as an intact package). The viability of these options will be analyzed as a part of future planning and preparation activities. If segmented, it is likely that the work would be performed remotely in-air, using a contamination control envelope.

Other major decommissioning activities that would be conducted include the removal and disposal of the steam generators, pressurizer, turbine, condenser, main steam piping, feed water piping, pumps and heaters, spent fuel pool support equipment, and neutron activated / contaminated concrete materials.

Other Decommissioning Activities

In addition to the reactor and large components discussed above, all other plant components will be removed from the Reactor, Turbine, Auxiliary and associated support buildings, radiologically surveyed and dispositioned appropriately.

2.2.2 Decontamination and Dismantlement Activities

The overall objective of D&D is to ensure that radioactively contaminated or activated materials will be removed from the site to allow the site to be released for unrestricted use. This is achieved in part by radioactive decay during the SAFSTOR period which will significantly reduce the quantity of contamination and radioactivity that must be disposed of during decontamination and dismantlement. The disposition of remaining radioactive materials will be accomplished by the decontamination and or dismantlement of contaminated structures. This may be accomplished by decontamination in place, off-site processing of the materials, or direct disposal of the materials as radioactive waste. A combination of these methods may be utilized. The methods chosen will be those deemed most appropriate for the particular circumstances.

Low-level radioactive waste will be managed in accordance with approved procedures and commercial disposal facility requirements. This includes characterizing contaminated materials, packaging, transporting and disposal at a licensed low-level radioactive waste (LLRW) disposal facility.

2.2.3 Radioactive Waste Management

A major component of the decommissioning work scope for the Fort Calhoun station is the packaging, transportation and disposing of primarily contaminated / activated equipment, piping, concrete, and if encountered, soil. A waste management plan will be developed to incorporate the most cost effective disposal strategy, consistent with regulatory requirements and disposal / processing options for each waste type at the time of the D&D activities. Decommissioning wastes from FCS may be disposed of at the Waste Control Specialists site in Andrews County, Texas and or Energy*Solutions* site in Clive, Utah. If other licensed disposal facilities become available in the future, OPPD may elect to use them. Radioactive wastes from Fort Calhoun will be transported by licensed transporters. The waste management plan will be based on the evaluation of available methods and strategies for processing, packaging, and transporting radioactive waste in conjunction with the available disposal facility options and associated waste acceptance criteria.

2.2.4 Removal of Mixed Wastes

If mixed wastes are generated they will be managed in accordance with applicable Federal and State regulations.

If generated, mixed wastes will be transported by authorized and licensed transporters and shipped to authorized and licensed facilities. If technology, resources, and approved processes are available, the processes will be evaluated to render the mixed waste non-hazardous.

2.2.5 Site Characterization

During the decommissioning process, site characterization will be performed in which radiological, regulated, and hazardous wastes will be identified, categorized, and quantified. Surveys will be conducted to establish the contamination and radiation levels throughout the plant. This information will be used in developing procedures to ensure that hazardous, regulated, and radiologically contaminated areas are remediated and to ensure that worker exposure is controlled. As decontamination and dismantlement work proceeds, surveys will be conducted to maintain a current site characterization and to ensure that decommissioning activities are adjusted accordingly.

As part of the site characterization process, a neutron activation analysis calculation study of the reactor internals and the reactor vessel was performed. Using the results of this analysis (along with benchmarking surveys), neutron irradiated components were classified (projected for the future D&D time-frame) in accordance with 10 CFR 61, "Licensing requirements for land disposal of radioactive waste." The results of the analysis form the basis of the plans for removal, segmentation, packaging and disposal.

2.2.6 Groundwater Protection and Radiological Decommissioning Records Program

A groundwater (GW) protection program currently exists at Fort Calhoun in accordance with the Nuclear Energy Institute (NEI) Technical Report 07-07, "Industry Groundwater Protection Initiative - Final Guidance Document." This program is directed by procedures and will continue during decommissioning.

OPPD will also continue to maintain the existing radiological decommissioning records program required by 10 CFR 50.75(g). The program is directed by procedures.

Neither the monitoring results of the groundwater protection program nor events noted in 10 CFR 50.75(g) indicate the presence of long-lived radionuclides in sufficient concentrations to preclude unrestricted release under 10 CFR 20.1402, "Radiological criteria for unrestricted use".

2.2.7 Changes to Management and Staffing

Throughout the decommissioning process, plant management and staffing levels will be adjusted to reflect the ongoing transition of the site organization. Staffing levels and qualifications of personnel used to monitor and maintain the plant during the various periods after plant shutdown will be subject to appropriate Technical Specification and Emergency Plan requirements. These staffing levels do not include contractor staffing which may be used to carry out the future fuel movements, plant modifications in preparation for SAFSTOR, and the D&D / license termination / site restoration work. Contractors may also be used to provide general services, staff augmentation or replace permanent staff. The monitoring and maintenance staff will be comprised of radiation protection, radiological environmental monitoring program, plant engineering and craft workers as appropriate for the anticipated work activities.

3.0 SCHEDULE OF PLANNED DECOMMISSIONING ACTIVITIES

OPPD intends to pursue the decommissioning of Fort Calhoun utilizing a SAFSTOR methodology and will make appropriate filings with the NRC to obtain authority prior to beginning radiological decommissioning. The SAFSTOR method involves removal of radioactively contaminated or activated material from the site following an extended period of dormancy. Work activities associated with the planning and preparation period began before the plant was permanently shut down and will continue into 2018. The schedule of spent fuel management and major decommissioning activities is provided in Table 2-1. Additional detail is provided in Attachment 1, the DCE.

The schedule accounts for spent fuel being stored in the ISFSI until the assumed date of transfer to the DOE.

4.0 ESTIMATE OF EXPECTED DECOMMISSIONING AND SPENT FUEL MANAGEMENT COSTS

10 CFR 50.82(a)(4)(i) requires the submission of a PSDAR within two years following permanent cessation of operations that contains a site-specific DCE, including the projected cost of managing irradiated fuel.

TLG Services, Inc. has prepared a site-specific decommissioning cost analysis for FCS, which also provides projected costs of managing spent fuel, as well as non-radiological decommissioning and site restoration costs, accounted for separately. The site-specific DCE is provided in Attachment 1 and fulfills the requirements of 10 CFR 50.82(a)(4)(i) and 10 CFR 50.82(a)(8)(iii). A summary of the site-specific DCE, including the projected cost of managing spent fuel is provided in Table 2-2.

The methodology used by TLG Services, Inc. to develop the site-specific DCE follows the basic approach originally advanced by the Atomic Industrial Forum (AIF) in its program to develop a standardized model for decommissioning cost estimates. The results of this program were published as AIF/NESP-036, "A Guideline for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," (Reference 5). The AIF document presents a unit cost factor method for estimating direct activity costs, simplifying the estimating process. The unit cost factors used in the study reflect the latest available data, at the time of the study, concerning worker productivity during decommissioning.

Under NRC regulations (10 CFR 50.82(a)(8)), a licensee must provide reasonable assurance that funds will be available (or "financial assurance") for decommissioning (i.e., license termination) costs. The regulations also describe the acceptable methods a licensee can use to demonstrate financial assurance. Most licensees do this by funding a nuclear decommissioning trust (NDT). Nebraska State Statues provides the regulatory authority that allows OPPD's Board of Directors to establish the inflation rates and earning rates of OPPD.

OPPD maintains two separate trust accounts for this purpose, one for the License Termination Expenditures (NRC minimum decommissioning amount) and another for the Spent Fuel Management and Site Restoration Expenditures. The trustee for both trust funds is First National Bank of Omaha. As of December 31, 2016, the License Termination Expenditures trust had a balance of $285,838,000 and the Spent Fuel Management and Site Restoration Expenditures trust had a balance of $96,296,000.

The two trust funds are not commingled and the funds accumulated for the additional decommissioning cost are not included as funds for the NRC minimum decommissioning amount. The funds accumulated for the additional decommissioning costs including additional radiological, site restoration and spent fuel management are available for radiological decommissioning without prior approval by a State regulatory authority and are not subject to disapproval for radiological decommissioning by a State regulatory authority.

10 CFR 50.82(a)(6)(iii) states that, "Licensees shall not perform any decommissioning activities," as defined in 10 CFR 50.2 that, "Result in there no longer being reasonable assurance that adequate funds will be available for decommissioning." OPPD does not intend to perform any decommissioning activities that would jeopardize the availability of adequate funds for the completion of decommissioning.

10 CFR 50.82(a)(8)(iv) states that, "For decommissioning activities that delay completion of decommissioning by including a period of storage or surveillance, the licensee shall provide a means of adjusting cost estimates and associated funding levels over the storage or surveillance period."

4.1 Means of Adjusting Cost Estimates

Costs are inflated using a blending of the IHS Global Insight's forecasts for Consumer Price Index, All-Urban and Employment Cost Index, Total Private Compensation. The indices are blended based on the ratio of labor and all other costs to the total DCE. For the years beyond the available forecast, the final forecast rate available is held constant for the duration of the analysis.

Consistent with Regulatory Guide 1.159 (Reference 6), OPPD will update the FCS DCE as required. In calculating projected earnings, OPPD uses the IHS Global Insight's forecast for the yield on 5-year Treasury Notes which is within a two percent (2%) annual real rate of return.

4.2 Means of Adjusting Associated Funding Levels

In the event that additional financial assurance beyond the amounts contained in the remaining trust fund for FCS is required pursuant to NRC regulations to complete radiological decommissioning and spent fuel management at FCS, OPPD will augment the NDTs with annual contributions to the NDTs.

As conditions may change, OPPD will adjust the funding, as appropriate, using alternative funding mechanisms acceptable to the NRC.

5.0 ENVIRONMENTAL IMPACTS

OPPD has concluded that the environmental impacts associated with planned FCS site-specific decommissioning activities are less than and bounded by the previously issued environmental impact statements. 10 CFR 50.82(a)(4)(i) requires that the PSDAR include, "...a discussion that provides the reasons for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate previously issued environmental impact statements." The following discussion provides the reasons for reaching this conclusion and is based on two previously issued environmental impact statements:

NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors (Reference 4) (Referred to as the GEIS).

NUREG-1496, Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities (Reference 7).

In evaluating whether the impacts in these previously issued environmental impact statements are bounding, information from NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 12, Regarding Fort Calhoun Station, Unit 1 (Reference 8) was also considered (herein referred to as the SEIS).

5.1 Environmental Impact of FCS Decommissioning

The following is a summary of the reasons for reaching the conclusion that the environmental impacts of decommissioning Fort Calhoun Station, Unit 1 (FCS) are bounded by the GEIS. Each environmental impact standard in the GEIS is listed along with a summary as to why OPPD concludes the GEIS analysis bounds the impacts of FCS decommissioning on that standard. As a general matter, FCS is smaller than the reference pressurized water reactor used in the GEIS to evaluate the environmental impacts of decommissioning, and is therefore bounded by those assessments. Further, no unique site-specific features or unique aspects of the planned decommissioning have been identified.

5.1.1 Onsite/Offsite Land Use

FCS has sufficient area onsite that has been previously disturbed (due to construction or operations activities) for use during decommissioning. Any construction activities that would disturb one acre or greater of soil would require a stormwater permit from the Nebraska Department of Environmental Quality (NDEQ) prior to proceeding with the activity. The stormwater permit would contain best management practices (BMPs) to control sediment and erosion effect on water courses and wetlands. Section 4.3.1 of the GEIS concluded that the impacts on land use are not detectable or small for facilities having only onsite land use changes as a result of large component removal, structure dismantlement, and low-level waste packaging and storage. FCS will be able to conduct all of these decommissioning activities on previously disturbed land.

Based on the GEIS, the experience of plants that are being decommissioned has not included any needs for additional land offsite. Consistent with this determination, OPPD does not anticipate any changes in land use beyond the site boundary during decommissioning. Therefore, OPPD concludes that the impacts of FCS decommissioning on onsite/offsite land use are bounded by the GEIS.

5.1.2 Water Use

After plant shutdown, the operational demand for cooling water and makeup water will dramatically decrease. Additionally, after the plant is shutdown and defueled, the amount of water used by the service water system will be much less than during normal operation of the plant. The need for cooling water will continue to decrease as the heat load of spent fuel in the spent fuel pool declines due to radioactive decay and as spent fuel is relocated from the spent fuel pool to the ISFSI. During plant shutdown, the use of potable water will decrease commensurate with the expected decrease in plant staffing levels. For these reasons, Section 4.3.2 of the GEIS concluded that water use at decommissioning nuclear reactor facilities is significantly smaller than water use during operation.

The GEIS also concluded that water use during the decontamination and dismantlement phase will be greater than that during the storage phase. However, there are no unique aspects associated with the decommissioning of FCS and water use for such activities as flushing piping, dust abatement, etc. Consequently, FCS water use impacts were addressed by the evaluation of the reference facility in the GEIS.

Therefore, OPPD concludes that the impacts of FCS decommissioning on water use are bounded by the GEIS.

5.1.3 Water Quality

OPPD has chosen to decommission FCS using the SAFSTOR method. During the SAFSTOR planning and actual storage periods, stormwater runoff and drainage paths will be maintained in their current configuration. Regulatory mandated programs and processes designed to minimize, detect, and contain spills will be maintained throughout the decommissioning process. Federal, state and local regulations and permits pertaining to water quality will also remain in effect and

FCS will continue to receive potable water from the City of Blair. In addition to the National Pollutant Discharge Elimination System (NPDES) permit, which regulates surface water discharges from the site (Reference 9), the following permits will remain in place:

- General NPDES Permit Number NER910000 for Stormwater Discharges From Industrial Activity to Waters of the State of Nebraska (Reference 10).
- General NPDES Permit Number NEG671000, A General NPDES Permit Authorizing Dewatering Discharges (References 11).

Therefore, OPPD concludes that the impacts of FCS decommissioning on water quality are bounded by the GEIS.

5.1.4 Air Quality

Air Quality Construction Permit (CP07-0063) was issued by the NDEQ and regulates air emission sources at FCS (Reference 12). This permit will remain in place during decommissioning. If new sources of air emissions are added or changed at the facility to support this process, the certificate will be modified as required. As new regulations are issued that impact these sources, these requirements will be addressed at the station. In addition, there are various other air quality regulations that will govern activities involving hazardous air pollutants and indoor air quality.

There are many types of decommissioning activities listed in the Section 4.3.4 of the GEIS that have the potential to affect air quality. For those activities applicable to the SAFSTOR option, OPPD does not anticipate any activities beyond those listed in the GEIS that could potentially affect air quality. In addition, federal, state and local regulations pertaining to air quality will remain in effect to regulate emissions associated with fugitive dust; criteria air pollutants, hazardous air pollutants, and ozone-depleting gases. Therefore, OPPD concludes that the impacts of FCS decommissioning on air quality are bounded by the GEIS.

5.1.5 Aquatic Ecology

Aquatic ecology encompasses the plants and animals in the Missouri River and wetlands near FCS. Aquatic ecology also includes the interaction of those organisms with each other and the environment. Section 4.3.5 of the GEIS evaluates both the direct and indirect impacts from decommissioning on aquatic ecology.

Direct impacts can result from activities such as the removal of shoreline structures or the active dredging of canals. FCS's shoreline structures are similar to the plants listed in Table E-2 of the GEIS, and there are no apparent discriminators based on the salient characteristics (size and location) listed in Table E-5 of the GEIS. Removal of the intake and discharge facilities as well as other shoreline structures will be conducted in accordance with BMPs outlined in permits issued by the NDEQ and if necessary, the U. S. Army Corps of Engineers. Intake structure dredging will be greatly reduced due to the diminished residual heat removal requirements, and the eventual relocation of the spent fuel to the ISFSI.

As previously discussed in Section 5.1.2, the amount of cooling water withdrawn from the Missouri River will significantly decrease thus reducing the potential impacts from impingement and entrainment of aquatic species. Additionally, any significant potential for sediment runoff or erosion on disturbed areas will be controlled in accordance with BMPs outlined in the stormwater permit. OPPD does not anticipate disturbance of lands beyond the current operational areas of the plant, so there should not be any new impacts to aquatic ecology from runoff associated with land disturbance activities.

Therefore, OPPD concludes that the impacts of FCS decommissioning on aquatic ecology are bounded by the GEIS.

5.1.6 Terrestrial Ecology

Terrestrial ecology considers the plants and animals in the vicinity of FCS as well as the interaction of those organisms with each other and the environment. Evaluations of impacts to terrestrial ecology are usually directed at important habitats and species, including plant and animals that are important to industry, recreational activities, the area ecosystems, and those protected by endangered species regulations and legislation. Section 4.3.6 of the GEIS evaluates the potential impacts from both direct and indirect disturbance of terrestrial ecology.

Direct impacts can result from activities such as clearing native vegetation or filling a wetland. OPPD does not anticipate disturbing habitat beyond the operational areas of the plant. All dismantlement, demolition, and waste staging activities are envisioned to be conducted within the industrial area of the site. Also the NDEQ controls significant impacts to the environment through regulation of construction activities.

Indirect impacts may result from effects such as erosional runoff, dust or noise. Any construction activities that would disturb one acre or greater of soil would require a stormwater permit from the NDEQ prior to proceeding with the activity. The stormwater permit would contain BMPs to control sediment and the effects of erosion associated with the construction activity. Fugitive dust emissions will be controlled through the judicial use of water spraying. The basis for concluding that the environmental impacts of noise are bounded by the GEIS is discussed in Section 5.1.16 below.

Section 4.3.6 of the GEIS concludes that if BMPs are used to control indirect disturbances and habitat disturbance is limited to operational areas, the potential impacts to terrestrial ecology are small. As discussed above, there are no unique disturbances to the terrestrial ecology anticipated during the decommissioning of FCS. Therefore, OPPD concludes that the impacts of FCS decommissioning on terrestrial ecology are bounded by the GEIS.

5.1.7 Threatened and Endangered Species

Based on the SEIS (Reference 8), there was one federally-listed endangered aquatic species reported to inhabit the Missouri River: pallid sturgeon. This species was also listed by the State of Nebraska as endangered. In addition, the lake sturgeon was listed by the State of Iowa as an endangered aquatic species, but the species is currently known only from the West River. It was determined in the SEIS that both of these federally-and state-listed species could occur within the vicinity of FCS, and that no designated critical habitat for the species existed within the vicinity of FCS.

The SEIS also identified one federally-listed endangered terrestrial species with the potential to occur within the vicinity of FCS: least tern. The bald eagle, piping plover and western prairie fringed orchid were listed in the SEIS as federally-listed threatened species. The bald eagle has since been delisted. These same species, including the bald eagle, are state-listed as endangered or threatened. It was determined in the SEIS that, due to channelization of the Missouri River removing the sandbars, both the least turn and piping plover are not likely to be found at FCS. The western prairie fringed orchid potentially occurs in Washington County based on historic observations. However, no populations are known to occur in the county, and the potential for occurrence on or near Fort Calhoun Station is low given the lack of prairie habitat in these areas. The SEIS also listed an additional 4 terrestrial species for the State of Nebraska terrestrial species (3 plants and 1 animal) as threatened that could potentially occur in the vicinity of the FCS site. The SEIS lists 10 additional terrestrial species listed by the State of Iowa (3 plants and 7 animals) as threatened or endangered that could exist in the vicinity of FCS. Of the terrestrial species, only the state-listed bald eagle is known to occur seasonally on the FCS site.

Section 4.3.7 of the GEIS does not make a generic determination on the impact of decommissioning on threatened and endangered species. Rather it concludes that the adverse impacts and associated significance of the impacts must be determined on a site-specific basis.

With respect to the threatened and endangered aquatic species, the environmental impacts during decommissioning are expected to be minimal. Removal of the intake and discharge facilities as well as other shoreline structures will be conducted in accordance with BMPs outlined in permits issued by the NDEQ and the U. S. Army Corps of Engineers. As previously discussed in Section 5.1.2, the amount of cooling water withdrawn from the Missouri River will significantly decrease thus reducing the potential impacts of impingement, entrainment, and thermal discharges on aquatic species. One potential adverse impact from the decrease in cooling water withdrawn may be the elimination of the thermal refuge for aquatic species in the discharge area which are preyed upon by the bald eagle when FCS is not operating in the winter months.

The environmental impacts during decommissioning are expected to be minimal on threatened and endangered terrestrial species. OPPD does not anticipate disturbing habitat beyond the operational areas of the plant for decommissioning and construction activities. Construction activities that disturb one acre or greater of soil necessitate permits by the NDEQ and BMPs are required to be implemented to control sediment and the effects of erosion. Additionally, FCS has administrative controls in place which require that significant project activities undergo an environmental review prior to the activity occurring, which ensures that impacts are minimized through implementation of BMPs. Federal and state regulations pertaining to listed species will also remain in effect, which will further ensure that impacts to listed species and their habitats are minimized.

Section 4.3.7 of the GEIS also suggests that care be exercised in conducting decommissioning activities after an extended SAFSTOR period because there is a greater potential for rare species to colonize the disturbed portion of the site. However as previously discussed, administrative controls and federal and state regulations that will remain in effect would ensure that mitigation measures are implemented as appropriate to protect wildlife.

Based on the above, the planned decommissioning of FCS will not result in a direct mortality or otherwise jeopardize the local population of any threatened or endangered species. Therefore, OPPD concludes that the impacts of FCS decommissioning on threatened and endangered species are bounded by the GEIS.

5.1.8 Radiological

The GEIS considered radiological doses to workers and members of the public when evaluating the potential consequences of decommissioning activities.

Occupational Dose

The occupational radiation exposure to FCS plant personnel will be maintained As Low as Reasonably Achievable (ALARA) and below the occupational dose limits in 10 CFR Part 20 during decommissioning. The need for plant personnel to routinely enter radiological areas to conduct maintenance, calibration, inspection, and other activities associated with an operating plant will be reduced, thus it is expected that the occupational dose to plant personnel will significantly decrease after the plant is shutdown and defueled.

OPPD has elected to decommission FCS using the SAFSTOR alternative. It is expected that the occupational dose required to complete the decommissioning activities at FCS will be within the range of SAFSTOR dose estimates (308-664 person-rem) provided in Table 4-1 of the GEIS. This is based on the fact that FCS is bounded by the PWRs evaluated in the GEIS as previously discussed in Section 5.1, and because the ALARA program will be maintained to ensure that occupational dose is maintained ALARA and well within 10 CFR Part 20 limits.

Public Dose

Section 4.3.8 of the GEIS considered doses from liquid and gaseous effluents when evaluating the potential impacts of decommissioning activities on the public. Table G-15 of the GEIS compared effluent releases between operating facilities and decommissioning facilities and concluded that decommissioning releases are lower. The GEIS also concluded that the collective dose and the dose to the maximally exposed individual from decommissioning activities are expected to be well within the regulatory standards in 10 CFR Part 20 and Part 50.

The expected radiation dose to the public from FCS decommissioning activities will be maintained within regulatory limits and below comparable levels when the plant was operating through the continued application of radiation protection and contamination controls combined with the reduced source term available in the facility. Also Section 4.12.2 of the SEIS (Reference 8) concluded that there were no site-specific radiological dose aspects associated with decommissioning of FCS. Therefore, OPPD concludes that the impacts of FCS decommissioning on public dose are small and are bounded by the GEIS.

5.1.9 Radiological Accidents

The likelihood of a large offsite radiological release that impacts public health and safety after FCS is shut down and defueled is considerably lower than the likelihood of a release from the plant during power operation. This is because the majority of the potential releases associated with power operation are not relevant after the fuel has been removed from the reactor. Furthermore, handling of spent fuel assemblies will continue to be controlled under work procedures designed to minimize the likelihood and consequences of a fuel handling accident. In addition, emergency plans and procedures will remain in place to protect the health and safety of the public while the possibility of significant radiological releases exists.

Section 4.3.9 of the GEIS assessed the range of possible radiological accidents during decommissioning and separated them into two general categories; fuel related accidents and non-fuel related accidents. Fuel related accidents have the potential to be more severe and zirconium fire accidents, in particular, could produce offsite doses that exceed EPA's protective action guides (Reference 13). As part of its effort to develop generic, risk-informed requirements for decommissioning, the NRC staff performed analysis of the offsite radiological consequences of beyond-design-basis spent fuel pool accidents using fission product inventories at 30 and 90 days and 2, 5, and 10 years. The results of the study indicate that the risk at spent fuel pools is low and well within the Commission's Quantitative Health Objectives. The generic risk is low primarily due to the very low likelihood of a zirconium fire. (Reference 4)

The potential for decommissioning activities to result in radiological releases not involving spent fuel (i.e., releases related to decontamination, dismantlement, and waste handling activities) will be minimized by use of procedures designed to minimize the likelihood and consequences of such releases.

Therefore, OPPD concludes that the impacts of FSC decommissioning on radiological accidents are small and are bounded by the previously issued GEIS.

5.1.10 Occupational Issues

Occupational issues are related to human health and safety. Section 4.3.10 of the GEIS evaluates physical, chemical, ergonomic, and biological hazards. OPPD has reviewed these occupational hazards in the GEIS and concluded that the decommissioning approach chosen for FCS poses no unique hazards from what was evaluated in the GEIS. OPPD will continue to maintain appropriate administrative controls and requirements to ensure occupational hazards are minimized and that applicable federal, state and local occupational safety standards and requirements continue to be met. Therefore, OPPD concludes that the impacts of FCS decommissioning on occupational issues are bounded by the GEIS.

5.1.11 Cost

Decommissioning costs for FCS are discussed in Section 4.0 and in Attachment 1 to this report. Section 4.3.11 of the GEIS recognizes that an evaluation of decommissioning cost is not a National Environmental Policy Act requirement. Therefore, a bounding analysis is not applicable.

5.1.12 Socioeconomics

Decommissioning of FCS is expected to result in negative socioeconomic impacts. As FCS transitions from an operating plant to a shutdown plant and into the different phases of decommissioning, an overall decrease in plant staff will occur. The lost wages of these plant staff will result in decreases in revenues available to support the local economy and local tax authorities. Some laid-off workers may relocate, thus potentially impacting the local cost of housing and availability of public services.

Section 4.3.12 of the GEIS evaluated changes in workforce and population, changes in local tax revenues, and changes in public services. The evaluation also examined large plants located in rural areas that permanently shut down early and selected the SAFSTOR option. The GEIS determined that this situation is the likeliest to have negative impacts. The GEIS concluded that socioeconomic impacts are neither detectable nor destabilizing and that mitigation measures are not warranted. Therefore, OPPD concludes that the impacts of FSC decommissioning on socioeconomic impacts are bounded by the GEIS.

5.1.13 Environmental Justice

Executive Order 12898 dated February 16, 1994, directs Federal executive agencies to consider environmental justice under the National Environmental Policy Act. It is designed to ensure that low-income and minority populations do not experience disproportionately high and adverse human health or environmental effects because of Federal actions.

Section 4.4.6 of the SEIS (Reference 8) analyzed 2000 census data within 50 miles of FCS to identify minority and low income populations. The SEIS analysis concluded that there were three counties in Nebraska (Thurston, Colfax, and Douglas) and one in Iowa (Crawford) within the 50-mile region that exceeded the NRC thresholds defining minority populations. Three counties in Nebraska (Thurston, Burt, and Douglas) and one in Iowa (Pottawattamie) within the 50-mile region exceeded the NRC thresholds defining low-income populations.

Section 4.13.3 of the GEIS reviewed environmental justice decommissioning impacts related to land use, environmental and human health, and socioeconomics. OPPD does not anticipate any offsite land disturbances during decommissioning, thus the land use impacts are not applicable for FCS. In addition as previously discussed in Section 5.1.12, it was determined that socioeconomic impacts from decommissioning are bounded by the GEIS. Potential impacts to minority and low-income populations would mostly consist of radiological effects. Based on the radiological environmental monitoring program data from FCS, the SEIS determined that the radiation and radioactivity in the environmental media monitored around the plant have been well within applicable regulatory limits. As a result, the SEIS found that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations (i.e., minority and or low income populations) in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

Therefore, OPPD concludes that the impacts of FSC decommissioning on environmental justice are small and are bounded by the GEIS.

5.1.14 Cultural, Historic and Archeological Resources

Based on a review of the FCS property through the Nebraska State Historic Preservation Office (NSHPO) files and information provided by the applicant, the NRC concluded in Section 4.4.5 of the SEIS (Reference 8) that the potential impacts from decommissioning of FCS on historic and archaeological resources would be small. The NRC identified the section of the plant site that lies north of the rail spur and is bounded on the west by U.S. Highway 75 as having Moderate-to-High Potential. It contains remnants of the former town of Desoto, a historic property that is potentially eligible for listing on the National Register of Historic Places. Based on the impacts of past construction activities, the plant site being situated on floodplain alluvium, and having been developed since 1850, the section of the site that lies south of the current Union Pacific rail spur should be categorized as having No Potential for cultural resources, either prehistoric or historic. Environmental review procedures have been put in place at FCS regarding undertakings that involve land disturbing activities in undisturbed surface and subsurface areas. These environmental protection procedures include contacting the SHPO to establish the actions necessary to protect known or as of yet undiscovered cultural resources before an action is allowed to occur. The cultural, historic, and archeological impact evaluation conducted in the GEIS (Reference 7) focused on similar attributes as the SEIS (Reference 8). The GEIS evaluated direct effects such as land clearing and indirect effects such as erosion and siltation.

The conclusion for the license renewal evaluation is also applicable to the decommissioning period because:

1) decommissioning activities will be primarily contained to disturbed areas located away from areas of existing or high potential for archaeological sites,

2) construction activities that disturb one acre or greater of soil are permitted by NDEQ approval and BMPs are required to control sediment and the effects of erosion, and

3) environmental protection procedures pertaining to archaeological and cultural resources will remain in effect during decommissioning. Therefore, OPPD concludes that the impacts of FCS decommissioning on cultural, historic, and archeological resources are small and are bounded by the GEIS.

5.1.15 Aesthetic Issues

During decommissioning, the impact of activities on aesthetic resources will be temporary and remain consistent with the aesthetics of an industrial plant. In most cases, Section 4.3.15 of the GEIS concludes that impacts such as dust, construction disarray, and noise would not easily be detectable offsite.

The GEIS concluded that the retention of structures during a SAFSTOR period or the retention of structures onsite at the time the license is terminated is likewise not an increased visual impact, but instead a continuation of the visual impact analyzed in the facility construction or operations final environmental statement.

After the decommissioning process is complete, site restoration activities may result in structures being removed from the site and the site being backfilled, graded and landscaped as needed. The GEIS concludes that the removal of structures is generally considered beneficial to the aesthetic impacts of the site. Therefore, OPPD concludes that the impacts of FCS decommissioning on aesthetic issues are bounded by the GEIS.

5.1.16 Noise

General noise levels during the decommissioning process are not expected to be any more severe than during refueling outages and are not expected to present an audible intrusion on the surrounding community. Some decommissioning activities may result in higher than normal onsite noise levels (i.e., some types of demolition activities). However, these noise levels would be temporary and are not expected to experience an audible intrusion on the surrounding community.

Section 4.3.16 of the GEIS indicates that noise impacts are not detectable or destabilizing and makes a generic conclusion that potential noise impacts are small. Based on the standard decommissioning approach proposed for FCS, OPPD concludes that the impacts of FCS decommissioning on noise are bounded by the GEIS.

5.1.17 Transportation

The transportation impacts of decommissioning are dependent on the number of shipments to and from the plant, the types of shipments, the distance the material is shipped, and the radiological waste quantities and disposal plans. The shipments from the plant would be primarily radioactive wastes and non-radioactive wastes associated with dismantlement and disposal of structures, systems and components.

The estimated volume of radioactive waste associated with FCS decommissioning based on the SAFSTOR scenarios that will either be destined for land disposal (Class A, B and C) or a geologic repository (Greater than Class C) is summarized as follows:

- Class A: 198,630 cubic feet
- Class B: 725 cubic feet
- Class C: 963 cubic feet
- Greater than Class C (GTCC): 825 cubic feet

In addition to the above, there will also be 305,976 cubic feet of Class A waste that will be processed/conditioned at an offsite recycling center.

Table 4-7 of the GEIS estimated that the volume of land needed for LLRW disposal from the referenced PWR was 591,600 cubic feet under the SAFSTOR alternative. OPPD estimates the LLRW volume (Class A, B, and C) for FCS that is destined for land disposal will be approximately 200,318 cubic feet using the SAFSTOR alternative. This volume of radioactive waste is well within the range analyzed in the GEIS.

