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DECOMMISSIONING COST ANALYSIS

for the

COLUMBIA GENERATING STATION

prepared for the

Bonneville Power Administration

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

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EXECUTIVE SUMMARY

This report presents estimates of the cost to decommission the Columbia Generating Station (Columbia) for the selected decommissioning alternatives following the scheduled and permanent cessation of plant operations. The estimates are designed to provide the Bonneville Power Administration[1] (BPA) with sufficient information to assess the financial obligations, as they pertain to the eventual decommissioning of the nuclear station.

The analysis relies upon site-specific, technical information from an evaluation prepared in 1989,[2] updated to reflect current assumptions pertaining to the operating life of the reactor, disposition of the nuclear plant and relevant industry experience in undertaking such projects. The costs are based on several key assumptions in areas of regulation, component characterization, high-level radioactive waste management, low-level radioactive waste disposal, performance uncertainties (contingency) and site restoration requirements.

The costs to decommission Columbia for the DECON and SAFSTOR alternatives are shown below. Costs are reported in 2018 dollars and include monies anticipated to be spent for radiological remediation and operating license termination, spent fuel management, and site restoration activities.

Alternative	DECON	SAFSTOR
	(thousands, $2018)	
License Termination (Radiological Remediation)	$794,924	$1,059,307
Spent Fuel Management	$497,388	$452,479
Site Restoration	$140,127	$138,748
Total	$1,432,439	$1,650,534

The analysis is not a detailed engineering evaluation, but estimates prepared in advance of the detailed engineering required to carry out the decommissioning of the nuclear unit. It may also not reflect the actual plan to decommission Columbia; the plan may differ from the assumptions made in this analysis based on facts that exist at the time of decommissioning.

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1 Columbia is owned and operated by Energy Northwest, a joint operating agency comprising 22 public utility districts and five municipalities. All electrical energy produced by Columbia is delivered to electrical distribution facilities owned and operated by BPA as part of the Federal Columbia River Power System.

2 "Decommissioning Cost Study for the WPPSS Nuclear Project No. 2," Document B04-25-001, Rev. 1, prepared for Battelle Pacific Northwest Laboratories by TLG Services, Inc., June 1989

The plant inventory, the basis for the decontamination and dismantling requirements and cost, and the decommissioning waste streams, was reviewed for this analysis. It was updated to reflect the current physical plant (systems and site structures).

The summary tables at the end of this section identify the major cost elements and their contribution to the total cost for each alternative. A complete discussion of the assumptions relied upon in this analysis is provided in Section 3, along with schedules of annual expenditures for each scenario. A sequence of significant project activities is provided in Section 4 with a timeline for each scenario. Detailed cost reports, used to generate the summary tables contained within this document, are provided in Appendices C and D.

The current cost estimates assume that the shutdown of the nuclear unit is a scheduled and pre-planned event (e.g., there is no delay in transitioning the plant and workforce from operations or in obtaining regulatory relief from operating requirements). The estimates include the continued operation of the reactor building as an interim wet fuel storage facility for approximately five and one-half years after operations cease. During this time period, the spent fuel residing in the wet storage pool, assuming that the Department of Energy (DOE) has not performed, will be moved to an on-site independent spent fuel storage installation (ISFSI) for storage.

The ISFSI will remain operational until the DOE is able to complete the transfer of the fuel to a federal facility (e.g., a monitored retrievable storage facility).[3] DOE has breached its obligations to remove fuel from reactor sites, and has also failed to provide the plant owners 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 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 perform, and for purposes of this analysis only, it is assumed that DOE will accept already-canistered fuel. (It is recognized that the canisters may not be licensed or licensable for transportation when DOE performs.) If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers.

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3 Projected expenditures for spent fuel management identified in the cost analyses do not consider the outcome of the litigation with the DOE with regard to the delays incurred by Energy Northwest in the timely removal of spent fuel from the site.

Alternatives and Regulations

The Nuclear Regulatory Commission (NRC) provided general decommissioning requirements in a rule adopted on June 27, 1988.[4] In this rule, the NRC set forth technical and financial criteria for decommissioning licensed nuclear facilities. The regulations addressed planning needs, timing, funding methods, and environmental review requirements for decommissioning. The rule also defined the decommissioning alternatives as being acceptable to the NRC, including DECON and SAFSTOR which were evaluated for Columbia.

> 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."[5]
>
> 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."[6] Decommissioning is required to be completed within 60 years, although longer time periods will be considered when necessary to protect public health and safety.

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.[7] The amendments allow for greater public participation and better define the transition process from operations to decommissioning. Regulatory Guide 1.184, issued in July 2000, (as revised 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

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

5 Ibid. Page FR24022, Column 3

6 Ibid.

7 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

content of the estimates is also consistent with the recommendations of Regulatory Guide 1.202, issued in February 2005.[8]

In 2011, the NRC issued regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[9] The 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 E.

Decommissioning Scenarios

Two decommissioning scenarios were evaluated for Columbia. The scenarios selected are representative of alternatives currently available and are defined as follows:

1. The first scenario assumes that the unit is promptly decommissioned (DECON alternative) upon the expiration of the current operating license in 2043. Following the cessation of operations, and assuming that the DOE has not performed, the spent fuel that is relocated from the wet storage pool to the ISFSI for interim storage so as to facilitate decontamination and dismantling activities within the reactor building. Once the spent fuel has been removed from the reactor building, the reactor building and remaining portions of the power block are decommissioned, non-essential structures dismantled and the site, exclusive of the ISFSI, remediated and dismantled. The ISFSI remains operational until the transfer of the spent fuel to the DOE is complete. Once completed, the ISFSI is decommissioned and the pad demolished.

2. In the second scenario, the nuclear unit is placed into safe-storage (SAFSTOR alternative) upon the expiration of the current operating license in 2043. As with the first scenario, spent fuel is transferred to the ISFSI for interim storage. ISFSI operations continue at the site until the transfer of the spent fuel to the DOE is complete. The start of decontamination and dismantling activities is deferred to the maximum extent (approximately 50 years from the cessation of operations) such that the license is terminated within the required 60-year period.

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

9 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

Methodology

The methodology used to develop the estimates follows the basic approach originally presented in the cost estimating guidelines[10] developed by the Atomic Industrial Forum (now Nuclear Energy Institute). This reference describes a unit cost factor method for estimating decommissioning activity costs. The unit cost factors used in this analysis incorporate site-specific costs and the latest available information about worker productivity in decommissioning.

The estimates also reflect 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 Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee, Crystal River, Vermont Yankee, and Fort Calhoun nuclear units have provided additional insight into the process, the regulatory aspects, and the technical challenges of decommissioning commercial nuclear units.

Contingency

Consistent with cost estimating practice, contingencies are applied to the decontamination and dismantling costs developed 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."[11] The cost elements in the estimates 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 remaining operating life of the station.

Contingency funds are expected to be fully expended throughout the program. As such, inclusion of contingency is necessary to provide assurance that sufficient funding will be available to accomplish the intended tasks.

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

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

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,[12] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

Washington State is a member of the eight-state NorthWest Interstate Compact, created in 1981 to share the responsibilities of low-level radioactive waste management. It is assumed, for purposes of this analysis, that Energy Northwest will continue to have access to the commercial disposal facility operated by US Ecology Washington in Richland, Washington

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to Energy Northwest. The majority of the low-level radioactive waste designated for direct disposal is assumed to sent to the Richland, Washington site. Disposal costs are based upon US Ecology's current operating budget.

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.

The DOE issued its final Environmental Impact Statement for the disposal of GTCC on January 2016.[13] The study evaluated the potential environmental impacts associated with constructing and operating a new facility or using an existing facility, disposal methods, and locations. DOE is awaiting Congressional action on the report and its recommendations. At this time, the federal government has not identified a specific cost for disposing of GTCC or a schedule for acceptance.

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

13 "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)," January 2016

For purposes of this analysis only, the GTCC radioactive waste is assumed to be packaged and disposed of in a manner similar to irradiated spent fuel and at a cost equivalent to that envisioned for the spent fuel. The GTCC is packaged in the same canisters used for spent fuel and either stored on site or shipped directly to a licensed facility as it is generated (depending upon the timing of the decommissioning and whether the spent fuel has already 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 estimates reflect the savings from waste recovery/volume reduction.

High-Level Radioactive Waste Management

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.[14] Energy Northwest's current spent fuel

14 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 Columbia, 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

management plan for the Columbia spent fuel is based in general upon: 1) the latest start date for DOE initiating transfer of spent fuel from the site without impacting deferred decommissioning activities in a SAFSTOR scenario, and 2) an assumed schedule for spent fuel receipt by the DOE for the Columbia 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, [15] the removal of spent fuel from the site is completed in 2096, for a 2043 shutdown. Different DOE acceptance schedules may result in different completion dates.

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.[16] 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.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[17]), has been constructed to support continued plant operations. The facility is assumed to be available to support future decommissioning operations. The fuel in the wet storage pool at the permanent cessation of operations, including the final core, is packaged for storage at the ISFSI. Once the spent fuel storage pool is emptied, the reactor building can be either decontaminated and dismantled or prepared for long term storage.

Energy Northwest's position is that the DOE has a contractual obligation to accept the spent fuel earlier than the projections set out above consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this claim. However, at this time, including the cost of storing spent fuel in this study is the most reasonable approach because it insures the availability of sufficient decommissioning funds at the end of the station's life if, contrary to its contractual obligation, the DOE has not performed earlier.

First" priority ranking. The plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance.

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

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

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

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.

Consequently, this study assumes that non-essential site structures addressed by this analysis are completely removed, once remediation is complete. The site is then graded and stabilized.

Summary

The estimates to decommission Columbia assume the removal of all contaminated and activated plant components and structural materials such that the owners 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 alternatives evaluated in this analysis are 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 Appendices C and D. The major cost components are also identified in the cost summary provided at the end of this section.

The cost elements in the estimates for the DECON and SAFSTOR alternatives 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). The cost reported for this subcategory is generally sufficient to terminate the unit'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). Section 3.4.1 provides the basis for the ISFSI decommissioning cost delineated in Appendix E.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the wet storage pool to the ISFSI for interim storage, as well as the transfer of the spent fuel in storage at the ISFSI to the DOE. Costs are included for the operation of the storage pool and the management of the ISFSI until such time that the transfer is complete. It does not include any spent fuel management expenses incurred prior to the cessation of plant operations, nor does it 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 completely removed, with excavations 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 Obligation 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 estimates were developed and costs are presented in 2018 dollars. As such, the estimates do not reflect the escalation of costs (due to inflationary and market forces) over the remaining operating life of the plant or during the decommissioning period.

DECON COST SUMMARY
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost
Decontamination	23,699
Removal	211,340
Packaging	38,641
Transportation	3,620
Waste Disposal	109,425
Off-site Waste Processing	32,847
Program Management [1]	414,431
Security	284,157
Spent Fuel Pool Isolation	13,800
Spent Fuel Storage and Transfer [2]	189,535
Insurance and Regulatory Fees	44,972
Energy	7,647
Characterization and Licensing Surveys	40,052
Property Taxes	0
Miscellaneous Equipment	7,176
Site O&M Cost	8,051
Groundwater Monitoring	3,047
Total [3]	1,432,439

Cost Category	Cost
License Termination	794,924
Spent Fuel Management	497,388
Site Restoration	140,127
Total [3]	1,432,439

[1] Includes engineering costs
[2] Includes costs for operation of the spent fuel pool, transfer of spent fuel into dry storage, ISFSI operations (excluding staff), and transfer of the spent fuel to the DOE
[3] Columns may not add due to rounding

SAFSTOR COST SUMMARY
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost
Decontamination	32,137
Removal	209,881
Packaging	32,686
Transportation	2,179
Waste Disposal	90,961
Off-site Waste Processing	38,213
Program Management [1]	531,199
Security	370,583
Spent Fuel Pool Isolation	13,800
Spent Fuel Storage and Transfer [2]	173,814
Insurance and Regulatory Fees	62,435
Energy	15,461
Characterization and Licensing Surveys	40,067
Property Taxes	0
Miscellaneous Equipment	25,052
Site O&M Cost	8,551
Groundwater Monitoring	3,515
Total [3]	1,650,534

Cost Category	Cost
License Termination	1,059,307
Spent Fuel Management	452,479
Site Restoration	138,748
Total [3]	1,650,534

[1] Includes engineering costs
[2] Includes costs for operation of the spent fuel pool, transfer of spent fuel into dry storage, ISFSI operations (excluding staff), and transfer of the spent fuel to the DOE
[3] Columns may not add due to rounding

1. INTRODUCTION

This report presents estimates of the cost to decommission the Columbia Generating Station (Columbia) for the selected decommissioning alternatives following the scheduled and permanent cessation of plant operations. The estimates are designed to provide the Bonneville Power Administration (BPA) with sufficient information to assess the financial obligations, as they pertain to the eventual decommissioning of the nuclear station.

The analysis relies upon site-specific, technical information from an earlier evaluation prepared in 1989,[1]* updated to reflect current assumptions pertaining to the disposition of the nuclear plant and relevant industry experience in undertaking such projects. The costs are based on several key assumptions in areas of regulation, component characterization, high-level radioactive waste management, low-level radioactive waste disposal, performance uncertainties (contingency) and site restoration requirements.

The analysis is not a detailed engineering evaluation, but rather estimates prepared in advance of the detailed engineering required to carry out the decommissioning of the nuclear unit. It may also not reflect the actual plan to decommission Columbia; the plan may differ from the assumptions made in this analysis based on facts that exist at the time of decommissioning.

The plant inventory, the basis for the decontamination and dismantling requirements and cost, and the decommissioning waste streams, was reviewed for this analysis. It was updated to reflect the current physical plant (systems and site structures).

1.1 OBJECTIVES OF STUDY

The objectives of this study are to prepare comprehensive estimates of the costs to decommission Columbia, to provide a sequence or schedule for the associated activities, and to develop waste stream projections from the decontamination and dismantling activities.

Energy Northwest was granted an operating license for Columbia on December 20, 1983, and the plant began commercial operation on December 13, 1984. In January 2010, Energy Northwest submitted an application to renew the license for an additional 20 years. The application was approved by the NRC on May 22, 2012, for plant operation through midnight, December 20, 2043. The current cost estimates assume operation of Columbia until that date.

* References are provided in Section 7 of the document

1.2 SITE DESCRIPTION

The Columbia unit is located in the southeast area of the Department of Energy's (DOE) Hanford Reservation in Benton County, Washington. The site is approximately 3 miles west of the Columbia River at River Mile 352, approximately 12 miles north of the City of Richland, 18 miles northwest of Pasco, and 21 miles northwest of Kennewick. The site is approximately square shaped with a corridor extending to the makeup water pump house located on the Columbia River.

The Columbia site encompasses approximately 1,089 acres. The single unit plant is operated by Energy Northwest(Energy Northwest, the licensee for Columbia, is a joint operating agency comprising 22 public utility districts and five municipalities). The plant employs a boiling water reactor (BWR) nuclear steam supply system (NSSS) furnished by General Electric Company. The authorized maximum rated power level limit of the reactor is 3,544 MWt. The design power level limit is 3,629 MWt. The net electrical power output is approximately 1,190 MWe and the gross electrical output is 1,230 MWe. All electrical energy produced by Columbia is delivered to electrical distribution facilities owned and operated by BPA as part of the Federal Columbia River Power System. BPA in turn distributes the electricity to electric utility systems throughout the northwest.

The reactor building houses the major portion of the NSSS, the drywell, suppression pool, primary containment, new and spent fuel pools, refueling equipment, and emergency core cooling systems. The containment was designed by Burns and Roe, Inc., and consists of primary and secondary containment systems. The primary containment structure is a free-standing steel pressure vessel containing both a drywell and a suppression chamber, which is consistent with the features of a BWR/Mark II containment. The nuclear system includes a direct-cycle, forced-circulation, boiling water reactor that produces steam for direct use in the steam turbine. Steam generated in the reactor vessel is routed to the turbine building for power conversion.

The turbine is an 1800 rpm, tandem-compound (one double-flow high-pressure turbine and three double-flow low-pressure turbines), reheat unit with an electrohydraulic governor for normal operation. Cooling and heat rejection is through the main condenser and the plant's circulating water system.

The circulating water system provides the condenser with a continuous supply of cooling water. The closed system uses forced draft cooling towers with makeup water provided by the Columbia River (the makeup water replaces the water lost by evaporation, drift, and blowdown).

1.3 REGULATORY GUIDANCE

The Nuclear Regulatory Commission (NRC or Commission) provided initial decommissioning requirements in its rule "General Requirements for Decommissioning Nuclear Facilities," issued in June 1988.[2] 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,"[3] 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 50 to 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,[4] 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.[5] 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 a draft regulatory basis document published in March 2017 in support of rulemaking that would amend NRC regulations concerning nuclear plant decommissioning, the NRC staff proposes removing any discussion of the ENTOMB option from existing guidance documents since the method is not deemed practically feasible.

In 1996, the NRC published revisions to the general requirements for decommissioning nuclear power plants.[6] 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. Prior to or within 2 years following permanent cessation of operations, the licensee is required to submit a Post-Shutdown Decommissioning Activities Report (PSDAR) to the NRC, and a copy to the affected State(s) (10 CFR 50.82(a)(4)(i)). 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 issued regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[7] The 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 E.

1.3.1 High-Level Radioactive Waste Management

Congress passed the "Nuclear Waste Policy Act"[8] (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. It 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.

Today, the country is at an impasse on high-level waste disposal, even with the License Application for a geologic repository submitted by the DOE to the NRC in 2008. The Obama administration has cut 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 Obama 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."[9]

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."[10]

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..."[11]

"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 Obama 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)[12] 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 adjudicatory hearing on the contentions filed by interested parties must be completed before a licensing decision can be made. Although the DOE proposed it would start fuel acceptance in 2025, no progress has been made in the repository program since DOE's 2013 strategy was issued except for the completion of the Yucca Mountain safety evaluation report.

Holtec International submitted a license application to the NRC on March 30, 2017 for a consolidated interim spent fuel storage facility in southeast New Mexico called HI-STORE CIS (Consolidated Interim Storage) under the provisions of 10 CFR Part 72. The application is currently under NRC review.

Waste Control Specialists submitted an application to the NRC on April 28, 2016, to construct and operate a Consolidated Interim Storage Facility (CISF) at its West Texas facility. On April 18, 2017, WCS requested that the NRC temporarily suspend all safety and environmental review activities, as well as public participation activities associated with WCS's license application. In March 2018, WCS and Orano USA, announced their intent to form a joint venture to license the facility. The joint venture has stated that they will request that the NRC resume its review of the original CISF license application.