OPPD must comply with applicable regulations when shipping radioactive waste from decommissioning. The NRC has concluded in Section 4.3.17 of the GEIS that these regulations are adequate to protect the public against unreasonable risk from the transportation of radioactive materials.

The number of GTCC waste shipments expected to occur during decommissioning is expected to be below the number referenced in Table 4-6 of the GEIS. These shipments will occur over an extended period of time and will not result in significant changes to local traffic density or patterns, the need for construction of new methods of transportation, or significant dose to workers or the public.

In addition, shipments of non-radioactive wastes from the site are not expected to result in measurable deterioration of affected roads or a destabilizing increase in traffic density.

Therefore, OPPD concludes that the impacts of FCS decommissioning on transportation are bounded by the GEIS.

5.1.18 Irreversible and Irretrievable Commitment of Resources

Irreversible commitments are commitments of resources that cannot be recovered, and irretrievable commitments of resources are those that are lost for only a period of time.

Uranium is a natural resource that is irretrievably consumed during power operation. After the plant is shutdown, uranium is no longer consumed. The use of the environment (air, water, land) is not considered to represent a significant irreversible or irretrievable resource commitment, but rather a relatively short-term investment. Since the FCS site will be decommissioned to meet the unrestricted release criteria found in 10 CFR 20.1402, the land is not considered an irreversible resource. The only irretrievable resources that would occur during decommissioning would be materials used to decontaminate the facility (e.g., rags, solvents, gases, and tools), and the fuel used for decommissioning activities and transportation of materials to and from the site. However, the use of these resources is minor.

Therefore, OPPD concludes that the impacts of FCS decommissioning on irreversible and irretrievable commitment of resources are bounded by the GEIS.

5.2 Environmental Impacts of License Termination - NUREG-1496

According to the schedule provided in Section 3 of this report, a license termination plan for FCS will not be developed until approximately two years prior to the final site decontamination (approximately the year 2063). At that time, a supplemental environmental report will be submitted as required by 10 CFR 50.82(a) (9). While detailed planning for license termination activities will not be performed until after the SAFSTOR period, the absence of any unique site-specific factors, significant groundwater contamination, unusual demographics, or impediments to achieving unrestricted release suggest that impacts resulting from license termination will be similar to those evaluated in NUREG-1496.

5.3 Discussion of Decommissioning in the SEIS

Postulated impacts associated with decommissioning are discussed in Section 7.0 of the SEIS (Reference 8), which identified six issues related to decommissioning as follows:

- Radiation Doses
- Waste Management

- Air Quality
- Water Quality
- Ecological Resources
- Socioeconomic Impacts

The NRC staff did not identify any new and significant information during their independent review of the FCS license renewal environmental report at that time (Reference 14), the site audit, or the scoping process for license renewal. Therefore, the NRC concluded that there are no impacts related to these issues beyond those discussed in the GEIS for license renewal (Reference 15) or the GEIS for decommissioning (Reference 4). For the issues above, the license renewal and decommissioning GEISs both concluded the impacts are small. The NRC found no site-specific issues related to decommissioning and there are no decommissioning activities contemplated that would alter that conclusion.

5.4 Additional Considerations

While not quantitative, the following considerations are relevant to concluding that decommissioning activities will not result in significant environmental impacts not previously reviewed:

The release of effluents will continue to be controlled by plant license requirements and plant procedures.

FCS will continue to comply with the Offsite Dose Calculation Manual, Radiological Environmental Monitoring Program, and the Groundwater Protection Initiative Program during decommissioning.

Releases of non-radiological effluents will continue to be controlled per the requirements of the NPDES permit and applicable State of Nebraska permits.

Systems used to treat or control effluents during power operation will either be maintained or replaced by temporary or mobile systems for the decommissioning activities.

Radiation protection principles used during plant operations will remain in effect during decommissioning.

Sufficient decontamination and source term reduction prior to dismantlement will be performed to ensure that occupational dose and public exposure will be maintained below applicable limits.

Transport of hazardous and or radioactive waste will be in accordance with plant procedures, applicable Federal regulations, and the requirements of the receiving facility.

Site access control during decommissioning will minimize or eliminate radiation release pathways to the public.

Additionally, NUREG-2157 found that the generic environmental impacts of ongoing spent fuel storage are small (Reference 16).

5.5 Conclusions

Based on the above discussions, OPPD concludes that the environmental impacts associated with planned FCS site-specific decommissioning activities will be bounded by appropriate, previously issued environmental impact statements. Specifically, the environmental impacts are bounded by the GEIS (Reference 4) and SEIS (Reference 8).

The postulated impacts associated with the decommissioning method chosen, SAFSTOR, have already been considered in the SEIS and GEIS.

There are no unique aspects of FCS or of the decommissioning techniques to be utilized that would invalidate the conclusions reached in the SEIS and GEIS.

The methods assumed to be employed to dismantle and decontaminate FCS are standard construction-based techniques fully considered in the SEIS and GEIS.

Therefore, it can be concluded that the environmental impacts associated with the site-specific decommissioning activities for FCS will be bounded by appropriate previously issued environmental impact statements.

10 CFR 50.82(a) (6) (ii) states that licensees shall not perform any decommissioning activities, as defined in 10 CFR 50.2 that result in significant environmental impacts not previously reviewed. No such impacts have been identified.

6.0 REFERENCES

1. Regulatory Guide 1.185, Standard Format and Content for Post-Shutdown Decommissioning Activities Report, Revision 1. June 2013.

2. Letters, OPPD to USNRC, Certification of Permanent Cessation of Power Operations, dated June 24 and August 25, 2016. (ADAMS Accession Nos. ML16176A213 and ML16242A127).

3. Letter, OPPD to USNRC, Certification of Permanent of Fuel from the Reactor Vessel, dated November 13, 2016.(ADAMS Accession No. ML16319A254).

4. NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors, Final Report. November 2002.

5. AIF/NESP-036, A Guideline for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates. May 1986.

6. Regulatory Guide 1.159, Assuring the Availability of Funds for Decommissioning Nuclear Reactors, Revision 2. October 2011.

7. NUREG-1496, Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities. July 1997.

8. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 12, Regarding Fort Calhoun Nuclear Power Station. August 2007.

9. Fort Calhoun Station, NPDES Permit No. 0000418. January 2016.

10. Fort Calhoun Station, Stormwater Discharge Permit NER910000. July 2011.

11. Fort Calhoun Station, Dewatering Authorization. Permit NEG671000. January 2012.

12. Fort Calhoun Station, Air Quality Construction Permit. CP07-0063. February 2008.

13. PAG Manual, Protective Action Guides and Planning Guidance for Radiological Incidents, Draft for Interim Use and Public Comment. March 2013.

14. FCS Nuclear Power Station, License Renewal Application. Appendix E, Applicant's Environmental Report. January 2002.

15. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants. June 2013.

16. NUREG-2157, Waste Confidence Generic Environmental Impact Statement, Draft Report for Comment. September 2013.

Attachment 1: FCS Site-Specific Decommissioning Cost Estimate

Document O02-1737-001, Rev. 0

SITE-SPECIFIC DECOMMISSIONING COST ESTIMATE

for the

FORT CALHOUN STATION

prepared for

OMAHA PUBLIC POWER DISTRICT

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

February 2017

APPROVALS

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No.	Date	Item Revised	Reason for Revision
0	02-14-2017		Original Issue

EXECUTIVE SUMMARY

This report presents an estimate of the cost to decommission the Fort Calhoun Station (Fort Calhoun) for the Nuclear Regulatory Commission's (NRC) approved SAFSTOR decommissioning alternative. The nuclear unit ceased operations on October 24, 2016 and completed the defueling of the reactor on November 13, 2016.[1] This estimate has been prepared for the Omaha Public Power District (OPPD) to comply with the requirements of 10 CFR 50.82(a)(8)(iii).[2]

The analysis relies upon the detailed planning that has been performed with the permanent cessation of operations and the site-specific, technical information from an earlier evaluation prepared in 2013,[3] updated to reflect current assumptions pertaining to the disposition of the nuclear unit and relevant industry experience in undertaking such projects.

The current estimate is designed to provide OPPD with sufficient information to assess its financial obligations, as they pertain to the decommissioning of the nuclear unit. It is not a detailed budget and engineering document, but a financial analysis prepared in advance of the detailed budgeting and engineering work that will be required to carry out the decommissioning.

The estimate does include the detailed planning (and budgeting) for placing the unit in safe-storage and moving the spent fuel from the pool located within the fuel handling area of the auxiliary building to the on-site independent spent fuel storage installation (ISFSI). It may not reflect the actual plan to decommission Fort Calhoun following a period of safe storage; the plan may differ from the assumptions made in this analysis based on facts that exist at the time the plant is dismantled.

The projected total cost to decommission the nuclear unit, after an extended period of safe storage, is estimated at $1.383 billion, as reported in 2016 dollars. The cost includes monies anticipated to be spent for operating license termination (radiological remediation), interim spent fuel storage and site restoration activities. The cost is based on several key assumptions in areas of regulation, component characterization, high-level radioactive waste management, low-level radioactive waste disposal,

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1 Letter from OPPD to the NRC, LIC-16-0074, "Certification of Permanent Removal of Fuel from the Reactor Vessel," dated November 13, 2016, NRC Accession No. ML16319A254

2 Within 2 years following permanent cessation of operations, if not already submitted, the licensee shall submit a site-specific decommissioning cost estimate.

3 "SAFSTOR Decommissioning Cost Analysis for the Fort Calhoun Station," TLG Document No. O02-1675-002, Rev. 0, August 2013

performance uncertainties (contingency) and site remediation and restoration requirements.

A discussion of the assumptions relied upon in this analysis is provided in Section 3, along with schedules of annual expenditures. A sequence of significant project activities is provided in Section 4 along with a timeline for the scenario. A detailed cost report, used to generate the summary tables presented within this document, is provided in Appendix C.

The estimate includes the continued operation of the fuel handling area of the auxiliary building as an interim wet fuel storage facility for approximately six years (until the end of 2022). During this time period, the spent fuel residing in the storage pool will be transferred to an independent spent fuel storage installation (ISFSI) at the site. The ISFSI will remain operational until the Department of Energy (DOE) is able to complete the transfer of the fuel to a federal facility (e.g., a monitored retrievable storage facility).[4]

DOE has breached its obligations to remove fuel from reactor sites on the contracted schedule, and has also failed to provide plant owners with information about how it will ultimately perform and fulfill its obligation. DOE officials have stated that DOE does not have an obligation to accept already-canistered fuel without an amendment to DOE's contracts with plant licensees to remove the fuel (the "Standard Contract"), but DOE has not explained what costs any such amendment would involve. Consequently, the plant owner has no information or expectations on how DOE will remove fuel from the site in the future. In the absence of information about how DOE will specifically deal with already-canistered fuel, and for purposes of this analysis only, this cost estimate assumes that there will be no additional costs associated with DOE's acceptance of such fuel. If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers, and to dispose of existing containers.

Alternatives and Regulations

The NRC provided general decommissioning guidance in a rule adopted on June 27, 1988.[5] In this rule, the NRC set forth technical and financial criteria for

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4 Projected expenditures for spent fuel management identified in the cost analyses do not consider the outcome of the litigation (including compensation for damages) with the DOE with regard to the delays incurred by the OPPD in the timely removal of spent fuel from the site. As such, this analysis takes no credit for collection of damages, even though utilities are now routinely being awarded such damages in the courts. Collection of spent fuel damages from the DOE is expected to provide the majority of funds needed for spent fuel management.

5 U.S. Code of Federal Regulations, Title 10, Parts 30, 40, 50, 51, 70 and 72 "General Requirements for Decommissioning Nuclear Facilities," Nuclear Regulatory Commission, Federal Register Volume

decommissioning licensed nuclear facilities. The regulations addressed planning needs, timing, funding methods, and environmental review requirements for decommissioning. The rule also defined three decommissioning alternatives as being acceptable to the NRC: DECON, SAFSTOR, and ENTOMB.

> DECON is defined as "the alternative in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations."[6]
>
> SAFSTOR is defined as "the alternative in which the nuclear facility is placed and maintained in a condition that allows the nuclear facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use."[7] Decommissioning is required to be completed within 60 years, although longer time periods will be considered when necessary to protect public health and safety.
>
> ENTOMB is defined as "the alternative in which radioactive contaminants are encased in a structurally long-lived material, such as concrete; the entombed structure is appropriately maintained and continued surveillance is carried out until the radioactive material decays to a level permitting unrestricted release of the property."[8] As with the SAFSTOR alternative, decommissioning is currently required to be completed within 60 years, although longer time periods will also be considered when necessary to protect public health and safety.
>
> The 60-year restriction has limited the practicality for the ENTOMB alternative at commercial reactors that generate significant amounts of long-lived radioactive material. In 1997, the Commission directed its staff to re-evaluate this alternative and identify the technical requirements and regulatory actions that would be necessary for entombment to become a viable option. The resulting evaluation provided several recommendations, however, rulemaking has been deferred pending the completion of additional research studies (e.g., on engineered barriers).

53, Number 123 (p 24018 et seq.), June 27, 1988

6 Ibid. Page FR24022, Column 3

7 Ibid.

8 Ibid. Page FR24023, Column 2

In 1996, the NRC published revisions to its general requirements for decommissioning nuclear power plants to clarify ambiguities and codify procedures and terminology as a means of enhancing efficiency and uniformity in the decommissioning process.[9] The amendments allow for greater public participation and better define the transition process from operations to decommissioning. Regulatory Guide 1.184 Revision 1, issued in October 2013, further described the methods and procedures that are acceptable to the NRC staff for implementing the requirements of the 1996 revised rule that relate to the initial activities and the major phases of the decommissioning process. The costs and schedules presented in this analysis follow the general guidance and sequence in the amended regulations. The format and content of the estimate is also consistent with the recommendations of Regulatory Guide 1.202, issued February 2005.[10]

In 2011, the NRC published amended regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[11] The amended regulations require licensees to report additional details in their decommissioning cost estimate including a decommissioning estimate for the ISFSI. This estimate is provided in Appendix D.

Basis of the Cost Estimate

For planning purposes, the SAFSTOR decommissioning alternative has been selected by OPPD for Fort Calhoun. In SAFSTOR, the facility is placed in a safe and stable condition and maintained in that state, allowing levels of radioactivity to decrease through radioactive decay. After the safe storage period, the facility is decontaminated and dismantled, removing residual radioactivity so as to permit termination of the operating license and unrestricted use of the site.

The spent fuel will remain in storage at the site until it can be transferred to a DOE facility. The existing ISFSI pad is able to accommodate the entire inventory of spent fuel that has been generated over the reactor's operating life. Based upon the performance assumptions discussed herein, the OPPD anticipates that the removal of spent fuel from the site could be completed by the end of 2058.

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9 U.S. Code of Federal Regulations, Title 10, Parts 2, 50, and 51, "Decommissioning of Nuclear Power Reactors," Nuclear Regulatory Commission, Federal Register Volume 61, (p 39278 et seq.), July 29, 1996

10 "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors," Regulatory Guide 1.202, Nuclear Regulatory Commission, February 2005

11 U.S. Code of Federal Regulations, Title 10, Parts 20, 30, 40, 50, 70, and 72, "Decommissioning Planning," Nuclear Regulatory Commission, Federal Register Volume 76, (p 35512 et seq.), June 17, 2011

For purposes of this analysis, the plant is assumed to remain in safe-storage until the spent fuel has been removed from the site (e.g., through 2058), at which time decommissioning will commence. The start date allows sufficient time to accomplish the activities described in this document and to terminate the operating license within the required 60-year time period.

Methodology

The OPPD decommissioning project organization, plant staff, and numerous other subject matter experts have been engaged in the detailed planning and engineering needed to transition the nuclear unit and its operating organization from power generation to safe-storage. This information will be used to create working budgets and a forecast for the first six years following the cessation of operations, or until the spent fuel is relocated to the ISFSI (years 2016 through 2022), and the plant secured for long-term storage.

The methodology used to develop the estimate for the deferred decontamination and dismantling activities described within this document (years 2059 through 2066) follows the basic approach originally presented in the cost estimating guidelines[12] developed by the Atomic Industrial Forum (now Nuclear Energy Institute). This reference describes a unit factor method for determining decommissioning activity costs. The unit factors used in this analysis incorporate site-specific costs and the latest available information on worker productivity in decommissioning.

An activity duration critical path is used to determine the total decommissioning program schedule. The schedule is relied upon in calculating the carrying costs, which include program management, administration, field engineering, equipment rental, and support services such as quality control and security. This systematic approach for assembling decommissioning estimates ensures a high degree of confidence in the reliability of the resulting cost estimate.

Contingency

Consistent with standard cost estimating practices, contingencies are applied to the decontamination and dismantling costs developed as a "specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur."[13] The cost elements

[12] T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986

[13] Project and Cost Engineers' Handbook, Second Edition, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York, p. 239.

in the estimate are based on ideal conditions; therefore, the types of unforeseeable events that are almost certain to occur in decommissioning, based on industry experience, are addressed through a percentage contingency applied on a line-item basis. This contingency factor is a nearly universal element in all large-scale construction and demolition projects. It should be noted that contingency, as used in this analysis, does not account for price escalation and inflation in the cost of decommissioning over the period of performance (these factors are typically addressed in a funding analysis).

The use and role of contingency within decommissioning estimates is not a safety factor issue. Safety factors provide additional security and address situations that may never occur. Contingency funds, by contrast, are expected to be fully expended throughout the program. Inclusion of contingency is necessary to provide assurance that sufficient funding is available to accomplish the intended tasks.

Low-Level Radioactive Waste Management

The contaminated and activated material generated in the decontamination and dismantling of a commercial nuclear reactor is generally classified as low-level radioactive waste, although not all of the material is suitable for shallow-land disposal. With the passage of the "Low-Level Radioactive Waste Disposal Act" in 1980 and its Amendments of 1985,[14] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

With the exception of Texas, no new compact facilities have been successfully sited, licensed, and constructed. The Texas Compact disposal facility, operated by Waste Control Specialists (WCS), is now operational. The facility is able to accept limited quantities of non-Compact waste; however, at this time the cost for non-Compact generators is being negotiated on an individual basis.

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to the OPPD. The majority of the low-level radioactive waste designated for direct disposal (Class A[15]) can be sent to Energy*Solutions'* facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon OPPD's agreement with Energy*Solutions*. This facility is not licensed to receive the higher activity portion (Classes B and C) of the decommissioning waste stream.

14 "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, January 15, 1986

15 Low-level radioactive waste is classified in accordance with U.S. Code of Federal Regulations, Title 10, Part 61.55

The Texas facility is able to receive the higher activity waste forms (Classes B and C). As such, for this analysis, disposal costs for the Class B and C waste were based upon indicative information on the cost for such from the Texas Commission on Environmental Quality.

The dismantling of the components residing closest to the reactor core generates radioactive waste that may be considered unsuitable for shallow-land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the federal government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. However, to date, the federal government has not identified a cost for disposing of GTCC or a schedule for acceptance.

For purposes of this analysis only, the GTCC radioactive waste is assumed to be packaged and disposed of in a similar manner as high-level waste and at a cost equivalent to that envisioned for the spent fuel. The GTCC is shipped directly to a DOE facility as it is generated (assuming that the spent fuel has been removed from the site prior to the start of decommissioning).

A significant portion of the waste material generated during decommissioning may only be potentially contaminated by radioactive materials. This waste can be analyzed on site or shipped off site to licensed facilities for further analysis, for processing and/or for conditioning/recovery. Reduction in the volume of low-level radioactive waste requiring disposal in a licensed low-level radioactive waste disposal facility can be accomplished through a variety of methods, including analyses and surveys or decontamination to eliminate the portion of waste that does not require disposal as radioactive waste, compaction, incineration or metal melt. The estimate reflects the savings from waste recovery/volume reduction.

<u>High-Level Radioactive Waste Management</u>

Congress passed the "Nuclear Waste Policy Act" (NWPA) in 1982, assigning the federal government's long-standing responsibility for disposal of the spent nuclear fuel created by the commercial nuclear generating plants to the DOE. The DOE was to begin accepting spent fuel by January 31, 1998; however, to date no progress in the removal of spent fuel from commercial generating sites has been made.

Completion of the decommissioning process is dependent upon the DOE's ability to remove spent fuel from the site in a timely manner. DOE's repository program assumes that spent fuel allocations will be accepted for disposal from the nation's commercial nuclear plants, with limited exceptions, in the order (the "queue") in which it was discharged from the reactor.[16] The plan for the management of all irradiated fuel at the reactor was based in general upon: 1) a 2030 start date for DOE initiating transfer of commercial spent fuel to a federal facility (not necessarily a final repository), and 2) expectations for spent fuel receipt by the DOE for the Fort Calhoun fuel. The DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority. Assuming a maximum rate of transfer of 3,000 metric tons of uranium (MTU)/year, [17] the removal of spent fuel from the site is assumed to be completed in 2058. Different DOE acceptance schedules may result in different completion dates.

Today, the country is at an impasse on high-level waste disposal, despite DOE's submittal of its License Application for a geologic repository to the NRC in 2008. The Obama administration eliminated the budget for the repository program while promising to "conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle ... and make recommendations for a new plan."[18] Towards this goal, the administration appointed a Blue Ribbon Commission on America's Nuclear Future (Blue Ribbon Commission) to make recommendations for a new plan for nuclear waste disposal. The Blue Ribbon Commission's charter includes a requirement that it consider "[o]ptions for safe storage of used nuclear fuel while final disposition pathways are selected and deployed."[19]

On January 26, 2012, the Blue Ribbon Commission issued its "Report to the Secretary of Energy" containing a number of recommendations on nuclear waste disposal. Two of the recommendations that may impact decommissioning planning are:

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16 In 2008, the DOE issued a report to Congress in which it concluded that it did not have authority, under present law, to accept spent nuclear fuel for interim storage from decommissioned commercial nuclear power reactor sites. However, the Blue Ribbon Commission, in its final report, noted that: "[A]ccepting spent fuel according to the OFF [Oldest Fuel First] priority ranking instead of giving priority to shutdown reactor sites could greatly reduce the cost savings that could be achieved through consolidated storage if priority could be given to accepting spent fuel from shutdown reactor sites before accepting fuel from still-operating plants. .... The magnitude of the cost savings that could be achieved by giving priority to shutdown sites appears to be large enough (i.e., in the billions of dollars) to warrant DOE exercising its right under the Standard Contract to move this fuel first." For planning purposes only, this estimate does not assume that Fort Calhoun, as a permanently shutdown unit, will receive priority; the fuel removal schedule assumed in this estimate is based upon DOE acceptance of fuel according to the "Oldest Fuel First" priority ranking. The plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance.

17 "Acceptance Priority Ranking & Annual Capacity Report," DOE/RW-0567, July 2004

18 "Advisory Committee Charter, Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy," https://energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf, Appendix A, January 2012

19 Ibid.

- "[T]he United States [should] establish a program that leads to the timely development of one or more consolidated storage facilities"[20]
- "[T]he United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste."[21]

In January 2013, the DOE issued the "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," in response to the recommendations made by the Blue Ribbon Commission and as "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel..."[22] This document states:

"With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048."[23]

The NRC's review of DOE's license application to construct a geologic repository at Yucca Mountain was suspended in 2011 when the Administration significantly reduced the budget for completing that work. However, the US Court of Appeals for the District of Columbia Circuit issued a writ of mandamus (in August 2013)[24]

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20 "Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy," https://energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf, p. 32, January 2012

21 Ibid., p.27

22 "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," U.S. DOE, January 11, 2013

23 Ibid., p.2

24 U.S. Court of Appeals for the District Of Columbia Circuit, In Re: Aiken County, et al, Aug. 2013,http://www.cadc.uscourts.gov/internet/opinions.nsf/BAE0CF34F762EBD985257BC6004DEB18/$file/11-1271-1451347.pdf

ordering NRC to comply with federal law and resume its review of DOE's Yucca Mountain repository license application to the extent allowed by previously appropriated funding for the review. That review is now complete with the publication of the five-volume safety evaluation report. A supplement to DOE's environmental impact statement and an adjudicatory hearing on the contentions filed by interested parties must be completed before a licensing decision can be made.

The NRC requires that licensees establish a program to manage and provide funding for the caretaking of all irradiated fuel at the reactor site until title of the fuel is transferred to the DOE.[25] Interim storage of the fuel, until the DOE has completed the transfer, will be in the auxiliary building's spent fuel storage pool, as well as at an on-site ISFSI.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[26]), was constructed to support continued plant operations. The facility is able to accommodate all the spent fuel generated during operations. Once the spent fuel storage pool is emptied, the auxiliary building will be prepared for long term storage.

OPPD's position is that the DOE has a contractual obligation to accept the spent fuel earlier than the projections set out in this cost study, consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this position. However, at this time, including the cost of long-term spent fuel storage at Fort Calhoun in this study and assuming DOE acceptance of fuel on an Oldest Fuel First basis is the most reasonable approach because it insures the availability of sufficient decommissioning funds given that, contrary to its contractual obligation, the DOE has not performed to date.

Site Restoration

The efficient removal of the contaminated materials at the site may result in damage to many of the site structures. Blasting, coring, drilling, and the other decontamination activities can substantially damage power block structures, potentially weakening the footings and structural supports. It is unreasonable to anticipate that these structures would be repaired and preserved after the radiological contamination is removed. The cost to dismantle site structures with a work force already mobilized is more efficient and less costly than if the process is deferred.

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25 U.S. Code of Federal Regulations, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," Subpart 54 (bb), "Conditions of Licenses"

26 U.S. Code of Federal Regulations, Title 10, Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites"

This study consequently assumes that the site structures addressed by this analysis are removed and further assumes that such removal will be to a nominal depth of three feet below the local grade level wherever possible. The site can then be graded and stabilized.

Summary

The estimate to decommission Fort Calhoun assumes the removal of all contaminated and activated plant components and structural materials such that the owner may then have unrestricted use of the site with no further requirements for an operating license. Low-level radioactive waste, other than GTCC waste, is sent to a commercial processor for treatment/conditioning or to a controlled disposal facility.

Decommissioning is accomplished within the 60-year period required by current NRC regulations. In the interim, the spent fuel remains in storage at the site until such time that the transfer to a DOE facility is complete.

The SAFSTOR alternative evaluated in this analysis is described in Section 2. The assumptions are presented in Section 3, along with schedules of annual expenditures. The major cost contributors are identified in Section 6, with detailed activity costs, waste volumes, and associated manpower requirements delineated in Appendix C. The major cost components are also identified in the cost summary provided at the end of this section.

The cost elements are assigned to one of three subcategories: NRC License Termination (radiological remediation), Spent Fuel Management, and Site Restoration. The subcategory "NRC License Termination" is used to accumulate costs that are consistent with "decommissioning" as defined by the NRC in its financial assurance regulations (i.e., 10 CFR §50.75). In situations where the long-term management of spent fuel is not an issue, the cost reported for this subcategory is generally sufficient to terminate a reactor's operating license.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel to the ISFSI, and the operation of the ISFSI until such time that the transfer of all fuel from this facility to an off-site location is complete. It does not include any costs related to the final disposal of the spent fuel.

"Site Restoration" is used to capture costs associated with the dismantling and demolition of buildings and facilities demonstrated to be free from contamination. This includes structures never exposed to radioactive materials, as well as those facilities that have been decontaminated to appropriate levels. Structures are assumed to be removed to a nominal depth of three feet and backfilled to conform to local grade.

It should be noted that the costs assigned to these subcategories are allocations. Delegation of cost elements is for the purposes of comparison (e.g., with NRC financial guidelines) or to permit specific financial treatment (e.g., Asset Retirement Obligations determinations). In reality, there can be considerable interaction between the activities in the three subcategories. For example, an owner may decide to remove non-contaminated structures early in the project to improve access to highly contaminated facilities or plant components. In these instances, the non-contaminated removal costs could be reassigned from Site Restoration to an NRC License Termination support activity. However, in general, the allocations represent a reasonable accounting of those costs that can be expected to be incurred for the specific subcomponents of the total estimated program cost, if executed as described.

As noted within this document, the estimate was developed and costs are presented in 2016 dollars. The estimate does not reflect the escalation of costs (due to inflationary and market forces) over the safe-storage and decommissioning period.

The decommissioning subperiods and milestone dates for the analyzed SAFSTOR decommissioning alternative are identified in Table 1. The cost projected for license termination (in accordance with 10 CFR 50.75) is shown in Table 2, along with the costs for spent fuel management and site restoration. The schedule of expenditures for license termination activities is provided in Table 3.

TABLE 1
DECOMMISSIONING SCHEDULE AND PLANT STATUS SUMMARY

Decommissioning Activities / Plant Status	Start	End	Approximate Duration (years)
Pre-Shutdown Planning	2016	Oct 2016	--------
Transition from Operations			
Plant Shutdown	24 Oct 2016	--------	--------
Preparations for SAFSTOR Dormancy	24 Oct 2016	01 Jul 2018	1.68
SAFSTOR Dormancy			
Dormancy w/Wet Fuel Storage	2018	2022	4.51
Dormancy w/Dry Fuel Storage	2023	2058	36.02
Decommissioning Preparations			
Preparations for D&D	2059	2060	1.49
Dismantling & Decontamination			
Large Component Removal	2060	2061	1.10
Plant Systems Removal and Building Decontamination	2061	2064	3.11
License Termination	2064	2065	0.75
Site Restoration			
Site Restoration	2065	2066	1.50
Total from Shutdown to Completion of Site Restoration	---------	--------	50.16

TABLE 2
DECOMMISSIONING COST SUMMARY
(thousands of 2016 dollars)

Decommissioning Periods	License Termination	Spent Fuel Management	Site Restoration
Pre-shutdown Planning	1,482	-	-
Planning and Preparations	182,134	38,401	-
Dormancy w/Wet Fuel Storage	101,964	175,296	-
Dormancy w/Dry Fuel Storage	194,080	191,846	-
Site Reactivation	50,075	-	626
Decommissioning Preparation	26,644	-	821
Large Component Removal	141,440	-	1,037
Plant Sys. Removal and Bldg. Remediation	208,777	-	7,641
License Termination	25,174	-	-
Site Restoration	205	-	35,733
Total [1]	931,973	405,543	45,857

[1] Columns may not add due to rounding

TABLE 3
LICENSE TERMINATION EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2016	19,405	98	120	15	9,373	29,011
2017	68,483	823	490	197	33,361	103,353
2018	35,693	411	416	111	26,025	62,657
2019	3,438	6	344	26	18,810	22,624
2020	3,447	6	345	26	18,861	22,686
2021	3,438	6	344	26	18,810	22,624
2022	3,438	6	344	26	18,810	22,624
2023	3,906	169	0	1,140	1,750	6,965
2024	3,451	82	0	1,125	6,528	11,187
2025	3,441	3	0	12	1,715	5,171
2026	3,441	3	0	12	1,715	5,171
2027	3,441	3	0	12	1,715	5,171
2028	3,451	3	0	12	1,720	5,185
2029	3,441	3	0	12	1,715	5,171
2030	3,441	3	0	12	1,715	5,171
2031	3,441	3	0	12	1,715	5,171
2032	3,451	3	0	12	1,720	5,185
2033	3,441	3	0	12	1,715	5,171
2034	3,441	3	0	12	1,715	5,171
2035	3,441	3	0	12	1,715	5,171
2036	3,451	3	0	12	1,720	5,185
2037	3,441	3	0	12	1,715	5,171
2038	3,441	3	0	12	1,715	5,171
2039	3,441	3	0	12	1,715	5,171
2040	3,451	3	0	12	1,720	5,185
2041	3,441	3	0	12	1,715	5,171
2042	3,441	3	0	12	1,715	5,171
2043	3,441	3	0	12	1,715	5,171
2044	3,451	3	0	12	1,720	5,185
2045	3,441	3	0	12	1,715	5,171
2046	3,441	3	0	12	1,715	5,171
2047	3,441	3	0	12	1,715	5,171

TABLE 3 (continued)
LICENSE TERMINATION EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2048	3,451	3	0	12	1,720	5,185
2049	3,441	3	0	12	1,715	5,171
2050	3,441	3	0	12	1,715	5,171
2051	3,441	3	0	12	1,715	5,171
2052	3,451	3	0	12	1,720	5,185
2053	3,441	3	0	12	1,715	5,171
2054	3,441	3	0	12	1,715	5,171
2055	3,441	3	0	12	1,715	5,171
2056	3,451	3	0	12	1,720	5,185
2057	3,441	3	0	12	1,715	5,171
2058	3,441	3	0	12	1,715	5,171
2059	41,433	5,010	0	46	3,585	50,075
2060	46,968	19,819	0	14,717	10,582	92,087
2061	46,720	21,987	0	20,872	13,802	103,381
2062	42,514	6,482	0	9,335	8,749	67,081
2063	42,514	6,482	0	9,335	8,749	67,081
2064	38,736	5,050	0	6,585	6,839	57,210
2065	13,478	740	0	19	1,033	15,270
2066	130	0	0	0	0	130
Total	534,276	67,277	2,403	64,007	264,010	931,973

1. INTRODUCTION

This report presents an estimate of the cost to decommission the Fort Calhoun Station (Fort Calhoun) for the Nuclear Regulatory Agency's (NRC) approved SAFSTOR decommissioning alternative. The nuclear unit ceased operations on October 24, 2016 and completed the defueling of the reactor on November 13, 2016.[1] This estimate has been prepared for the Omaha Public Power District (OPPD) to comply with the requirements of 10 CFR 50.82(a)(8)(iii).[2]

The analysis relies upon the detailed planning that has been performed with the permanent cessation of operations and the site-specific, technical information from an earlier evaluation prepared in 2013,[3] updated to reflect current assumptions pertaining to the disposition of the nuclear unit and relevant industry experience in undertaking such projects.

The current estimate is designed to provide OPPD with sufficient information to assess its financial obligations, as they pertain to the decommissioning of the nuclear unit. It is not a detailed budget and engineering document, but a financial analysis prepared in advance of the detailed budgeting and engineering work that will be required to carry out the decommissioning.

The estimate does include the detailed planning (and budgeting) for placing the unit in safe-storage and moving the spent fuel from the pool located within the fuel handling area of the auxiliary building to the on-site dry storage facility. It may not reflect the actual plan to decommission Fort Calhoun; the plan may differ from the assumptions made in this analysis based on facts that exist at the plant.

1.1 OBJECTIVE

The plant entered commercial operation in 1973. In January 2002, OPPD submitted an application to the NRC for renewal of the facility's operating license (DPR-40) for an additional 20 years. In November 2003, the NRC approved the request to extend the facility operating license from midnight August 9, 2013, until midnight August 9, 2033.

On June 16, 2016, the OPPD Board of Directors voted to cease nuclear operations and begin decommissioning the Fort Calhoun nuclear power plant. The plant permanently ceased operations on October 24, 2016.

The objective of this analysis is to prepare a comprehensive estimate of the cost, detailed schedule of the associated activities, and projections of the low-level radioactive waste generated in decommissioning Fort Calhoun for the SAFSTOR alternative. The estimate is based upon the assumptions delineated within this document, including the Department of Energy's (DOE) performance as it relates to the removal of spent fuel from the site.

1.2 SITE DESCRIPTION

Fort Calhoun is located on the west bank of the Missouri River between the towns of Fort Calhoun and Blair, approximately 19 miles north of Omaha, Nebraska. The Nuclear Steam Supply System (NSSS) consists of a pressurized water reactor supplied by Combustion Engineering Corporation and two heat transfer loops, each containing a vertical shell and U-tube steam generator, and two vertical centrifugal reactor coolant pumps. In addition, the system includes an electrically heated pressurizer, a pressurizer relief tank, and interconnecting piping and valves. The reactor operated at a rated power level of 1,500 megawatts thermal. The corresponding net electrical output was approximately 480 megawatts electric.

The NSSS system is housed within the reactor building, a seismic Category I structure. The reactor building has cylindrical walls, a flat foundation mat, and a shallow dome roof. The foundation slab is reinforced with conventional mild-steel reinforcing. The cylindrical wall is prestressed with a post tensioning system in a helical pattern. The dome roof is prestressed, utilizing a three-way post-tensioning system. The inside surface of the reactor building is lined with a carbon steel liner to ensure a high degree of leak tightness during operating and accident conditions.

A turbine-generator system converted the thermal energy of the steam produced in the steam generators into mechanical shaft power and then into electrical energy. The turbine consists of a high-pressure cylinder and two double-flow low-pressure cylinders all aligned in tandem. The generator is a direct driven 1800-rpm conductor-cooled, synchronous generator. The turbine operated in a closed feedwater cycle that condensed the steam; the heated feedwater was returned to the steam generators. Heat rejected in the main condensers was removed by the circulating water system.

The circulating water system provided the heat sink required for removal of waste heat in the power plant's thermal cycle. This system had the principal function of removing heat by absorbing this energy in the main condenser. The Missouri River served as the normal and ultimate heat sink, with the condenser circulating water taken from and returned to the Missouri River through the intake and discharge canals, respectively.

1.3 REGULATORY GUIDANCE

The NRC (or Commission) provided initial decommissioning requirements in its rule "General Requirements for Decommissioning Nuclear Facilities," issued in June 1988.[4] This rule set forth financial criteria for decommissioning licensed nuclear power facilities. The regulation addressed decommissioning planning needs, timing, funding methods, and environmental review requirements. The intent of the rule was to ensure that decommissioning would be accomplished in a safe and timely manner and that adequate funds would be available for this purpose. Subsequent to the rule, the NRC issued Regulatory Guide 1.159, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors,"[5] which provided additional guidance to the licensees of nuclear facilities on the financial methods acceptable to the NRC staff for complying with the requirements of the rule. The regulatory guide addressed the funding requirements and provided guidance on the content and form of the financial assurance mechanisms indicated in the rule.

The rule defined three decommissioning alternatives as being acceptable to the NRC: DECON, SAFSTOR, and ENTOMB. The DECON alternative assumes that any contaminated or activated portion of the plant's systems, structures and facilities are removed or decontaminated to levels that permit the site to be released for unrestricted use shortly after the cessation of plant operations, while the SAFSTOR and ENTOMB alternatives defer the process.

The rule also placed limits on the time allowed to complete the decommissioning process. For all alternatives, the process is restricted in overall duration to 60 years, unless it can be shown that a longer duration is necessary to protect public health and safety. At the conclusion of a 60-year dormancy period (or longer if the NRC approves such a case), the site would still require significant remediation to meet the unrestricted release limits for license termination.

The ENTOMB alternative has not been viewed as a viable option for power reactors due to the significant time required to isolate the long-lived radionuclides for decay to permissible levels. However, with rulemaking permitting the controlled release of a site,[6] the NRC did re-evaluate the alternative. The resulting feasibility study, based upon an assessment by Pacific Northwest National Laboratory, concluded that the method did have conditional merit for some, if not most reactors. The staff also found that additional rulemaking would be needed before this option could be treated as a generic alternative.

The NRC had considered rulemaking to alter the 60-year time for completing decommissioning and to clarify the use of engineered barriers for reactor entombments.[7] However, the NRC's staff has subsequently recommended that rulemaking be deferred, based upon several factors (e.g., no licensee has committed to pursuing the entombment option, the unresolved issues associated with the disposition of greater-than-Class C material (GTCC), and the NRC's current priorities), at least until after the additional research studies are complete. The Commission concurred with the staff's recommendation.

In 1996, the NRC published revisions to the general requirements for decommissioning nuclear power plants.[8] When the decommissioning regulations were adopted in 1988, it was assumed that the majority of licensees would decommission at the end of the facility's operating licensed life. Since that time, several licensees permanently and prematurely ceased operations. Exemptions from certain operating requirements were required once the reactor was defueled to facilitate the decommissioning. Each case was handled individually, without clearly defined generic requirements. The NRC amended the decommissioning regulations in 1996 to clarify ambiguities and codify procedures and terminology as a means of enhancing efficiency and uniformity in the decommissioning process. The amendments allow for greater public participation and better define the transition process from operations to decommissioning.

Under the revised regulations, licensees will submit written certification to the NRC within 30 days after the decision to cease operations. Certification will also be required once the fuel is permanently removed from the reactor vessel. Submittal of these notices, along with related changes to Technical Specifications, entitle the licensee to a fee reduction and eliminate the obligation to follow certain requirements needed only during operation of the reactor. Within two years of submitting notice of permanent cessation of operations, the licensee is required to submit a Post-Shutdown Decommissioning Activities Report (PSDAR) to the NRC. The PSDAR describes the planned decommissioning activities, the associated sequence and schedule, and an estimate of expected costs. Prior to completing decommissioning, the licensee is required to submit an application to the NRC to terminate the license, which includes a license termination plan (LTP).

In 2011, the NRC published amended regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[9] The amended regulations require licensees to conduct their operations to minimize the introduction of residual radioactivity into the site, which includes the site's subsurface soil and groundwater. Licensees also may be required to perform site surveys to determine whether residual radioactivity is present in subsurface areas and to keep records of these surveys with records important for decommissioning. The amended regulations require licensees to report additional details in their decommissioning cost estimate as well as requiring additional financial reporting and assurances. These additional details, including an ISFSI decommissioning estimate, are included in this analysis.

1.3.1 High-Level Radioactive Waste Management

Congress passed the "Nuclear Waste Policy Act" (NWPA) in 1982,[10] assigning the federal government's long-standing responsibility for disposal of the spent nuclear fuel created by the commercial nuclear generating plants to the DOE. The NWPA Amendments Act of 1987[11] designated Yucca Mountain as the sole site to be considered for a permanent geologic repository. The DOE was to begin accepting spent fuel by January 31, 1998; however, to date no progress in the removal of spent fuel from commercial generating sites has been made.

Completion of the decommissioning process is dependent upon the DOE's ability to remove spent fuel from the site in a timely manner. DOE's repository program assumes that spent fuel allocations will be accepted for disposal from the nation's commercial nuclear plants, with limited exceptions, in the order (the "queue") in which it was discharged from the reactor. The plan for the management of all irradiated fuel at the reactor was based in general upon: 1) a 2030 start date for DOE initiating transfer of commercial spent fuel to a federal facility (not necessarily a final repository), and 2) expectations for spent fuel receipt by the DOE for the Fort Calhoun fuel. The DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority. Assuming a maximum rate of transfer of 3,000 metric tons of uranium (MTU)/year, as reflected in DOE's latest Acceptance Priority Ranking and Annual Capacity Report dated June 2004 (DOE/RW-0567),[12] the removal of spent fuel from the site is assumed to be completed in 2058. Different DOE acceptance schedules may result in different completion dates.

Today, the country is at an impasse on high-level waste disposal, despite DOE's submittal of its License Application for a geologic repository to the NRC in 2008. The Obama administration eliminated the budget for the repository program while promising to "conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle ... and make recommendations for a new plan." Towards this goal, the administration appointed a Blue Ribbon Commission on America's Nuclear Future (Blue Ribbon Commission) to make recommendations for a new plan for nuclear waste disposal. The Blue Ribbon Commission's charter includes a requirement that it consider "[o]ptions for safe storage of used nuclear fuel while final disposition pathways are selected and deployed."[13]

On January 26, 2012, the Blue Ribbon Commission issued its "Report to the Secretary of Energy" containing a number of recommendations on nuclear waste disposal. Two of the recommendations that may impact decommissioning planning are:

- "[T]he United States [should] establish a program that leads to the timely development of one or more consolidated storage facilities"
- "[T]he United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste."[14]

In January 2013, the DOE issued the "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," in response to the recommendations made by the Blue Ribbon Commission and as "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel..."[15] This document states:

"With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048."

The NRC's review of DOE's license application to construct a geologic repository at Yucca Mountain was suspended in 2011 when the Administration significantly reduced the budget for completing that work. However, the US Court of Appeals for the District of Columbia Circuit issued a writ of mandamus (in August 2013) [16] ordering NRC to comply with federal law and resume its review of DOE's Yucca Mountain repository license application to the extent allowed by previously appropriated funding for the review. That review is now complete with the publication of the five-volume safety evaluation report. A supplement to DOE's environmental impact statement and an adjudicatory hearing on the contentions filed by interested parties must be completed before a licensing decision can be made.

The NRC requires that licensees establish a program to manage and provide funding for the caretaking of all irradiated fuel at the reactor site until title of the fuel is transferred to the DOE.[17] Interim storage of the fuel, until the DOE has completed the transfer, will be in the reactor building's spent fuel storage pool, as well as at an on-site ISFSI. DOE has breached its obligations to remove fuel from reactor sites, and has also failed to provide the plant owner with information about how it will ultimately perform. DOE officials have stated that DOE does not have an obligation to accept already-canistered fuel without an amendment to DOE's contracts with plant licensees to remove the fuel (the "Standard Contract"), but DOE has not explained what costs any such amendment would involve. Consequently, the plant owner has no information or expectations on how DOE will remove fuel from the site in the future. In the absence of information about how DOE will specifically deal with already-canistered fuel, and for purposes of this analysis only, this cost estimate assumes that there will be no additional costs associated with DOE's acceptance of such fuel. If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers, and to dispose of existing containers.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K),[18] has been constructed to support continued plant operations. The facility will be expanded to accommodate all spent fuel generated over the plant life. Once the spent fuel storage pool is emptied the auxiliary building will be prepared for long term storage.

OPPD's position is that the DOE has a contractual obligation to accept Fort Calhoun's fuel earlier than the projections set out in this cost study, consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this position. However, at this time, including the cost of long-term spent fuel storage at Fort Calhoun in this study and assuming DOE acceptance of fuel on an Oldest Fuel First basis is the most reasonable approach because it insures the availability of sufficient decommissioning funds given that, contrary to its contractual obligation, the DOE has not performed to date.

1.3.2 Low-Level Radioactive Waste Management

The contaminated and activated material generated in the decontamination and dismantling of a commercial nuclear reactor is classified as low-level (radioactive) waste, although not all of the material is suitable for "shallow-land" disposal. With the passage of the "Low-Level Radioactive Waste Policy Act" in 1980,[19] and its Amendments of 1985,[20] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

In 2011, a new low-level waste disposal facility was successfully completed and opened in Andrews County, Texas pursuant to the Texas Low-Level Radioactive Waste Disposal Compact. The facility has been declared operational by the operator, Waste Control Specialists (WCS). The facility will be able to accept limited quantities of non-Compact waste; however, at this time the cost for non-Compact generators is being negotiated on an individual basis.

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to OPPD. The majority of the low-level radioactive waste designated for direct disposal (Class A [21]) can be sent to Energy*Solutions'* facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon OPPD's agreement with Energy*Solutions*. This facility is not licensed to receive the higher activity portion (Classes B and C) of the waste stream.

The Texas facility is able to receive the higher activity waste forms (Classes B and C). As such, for this analysis, disposal costs for the Class B and C waste are based upon the preliminary and indicative information on the cost from the Texas Commission on Environmental Quality.

The dismantling of the components residing closest to the reactor core generates radioactive waste that may be considered unsuitable for shallow-land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the federal government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. However, to date, the federal government has not identified a cost for disposing of GTCC or a schedule for acceptance.

For purposes of this analysis, the GTCC radioactive waste is assumed to be packaged and disposed of in a similar manner as high-level waste and at a cost equivalent to that envisioned for the spent fuel. The GTCC is shipped directly to a DOE facility as it is generated (assuming that the spent fuel has been removed from the site prior to the start of delayed decommissioning).

A significant portion of the waste material generated during decommissioning may only be potentially contaminated by radioactive materials. This waste can be analyzed on site or shipped off site to licensed facilities for further analysis, for processing and/or for conditioning/recovery. Reduction in the volume of low-level radioactive waste requiring disposal in a licensed low-level radioactive waste disposal facility can be accomplished through a variety of methods, including analyses and surveys or decontamination to eliminate the portion of waste that does not require disposal as radioactive waste, compaction, incineration or metal melt. The estimate reflects the savings from waste recovery/volume reduction.

1.3.3 Radiological Criteria for License Termination

In 1997, the NRC published Subpart E, "Radiological Criteria for License Termination,"[22] amending 10 CFR Part 20. This subpart provides radiological criteria for releasing a facility for unrestricted use. The regulation states that the site can be released for unrestricted use if radioactivity levels are such that the average member of a critical group would not receive a Total Effective Dose Equivalent (TEDE) in excess of 25 millirem per year, and provided that residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA). The decommissioning estimate assumes that the Fort Calhoun site will be remediated to a residual level consistent with the NRC-prescribed level.

It should be noted that the NRC and the Environmental Protection Agency (EPA) differ on the amount of residual radioactivity considered acceptable in site remediation. The EPA has two limits that apply to radioactive materials. An EPA limit of 15 millirem per year is derived from criteria established by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund).[23] An additional and separate limit of 4 millirem per year, as defined in 40 CFR §141.16, is applied to drinking water.[24]

On October 9, 2002, the NRC signed an agreement with the EPA on the radiological decommissioning and decontamination of NRC-licensed sites. The Memorandum of Understanding (MOU)[25] provides that EPA will defer exercise of authority under CERCLA for the majority of facilities decommissioned under NRC authority. The MOU also includes provisions for NRC and EPA consultation for certain sites when, at the time of license termination, (1) groundwater contamination exceeds EPA-permitted levels; (2) NRC contemplates restricted release of the site; and/or (3) residual radioactive soil concentrations exceed levels defined in the MOU.

The MOU does not impose any new requirements on NRC licensees and should reduce the involvement of the EPA with NRC licensees who are decommissioning. Most sites are expected to meet the NRC criteria for unrestricted use, and the NRC believes that only a few sites will have groundwater or soil contamination in excess of the levels specified in the MOU that trigger consultation with the EPA. However, if there are other hazardous materials on the site, the EPA may be involved in the cleanup. As such, the possibility of dual regulation remains for certain licensees. The present study does not include any costs for this possibility.

2. SAFSTOR DECOMMISSIONING ALTERNATIVE

Costs were determined for decommissioning Fort Calhoun based upon the NRC-approved SAFSTOR decommissioning alternative. The following sections describe the basic activities associated with the SAFSTOR alternative. Although detailed procedures for each activity identified are not provided, and the actual sequence of work may vary, the activity descriptions provide a basis not only for estimating but also for the expected scope of work (i.e., engineering and planning).

The conceptual approach that the NRC has described in its regulations divides decommissioning into three phases. The initial phase commences with the effective date of permanent cessation of operations and involves the transition of both plant and licensee from reactor operations (i.e., power production) to facility de-activation and closure. During the first phase, notification was provided to the NRC certifying the permanent cessation of operations and the removal of fuel from the reactor vessel.

The second phase encompasses activities during the storage period. The third phase pertains to the activities involved in license termination. The decommissioning estimate developed for Fort Calhoun is also divided into phases or periods; however, demarcation of the phases is based upon major milestones within the project or significant changes in the projected expenditures.

2.1 PERIOD 1 - PREPARATIONS

The NRC defines SAFSTOR as "the alternative in which the nuclear facility is placed and maintained in a condition that allows the nuclear facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use." The facility is left intact (during the dormancy period), with structures maintained in a sound condition. Systems that are not required to support the spent fuel pool or site surveillance and security are drained, de-energized, and secured. Minimal cleaning/removal of loose contamination and/or fixation and sealing of remaining contamination are performed. Access to contaminated areas is secured to provide controlled access for inspection and maintenance.

2.1.1 Engineering and Planning

Detailed preparations have been undertaken to provide a smooth transition from plant operations to site decommissioning. Through implementation of a staffing transition plan, the organization required to manage the intended decommissioning activities is assembled from available plant staff and outside resources. Preparations include the planning for permanent defueling of the reactor, revision of technical specifications applicable to the operating conditions and requirements, addition of security barriers, a limited characterization of the facility and major components, and the development of the PSDAR.

2.1.2 Site Preparations

The process of placing the plant in safe-storage will include, but is not limited to, the following activities:

- Creation of an organizational structure to support the decommissioning plan and evolving emergency planning and site security requirements.
- Revision of technical specifications, plans and operating procedures appropriate to the operating conditions and requirements.
- Characterization of the facility and major components as may be necessary to plan and prepare for the dormancy phase.
- Management of the spent fuel pool and reconfiguring fuel pool support systems so that draining and de-energizing may commence in other areas of the plant.
- Deactivation (de-energizing and /or draining) of systems that are no longer required during the dormancy period.
- Processing and disposal of water and water filter and treatment media not required to support dormancy operation.
- Disposition of incidental waste that is present prior to the start of the dormancy period, such as excess tools and equipment and waste produced while deactivating systems and preparing the facility for dormancy.
- Reconfiguration of power, lighting, heating, ventilation, fire protection, and any other services needed to support long-term storage and periodic plant surveillance and maintenance.
- Stabilization by fixing or removing loose incidental surface contamination to facilitate future building access and plant maintenance. Decontamination of high-dose areas is not anticipated.
- Performance of interim radiation surveys of the plant, posting caution signs and establishing access requirements, where appropriate.

- Maintenance of appropriate barriers for contaminated and radiation areas.
- Reconfiguration of security boundaries and surveillance systems, as required.

2.2 PERIOD 2 - DORMANCY

The second phase identified by the NRC in its rule addresses licensed activities during a storage period and is applicable to the dormancy phases of a deferred decommissioning alternative. Activities required during the early dormancy period while spent fuel is stored in the fuel pool will be substantially different than those activities required during dry fuel storage.

Early activities include operating and maintaining the spent fuel pool and its associated systems, expanding the ISFSI, and transferring spent fuel from the pool to the ISFSI. Spent fuel transfer is expected to be complete by end of 2022. After the fuel transfer is completed, the pool and systems will be drained and de-energized for long-term storage.

Dormancy activities will include a 24-hour security force, preventive and corrective maintenance on security systems, area lighting, general building maintenance, freeze protection heating, ventilation of buildings for periodic habitability, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program.

Security during the dormancy period will be conducted primarily to safeguard the spent fuel on site and prevent unauthorized entry. A security barrier, sensors, alarms, and other surveillance equipment will be maintained as required to provide security.

An environmental surveillance program will be carried out during the dormancy period to monitor for radioactive material in the environment. Appropriate procedures will be established and initiated for potential releases that exceed prescribed limits. The environmental surveillance program will consist of a version of the program in effect during normal plant operations that will be modified to reflect the plant's conditions and risks at the time.

Late in the dormancy period, additional activities will include transferring the spent fuel from the ISFSI to the DOE. For planning purposes, OPPD's current spent fuel management plan for the Fort Calhoun spent fuel is based, in general, upon the following projections: 1) a 2030 start date for the DOE initiating transfer of commercial spent fuel to a federal facility, 2) a corresponding 2032 start date for removal of spent fuel from the Fort Calhoun ISFSI, and 3) a 2058 completion date for removal of all Fort Calhoun spent fuel from the site. This assumption is made for purposes of this estimate, although it is acknowledged that the plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance. The ISFSI pad and associated facilities are assumed to be decommissioned along with the power block structures during the deferred decontamination and dismantling phases.

After a period of safe-storage, it is required that the licensee submit an application to terminate the license, thereby initiating the third phase.

2.3 PERIOD 3 – PREPARATIONS FOR DECOMMISSIONING

Prior to the commencement of decommissioning operations, preparations will be undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a site characterization, and the assembly of a decommissioning management organization. This would likely include the development of work plans, specifications and procedures.

2.4 PERIOD 4 – DECOMMISSIONING OPERATIONS (DECONTAMINATION AND DISMANTLING)

Following the preparations for decommissioning, physical decommissioning activities will take place. This includes the removal and disposal of contaminated and activated components and structures, leading to the termination of the 10 CFR 50 operating license. Although much of the radioactivity will decrease during the dormancy period due to decay of ^{60}Co and other short-lived radionuclides, the internal components of the reactor vessel will still exhibit radiation dose rates that will likely require remote sectioning under water due to the presence of long-lived radionuclides such as ^{94}Nb, ^{59}Ni, and ^{63}Ni. Portions of the biological shield wall may also be radioactive due to the presence of activated trace elements with longer half-lives (such as ^{152}Eu and ^{154}Eu). It is assumed that radioactive contamination on structures, systems, and component surfaces will not have decayed to levels that will permit unrestricted release. These surfaces will be surveyed and items dispositioned in accordance with the existing radioactive release criteria.

Significant decommissioning activities in this phase include:

- Reconfiguration and modification of site structures and facilities, as needed, to support decommissioning operations. Modifications may also be required to the reactor or other buildings to facilitate movement of equipment and materials, support the segmentation of the reactor vessel and reactor vessel internals, and for large component removal.

- Design and fabrication of temporary and longer-term shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.
- Procurement or leasing of shipping cask, cask liners, and industrial packages for the disposition of low-level radioactive waste.
- Decontamination of components and piping systems, as required, to control (minimize) worker exposure.
- Removal of piping and components no longer essential to support decommissioning operations.
- Removal of control rod drive housings and the head service structure from reactor vessel head. Segmentation of the vessel closure head.
- Removal and segmentation of the upper internals assemblies. Segmentation will maximize the loading of the shielded transport casks, i.e., by weight and activity. The operations are conducted under water using remotely operated tooling and contamination controls.
- Disassembly and segmentation of the remaining reactor internals, including the core former and lower core support assembly. Some material is expected to exceed Class C disposal requirements. As such, the segments will be packaged in modified fuel storage canisters for geologic disposal.
- Segmentation of the reactor vessel. A shielded platform is installed for segmentation as cutting operations are performed in-air using remotely operated equipment within a contamination control envelope. The water level is maintained just below the cut to minimize the working area dose rates. Segments are transferred in-air to containers that are stored under water, for example, in an isolated area of the refueling canal.
- Removal of the activated portions of the concrete biological shield and accessible contaminated concrete surfaces. If dictated by the steam generator and pressurizer removal scenarios, those portions of the associated cubicles necessary for access and component extraction are removed.
- Removal of the steam generators and pressurizer for material recovery and controlled disposal. The generators will be moved to an on-site processing center, the steam domes removed and the internal components segregated for recycling. The lower shell and tube bundle will be packaged for direct disposal. These components can serve as their

own burial containers provided that all penetrations are properly sealed and the internal contaminants are stabilized, e.g., with grout.

- Remediation of contaminated surface soil or sub-surface media will be performed as necessary to meet the unrestricted use criteria in 10 CFR 20.1402.
- Underground piping (or similar items) and associated soil will be removed as necessary to meet license termination criteria.

At least two years prior to the anticipated date of license termination, a License Termination Plan (LTP) will be submitted to the NRC. That plan will include: a site characterization, description of the remaining dismantling / removal activities, plans for remediation of remaining radioactive materials, developed site-specific Derived Concentration Guideline Levels, plans for the final status (radiation) survey, designation of the end use of the site, an updated cost estimate to complete the decommissioning, and associated environmental concerns.

The final status survey plan will identify the radiological surveys to be performed once the decontamination activities are completed and will be developed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)."[26] This document incorporates statistical approaches to survey design and data evaluation. It also identifies commercially available instrumentation and procedures for conducting radiological surveys. Use of this guidance ensures that the surveys are conducted in a manner that provides a high degree of confidence that applicable NRC criteria are satisfied. Once the final status survey is complete, the results will be submitted to the NRC, along with a request for termination of the NRC license.

2.5 PERIOD 5 – SITE RESTORATION

After the NRC terminates the license, site restoration activities will be performed, at the licensee's discretion. Efficient removal of the contaminated materials and verification that residual radionuclide concentrations are below the NRC limits will result in substantial damage to many of the structures. Although performed in a controlled, safe manner, blasting, coring, drilling, scarification (surface removal), and the other decontamination activities may substantially degrade power block structures including the containment, auxiliary, turbine, service, technical support center, maintenance shop, chemistry and radiation protection facility, and the radioactive waste processing buildings.

Under certain circumstances, verifying that subsurface radionuclide concentrations meet NRC site release requirements will require removal of grade slabs and lower floors, potentially weakening footings and structural supports. This removal activity will be necessary for those facilities and plant areas where historical records, when available, indicate the potential for radionuclides having been present in the soil, where system failures have been recorded, or where it is required to confirm that subsurface process and drain lines were not breached over the operating life of the station.

It is not currently anticipated that these structures would be repaired and preserved after the radiological contamination is removed. The cost to dismantle site structures with a work force already mobilized on site is more efficient than if the process is deferred.

This cost study presumes that non-essential structures and site facilities are dismantled as a continuation of the decommissioning activity. Foundations and exterior walls are removed to a nominal depth of three feet below grade. The three-foot depth allows for the placement of gravel for drainage, as well as topsoil, so that vegetation can be established for erosion control. Site areas affected by the dismantling activities are restored and the plant area graded as required to prevent ponding and inhibit the refloating of subsurface materials.

Non-contaminated concrete rubble produced by demolition activities is processed to remove reinforcing steel and miscellaneous embedments. The processed material is then used on site to backfill foundation voids. Excess non-contaminated materials are trucked to an off-site area for disposal as construction debris.

3. COST ESTIMATE

The estimate prepared for decommissioning Fort Calhoun considers the unique features of the site, including the nuclear steam supply system, electric power generating systems, structures, and supporting facilities. The basis of the estimate, including the sources of information relied upon, the estimating methodology employed, site-specific considerations, and other pertinent assumptions, is described in this section.

3.1 BASIS OF ESTIMATE

The estimate relies upon the detailed planning and engineering that has been performed with the permanent cessation of operations and the site-specific, technical information from an earlier evaluation prepared in 2013. The 2013 information was reviewed for the current analysis and updated to reflect any significant changes in the plant configuration over the past three years. The site-specific considerations and assumptions used in the previous evaluation were also revisited. Modifications were incorporated where new information was available or experience from previously completed decommissioning projects provided viable alternatives or improved processes.

3.2 METHODOLOGY

OPPD's decommissioning organization, plant staff, and numerous other subject matter experts have been engaged in the detailed planning and engineering needed to transition the nuclear unit and its operating organization from power generation to safe-storage. This information will be used to assist in creating working budgets and the forecast for the first six years following the cessation of operations, or until the spent fuel is relocated to the ISFSI (years 2016 through 2022) and the plant secured for long-term storage.

The methodology used to develop the estimate follows the basic approach originally presented in the AIF/NESP-036 study report, "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,"[27] and the DOE "Decommissioning Handbook."[28] These documents present a unit factor method for estimating decommissioning activity costs, which simplifies the estimating calculations. Unit factors for concrete removal ($/cubic yard), steel removal ($/ton), and cutting costs ($/inch) are developed using local labor rates. The activity-dependent costs are estimated with the item quantities (cubic yards and tons), developed from plant drawings and inventory documents. Removal rates and material costs for the conventional disposition of components and structures rely upon information available in the industry publication, "Building Construction Cost Data," published by R.S. Means.[29]

The unit factor method provides a demonstrable basis for establishing reliable cost estimates. The detail provided in the unit factors, including activity duration, labor costs (by craft), and equipment and consumable costs, ensures that essential elements have not been omitted. Appendix A presents the detailed development of a typical unit factor. Appendix B provides the values contained within one set of factors developed for this analysis.

This analysis reflects lessons learned from TLG's involvement in the Shippingport Station Decommissioning Project, completed in 1989, as well as the decommissioning of the Cintichem reactor, hot cells, and associated facilities, completed in 1997. In addition, the planning and engineering for the Pathfinder, Shoreham, Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee, San Onofre-1, Crystal River and Vermont Yankee nuclear units have provided additional insight into the process, the regulatory aspects, and the technical challenges of decommissioning commercial nuclear units.

Work Difficulty Factors

TLG has historically applied work difficulty adjustment factors (WDFs) to account for the inefficiencies in working in a power plant environment. WDFs are assigned to each unique set of unit factors, commensurate with the inefficiencies associated with working in confined, hazardous environments. The ranges used for the WDFs for the SAFSTOR estimate are as follows:

- Access Factor 0% to 20%
- Respiratory Protection Factor 0% to 50%
- Radiation/ALARA Factor 0% to 15%
- Protective Clothing Factor 0% to 30%
- Work Break Factor 8.33%

The factors and their associated range of values were developed in conjunction with the AIF/NESP-036 study. The application of the factors is discussed in more detail in that publication.

Scheduling Program Durations

An activity duration critical path is used to determine the total decommissioning program schedule. The schedule is relied upon in calculating the carrying costs, which include program management, administration, field engineering, equipment rental, and support services such as quality control and security. This systematic approach for assembling decommissioning estimates ensures a high degree of confidence in the reliability of the resulting costs.

The unit factors, adjusted by the WDFs as described above, are applied against the inventory of materials to be removed in the radiological controlled areas. The resulting labor-hours, or crew-hours, are used in the development of the decommissioning program schedule, using resource loading and event sequencing considerations. The scheduling of conventional removal and dismantling activities is based upon productivity information available from the "Building Construction Cost Data" publication.