On May 10, 2018, the U.S. House of Representatives passed H.R. 3053, the "Nuclear Waste Policy Amendments Act of 2018." Proposed to amend the Nuclear Waste Policy Act of 1982, the legislation, if approved by the Senate and signed by the President, would provide the DOE the authority to site, construct, and operate one or more Monitored Retrieval Storage (MRS) facilities while a permanent repository is licensed and constructed and/or to enter into an MRS agreement with a non-Federal entity for temporary storage.

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. Energy Northwest's current spent fuel management plan for the Columbia spent fuel is based in general upon: 1) the latest start date for DOE initiating transfer of spent fuel from the site without impacting deferred decommissioning activities in a SAFSTOR scenario, and 2) an assumed schedule for spent fuel receipt by the DOE for the Columbia 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),[13] the removal of spent fuel from the site is completed in 2096, for a 2043 shutdown. Different DOE acceptance schedules may result in different completion dates.

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.[14] 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.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[15]), has been constructed to support continued plant operations. The facility is assumed to be available to support future decommissioning operations. The fuel in the wet storage pool at the permanent cessation of operations, including the final core, is packaged for storage at the ISFSI. Once the spent fuel storage pool is emptied, the reactor building can be either decontaminated and dismantled or prepared for long term storage.

DOE has breached its obligations to remove fuel from reactor sites, and has also failed to provide the plant owners 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 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 perform, and for purposes of this analysis only, it is assumed that DOE will accept already-canistered fuel. (It is recognized that the canisters may not be licensed or licensable for transportation when DOE performs.) If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers.

Energy Northwest's position is that the DOE has a contractual obligation to accept Columbia's fuel earlier than the projections set out above consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this claim. However, at this time, including the cost of storing spent fuel in this study is the most reasonable approach because it insures the availability of sufficient decommissioning funds at the end of the station's life if, contrary to its contractual obligation, the DOE has not performed earlier.

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"[16] in 1980, and its Amendments of 1985,[17] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

Washington State is a member of the eight-state NorthWest Interstate Compact, created in 1981 to share the responsibilities of low-level radioactive waste management. It is assumed, for purposes of this analysis, that Energy Northwest will continue to have access to the commercial disposal facility operated by US Ecology Washington in Richland, Washington.

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to Energy Northwest. The majority of the low-level radioactive waste designated for direct disposal is assumed to sent to the Richland, Washington site. Disposal costs are based upon US Ecology's current operating budget.

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.

The DOE issued its final Environmental Impact Statement for the disposal of GTCC on January 2016.[18] The study evaluated the potential environmental impacts associated with constructing and operating a new facility or using an existing facility, disposal methods, and locations. DOE is awaiting Congressional action on the report and its recommendations. At this time, the federal government has not identified a specific 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 manner similar to high-level waste and at a cost equivalent to that envisioned for the spent fuel. The GTCC is packaged in the same canisters used for spent fuel and either stored on site or shipped directly to a federal facility as it is generated (depending upon the timing of the decommissioning and whether the spent fuel has already 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 estimates reflect 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,"[19] 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 estimates assume that the Columbia 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).[20] An additional and separate limit of 4 millirem per year, as defined in 40 CFR §141.66, is applied to drinking water.[21]

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)[22] 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 occurrence.

2. DECOMMISSIONING ALTERNATIVES

Detailed cost estimates were developed to decommission Columbia based upon the approved decommissioning alternatives: DECON and SAFSTOR. Although the alternatives differ with respect to technique, process, cost, and schedule, they attain the same result: the ultimate release of the site for unrestricted use.

Two decommissioning scenarios were evaluated for Columbia. The scenarios selected are representative of alternatives currently available and are defined as follows:

1. The first scenario assumes that the unit is promptly decommissioned (DECON alternative) upon the expiration of the current operating license in 2043. Following the cessation of operations, and assuming that the DOE has not performed, the spent fuel that is relocated from the wet storage pool to the ISFSI for interim storage so as to facilitate decontamination and dismantling activities within the reactor building. Once the spent fuel has been removed from the reactor building, the reactor building and remaining portions of the power block are decommissioned, non-essential structures dismantled and the site, exclusive of the ISFSI, remediated and dismantled. The ISFSI remains operational until the transfer of the spent fuel to the DOE is complete. Once completed, the ISFSI is decommissioned and the pad demolished.

2. In the second scenario, the nuclear unit is placed into safe-storage (SAFSTOR alternative) upon the expiration of the current operating license in 2043. As with the first scenario, spent fuel is transferred to the ISFSI for interim storage. ISFSI operations continue at the site until the transfer of the spent fuel to the DOE is complete. The start of decontamination and dismantling activities is deferred to the maximum extent (approximately 50 years from the cessation of operations) such that the license is terminated within the required 60-year period.

The following sections describe the basic activities associated with each 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 at the time of decommissioning.

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 is to be provided to the NRC

certifying the permanent cessation of operations and the removal of fuel from the reactor vessel. The licensee is then prohibited from reactor operation.

The second phase encompasses activities during the storage period or during major decommissioning activities, or a combination of the two. The third phase pertains to the activities involved in license termination. The decommissioning estimates developed for Columbia are 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 DECON

The DECON alternative, as defined by the NRC, is "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." This study does not address the cost to dispose of the spent fuel residing at the site; such costs are funded through a surcharge on electrical generation. However, the study does estimate the costs incurred with the interim on-site storage of the fuel pending shipment by the DOE to an off-site disposal facility.

2.1.1 Period 1 - Preparations

In anticipation of the cessation of plant operations, detailed preparations are 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, a characterization of the facility and major components, and the development of the PSDAR.

Engineering and Planning

The PSDAR, required prior to or within two years of permanent cessation of operations, provides a description of the licensee's planned decommissioning activities, a timetable, a site-specific decommissioning cost estimate, and the associated financial requirements of the intended decommissioning program. Upon receipt of the PSDAR, the NRC will make the document available to the public for comment in a local

hearing to be held in the vicinity of the reactor site. Ninety days following submittal and NRC receipt of the PSDAR, the licensee may begin to perform major decommissioning activities under a modified 10 CFR §50.59 procedure (10 CFR §50.59 establishes the conditions under which licensees may make changes to the facility or procedures and conduct test or experiments without prior NRC approval). Major activities are defined as 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 GTCC, as defined by 10 CFR §61.55. Major components are further defined as comprising the reactor vessel and internals, large bore reactor coolant system piping, and other large components that are radioactive. The NRC includes the following additional criteria for use of the §50.59 process in decommissioning. The proposed activity must not:

- foreclose release of the site for possible unrestricted use,
- significantly increase decommissioning costs,
- cause any significant environmental impact, or
- violate the terms of the licensee's existing license.

Existing operational technical specifications are reviewed and modified to reflect plant conditions and the safety concerns associated with permanent cessation of operations. The environmental impact associated with the planned decommissioning activities is also considered. Typically, a licensee will not be allowed to proceed if the consequences of a particular decommissioning activity are greater than that bounded by previously evaluated environmental assessments or impact statements. In this instance, the licensee would have to submit a license amendment for the specific activity and update the environmental report.

The decommissioning program outlined in the PSDAR will be designed to accomplish the required tasks within the ALARA guidelines (as defined in 10 CFR Part 20) for protection of personnel from exposure to radiation hazards. It will also address the continued protection of the health and safety of the public and the environment during the dismantling activity. Consequently, with the development of the PSDAR, activity specifications, cost-benefit and safety analyses, work packages, and procedures, would be assembled to support the proposed decontamination and dismantling activities.

Site Preparations

Following final plant shutdown, and in preparation for actual decommissioning activities, the following activities are initiated:

- Characterization of the site and surrounding environs. This includes radiation surveys of work areas, major components (including the reactor vessel and its internals), internal piping, and primary shield cores.
- Isolation of the spent fuel storage pool and reactor systems, such that decommissioning operations can commence on the balance of the plant. The pool will remain operational for approximately five and one-half years following the cessation of operations. During this time period, it is assumed that the spent fuel residing in the pool will be moved to an ISFSI for temporary storage.
- Specification of transport and disposal requirements for activated materials and/or hazardous materials, including shielding and waste stabilization.
- Development of procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radwaste (including dry-active waste, resins, filter media, metallic and non-metallic components generated in decommissioning), site security and emergency programs, and industrial safety.

2.1.2 Period 2 - Decommissioning Operations

This period includes the physical decommissioning activities associated with the removal and disposal of contaminated and activated components and structures, including the successful release of the site from the 10 CFR Part 50 operating license, exclusive of the ISFSI. Significant decommissioning activities in this phase include:

- Construction of temporary facilities and/or modification of existing facilities to support dismantling activities. For example, this will include a centralized processing area to facilitate equipment removal and component preparations for off-site disposal.
- Reconfiguration and modification of site structures and facilities as needed to support decommissioning operations. This will include the upgrading of roads (on- and off-site) as required to facilitate hauling and transport. Modifications will be required to the containment structure to facilitate access of large/heavy equipment. Modifications

will also be required to the refueling area of the building to support the segmentation of the reactor vessel internals and component extraction.

- Transfer of the spent fuel from the storage pool to the ISFSI pad.
- Design and fabrication of temporary and permanent shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.
- Procurement (lease or purchase) of shipping canisters, cask liners, and industrial packages.
- 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.
- Disconnection of the control blades from the drives on the vessel lower head. Blades are transferred to the spent fuel pool.
- Removal and segmentation of the steam separator and dryer 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 shroud, jet pumps, spargers and in-core guide tubes. Some material is expected to exceed Class C disposal requirements. As such, and to the extent required, the segments are 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 the dryer-separator pool.
- Disconnection of the control rod drives and instrumentation tubes from reactor vessel lower head. The lower reactor head and vessel supporting structure are then segmented.
- Removal of the reactor recirculation pumps. Exterior surfaces are decontaminated and openings covered. Components can serve as

their own burial containers provided that all penetrations are properly sealed.

- Demolition of the sacrificial shield activated concrete by controlled demolition.

At least two years prior to the anticipated date of license termination, an LTP is required. Submitted as a supplement to the Final Safety Analysis Report (FSAR) or its equivalent, the plan must include: a site characterization, description of the remaining dismantling activities, plans for site remediation, procedures for the final radiation survey, designation of the end use of the site, an updated cost estimate to complete the decommissioning, and any associated environmental concerns. The NRC will notice the receipt of the plan, make the plan available for public comment, and schedule a local hearing. LTP approval will be subject to any conditions and limitations as deemed appropriate by the Commission. The licensee may then commence with the final remediation of site facilities and services, including:

- Removal of remaining plant systems and associated components as they become nonessential to the decommissioning program or worker health and safety (e.g., waste collection and treatment systems, electrical power and ventilation systems).
- Removal of the steel liners from the drywell and suppression chamber, disposing of the activated and contaminated sections as radioactive waste. Removal of any activated/contaminated concrete.
- Removal of the steel liners from the dryer-separator pool, fuel storage pool and the reactor well.
- Surveys of the decontaminated areas of the containment structure.
- Removal of the contaminated equipment and material from the turbine, reactor and radwaste buildings, and any other contaminated facility. Use of radiation and contamination control techniques until radiation surveys indicate that the structures can be released for unrestricted access and conventional demolition. This activity may necessitate the dismantling and disposition of most of the systems and components (both clean and contaminated) located within these buildings. This activity will facilitate surface decontamination and subsequent verification surveys required prior to obtaining release for demolition.
- Routing of material removed in the decontamination and dismantling to a central processing area. Material certified to be free of

contamination is released for unrestricted disposition, e.g., as scrap, recycle, or general disposal. Contaminated material is characterized and segregated for additional off-site processing (disassembly, chemical cleaning, volume reduction, and waste treatment), and/or packaged for controlled disposal at a low-level radioactive waste disposal facility.

Incorporated into the LTP is the Final Survey Plan. This plan identifies the radiological surveys to be performed once the decontamination activities are completed and is developed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)."[23] This document incorporates the statistical approaches to survey design and data interpretation used by the EPA. 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 survey is complete, the results are provided to the NRC in a format that can be verified. The NRC then reviews and evaluates the information, performs an independent confirmation of radiological site conditions, and makes a determination on the requested change to the operating license (that would release the property, exclusive of the ISFSI, for unrestricted use).

The NRC will amend the operating license if it determines that site remediation has been performed in accordance with the LTP, and that the terminal radiation survey and associated documentation demonstrate that the property (exclusive of the ISFSI) is suitable for release.

2.1.3 Period 3 - Site Restoration

Following completion of decommissioning operations, site restoration activities can begin. 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 will substantially degrade power block structures including the reactor, radwaste and reactor 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, once remediation is complete, 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 completely removed. Site areas affected by the dismantling activities are restored as nearly as possible to its original condition and the plant area graded as required to prevent ponding.

Non-contaminated concrete rubble produced by demolition activities is processed to remove reinforcing steel and miscellaneous embedments. The processed material is then available for use as clean fill..

2.1.4 ISFSI Operations and Decommissioning

For purposes only of this estimate, transfer of spent fuel to a DOE repository or interim facility is assumed to be exclusively from the ISFSI once the fuel pool has been emptied and the reactor building released for decommissioning. 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. The ISFSI will continue to operate under a general license (10 CFR Part 50) following the amendment of the operating license to release the adjacent (power block) property.

Assuming the DOE starts accepting fuel from Columbia in 2051, transfer of spent fuel from the ISFSI is anticipated to continue through the year 2096. 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.

At the conclusion of the spent fuel transfer process, the ISFSI will be decommissioned. The Commission will terminate the Part 50 license if it determines that the remediation of the ISFSI has been performed in accordance with an ISFSI license termination plan and that the final radiation survey and associated documentation demonstrate that the facility is suitable for release. Once the requirements are satisfied, the NRC can terminate the license for the ISFSI.

The design of the ISFSI is based upon the use of a multi-purpose canister and a vertical concrete module/overpack for pad storage. It is assumed that once the inner canisters containing the spent fuel assemblies have been removed, any required decontamination is performed on the storage modules (some minor neutron activation is assumed), and the license for the facility terminated, the modules can be dismantled using conventional techniques for the demolition of reinforced concrete. The concrete storage pad is then removed and the area regraded.

2.2 SAFSTOR

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.

The engineering and planning requirements are similar to those for the DECON alternative, although a shorter time period is expected for these activities due to the more limited work scope. Site preparations are also similar to those for the DECON alternative. However, with the exception of the required radiation surveys and site characterizations, the mobilization and preparation of site facilities is less extensive.

2.2.1 Period 1 - Preparations

Preparations for long-term storage include the planning for permanent defueling of the reactor, revision of technical specifications appropriate

to the operating conditions and requirements, a characterization of the facility and major components, and the development of the PSDAR.

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

- Isolation of the spent fuel storage services and fuel handling systems so that safe-storage operations may commence on the balance of the plant. This activity may be carried out by plant personnel in accordance with existing operating technical specifications. Activities are scheduled around the fuel handling systems to the greatest extent possible.
- Transferring the spent fuel from the storage pool to the ISFSI, following the minimum required cooling period in the spent fuel pool.
- Draining and de-energizing of the non-contaminated systems not required to support continued site operations or maintenance.
- Disposing of contaminated filter elements and resin beds not required for processing wastes from layup activities for future operations.
- Draining of the reactor vessel, with the internals left in place and the vessel head secured.
- Draining and de-energizing non-essential, contaminated systems with decontamination as required for future maintenance and inspection.
- Preparing lighting and alarm systems whose continued use is required; de-energizing portions of fire protection, electric power, and HVAC systems whose continued use is not required.
- Cleaning of the loose surface contamination from building access pathways.
- Performing an interim radiation survey of plant, posting warning signs where appropriate.
- Erecting physical barriers and/or securing all access to radioactive or contaminated areas, except as required for inspection and maintenance.
- Installing security and surveillance monitoring equipment and relocating security fence around secured structures, as required.

2.2.2 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 the deferred decommissioning alternatives. Dormancy activities include a 24-hour security force, preventive and corrective maintenance on security systems, area lighting, general building maintenance, heating and ventilation of buildings, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program. Resident maintenance personnel perform equipment maintenance, inspection activities, routine services to maintain safe conditions, adequate lighting, heating, and ventilation, and periodic preventive maintenance on essential site services.

An environmental surveillance program is carried out during the dormancy period to ensure that releases of radioactive material to the environment are prevented or detected and controlled. Appropriate emergency procedures are established and initiated for potential releases that exceed prescribed limits. The environmental surveillance program constitutes an abbreviated version of the program in effect during normal plant operations.

Security during the dormancy period is conducted primarily to prevent unauthorized entry and to protect the public from the consequences of its own actions. The security fence, sensors, alarms, and other surveillance equipment are maintained throughout the dormancy period. Fire and radiation alarms are also functional.

Consistent with the DECON scenario, the spent fuel storage pool is emptied within five and one-half years of the cessation of operations. It is assumed that the transfer of the spent fuel from the site to the DOE begins in 2051. The transfer continues throughout the dormancy period until completed in 2096. 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. If the assumption of transfer of fuel from the ISFSI to DOE 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. Once emptied, the ISFSI is secured for storage and decommissioned along with the power block structures in Period 4.

After a period of storage (such that license termination is accomplished within 60 years of final shutdown), it is required that the licensee submit an application to terminate the license, along with a LTP (described in Section 2.1.2), thereby initiating the third phase.

2.2.3 Periods 3 and 4 - Delayed Decommissioning

Prior to the commencement of decommissioning operations, preparations are undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a detailed site characterization, and the assembly of a decommissioning management organization. Final planning and the assembly of activity specifications and detailed work procedures are also initiated at this time.

Much of the work in developing a termination plan is relevant to the development of the detailed engineering plans and procedures. The activities associated with this phase and the follow-on decontamination and dismantling processes are detailed in Sections 2.1.1 and 2.1.2. The primary difference between the sequences anticipated for the DECON and this deferred scenario is the absence, in the latter, of any constraint on the dismantling process due to the operation of the spent fuel pool in the DECON option.

Radioactive decay over the length of the dormancy period will have some effect upon the quantities of radioactive wastes generated from system and structure removal operations. However, given the levels of radioactivity and spectrum of radionuclides expected from sixty years of plant operation, no plant process system identified as being contaminated upon final shutdown will become releasable due to the decay period alone. However, due to the lower activity levels, a greater percentage of the waste volume can be designated for off-site processing and recovery.

The delay in decommissioning also yields lower working area radiation levels. As such, the estimate for this delayed scenario incorporates reduced ALARA controls for the SAFSTOR's lower occupational exposure potential.

Although the initial radiation levels due to ^{60}Co will substantially decrease during the dormancy period, the internal components of the reactor vessel will still exhibit sufficiently high radiation dose rates to require remote sectioning under water due to the presence of long-lived

radionuclides such as ^{94}Nb, ^{59}Ni, and ^{63}Ni. Therefore, the dismantling procedures described for the DECON alternative would still be employed during this scenario. Portions of the primary shield will still be radioactive due to the presence of activated trace elements with long half-lives (^{152}Eu and ^{154}Eu). Decontamination will require controlled removal and disposal. It is assumed that radioactive corrosion products on inner surfaces of piping and components will not have decayed to levels that will permit unrestricted use or allow conventional removal. These systems and components will be surveyed as they are removed and disposed of in accordance with the existing radioactive release criteria.

2.2.4 Period 5 - Site Restoration

Following completion of decommissioning operations, site-restoration activities begin. Dismantling, as a continuation of the decommissioning process, is a cost-effective option, as described in Section 2.1.3. The basis for the dismantling cost is consistent with that described for DECON, presuming the complete removal of structures and site facilities and the limited restoration of the site.

3. COST ESTIMATES

The cost estimates prepared for decommissioning Columbia consider the unique features of the site, including the nuclear steam supply system, electric power generating systems, structures and supporting facilities. The basis of the estimates, 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 ESTIMATES

The current estimates were developed using the site-specific, technical information relied upon in the decommissioning analysis prepared in 1989. This information was reviewed for the current analysis and updated as deemed appropriate. 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 ongoing decommissioning programs provided viable alternatives or improved processes.

3.2 METHODOLOGY

The methodology used to develop the estimates follows the basic approach originally presented in the AIF/NESP-036 study report, "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,"[24] and the DOE "Decommissioning Handbook."[25] 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 RSMeans.[26]

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.

Regulatory Guide 1.184[27] Revision 1, issued in October 2013, describes the methods and procedures that are acceptable to the NRC staff for implementing the requirements 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 regulations. The format and content of the estimates is also consistent with the recommendations of Regulatory Guide 1.202,[28] issued February 2005.

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 Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee, Crystal River, Vermont Yankee and Fort Calhoun nuclear units have provided additional insight into the process, the regulatory aspects, and the technical challenges of decommissioning commercial nuclear units.

Work Difficulty Factors

The estimates follow 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.

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

- Access Factor 10% to 20%
- Respiratory Protection Factor 10% to 50%
- Radiation/ALARA Factor 10% to 37%
- Protective Clothing Factor 10% 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

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. In the DECON alternative, dismantling of the reactor building systems and decontamination of the spent fuel pool is dependent upon the timetable for the transfer of the spent fuel assemblies from the pool to the ISFSI.

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.

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"[29] 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 in the cost of decommissioning over the remaining operating life of the station.

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%

- Low-Level Radioactive Waste Processing 15%
- 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%
- Energy 15%
- Insurance, Taxes and Fees 10%
- Staffing 15%
- Characterization and Termination Surveys 30%
- Operations and Maintenance Expense 15%
- ISFSI Decommissioning 25%

The contingency values are applied to the appropriate components of the estimates on a line item basis. A composite value is then reported at the end of each detailed estimate (as provided in Appendix C and D). A contingency of 25% is applied to the subtotal of the ISFSI decommissioning costs.

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:

- Transition activities and costs: ancillary expenses associated with reducing the size of the labor force 50% to 80% shortly after the cessation of plant operations, national or company-mandated retraining, and retention incentives for key personnel.
- Delays in approval of the decommissioning plan due to intervention, public participation in local community meetings, 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, for example, 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, since there is insufficient historical data from which to project future liabilities. Consequently, the areas of uncertainty or risk should be revisited periodically and addressed through updates of the base estimates.

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 estimates to decommission Columbia. 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 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, requires 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 estimates, as described below.

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. Energy Northwest's current spent fuel management plan for the Columbia spent fuel is based in general upon: 1) the latest start date for DOE initiating transfer of spent fuel from the site without impacting deferred decommissioning activities in a SAFSTOR scenario, and 2) an assumed schedule for spent fuel receipt by the DOE for the Columbia fuel.

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.[30] Assuming that DOE starts accepting fuel in 2051, the removal of spent fuel from the site could be completed in 2096, for a 2043 shutdown. Different DOE acceptance schedules may result in different completion dates.

ISFSI

Due to DOE's inability to remove fuel from the site, an ISFSI has been constructed at the site and fuel casks have been emplaced thereon to support continued plant operations.

Operation and maintenance costs for the spent fuel pool and the ISFSI are included within the estimates and address the cost for staffing the facility, as well as security, insurance, and licensing fees. The estimates include the costs to purchase, load, and transfer the multi-purpose spent fuel storage canisters (MPCs) from the pool to the ISFSI. Costs are also provided for transfer of the MPCs to the DOE from the ISFSI (although it is acknowledged that this may not occur and that the fuel in the MPCs may have to be repackaged at DOE expense).

Storage Canister Design

The Columbia ISFSI uses a Holtec International (Holtec) HI-STORM 100S (243) dry storage system. The HI-STORM 100S is comprised of a steel multi-purpose canister (MPC) capable of storing up to 68 irradiated fuel assemblies and a concrete storage overpack.

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 needs to 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.

The dry storage vendor does not expect the concrete casks to have any interior or exterior radioactive surface contamination. Any neutron activation of the steel and concrete is also expected to be extremely small. However, the decommissioning estimate is based on the premise that some of the concrete casks will contain low levels of neutron-induced residual radioactivity that would necessitate remediation at the time of decommissioning. As an allowance, 12 of the 123 overpack liners are assumed to be affected, i.e., contain residual radioactivity. The allowance quantity is based upon the number of casks required for the final core off-load (i.e., 764 offloaded assemblies, 68 assemblies per cask) which results in 12 overpacks. It is assumed that these are the final casks 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.

In accordance with the specific requirements of 10 CFR §72.30 for the ISFSI work scope, 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 summary for decommissioning the ISFSI is presented in Appendix E.

GTCC

The dismantling of the reactor internals is expected to generate 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 same canisters used to store spent fuel and disposed of as high-level waste, 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 experience at Maine Yankee (e.g., the constraints on loading as identified in the canister's certificate of compliance).

It is assumed only for purposes of these estimates that the DOE would not accept this waste prior to completing the transfer of spent fuel. Therefore, until such time as the DOE is ready to accept GTCC waste, it is assumed that this material would remain in storage at the Columbia site (for the DECON alternative). It is acknowledged, however, that the plant owner will seek the most expeditious means of removing GTCC from the site when DOE commences performance. In the SAFSTOR scenario, the GTCC material is 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.

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 the Columbia plant ceases operation. 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. Additionally, with BWRs, the diameter of the reactor vessel may severely limit overland transport. Consequently, the study assumes that the reactor vessel will require segmentation, as a bounding condition.

3.4.3 Primary System Components

In the DECON scenario, the reactor recirculation system components are assumed to be decontaminated using chemical agents prior to the start of dismantling operations. This type of decontamination can be expected to have a significant ALARA impact, since in this scenario the removal work is done within the first few years of shutdown. Disposal of the decontamination solution effluent is included within the estimate as a "process liquid waste" charge. In the SAFSTOR scenario, radionuclide decay is expected to provide the same benefit and, therefore, a chemical decontamination is not included.

Reactor recirculation 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 recirculation 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 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.[31] The contaminated material will be packaged in Industrial Packages (IP-1, IP-2, or IP-3, as defined in 49 CFR §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, and/or multi-wheeled transporter.

Transportation costs for radioactive material requiring additional processing or controlled disposal are based upon the route and mileage to the US Ecology's site in Richland, Washington and Grand View, Idaho. Transportation cost for the GTCC material is assumed to be included within the disposal charge. Truck transport costs were developed from published tariffs from Tri-State Motor Transit.[32]

3.4.6 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 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 detailed Appendices C and D, 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.

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 US Ecology's current operating budget for the Richland, Washington site and a proxy for the Grand View Idaho site.

3.4.7 Site Conditions Following Decommissioning

The NRC will amend or 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 owners' own future plans for the site.

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 four 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.

Only existing site structures are considered in the dismantling cost, excluding structures such as the electrical switchyard since it may be needed to support of the regional transmission and distribution system.

Structures are removed completely (including foundations). 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 is processed and made available as clean fill for the power block foundations. Additional

fill is brought in to cap the power block excavations and to permit seeding for erosion control.

The estimates include the remediation of evaporation pond sediment. The sediment is assumed to be shipped to a licensed facility for disposal, such as US Ecology's facility in Grand View, Idaho.

3.5 ASSUMPTIONS

The following are the major assumptions made in the development of the estimates 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 2018 dollars. Costs provided as input to the decommissioning cost model in dollars other than 2018 dollars were escalated to 2018 dollars.

The estimates rely upon the physical plant inventory that was the basis for the 1989 analysis.

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

Energy Northwest will hire a Decommissioning Operations Contractor (DOC) to manage the decommissioning. The owner will provide site security, radiological health and safety, quality assurance and overall site administration during the decommissioning and demolition phases. Contract personnel will provide engineering services, e.g., for preparing the activity specifications, work procedures, activation, and structural analyses, under the direction of the owner.

Reduction in the operating organization is assumed to be handled through normal company human resource practices (e.g., reassignment and outplacement).

Personnel costs are based upon average salary information provided by Energy Northwest. Overhead costs are included for site and corporate support, reduced commensurate with the staffing of the project.

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

A profile of the staffing levels for decommissioning, including contractors and craft, is provided in Figures 3.1 and 3.2 for the DECON and SAFSTOR scenarios, respectively. Utility staffing levels will gradually decrease after completing the removal of physical systems. Staffing levels and management support will vary based upon the amount and type of decommissioning work. Craft manpower levels decrease after systems removal and structures decontamination and drop substantially during the license termination survey period. However, craft levels increase again during the site restoration period due to the work associated with structures demolition.

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 2096, the security organization will be reduced to Part 37 requirements for deferred dismantling under the SAFSTOR alternative.

3.5.3 Design Conditions

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 NSSS components to be shipped under current transportation regulations and disposal requirements.

The curie contents of the vessel and internals at final shutdown are derived from those listed in NUREG/CR-3474.[33] Actual estimates are derived from the curie/gram values contained therein and adjusted for the different mass of the Columbia components, projected operating life,

and different periods of decay. Additional short-lived isotopes were derived from NUREG/CR-0130[34] and NUREG/CR-0672,[35] and benchmarked to the long-lived values from NUREG/CR-3474.

The disposal cost for the control blades removed from the vessel with the final core load is included within the estimates. Disposition of any blades stored in the pools from operations is considered an operating expense and therefore not accounted for in the estimates.

Neutron activation of the reactor building structure is assumed to be confined to the sacrificial shield wall.

3.5.4 General

Transition Activities

Existing warehouses are cleared of non-essential material and remain for use by Energy Northwest and its subcontractors. The warehouses are removed once they are no longer needed. 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.
- Process operating waste inventories. Disposal of operating wastes (e.g., filtration media, resins) during this initial period is not considered a decommissioning expense.

Scrap and Salvage

The existing plant equipment is considered obsolete and suitable for scrap as deadweight quantities only. Energy Northwest 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 estimates 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.

Energy

For estimating purposes, the plant is assumed to be de-energized, with the exception of those facilities associated with spent fuel storage. Replacement power costs are used to calculate the cost of energy consumed during decommissioning for tooling, lighting, ventilation, and essential services.

Emergency Planning

FEMA fees associated with emergency planning are assumed to continue for approximately 12 months following the cessation of operations. At this time, the 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). State fees are included until all fuel has been moved from the pool into dry storage (approximately five and one-half years following the cessation of operations).

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 provided in SECY-00-0145, "Integrated Rulemaking Plan for Nuclear Power Plant Decommissioning."[36] The NRC's financial protection requirements are based on various reactor (and spent fuel) configurations.

Taxes

Property taxes are not included within the estimates.

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 Tables 3.1 and 3.2. The tables delineate the cost contributors by year of expenditures as well as cost contributor (e.g., labor, materials, and waste disposal).

The tables in Appendices C and D provide additional detail. The cost elements in these tables 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 that is included in both Appendices C and D is provided in Appendix E.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the wet storage pool to the ISFSI for interim storage, as well as the transfer of the spent fuel in storage at

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 completely removed to the extent possible.

As discussed in Section 3.4.1, it is assumed that the DOE will not accept the GTCC waste prior to completing the transfer of spent fuel. Therefore, the cost of GTCC disposal is shown in the final year of ISFSI operation (for the DECON alternative). While designated for disposal at a federal facility 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 2018 dollars. Costs are not inflated, escalated, or discounted over the period of expenditure (or projected lifetime of the plant). The schedules are based upon the detailed activity costs reported in Appendices C and D, along with the timelines presented in Section 4.

TABLE 3.1
DECON ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	5,000	5,000
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	2,289	64	42	5	333	2,733
2044	70,354	2,670	1,330	784	11,017	86,156
2045	85,043	28,657	1,840	27,671	20,786	163,997
2046	85,219	34,096	1,217	36,445	8,993	165,970
2047	85,622	36,731	1,064	24,428	8,205	156,050
2048	86,130	38,614	963	16,370	7,694	149,770
2049	76,867	40,515	721	24,638	8,560	151,302
2050	49,165	8,194	225	183	3,491	61,258
2051	34,390	25,746	128	0	5,813	66,077
2052	27,198	19,257	96	0	4,697	51,247
2053	6,081	864	0	0	1,368	8,313
2054	6,009	648	0	0	1,368	8,026
2055	6,009	648	0	0	1,368	8,026
2056	5,881	217	0	0	1,372	7,470
2057	5,937	432	0	0	1,368	7,738
2058	6,009	648	0	0	1,368	8,026
2059	5,865	217	0	0	1,368	7,451
2060	5,881	217	0	0	1,372	7,470
2061	6,009	648	0	0	1,368	8,026
2062	6,009	648	0	0	1,368	8,026
2063	6,009	648	0	0	1,368	8,026
2064	6,025	648	0	0	1,372	8,045
2065	6,009	648	0	0	1,368	8,026
2066	6,009	648	0	0	1,368	8,026
2067	6,009	648	0	0	1,368	8,026
2068	5,953	432	0	0	1,372	7,758
2069	5,937	432	0	0	1,368	7,738

TABLE 3.1 (continued)
DECON ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	5,937	432	0	0	1,368	7,738
2071	6,009	648	0	0	1,368	8,026
2072	6,025	648	0	0	1,372	8,045
2073	6,009	648	0	0	1,368	8,026
2074	6,009	648	0	0	1,368	8,026
2075	6,009	648	0	0	1,368	8,026
2076	6,025	648	0	0	1,372	8,045
2077	6,009	648	0	0	1,368	8,026
2078	6,009	648	0	0	1,368	8,026
2079	6,009	648	0	0	1,368	8,026
2080	6,025	648	0	0	1,372	8,045
2081	6,009	648	0	0	1,368	8,026
2082	6,009	648	0	0	1,368	8,026
2083	6,009	648	0	0	1,368	8,026
2084	6,025	648	0	0	1,372	8,045
2085	6,009	648	0	0	1,368	8,026
2086	6,009	648	0	0	1,368	8,026
2087	6,009	648	0	0	1,368	8,026
2088	6,025	648	0	0	1,372	8,045
2089	6,009	648	0	0	1,368	8,026
2090	6,009	648	0	0	1,368	8,026
2091	6,009	648	0	0	1,368	8,026
2092	6,025	648	0	0	1,372	8,045
2093	6,009	648	0	0	1,368	8,026
2094	6,009	648	0	0	1,368	8,026
2095	6,009	648	0	0	1,368	8,026
2096	5,894	1,467	0	0	9,067	16,427
2097	5,407	1,870	21	1,999	4,443	13,740
Total	871,482	263,809	7,647	132,524	156,977	1,432,439

TABLE 3.1a
DECON ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	2,281	64	42	5	265	2,658
2044	70,122	2,670	1,330	784	8,980	83,886
2045	82,607	25,319	1,840	27,671	19,544	156,980
2046	81,011	27,878	1,217	36,445	7,751	154,303
2047	76,091	16,418	1,064	24,428	6,962	124,964
2048	72,973	8,714	963	16,370	6,448	105,468
2049	62,245	10,312	721	24,638	7,917	105,833
2050	36,179	1,621	192	183	2,125	40,301
2051	47	0	0	0	755	802
2052	35	0	0	0	579	615
2053	0	0	0	0	57	57
2054	0	0	0	0	57	57
2055	0	0	0	0	57	57
2056	0	0	0	0	58	58
2057	0	0	0	0	57	57
2058	0	0	0	0	57	57
2059	0	0	0	0	57	57
2060	0	0	0	0	58	58
2061	0	0	0	0	57	57
2062	0	0	0	0	57	57
2063	0	0	0	0	57	57
2064	0	0	0	0	58	58
2065	0	0	0	0	57	57
2066	0	0	0	0	57	57
2067	0	0	0	0	57	57
2068	0	0	0	0	58	58
2069	0	0	0	0	57	57

TABLE 3.1a (continued)
DECON ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	0	0	0	0	57	57
2071	0	0	0	0	57	57
2072	0	0	0	0	58	58
2073	0	0	0	0	57	57
2074	0	0	0	0	57	57
2075	0	0	0	0	57	57
2076	0	0	0	0	58	58
2077	0	0	0	0	57	57
2078	0	0	0	0	57	57
2079	0	0	0	0	57	57
2080	0	0	0	0	58	58
2081	0	0	0	0	57	57
2082	0	0	0	0	57	57
2083	0	0	0	0	57	57
2084	0	0	0	0	58	58
2085	0	0	0	0	57	57
2086	0	0	0	0	57	57
2087	0	0	0	0	57	57
2088	0	0	0	0	58	58
2089	0	0	0	0	57	57
2090	0	0	0	0	57	57
2091	0	0	0	0	57	57
2092	0	0	0	0	58	58
2093	0	0	0	0	57	57
2094	0	0	0	0	57	57
2095	0	0	0	0	57	57
2096	235	1,250	0	0	7,788	9,273
2097	1,293	521	0	1,999	3,556	7,370
Total	485,121	94,766	7,370	132,524	75,143	794,924

TABLE 3.1b
DECON ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	0	0	0	0	68	68
2044	0	0	0	0	2,038	2,038
2045	1,095	3,286	0	0	1,242	5,624
2046	2,040	6,120	0	0	1,242	9,403
2047	6,737	20,211	0	0	1,242	28,190
2048	9,931	29,794	0	0	1,246	40,971
2049	13,124	30,154	0	0	644	43,923
2050	5,879	131	0	0	191	6,201
2051	6,149	188	0	0	396	6,732
2052	6,075	141	0	0	630	6,846
2053	6,081	864	0	0	1,311	8,256
2054	6,009	648	0	0	1,311	7,968
2055	6,009	648	0	0	1,311	7,968
2056	5,881	217	0	0	1,315	7,413
2057	5,937	432	0	0	1,311	7,681
2058	6,009	648	0	0	1,311	7,968
2059	5,865	217	0	0	1,311	7,393
2060	5,881	217	0	0	1,315	7,413
2061	6,009	648	0	0	1,311	7,968
2062	6,009	648	0	0	1,311	7,968
2063	6,009	648	0	0	1,311	7,968
2064	6,025	648	0	0	1,315	7,988
2065	6,009	648	0	0	1,311	7,968
2066	6,009	648	0	0	1,311	7,968
2067	6,009	648	0	0	1,311	7,968
2068	5,953	432	0	0	1,315	7,700
2069	5,937	432	0	0	1,311	7,681