3.3 FINANCIAL COMPONENTS OF THE COST MODEL

TLG's proprietary decommissioning cost model, DECCER, produces a number of distinct cost elements. These direct expenditures, however, do not comprise the total cost to accomplish the project goal, i.e., license termination, spent fuel management and site restoration.

3.3.1 Contingency

Inherent in any cost estimate that does not rely on historical data is the inability to specify the precise source of costs imposed by factors such as tool breakage, accidents, illnesses, weather delays, and labor stoppages. In the DECCER cost model, contingency fulfills this role. Contingency is added to each line item to account for costs that are difficult or impossible to develop analytically. Such costs are historically inevitable over the duration of a job of this magnitude; therefore, this cost analysis includes funds to cover these types of expenses.

The activity- and period-dependent costs are combined to develop the total decommissioning cost. A contingency is then applied on a line-item basis, using one or more of the contingency types listed in the AIF/NESP-036 study. "Contingencies" are defined in the American Association of Cost Engineers "Project and Cost Engineers' Handbook"[30] as "specific provision for unforeseeable elements of cost within the defined project scope; particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur." The cost elements in this analysis are based upon ideal conditions and maximum efficiency; therefore, consistent with industry practice, contingency is included. In the AIF/NESP-036 study, the types of unforeseeable events that are likely to occur in decommissioning are discussed and guidelines are provided for a contingency percentage in each category. It should be noted that contingency, as used in this analysis, does not account for price escalation and inflation over the period of performance (these factors are typically addressed in the funding analysis).

Contingency funds are an integral part of the total cost to complete the decommissioning process. Exclusion of this component puts at risk a successful completion of the intended tasks and, potentially, subsequent related activities. For this study, TLG examined the major activity-related problems (decontamination, segmentation, equipment handling, packaging, transport, and waste disposal) that necessitate a contingency. Individual activity contingencies ranged from 10% to 75%, depending on the degree of difficulty judged to be appropriate from TLG's actual decommissioning experience. The contingency values used in this study are as follows:

• Decontamination	50%
• Contaminated Component Removal	25%
• Contaminated Component Packaging	10%
• Contaminated Component Transport	15%
• Low-Level Radioactive Waste Disposal	25%
• Reactor Segmentation	75%
• NSSS Component Removal	25%
• Reactor Waste Packaging	25%
• Reactor Waste Transport	25%
• Reactor Vessel Component Disposal	50%
• GTCC Disposal	15%
• Non-Radioactive Component Removal	15%
• Heavy Equipment and Tooling	15%
• Supplies	25%
• Engineering	15%
• Insurance, Taxes and Fees	10%
• Staffing	15%
• Characterization and Termination Surveys	30%
• Operations and Maintenance Expenses	15%
• ISFSI Decommissioning	25%

The contingency values are applied to the appropriate components of the estimate on a line item basis. A composite value is then reported at the end of the detailed estimate (provided in Appendix C). The composite contingency value reported for the SAFSTOR alternative in Appendix C is approximately 16.33%. Appendix D, the ISFSI decommissioning calculation, uses a flat 25% contingency added at the end of the calculation.

It should be noted that where OPPD provided cost information for near-term projects or site activities, the contingency component value(s) may be less, commensurate with the increased cost certainty. In some instances, OPPD did not specify a contingency component for a specific project and/or site activity. This can be seen for several line item costs in the first in six years (Periods 1 through 2a in Appendix C).

3.3.2 Financial Risk

In addition to the routine uncertainties addressed by contingency, another cost element that is sometimes necessary to consider when bounding decommissioning costs relates to uncertainty, or risk. Examples can include changes in work scope, pricing, job performance, and other variations that could conceivably, but not necessarily, occur. Consideration is sometimes necessary to generate a level of confidence in the estimate, within a range of probabilities. TLG considers these types of costs under the broad term "financial risk." Included within the category of financial risk are:

- Delays in approval of the decommissioning plan due to intervention, legal challenges, and national and local hearings.
- Changes in the project work scope from the baseline estimate, involving the discovery of unexpected levels of contaminants, contamination in places not previously expected, contaminated soil previously undiscovered (either radioactive or hazardous material contamination), variations in plant inventory or configuration not indicated by the as-built drawings.
- Regulatory changes (e.g., affecting worker health and safety, site release criteria, waste transportation, and disposal).
- Policy decisions altering national commitments (e.g., in the ability to accommodate certain waste forms for disposition, or in the timetable for such, or the start and rate of acceptance of spent fuel by the DOE).
- Pricing changes for basic inputs, such as labor, energy, materials, and waste disposal.

This cost study does not add any additional costs to the estimate for financial risk. Uncertainties as discussed above that would impact the estimate are revisited periodically and addressed through repeated revisions or updates of the base estimate (e.g., in accordance with Regulatory Guide 1.159).

3.4 SITE-SPECIFIC CONSIDERATIONS

There are a number of site-specific considerations that affect the method for dismantling and removal of equipment from the site and the degree of restoration required. The cost impact of the considerations identified below is included in this cost study.

3.4.1 Spent Fuel Management

The cost to dispose the spent fuel generated from plant operations is not reflected within the estimate to decommission Fort Calhoun. Ultimate disposition of the spent fuel is within the province of the DOE's Waste Management System, as defined by the Nuclear Waste Policy Act. As such, the disposal cost is financed by a 1 mill/kW-hr surcharge paid into the DOE's waste fund during operations. On November 19, 2013, the U.S. Court of Appeals for the D.C. Circuit ordered the Secretary of the Department of Energy to suspend collecting annual fees for nuclear waste disposal from nuclear power plant operators until the DOE has conducted a legally adequate fee assessment.

The NRC does, however, require licensees to establish a program to manage and provide funding for the management of all irradiated fuel at the reactor site until title of the fuel is transferred to the Secretary of Energy. This requirement is prepared for through inclusion of certain high-level waste cost elements within the estimate, as described below.

Completion of the decommissioning process is highly dependent upon the DOE's ability to remove spent fuel from the site. DOE's repository program assumes that spent fuel is accepted for disposal from the nation's commercial nuclear plants in the order (the "queue") in which it was removed from service ("oldest fuel first"). The contracts that U.S. generators have with the DOE provide mechanisms for altering the oldest fuel first allocation scheme, including emergency deliveries, exchanges of allocations amongst generators and the option of providing priority acceptance from permanently shutdown nuclear reactors. Given DOE's failure to accept fuel under its contracts, it is unclear how these mechanisms may operate once DOE begins accepting spent fuel from commercial reactors. Accordingly, this study assumes that DOE will accept spent fuel in an oldest fuel first order. The timing for removal of spent fuel from the site is based upon the DOE's most recently published annual acceptance rates of 400 MTU/year for year 1, 3,800 MTU total for years 2 through 4 and 3,000 MTU/year for year 5 and beyond.[31]

Irradiated Fuel Storage System

The design and capacity of the current ISFSI is based upon the Transnuclear, Inc., NUHOMS®-32PT dry cask storage system. The system consists of a dry fuel storage canister (DSC) with a nominal capacity of 32 pressurized water reactor fuel assemblies and a concrete horizontal storage module (HSM). DOE has not identified any cask systems it may use.

The estimate includes the costs to purchase, load, and transfer the DSCs from the pool to the HSMs on the ISFSI pad and from the ISFSI to the DOE.

ISFSI Pad

An ISFSI pad had been constructed within the protected area to support plant operations. Ten HSMs were loaded in two campaigns between 2006 and 2009. It is expected that another 30 modules (each containing a DSC able to accommodate 32 pressurized water reactor spent fuel assemblies) will be required to off-load the spent fuel pool, for a total of 40 HSMs. With a current capacity of 40 HSMs, the existing pad is capable of supporting long term storage operations without modification.

The ISFSI will be expected to operate until such time that the transfer of spent fuel to the DOE can be completed. Assuming that DOE begins accepting commercial spent fuel in 2030, Fort Calhoun fuel is projected to be removed from the site beginning in 2032. The process is expected to be completed by the year 2058 based upon the previously stated assumptions.

Operations and Maintenance

The estimate includes the cost of operating and maintaining the spent fuel pool and the ISFSI, respectively. Pool operations are expected to continue approximately six years (from the permanent cessation of operations). It is assumed that this time provides the necessary cooling period for the final core to meet the dry cask storage vendor's system. ISFSI operating costs are based upon the previously stated assumptions on fuel transfer expectations.

ISFSI Decommissioning

In accordance with 10 CFR §72.30, licensees must have a proposed decommissioning plan for the ISFSI site and facilities that includes a cost estimate for the plan. The plan should contain sufficient information on the proposed practices and procedures for the decontamination of the ISFSI and for the disposal of residual radioactive materials after all spent fuel, high-level radioactive waste, and reactor-related GTCC waste have been removed.

A multi-purpose (storage and transport) DSC with a HSM is used as a basis for the cost analyses. The HSMs are assumed to have some level of neutron-induced activation as a result of the long-term storage of the fuel, i.e., to levels exceeding free-release limits. As an allowance, a total of 5 NUHOMS modules are assumed to be affected, i.e., contain residual radioactivity. The allowance is based upon the number of modules required for the final core off-load (i.e., 133 offloaded assemblies, 32 assemblies per cask) which results in 5 DSCs. It is assumed that these are the final modules offloaded; consequently they have the least time for radioactive decay of the neutron activation products.

No contamination or activation of the ISFSI pad is assumed. It would be expected that this assumption would be confirmed as a result of good radiological practice of surveying potentially impacted areas after each spent fuel transfer campaign. As such, only verification surveys are included for the pad in the decommissioning estimate. The estimate is limited to costs necessary to terminate the ISFSI's NRC license and meet the §20.1402 criteria for unrestricted use.

The cost estimate for decommissioning the ISFSI reflects: 1) the cost of an independent contractor performing the decommissioning activities; 2) an adequate contingency factor; and 3) the cost of meeting the criteria for unrestricted use. The cost of the disposition of this material, as well as the demolition of the ISFSI facility, is included in the estimate. The cost summary for decommissioning the ISFSI is presented in Appendix D.

GTCC

The dismantling of the reactor internals generates radioactive waste considered unsuitable for shallow land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the Federal Government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. Although the DOE is responsible for disposing of GTCC waste, any costs for that service have not been determined. For purposes of this estimate, the GTCC radioactive waste has been assumed to be packaged in the spent fuel DSCs (the DOE has not identified a disposal package), at a cost equivalent to that envisioned for the spent fuel. The number of canisters required and the packaged volume for GTCC was based upon the activation analysis prepared by WMG, Inc.

The GTCC material is assumed to be shipped directly to a DOE facility as it is generated (since the fuel is assumed to have been removed from the site prior to the start of decommissioning and the ISFSI deactivated).

3.4.2 Reactor Vessel and Internal Components

The reactor pressure vessel and internal components are segmented for disposal in shielded, reusable transportation casks. Segmentation is performed in the refueling canal, where a turntable and remote cutter are installed. The vessel is segmented in place, using a mast-mounted cutter supported off the lower head and directed from a shielded work platform installed overhead in the reactor cavity. Transportation cask specifications and transportation regulations dictate the segmentation and packaging methodology.

Intact disposal of reactor vessel shells has been successfully demonstrated at several of the sites that have been decommissioned. Access to navigable waterways has allowed these large packages to be transported to the Barnwell disposal site with minimal overland travel. Intact disposal of the reactor vessel and internal components can provide savings in cost and worker exposure by eliminating the complex segmentation requirements, isolation of the GTCC material, and transport/storage of the resulting waste packages. Portland General Electric (PGE) was able to dispose of the Trojan reactor as an intact package (including the internals). However, its location on the Columbia River simplified the transportation analysis since:

- the reactor package could be secured to the transport vehicle for the entire journey, i.e., the package was not lifted during transport,
- there were no man-made or natural terrain features between the plant site and the disposal location that could produce a large drop, and
- transport speeds were very low, limited by the overland transport vehicle and the river barge.

As a member of the Northwest Compact, PGE had a site available for disposal of the package - the US Ecology facility in Washington State. The characteristics of this arid site proved favorable in demonstrating compliance with land disposal regulations.

It is not known whether this option will be available when Fort Calhoun decides to dismantle the unit. Future viability of this option will depend upon the ultimate location of the disposal site, as well as the disposal site licensee's ability to accept highly radioactive packages and effectively isolate them from the environment. Consequently, the study assumes that the reactor vessel will require segmentation, as a bounding condition.

3.4.3 Primary System Components

Since this estimate is based on a SAFSTOR scenario, a chemical decontamination of the reactor coolant system is not included. With a nominal dormancy period of 40 years, radionuclide decay is expected to provide the same benefit.

The following discussion deals with the removal and disposition of the steam generators, but the techniques involved are also applicable to other large components, such as heat exchangers, component coolers, and the pressurizer. The steam generators' size and weight, as well as their location within the reactor building, will ultimately determine the removal strategy.

A trolley crane is set up for the removal of the generators. It can also be used to move portions of the steam generator cubicle walls and floor slabs from the reactor building to a location where they can be decontaminated and transported to the material handling area. Interferences within the work area, such as grating, piping, and other components are removed to create sufficient laydown space for processing these large components.

The generators are rigged for removal, disconnected from the surrounding piping and supports, and maneuvered into the open area where they are lowered onto a dolly. Each generator is rotated into the horizontal position for extraction from the containment and placed onto a multi-wheeled vehicle for transport to an on-site processing and storage area.

The generators are disassembled on-site with the outer shell and lightly contaminated subassemblies designated for off-site recycling. The more highly contaminated tube sheet and tube bundle are packaged for direct disposal.

Disposal costs are based upon the displaced volume and weight of the units. Each component is then loaded onto a rail car for transport to the disposal facility.

Reactor coolant piping is cut from the reactor vessel once the water level in the vessel (used for personnel shielding during dismantling and cutting operations in and around the vessel) is dropped below the nozzle zone. The piping is boxed and transported by shielded van. The reactor coolant pumps and motors are lifted out intact, packaged, and transported for processing and/or disposal.

3.4.4 Main Turbine and Condenser

The main turbine is dismantled using conventional maintenance procedures. The turbine rotors and shafts are removed to a laydown area. The lower turbine casings are removed from their anchors by controlled demolition. The main condensers are also disassembled and moved to a laydown area. Material is then prepared for transportation to an off-site recycling facility where it is surveyed and designated for either decontamination or volume reduction, conventional disposal, or controlled disposal. Components are packaged and readied for transport in accordance with the intended disposition.

3.4.5 Retired Components

The estimate included the disposition of previously retired components, including:

- Steam Generators (2)
- Pressurizer
- Reactor Pressure Vessel Closure Head

3.4.6 Transportation Methods

Contaminated piping, components, and structural material other than the highly activated reactor vessel and internal components will qualify as LSA-I, II or III or Surface Contaminated Object, SCO-I or II, as described in Title 49.[32] The contaminated material will be packaged in Industrial Packages (IP-1, IP-2, or IP-3, as defined in subpart 173.411) for transport unless demonstrated to qualify as their own shipping containers. The reactor vessel and internal components are expected to be transported in accordance with 10 CFR Part 71, in Type B containers. It is conceivable that the reactor, due to its limited specific activity, could qualify as LSA II or III. However, the high radiation levels on the outer surface would require that additional shielding be incorporated within the packaging so as to attenuate the dose to levels acceptable for transport.

Any fuel cladding failure that occurred during the lifetime of the plant is assumed to have released fission products at sufficiently low levels that the buildup of quantities of long-lived isotopes (e.g., ^{137}Cs, ^{90}Sr, or transuranics) has been prevented from reaching levels exceeding those that permit the major reactor components to be shipped under current transportation regulations and disposal requirements.

Transport of the highly activated metal, produced in the segmentation of the reactor vessel and internal components, will be by shielded truck cask. Cask shipments may exceed 95,000 pounds, including vessel segment(s), supplementary shielding, cask tie-downs, and tractor-trailer. The maximum level of activity per shipment assumed permissible was based upon the license limits of the available shielded transport casks. The segmentation scheme for the vessel and internal segments is designed to meet these limits.

The transport of large intact components (e.g., large heat exchangers and other oversized components) will be by a combination of truck, rail, and/or multi-wheeled transporter.

Transportation costs for Class A radioactive material requiring controlled disposal are based upon the mileage to the Energy*Solutions* facility in Clive, Utah. Transportation costs for the higher activity Class B and C radioactive material are based upon the mileage to the WCS facility in Andrews County, Texas. The transportation cost for the GTCC material is assumed to be contained within the disposal cost. Transportation costs for off-site waste processing are based upon the mileage to Oak Ridge, Tennessee. Truck transport costs were developed from published tariffs from Tri-State Motor Transit.[33]

3.4.7 Low-Level Radioactive Waste Disposal

To the greatest extent practical, metallic material generated in the decontamination and dismantling processes is processed to reduce the total cost of controlled disposal. Material meeting the regulatory and/or site release criterion, is released as scrap, requiring no further cost consideration. Conditioning (preparing the material to meet the waste acceptance criteria of the disposal site) and recovery of the waste stream is performed off site at a licensed processing center. Any material leaving the site is subject to a survey and release charge, at a minimum.

The mass of radioactive waste generated during the various decommissioning activities at the site is shown on a line-item basis in the Appendix C, and summarized in Section 5. The quantified waste summaries shown in these tables are consistent with 10 CFR Part 61 classifications. Commercially available steel containers are presumed to be used for the disposal of piping, small components, and concrete. Larger components can serve as their own containers, with proper closure of all openings, access ways, and penetrations. The volumes are calculated based on the exterior package dimensions for containerized material or a specific calculation for components serving as their own waste containers.

The more highly activated reactor components will be shipped in reusable, shielded truck casks with disposable liners. In calculating disposal costs, the burial fees are applied against the liner volume, as well as the special handling requirements of the payload. Packaging efficiencies are lower for the highly activated materials (greater than Class A waste), where high concentrations of gamma-emitting radionuclides limit the capacity of the shipping canisters.

Disposal fees are based upon estimated charges, with surcharges added for the highly activated components, for example, generated in the segmentation of the reactor vessel. The cost to dispose of the lowest level waste and the majority of the material generated from the decontamination and dismantling activities is based upon the current cost for disposal at Energy*Solutions* facility in Clive, Utah. Disposal costs for the higher activity waste (Class B and C) were based upon information available from Texas Commission on Environmental Quality for the Andrews County facility.

3.4.8 Site Remediation

A limited Historical Site Assessment (HSA)[34] was conducted at Fort Calhoun between August and October 2016. The HSA effort focused on environmental (open land) areas at the FCS site; assessment of potential radiological impact to FCS site buildings, structures, or systems was not included. As a follow-up to the HSA, a Limited Radiological Characterization Plan (LRCP)[35] was developed with the objective of closing the gaps in historical radiological data identified by the HSA. The LRCP was implemented at the FCS site between October 19th and 28th, 2016 and included the collection of 52 soil samples (36 surface soil samples and 16 subsurface soil samples) from potentially radiologically impacted environmental areas. Additionally, several gamma scans were performed within each target environmental area.

Laboratory results identified low concentrations of ^{137}Cs (i.e., approximately 0.1 pCi/g to 0.4 pCi/g) in 5 of the 36 surface soil samples. However, the ^{137}Cs concentrations were small percentages (i.e., <4%) of the NRC screening value for ^{137}Cs (11 pCi/g) published in NUREG 1757,[36] and are well below concentrations that would require remediation or special consideration during decommissioning. Results for all other plant-related radionuclides were below the a posteriori minimum detectable concentration (MDC) values.

The gamma scans did not identify any elevated radiation levels within the targeted environmental areas.

The limited scope of this project did not include the collection of sub-surface soil from under building foundations (e.g., containment, auxiliary, turbine, service, technical support center, maintenance shop, radioactive waste processing, and the chemistry and radiation protection facility) or soil adjacent to underground systems, structures, and components containing radioactive materials (e.g., radioactive waste lines and sumps).

At this time, and for purposes of this SAFSTOR estimate (recognizing that they could be up to 40 years of additional decay), no cost for radiologically contaminated soil remediation is included.

A limited site non-radiological characterization investigation was also conducted.[37] The investigation was designed to identify significant environmental impacts to soils, sediments, and groundwater to the extent that subsequent characterization and remediation could impact the DCE and/or decommissioning schedule.

Only two areas of interest were identified where chemical or non-radiological constituents impacted environmental media; the Fire Training Area and Firing Range.

Perfluoroalkyl surfactants (PFAs) were found in the Fire Training Area in excess of the EPA Health Advisory standard of 0.07 micrograms per liter. PFAs do not have a Nebraska Department of Environmental Quality criteria, but have been identified recently by EPA as an emerging compound, with a Health Advisory number for drinking water already in effect. Although the site will require a more thorough characterization, an allowance for remediation of the Fire Training Area (soil removal) has been included in the estimate.

Elevated concentrations of lead, above the EPA hazardous threshold of 5 mg/L, are present in samples of the berm at the Firing Range. Groundwater grab samples, collected on the downgradient site of the Firing Range also reported lead. Although the site will require a more thorough characterization, an allowance for lead remediation and closure of the Firing Range has been included in the estimate.

3.4.9 Disposition of Underground Piping and Site Services

A significant amount of the below grade piping is located around the perimeter of the power block. The estimate includes a cost to excavate this area to an average depth of six feet so as to expose the piping, duct bank, conduit, and any near-surface grounding grid. The overburden is surveyed and stockpiled on site for future use in backfilling the below grade voids.

3.4.10 Site Conditions Following Decommissioning

The NRC will terminate the site license if it determines that site remediation has been performed in accordance with the license termination plan, and that the terminal radiation survey and associated documentation demonstrate that the facility is suitable for release. The NRC's involvement in the decommissioning process will end at this point. Building codes and environmental regulations will dictate the next step in the decommissioning process, as well as owner's own future plans for the site.

Only existing site structures are considered in the dismantling cost. The electrical switchyard remains after Fort Calhoun is decommissioned in support of the regional transmission and distribution system. Structures are removed to a nominal depth of three feet below grade. The voids are backfilled with clean debris and capped with soil. The site is then re-graded to conform to the adjacent landscape. Vegetation is established to inhibit erosion. These "non-radiological costs" are included in the total cost of decommissioning.

Concrete rubble generated from demolition activities (after the NRC license is terminated) is processed (crushed and rebar removed) and made available as clean fill for below grade voids, such as the power block foundations. If necessary, excess construction debris is trucked off site. The excavations will be regraded such that the power block area will have a final contour consistent with adjacent surroundings.

3.5 ASSUMPTIONS

The following are the major assumptions made in the development of the estimate for decommissioning the site.

3.5.1 Estimating Basis

Decommissioning costs are reported in the year of projected expenditure; however, the values are provided in 2016 dollars. Costs are not inflated, escalated, or discounted over the periods of performance.

The estimate relies upon the physical plant inventory that was the basis for the 2013 analysis. There were no material changes to the site since that time with the exception of a new security building. The structure was added to the inventory of site facilities to be dismantled during the site restoration phase.

The study follows the principles of ALARA through the use of work duration adjustment factors. These factors address the impact of activities such as radiological protection instruction, mock-up training, and the use of respiratory protection and protective clothing. The factors lengthen a task's duration, increasing costs and lengthening the overall schedule. ALARA planning is considered in the costs for engineering and planning, and in the development of activity specifications and detailed procedures. Changes to worker exposure limits may impact the decommissioning cost and project schedule.

3.5.2 Labor Costs

For purposes of this estimate, it is assumed that OPPD (or a comparable organization) will manage the decontamination and dismantling of the nuclear unit in addition to maintaining site security, radiological health and safety, quality assurance and overall site administration during the decommissioning. A Decommissioning Operations Contractor (DOC) will provide the supervisory staff needed to oversee the labor subcontractors, consultants, and specialty contractors engaged to perform the field work associated with the decontamination and dismantling efforts.

Personnel costs are based upon a single average salary provided by OPPD for all site personnel. Overhead costs are included for site and corporate support; such overhead costs are reduced commensurate with the staffing levels envisioned throughout the project. Personnel staffing levels through the SAFSTOR dormancy period were provided by OPPD.

Reduction in the operating organization is assumed to be handled through normal staffing processes (e.g., reassignment and outplacement).

The craft labor required to decontaminate and dismantle the nuclear unit is acquired through standard site contracting practices. The current cost of contracted labor is used as an estimating basis.

Security, while reduced from operating levels, is maintained throughout the decommissioning for access control, material control, and to safeguard the spent fuel (in accordance with the requirements of 10 CFR Part 37, Part 72, and Part 73). Once the fuel has been transferred to the DOE in 2058, the security organization will be reduced to Part 37 requirements.

3.5.3 Non-Labor Recurring Costs

Non-labor (non-payroll) costs were derived from a 2017 site budget. Expenses associated with the site personnel were adjusted as the headcount changed over time. Costs identified by the OPPD as near-term or one-time expenditures were removed from the budget as the schedule dictated. Miscellaneous costs were applied based on information provided by the OPPD or ramped down over the period during which spent fuel was transferred to the ISFSI.

3.5.4 Design Conditions

Activation levels in the vessel and internal components are based upon an activation analysis prepared by WMG, Inc.[38] The activation source terms were adjusted for decay for the safe-storage period (approximately 40 years).

It is anticipated that there will be five-fingered control element assemblies (CEAs) in the spent fuel pool at the cessation of operations (including the CEAs from the final core). This analysis assumes that the CEAs can be disposed of along with the spent fuel at no additional cost (in accordance with Appendix E of the Standard Contract). This analysis further assumes that the CEAs would be loaded into the DSCs at the time spent fuel is transferred from the spent fuel pool to the ISFSI.

Neutron activation of the containment building structure is assumed to be confined to the biological shield.

The estimate includes an allowance for the disposition of Tri Nuc filters, filter baskets, equipment, tools and other miscellaneous material currently stored in the spent fuel pool.

3.5.5 General

Transition Activities

The estimate includes costs for the processing of water in various tanks, sumps, the spent fuel pool and spent fuel transfer canal as well as water collected on site.

Existing warehouses are cleared of non-essential material and remain for use by the OPPD and its subcontractors. The plant's operating staff performs the following activities at no additional cost or credit to the project during the transition period:

- Drain and collect fuel oils, lubricating oils, and transformer oils for recycle and/or sale.
- Drain and collect acids, caustics, and other chemical stores for recycle and/or sale.

Scrap and Salvage

The existing plant equipment is considered obsolete and suitable for scrap as deadweight quantities only. OPPD will make economically reasonable efforts to salvage equipment following final plant shutdown. However, dismantling techniques assumed by TLG for equipment in this analysis are not consistent with removal techniques required for salvage (resale) of equipment. Experience has indicated that some buyers wanted equipment stripped down to very specific requirements before they would consider purchase. This required expensive rework after the equipment had been removed from its installed location. Since placing a salvage value on this machinery and equipment would be speculative, and the value would be small in comparison to the overall decommissioning expenses, this analysis does not attempt to quantify the value that an owner may realize based upon those efforts.

It is assumed, for purposes of this analysis, that any value received from the sale of scrap generated in the dismantling process would be more than offset by the on-site processing costs. The dismantling techniques assumed in the decommissioning estimate do not include the additional cost for size reduction and preparation to meet "furnace ready" conditions. For example, the recovery of copper from electrical cabling may require the removal and disposition of any contaminated insulation, an added expense. With a volatile market, the potential profit margin in scrap recovery is highly speculative, regardless of the ability to free release this material. This assumption is an implicit recognition of scrap value in the disposal of clean metallic waste at no additional cost to the project.

Furniture, tools, mobile equipment such as forklifts, trucks, bulldozers, and other property is removed at no cost or credit to the decommissioning project. Disposition may include relocation to other facilities. Spare parts are also made available for alternative use.

Mobile vehicle barriers are assumed to be potentially useful at other facilities. As such, the cost for disposing of the barriers is not included in the estimate. To encourage salvage of this material, costs for intact removal and local transport of the mobile vehicle barriers are included in the estimate.

Energy

For estimating purposes, the plant is assumed to be de-energized, with the exception of those facilities associated with spent fuel storage.

Electricity is provided to the site by OPPD at no cost to the project. The estimate does include a cost for heating oil through the year 2021, at which time the site will be converted to electric.

Emergency Planning

FEMA, state and local fees associated with emergency planning are assumed to continue through mid-2018. At this time, the FEMA fees are discontinued. The timing is based upon the anticipated condition of the spent fuel (i.e., the hottest spent fuel assemblies are assumed to be cool enough that no substantial Zircaloy oxidation and off-site event would occur with the loss of spent fuel pool water).

A nominal value for miscellaneous expenses is included until the spent fuel is removed from the site.

NRC Fees

The estimate includes several cost elements associated with the NRC and its oversight of the decommissioning process, including:

- An annual fee assessed to a power reactor holding a 10 CFR Part 50 license that is in decommissioning (until the license is terminated),
- An NRC resident (full-time for the first half of 2017), and
- NRC review of OPPD submittals (license amendment requests, exemptions, etc.), based upon the published cost of a professional staff-hour

Insurance

Costs for continuing coverage (nuclear liability and property insurance) following cessation of plant operations and during decommissioning are included and based upon current operating premiums. Reductions in premiums, throughout the decommissioning process, are based upon the guidance and the limits for coverage defined in the NRC's proposed rulemaking "Financial Protection Requirements for Permanently Shutdown Nuclear Power Reactors."[39] The NRC's financial protection requirements are based on various reactor (and spent fuel) configurations.

Taxes

Property taxes are not included within the estimate with the exception of a nominal allowance associated with state of Iowa.

Site Modifications

The perimeter fence and in-plant security barriers will be moved, as appropriate, to conform to the Site Security Plan in force during the various stages of the project.

3.6 COST ESTIMATE SUMMARY

Schedules of expenditures are provided in Table 3.2. The schedules are based upon the costs reported in Appendix C.

The cost elements in Appendix C are assigned to one of three subcategories: "License Termination," "Spent Fuel Management," and "Site Restoration." The subcategory "License Termination" is used to accumulate costs that are consistent with "decommissioning" as defined by the NRC in its financial assurance regulations (i.e., 10 CFR §50.75). The cost reported for this subcategory is generally sufficient to terminate the plant's operating license, recognizing that there may be some additional cost impact from spent fuel management. The License Termination cost subcategory also includes costs to decommission the ISFSI (as required by 10 CFR §72.30). The basis for the ISFSI decommissioning cost is provided in Appendix D.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the pool to the ISFSI, and the transfer of the multipurpose canisters from the ISFSI to the DOE. Costs are also included for the operations of the pool and management of the ISFSI until such time that the transfer of all fuel from this facility to an off-site location (e.g., interim storage facility) is complete.

"Site Restoration" is used to capture costs associated with the dismantling and demolition of buildings and facilities demonstrated to be free from contamination. This includes structures never exposed to radioactive materials, as well as those facilities that have been decontaminated to appropriate levels. Structures are assumed to be removed to a nominal depth of three feet and backfilled to conform to local grade.

The disposal of the GTCC is assumed to be concurrent with the disposal of the other reactor internals. While designated for disposal at the geologic repository along with the spent fuel, GTCC waste is still classified as low-level radioactive waste and, as such, included as a "License Termination" expense.

Decommissioning costs are reported in 2016 dollars. Costs are not inflated, escalated, or discounted over the period of expenditure. The schedules are based upon the detailed activity costs reported in Appendix C, along with the timeline presented in Section 4.

TABLE 3.1
SPENT FUEL MANAGEMENT SCHEDULE
(Fuel Assembly Totals by Location)

Year	Pool Inventory	ISFSI Inventory	DOE Acceptance[1]
2016	944	320	
2017	944	320	
2018	944	320	
2019	944	320	
2020	944	320	
2021	784	480	
2022	0	1,264	
2023		1,264	
2024		1,264	
2025		1,264	
2026		1,264	
2027		1,264	
2028		1,264	
2029		1,264	
2030		1,264	
2031		1,264	
2032		1,203	61
2033		1,107	96
2034		1,067	40
2035		1,007	60
2036		917	90
2037		871	46
2038		827	44
2039		790	37
2040		757	33
2041		732	25
2042		704	28
2043		652	52
2044		603	49
2045		558	45
2046		465	93
2047		425	40

TABLE 3.1 (continued)
SPENT FUEL MANAGEMENT SCHEDULE
(Fuel Assembly Totals by Location)

Year	Pool Inventory	ISFSI Inventory	DOE Acceptance[1]
2048		384	41
2049		353	31
2050		327	26
2051		327	0
2052		290	37
2053		233	57
2054		173	60
2055		173	0
2056		173	0
2057		133	40
2058		0	133
Total			1,264

[1] DOE acceptance schedule assuming industry acceptance begins in year 2030 and Fort Calhoun acceptance begins in year 2032. The schedule is provided for illustrative purposes only. It is expected that OPPD will seek to accelerate acceptance based on shutdown reactor priority, exchanges of acceptance allocations and other contractual provisions.

TABLE 3.2
TOTAL ANNUAL EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2016	19,405	98	120	15	10,179	29,817
2017	68,483	823	490	197	58,493	128,485
2018	49,321	411	416	111	44,468	94,727
2019	30,471	6	344	26	30,672	61,520
2020	30,554	6	345	26	30,756	61,688
2021	30,471	6	344	26	30,672	61,520
2022	30,471	6	344	26	30,672	61,520
2023	8,776	169	0	1,140	1,887	11,971
2024	8,333	82	0	1,125	6,666	16,207
2025	8,310	3	0	12	1,852	10,177
2026	8,310	3	0	12	1,852	10,177
2027	8,310	3	0	12	1,852	10,177
2028	8,333	3	0	12	1,857	10,205
2029	8,310	3	0	12	1,852	10,177
2030	8,310	3	0	12	1,852	10,177
2031	8,310	3	0	12	1,852	10,177
2032	8,477	434	0	12	1,857	10,780
2033	8,526	650	0	12	1,852	11,040
2034	8,382	219	0	12	1,852	10,465
2035	8,454	434	0	12	1,852	10,752
2036	8,549	650	0	12	1,857	11,068
2037	8,382	219	0	12	1,852	10,465
2038	8,382	219	0	12	1,852	10,465
2039	8,382	219	0	12	1,852	10,465
2040	8,405	219	0	12	1,857	10,493
2041	8,382	219	0	12	1,852	10,465
2042	8,382	219	0	12	1,852	10,465
2043	8,454	434	0	12	1,852	10,752
2044	8,477	434	0	12	1,857	10,780
2045	8,382	219	0	12	1,852	10,465
2046	8,526	650	0	12	1,852	11,040
2047	8,382	219	0	12	1,852	10,465
2048	8,333	3	0	12	1,857	10,205

TABLE 3.2 (continued)
TOTAL ANNUAL EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2049	8,382	219	0	12	1,852	10,465
2050	8,382	219	0	12	1,852	10,465
2051	8,454	434	0	12	1,852	10,752
2052	8,405	219	0	12	1,857	10,493
2053	8,382	219	0	12	1,852	10,465
2054	8,454	434	0	12	1,852	10,752
2055	8,382	219	0	12	1,852	10,465
2056	8,405	219	0	12	1,857	10,493
2057	8,454	434	0	12	1,852	10,752
2058	8,454	434	0	12	1,852	10,752
2059	42,059	5,010	0	46	3,585	50,700
2060	48,248	19,839	0	14,717	10,582	93,387
2061	47,944	22,190	0	20,872	13,935	104,940
2062	44,205	6,921	0	9,335	9,076	69,536
2063	44,205	6,921	0	9,335	9,076	69,536
2064	39,926	5,359	0	6,585	7,069	58,939
2065	21,297	4,915	0	19	2,015	28,246
2066	13,844	7,321	0	0	1,722	22,887
Total	863,626	88,805	2,403	64,007	364,532	1,383,373

TABLE 3.2a
LICENSE TERMINATION EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2016	19,405	98	120	15	9,373	29,011
2017	68,483	823	490	197	33,361	103,353
2018	35,693	411	416	111	26,025	62,657
2019	3,438	6	344	26	18,810	22,624
2020	3,447	6	345	26	18,861	22,686
2021	3,438	6	344	26	18,810	22,624
2022	3,438	6	344	26	18,810	22,624
2023	3,906	169	0	1,140	1,750	6,965
2024	3,451	82	0	1,125	6,528	11,187
2025	3,441	3	0	12	1,715	5,171
2026	3,441	3	0	12	1,715	5,171
2027	3,441	3	0	12	1,715	5,171
2028	3,451	3	0	12	1,720	5,185
2029	3,441	3	0	12	1,715	5,171
2030	3,441	3	0	12	1,715	5,171
2031	3,441	3	0	12	1,715	5,171
2032	3,451	3	0	12	1,720	5,185
2033	3,441	3	0	12	1,715	5,171
2034	3,441	3	0	12	1,715	5,171
2035	3,441	3	0	12	1,715	5,171
2036	3,451	3	0	12	1,720	5,185
2037	3,441	3	0	12	1,715	5,171
2038	3,441	3	0	12	1,715	5,171
2039	3,441	3	0	12	1,715	5,171
2040	3,451	3	0	12	1,720	5,185
2041	3,441	3	0	12	1,715	5,171
2042	3,441	3	0	12	1,715	5,171
2043	3,441	3	0	12	1,715	5,171
2044	3,451	3	0	12	1,720	5,185
2045	3,441	3	0	12	1,715	5,171
2046	3,441	3	0	12	1,715	5,171
2047	3,441	3	0	12	1,715	5,171
2048	3,451	3	0	12	1,720	5,185

TABLE 3.2a (continued)
LICENSE TERMINATION EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2049	3,441	3	0	12	1,715	5,171
2050	3,441	3	0	12	1,715	5,171
2051	3,441	3	0	12	1,715	5,171
2052	3,451	3	0	12	1,720	5,185
2053	3,441	3	0	12	1,715	5,171
2054	3,441	3	0	12	1,715	5,171
2055	3,441	3	0	12	1,715	5,171
2056	3,451	3	0	12	1,720	5,185
2057	3,441	3	0	12	1,715	5,171
2058	3,441	3	0	12	1,715	5,171
2059	41,433	5,010	0	46	3,585	50,075
2060	46,968	19,819	0	14,717	10,582	92,087
2061	46,720	21,987	0	20,872	13,802	103,381
2062	42,514	6,482	0	9,335	8,749	67,081
2063	42,514	6,482	0	9,335	8,749	67,081
2064	38,736	5,050	0	6,585	6,839	57,210
2065	13,478	740	0	19	1,033	15,270
2066	130	0	0	0	0	130
Total	534,276	67,277	2,403	64,007	264,010	931,973

TABLE 3.2b
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2016	0	0	0	0	806	806
2017	0	0	0	0	25,132	25,132
2018	13,628	0	0	0	18,443	32,070
2019	27,033	0	0	0	11,863	38,895
2020	27,107	0	0	0	11,895	39,002
2021	27,033	0	0	0	11,863	38,895
2022	27,033	0	0	0	11,863	38,895
2023	4,869	0	0	0	137	5,006
2024	4,882	0	0	0	137	5,020
2025	4,869	0	0	0	137	5,006
2026	4,869	0	0	0	137	5,006
2027	4,869	0	0	0	137	5,006
2028	4,882	0	0	0	137	5,020
2029	4,869	0	0	0	137	5,006
2030	4,869	0	0	0	137	5,006
2031	4,869	0	0	0	137	5,006
2032	5,026	431	0	0	137	5,595
2033	5,085	647	0	0	137	5,869
2034	4,941	216	0	0	137	5,294
2035	5,013	431	0	0	137	5,581
2036	5,098	647	0	0	137	5,882
2037	4,941	216	0	0	137	5,294
2038	4,941	216	0	0	137	5,294
2039	4,941	216	0	0	137	5,294
2040	4,954	216	0	0	137	5,307
2041	4,941	216	0	0	137	5,294
2042	4,941	216	0	0	137	5,294
2043	5,013	431	0	0	137	5,581
2044	5,026	431	0	0	137	5,595
2045	4,941	216	0	0	137	5,294
2046	5,085	647	0	0	137	5,869
2047	4,941	216	0	0	137	5,294
2048	4,882	0	0	0	137	5,020

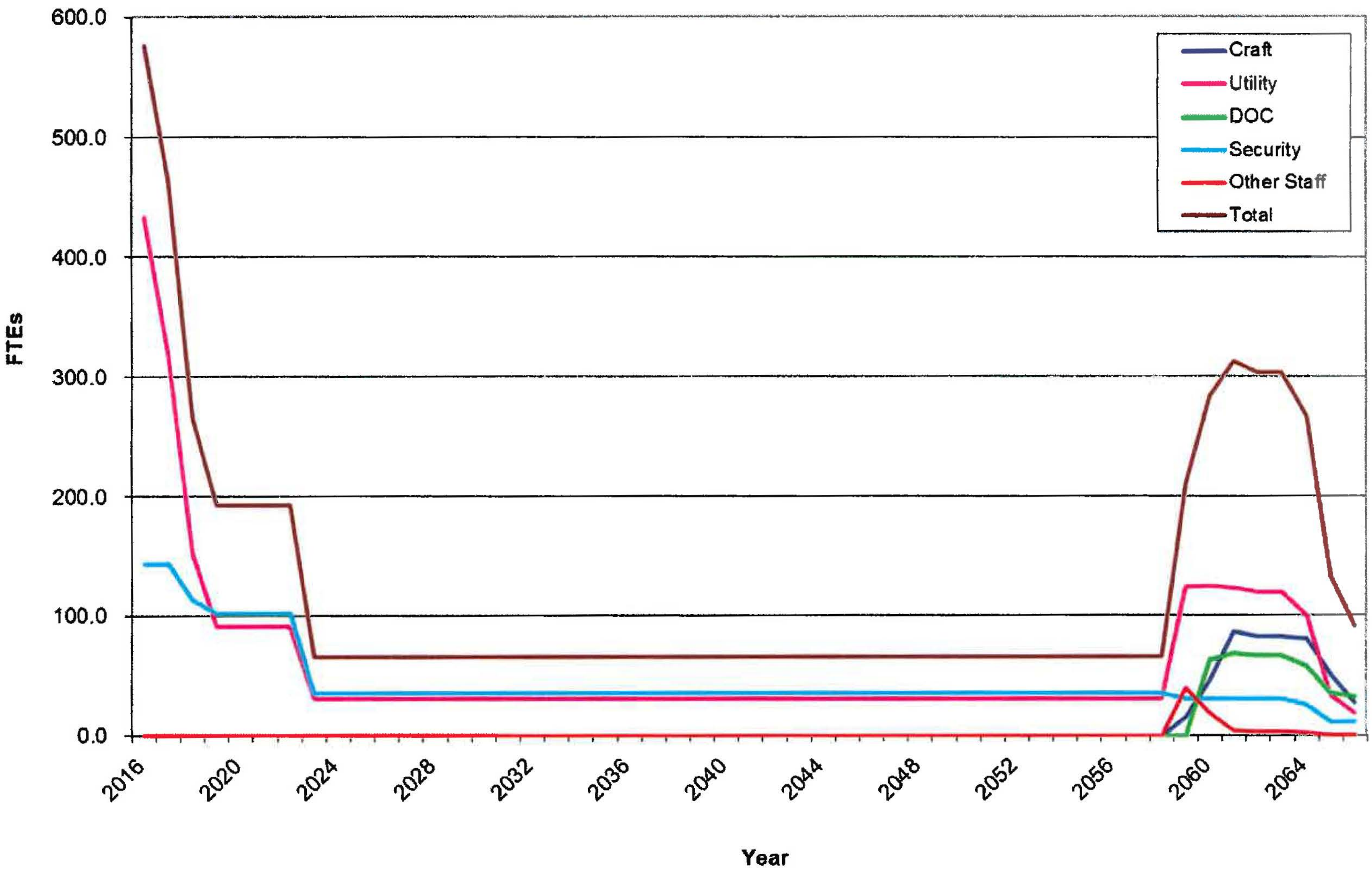
TABLE 3.2b (continued)
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2049	4,941	216	0	0	137	5,294
2050	4,941	216	0	0	137	5,294
2051	5,013	431	0	0	137	5,581
2052	4,954	216	0	0	137	5,307
2053	4,941	216	0	0	137	5,294
2054	5,013	431	0	0	137	5,581
2055	4,941	216	0	0	137	5,294
2056	4,954	216	0	0	137	5,307
2057	5,013	431	0	0	137	5,581
2058	5,013	431	0	0	137	5,581
Total	300,115	8,625	0	0	96,802	405,543

TABLE 3.2c
SITE RESTORATION EXPENDITURES
(thousands, 2016 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2059	626	0	0	0	0	626
2060	1,281	20	0	0	0	1,301
2061	1,224	202	0	0	133	1,559
2062	1,691	438	0	0	326	2,455
2063	1,691	438	0	0	326	2,455
2064	1,190	309	0	0	230	1,729
2065	7,820	4,174	0	0	982	12,976
2066	13,714	7,321	0	0	1,722	22,757
Total	29,235	12,903	0	0	3,720	45,857

FIGURE 3.1
SITE STAFFING LEVELS
(Full Time Equivalent Positions)



4. SCHEDULE ESTIMATE

The schedule for the SAFSTOR decommissioning scenario follows the sequence presented in the AIF/NESP-036 study, with minor changes to reflect recent experience and site-specific constraints. In addition, the scheduling has been revised to reflect the spent fuel management described in Section 3.4.1.

A schedule or sequence of activities for the SAFSTOR alternative is presented in Figure 4.1. The scheduling sequence is based on the fuel being removed from the spent fuel pool within six years after shutdown. The key activities listed in the schedule do not reflect a one-to-one correspondence with those activities in the cost tables, but reflect dividing some activities for clarity and combining others for convenience. The schedule was prepared using the "Microsoft Project Professional" computer software.[40]

4.1 SCHEDULE ESTIMATE ASSUMPTIONS

The schedule reflects the results of a precedence network developed for the site decommissioning activities, i.e., a PERT (Program Evaluation and Review Technique) Software Package. The work activity durations used in the precedence network reflect the actual man-hour estimate from the cost table, adjusted by stretching certain activities over their slack range and shifting the start and end dates of others. The following assumptions were made in the development of the decommissioning schedule:

- The fuel handling area of the auxiliary building is isolated until such time that all spent fuel has been discharged from the spent fuel pool to the ISFSI. Layup of the storage pool is initiated once the transfer of spent fuel is complete.
- All work (except vessel and internals removal) is performed during an 8-hour workday, 5 days per week, with no overtime.
- Reactor and internals removal activities are performed by using separate crews for different activities working on different shifts, with a corresponding backshift charge for the second shift.
- Multiple crews work parallel activities to the maximum extent possible, consistent with optimum efficiency, adequate access for cutting, removal and laydown space, and with the stringent safety measures necessary during demolition of heavy components and structures.
- For plant systems removal, the systems with the longest removal durations in areas on the critical path are considered to determine the duration of the activity.

4.2 PROJECT SCHEDULE

The period-dependent costs presented in the detailed cost table are based upon the durations developed in the schedules for decommissioning. Durations are established between several milestones in each project period; these durations are used to establish a critical path for the entire project. In turn, the critical path duration for each period is used as the basis for determining the period-dependent costs.

A project timelines is provided in Figure 4.2, with milestone dates based on an October 24, 2016 shutdown date. The fuel pool is emptied approximately six years after shutdown, while ISFSI operations continue until the DOE can complete the transfer of assemblies. For purposes of this analysis, the plant is assumed to remain in safe-storage until the spent fuel has been removed from the site (through 2058). Deferred decommissioning is assumed to commence such that the operating license is terminated within the required 60-year time period (from the cessation of plant operations).

FIGURE 4.1a
SAFSTOR ACTIVITY SCHEDULE
(Years 2016 through 2022)

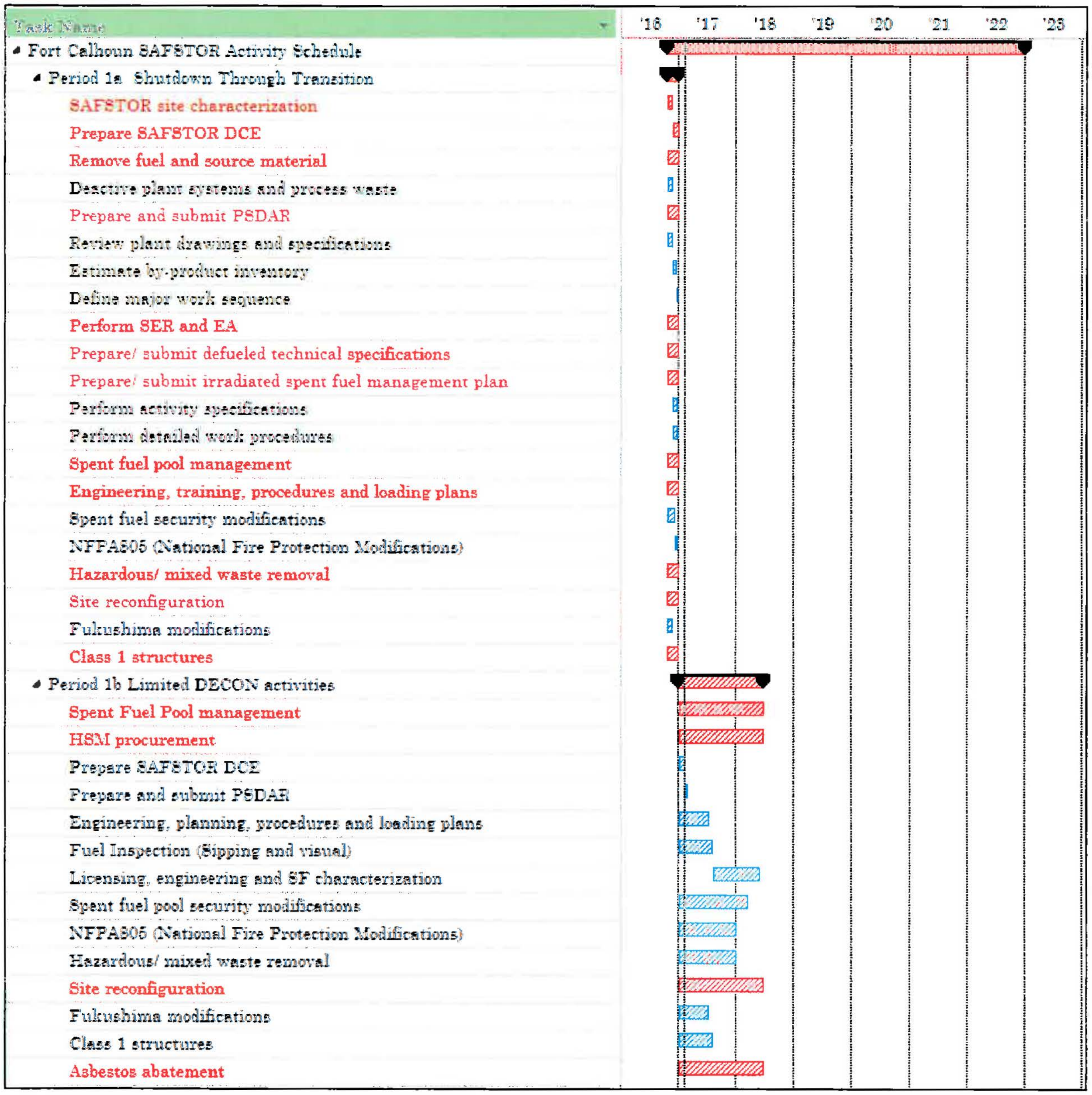


FIGURE 4.1a (continued)
SAFSTOR ACTIVITY SCHEDULE
(Years 2016 through 2022)

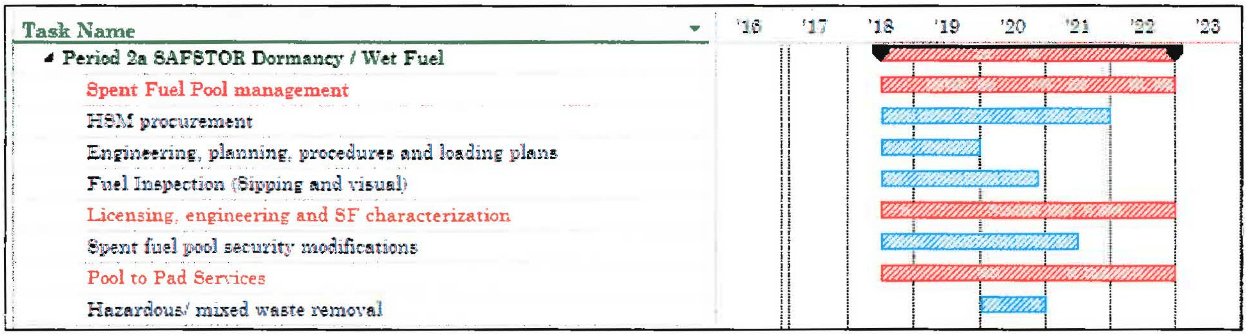


FIGURE 4.1b
SAFSTOR ACTIVITY SCHEDULE
(Years 2059 through 2066)

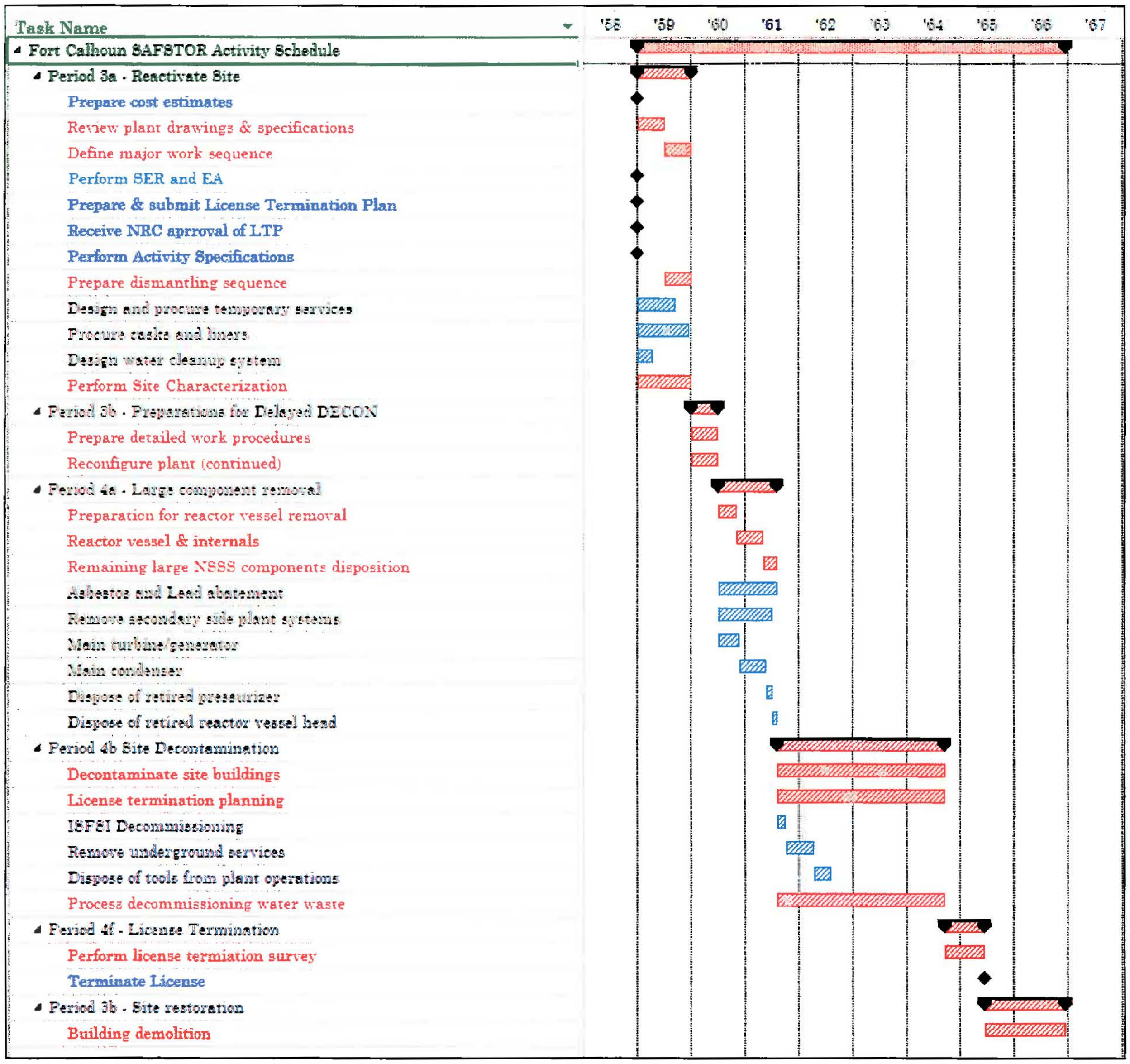
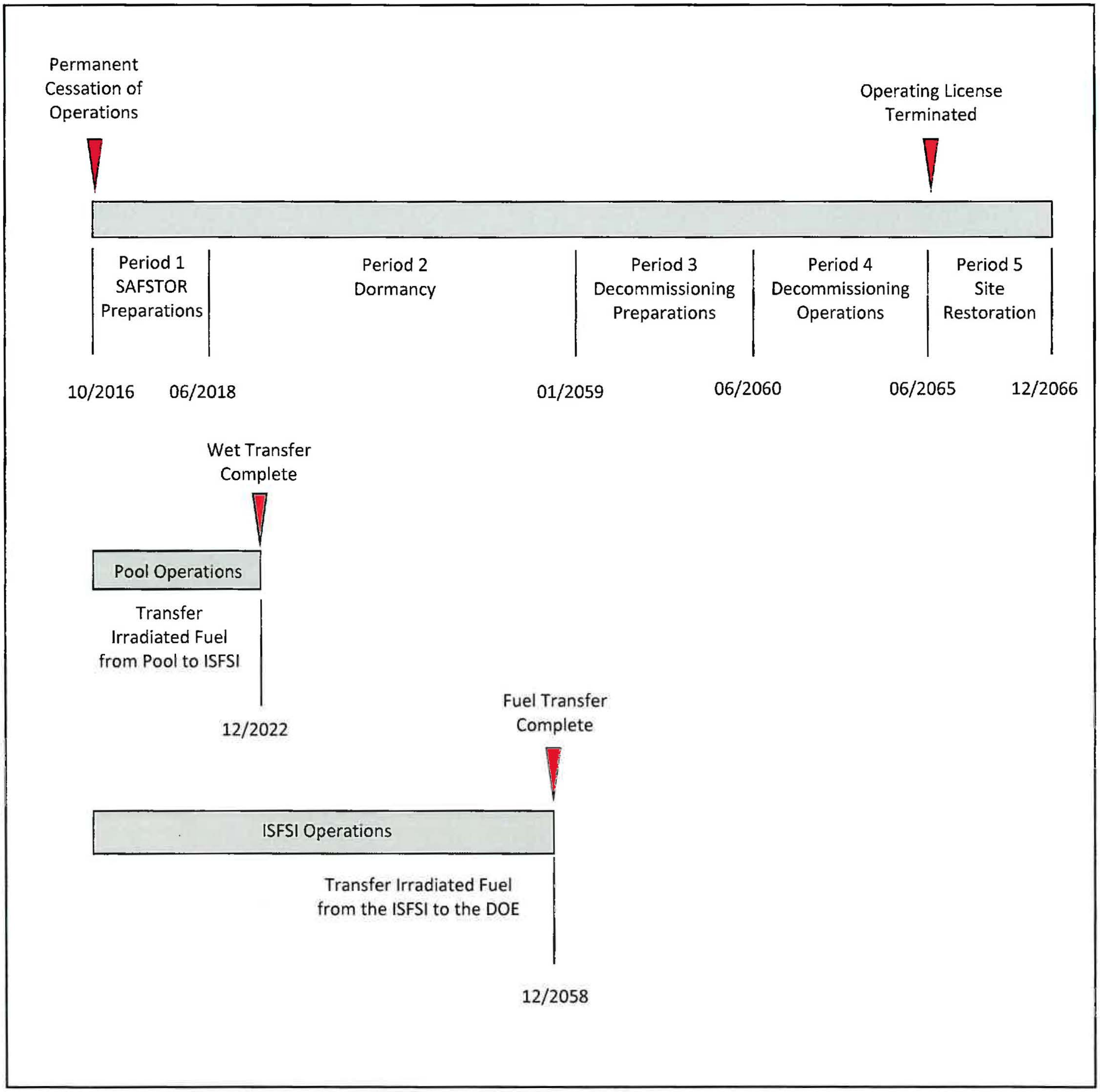


TABLE 4.1
DECOMMISSIONING SCHEDULE AND PLANT STATUS SUMMARY

Decommissioning Activities / Plant Status	Start	End	Approximate Duration (years)
Pre-Shutdown Planning	2016	Oct 2016	--------
Transition from Operations			
Plant Shutdown	24 Oct 2016	--------	--------
Preparations for SAFSTOR Dormancy	24 Oct 2016	01 Jul 2018	1.68
SAFSTOR Dormancy			
Dormancy w/Wet Fuel Storage	2018	2022	4.51
Dormancy w/Dry Fuel Storage	2023	2058	36.02
Decommissioning Preparations			
Preparations for D&D	2059	2060	1.49
Dismantling & Decontamination			
Large Component Removal	2060	2061	1.10
Plant Systems Removal and Building Decontamination	2061	2064	3.11
License Termination	2064	2065	0.75
Site Restoration			
Site Restoration	2065	2066	1.50
Total from Shutdown to Completion of Site Restoration	---------	--------	50.16

FIGURE 4.2
DECOMMISSIONING TIMELINE
(not to scale)



5. RADIOACTIVE WASTES

The objectives of the decommissioning process are the removal of all radioactive material from the site that would restrict its future use and the termination of the NRC license. This currently requires the remediation of all radioactive material at the site in excess of applicable legal limits. Under the Atomic Energy Act,[41] the NRC is responsible for protecting the public from sources of ionizing radiation. Title 10 of the Code of Federal Regulations delineates the production, utilization, and disposal of radioactive materials and processes. In particular, Part 71 defines radioactive material as it pertains to transportation and Part 61 specifies its disposition.

Most of the materials being transported for controlled burial are categorized as Low Specific Activity (LSA) or Surface Contaminated Object (SCO) materials containing Type A quantities, as defined in 49 CFR Parts 173-178. Shipping containers are required to be Industrial Packages (IP-1, IP-2 or IP-3, as defined in 10 CFR §173.411). For this study, commercially available steel containers are presumed to be used for the disposal of piping, small components, and concrete. Larger components can serve as their own containers, with proper closure of all openings, access ways, and penetrations.

The destinations for the various waste streams from decommissioning are identified in Figure 5.1. The volumes are shown on a line-item basis in Appendix C and summarized in Table 5.1. The volumes are calculated based on the exterior dimensions for containerized material and on the displaced volume of components serving as their own waste containers.

The reactor vessel and internals are categorized as large quantity shipments and, accordingly, will be shipped in reusable, shielded truck casks with disposable liners. In calculating disposal costs, the burial fees are applied against the liner volume, as well as the special handling requirements of the payload. Packaging efficiencies are lower for the highly activated materials (greater than Type A quantity waste), where high concentrations of gamma-emitting radionuclides limit the capacity of the shipping canisters.

No process system containing/handling radioactive substances at shutdown is presumed to meet material release criteria by decay alone (i.e., systems radioactive at shutdown will still be radioactive over the time period during which the decommissioning is accomplished, due to the presence of long-lived radionuclides). While the dose rates decrease with time, radionuclides such as ^{137}Cs will still control the disposition requirements.

The waste material produced in the decontamination and dismantling of the nuclear plant is primarily generated during Period 4 of SAFSTOR. Material that is considered potentially contaminated when removed from the radiological controlled area is sent to processing facilities in Tennessee for conditioning and disposal. Heavily contaminated components and activated materials are routed for controlled disposal. The disposal volumes reported in the tables reflect the savings resulting from reprocessing and recycling.

For purposes of constructing the estimate, the current cost for disposal at Energy*Solutions* facility in Clive, Utah was used for a majority of the radioactive waste produced from the decommissioning activities. Separate rates were used for containerized waste and large components. Demolition debris including miscellaneous steel, scaffolding, and concrete was disposed of at a bulk rate. The decommissioning waste stream also included resins and dry active waste.

Since Energy*Solutions* is not currently able to receive the more highly radioactive components generated in the decontamination and dismantling of the reactor, disposal costs for the Class B and C material were based upon preliminary information from the Texas Commission on Environmental Quality on the cost at the Andrews County, Texas facility.

The estimate includes the disposition of retired components currently stored on site, as well as contaminated tools necessary to support current operations and maintenance activities.