TABLE 3.1b (continued)
DECON ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	5,937	432	0	0	1,311	7,681
2071	6,009	648	0	0	1,311	7,968
2072	6,025	648	0	0	1,315	7,988
2073	6,009	648	0	0	1,311	7,968
2074	6,009	648	0	0	1,311	7,968
2075	6,009	648	0	0	1,311	7,968
2076	6,025	648	0	0	1,315	7,988
2077	6,009	648	0	0	1,311	7,968
2078	6,009	648	0	0	1,311	7,968
2079	6,009	648	0	0	1,311	7,968
2080	6,025	648	0	0	1,315	7,988
2081	6,009	648	0	0	1,311	7,968
2082	6,009	648	0	0	1,311	7,968
2083	6,009	648	0	0	1,311	7,968
2084	6,025	648	0	0	1,315	7,988
2085	6,009	648	0	0	1,311	7,968
2086	6,009	648	0	0	1,311	7,968
2087	6,009	648	0	0	1,311	7,968
2088	6,025	648	0	0	1,315	7,988
2089	6,009	648	0	0	1,311	7,968
2090	6,009	648	0	0	1,311	7,968
2091	6,009	648	0	0	1,311	7,968
2092	6,025	648	0	0	1,315	7,988
2093	6,009	648	0	0	1,311	7,968
2094	6,009	648	0	0	1,311	7,968
2095	6,009	648	0	0	1,311	7,968
2096	5,659	217	0	0	1,278	7,154
2097	0	0	0	0	0	0
Total	314,595	116,171	0	0	66,622	497,388

TABLE 3.1c
DECON ALTERNATIVE
SITE RESTORATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	5,000	5,000
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	7	0	0	0	0	7
2044	7	0	0	0	0	7
2045	232	0	0	0	0	232
2046	1,341	52	0	0	0	1,393
2047	2,168	97	0	0	0	2,265
2048	2,794	102	0	0	0	2,896
2049	3,225	106	0	0	0	3,331
2050	1,498	49	0	0	0	1,547
2051	7,106	6,442	32	0	1,175	14,756
2052	28,194	25,558	128	0	4,663	58,542
2053 -96	0	0	0	0	0	0
2097	4,113	1,349	21	0	887	6,370
Total	71,766	52,871	277	0	15,212	140,127

TABLE 3.2
SAFSTOR ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	5,000	5,000
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	2,021	47	42	5	331	2,447
2044	62,913	2,205	1,285	298	11,976	78,676
2045	48,841	16,285	725	1,471	16,431	83,753
2046	26,694	18,751	256	63	3,094	48,858
2047	26,694	18,751	256	63	3,094	48,858
2048	26,767	18,802	257	63	3,103	48,992
2049	17,375	9,105	188	45	2,192	28,906
2050	9,252	696	128	30	1,406	11,512
2051	9,323	911	128	30	1,406	11,799
2052	9,349	913	128	30	1,410	11,831
2053	9,539	1,558	128	30	1,406	12,662
2054	9,467	1,343	128	30	1,406	12,374
2055	9,467	1,343	128	30	1,406	12,374
2056	9,349	913	128	30	1,410	11,831
2057	9,395	1,127	128	30	1,406	12,087
2058	9,467	1,343	128	30	1,406	12,374
2059	9,323	911	128	30	1,406	11,799
2060	9,349	913	128	30	1,410	11,831
2061	9,467	1,343	128	30	1,406	12,374
2062	9,467	1,343	128	30	1,406	12,374
2063	9,467	1,343	128	30	1,406	12,374
2064	9,492	1,345	128	30	1,410	12,406
2065	9,467	1,343	128	30	1,406	12,374
2066	9,467	1,343	128	30	1,406	12,374
2067	9,467	1,343	128	30	1,406	12,374
2068	9,421	1,129	128	30	1,410	12,118
2069	9,395	1,127	128	30	1,406	12,087

TABLE 3.2 (continued)
SAFSTOR ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	9,395	1,127	128	30	1,406	12,087
2071	9,467	1,343	128	30	1,406	12,374
2072	9,492	1,345	128	30	1,410	12,406
2073	9,467	1,343	128	30	1,406	12,374
2074	9,467	1,343	128	30	1,406	12,374
2075	9,467	1,343	128	30	1,406	12,374
2076	9,492	1,345	128	30	1,410	12,406
2077	9,467	1,343	128	30	1,406	12,374
2078	9,467	1,343	128	30	1,406	12,374
2079	9,467	1,343	128	30	1,406	12,374
2080	9,492	1,345	128	30	1,410	12,406
2081	9,467	1,343	128	30	1,406	12,374
2082	9,467	1,343	128	30	1,406	12,374
2083	9,467	1,343	128	30	1,406	12,374
2084	9,492	1,345	128	30	1,410	12,406
2085	9,467	1,343	128	30	1,406	12,374
2086	9,467	1,343	128	30	1,406	12,374
2087	9,467	1,343	128	30	1,406	12,374
2088	9,492	1,345	128	30	1,410	12,406
2089	9,467	1,343	128	30	1,406	12,374
2090	9,467	1,343	128	30	1,406	12,374
2091	9,467	1,343	128	30	1,406	12,374
2092	9,492	1,345	128	30	1,410	12,406
2093	9,467	1,343	128	30	1,406	12,374
2094	9,467	1,343	128	30	1,406	12,374
2095	9,467	1,343	128	30	1,406	12,374
2096	9,349	913	128	30	1,410	11,831
2097	4,298	343	128	28	898	5,695
2098	43,659	5,085	1,256	138	2,848	52,985

TABLE 3.2 (continued)
SAFSTOR ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2099	59,726	19,740	1,250	21,564	7,516	109,796
2100	70,796	33,421	1,212	43,882	12,336	161,647
2101	63,977	10,207	961	22,450	8,746	106,340
2102	63,977	10,207	961	22,450	8,746	106,340
2103	51,187	4,711	408	5,077	3,804	65,188
2104	29,855	26,236	128	0	5,088	61,307
2105	28,713	25,232	124	0	4,893	58,962
Total	1,071,458	278,379	15,461	119,014	166,221	1,650,534

TABLE 3.2a
SAFSTOR ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	2,021	47	42	5	264	2,379
2044	62,913	2,205	1,285	298	9,938	76,639
2045	42,244	6,378	725	1,471	15,110	65,928
2046	14,532	489	256	63	1,707	17,047
2047	14,532	489	256	63	1,707	17,047
2048	14,572	490	257	63	1,712	17,093
2049	9,021	415	188	45	1,199	10,868
2050	4,216	351	128	30	755	5,481
2051	4,216	351	128	30	755	5,481
2052	4,228	352	128	30	757	5,496
2053	4,216	351	128	30	755	5,481
2054	4,216	351	128	30	755	5,481
2055	4,216	351	128	30	755	5,481
2056	4,228	352	128	30	757	5,496
2057	4,216	351	128	30	755	5,481
2058	4,216	351	128	30	755	5,481
2059	4,216	351	128	30	755	5,481
2060	4,228	352	128	30	757	5,496
2061	4,216	351	128	30	755	5,481
2062	4,216	351	128	30	755	5,481
2063	4,216	351	128	30	755	5,481
2064	4,228	352	128	30	757	5,496
2065	4,216	351	128	30	755	5,481
2066	4,216	351	128	30	755	5,481
2067	4,216	351	128	30	755	5,481
2068	4,228	352	128	30	757	5,496
2069	4,216	351	128	30	755	5,481

TABLE 3.2a (continued)
SAFSTOR ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	4,216	351	128	30	755	5,481
2071	4,216	351	128	30	755	5,481
2072	4,228	352	128	30	757	5,496
2073	4,216	351	128	30	755	5,481
2074	4,216	351	128	30	755	5,481
2075	4,216	351	128	30	755	5,481
2076	4,228	352	128	30	757	5,496
2077	4,216	351	128	30	755	5,481
2078	4,216	351	128	30	755	5,481
2079	4,216	351	128	30	755	5,481
2080	4,228	352	128	30	757	5,496
2081	4,216	351	128	30	755	5,481
2082	4,216	351	128	30	755	5,481
2083	4,216	351	128	30	755	5,481
2084	4,228	352	128	30	757	5,496
2085	4,216	351	128	30	755	5,481
2086	4,216	351	128	30	755	5,481
2087	4,216	351	128	30	755	5,481
2088	4,228	352	128	30	757	5,496
2089	4,216	351	128	30	755	5,481
2090	4,216	351	128	30	755	5,481
2091	4,216	351	128	30	755	5,481
2092	4,228	352	128	30	757	5,496
2093	4,216	351	128	30	755	5,481
2094	4,216	351	128	30	755	5,481
2095	4,216	351	128	30	755	5,481
2096	4,228	352	128	30	757	5,496
2097	4,298	343	128	28	898	5,695
2098	43,423	5,085	1,256	138	2,848	52,750

TABLE 3.2a (continued)
SAFSTOR ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2099	58,139	19,681	1,250	21,564	7,516	108,150
2100	67,926	33,299	1,212	43,882	12,336	158,655
2101	61,012	10,110	961	22,450	8,746	103,278
2102	61,012	10,110	961	22,450	8,746	103,278
2103	49,552	3,830	404	5,077	3,639	62,502
2104	48	0	0	0	58	105
2105	46	0	0	0	55	101
Total	703,604	109,481	15,205	119,014	112,002	1,059,307

TABLE 3.2b
SAFSTOR ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	0	0	0	0	68	68
2044	0	0	0	0	2,038	2,038
2045	6,597	9,907	0	0	1,321	17,825
2046	12,162	18,263	0	0	1,387	31,811
2047	12,162	18,263	0	0	1,387	31,811
2048	12,195	18,313	0	0	1,391	31,898
2049	8,354	8,690	0	0	994	18,038
2050	5,035	345	0	0	651	6,030
2051	5,107	560	0	0	651	6,318
2052	5,121	561	0	0	652	6,334
2053	5,323	1,207	0	0	651	7,180
2054	5,251	992	0	0	651	6,893
2055	5,251	992	0	0	651	6,893
2056	5,121	561	0	0	652	6,334
2057	5,179	776	0	0	651	6,605
2058	5,251	992	0	0	651	6,893
2059	5,107	560	0	0	651	6,318
2060	5,121	561	0	0	652	6,334
2061	5,251	992	0	0	651	6,893
2062	5,251	992	0	0	651	6,893
2063	5,251	992	0	0	651	6,893
2064	5,264	993	0	0	652	6,909
2065	5,251	992	0	0	651	6,893
2066	5,251	992	0	0	651	6,893
2067	5,251	992	0	0	651	6,893
2068	5,193	777	0	0	652	6,622
2069	5,179	776	0	0	651	6,605

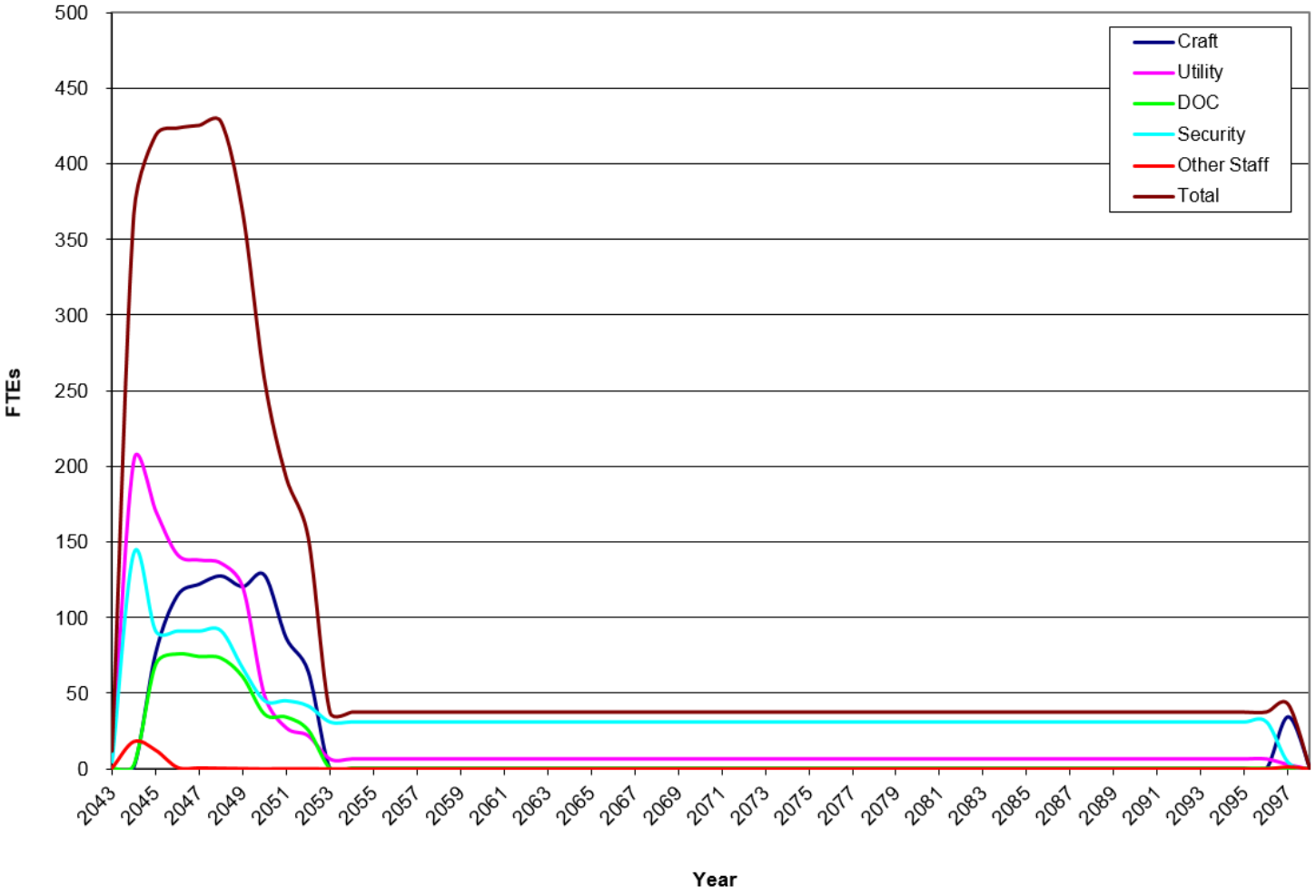
TABLE 3.2b (continued)
SAFSTOR ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2070	5,179	776	0	0	651	6,605
2071	5,251	992	0	0	651	6,893
2072	5,264	993	0	0	652	6,909
2073	5,251	992	0	0	651	6,893
2074	5,251	992	0	0	651	6,893
2075	5,251	992	0	0	651	6,893
2076	5,264	993	0	0	652	6,909
2077	5,251	992	0	0	651	6,893
2078	5,251	992	0	0	651	6,893
2079	5,251	992	0	0	651	6,893
2080	5,264	993	0	0	652	6,909
2081	5,251	992	0	0	651	6,893
2082	5,251	992	0	0	651	6,893
2083	5,251	992	0	0	651	6,893
2084	5,264	993	0	0	652	6,909
2085	5,251	992	0	0	651	6,893
2086	5,251	992	0	0	651	6,893
2087	5,251	992	0	0	651	6,893
2088	5,264	993	0	0	652	6,909
2089	5,251	992	0	0	651	6,893
2090	5,251	992	0	0	651	6,893
2091	5,251	992	0	0	651	6,893
2092	5,264	993	0	0	652	6,909
2093	5,251	992	0	0	651	6,893
2094	5,251	992	0	0	651	6,893
2095	5,251	992	0	0	651	6,893
2096	5,121	561	0	0	652	6,334
Total	297,122	116,171	0	0	39,186	452,479

TABLE 3.2c
SAFSTOR ALTERNATIVE
SITE RESTORATION EXPENDITURES
(thousands, 2018 dollars)

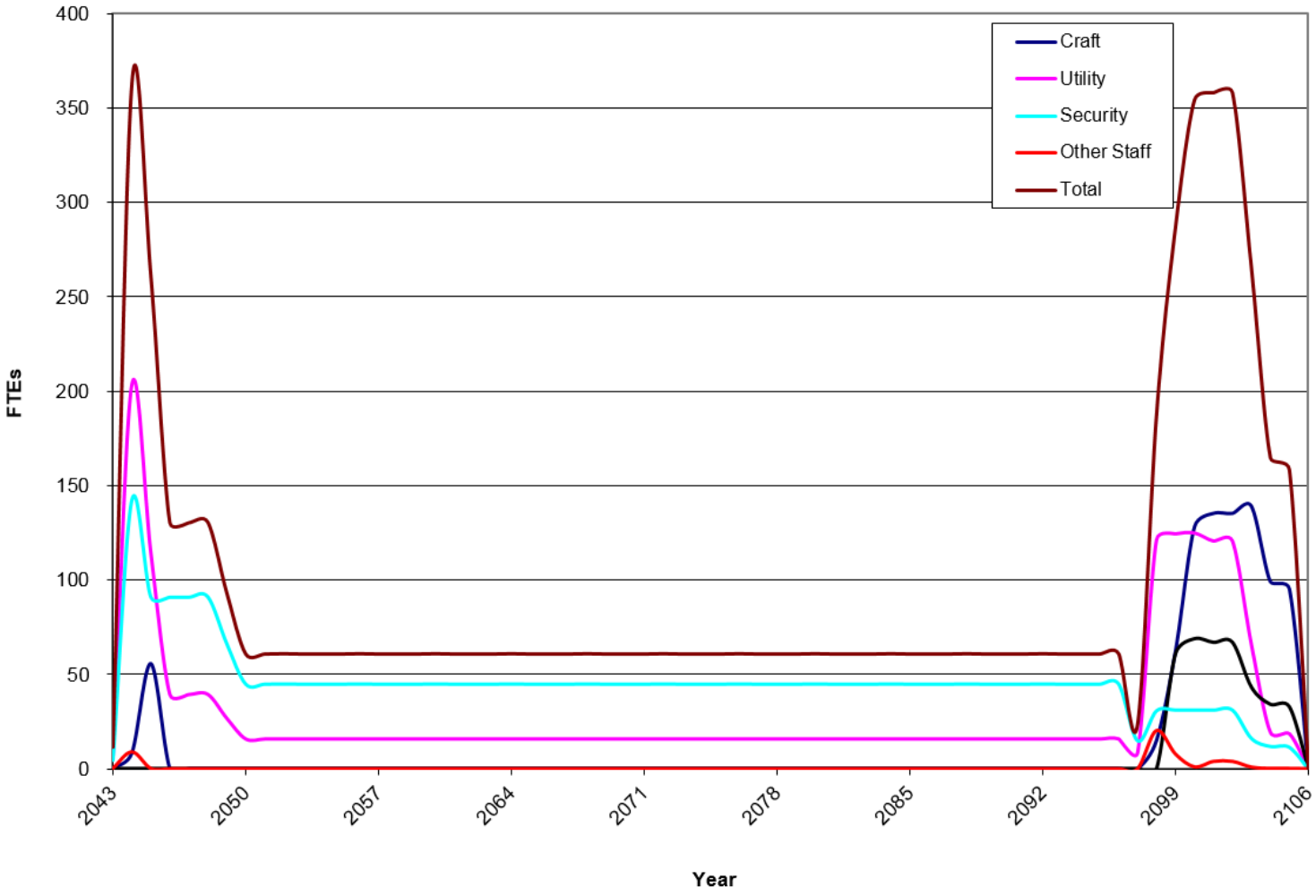
Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2038	0	0	0	0	5,000	5,000
2039-97	0	0	0	0	0	0
2098	236	0	0	0	0	236
2099	1,587	59	0	0	0	1,646
2100	2,870	122	0	0	0	2,992
2101	2,965	97	0	0	0	3,062
2102	2,965	97	0	0	0	3,062
2103	1,635	882	4	0	165	2,686
2104	29,808	26,236	128	0	5,030	61,202
2105	28,668	25,232	124	0	4,838	58,861
Total	70,733	52,726	256	0	15,033	138,748

FIGURE 3.1
DECOMMISSIONING PERSONNEL LEVELS
DECON



Note that the labor hour basis of this chart was taken from Appendix C; however not all line items in Appendix C have labor hour values available (e.g. spent fuel canister loading estimates)

FIGURE 3.2
DECOMMISSIONING PERSONNEL LEVELS
SAFSTOR



Note that the labor hour basis of this chart was taken from Appendix D; however not all line items in Appendix D have labor hour values available (e.g. spent fuel canister loading estimates)

4. SCHEDULE ESTIMATE

The schedules for the decommissioning scenarios considered in this analysis follow the sequences 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 DECON alternative is presented in Figure 4.1. The scheduling sequence is based on the fuel being removed from the spent fuel pool within five and one-half years. The key activities listed in the schedule do not reflect a one-to-one correspondence with those activities in the cost table but reflect dividing some activities for clarity and combining others for convenience. The schedule was prepared using the "Microsoft Project Professional" computer software.[37]

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 estimates 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 reactor building is isolated until such time that all spent fuel has been discharged from the spent fuel pool to the ISFSI. Decontamination and dismantling of the storage pool is initiated once the transfer of spent fuel is complete (DECON option).
- All work (except reactor vessel and reactor vessel internals removal and the spent fuel loading campaigns) 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.

4.2 PROJECT SCHEDULE

The period-dependent costs presented in the detailed cost tables 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 second critical path is shown for the spent fuel storage period, which determines the release of the reactor building for final decontamination.

Project timelines are provided in Figures 4.2 and 4.3, with milestone dates based on the 2043 shutdown date. The fuel pool is emptied approximately five and one-half years after shutdown, while ISFSI operations continue until the DOE can complete the transfer of assemblies. Deferred decommissioning in the SAFSTOR scenario is assumed to commence so that the operating license is terminated within a 60-year period from the cessation of plant operations.

FIGURE 4.1
ACTIVITY SCHEDULE

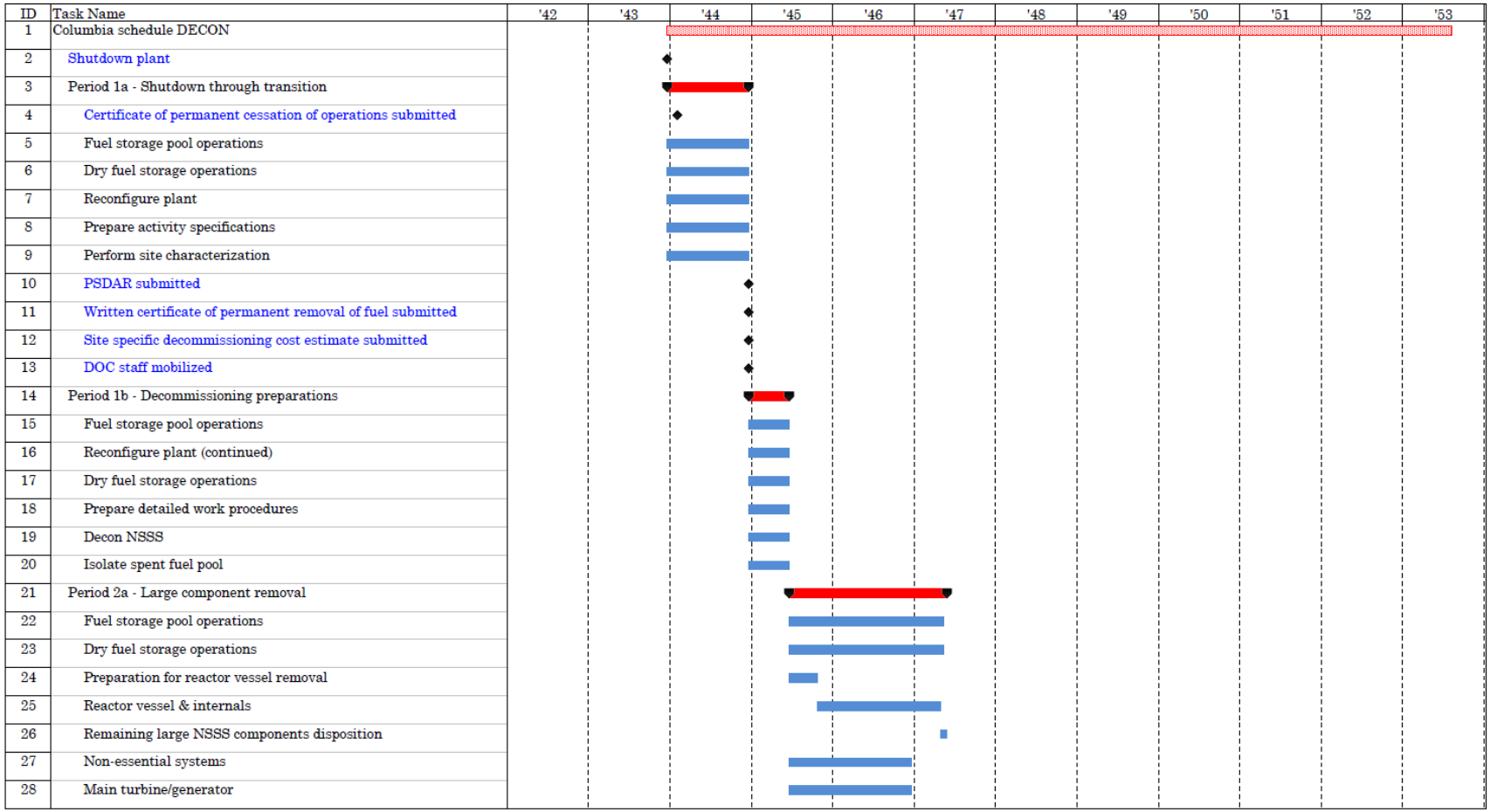
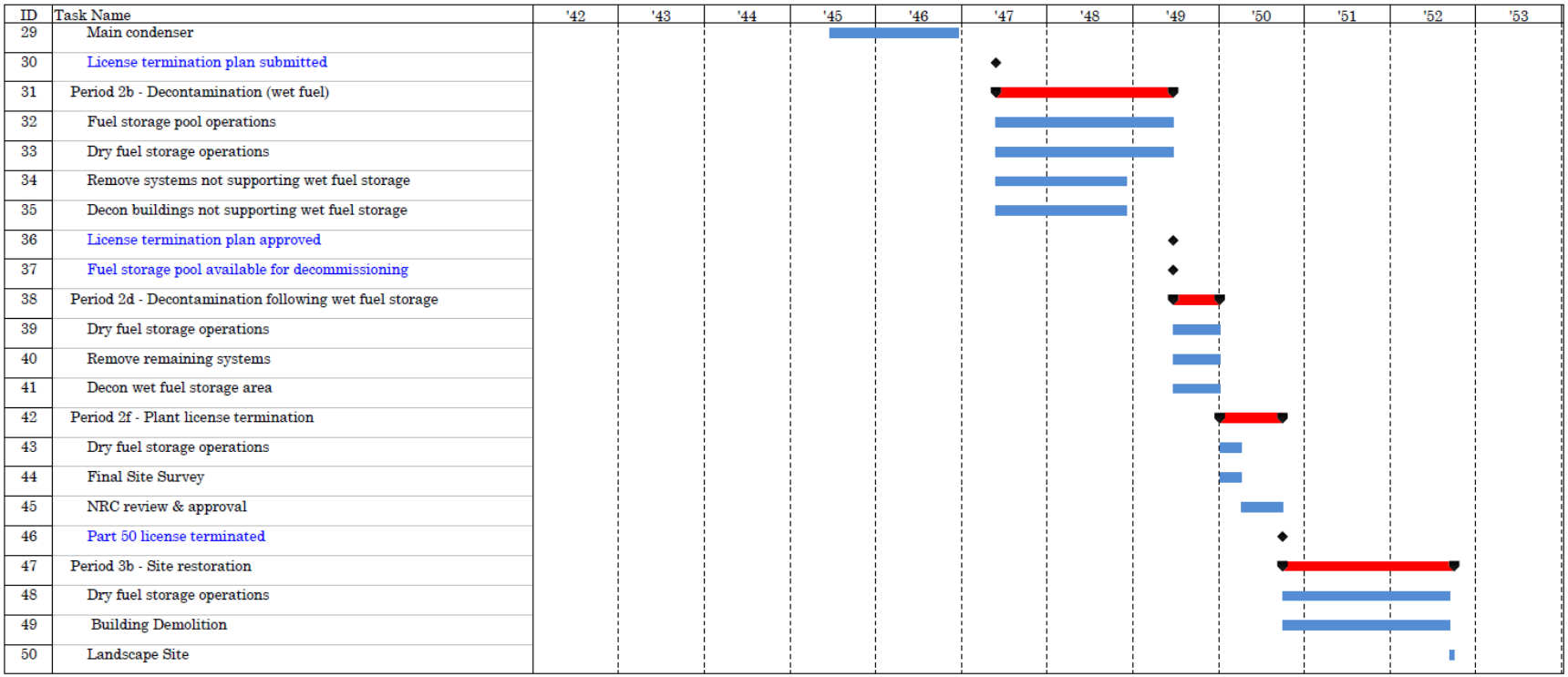


FIGURE 4.1 (continued)
ACTIVITY SCHEDULE



LEGEND

1. Red scheduling bars indicate critical path activities
2. Red scheduling bars with black border are associated with major decommissioning periods, e.g., Period 1a, indicating overall duration of that period
3. Diamond symbols indicate major milestones

FIGURE 4.2
DECOMMISSIONING TIMELINE
DECON
(not to scale)

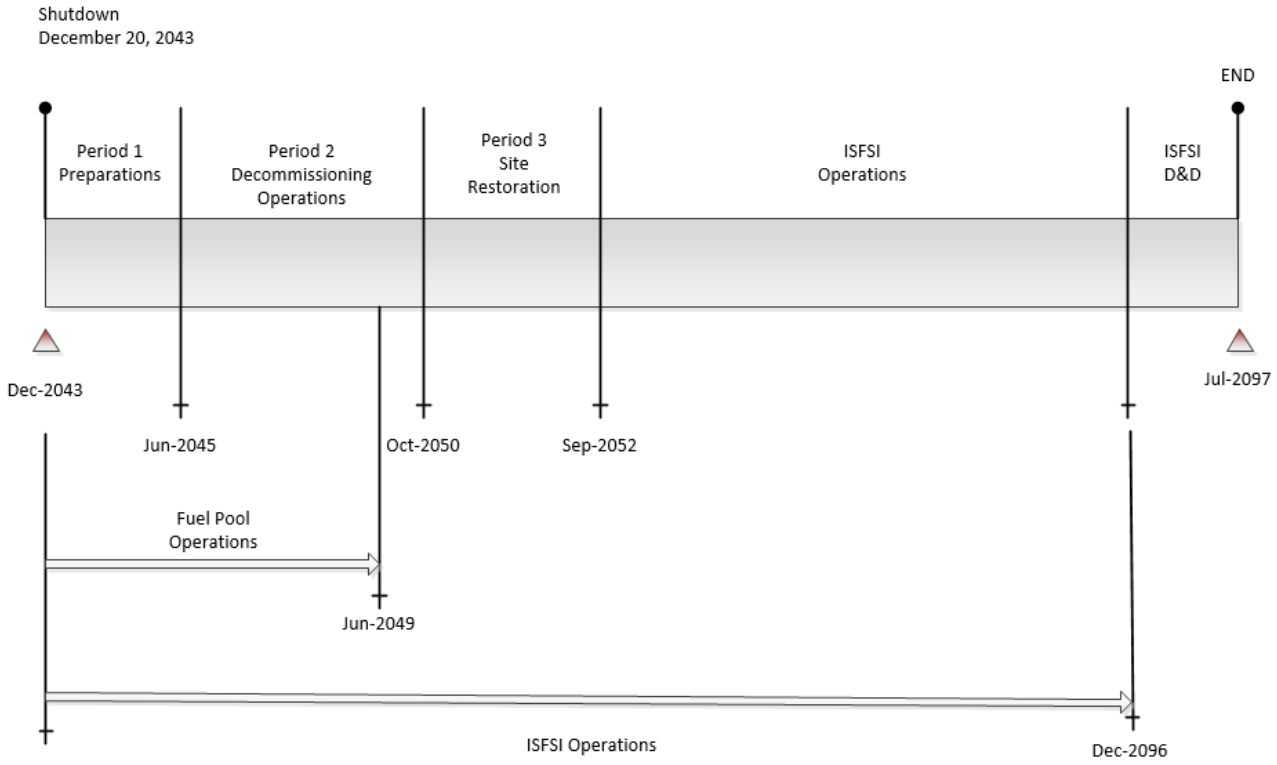
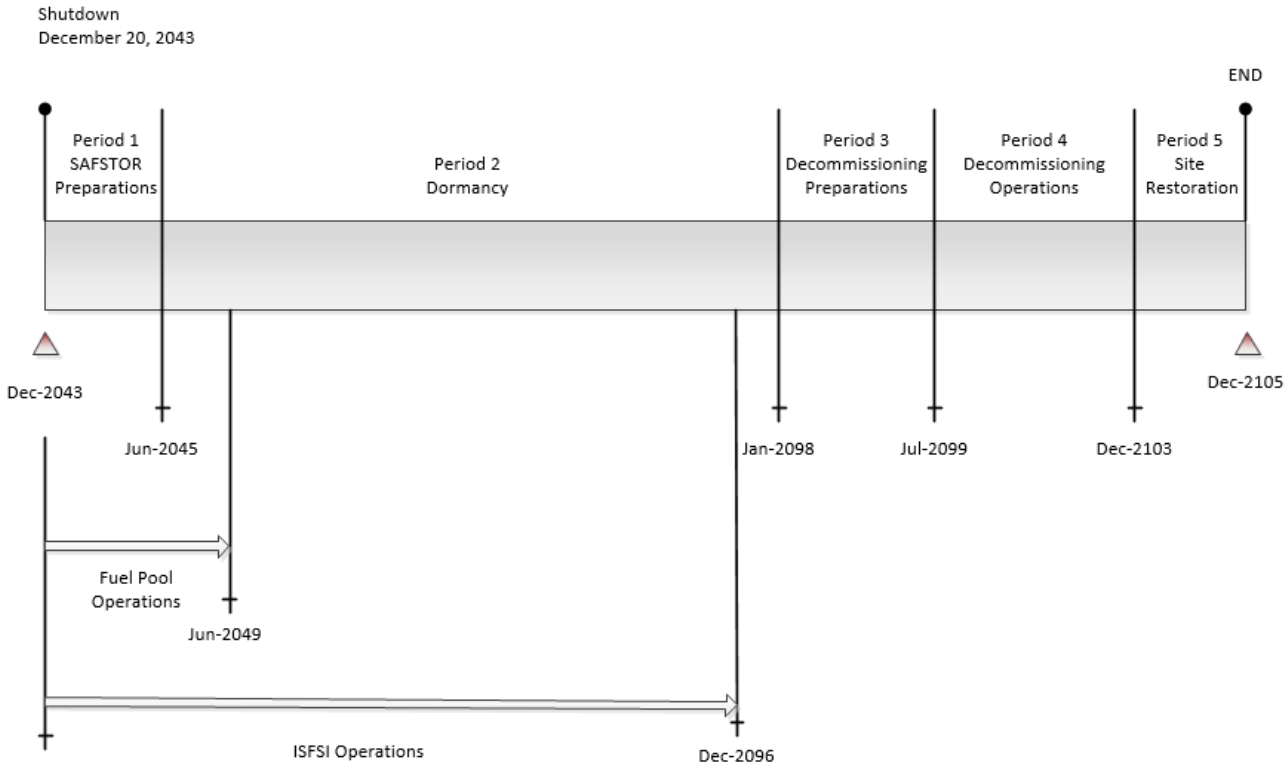


FIGURE 4.3
DECOMMISSIONING TIMELINE
SAFSTOR
(not to scale)



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,[38] 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 49 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 volumes are shown on a line-item basis in Appendices C and D and summarized in Tables 5.1 and 5.2. 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 2 of DECON and Period 4 of SAFSTOR. Material that is considered potentially contaminated when removed from the radiological controlled area is sent for additional processing. 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 estimates, the current cost for disposal at US Ecology facility in Richland, Washington 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. Soil was sent to the US Ecology facility in Grand View, Idaho.