FIGURE 5.1
RADIOACTIVE WASTE DISPOSITION

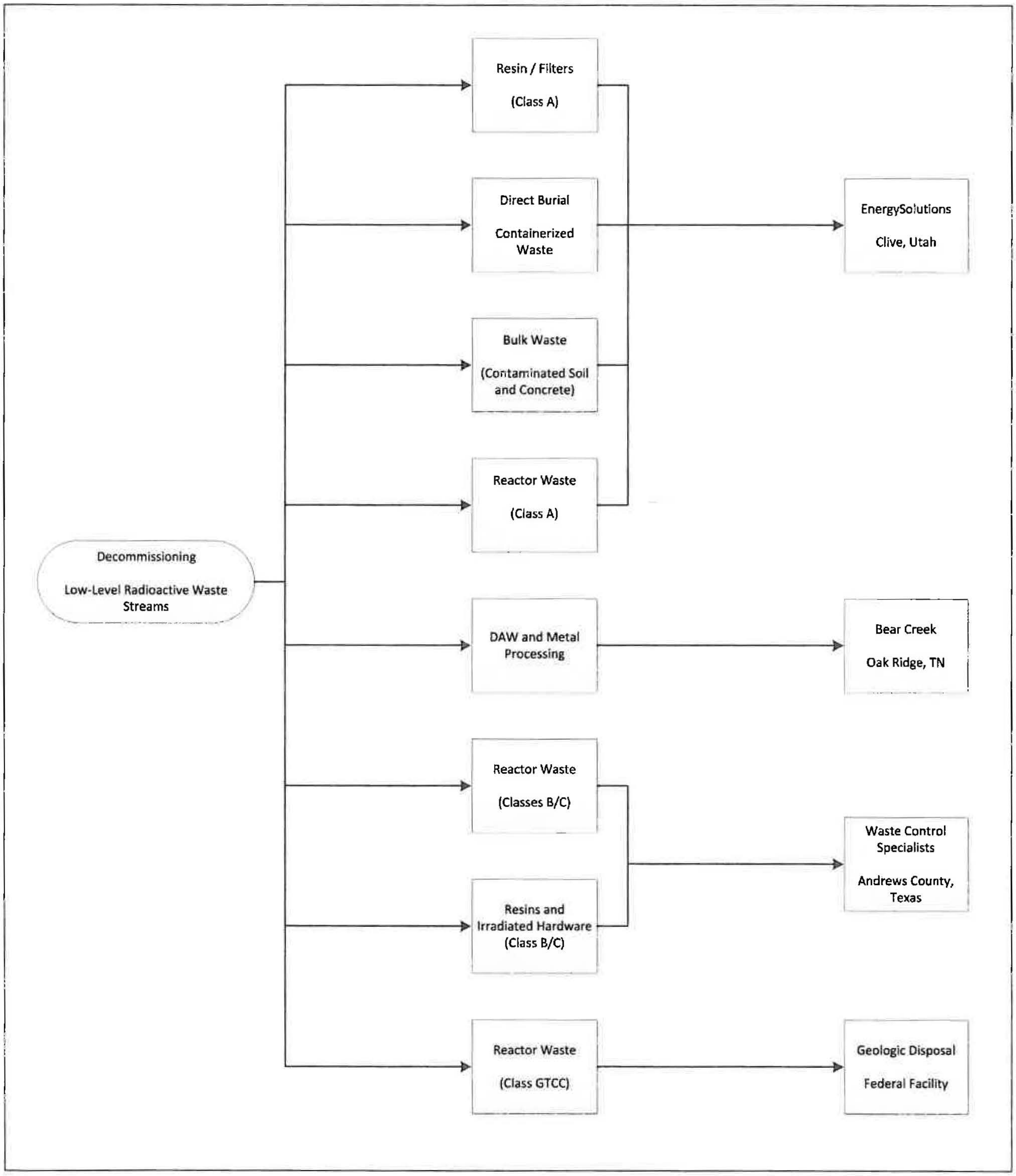


FIGURE 5.2
DECOMMISSIONING WASTE DESTINATIONS
RADIOLOGICAL

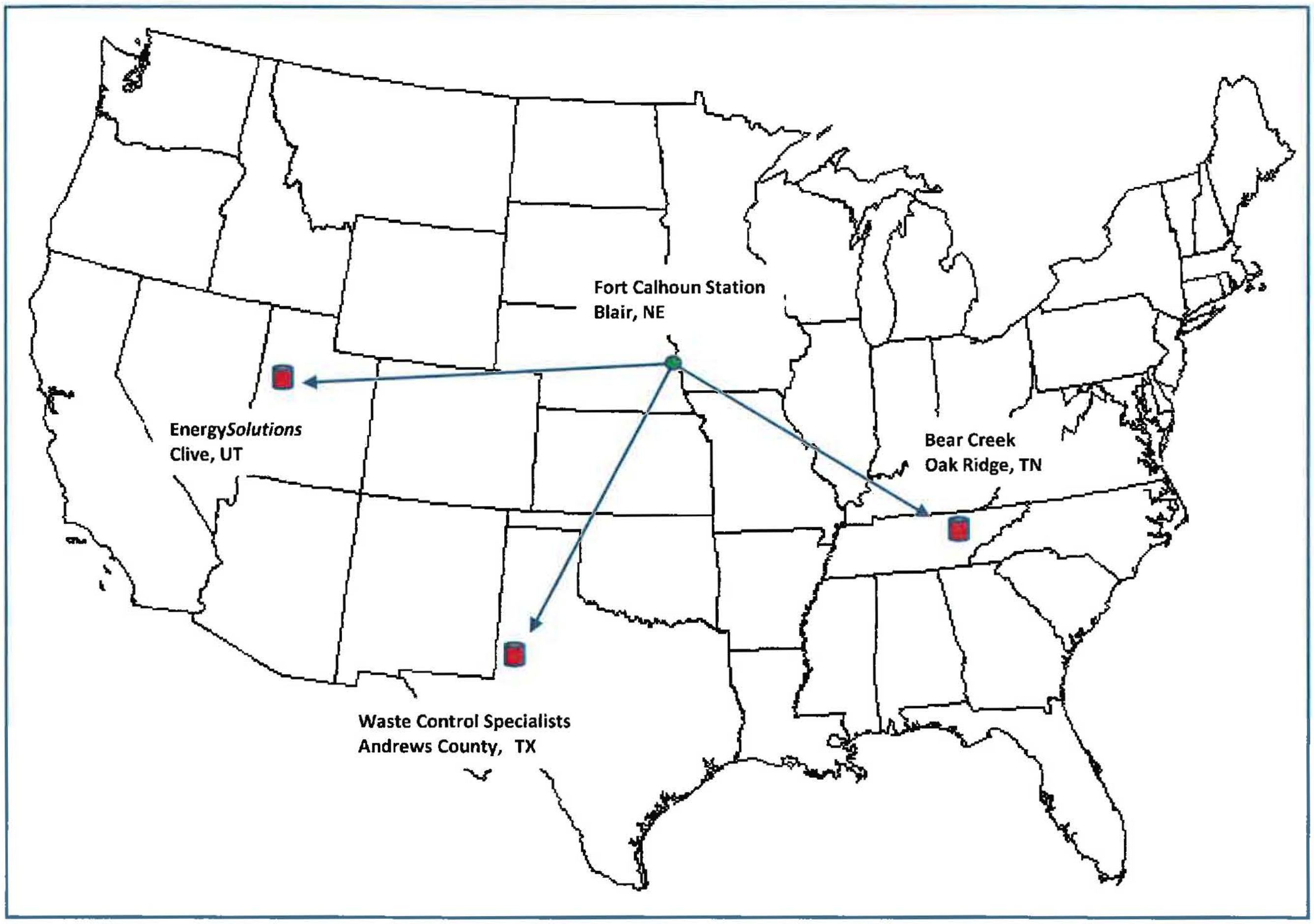


TABLE 5.1
SAFSTOR ALTERNATIVE
DECOMMISSIONING WASTE SUMMARY

Waste	Cost Basis	Class [1]	Waste Volume (cubic feet)	Weight (pounds)
Low-Level Radioactive Waste (near-surface disposal)	Energy*Solutions*	A	198,630	8,083,798
	WCS	B	725	52,346
	WCS	C	963	108,247
Greater than Class C (geologic repository)	Spent Fuel Equivalent	GTCC	825	147,014
Processed/Conditioned (off-site recycling center)	Recycling Vendors	A	305,976	12,000,000
Total [2]			507,118	20,391,406

[1] Waste is classified according to the requirements as delineated in Title 10 CFR, Part 61.55

[2] Columns may not add due to rounding

6. RESULTS

The analysis to estimate the costs to decommission Fort Calhoun relied upon the planning by OPPD's decommissioning organization as well as the site-specific, technical information developed for a previous analysis prepared in 2013. While not an engineering study, the estimate provides the owner with sufficient information to assess its financial obligations, as they pertain to the eventual decommissioning of the nuclear station.

The estimate described in this report is based on numerous fundamental assumptions, including regulatory requirements, project contingencies, low-level radioactive waste disposal practices, high-level radioactive waste management options, and site restoration requirements. The decommissioning scenarios assume continued operation of the station's spent fuel pool for a minimum of six years following the cessation of operations for continued cooling of the assemblies.

The cost projected for deferred decommissioning (SAFSTOR) is estimated to be $1.383 billion. The majority of this cost (approximately 67.4%) is associated with placing the plant in storage, ongoing caretaking of the plant during dormancy, and the eventual physical decontamination and dismantling of the nuclear plant so that the operating license can be terminated. Another 29.3% is associated with the management, interim storage, and eventual transfer of the spent fuel. The remaining 3.3% is for the demolition of the designated structures and limited restoration of the site.

The primary cost contributors, identified in Table 6.1, are either labor-related or associated with the management and disposition of the radioactive waste. Program management is the largest single contributor to the overall cost. The magnitude of the expense is a function of both the size of the organization required to manage the decommissioning, as well as the duration of the program. It is assumed, for purposes of this analysis, that OPPD will oversee the decommissioning program, using a DOC to manage the decommissioning labor force and the associated subcontractors. The size and composition of the management organization varies with the decommissioning phase and associated site activities.

As described in this report, the spent fuel pool will remain operational for a minimum of six years from the cessation of operations (2022). Over this period, period, the spent fuel will be packaged into transportable canisters and relocated to the on-site ISFSI.

The cost for waste disposal includes only those costs associated with the controlled disposition of the low-level radioactive waste generated from decontamination and dismantling activities, including plant equipment and components, structural material, filters, resins and dry-active waste. As described in Section 5, disposition of the majority of the low-level radioactive material requiring controlled disposal is at the Energy*Solutions*' facility in Utah or Waste Control Specialists' facility in Texas. Highly activated components, requiring additional isolation from the environment (GTCC), are packaged for geologic disposal. The cost of geologic disposal is based upon a cost equivalent for spent fuel.

A significant portion of the metallic waste is designated for additional processing and treatment at an off-site facility. Processing reduces the volume of material requiring controlled disposal through such techniques and processes as survey and sorting, decontamination, and volume reduction. The material that cannot be unconditionally released is packaged for controlled disposal at one of the currently operating facilities. The cost identified in the summary tables for processing is all-inclusive, incorporating the ultimate disposition of the material.

Removal costs reflect the labor-intensive nature of the decommissioning process, as well as the management controls required to ensure a safe and successful program. Decontamination and packaging costs also have a large labor component that is based upon prevailing wages. Non-radiological demolition is a natural extension of the decommissioning process. The methods employed in decontamination and dismantling are generally destructive and indiscriminate in inflicting collateral damage. With a work force mobilized to support decommissioning operations, non-radiological demolition can be an integrated activity and a logical expansion of the work being performed in the process of terminating the operating license.

The reported cost for transport includes the tariffs and surcharges associated with moving large components and/or overweight shielded casks overland, as well as the general expense, e.g., labor and fuel, of transporting material to the destinations identified in this report. For purposes of this analysis, material is primarily moved overland by truck, although large components, such as the steam generators are transported via railway.

Decontamination is used to reduce the plant's radiation fields and minimize worker exposure. Slightly contaminated material or material located within a contaminated area is sent to an off-site processing center, i.e., this analysis does not assume that contaminated plant components and equipment can be decontaminated for uncontrolled release in-situ. Centralized processing centers have proven to be a more economical means of handling the large volumes of material produced in the dismantling of a nuclear plant.

License termination survey costs are associated with the labor intensive and complex activity of verifying that contamination has been removed from the site to the levels specified by the regulating agency. This process involves a systematic survey of all remaining plant surface areas and surrounding environs, sampling, isotopic analysis, and documentation of the findings. The status of any plant components and materials not removed in the decommissioning process will also require confirmation and will add to the expense of surveying the facilities alone.

The remaining costs include allocations for heavy equipment and temporary services, as well as for other expenses such as regulatory fees and the premiums for nuclear insurance. While site operating costs are greatly reduced following the final cessation of plant operations, certain administrative functions do need to be maintained either at a basic functional or regulatory level.

TABLE 6.1
DECOMMISSIONING COST SUMMARY
(thousands of 2016 dollars)

Decommissioning Periods	License Termination	Spent Fuel Management	Site Restoration
Pre-shutdown Planning	1,482	-	-
Planning and Preparations	182,134	38,401	-
Dormancy w/Wet Fuel Storage	101,964	175,296	-
Dormancy w/Dry Fuel Storage	194,080	191,846	-
Site Reactivation	50,075	-	626
Decommissioning Preparation	26,644	-	821
Large Component Removal	141,440	-	1,037
Plant Sys. Removal and Bldg. Remediation	208,777	-	7,641
License Termination	25,174	-	-
Site Restoration	205	-	35,733
Total [1]	931,973	405,543	45,857

[1] Columns may not add due to rounding

TABLE 6.2
DECOMMISSIONING COST ELEMENTS
(thousands of $2016)

Cost Elements	$000
Decontamination	6,067
Removal	105,492
Waste Packaging	11,490
Transportation	8,726
Low-Level Radioactive Waste Disposal	37,310
Off-site Waste Processing	29,128
Program Management	508,716
Site Non-Labor Overhead	77,306
Corporate A&G	19,082
Security	284,842
Property Taxes	1,103
Insurance	33,213
NRC Fees	20,651
Energy	2,404
Characterization and Surveys	110,978
Support Services	26,488
Projects	58,786
Spent Fuel Management	32,678
Other	8,914
TOTAL [1]	1,383,373

Cost Categories	$000
License Termination	931,973
Spent Fuel Management [2]	405,543
Site Restoration	45,857
TOTAL [1]	1,383,373

[1] Columns may not add due to rounding

[2] Includes period dependent costs, as appropriate, during fuel storage periods

7. REFERENCES

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2. U.S. Code of Federal Regulations, Title 10, Subpart 50.82(a)(8)(iii); "Termination of License"

3. "SAFSTOR Decommissioning Cost Analysis for the Fort Calhoun Station," TLG Document No. O02-1675-002, Rev. 0, August 2013

4. U.S. Code of Federal Regulations, Title 10, Parts 30, 40, 50, 51, 70 and 72, "General Requirements for Decommissioning Nuclear Facilities," Nuclear Regulatory Commission, 53 Fed. Reg. 24018, June 27, 1988

5. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.159, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors," Rev. 2, October 2011

6. U.S. Code of Federal Regulations, Title 10, Part 20, Subpart E, "Radiological Criteria for License Termination"

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16. United States Court of Appeals for the District of Columbia Circuit, In Re: Aiken County, Et Al., August 2013, http://www.cadc.uscourts.gov/internet/opinions.nsf/BAE0CF34F762EBD985257BC6004DEB18/$file/11-1271-1451347.pdf

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18. U.S. Code of Federal Regulations, Title 10, Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites"

19. "Low Level Radioactive Waste Policy Act," Public Law 96-573, 1980

20. "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, 1986

21. U.S. Code of Federal Regulations, Title 10, Part 61.55 "Waste Classification"

22. U.S. Code of Federal Regulations, Title 10, Part 20, Subpart E, "Final Rule, Radiological Criteria for License Termination," 62 Fed. Reg. 39058, July 21, 1997

23. "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," EPA Memorandum OSWER No. 9200.4-18, August 22, 1997

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24. U.S. Code of Federal Regulations, Title 40, Part 141.16, "Maximum contaminant levels for beta particle and photon radioactivity from man-made radionuclides in community water systems"

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26. "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," NUREG/CR-1575, Rev. 1, EPA 402-R-97-016, Rev. 1, August 2000

27. T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986

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APPENDIX A

UNIT COST FACTOR DEVELOPMENT

APPENDIX A
UNIT COST FACTOR DEVELOPMENT

Example: Unit Factor for Removal of Contaminated Heat Exchanger < 3,000 lbs.

1. SCOPE

Heat exchangers weighing < 3,000 lbs. will be removed in one piece using a crane or small hoist. They will be disconnected from the inlet and outlet piping. The heat exchanger will be sent to the waste processing area.

2. CALCULATIONS

Act ID	Activity Description	Activity Duration (minutes)	Critical Duration (minutes)*
a	Remove insulation	60	(b)
b	Mount pipe cutters	60	60
c	Install contamination controls	20	(b)
d	Disconnect inlet and outlet lines	60	60
e	Cap openings	20	(d)
f	Rig for removal	30	30
g	Unbolt from mounts	30	30
h	Remove contamination controls	15	15
i	Remove, wrap, send to waste processing area	60	60
	Totals (Activity/Critical)	355	255

Duration adjustment(s):	
+ Respiratory protection adjustment (50% of critical duration)	128
+ Radiation/ALARA adjustment (15 % of critical duration)	38
Adjusted work duration	421
+ Protective clothing adjustment (30% of adjusted duration)	126
Productive work duration	547
+ Work break adjustment (8.33 % of productive duration)	46
Total work duration (minutes)	593

***** Total duration = 9.883 hr *****

* alpha designators indicate activities that can be performed in parallel

APPENDIX A
(continued)

3. LABOR REQUIRED

Crew	Number	Duration (hours)	Rate ($/hr)	Cost
Laborers	3.00	9.883	$36.08	$1,069.74
Craftsmen	2.00	9.883	$53.79	$1,063.21
Foreman	1.00	9.883	$57.02	$563.53
General Foreman	0.25	9.883	$59.35	$146.64
Fire Watch	0.05	9.883	$36.08	$17.83
Health Physics Technician	1.00	9.883	$63.94	$631.92
Total Labor Cost				$3,492.87

4. EQUIPMENT & CONSUMABLES COSTS

Equipment Costs	none
Consumables/Materials Costs	
-Universal Sorbent 50 @ $0.57 sq. ft. {1}	$28.50
-Tarpaulins (oil resistant/fire retardant) 50 @ $0.39/sq. ft. {2}	$19.50
-Gas torch consumables 1 @ $18.96/hr. x 1 hr. {3}	$18.96
Subtotal cost of equipment and materials	$66.96
Overhead & profit on equipment and materials @ 15.5 %	$10.38
Total costs, equipment & material	$77.34

TOTAL COST:

Removal of contaminated heat exchanger <3000 pounds:	**$3,570.21**
Total labor cost:	$3,492.87
Total equipment/material costs:	$77.34
Total craft labor man-hours required per unit:	72.146

5. NOTES AND REFERENCES

- Work difficulty factors were developed in conjunction with the Atomic Industrial Forum's (now NEI) program to standardize nuclear decommissioning cost estimates and are delineated in Volume 1, Chapter 5 of the "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986.

- References for equipment & consumables costs:

    1. www.mcmaster.com online catalog, McMaster Carr Spill Control (7193T88)
    2. R.S. Means (2016) Division 01 56, Section 13.60-0600, page 22
    3. R.S. Means (2016) Division 01 54 33, Section 40-6360, page 710

- Material and consumable costs were adjusted using the regional indices for Omaha, Nebraska.

APPENDIX B

UNIT COST FACTOR LISTING
(SAFSTOR: Power Block Structures Only)

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of clean instrument and sampling tubing, $/linear foot	0.41
Removal of clean pipe 0.25 to 2 inches diameter, $/linear foot	4.37
Removal of clean pipe >2 to 4 inches diameter, $/linear foot	6.34
Removal of clean pipe >4 to 8 inches diameter, $/linear foot	12.70
Removal of clean pipe >8 to 14 inches diameter, $/linear foot	24.15
Removal of clean pipe >14 to 20 inches diameter, $/linear foot	31.51
Removal of clean pipe >20 to 36 inches diameter, $/linear foot	46.34
Removal of clean pipe >36 inches diameter, $/linear foot	55.00
Removal of clean valve >2 to 4 inches	83.77
Removal of clean valve >4 to 8 inches	127.02
Removal of clean valve >8 to 14 inches	241.52
Removal of clean valve >14 to 20 inches	315.10
Removal of clean valve >20 to 36 inches	463.35
Removal of clean valve >36 inches	550.05
Removal of clean pipe hanger for small bore piping	29.65
Removal of clean pipe hanger for large bore piping	101.31
Removal of clean pump, <300 pound	216.53
Removal of clean pump, 300-1000 pound	605.48
Removal of clean pump, 1000-10,000 pound	2,367.42
Removal of clean pump, >10,000 pound	4,586.44
Removal of clean pump motor, 300-1000 pound	251.69
Removal of clean pump motor, 1000-10,000 pound	981.62
Removal of clean pump motor, >10,000 pound	2,208.65
Removal of clean heat exchanger <3000 pound	1,276.22
Removal of clean heat exchanger >3000 pound	3,223.54
Removal of clean feedwater heater/deaerator	9,052.02
Removal of clean moisture separator/reheater	18,562.43
Removal of clean tank, <300 gallons	278.25
Removal of clean tank, 300-3000 gallon	873.05
Removal of clean tank, >3000 gallons, $/square foot surface area	7.46

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of clean electrical equipment, <300 pound	116.07
Removal of clean electrical equipment, 300-1000 pound	409.77
Removal of clean electrical equipment, 1000-10,000 pound	819.54
Removal of clean electrical equipment, >10,000 pound	1,962.46
Removal of clean electrical transformer < 30 tons	1,362.90
Removal of clean electrical transformer > 30 tons	3,924.92
Removal of clean standby diesel generator, <100 kW	1,392.09
Removal of clean standby diesel generator, 100 kW to 1 MW	3,107.23
Removal of clean standby diesel generator, >1 MW	6,432.59
Removal of clean electrical cable tray, $/linear foot	11.00
Removal of clean electrical conduit, $/linear foot	4.81
Removal of clean mechanical equipment, <300 pound	116.07
Removal of clean mechanical equipment, 300-1000 pound	409.77
Removal of clean mechanical equipment, 1000-10,000 pound	819.54
Removal of clean mechanical equipment, >10,000 pound	1,962.46
Removal of clean HVAC equipment, <300 pound	140.35
Removal of clean HVAC equipment, 300-1000 pound	492.38
Removal of clean HVAC equipment, 1000-10,000 pound	981.30
Removal of clean HVAC equipment, >10,000 pound	1,962.46
Removal of clean HVAC ductwork, $/pound	0.44
Removal of contaminated instrument and sampling tubing, $/linear foot	1.32
Removal of contaminated pipe 0.25 to 2 inches diameter, $/linear foot	19.03
Removal of contaminated pipe >2 to 4 inches diameter, $/linear foot	31.19
Removal of contaminated pipe >4 to 8 inches diameter, $/linear foot	51.20
Removal of contaminated pipe >8 to 14 inches diameter, $/linear foot	97.42
Removal of contaminated pipe >14 to 20 inches diameter, $/linear foot	116.67
Removal of contaminated pipe >20 to 36 inches diameter, $/linear foot	160.81
Removal of contaminated pipe >36 inches diameter, $/linear foot	189.37
Removal of contaminated valve >2 to 4 inches	388.98
Removal of contaminated valve >4 to 8 inches	457.81

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated valve >8 to 14 inches	918.76
Removal of contaminated valve >14 to 20 inches	1,168.47
Removal of contaminated valve >20 to 36 inches	1,552.65
Removal of contaminated valve >36 inches	1,838.25
Removal of contaminated pipe hanger for small bore piping	128.34
Removal of contaminated pipe hanger for large bore piping	405.01
Removal of contaminated pump, <300 pound	811.87
Removal of contaminated pump, 300-1000 pound	1,870.25
Removal of contaminated pump, 1000-10,000 pound	5,910.20
Removal of contaminated pump, >10,000 pound	14,367.52
Removal of contaminated pump motor, 300-1000 pound	814.66
Removal of contaminated pump motor, 1000-10,000 pound	2,414.12
Removal of contaminated pump motor, >10,000 pound	5,429.46
Removal of contaminated heat exchanger <3000 pound	3,570.21
Removal of contaminated heat exchanger >3000 pound	10,422.06
Removal of contaminated tank, <300 gallons	1,354.86
Removal of contaminated tank, >300 gallons, $/square foot	26.43
Removal of contaminated electrical equipment, <300 pound	628.43
Removal of contaminated electrical equipment, 300-1000 pound	1,508.24
Removal of contaminated electrical equipment, 1000-10,000 pound	2,909.39
Removal of contaminated electrical equipment, >10,000 pound	5,773.33
Removal of contaminated electrical cable tray, $/linear foot	30.48
Removal of contaminated electrical conduit, $/linear foot	15.34
Removal of contaminated mechanical equipment, <300 pound	700.02
Removal of contaminated mechanical equipment, 300-1000 pound	1,685.52
Removal of contaminated mechanical equipment, 1000-10,000 pound	3,244.93
Removal of contaminated mechanical equipment, >10,000 pound	5,773.33
Removal of contaminated HVAC equipment, <300 pound	700.02
Removal of contaminated HVAC equipment, 300-1000 pound	1,685.52
Removal of contaminated HVAC equipment, 1000-10,000 pound	3,244.93

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated HVAC equipment, >10,000 pound	5,773.33
Removal of contaminated HVAC ductwork, $/pound	1.89
Removal/plasma arc cut of contaminated thin metal components, $/linear in.	3.29
Additional decontamination of surface by washing, $/square foot	6.77
Additional decontamination of surfaces by hydrolasing, $/square foot	30.66
Decontamination rig hook up and flush, $/ 250 foot length	5,882.59
Chemical flush of components/systems, $/gallon	18.64
Removal of clean standard reinforced concrete, $/cubic yard	66.34
Removal of grade slab concrete, $/cubic yard	75.45
Removal of clean concrete floors, $/cubic yard	347.13
Removal of sections of clean concrete floors, $/cubic yard	1,024.02
Removal of clean heavily rein concrete w/#9 rebar, $/cubic yard	95.73
Removal of contaminated heavily rein concrete w/#9 rebar, $/cubic yard	1,824.62
Removal of clean heavily rein concrete w/#18 rebar, $/cubic yard	129.76
Removal of contaminated heavily rein concrete w/#18 rebar, $/cubic yard	2,410.75
Removal heavily rein concrete w/#18 rebar & steel embedments, $/cubic yard	424.42
Removal of below-grade suspended floors, $/cubic yard	181.93
Removal of clean monolithic concrete structures, $/cubic yard	844.67
Removal of contaminated monolithic concrete structures, $/cubic yard	1,811.73
Removal of clean foundation concrete, $/cubic yard	665.72
Removal of contaminated foundation concrete, $/cubic yard	1,686.82
Explosive demolition of bulk concrete, $/cubic yard	46.26
Removal of clean hollow masonry block wall, $/cubic yard	23.61
Removal of contaminated hollow masonry block wall, $/cubic yard	55.60
Removal of clean solid masonry block wall, $/cubic yard	23.61
Removal of contaminated solid masonry block wall, $/cubic yard	55.60
Backfill of below-grade voids, $/cubic yard	31.35
Removal of subterranean tunnels/voids, $/linear foot	104.20
Placement of concrete for below-grade voids, $/cubic yard	123.58
Excavation of clean material, $/cubic yard	2.96

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Excavation of contaminated material, $/cubic yard	36.39
Removal of clean concrete rubble (tipping fee included), $/cubic yard	23.59
Removal of contaminated concrete rubble, $/cubic yard	21.89
Removal of building by volume, $/cubic foot	0.29
Removal of clean building metal siding, $/square foot	1.20
Removal of contaminated building metal siding, $/square foot	3.94
Removal of standard asphalt roofing, $/square foot	1.94
Removal of transite panels, $/square foot	1.93
Scarifying contaminated concrete surfaces (drill & spall), $/square foot	10.92
Scabbling contaminated concrete floors, $/square foot	6.45
Scabbling contaminated concrete walls, $/square foot	17.22
Scabbling contaminated ceilings, $/square foot	58.99
Scabbling structural steel, $/square foot	5.42
Removal of clean overhead crane/monorail < 10 ton capacity	583.67
Removal of contaminated overhead crane/monorail < 10 ton capacity	1,587.08
Removal of clean overhead crane/monorail >10-50 ton capacity	1,400.79
Removal of contaminated overhead crane/monorail >10-50 ton capacity	3,807.09
Removal of polar crane > 50 ton capacity	5,883.62
Removal of gantry crane > 50 ton capacity	24,530.76
Removal of structural steel, $/pound	0.19
Removal of clean steel floor grating, $/square foot	4.44
Removal of contaminated steel floor grating, $/square foot	11.91
Removal of clean free standing steel liner, $/square foot	11.19
Removal of contaminated free standing steel liner, $/square foot	30.65
Removal of clean concrete-anchored steel liner, $/square foot	5.59
Removal of contaminated concrete-anchored steel liner, $/square foot	35.61
Placement of scaffolding in clean areas, $/square foot	15.11
Placement of scaffolding in contaminated areas, $/square foot	23.55
Landscaping with topsoil, $/acre	21,565.70
Cost of CPC B-88 LSA box & preparation for use	1,866.96

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Cost of CPC B-25 LSA box & preparation for use	1,757.45
Cost of CPC B-12V 12 gauge LSA box & preparation for use	1,394.93
Cost of CPC B-144 LSA box & preparation for use	9,533.15
Cost of LSA drum & preparation for use	182.63
Cost of cask liner for CNSI 8 120A cask (resins)	11,157.85
Cost of cask liner for CNSI 8 120A cask (filters)	8,003.93
Decontamination of surfaces with vacuuming, $/square foot	0.72