TABLE 5.1
DECON ALTERNATIVE
DECOMMISSIONING WASTE SUMMARY

Waste	Cost Basis	Class [1]	Waste Volume (cubic feet)	Mass (pounds)
Low-Level Radioactive Waste (near-surface disposal)	U.S. Ecology - Containerized	A	168,017	10,752,460
	U.S. Ecology - Bulk	A	120,655	5,156,070
	U.S. Ecology	B	3,483	423,601
	U.S. Ecology	C	954	75,142
Greater than Class C (geologic repository)	Spent Fuel Equivalent	GTCC	1,633	319,745
Processed/Conditioned (off-site recycling center)	U.S. Ecology	A	435,084	18,427,210
Soil	U.S. Ecology-Idaho		201,399	25,174,810
Total [2]			931,225	60,329,037

[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

TABLE 5.2
SAFSTOR ALTERNATIVE
DECOMMISSIONING WASTE SUMMARY

Waste	Cost Basis	Class [1]	Waste Volume (cubic feet)	Mass (pounds)
Low-Level Radioactive Waste (near-surface disposal)	U.S. Ecology - Containerized	A	153,349	9,630,120
	U.S. Ecology - Bulk	A	124,040	5,223,760
	U.S. Ecology	B	2,880	276,887
	U.S. Ecology	C	281	39,659
Greater than Class C (geologic repository)	Spent Fuel Equivalent	GTCC	1,633	319,745
Processed/Conditioned (off-site recycling center)	U.S. Ecology	A	501,548	21,438,140
Soil	U.S. Ecology-Idaho		201,399	25,174,810
Total [2]			985,128	62,103,121

[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 Columbia relied upon the site-specific, technical information developed for a previous analysis prepared in 1989. While not an engineering study, the estimates provide sufficient information to assess the financial obligations, as they pertain to the eventual decommissioning of the nuclear station.

The estimates described in this report are 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 cost projected to promptly decommission the station, dismantle the structures, and manage the spent fuel is estimated to be $1.432 billion. The majority of this cost (approximately 55.5%) is associated with the physical decontamination and dismantling of the nuclear plant so that the operating license can be terminated. Another 34.7% is associated with the management, interim storage, and eventual transfer of the spent fuel. The remaining 9.8% is for the demolition of the designated structures and limited restoration of the site.

The cost projected for deferred decommissioning (SAFSTOR) is estimated to be $1.650 billion. The majority of this cost (approximately 64.2%) 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 27.4% is associated with the management, interim storage, and eventual transfer of the spent fuel. The remaining 8.4% is for the demolition of the designated structures and limited restoration of the site.

The primary cost contributors, identified in Tables 6.1 and 6.2, 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 Energy Northwest 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. However, once the operating license is amended or terminated, the staff is substantially reduced for the conventional demolition and restoration of the site, and the long-term care of the spent fuel (for the DECON alternative).

As described in this report, the spent fuel pool will remain operational for a minimum of five and one-half years following the cessation of operations. The pool will be isolated and an independent spent fuel island created. This will allow decommissioning operations to proceed in and around the pool area. Over the five and one-half year period, the spent fuel will be packaged into canisters and relocated to the 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 US Ecology facility in Richland, Washington. 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. 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. 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.

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 a 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
DECON ALTERNATIVE
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost	Percentage
Decontamination	23,699	1.7
Removal	211,340	14.8
Packaging	38,641	2.7
Transportation	3,620	0.3
Waste Disposal	109,425	7.6
Off-site Waste Processing	32,847	2.3
Program Management [1]	414,431	28.9
Security	284,157	19.8
Spent Fuel Pool Isolation	13,800	1.0
Spent Fuel Storage and Transfer [2]	189,535	13.2
Insurance and Regulatory Fees	44,972	3.1
Energy	7,647	0.5
Characterization and Licensing Surveys	40,052	2.8
Property Taxes	0	0.0
Miscellaneous Equipment	7,176	0.5
Site O&M	8,051	0.6
Groundwater Monitoring	3,047	0.2
Total [3]	1,432,439	100.0

Cost Category	Cost	Percentage
License Termination	794,924	55.5
Spent Fuel Management	497,388	34.7
Site Restoration	140,127	9.8
Total [3]	1,432,439	100.0

[1] Includes engineering costs
[2] Includes costs for operation of the spent fuel pool, transfer of spent fuel into dry storage, ISFSI operations (excluding staff), and transfer of the spent fuel to the DOE
[3] Columns may not add due to rounding

TABLE 6.2
SAFSTOR ALTERNATIVE
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost	Percentage
Decontamination	32,137	1.9
Removal	209,881	12.7
Packaging	32,686	2.0
Transportation	2,179	0.1
Waste Disposal	90,961	5.5
Off-site Waste Processing	38,213	2.3
Program Management [1]	531,199	32.2
Security	370,583	22.5
Spent Fuel Pool Isolation	13,800	0.8
Spent Fuel Storage and Transfer [2]	173,814	10.5
Insurance and Regulatory Fees	62,435	3.8
Energy	15,461	0.9
Characterization and Licensing Surveys	40,067	2.4
Property Taxes	0	0.0
Miscellaneous Equipment	25,052	1.5
Site O&M	8,551	0.5
Groundwater Monitoring	3,515	0.2
Total [3]	1,650,534	100.0

Cost Category	Cost	Percentage
License Termination	1,059,307	64.2
Spent Fuel Management	452,479	27.4
Site Restoration	138,748	8.4
Total [3]	1,650,534	100.0

[1] Includes engineering costs
[2] Includes costs for operation of the spent fuel pool, transfer of spent fuel into dry storage, ISFSI operations (excluding staff), and transfer of the spent fuel to the DOE
[3] Columns may not add due to rounding

7. REFERENCES

1. "Decommissioning Cost Study for the WPPSS Nuclear Project No. 2," Document B04-25-001, Rev. 1, prepared for Battelle Pacific Northwest Laboratories by TLG Services, Inc., June 1989

2. 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 [Open]

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

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

5. U.S. Code of Federal Regulations, Title 10, Parts 20 and 50, "Entombment Options for Power Reactors," Advance Notice of Proposed Rulemaking, 66 Fed. Reg. 52551, October 16, 2001 [Open]

6. U.S. Code of Federal Regulations, Title 10, Parts 2, 50 and 51, "Decommissioning of Nuclear Power Reactors," Nuclear Regulatory Commission, 61 Fed. Reg. 39278, July 29, 1996 [Open]

7. 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 [Open]

8. "Nuclear Waste Policy Act of 1982," 42 U.S. Code 10101, et seq. [Open]

9. Charter of the Blue Ribbon Commission on America's Nuclear Future, "Objectives and Scope of Activities" [Open]

10. "Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy," p. 27, 32, January 2012 [Open]

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

12. United States Court of Appeals for the District of Columbia Circuit, In Re: Aiken County, Et Al., August 2013 [Open]

7. REFERENCES
(continued)

13. "Acceptance Priority Ranking & Annual Capacity Report," DOE/RW-0567, July 2004 [Open]

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

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

16. "Low-Level Radioactive Waste Policy Act," Public Law 96-573, 1980 [Open]

17. "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, January 15, 1986 [Open]

18. "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste," (DOE/EIS-0375), January 2016

19. 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 [Open]

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

21. U.S. Code of Federal Regulations, Title 40, Part 141.66, "Maximum contaminant levels for radionuclides" [Open]

22. "Memorandum of Understanding Between the Environmental Protection Agency and the Nuclear Regulatory Commission: Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites," OSWER 9295.8-06a, October 9, 2002 [Open]

23. "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," NUREG-1575, Rev. 1, EPA 402-R-97-016, Rev. 1, August 2000 [Open]

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

7. REFERENCES
(continued)

25. W.J. Manion and T.S. LaGuardia, "Decommissioning Handbook," U.S. Department of Energy, DOE/EV/10128-1, November 1980 [Open]

26. "Building Construction Cost Data 2018," RSMeans (From the Gordian Group), Rockland, Massachusetts

27. "Decommissioning of Nuclear Power Reactors," Regulatory Guide 1.184, Nuclear Regulatory Commission, October 2013 [Open]

28. "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors," Regulatory Guide 1.202, Nuclear Regulatory Commission, February 2005 [Open]

29. Project and Cost Engineers' Handbook, Second Edition, p. 239, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York, 1984

30. DOE/RW-0351, "Civilian Radioactive Waste Management System Waste Acceptance System Requirements Document", Revision 5, May 31, 2007 [Open]

31. U.S. Department of Transportation, Title 49 of the Code of Federal Regulations, "Transportation," Parts 173 through 178 [Open]

32. Tri-State Motor Transit Company, Radioactive Materials Tariffs, TSMT 4007-E, January 2018

33. J.C. Evans et al., "Long-Lived Activation Products in Reactor Materials" NUREG/CR-3474, Pacific Northwest Laboratory for the Nuclear Regulatory Commission, August 1984 [Open]

34. R.I. Smith, G.J. Konzek, W.E. Kennedy, Jr., "Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station," NUREG/CR-0130 and addenda, Pacific Northwest Laboratory for the Nuclear Regulatory Commission, June 1978 [Open Main Report] [Open Appendices]

35. H.D. Oak, et al., "Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station," NUREG/CR-0672 and addenda, Pacific Northwest Laboratory for the Nuclear Regulatory Commission, June 1980 [Open Main Report] [Open Appendices]

7. REFERENCES
(continued)

36. SECY-00-0145, “Integrated Rulemaking Plan for Nuclear Power Plant Decommissioning,” June 2000." [Open]

37. "Microsoft Project Professional," Microsoft Corporation, Redmond, WA

38. “Atomic Energy Act of 1954,” (68 Stat. 919) [Open]

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 (37% of critical duration)	95
Adjusted work duration	478
+ Protective clothing adjustment (30% of adjusted duration)	143
Productive work duration	621
+ Work break adjustment (8.33 % of productive duration)	52
Total work duration (minutes)	673

***** Total duration = 11.217 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	11.217	$48.43	$1,629.72
Craftsmen	2.00	11.217	$71.53	$1,604.70
Foreman	1.00	11.217	$75.57	$847.67
General Foreman	0.25	11.217	$80.48	$225.69
Fire Watch	0.05	11.217	$48.43	$27.16
Health Physics Technician	1.00	11.217	$73.00	$818.84
Total Labor Cost				$5,153.78

4. EQUIPMENT & CONSUMABLES COSTS

Equipment Costs	none
Consumables/Materials Costs	
• Universal Sorbent 50 @ $0.69 sq ft {1}	$34.50
• Tarpaulins (oil resistant/fire retardant) 50 @ $0.54/sq ft {2}	$27.00
• Gas torch consumables 1 @ $22.97/hr x 1 hr {3}	$22.97
Subtotal cost of equipment and materials	$84.47
Overhead & profit on equipment and materials @ 18.60 %	$15.71
Total costs, equipment & material	$100.18

TOTAL COST:

Removal of contaminated heat exchanger <3000 pounds:	**$5,253.96**
Total labor cost:	$5,153.78
Total equipment/material costs:	$100.18
Total craft labor man-hours required per unit:	81.88

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. RSMeans (2018) Division 01 56, Section 13.60-0600, page 23
    3. RSMeans (2018) Division 01 54 33, Section 40-6360, page 734

- Material and consumable costs were adjusted using the regional indices for Richland, Washington.

APPENDIX B

UNIT COST FACTOR LISTING
(DECON: 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	0.56
Removal of clean pipe 0.25 to 2 inches diameter, $/linear foot	5.84
Removal of clean pipe >2 to 4 inches diameter, $/linear foot	8.48
Removal of clean pipe >4 to 8 inches diameter, $/linear foot	16.95
Removal of clean pipe >8 to 14 inches diameter, $/linear foot	32.28
Removal of clean pipe >14 to 20 inches diameter, $/linear foot	42.08
Removal of clean pipe >20 to 36 inches diameter, $/linear foot	61.88
Removal of clean pipe >36 inches diameter, $/linear foot	73.47
Removal of clean valve >2 to 4 inches	111.91
Removal of clean valve >4 to 8 inches	169.54
Removal of clean valve >8 to 14 inches	322.78
Removal of clean valve >14 to 20 inches	420.79
Removal of clean valve >20 to 36 inches	618.83
Removal of clean valve >36 inches	734.74
Removal of clean pipe hanger for small bore piping	39.19
Removal of clean pipe hanger for large bore piping	134.72
Removal of clean pump, <300 pound	288.40
Removal of clean pump, 300-1000 pound	806.60
Removal of clean pump, 1000-10,000 pound	3,158.44
Removal of clean pump, >10,000 pound	6,116.76
Removal of clean pump motor, 300-1000 pound	335.83
Removal of clean pump motor, 1000-10,000 pound	1,310.39
Removal of clean pump motor, >10,000 pound	2,948.39
Removal of clean heat exchanger <3000 pound	1,701.77
Removal of clean heat exchanger >3000 pound	4,295.51
Removal of clean feedwater heater/deaerator	12,068.21
Removal of clean moisture separator/reheater	24,755.79
Removal of clean tank, <300 gallons	370.68
Removal of clean tank, 300-3000 gallon	1,164.25
Removal of clean tank, >3000 gallons, $/square foot surface area	9.93

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of clean electrical equipment, <300 pound	155.04
Removal of clean electrical equipment, 300-1000 pound	546.74
Removal of clean electrical equipment, 1000-10,000 pound	1,093.51
Removal of clean electrical equipment, >10,000 pound	2,617.77
Removal of clean electrical transformer < 30 tons	1,818.00
Removal of clean electrical transformer > 30 tons	5,235.52
Removal of clean standby diesel generator, <100 kW	1,856.93
Removal of clean standby diesel generator, 100 kW to 1 MW	4,144.78
Removal of clean standby diesel generator, >1 MW	8,580.54
Removal of clean electrical cable tray, $/linear foot	14.67
Removal of clean electrical conduit, $/linear foot	6.42
Removal of clean mechanical equipment, <300 pound	155.04
Removal of clean mechanical equipment, 300-1000 pound	546.74
Removal of clean mechanical equipment, 1000-10,000 pound	1,093.51
Removal of clean mechanical equipment, >10,000 pound	2,617.77
Removal of clean HVAC equipment, <300 pound	187.48
Removal of clean HVAC equipment, 300-1000 pound	656.97
Removal of clean HVAC equipment, 1000-10,000 pound	1,309.32
Removal of clean HVAC equipment, >10,000 pound	2,617.77
Removal of clean HVAC ductwork, $/pound	0.59
Removal of contaminated instrument and sampling tubing, $/linear foot	1.87
Removal of contaminated pipe 0.25 to 2 inches diameter, $/linear foot	26.55
Removal of contaminated pipe >2 to 4 inches diameter, $/linear foot	44.76
Removal of contaminated pipe >4 to 8 inches diameter, $/linear foot	72.75
Removal of contaminated pipe >8 to 14 inches diameter, $/linear foot	139.52
Removal of contaminated pipe >14 to 20 inches diameter, $/linear foot	167.19
Removal of contaminated pipe >20 to 36 inches diameter, $/linear foot	230.33
Removal of contaminated pipe >36 inches diameter, $/linear foot	271.68
Removal of contaminated valve >2 to 4 inches	546.97
Removal of contaminated valve >2 to 4 inches	546.97

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated valve >4 to 8 inches	655.74
Removal of contaminated valve >8 to 14 inches	1,322.30
Removal of contaminated valve >14 to 20 inches	1,678.15
Removal of contaminated valve >20 to 36 inches	2,230.34
Removal of contaminated valve >36 inches	2,643.88
Removal of contaminated pipe hanger for small bore piping	180.30
Removal of contaminated pipe hanger for large bore piping	580.73
Removal of contaminated pump, <300 pound	1,173.05
Removal of contaminated pump, 300-1000 pound	2,712.53
Removal of contaminated pump, 1000-10,000 pound	8,613.55
Removal of contaminated pump, >10,000 pound	20,979.40
Removal of contaminated pump motor, 300-1000 pound	1,167.92
Removal of contaminated pump motor, 1000-10,000 pound	3,521.32
Removal of contaminated pump motor, >10,000 pound	7,905.97
Removal of contaminated heat exchanger <3000 pound	5,253.96
Removal of contaminated heat exchanger >3000 pound	15,280.15
Removal of contaminated feedwater heater/deaerator	37,154.39
Removal of contaminated moisture separator/reheater	80,606.10
Removal of contaminated tank, <300 gallons	1,953.18
Removal of contaminated tank, >300 gallons, $/square foot	37.80
Removal of contaminated electrical equipment, <300 pound	903.09
Removal of contaminated electrical equipment, 300-1000 pound	2,204.46
Removal of contaminated electrical equipment, 1000-10,000 pound	4,246.95
Removal of contaminated electrical equipment, >10,000 pound	8,356.36
Removal of contaminated electrical cable tray, $/linear foot	43.68
Removal of contaminated electrical conduit, $/linear foot	21.89
Removal of contaminated mechanical equipment, <300 pound	1,004.33
Removal of contaminated mechanical equipment, 300-1000 pound	2,433.17
Removal of contaminated mechanical equipment, 1000-10,000 pound	4,679.86
Removal of contaminated mechanical equipment, >10,000 pound	8,356.36

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated HVAC equipment, 300-1000 pound	2,433.17
Removal of contaminated HVAC equipment, 1000-10,000 pound	4,679.86
Removal of contaminated HVAC equipment, >10,000 pound	8,356.36
Removal of contaminated HVAC ductwork, $/pound	2.64
Removal/plasma arc cut of contaminated thin metal components, $/linear in.	4.77
Additional decontamination of surface by washing, $/square foot	9.65
Additional decontamination of surfaces by hydrolasing, $/square foot	44.32
Decontamination rig hook up and flush, $/ 250 foot length	8,440.75
Chemical flush of components/systems, $/gallon	23.74
Removal of clean standard reinforced concrete, $/cubic yard	82.61
Removal of grade slab concrete, $/cubic yard	93.94
Removal of clean concrete floors, $/cubic yard	447.35
Removal of sections of clean concrete floors, $/cubic yard	1,338.11
Removal of clean heavily rein concrete w/#9 rebar, $/cubic yard	119.21
Removal of contaminated heavily rein concrete w/#9 rebar, $/cubic yard	2,580.64
Removal of clean heavily rein concrete w/#18 rebar, $/cubic yard	161.56
Removal of contaminated heavily rein concrete w/#18 rebar, $/cubic yard	3,411.92
Removal heavily rein concrete w/#18 rebar & steel embedments, $/cubic yard	539.97
Removal of below-grade suspended floors, $/cubic yard	226.50
Removal of clean monolithic concrete structures, $/cubic yard	1,080.30
Removal of contaminated monolithic concrete structures, $/cubic yard	2,563.08
Removal of clean foundation concrete, $/cubic yard	850.66
Removal of contaminated foundation concrete, $/cubic yard	2,388.28
Explosive demolition of bulk concrete, $/cubic yard	59.18
Removal of clean hollow masonry block wall, $/cubic yard	28.85
Removal of contaminated hollow masonry block wall, $/cubic yard	76.54
Removal of clean solid masonry block wall, $/cubic yard	28.85
Removal of contaminated solid masonry block wall, $/cubic yard	76.54
Backfill of below-grade voids, $/cubic yard	35.42
Removal of subterranean tunnels/voids, $/linear foot	130.99

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Placement of concrete for below-grade voids, $/cubic yard	172.64
Excavation of clean material, $/cubic yard	3.48
Excavation of contaminated material, $/cubic yard	50.24
Removal of clean concrete rubble (tipping fee included), $/cubic yard	29.36
Removal of contaminated concrete rubble, $/cubic yard	31.14
Removal of building by volume, $/cubic foot	0.35
Removal of clean building metal siding, $/square foot	1.56
Removal of contaminated building metal siding, $/square foot	5.57
Removal of standard asphalt roofing, $/square foot	2.60
Removal of transite panels, $/square foot	2.47
Scarifying contaminated concrete surfaces (drill & spall), $/square foot	15.27
Scabbling contaminated concrete floors, $/square foot	9.20
Scabbling contaminated concrete walls, $/square foot	24.33
Scabbling contaminated ceilings, $/square foot	83.52
Scabbling structural steel, $/square foot	7.71
Removal of clean overhead crane/monorail < 10 ton capacity	777.84
Removal of contaminated overhead crane/monorail < 10 ton capacity	2,280.05
Removal of clean overhead crane/monorail >10-50 ton capacity	1,866.81
Removal of contaminated overhead crane/monorail >10-50 ton capacity	5,471.17
Removal of polar crane > 50 ton capacity	7,840.02
Removal of gantry crane > 50 ton capacity	32,721.97
Removal of structural steel, $/pound	0.23
Removal of clean steel floor grating, $/square foot	5.87
Removal of contaminated steel floor grating, $/square foot	17.36
Removal of clean free standing steel liner, $/square foot	14.89
Removal of contaminated free standing steel liner, $/square foot	44.17
Removal of clean concrete-anchored steel liner, $/square foot	7.44
Removal of contaminated concrete-anchored steel liner, $/square foot	51.50
Placement of scaffolding in clean areas, $/square foot	19.44
Placement of scaffolding in contaminated areas, $/square foot	32.01

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Landscaping with topsoil, $/acre	27,424.99
Cost of CPC B-88 LSA box & preparation for use	2,362.85
Cost of CPC B-25 LSA box & preparation for use	2,213.64
Cost of CPC B-12V 12 gauge LSA box & preparation for use	1,888.39
Cost of CPC B-144 LSA box & preparation for use	12,157.20
Cost of LSA drum & preparation for use	248.92
Cost of cask liner for CNSI 8 120A cask (resins)	13,927.45
Cost of cask liner for CNSI 8 120A cask (filters)	10,023.31
Decontamination of surfaces with vacuuming, $/square foot	0.95

APPENDIX C

DETAILED COST ANALYSIS

DECON

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
PERIOD 0a - Pre-Shutdown Early Planning																					
Period 0a Direct Decommissioning Activities																					
Period 0a Collateral Costs																					
0a.3.1	Site Restoration Study	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
0a.3	Subtotal Period 0a Collateral Costs	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
0a.0	TOTAL PERIOD 0a COST	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
PERIOD 1a - Shutdown through Transition																					
Period 1a Direct Decommissioning Activities																					
1a.1.1	Prepare preliminary decommissioning cost	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
1a.1.2	Notification of Cessation of Operations									a											
1a.1.3	Remove fuel & source material									n/a											
1a.1.4	Notification of Permanent Defueling									a											
1a.1.5	Deactivate plant systems & process waste									a											
1a.1.6	Prepare and submit PSDAR	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1a.1.7	Review plant dwgs & specs.	-	-	-	-	-	-	243	36	280	280	-	-	-	-	-	-	-	-	-	1,927
1a.1.8	Perform detailed rad survey									a											
1a.1.9	Estimate by-product inventory	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.10	End product description	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.11	Detailed by-product inventory	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
1a.1.12	Define major work sequence	-	-	-	-	-	-	397	59	456	456	-	-	-	-	-	-	-	-	-	3,143
1a.1.13	Perform SER and EA	-	-	-	-	-	-	164	25	189	189	-	-	-	-	-	-	-	-	-	1,299
1a.1.14	Prepare/submit Defueled Technical Specifications	-	-	-	-	-	-	397	59	456	456	-	-	-	-	-	-	-	-	-	3,143
1a.1.15	Perform Site-Specific Cost Study	-	-	-	-	-	-	264	40	304	304	-	-	-	-	-	-	-	-	-	2,095
1a.1.16	Prepare/submit Irradiated Fuel Management Plan	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
Activity Specifications																					
1a.1.17.1	Plant & temporary facilities	-	-	-	-	-	-	260	39	299	269	-	30	-	-	-	-	-	-	-	2,061
1a.1.17.2	Plant systems	-	-	-	-	-	-	220	33	253	228	-	25	-	-	-	-	-	-	-	1,746
1a.1.17.3	NSSS Decontamination Flush	-	-	-	-	-	-	26	4	30	30	-	-	-	-	-	-	-	-	-	210
1a.1.17.4	Reactor internals	-	-	-	-	-	-	375	56	432	432	-	-	-	-	-	-	-	-	-	2,975
1a.1.17.5	Reactor vessel	-	-	-	-	-	-	344	52	395	395	-	-	-	-	-	-	-	-	-	2,724
1a.1.17.6	Sacrificial shield	-	-	-	-	-	-	26	4	30	30	-	-	-	-	-	-	-	-	-	210
1a.1.17.7	Moisture separators/reheaters	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.17.8	Reinforced concrete	-	-	-	-	-	-	85	13	97	49	-	49	-	-	-	-	-	-	-	670
1a.1.17.9	Main Turbine	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
1a.1.17.10	Main Condensers	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
1a.1.17.11	Pressure suppression structure	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1a.1.17.12	Drywell	-	-	-	-	-	-	85	13	97	97	-	-	-	-	-	-	-	-	-	670
1a.1.17.13	Plant structures & buildings	-	-	-	-	-	-	165	25	190	95	-	95	-	-	-	-	-	-	-	1,307
1a.1.17.14	Waste management	-	-	-	-	-	-	243	36	280	280	-	-	-	-	-	-	-	-	-	1,927
1a.1.17.15	Facility & site closeout	-	-	-	-	-	-	48	7	55	27	-	27	-	-	-	-	-	-	-	377
1a.1.17	Total	-	-	-	-	-	-	2,257	339	2,596	2,369	-	226	-	-	-	-	-	-	-	17,884
Planning & Site Preparations																					
1a.1.18	Prepare dismantling sequence	-	-	-	-	-	-	127	19	146	146	-	-	-	-	-	-	-	-	-	1,006
1a.1.19	Plant prep. & temp. svces	-	-	-	-	-	-	3,300	495	3,795	3,795	-	-	-	-	-	-	-	-	-	-
1a.1.20	Design water clean-up system	-	-	-	-	-	-	74	11	85	85	-	-	-	-	-	-	-	-	-	587
1a.1.21	Rigging/Cont. Cntrl Envlps/tooling/etc.	-	-	-	-	-	-	2,300	345	2,645	2,645	-	-	-	-	-	-	-	-	-	-
1a.1.22	Procure casks/liners & containers	-	-	-	-	-	-	65	10	75	75	-	-	-	-	-	-	-	-	-	515
1a.1	Subtotal Period 1a Activity Costs	-	-	-	-	-	-	9,990	1,498	11,488	11,262	-	226	-	-	-	-	-	-	-	34,782
Period 1a Collateral Costs																					
1a.3.1	Security O&M	-	-	-	-	-	-	1,167	175	1,342	1,342	-	-	-	-	-	-	-	-	-	-
1a.3.2	Groundwater Monitoring	-	-	-	-	-	-	48	7	55	55	-	-	-	-	-	-	-	-	-	-
1a.3	Subtotal Period 1a Collateral Costs	-	-	-	-	-	-	1,216	182	1,398	1,398	-	-	-	-	-	-	-	-	-	-
Period 1a Period-Dependent Costs																					
1a.4.1	Insurance	-	-	-	-	-	-	3,199	320	3,519	3,519	-	-	-	-	-	-	-	-	-	-
1a.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1a.4.3	Health physics supplies	-	521	-	-	-	-	-	130	651	651	-	-	-	-	-	-	-	-	-	-
1a.4.4	Heavy equipment rental	-	546	-	-	-	-	-	82	628	628	-	-	-	-	-	-	-	-	-	-
1a.4.5	Disposal of DAW generated	-	-	15	0	-	133	-	35	183	183	-	-	-	610	-	-	-	12,190	20	-
1a.4.6	Plant energy budget	-	-	-	-	-	-	1,114	167	1,281	1,281	-	-	-	-	-	-	-	-	-	-

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 1a Period-Dependent Costs (continued)																					
1a.4.7	NRC Fees	-	-	-	-	-	-	1,141	114	1,255	1,255	-	-	-	-	-	-	-	-	-	-
1a.4.8	Emergency Planning Fees	-	-	-	-	-	-	917	92	1,008	-	1,008	-	-	-	-	-	-	-	-	-
1a.4.9	Site O&M Cost	-	-	-	-	-	-	746	112	858	858	-	-	-	-	-	-	-	-	-	-
1a.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	810	121	931	-	931	-	-	-	-	-	-	-	-	-
1a.4.11	ISFSI Operating Costs	-	-	-	-	-	-	106	16	122	-	122	-	-	-	-	-	-	-	-	-
1a.4.12	Corporate A&G Cost	-	-	-	-	-	-	2,035	305	2,340	2,340	-	-	-	-	-	-	-	-	-	-
1a.4.13	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	29	4	33	33	-	-	-	-	-	-	-	-	-	-
1a.4.14	Security Staff Cost	-	-	-	-	-	-	16,359	2,454	18,813	18,813	-	-	-	-	-	-	-	-	-	299,315
1a.4.15	Utility Staff Cost	-	-	-	-	-	-	33,583	5,037	38,621	38,621	-	-	-	-	-	-	-	-	-	422,240
1a.4	Subtotal Period 1a Period-Dependent Costs	-	1,067	15	0	-	133	60,039	8,990	70,244	68,183	2,061	-	-	610	-	-	-	12,190	20	721,555
1a.0	TOTAL PERIOD 1a COST	-	1,067	15	0	-	133	71,244	10,671	83,130	80,842	2,061	226	-	610	-	-	-	12,190	20	756,337
PERIOD 1b - Decommissioning Preparations																					
Period 1b Direct Decommissioning Activities																					
Detailed Work Procedures																					
1b.1.1.1	Plant systems	-	-	-	-	-	-	250	38	288	259	-	29	-	-	-	-	-	-	-	1,983
1b.1.1.2	NSSS Decontamination Flush	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1b.1.1.3	Reactor internals	-	-	-	-	-	-	212	32	243	243	-	-	-	-	-	-	-	-	-	1,676
1b.1.1.4	Remaining buildings	-	-	-	-	-	-	71	11	82	21	-	62	-	-	-	-	-	-	-	566
1b.1.1.5	CRD housings & NIs	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1b.1.1.6	Incore instrumentation	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1b.1.1.7	Removal primary containment	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1b.1.1.8	Reactor vessel	-	-	-	-	-	-	192	29	221	221	-	-	-	-	-	-	-	-	-	1,521
1b.1.1.9	Facility closeout	-	-	-	-	-	-	63	10	73	36	-	36	-	-	-	-	-	-	-	503
1b.1.1.10	Sacrificial shield	-	-	-	-	-	-	63	10	73	73	-	-	-	-	-	-	-	-	-	503
1b.1.1.11	Reinforced concrete	-	-	-	-	-	-	53	8	61	30	-	30	-	-	-	-	-	-	-	419
1b.1.1.12	Main Turbine	-	-	-	-	-	-	110	16	126	126	-	-	-	-	-	-	-	-	-	872
1b.1.1.13	Main Condensers	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
1b.1.1.14	Moisture separators & reheaters	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1b.1.1.15	Radwaste building	-	-	-	-	-	-	144	22	166	149	-	17	-	-	-	-	-	-	-	1,144
1b.1.1.16	Reactor building	-	-	-	-	-	-	144	22	166	149	-	17	-	-	-	-	-	-	-	1,144
1b.1.1	Total	-	-	-	-	-	-	1,784	268	2,052	1,861	-	190	-	-	-	-	-	-	-	14,137
1b.1.2	Decon NSSS	1,403	-	-	-	-	-	-	702	2,105	2,105	-	-	-	-	-	-	-	-	1,067	-
1b.1	Subtotal Period 1b Activity Costs	1,403	-	-	-	-	-	1,784	969	4,156	3,966	-	190	-	-	-	-	-	-	1,067	14,137
Period 1b Additional Costs																					
1b.2.1	Spent fuel pool isolation	-	-	-	-	-	-	12,000	1,800	13,800	13,800	-	-	-	-	-	-	-	-	-	-
1b.2.2	Site Characterization	-	-	-	-	-	-	6,705	2,011	8,716	8,716	-	-	-	-	-	-	-	-	30,500	10,852
1b.2	Subtotal Period 1b Additional Costs	-	-	-	-	-	-	18,705	3,811	22,516	22,516	-	-	-	-	-	-	-	-	30,500	10,852
Period 1b Collateral Costs																					
1b.3.1	Decon equipment	999	-	-	-	-	-	-	150	1,148	1,148	-	-	-	-	-	-	-	-	-	-
1b.3.2	DOC staff relocation expenses	-	-	-	-	-	-	1,297	195	1,492	1,492	-	-	-	-	-	-	-	-	-	-
1b.3.3	Process decommissioning water waste	57	-	41	28	-	130	-	69	325	325	-	-	-	352	-	-	-	21,137	69	-
1b.3.4	Process decommissioning chemical flush waste	4	-	167	271	-	6,771	-	1,752	8,965	8,965	-	-	-	-	1,498	-	-	159,613	280	-
1b.3.5	Small tool allowance	-	2	-	-	-	-	-	0	2	2	-	-	-	-	-	-	-	-	-	-
1b.3.6	Pipe cutting equipment	-	1,200	-	-	-	-	-	180	1,380	1,380	-	-	-	-	-	-	-	-	-	-
1b.3.7	Decon rig	2,016	-	-	-	-	-	-	302	2,319	2,319	-	-	-	-	-	-	-	-	-	-
1b.3.8	Security O&M	-	-	-	-	-	-	383	57	441	441	-	-	-	-	-	-	-	-	-	-
1b.3.9	Groundwater Monitoring	-	-	-	-	-	-	25	4	29	29	-	-	-	-	-	-	-	-	-	-
1b.3	Subtotal Period 1b Collateral Costs	3,076	1,202	208	299	-	6,901	1,706	2,710	16,101	16,101	-	-	-	352	1,498	-	-	180,750	349	-
Period 1b Period-Dependent Costs																					
1b.4.1	Decon supplies	36	-	-	-	-	-	-	9	45	45	-	-	-	-	-	-	-	-	-	-
1b.4.2	Insurance	-	-	-	-	-	-	316	32	348	348	-	-	-	-	-	-	-	-	-	-
1b.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1b.4.4	Health physics supplies	-	292	-	-	-	-	-	73	365	365	-	-	-	-	-	-	-	-	-	-
1b.4.5	Heavy equipment rental	-	272	-	-	-	-	-	41	313	313	-	-	-	-	-	-	-	-	-	-
1b.4.6	Disposal of DAW generated	-	-	9	0	-	78	-	20	107	107	-	-	-	356	-	-	-	7,122	12	-
1b.4.7	Plant energy budget	-	-	-	-	-	-	1,111	167	1,278	1,278	-	-	-	-	-	-	-	-	-	-
1b.4.8	NRC Fees	-	-	-	-	-	-	328	33	361	361	-	-	-	-	-	-	-	-	-	-
1b.4.9	Emergency Planning Fees	-	-	-	-	-	-	86	9	94	-	94	-	-	-	-	-	-	-	-	-
1b.4.10	Site O&M Cost	-	-	-	-	-	-	372	56	428	428	-	-	-	-	-	-	-	-	-	-