APPENDIX C

DETAILED COST ANALYSIS

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
PERIOD 0 - Pre-Shutdown Early Planning																					
0a.2.40	Decommissioning Shine Calc and Decay Heat Generation			-	-	-	-	76	-	76	76	-	-	-	-	-	-	-	-	-	-
0a.2.41	Tech Support for EP Decommissioning Changes			-	-	-	-	247	-	247	247	-	-	-	-	-	-	-	-	-	-
0a.2.42	Site Specific DCE and PSDAR Development			-	-	-	-	407	-	407	407	-	-	-	-	-	-	-	-	-	-
0a.2.43	HSA and Limited Site Characterization			-	-	-	-	449	-	449	449	-	-	-	-	-	-	-	-	-	-
0a.2.44	Decommissioning LAR Support			-	-	-	-	250	-	250	250	-	-	-	-	-	-	-	-	-	-
0a.2.45	Zirc Fire Analysis for FCS Decommissioning Planning			-	-	-	-	53	-	53	53	-	-	-	-	-	-	-	-	-	-
0a.2	Subtotal Period 0a Additional Costs			-	-	-	-	1,482	-	1,482	1,482	-	-	-	-	-	-	-	-	-	-
PERIOD 0 TOTALS		-	-	-	-	-	-	1,482	-	1,482	1,482	-	-	-	-	-	-	-	-	-	-
PERIOD 1a - Shutdown through Transition																					
Period 1a Additional Costs																					
1a.2.7	Spent Fuel Security Modifications	-	-	-	-	-	-	250	38	288	-	288	-	-	-	-	-	-	-	-	-
1a.2.10	NFPA 805 (National Fire Protection As	-	-	-	-	-	-	63	9	72	72	-	-	-	-	-	-	-	-	-	-
1a.2.11	Hazardous/Mixed Waste	-	-	-	-	-	-	317	48	364	364	-	-	-	-	-	-	-	-	-	-
1a.2.13	Fukushima	-	-	-	-	-	-	400	60	460	460	-	-	-	-	-	-	-	-	-	-
1a.2.14	Class 1 Structures	-	-	-	-	-	-	1.100	165	1,265	1,265	-	-	-	-	-	-	-	-	-	-
Period 1a Collateral Costs																					
1a.3.1	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	2,153	323	2,476	2,476	-	-	-	-	-	-	-	-	-	-
1a.3	Subtotal Period 1a Collateral Costs	-	-	-	-	-	-	2,153	323	2,476	2,476	-	-	-	-	-	-	-	-	-	-
Period 1a Period-Dependent Costs																					
1a.4.1	Insurance	-	-	-	-	-	-	301	30	331	331	-	-	-	-	-	-	-	-	-	-
1a.4.2	Property taxes	-	-	-	-	-	-	4	0	4	4	-	-	-	-	-	-	-	-	-	-
1a.4.4	Equipment rental	-	115	-	-	-	-	-	17	132	132	-	-	-	-	-	-	-	-	-	-
1a.4.5	Disposal of DAW generated	-	-	3	1	-	12	-	4	20	20	-	-	-	168	-	-	-	3,352	5	-
1a.4.6	Plant energy budget	-	-	-	-	-	-	104	16	120	120	-	-	-	-	-	-	-	-	-	-
1a.4.7	NRC Fees	-	-	-	-	-	-	467	47	514	514	-	-	-	-	-	-	-	-	-	-
1a.4.8	Emergency Planning Fees	-	-	-	-	-	-	293	29	323	-	323	-	-	-	-	-	-	-	-	-
1a.4.9	Corporate A&G	-	-	-	-	-	-	207	31	238	238	-	-	-	-	-	-	-	-	-	-
1a.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	151	23	174	-	174	-	-	-	-	-	-	-	-	-
1a.4.11	ISFSI Operating Costs	-	-	-	-	-	-	19	3	22	-	22	-	-	-	-	-	-	-	-	-
1a.4.12	Support Services	-	-	-	-	-	-	1,659	249	1,907	1,907	-	-	-	-	-	-	-	-	-	-
1a.4.13	Post-operations water processing	-	-	-	-	-	-	60	9	69	69	-	-	-	-	-	-	-	-	-	-
1a.4.14	Security Staff Cost	-	-	-	-	-	-	3,165	475	3,640	3,640	-	-	-	-	-	-	-	-	-	56,622
1a.4.15	Utility Staff Cost	-	-	-	-	-	-	13,840	2,076	15,917	15,917	-	-	-	-	-	-	-	-	-	170,258
1a.4	Subtotal Period 1a Period-Dependent (	-	115	3	1	-	12	20,270	3,008	23,410	22,891	518	-	-	168	-	-	-	3,352	5	226,880
1a.0	TOTAL PERIOD 1a COST	-	115	3	1	-	12	24,553	3,651	28,335	27,529	806	-	-	168	-	-	-	3,352	5	226.880
PERIOD 1b - SAFSTOR Limited DECON Activities																					
Period 1b Additional Costs																					
1b.2.1	Spent Fuel Pool Management	-	-	-	-	-	-	2,087	313	2,400	2,400	-	-	-	-	-	-	-	-	-	-
1b.2.2	HSM Fabrication	-	-	-	-	-	-	15,467	2,320	17,787	-	17,787	-	-	-	-	-	-	-	-	-
1b.2.4	Engineering, Training, Procedures, Lo	-	-	-	-	-	-	3,490	524	4,014	-	4,014	-	-	-	-	-	-	-	-	-
1b.2.5	Fuel Inspection (Sipping & Visual)	-	-	-	-	-	-	859	129	988	-	988	-	-	-	-	-	-	-	-	-
1b.2.6	Licensing, Engineering, SF Characteri	-	-	-	-	-	-	86	13	99	-	99	-	-	-	-	-	-	-	-	-
1b.2.7	Spent Fuel Security Modifications	-	-	-	-	-	-	1,596	239	1,835	-	1,835	-	-	-	-	-	-	-	-	-
1b.2.8	Pool to Pad Services	-	-	-	-	-	-	7,561	1,134	8,696	-	8,696	-	-	-	-	-	-	-	-	-
1b.2.10	NFPA 805 (National Fire Protection As	-	-	-	-	-	-	194	29	223	223	-	-	-	-	-	-	-	-	-	-
1b.2.11	Hazardous/Mixed Waste	-	-	-	-	-	-	474	71	545	545	-	-	-	-	-	-	-	-	-	-
1b.2.12	Site Reconfiguration	-	-	-	-	-	-	230	35	265	265	-	-	-	-	-	-	-	-	-	-
1b.2.13	Fukushima	-	-	-	-	-	-	1,698	255	1,953	1,953	-	-	-	-	-	-	-	-	-	-
1b.2.14	Class 1 Structures	-	-	-	-	-	-	1,700	255	1,955	1,955	-	-	-	-	-	-	-	-	-	-
1b.2.15	Asbestos abatement	-	-	-	-	-	-	2,000	-	2,000	2,000	-	-	-	54,000	-	-	-	702,000	-	-
1b.2	Subtotal Period 1b Additional Costs	-	-	-	-	-	-	37.442	5,316	42.759	9,340	33.419	-	-	54,000	-	-	-	702,000	-	-
Period 1b Collateral Costs																					
1b.3.2	Process decommissioning water waste	77	-	45	102	-	155	-	97	476	476	-	-	-	489	-	-	-	29,321	95	-
1b.3.4	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	15.346	2,302	17,648	17,648	-	-	-	-	-	-	-	-	-	-
1b.3	Subtotal Period 1b Collateral Costs	77	-	45	102	-	155	15,346	2,399	18.124	18.124	-	-	-	489	-	-	-	29,321	95	-
Period 1b Period-Dependent Costs																					
1b.4.2	Insurance	-	-	-	-	-	-	2,379	238	2,617	2,617	-	-	-	-	-	-	-	-	-	-
1b.4.3	Property taxes	-	-	-	-	-	-	30	3	33	33	-	-	-	-	-	-	-	-	-	-
1b.4.5	Equipment rental	-	910	-	-	-	-	-	137	1,047	1,047	-	-	-	-	-	-	-	-	-	-
1b.4.6	Disposal of DAW generated	-	-	22	7	-	81	-	24	134	134	-	-	-	1.121	-	-	-	22,424	37	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 1b Period-Dependent Costs (continued)																					
1b.4.7	Plant energy budget	-	-	-	-	-	-	637	96	732	732	-	-	-	-	-	-	-	-	-	-
1b.4.8	NRC Fees	-	-	-	-	-	-	2,512	251	2,763	2,763	-	-	-	-	-	-	-	-	-	-
1b.4.9	Emergency Planning Fees	-	-	-	-	-	-	2,388	239	2,626	-	2,626	-	-	-	-	-	-	-	-	-
1b.4.10	Corporate A&G	-	-	-	-	-	-	1,617	242	1,859	1,859	-	-	-	-	-	-	-	-	-	-
1b.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	1,198	180	1,378	-	1,378	-	-	-	-	-	-	-	-	-
1b.4.12	ISFSI Operating Costs	-	-	-	-	-	-	150	23	173	-	173	-	-	-	-	-	-	-	-	-
1b.4.13	Support Services	-	-	-	-	-	-	13,124	1,969	15,093	15,093	-	-	-	-	-	-	-	-	-	-
1b.4.14	Post-operations water processing	-	-	-	-	-	-	370	55	425	425	-	-	-	-	-	-	-	-	-	-
1b.4.15	Security Staff Cost	-	-	-	-	-	-	23,315	3,497	26,812	26,812	-	-	-	-	-	-	-	-	-	448,049
1b.4.16	Utility Staff Cost	-	-	-	-	-	-	65,761	9,864	75,625	75,625	-	-	-	-	-	-	-	-	-	993,278
1b.4	Subtotal Period 1b Period-Dependent (	-	910	22	7	-	81	113,480	16,817	131,317	127,140	4,177	-	-	1,121	-	-	-	22,424	37	1,441,327
1b.0	TOTAL PERIOD 1b COST	77	910	67	109	-	235	166,268	24,532	192,200	154,605	37,595	-	-	55,610	-	-	-	753,744	132	1,441,327
PERIOD 1 TOTALS		77	1,025	71	110	-	248	190,821	28,182	220,535	182,134	38,401	-	-	55,777	-	-	-	757,096	137	1,668,207
PERIOD 2a - SAFSTOR Dormancy with Wet Spent Fuel Storage																					
Period 2a Additional Costs																					
2a.2.2	HSM Fabrication	-	-	-	-	-	-	23,664	3,550	27,213	-	27,213	-	-	-	-	-	-	-	-	-
2a.2.4	Engineering, Training, Procedures, Loading Plans	-	-	-	-	-	-	3,510	526	4,036	-	4,036	-	-	-	-	-	-	-	-	-
2a.2.5	Fuel Inspection (Sipping & Visual)	-	-	-	-	-	-	1,315	197	1,512	-	1,512	-	-	-	-	-	-	-	-	-
2a.2.6	Licensing, Engineering, SF Characterization	-	-	-	-	-	-	131	20	151	-	151	-	-	-	-	-	-	-	-	-
2a.2.7	Spent Fuel Security Modifications	-	-	-	-	-	-	2,154	323	2,477	-	2,477	-	-	-	-	-	-	-	-	-
2a.2.8	Pool to Pad Services	-	-	-	-	-	-	11,569	1,735	13,304	-	13,304	-	-	-	-	-	-	-	-	-
2a.2.11	Hazardous/Mixed Waste	-	-	-	-	-	-	793	119	912	912	-	-	-	-	-	-	-	-	-	-
2a.2	Subtotal Period 2a Additional Costs	-	-	-	-	-	-	43,136	6,470	49,606	912	48,694	-	-	-	-	-	-	-	-	-
Period 2a Collateral Costs																					
2a.3.1	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	25,462	3,819	29,281	29,281	-	-	-	-	-	-	-	-	-	-
2a.3	Subtotal Period 2a Collateral Costs	-	-	-	-	-	-	25,462	3,819	29,281	29,281	-	-	-	-	-	-	-	-	-	-
Period 2a Period-Dependent Costs																					
2a.4.1	Insurance	-	-	-	-	-	-	2,660	266	2,926	2,926	-	-	-	-	-	-	-	-	-	-
2a.4.2	Property taxes	-	-	-	-	-	-	90	9	99	99	-	-	-	-	-	-	-	-	-	-
2a.4.4	Disposal of DAW generated	-	-	26	9	-	95	-	28	157	157	-	-	-	1,316	-	-	-	26,330	43	-
2a.4.5	Plant energy budget	-	-	-	-	-	-	1,349	202	1,551	1,551	-	-	-	-	-	-	-	-	-	-
2a.4.6	NRC Fees	-	-	-	-	-	-	3,636	364	4,000	4,000	-	-	-	-	-	-	-	-	-	-
2a.4.7	Emergency Planning Fees	-	-	-	-	-	-	89	9	98	-	98	-	-	-	-	-	-	-	-	-
2a.4.8	Corporate A&G	-	-	-	-	-	-	4,558	684	5,242	5,242	-	-	-	-	-	-	-	-	-	-
2a.4.9	Spent Fuel Pool O&M	-	-	-	-	-	-	3,609	541	4,151	-	4,151	-	-	-	-	-	-	-	-	-
2a.4.10	ISFSI Operating Costs	-	-	-	-	-	-	452	68	520	-	520	-	-	-	-	-	-	-	-	-
2a.4.11	Support Services	-	-	-	-	-	-	36,336	5,450	41,786	41,786	-	-	-	-	-	-	-	-	-	-
2a.4.12	Post-operations water processing	-	-	-	-	-	-	450	68	518	518	-	-	-	-	-	-	-	-	-	-
2a.4.13	Security Staff Cost	-	-	-	-	-	-	54,825	8,224	63,049	9,773	53,276	-	-	-	-	-	-	-	-	956,173
2a.4.14	Utility Staff Cost	-	-	-	-	-	-	64,588	9,688	74,277	5,719	68,557	-	-	-	-	-	-	-	-	853,056
2a.4	Subtotal Period 2a Period-Dependent (	-	-	26	9	-	95	172,643	25,600	198,373	71,771	126,602	-	-	1,316	-	-	-	26,330	43	1,809,230
2a.0	TOTAL PERIOD 2a COST	-	-	26	9	-	95	241,240	35,890	277,260	101,964	175,296	-	-	1,316	-	-	-	26,330	43	1,809,230
PERIOD 2b - SAFSTOR Dormancy with Dry Spent Fuel Storage																					
Period 2b Additional Costs																					
2b.2.15	Spent Fuel Pool Non-fuel Inventory	-	-	72	182	-	891	-	257	1,402	1,402	-	-	-	376	250	56	-	14,311	-	-
2b.2.17	Soil Remediation	-	-	-	-	-	-	100	15	115	115	-	-	-	-	-	-	-	-	-	-
2b.2.18	Spent Fuel Pool Cleanup	-	-	-	-	-	-	4,000	600	4,600	4,600	-	-	-	-	-	-	-	-	-	-
2b.2.19	Remove spent fuel racks	308	34	116	30	-	903	-	404	1,794	1,794	-	-	-	2,865	-	-	-	181,987	789	-
2b.2	Subtotal Period 2b Additional Costs	308	34	188	212	-	1,793	4,100	1,276	7,911	7,911	-	-	-	3,240	250	56	-	196,298	789	-
Period 2b Collateral Costs																					
2b.3.1	Process decommissioning water waste	2	-	2	5	-	8	-	4	21	21	-	-	-	25	-	-	-	1,473	5	-
2b.3.3	Small tool allowance	-	5	-	-	-	-	-	1	6	6	-	-	-	-	-	-	-	-	-	-
2b.3.4	Spent Fuel Capital and Transfer	-	-	-	-	-	-	10,000	1,500	11,500	-	11,500	-	-	-	-	-	-	-	-	-
2b.3.5	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	15,549	2,332	17,881	17,881	-	-	-	-	-	-	-	-	-	-
2b.3	Subtotal Period 2b Collateral Costs	2	5	2	5	-	8	25,549	3,837	29,408	17,908	11,500	-	-	25	-	-	-	1,473	5	-
Period 2b Period-Dependent Costs																					
2b.4.1	Insurance	-	-	-	-	-	-	21,259	2,126	23,385	23,385	-	-	-	-	-	-	-	-	-	-
2b.4.2	Property taxes	-	-	-	-	-	-	720	72	792	792	-	-	-	-	-	-	-	-	-	-
2b.4.4	Disposal of DAW generated	-	-	90	30	-	334	-	97	552	552	-	-	-	4,632	-	-	-	92,648	151	-
2b.4.5	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2b.4.6	NRC Fees	-	-	-	-	-	-	8,876	888	9,764	9,764	-	-	-	-	-	-	-	-	-	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 2b Period-Dependent Costs (continued)																					
2b.4.7	Emergency Planning Fees	-	-	-	-	-	-	712	71	783	-	783	-	-	-	-	-	-	-	-	-
2b.4.8	Corporate A&G	-	-	-	-	-	-	4,921	738	5,659	5,659	-	-	-	-	-	-	-	-	-	-
2b.4.9	ISFSI Operating Costs	-	-	-	-	-	-	3,613	542	4,155	-	4,155	-	-	-	-	-	-	-	-	-
2b.4.10	Post-operations water processing	-	-	-	-	-	-	3,600	540	4,140	4,140	-	-	-	-	-	-	-	-	-	-
2b.4.11	Security Staff Cost	-	-	-	-	-	-	138,052	20,708	158,760	78,269	80,491	-	-	-	-	-	-	-	-	2,622,595
2b.4.12	Utility Staff Cost	-	-	-	-	-	-	122,275	18,341	140,616	45,700	94,916	-	-	-	-	-	-	-	-	2,322,870
2b.4	Subtotal Period 2b Period-Dependent (	-	-	90	30	-	334	304,028	44,123	348,606	168,261	180,346	-	-	4,632	-	-	-	92,648	151	4,945,465
2b.0	TOTAL PERIOD 2b COST	310	39	280	247	-	2,136	333,677	49,236	385,925	194,080	191,846	-	-	7,897	250	56	-	290,419	945	4,945,465
PERIOD 2 TOTALS		310	39	306	256	-	2,231	574,917	85,126	663,185	296,043	367,142	-	-	9,214	250	56	-	316,749	988	6,754,695
PERIOD 3a - Reactivate Site Following SAFSTOR Dormancy																					
Period 3a Direct Decommissioning Activities																					
3a.1.1	Prepare preliminary decommissioning	-	-	-	-	-	-	148	22	171	171	-	-	-	-	-	-	-	-	-	1,300
3a.1.2	Review plant dwgs & specs.	-	-	-	-	-	-	525	79	604	604	-	-	-	-	-	-	-	-	-	4,600
3a.1.3	Perform detailed rad survey	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
3a.1.4	End product description	-	-	-	-	-	-	114	17	131	131	-	-	-	-	-	-	-	-	-	1,000
3a.1.5	Detailed by-product inventory	-	-	-	-	-	-	148	22	171	171	-	-	-	-	-	-	-	-	-	1,300
3a.1.6	Define major work sequence	-	-	-	-	-	-	857	128	985	985	-	-	-	-	-	-	-	-	-	7,500
3a.1.7	Perform SER and EA	-	-	-	-	-	-	354	53	407	407	-	-	-	-	-	-	-	-	-	3,100
3a.1.8	Perform Site-Specific Cost Study	-	-	-	-	-	-	571	86	657	657	-	-	-	-	-	-	-	-	-	5,000
Activity Specifications																					
3a.1.9.1	Re-activate plant & temporary facilitie	-	-	-	-	-	-	842	126	968	871	-	97	-	-	-	-	-	-	-	7,370
3a.1.9.2	Plant systems	-	-	-	-	-	-	476	71	547	493	-	55	-	-	-	-	-	-	-	4,167
3a.1.9.3	Reactor internals	-	-	-	-	-	-	811	122	933	933	-	-	-	-	-	-	-	-	-	7,100
3a.1.9.4	Reactor vessel	-	-	-	-	-	-	742	111	854	854	-	-	-	-	-	-	-	-	-	6,500
3a.1.9.5	Biological shield	-	-	-	-	-	-	57	9	66	66	-	-	-	-	-	-	-	-	-	500
3a.1.9.6	Steam generators	-	-	-	-	-	-	356	53	410	410	-	-	-	-	-	-	-	-	-	3,120
3a.1.9.7	Reinforced concrete	-	-	-	-	-	-	183	27	210	105	-	105	-	-	-	-	-	-	-	1,600
3a.1.9.8	Main Turbine	-	-	-	-	-	-	46	7	53	-	-	53	-	-	-	-	-	-	-	400
3a.1.9.9	Main Condensers	-	-	-	-	-	-	46	7	53	-	-	53	-	-	-	-	-	-	-	400
3a.1.9.10	Plant structures & buildings	-	-	-	-	-	-	356	53	410	205	-	205	-	-	-	-	-	-	-	3,120
3a.1.9.11	Waste management	-	-	-	-	-	-	525	79	604	604	-	-	-	-	-	-	-	-	-	4,600
3a.1.9.12	Facility & site closeout	-	-	-	-	-	-	103	15	118	59	-	59	-	-	-	-	-	-	-	900
3a.1.9	Total	-	-	-	-	-	-	4,543	681	5,224	4,599	-	626	-	-	-	-	-	-	-	39,777
Planning & Site Preparations																					
3a.1.10	Prepare dismantling sequence	-	-	-	-	-	-	274	41	315	315	-	-	-	-	-	-	-	-	-	2,400
3a.1.11	Plant prep. & temp. svces	-	-	-	-	-	-	3,200	480	3,680	3,680	-	-	-	-	-	-	-	-	-	-
3a.1.12	Design water clean-up system	-	-	-	-	-	-	160	24	184	184	-	-	-	-	-	-	-	-	-	1,400
3a.1.13	Rigging/Cont. Cntrl Envlps/tooling/etc.	-	-	-	-	-	-	2,300	345	2,645	2,645	-	-	-	-	-	-	-	-	-	-
3a.1.14	Procure casks/liners & containers	-	-	-	-	-	-	140	21	162	162	-	-	-	-	-	-	-	-	-	1,230
3a.1	Subtotal Period 3a Activity Costs	-	-	-	-	-	-	13,336	2,000	15,336	14,710	-	626	-	-	-	-	-	-	-	68,607
Period 3a Additional Costs																					
3a.2.1	Site characterization	-	-	-	-	-	-	5,803	1,741	7,544	7,544	-	-	-	-	-	-	-	-	30,500	10,852
3a.2	Subtotal Period 3a Additional Costs	-	-	-	-	-	-	5,803	1,741	7,544	7,544	-	-	-	-	-	-	-	-	30,500	10,852
Period 3a Collateral Costs																					
3a.3.1	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	1,446	217	1,663	1,663	-	-	-	-	-	-	-	-	-	-
3a.3	Subtotal Period 3a Collateral Costs	-	-	-	-	-	-	1,446	217	1,663	1,663	-	-	-	-	-	-	-	-	-	-
Period 3a Period-Dependent Costs																					
3a.4.1	Insurance	-	-	-	-	-	-	581	58	639	639	-	-	-	-	-	-	-	-	-	-
3a.4.2	Property taxes	-	-	-	-	-	-	20	2	22	22	-	-	-	-	-	-	-	-	-	-
3a.4.3	Health physics supplies	-	449	-	-	-	-	-	112	562	562	-	-	-	-	-	-	-	-	-	-
3a.4.4	Equipment rental	-	609	-	-	-	-	-	91	700	700	-	-	-	-	-	-	-	-	-	-
3a.4.5	Disposal of DAW generated	-	-	10	3	-	37	-	11	61	61	-	-	-	514	-	-	-	10,287	17	-
3a.4.6	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3a.4.7	NRC Fees	-	-	-	-	-	-	343	34	378	378	-	-	-	-	-	-	-	-	-	-
3a.4.8	Corporate A&G	-	-	-	-	-	-	664	100	764	764	-	-	-	-	-	-	-	-	-	-
3a.4.9	Post-operations water processing	-	-	-	-	-	-	100	15	115	115	-	-	-	-	-	-	-	-	-	-
3a.4.10	Security Staff Cost	-	-	-	-	-	-	4,314	647	4,961	4,961	-	-	-	-	-	-	-	-	-	65,000
3a.4.11	Utility Staff Cost	-	-	-	-	-	-	15,613	2,342	17,955	17,955	-	-	-	-	-	-	-	-	-	257,920
3a.4	Subtotal Period 3a Period-Dependent (	-	1,058	10	3	-	37	21,636	3,413	26,157	26,157	-	-	-	514	-	-	-	10,287	17	322,920
3a.0	TOTAL PERIOD 3a COST	-	1,058	10	3	-	37	42,221	7,371	50,700	50,075	-	626	-	514	-	-	-	10,287	30,517	402,379

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
PERIOD 3b - Decommissioning Preparations																					
Period 3b Direct Decommissioning Activities																					
Detailed Work Procedures																					
3b.1.1.1	Plant systems	-	-	-	-	-	-	541	81	622	559	-	62	-	-	-	-	-	-	-	4,733
3b.1.1.2	Reactor internals	-	-	-	-	-	-	286	43	328	328	-	-	-	-	-	-	-	-	-	2,500
3b.1.1.3	Remaining buildings	-	-	-	-	-	-	154	23	177	44	-	133	-	-	-	-	-	-	-	1,350
3b.1.1.4	CRD cooling assembly	-	-	-	-	-	-	114	17	131	131	-	-	-	-	-	-	-	-	-	1,000
3b.1.1.5	CRD housings & ICI tubes	-	-	-	-	-	-	114	17	131	131	-	-	-	-	-	-	-	-	-	1,000
3b.1.1.6	Incore instrumentation	-	-	-	-	-	-	114	17	131	131	-	-	-	-	-	-	-	-	-	1,000
3b.1.1.7	Reactor vessel	-	-	-	-	-	-	415	62	477	477	-	-	-	-	-	-	-	-	-	3,630
3b.1.1.8	Facility closeout	-	-	-	-	-	-	137	21	158	79	-	79	-	-	-	-	-	-	-	1,200
3b.1.1.9	Missile shields	-	-	-	-	-	-	51	8	59	59	-	-	-	-	-	-	-	-	-	450
3b.1.1.10	Biological shield	-	-	-	-	-	-	137	21	158	158	-	-	-	-	-	-	-	-	-	1,200
3b.1.1.11	Steam generators	-	-	-	-	-	-	525	79	604	604	-	-	-	-	-	-	-	-	-	4,600
3b.1.1.12	Reinforced concrete	-	-	-	-	-	-	114	17	131	66	-	66	-	-	-	-	-	-	-	1,000
3b.1.1.13	Main Turbine	-	-	-	-	-	-	178	27	205	-	-	205	-	-	-	-	-	-	-	1,560
3b.1.1.14	Main Condensers	-	-	-	-	-	-	178	27	205	-	-	205	-	-	-	-	-	-	-	1,560
3b.1.1.15	Auxiliary building	-	-	-	-	-	-	312	47	359	323	-	36	-	-	-	-	-	-	-	2,730
3b.1.1.16	Reactor building	-	-	-	-	-	-	312	47	359	323	-	36	-	-	-	-	-	-	-	2,730
3b.1.1	Total	-	-	-	-	-	-	3,682	552	4,235	3,414	-	821	-	-	-	-	-	-	-	32,243
3b.1	Subtotal Period 3b Activity Costs	-	-	-	-	-	-	3,682	552	4,235	3,414	-	821	-	-	-	-	-	-	-	32,243
Period 3b Collateral Costs																					
3b.3.1	Decon equipment	945	-	-	-	-	-	-	142	1,087	1,087	-	-	-	-	-	-	-	-	-	-
3b.3.2	DOC staff relocation expenses	-	-	-	-	-	-	1,406	211	1,617	1,617	-	-	-	-	-	-	-	-	-	-
3b.3.3	Pipe cutting equipment	-	1,200	-	-	-	-	-	180	1,380	1,380	-	-	-	-	-	-	-	-	-	-
3b.3.4	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	713	107	820	820	-	-	-	-	-	-	-	-	-	-
3b.3	Subtotal Period 3b Collateral Costs	945	1,200	-	-	-	-	2,119	640	4,904	4,904	-	-	-	-	-	-	-	-	-	-
Period 3b Period-Dependent Costs																					
3b.4.1	Decon supplies	33	-	-	-	-	-	-	8	41	41	-	-	-	-	-	-	-	-	-	-
3b.4.2	Insurance	-	-	-	-	-	-	291	29	320	320	-	-	-	-	-	-	-	-	-	-
3b.4.3	Property taxes	-	-	-	-	-	-	10	1	11	11	-	-	-	-	-	-	-	-	-	-
3b.4.4	Health physics supplies	-	244	-	-	-	-	-	61	305	305	-	-	-	-	-	-	-	-	-	-
3b.4.5	Equipment rental	-	300	-	-	-	-	-	45	345	345	-	-	-	-	-	-	-	-	-	-
3b.4.6	Disposal of DAW generated	-	-	6	2	-	21	-	6	34	34	-	-	-	287	-	-	-	5,738	9	-
3b.4.7	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3b.4.8	NRC Fees	-	-	-	-	-	-	169	17	186	186	-	-	-	-	-	-	-	-	-	-
3b.4.9	Corporate A&G	-	-	-	-	-	-	328	49	377	377	-	-	-	-	-	-	-	-	-	-
3b.4.10	Post-operations water processing	-	-	-	-	-	-	49	7	57	57	-	-	-	-	-	-	-	-	-	-
3b.4.11	Security Staff Cost	-	-	-	-	-	-	2,128	319	2,447	2,447	-	-	-	-	-	-	-	-	-	32,055
3b.4.12	DOC Staff Cost	-	-	-	-	-	-	4,651	698	5,349	5,349	-	-	-	-	-	-	-	-	-	57,442
3b.4.13	Utility Staff Cost	-	-	-	-	-	-	7,700	1,155	8,855	8,855	-	-	-	-	-	-	-	-	-	127,193
3b.4	Subtotal Period 3b Period-Dependent (	33	544	6	2	-	21	15,325	2,396	18,326	18,326	-	-	-	287	-	-	-	5,738	9	216,690
3b.0	TOTAL PERIOD 3b COST	978	1,744	6	2	-	21	21,127	3,588	27,466	26,644	-	821	-	287	-	-	-	5,738	9	248,933
PERIOD 3 TOTALS		978	2,802	16	5	-	58	63,348	10,958	78,166	76,719	-	1,447	-	801	-	-	-	16,026	30,526	651,312
PERIOD 4a - Large Component Removal																					
Period 4a Direct Decommissioning Activities																					
Nuclear Steam Supply System Removal																					
4a.1.1.1	Reactor Coolant Piping	22	97	20	15	14	336	-	126	630	630	-	-	102	972	-	-	-	74,632	2,292	-
4a.1.1.2	Pressurizer Quench Tank	3	13	6	4	4	96	-	31	157	157	-	-	29	278	-	-	-	21,376	322	-
4a.1.1.3	Reactor Coolant Pumps & Motors	21	83	52	116	-	1,039	-	313	1,624	1,624	-	-	-	5,658	-	-	-	444,400	2,716	80
4a.1.1.4	Pressurizer	6	54	416	125	-	614	-	230	1,445	1,445	-	-	-	1,856	-	-	-	145,522	1,463	1,500
4a.1.1.5	Steam Generators	30	6,441	1,394	1,403	1,081	2,338	-	2,722	15,409	15,409	-	-	16,338	7,063	-	-	-	1,349,262	10,851	2,250
4a.1.1.6	Retired Steam Generator Units	-	-	1,394	1,403	1,081	2,338	-	1,096	7,312	7,312	-	-	16,338	7,063	-	-	-	1,349,262	5,400	2,250
4a.1.1.7	CRDMs/ICIs/Service Structure Remov:	22	170	166	24	16	520	-	206	1,124	1,124	-	-	203	2,117	-	-	-	112,422	3,699	-
4a.1.1.8	Reactor Vessel Internals	64	4,754	3,129	778	-	6,855	215	8,035	23,831	23,831	-	-	-	727	475	907	-	219,102	17,207	847
4a.1.1.9	Vessel & Internals GTCC Disposal	-	-	-	-	-	2,113	-	317	2,431	2,431	-	-	-	-	-	-	825	147,014	-	-
4a.1.1.10	Reactor Vessel	9	7,304	1,134	212	-	2,127	215	6,914	17,915	17,915	-	-	-	6,446	-	-	-	638,934	17,207	847
4a.1.1	Totals	177	18,916	7,710	4,079	2,197	18,378	431	19,991	71,878	71,878	-	-	33,010	32,181	475	907	825	4,501,926	61,157	7,773
Removal of Major Equipment																					
4a.1.2	Main Turbine/Generator	-	201	70	23	338	-	-	111	743	743	-	-	3,565	-	-	-	-	160,412	3,989	-
4a.1.3	Main Condensers	-	780	52	17	252	-	-	241	1,342	1,342	-	-	2,654	-	-	-	-	119,434	15,762	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Cascading Costs from Clean Building Demolition																					
4a.1.4.1	Containment	-	211	-	-	-	-	-	32	242	242	-	-	-	-	-	-	-	-	1,619	-
4a.1.4.2	Auxiliary	-	149	-	-	-	-	-	22	171	171	-	-	-	-	-	-	-	-	1,117	-
4a.1.4.3	Radwaste	-	23	-	-	-	-	-	3	27	27	-	-	-	-	-	-	-	-	183	-
4a.1.4	Totals	-	382	-	-	-	-	-	57	440	440	-	-	-	-	-	-	-	-	2,920	-
Disposal of Plant Systems																					
4a.1.5.1	Auxiliary Steam & Condensate Return	-	83	-	-	-	-	-	12	95	-	-	95	-	-	-	-	-	-	1,914	-
4a.1.5.2	Auxiliary Steam & Condensate Return	-	32	0	2	27	-	-	12	74	74	-	-	316	-	-	-	-	12,831	549	-
4a.1.5.3	Chemical Feed	-	6	-	-	-	-	-	1	7	-	-	7	-	-	-	-	-	-	134	-
4a.1.5.4	Chemical Feed-RCA	-	6	0	0	4	-	-	2	12	12	-	-	43	-	-	-	-	1,739	85	-
4a.1.5.5	Circulating Water	-	277	-	-	-	-	-	42	319	-	-	319	-	-	-	-	-	-	6,317	-
4a.1.5.6	Condensate	-	171	-	-	-	-	-	26	197	-	-	197	-	-	-	-	-	-	3,866	-
4a.1.5.7	Condenser Evacuation & H2-CO2 Pipi	-	39	-	-	-	-	-	6	45	-	-	45	-	-	-	-	-	-	857	-
4a.1.5.8	Gas Control	-	0	-	-	-	-	-	0	0	-	-	0	-	-	-	-	-	-	5	-
4a.1.5.9	Heater Drains & Vents	-	41	-	-	-	-	-	6	47	-	-	47	-	-	-	-	-	-	935	-
4a.1.5.10	Heater Drains & Vents-RCA	-	90	2	7	106	-	-	40	245	245	-	-	1,240	-	-	-	-	50,358	1,491	-
4a.1.5.11	Jacket Water For Diesel Gen # 1-RCA	-	5	0	0	4	-	-	2	11	11	-	-	46	-	-	-	-	1,875	90	-
4a.1.5.12	Jacket Water For Diesel Gen # 2-RCA	-	5	0	0	4	-	-	2	10	10	-	-	43	-	-	-	-	1,748	80	-
4a.1.5.13	Lube Oil	-	42	-	-	-	-	-	6	49	-	-	49	-	-	-	-	-	-	936	-
4a.1.5.14	Main Steam	-	123	-	-	-	-	-	19	142	-	-	142	-	-	-	-	-	-	2,755	-
4a.1.5.15	Main Steam-RCA	-	128	5	19	290	-	-	79	522	522	-	-	3,387	-	-	-	-	137,564	2,329	-
4a.1.5.16	Secondary Plant Sampling	-	18	-	-	-	-	-	3	21	-	-	21	-	-	-	-	-	-	437	-
4a.1.5.17	Shaft Sealing Steam	-	12	-	-	-	-	-	2	14	-	-	14	-	-	-	-	-	-	273	-
4a.1.5.18	Starting Air - RCA	-	52	1	3	50	-	-	21	126	126	-	-	579	-	-	-	-	23,511	959	-
4a.1.5.19	Stator Winding Cooling Water	-	20	-	-	-	-	-	3	23	-	-	23	-	-	-	-	-	-	440	-
4a.1.5.20	Steam Generator Blowdown Processing	-	186	3	11	160	-	-	72	432	432	-	-	1,869	-	-	-	-	75,911	3,146	-
4a.1.5.21	Steam Generator Feedwater & Blowdo	-	1,003	56	209	3,104	-	-	753	5,125	5,125	-	-	36,228	-	-	-	-	1,471,243	18,725	-
4a.1.5.22	Turbine Plant Cooling Water	-	55	-	-	-	-	-	8	63	-	-	63	-	-	-	-	-	-	1,239	-
4a.1.5.23	Turbine Plant Cooling Water-RCA	-	42	1	3	48	-	-	18	112	112	-	-	556	-	-	-	-	22,582	763	-
4a.1.5	Totals	-	2,435	68	255	3,797	-	-	1,135	7,690	6,669	-	1,020	44,308	-	-	-	-	1,799,361	48,327	-
4a.1.6	Scaffolding in support of decommission	-	664	13	4	58	17	-	181	938	938	-	-	614	54	-	-	-	31,075	15,113	-
4a.1	Subtotal Period 4a Activity Costs	177	23,379	7,913	4,379	6,642	18,395	431	21,716	83,031	82,010	-	1,020	84,151	32,235	475	907	825	6,612,208	147,266	7,773
Period 4a Additional Costs																					
4a.2.1	Retired Presurizer	-	-	416	125	-	614	-	214	1,369	1,369	-	-	-	1,856	-	-	-	145,522	-	-
4a.2.2	Retired RX closure head	-	115	264	661	-	371	-	247	1,660	1,660	-	-	-	2,029	-	-	-	164,824	3,157	2,000
4a.2.3	Remedial Action Surveys	-	-	-	-	-	-	1,465	439	1,904	1,904	-	-	-	-	-	-	-	-	22,908	-
4a.2.4	Lead Abatement Crew	-	648	-	-	-	-	-	162	810	810	-	-	-	-	-	-	-	-	13,745	-
4a.2.5	Asbestos abatement	-	-	-	-	-	-	4,000	-	4,000	4,000	-	-	-	27,000	-	-	-	351,000	-	-
4a.2	Subtotal Period 4a Additional Costs	-	764	680	786	-	986	5,465	1,063	9,743	9,743	-	-	-	30,885	-	-	-	661,346	39,811	2,000
Period 4a Collateral Costs																					
4a.3.1	Process decommissioning water waste	4	-	5	11	-	16	-	8	43	43	-	-	-	52	-	-	-	3,092	10	-
4a.3.3	Small tool allowance	-	141	-	-	-	-	-	21	163	146	-	16	-	-	-	-	-	-	-	-
4a.3.4	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	1,510	226	1,736	1,736	-	-	-	-	-	-	-	-	-	-
4a.3	Subtotal Period 4a Collateral Costs	4	141	5	11	-	16	1,510	256	1,942	1,926	-	16	-	52	-	-	-	3,092	10	-
Period 4a Period-Dependent Costs																					
4a.4.1	Decon supplies	74	-	-	-	-	-	-	18	92	92	-	-	-	-	-	-	-	-	-	-
4a.4.2	Insurance	-	-	-	-	-	-	650	65	715	715	-	-	-	-	-	-	-	-	-	-
4a.4.3	Property taxes	-	-	-	-	-	-	22	2	24	24	-	-	-	-	-	-	-	-	-	-
4a.4.4	Health physics supplies	-	1,340	-	-	-	-	-	335	1,675	1,675	-	-	-	-	-	-	-	-	-	-
4a.4.5	Equipment rental	-	2,444	-	-	-	-	-	367	2,810	2,810	-	-	-	-	-	-	-	-	-	-
4a.4.6	Disposal of DAW generated	-	-	57	19	-	211	-	61	349	349	-	-	-	2,924	-	-	-	58,477	95	-
4a.4.7	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a.4.8	NRC Fees	-	-	-	-	-	-	614	61	675	675	-	-	-	-	-	-	-	-	-	-
4a.4.9	Corporate A&G	-	-	-	-	-	-	732	110	842	842	-	-	-	-	-	-	-	-	-	-
4a.4.10	Liquid Radwaste Processing Equipmer	-	-	-	-	-	-	446	67	513	513	-	-	-	-	-	-	-	-	-	-
4a.4.11	Post-operations water processing	-	-	-	-	-	-	110	16	126	126	-	-	-	-	-	-	-	-	-	-
4a.4.12	Security Staff Cost	-	-	-	-	-	-	4,727	709	5,436	5,436	-	-	-	-	-	-	-	-	-	71,589
4a.4.13	DOC Staff Cost	-	-	-	-	-	-	12,668	1,900	14,568	14,568	-	-	-	-	-	-	-	-	-	158,069
4a.4.14	Utility Staff Cost	-	-	-	-	-	-	17,335	2,600	19,935	19,935	-	-	-	-	-	-	-	-	-	286,356
4a.4	Subtotal Period 4a Period-Dependent (	74	3,784	57	19	-	211	37,303	6,312	47,760	47,760	-	-	-	2,924	-	-	-	58,477	95	516,014
4a.0	TOTAL PERIOD 4a COST	254	28,068	8,654	5,195	6,642	19,608	44,709	29,347	142,476	141,440	-	1,037	84,151	66,095	475	907	825	7,335,124	187,182	525,787
PERIOD 4b - Site Decontamination																					
Disposal of Plant Systems																					
4b.1.2.1	Chemical & Volume Control	-	391	25	25	182	374	-	225	1,222	1,222	-	-	2,127	1,187	-	-	-	161,798	7,036	-
4b.1.2.2	Component Cooling - RCA	-	358	21	79	1,183	-	-	281	1,923	1,923	-	-	13,805	-	-	-	-	560,640	6,558	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Disposal of Plant Systems (continued)																					
4b.1.2.3	Compressed Air	-	52	-	-	-	-	-	8	60	-	-	60	-	-	-	-	-	-	1,188	-
4b.1.2.4	Compressed Air-RCA	-	22	0	1	12	-	-	7	42	42	-	-	141	-	-	-	-	5,716	377	-
4b.1.2.5	Demineralized Water	-	173	-	-	-	-	-	26	199	-	-	199	-	-	-	-	-	-	3,769	-
4b.1.2.6	Demineralized Water-RCA	-	78	1	5	70	-	-	31	185	185	-	-	818	-	-	-	-	33,204	1,311	-
4b.1.2.7	Electrical - Clean	-	3,587	-	-	-	-	-	538	4,125	-	-	4,125	-	-	-	-	-	-	77,827	-
4b.1.2.8	Electrical - Clean-RCA	-	6,596	128	478	7,122	-	-	2,802	17,126	17,126	-	-	83,110	-	-	-	-	3,375,151	125,395	-
4b.1.2.9	Electrical - Contaminated	-	959	14	53	790	-	-	367	2,183	2,183	-	-	9,216	-	-	-	-	374,272	18,552	-
4b.1.2.10	Fire Protection	-	98	-	-	-	-	-	15	113	-	-	113	-	-	-	-	-	-	2,211	-
4b.1.2.11	Fire Protection-RCA	-	179	4	16	235	-	-	83	518	518	-	-	2,747	-	-	-	-	111,573	3,164	-
4b.1.2.12	Fuel Oil	-	34	-	-	-	-	-	5	39	-	-	39	-	-	-	-	-	-	720	-
4b.1.2.13	Fuel Oil-RCA	-	3	0	0	2	-	-	1	7	7	-	-	24	-	-	-	-	971	48	-
4b.1.2.14	HVAC - Auxiliary	-	348	10	41	607	-	-	185	1,192	1,192	-	-	7,090	-	-	-	-	287,911	6,005	-
4b.1.2.15	HVAC - Chem & Radiation Prot. Fac.	-	25	-	-	-	-	-	4	29	-	-	29	-	-	-	-	-	-	572	-
4b.1.2.16	HVAC - Chem & Radiation Prot. Fac.-I	-	49	1	4	53	-	-	21	127	127	-	-	619	-	-	-	-	25,145	752	-
4b.1.2.17	HVAC - Containment	-	326	11	41	617	-	-	181	1,175	1,175	-	-	7,196	-	-	-	-	292,239	5,904	-
4b.1.2.18	HVAC - Intake Structure	-	21	-	-	-	-	-	3	25	-	-	25	-	-	-	-	-	-	532	-
4b.1.2.19	HVAC - Office/Cafeteria Addition	-	15	-	-	-	-	-	2	17	-	-	17	-	-	-	-	-	-	361	-
4b.1.2.20	HVAC - Rad Processing	-	106	3	10	147	-	-	50	315	315	-	-	1,714	-	-	-	-	69,606	1,816	-
4b.1.2.21	HVAC - Tech Support Center	-	15	-	-	-	-	-	2	17	-	-	17	-	-	-	-	-	-	359	-
4b.1.2.22	HVAC - Turbine Bldg	-	145	-	-	-	-	-	22	166	-	-	166	-	-	-	-	-	-	3,590	-
4b.1.2.23	Instrument Air	-	8	-	-	-	-	-	1	9	-	-	9	-	-	-	-	-	-	188	-
4b.1.2.24	Instrument Air-RCA	-	36	0	1	15	-	-	11	64	64	-	-	175	-	-	-	-	7,091	653	-
4b.1.2.25	Nitro/Hydro/Methane/Propane & Oxyg	-	1	-	-	-	-	-	0	1	-	-	1	-	-	-	-	-	-	26	-
4b.1.2.26	Nitro\Hydro\Methane\Propane & Ox	-	7	0	1	13	-	-	4	25	25	-	-	155	-	-	-	-	6,282	118	-
4b.1.2.27	PH Neutralization	-	78	2	6	95	-	-	35	216	216	-	-	1,114	-	-	-	-	45,238	1,444	-
4b.1.2.28	Post Accident Sampling	-	73	1	2	30	-	-	23	128	128	-	-	346	-	-	-	-	14,065	1,434	-
4b.1.2.29	Potable Water	-	21	-	-	-	-	-	3	24	-	-	24	-	-	-	-	-	-	476	-
4b.1.2.30	Potable Water-RCA	-	32	0	1	20	-	-	11	65	65	-	-	237	-	-	-	-	9,606	510	-
4b.1.2.31	Primary Plant Sampling	-	92	1	3	42	-	-	30	167	167	-	-	490	-	-	-	-	19,905	1,779	-
4b.1.2.32	Raw Water	-	74	-	-	-	-	-	11	86	-	-	86	-	-	-	-	-	-	1,705	-
4b.1.2.33	Raw Water-RCA	-	26	1	3	52	-	-	15	98	98	-	-	608	-	-	-	-	24,689	495	-
4b.1.2.34	Reactor Coolant Misc	-	43	2	3	20	35	-	23	127	127	-	-	239	113	-	-	-	16,835	849	-
4b.1.2.35	Safety Injection & Containment Spray	-	2,600	86	336	5,003	-	-	1,459	9,484	9,484	-	-	58,385	-	-	-	-	2,371,037	50,618	-
4b.1.2.36	Service Water	-	6	-	-	-	-	-	1	7	-	-	7	-	-	-	-	-	-	142	-
4b.1.2.37	Service Water-RCA	-	19	0	1	12	-	-	7	38	38	-	-	142	-	-	-	-	5,775	286	-
4b.1.2.38	Spent Fuel Pool Cooling	-	184	13	13	96	191	-	112	609	609	-	-	1,122	607	-	-	-	84,142	3,437	-
4b.1.2.39	Waste Disposal	-	1,101	62	72	631	874	-	605	3,345	3,345	-	-	7,368	2,773	-	-	-	475,356	19,564	-
4b.1.2	Totals	-	17,979	386	1,195	17,051	1,475	-	7,211	45,296	40,381	-	4,916	198,987	4,680	-	-	-	8,378,247	351,772	-
4b.1.3	Scaffolding in support of decommission	-	996	20	7	87	26	-	272	1,407	1,407	-	-	921	81	-	-	-	46,613	22,669	-
4b.1.5	Prepare/submit License Termination Plan			-	-	-	-	468	70	538	538	-	-	-	-	-	-	-	-	-	4,096
4b.1.6	Receive NRC approval of termination plan			-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
4b.1	Subtotal Period 4b Activity Costs	-	18,975	406	1,201	17,138	1,500	468	7,553	47,242	42,326	-	4,916	199,908	4,761	-	-	-	8,424,860	374,440	4,096
Period 4b Additional Costs																					
4b.2.1	License termination survey planning	-	-	-	-	-	-	1,185	355	1,540	1,540	-	-	-	-	-	-	-	-	-	12,480
4b.2.2	Remedial action surveys	-	-	-	-	-	-	4,139	1,242	5,381	5,381	-	-	-	-	-	-	-	-	64,736	-
4b.2.3	Underground Services Excavations	-	1,487	-	-	-	-	883	356	2,726	-	-	2,726	-	-	-	-	-	-	13,986	-
4b.2.4	Operational tools & equipment	-	-	8	57	618	-	-	102	785	785	-	-	11,710	-	-	-	-	292,750	44	-
4b.2.5	ISFSI Decommissioning	-	32	85	343	-	2,411	2,024	1,224	6,119	6,119	-	-	-	13,017	-	-	-	1,537,274	5,929	14,512
4b.2.6	Lead Abatement Crew	-	2,483	-	-	-	-	-	621	3,104	3,104	-	-	-	-	-	-	-	-	38,842	-
4b.2.7	Asbestos abatement	-	-	-	-	-	-	4,000	-	4,000	4,000	-	-	-	27,000	-	-	-	351,000	-	-
4b.2.8	Containment	1,161	602	29	116	145	1,022	-	1,029	4,104	4,104	-	-	1,691	10,300	-	-	-	556,345	33,336	-
4b.2.9	Auxiliary	607	182	10	41	32	369	-	453	1,695	1,695	-	-	374	3,745	-	-	-	192,346	15,020	-
4b.2.10	Radwaste	78	19	1	5	6	46	-	57	212	212	-	-	70	465	-	-	-	24,743	1,850	-
4b.2.11	Fuel Handling Area (Decon)	605	644	7	17	178	78	-	513	2,040	2,040	-	-	2,072	609	-	-	-	114,409	23,613	-
4b.2	Subtotal Period 4b Additional Costs	2,451	5,449	140	579	978	3,925	12,231	5,951	31,706	28,980	-	2,726	15,918	55,136	-	-	-	3,068,869	197,357	26,992
Period 4b Collateral Costs																					
4b.3.1	Process decommissioning water waste	8	-	11	24	-	37	-	18	97	97	-	-	-	116	-	-	-	6,967	23	-
4b.3.3	Small tool allowance	-	374	-	-	-	-	-	56	430	430	-	-	-	-	-	-	-	-	-	-
4b.3.4	Decommissioning Equipment Dispositi	-	-	128	50	570	167	-	147	1,062	1,062	-	-	6,000	529	-	-	-	303,608	147	-
4b.3.5	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	4,284	643	4,927	4,927	-	-	-	-	-	-	-	-	-	-
4b.3	Subtotal Period 4b Collateral Costs	8	374	139	74	570	203	4,284	864	6,516	6,516	-	-	6,000	645	-	-	-	310,575	170	-
Period 4b Period-Dependent Costs																					
4b.4.1	Decon supplies	246	-	-	-	-	-	-	62	308	308	-	-	-	-	-	-	-	-	-	-
4b.4.2	Insurance	-	-	-	-	-	-	1,837	184	2,020	2,020	-	-	-	-	-	-	-	-	-	-
4b.4.3	Property taxes	-	-	-	-	-	-	62	6	68	68	-	-	-	-	-	-	-	-	-	-
4b.4.4	Health physics supplies	-	3,942	-	-	-	-	-	986	4,928	4,928	-	-	-	-	-	-	-	-	-	-
4b.4.5	Equipment rental	-	7,091	-	-	-	-	-	1,064	8,155	8,155	-	-	-	-	-	-	-	-	-	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 4b Period-Dependent Costs (continued)																					
4b.4.6	Disposal of DAW generated	-	-	114	38	-	422	-	123	697	697	-	-	-	5,848	-	-	-	116,969	191	-
4b.4.7	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4b.4.8	NRC Fees	-	-	-	-	-	-	1,735	174	1,909	1,909	-	-	-	-	-	-	-	-	-	-
4b.4.9	Corporate A&G	-	-	-	-	-	-	2,068	310	2,378	2,378	-	-	-	-	-	-	-	-	-	-
4b.4.10	Liquid Radwaste Processing Equipmer	-	-	-	-	-	-	1,260	189	1,449	1,449	-	-	-	-	-	-	-	-	-	-
4b.4.11	Post-operations water processing	-	-	-	-	-	-	311	47	358	358	-	-	-	-	-	-	-	-	-	-
4b.4.12	Security Staff Cost	-	-	-	-	-	-	13,428	2,014	15,442	15,442	-	-	-	-	-	-	-	-	-	202,301
4b.4.13	DOC Staff Cost	-	-	-	-	-	-	34,839	5,226	40,064	40,064	-	-	-	-	-	-	-	-	-	433,734
4b.4.14	Utility Staff Cost	-	-	-	-	-	-	46,242	6,936	53,179	53,179	-	-	-	-	-	-	-	-	-	763,890
4b.4	Subtotal Period 4b Period-Dependent (	246	11,034	114	38	-	422	101,782	17,319	130,955	130,955	-	-	-	5,848	-	-	-	116,969	191	1,399,926
4b.0	TOTAL PERIOD 4b COST	2,705	35,832	799	1,893	18,686	6,051	118,764	31,687	216,418	208,777	-	7,641	221,826	66,391	-	-	-	11,900,000	572,158	1,431,014
PERIOD 4f - License Termination																					
Period 4f Direct Decommissioning Activities																					
4f.1.1	ORISE confirmatory survey	-	-	-	-	-	-	168	50	218	218	-	-	-	-	-	-	-	-	-	-
4f.1.2	Terminate license	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
4f.1	Subtotal Period 4f Activity Costs	-	-	-	-	-	-	168	50	218	218	-	-	-	-	-	-	-	-	-	-
Period 4f Additional Costs																					
4f.2.2	License termination survey	-	-	-	-	-	-	6,835	2,050	8,885	8,885	-	-	-	-	-	-	-	-	116,433	6,240
4f.2	Subtotal Period 4f Additional Costs	-	-	-	-	-	-	6,835	2,050	8,885	8,885	-	-	-	-	-	-	-	-	116,433	6,240
Period 4f Collateral Costs																					
4f.3.1	DOC staff relocation expenses	-	-	-	-	-	-	1,406	211	1,617	1,617	-	-	-	-	-	-	-	-	-	-
4f.3.2	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	418	63	480	480	-	-	-	-	-	-	-	-	-	-
4f.3	Subtotal Period 4f Collateral Costs	-	-	-	-	-	-	1,824	274	2,097	2,097	-	-	-	-	-	-	-	-	-	-
Period 4f Period-Dependent Costs																					
4f.4.1	Insurance	-	-	-	-	-	-	79	8	87	87	-	-	-	-	-	-	-	-	-	-
4f.4.2	Property taxes	-	-	-	-	-	-	15	2	17	17	-	-	-	-	-	-	-	-	-	-
4f.4.3	Health physics supplies	-	652	-	-	-	-	-	163	815	815	-	-	-	-	-	-	-	-	-	-
4f.4.4	Disposal of DAW generated	-	-	7	2	-	25	-	7	42	42	-	-	-	351	-	-	-	7,025	11	-
4f.4.5	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4f.4.6	NRC Fees	-	-	-	-	-	-	421	42	463	463	-	-	-	-	-	-	-	-	-	-
4f.4.7	Corporate A&G	-	-	-	-	-	-	501	75	576	576	-	-	-	-	-	-	-	-	-	-
4f.4.8	Post-operations water processing	-	-	-	-	-	-	75	11	87	87	-	-	-	-	-	-	-	-	-	-
4f.4.9	Security Staff Cost	-	-	-	-	-	-	1,248	187	1,435	1,435	-	-	-	-	-	-	-	-	-	18,805
4f.4.10	DOC Staff Cost	-	-	-	-	-	-	4,582	687	5,269	5,269	-	-	-	-	-	-	-	-	-	57,200
4f.4.11	Utility Staff Cost	-	-	-	-	-	-	4,506	676	5,182	5,182	-	-	-	-	-	-	-	-	-	74,438
4f.4	Subtotal Period 4f Period-Dependent C	-	652	7	2	-	25	11,427	1,859	13,973	13,973	-	-	-	351	-	-	-	7,025	11	150,444
4f.0	TOTAL PERIOD 4f COST	-	652	7	2	-	25	20,254	4,233	25,174	25,174	-	-	-	351	-	-	-	7,025	116,445	156,684
PERIOD 4 TOTALS		2,959	64,552	9,460	7,090	25,329	25,684	183,727	65,267	384,068	375,390	-	8,678	305,976	132,837	475	907	825	19,300,000	875,784	2,113,485
PERIOD 5b - Site Restoration																					
Period 5b Direct Decommissioning Activities																					
Demolition of Remaining Site Buildings																					
5b.1.1.1	Containment	-	1,199	-	-	-	-	-	180	1,379	-	-	1,379	-	-	-	-	-	-	9,293	-
5b.1.1.2	Administration	-	60	-	-	-	-	-	9	69	-	-	69	-	-	-	-	-	-	842	-
5b.1.1.3	Auxiliary	-	1,338	-	-	-	-	-	201	1,539	-	-	1,539	-	-	-	-	-	-	10,052	-
5b.1.1.4	Chemistry & Radiation Protection Fac.	-	124	-	-	-	-	-	19	143	-	-	143	-	-	-	-	-	-	1,504	-
5b.1.1.5	Intake	-	103	-	-	-	-	-	15	118	-	-	118	-	-	-	-	-	-	1,271	-
5b.1.1.6	Maintenance Shop	-	154	-	-	-	-	-	23	177	-	-	177	-	-	-	-	-	-	2,201	-
5b.1.1.7	Miscellaneous Structures	-	840	-	-	-	-	-	126	966	-	-	966	-	-	-	-	-	-	10,244	-
5b.1.1.8	New Security Access Facility	-	59	-	-	-	-	-	9	68	-	-	68	-	-	-	-	-	-	610	-
5b.1.1.9	Original Steam Generator Storage	-	125	-	-	-	-	-	19	144	-	-	144	-	-	-	-	-	-	763	-
5b.1.1.10	Radwaste	-	236	-	-	-	-	-	35	272	-	-	272	-	-	-	-	-	-	2,322	-
5b.1.1.11	Security	-	47	-	-	-	-	-	7	54	-	-	54	-	-	-	-	-	-	684	-
5b.1.1.12	Security Modifications	-	244	-	-	-	-	-	37	280	-	-	280	-	-	-	-	-	-	1,138	-
5b.1.1.13	Service	-	172	-	-	-	-	-	26	198	-	-	198	-	-	-	-	-	-	1,919	-
5b.1.1.14	Technical Support Center	-	59	-	-	-	-	-	9	68	-	-	68	-	-	-	-	-	-	468	-
5b.1.1.15	Turbine	-	839	-	-	-	-	-	126	964	-	-	964	-	-	-	-	-	-	13,015	-
5b.1.1.16	Turbine Pedestal	-	305	-	-	-	-	-	46	351	-	-	351	-	-	-	-	-	-	2,245	-
5b.1.1.17	Warehouse	-	234	-	-	-	-	-	35	269	-	-	269	-	-	-	-	-	-	2,467	-
5b.1.1	Totals	-	6,139	-	-	-	-	-	921	7,060	-	-	7,060	-	-	-	-	-	-	61,037	-

Table C
Fort Calhoun Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Site Closeout Activities																					
5b.1.2	Remove Rubble	-	565	-	-	-	-	-	85	649	-	-	649	-	-	-	-	-	-	3,280	-
5b.1.3	Grade & landscape site	-	533	-	-	-	-	-	80	613	-	-	613	-	-	-	-	-	-	1,326	-
5b.1.4	Final report to NRC	-	-	-	-	-	-	178	27	205	205	-	-	-	-	-	-	-	-	-	1,560
5b.1	Subtotal Period 5b Activity Costs	-	7,237	-	-	-	-	178	1,112	8,528	205	-	8,323	-	-	-	-	-	-	65,642	1,560
Period 5b Additional Costs																					
5b.2.1	Lagoon Closure	-	178	-	-	-	-	208	58	444	-	-	444	-	-	-	-	-	-	1,264	-
5b.2.2	Concrete Processing	-	365	-	-	-	-	11	56	432	-	-	432	-	-	-	-	-	-	1,931	-
5b.2.3	Demolition and site restoration - ISFSI	-	595	-	-	-	-	127	108	830	-	-	830	-	-	-	-	-	-	3,218	160
5b.2.4	Disposal of contruction debris from der	-	-	-	-	-	-	284	43	327	-	-	327	-	-	-	-	-	-	-	-
5b.2.5	Firing Range Closure	-	4	-	-	-	-	54	9	66	-	-	66	-	-	-	-	-	-	25	-
5b.2.6	Intake Cofferdam	-	934	-	-	-	-	-	140	1,074	-	-	1,074	-	-	-	-	-	-	8,721	-
5b.2.7	Demolition Credit from Site Reconfigu	-	(230)	-	-	-	-	-	-	(230)	-	-	(230)	-	-	-	-	-	-	-	-
5b.2	Subtotal Period 5b Additional Costs	-	1,846	-	-	-	-	683	414	2,942	-	-	2,942	-	-	-	-	-	-	15,157	160
Period 5b Collateral Costs																					
5b.3.1	Small tool allowance	-	67	-	-	-	-	-	10	77	-	-	77	-	-	-	-	-	-	-	-
5b.3.2	Site O&M (Non-Labor Overhead)	-	-	-	-	-	-	342	51	393	-	-	393	-	-	-	-	-	-	-	-
5b.3	Subtotal Period 5b Collateral Costs	-	67	-	-	-	-	342	61	470	-	-	470	-	-	-	-	-	-	-	-
Period 5b Period-Dependent Costs																					
5b.4.1	Insurance	-	-	-	-	-	-	158	16	173	-	-	173	-	-	-	-	-	-	-	-
5b.4.2	Property taxes	-	-	-	-	-	-	30	3	33	-	-	33	-	-	-	-	-	-	-	-
5b.4.3	Equipment rental	-	4,699	-	-	-	-	-	705	5,403	-	-	5,403	-	-	-	-	-	-	-	-
5b.4.4	Plant energy budget	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5b.4.5	Corporate A&G	-	-	-	-	-	-	998	150	1,147	-	-	1,147	-	-	-	-	-	-	-	-
5b.4.6	Post-operations water processing	-	-	-	-	-	-	150	23	173	-	-	173	-	-	-	-	-	-	-	-
5b.4.7	Security Staff Cost	-	-	-	-	-	-	2,487	373	2,860	-	-	2,860	-	-	-	-	-	-	-	37,474
5b.4.8	DOC Staff Cost	-	-	-	-	-	-	8,668	1,300	9,968	-	-	9,968	-	-	-	-	-	-	-	106,177
5b.4.9	Utility Staff Cost	-	-	-	-	-	-	3,686	553	4,239	-	-	4,239	-	-	-	-	-	-	-	60,896
5b.4	Subtotal Period 5b Period-Dependent (	-	4,699	-	-	-	-	16,177	3,122	23,997	-	-	23,997	-	-	-	-	-	-	-	204,547
5b.0	TOTAL PERIOD 5b COST	-	13,849	-	-	-	-	17,379	4,709	35,937	205	-	35,733	-	-	-	-	-	-	80,800	206,267
PERIOD 5 TOTALS		-	13,849	-	-	-	-	17,379	4,709	35,937	205	-	35,733	-	-	-	-	-	-	80,800	206,267
TOTAL COST TO DECOMMISSION		4,324	82,268	9,853	7,461	25,329	28,221	1,031,675	194,243	1,383,373	931,973	405,543	45,857	305,976	198,630	725	963	825	20,389,870	988,235	11,393,966

TOTAL COST TO DECOMMISSION WITH 16.33% CONTINGENCY:	1,383,373	thousands of 2016 dollars
TOTAL NRC LICENSE TERMINATION COST IS 67.37% OR:	931,973	thousands of 2016 dollars
SPENT FUEL MANAGEMENT COST IS 29.32% OR:	405,543	thousands of 2016 dollars
NON-NUCLEAR DEMOLITION COST IS 3.31% OR:	45,857	thousands of 2016 dollars
TOTAL LOW-LEVEL RADIOACTIVE WASTE VOLUME BURIED (EXCLUDING GT(	200,317	cubic feet
TOTAL GREATER THAN CLASS C RADWASTE VOLUME GENERATED:	825	cubic feet
TOTAL SCRAP METAL REMOVED:	26,693	tons
TOTAL CRAFT LABOR REQUIREMENTS:	988,235	man-hours

End Notes:
n/a - indicates that this activity not charged as decommissioning expense
a - indicates that this activity performed by decommissioning staff
0 - indicates that this value is less than 0.5 but is non-zero

APPENDIX D

ISFSI DECOMMISSIONING

Table D
Fort Calhoun Station
ISFSI Decommissioning Cost Estimate
(thousands of 2016 dollars)

Activity Description	Removal Costs	Packaging Costs	Transport Costs	LLRW Disposal Costs	Other Costs	Total Costs	Burial Volume Class A (cubic feet)	Craft Manhours	Oversight and Contractor Manhours
Decommissioning Contractor									
Planning (characterization, specs and procedures)	-	-	-	-	194	194	-	-	1,000
Decontamination (activated disposition)	32	85	343	2,411	26	2,897	13,017	358	
License Termination (radiological surveys)	-	-	-	-	738	738	-	5,571	-
Subtotal	**32**	**85**	**343**	**2,411**	**958**	**3,829**	**13,017**	**5,929**	**1,000**
Supporting Costs									
NRC and NRC Contractor Fees and Costs	-	-	-	-	365	365	-	-	776
Insurance					105	105	-	-	-
Property taxes					10	10	-	-	-
Plant energy budget					-	-	-	-	-
Non-Labor Overhead					30	30	-	-	-
Security Staff Cost					329	329	-	-	7,437
Oversight Staff Cost					228	228	-	-	5,300
Subtotal	**-**	**-**	**-**	**-**	**1,066**	**1,066**	**-**	**-**	**13,512**
Total (w/o contingency)	**32**	**85**	**343**	**2,411**	**2,024**	**4,895**	**13,017**	**5,929**	**14,512**
Total (w/25% contingency)	**40**	**106**	**429**	**3,013**	**2,530**	**6,119**			

The application of contingency (25%) is consistent with the evaluation criteria referenced by the NRC in NUREG-1757 ("Consolidated Decommissioning Guidance, Financial Assurance, Recordkeeping, and Timeliness," U.S. NRC's Office of Nuclear Material Safety and Safeguards, NUREG-1757, Vol. 3, Rev. 1, February 2012)