Table C
Columbia Generating Station
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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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 1b Period-Dependent Costs (continued)																					
1b.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	404	61	464	-	464	-	-	-	-	-	-	-	-	-
1b.4.12	ISFSI Operating Costs	-	-	-	-	-	-	53	8	61	-	61	-	-	-	-	-	-	-	-	-
1b.4.13	Corporate A&G Cost	-	-	-	-	-	-	1,020	153	1,173	1,173	-	-	-	-	-	-	-	-	-	-
1b.4.14	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	72	11	83	83	-	-	-	-	-	-	-	-	-	-
1b.4.15	Security Staff Cost	-	-	-	-	-	-	5,318	798	6,116	6,116	-	-	-	-	-	-	-	-	-	94,392
1b.4.16	DOC Staff Cost	-	-	-	-	-	-	6,323	948	7,271	7,271	-	-	-	-	-	-	-	-	-	63,266
1b.4.17	Utility Staff Cost	-	-	-	-	-	-	16,827	2,524	19,351	19,351	-	-	-	-	-	-	-	-	-	211,579
1b.4	Subtotal Period 1b Period-Dependent Costs	36	564	9	0	-	78	32,230	4,941	37,859	37,239	619	-	-	356	-	-	-	7,122	12	369,237
1b.0	TOTAL PERIOD 1b COST	4,516	1,767	217	299	-	6,978	54,425	12,432	80,633	79,823	619	190	-	708	1,498	-	-	187,872	31,927	394,226
PERIOD 1 TOTALS		4,516	2,833	232	299	-	7,111	125,669	23,102	163,762	160,665	2,681	417	-	1,318	1,498	-	-	200,062	31,947	1,150,563
PERIOD 2a - Large Component Removal																					
Period 2a Direct Decommissioning Activities																					
Nuclear Steam Supply System Removal																					
2a.1.1.1	Recirculation System Piping & Valves	190	185	46	7	-	464	-	263	1,154	1,154	-	-	-	1,978	-	-	-	137,997	5,326	-
2a.1.1.2	Recirculation Pumps & Motors	78	58	17	5	30	645	-	222	1,054	1,054	-	-	432	4,274	-	-	-	211,420	2,098	-
2a.1.1.3	CRDMs & NIs Removal	288	1,517	708	20	-	1,094	-	870	4,496	4,496	-	-	-	5,536	-	-	-	325,500	26,826	-
2a.1.1.4	Reactor Vessel Internals	279	7,555	16,009	1,065	-	6,976	485	13,635	46,003	46,003	-	-	-	1,628	1,985	954	-	501,530	42,415	1,855
2a.1.1.5	Reactor Vessel	234	10,069	4,223	401	-	10,462	485	14,129	40,003	40,003	-	-	-	28,585	-	-	-	1,990,866	42,415	1,855
2a.1.1	Totals	1,069	19,383	21,003	1,498	30	19,641	970	29,118	92,712	92,712	-	-	432	42,001	1,985	954	-	3,167,312	119,080	3,710
Removal of Major Equipment																					
2a.1.2	Main Turbine/Generator	-	674	3,035	70	8,249	1,054	-	1,983	15,065	15,065	-	-	118,264	4,939	-	-	-	5,635,672	10,222	-
2a.1.3	Main Condensers	-	1,469	2,163	50	5,879	751	-	1,661	11,974	11,974	-	-	84,292	3,521	-	-	-	4,016,810	22,580	-
Disposal of Plant Systems																					
2a.1.5.1	Auxiliary and Process Steam	-	154	-	-	-	-	-	23	177	-	-	177	-	-	-	-	-	-	2,639	-
2a.1.5.2	Circulating Water	-	1,161	-	-	-	-	-	174	1,335	-	-	1,335	-	-	-	-	-	-	19,825	-
2a.1.5.3	Closed Cooling Water	-	1,037	-	-	-	-	-	155	1,192	-	-	1,192	-	-	-	-	-	-	17,273	-
2a.1.5.4	Condensate and Feedwater	-	1,604	724	34	1,539	5,751	-	2,147	11,799	11,799	-	-	24,453	26,830	-	-	-	2,704,511	25,812	-
2a.1.5.5	Condensate Supply	-	1,662	189	12	864	1,440	-	926	5,094	5,094	-	-	13,733	6,730	-	-	-	986,119	25,414	-
2a.1.5.6	Containment Atmosphere Control	-	34	-	-	-	-	-	5	39	-	-	39	-	-	-	-	-	-	581	-
2a.1.5.7	Contain Aux and Process Steam	-	90	6	0	19	36	-	35	186	186	-	-	297	166	-	-	-	22,812	1,331	-
2a.1.5.8	Emergency Chilled Water-Control	-	124	-	-	-	-	-	19	143	-	-	143	-	-	-	-	-	-	2,059	-
2a.1.5.9	Extraction Steam and Heater Vents	-	1,039	78	7	571	510	-	482	2,686	2,686	-	-	9,069	2,380	-	-	-	520,115	15,859	-
2a.1.5.10	Gas and Air Removal	-	358	25	2	186	165	-	161	897	897	-	-	2,948	769	-	-	-	168,730	5,440	-
2a.1.5.11	Heater Drains	-	484	86	4	218	577	-	307	1,675	1,675	-	-	3,466	2,666	-	-	-	312,401	7,414	-
2a.1.5.12	Heating Hot Water and Chilled Water (RCA	-	196	-	-	-	-	-	29	226	-	-	226	-	-	-	-	-	-	3,280	-
2a.1.5.13	Heating Hot Water and Chilled Water	-	42	-	-	-	-	-	6	48	-	-	48	-	-	-	-	-	-	732	-
2a.1.5.14	Heating Steam	-	50	-	-	-	-	-	7	57	-	-	57	-	-	-	-	-	-	799	-
2a.1.5.15	HVAC (Clean)	-	340	-	-	-	-	-	51	391	-	-	391	-	-	-	-	-	-	5,914	-
2a.1.5.16	Main and Exhaust Steam	-	940	103	7	587	727	-	516	2,881	2,881	-	-	9,329	3,396	-	-	-	595,351	14,500	-
2a.1.5.17	Main Steam	-	691	62	5	456	386	-	345	1,945	1,945	-	-	7,244	1,797	-	-	-	409,126	10,630	-
2a.1.5.18	Main Steam Iso. Valve Leakage Control	-	4	0	0	0	1	-	1	7	7	-	-	7	4	-	-	-	566	58	-
2a.1.5.19	Off Gas Processing	-	561	45	3	223	313	-	257	1,402	1,402	-	-	3,539	1,455	-	-	-	236,769	8,467	-
2a.1.5.20	Plant Makeup Water Treatment	-	66	-	-	-	-	-	10	76	-	-	76	-	-	-	-	-	-	1,126	-
2a.1.5.21	Plant Service Water	-	96	-	-	-	-	-	14	110	-	-	110	-	-	-	-	-	-	1,567	-
2a.1.5.22	Post Accident Sampling	-	45	2	0	7	11	-	15	80	80	-	-	111	49	-	-	-	7,709	682	-
2a.1.5.23	Primary Containment Cooling	-	98	16	1	107	97	-	67	386	386	-	-	1,701	449	-	-	-	97,867	1,516	-
2a.1.5.24	Primary Containment N2 Inerting	-	75	6	0	10	33	-	29	154	154	-	-	156	149	-	-	-	16,105	1,067	-
2a.1.5.25	Radwaste - Condensate Demin	-	522	60	3	200	421	-	272	1,478	1,478	-	-	3,183	1,956	-	-	-	254,565	7,918	-
2a.1.5.26	Sanitary Waste	-	79	-	-	-	-	-	12	91	-	-	91	-	-	-	-	-	-	1,374	-
2a.1.5.27	Standby Liquid Control	-	38	3	0	13	20	-	17	91	91	-	-	207	93	-	-	-	14,414	555	-
2a.1.5.28	Standby Service Water	-	516	119	5	196	801	-	371	2,007	2,007	-	-	3,111	3,694	-	-	-	364,594	7,499	-
2a.1.5.29	Steam and Liquid Sampling	-	242	26	2	175	172	-	133	751	751	-	-	2,786	804	-	-	-	164,482	3,584	-
2a.1.5.30	Turbine Oil Purification	-	394	-	-	-	-	-	59	453	-	-	453	-	-	-	-	-	-	6,408	-
2a.1.5.31	Under Vessel Neutron Monitoring	-	39	2	0	2	20	-	15	79	79	-	-	38	93	-	-	-	7,474	602	-
2a.1.5	Totals	-	12,781	1,552	86	5,374	11,480	-	6,662	37,935	33,597	-	4,338	85,377	53,479	-	-	-	6,883,710	201,925	-
2a.1.6	Scaffolding in support of decommissioning	-	2,721	58	1	151	41	-	719	3,691	3,691	-	-	2,161	191	-	-	-	109,346	47,346	-
2a.1	Subtotal Period 2a Activity Costs	1,069	37,028	27,811	1,706	19,683	32,967	970	40,144	161,378	157,039	-	4,338	290,526	104,130	1,985	954	-	19,812,850	401,153	3,710

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															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 2a Additional Costs																					
2a.2.1	Remedial Action Surveys	-	-	-	-	-	-	2,943	883	3,826	3,826	-	-	-	-	-	-	-	-	40,320	-
2a.2.2	Asbestos Abatement	-	-	-	-	-	-	1,000	150	1,150	1,150	-	-	-	-	-	-	-	-	-	-
2a.2	Subtotal Period 2a Additional Costs	-	-	-	-	-	-	3,943	1,033	4,976	4,976	-	-	-	-	-	-	-	-	40,320	-
Period 2a Collateral Costs																					
2a.3.1	Process decommissioning water waste	104	-	76	51	-	241	-	127	599	599	-	-	-	652	-	-	-	39,111	127	-
2a.3.3	Small tool allowance	-	476	-	-	-	-	-	71	547	492	-	55	-	-	-	-	-	-	-	-
2a.3.4	Spent Fuel Capital and Transfer	-	-	-	-	-	-	13,764	2,065	15,829	-	15,829	-	-	-	-	-	-	-	-	-
2a.3.5	Security O&M	-	-	-	-	-	-	1,490	224	1,714	1,714	-	-	-	-	-	-	-	-	-	-
2a.3.6	Groundwater Monitoring	-	-	-	-	-	-	97	15	112	112	-	-	-	-	-	-	-	-	-	-
2a.3	Subtotal Period 2a Collateral Costs	104	476	76	51	-	241	15,351	2,501	18,799	2,916	15,829	55	-	652	-	-	-	39,111	127	-
Period 2a Period-Dependent Costs																					
2a.4.1	Decon supplies	141	-	-	-	-	-	-	35	176	176	-	-	-	-	-	-	-	-	-	-
2a.4.2	Insurance	-	-	-	-	-	-	1,230	123	1,353	1,353	-	-	-	-	-	-	-	-	-	-
2a.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2a.4.4	Health physics supplies	-	3,164	-	-	-	-	-	791	3,955	3,955	-	-	-	-	-	-	-	-	-	-
2a.4.5	Heavy equipment rental	-	4,131	-	-	-	-	-	620	4,750	4,750	-	-	-	-	-	-	-	-	-	-
2a.4.6	Disposal of DAW generated	-	-	197	4	-	1,752	-	458	2,412	2,412	-	-	-	8,028	-	-	-	160,561	262	-
2a.4.7	Plant energy budget	-	-	-	-	-	-	2,053	308	2,361	2,361	-	-	-	-	-	-	-	-	-	-
2a.4.8	NRC Fees	-	-	-	-	-	-	1,153	115	1,268	1,268	-	-	-	-	-	-	-	-	-	-
2a.4.9	Emergency Planning Fees	-	-	-	-	-	-	334	33	367	-	367	-	-	-	-	-	-	-	-	-
2a.4.10	Site O&M Cost	-	-	-	-	-	-	1,447	217	1,664	1,664	-	-	-	-	-	-	-	-	-	-
2a.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	1,570	236	1,806	-	1,806	-	-	-	-	-	-	-	-	-
2a.4.12	ISFSI Operating Costs	-	-	-	-	-	-	206	31	236	-	236	-	-	-	-	-	-	-	-	-
2a.4.13	Corporate A&G Cost	-	-	-	-	-	-	2,752	413	3,165	3,165	-	-	-	-	-	-	-	-	-	-
2a.4.14	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	282	42	324	324	-	-	-	-	-	-	-	-	-	-
2a.4.15	Security Staff Cost	-	-	-	-	-	-	20,674	3,101	23,775	23,775	-	-	-	-	-	-	-	-	-	366,900
2a.4.16	DOC Staff Cost	-	-	-	-	-	-	30,769	4,615	35,385	35,385	-	-	-	-	-	-	-	-	-	306,632
2a.4.17	Utility Staff Cost	-	-	-	-	-	-	46,771	7,016	53,786	53,786	-	-	-	-	-	-	-	-	-	570,900
2a.4	Subtotal Period 2a Period-Dependent Costs	141	7,295	197	4	-	1,752	109,240	18,154	136,784	134,374	2,410	-	-	8,028	-	-	-	160,561	262	1,244,432
2a.0	TOTAL PERIOD 2a COST	1,313	44,799	28,083	1,762	19,683	34,959	129,505	61,832	321,936	299,305	18,238	4,393	290,526	112,810	1,985	954	-	20,012,520	441,862	1,248,142
PERIOD 2b - Site Decontamination																					
Period 2b Direct Decommissioning Activities																					
Disposal of Plant Systems																					
2b.1.1.1	Chemical Feed	-	140	-	-	-	-	-	21	161	-	-	161	-	-	-	-	-	-	2,364	-
2b.1.1.2	Chemical Waste Processing	-	226	-	-	-	-	-	34	260	-	-	260	-	-	-	-	-	-	3,810	-
2b.1.1.3	Containment Instrument Air	-	161	-	-	-	-	-	24	185	-	-	185	-	-	-	-	-	-	2,734	-
2b.1.1.4	Control and Service Air	-	124	-	-	-	-	-	19	143	-	-	143	-	-	-	-	-	-	2,045	-
2b.1.1.5	Control Rod Drive	-	749	73	2	45	416	-	306	1,591	1,591	-	-	714	1,892	-	-	-	152,886	10,237	-
2b.1.1.6	Demineralized Water	-	161	-	-	-	-	-	24	185	-	-	185	-	-	-	-	-	-	2,659	-
2b.1.1.7	Diesel Oil and Misc	-	215	-	-	-	-	-	32	247	-	-	247	-	-	-	-	-	-	3,550	-
2b.1.1.8	Equip Drain Sys. - Reactor Bldg	-	1,292	102	4	24	917	-	567	2,905	2,905	-	-	389	4,294	-	-	-	288,753	18,753	-
2b.1.1.9	Equip and Floor Drains - Radwaste	-	143	17	1	15	137	-	74	388	388	-	-	242	639	-	-	-	50,672	2,136	-
2b.1.1.10	Equip and Floor Drains -Turbine	-	1,320	104	4	26	931	-	578	2,963	2,963	-	-	415	4,359	-	-	-	294,033	19,159	-
2b.1.1.11	Fire Protection (RCA)	-	270	-	-	-	-	-	40	310	-	-	310	-	-	-	-	-	-	4,459	-
2b.1.1.12	Fire Protection (Non RCA)	-	108	-	-	-	-	-	16	124	-	-	124	-	-	-	-	-	-	1,853	-
2b.1.1.13	Fire Protection-Well Water Pumphouse 2	-	124	-	-	-	-	-	19	142	-	-	142	-	-	-	-	-	-	1,989	-
2b.1.1.14	Floor Drain System-Reactor Bldg	-	97	11	0	2	82	-	46	239	239	-	-	39	381	-	-	-	25,991	1,387	-
2b.1.1.15	HPCS and LPCS	-	340	107	5	248	759	-	323	1,782	1,782	-	-	3,932	3,520	-	-	-	385,684	5,336	-
2b.1.1.16	HVAC Chilled Water-Radwaste	-	756	52	4	274	362	-	326	1,774	1,774	-	-	4,358	1,687	-	-	-	284,719	11,206	-
2b.1.1.17	Misc Drains Vents and Sealing	-	454	63	3	74	523	-	262	1,378	1,378	-	-	1,168	2,443	-	-	-	203,128	6,880	-
2b.1.1.18	Non-Radioactive Drains	-	1,290	-	-	-	-	-	194	1,484	-	-	1,484	-	-	-	-	-	-	22,270	-
2b.1.1.19	Nuclear Boiler Recirculation	-	262	114	4	104	804	-	294	1,582	1,582	-	-	1,655	3,715	-	-	-	306,385	4,022	-
2b.1.1.20	Potable Hot and Cold Water	-	81	-	-	-	-	-	12	93	-	-	93	-	-	-	-	-	-	1,406	-
2b.1.1.21	Radwaste - Equipment Drain Processing	-	341	44	2	104	331	-	188	1,010	1,010	-	-	1,650	1,541	-	-	-	165,506	5,204	-
2b.1.1.22	Radwaste - Floor Drain Processing	-	190	26	1	55	188	-	105	566	566	-	-	866	871	-	-	-	91,149	2,881	-
2b.1.1.23	Radwaste Disposal-Solids Handling	-	190	26	1	55	188	-	105	566	566	-	-	866	871	-	-	-	91,149	2,881	-
2b.1.1.24	Reactor Core Isolation Cooling	-	370	56	2	65	467	-	225	1,185	1,185	-	-	1,039	2,179	-	-	-	181,063	5,684	-
2b.1.1.25	Reactor Water Cleanup	-	234	26	1	22	182	-	110	575	575	-	-	343	838	-	-	-	67,976	3,452	-
2b.1.1.26	Residual Heat Removal	-	1,009	303	11	316	2,286	-	903	4,828	4,828	-	-	5,020	10,615	-	-	-	884,321	15,783	-
2b.1.1.27	Electrical (Clean)	-	3,068	-	-	-	-	-	460	3,528	-	-	3,528	-	-	-	-	-	-	49,651	-
2b.1.1	Totals	-	13,715	1,124	43	1,429	8,574	-	5,309	30,193	23,331	-	6,862	22,696	39,846	-	-	-	3,473,414	213,792	-

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
2b.1.2	Scaffolding in support of decommissioning	-	3,402	73	2	188	51	-	899	4,614	4,614	-	-	2,701	238	-	-	-	136,682	59,182	-
Decontamination of Site Buildings																					
2b.1.3.1	Reactor	6,493	5,448	411	79	2,931	9,586	-	7,497	32,446	32,446	-	-	46,566	80,241	-	-	-	5,714,518	167,817	-
2b.1.3.2	Radwaste Building	680	461	32	7	-	1,166	-	751	3,098	3,098	-	-	-	9,955	-	-	-	470,232	16,261	-
2b.1.3.3	Turbine Generator	899	610	40	9	22	1,444	-	972	3,997	3,997	-	-	351	12,328	-	-	-	596,295	21,602	-
2b.1.3	Totals	8,072	6,520	483	95	2,953	12,196	-	9,221	39,541	39,541	-	-	46,917	102,524	-	-	-	6,781,044	205,681	-
2b.1.4	Prepare/submit License Termination Plan	-	-	-	-	-	-	217	32	249	249	-	-	-	-	-	-	-	-	-	1,716
2b.1.5	Receive NRC approval of termination plan									a											
2b.1	Subtotal Period 2b Activity Costs	8,072	23,636	1,680	140	4,570	20,821	217	15,461	74,597	67,735	-	6,862	72,314	142,609	-	-	-	10,391,140	478,655	1,716
Period 2b Additional Costs																					
2b.2.1	Remedial Action Surveys	-	-	-	-	-	-	3,134	940	4,075	4,075	-	-	-	-	-	-	-	-	42,939	-
2b.2.2	Underground Storage Tanks	-	-	-	-	-	-	191	29	220	220	-	-	-	-	-	-	-	-	-	-
2b.2	Subtotal Period 2b Additional Costs	-	-	-	-	-	-	3,326	969	4,295	4,295	-	-	-	-	-	-	-	-	42,939	-
Period 2b Collateral Costs																					
2b.3.1	Process decommissioning water waste	144	-	107	73	-	341	-	179	843	843	-	-	-	924	-	-	-	55,437	180	-
2b.3.3	Small tool allowance	-	520	-	-	-	-	-	78	598	598	-	-	-	-	-	-	-	-	-	-
2b.3.4	Spent Fuel Capital and Transfer	-	-	-	-	-	-	71,164	10,675	81,838	-	81,838	-	-	-	-	-	-	-	-	-
2b.3.5	Security O&M	-	-	-	-	-	-	1,587	238	1,825	1,825	-	-	-	-	-	-	-	-	-	-
2b.3.6	Groundwater Monitoring	-	-	-	-	-	-	103	15	119	119	-	-	-	-	-	-	-	-	-	-
2b.3	Subtotal Period 2b Collateral Costs	144	520	107	73	-	341	72,854	11,185	85,223	3,385	81,838	-	-	924	-	-	-	55,437	180	-
Period 2b Period-Dependent Costs																					
2b.4.1	Decon supplies	2,004	-	-	-	-	-	-	501	2,505	2,505	-	-	-	-	-	-	-	-	-	-
2b.4.2	Insurance	-	-	-	-	-	-	1,310	131	1,441	1,441	-	-	-	-	-	-	-	-	-	-
2b.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2b.4.4	Health physics supplies	-	3,603	-	-	-	-	-	901	4,503	4,503	-	-	-	-	-	-	-	-	-	-
2b.4.5	Heavy equipment rental	-	4,534	-	-	-	-	-	680	5,214	5,214	-	-	-	-	-	-	-	-	-	-
2b.4.6	Disposal of DAW generated	-	-	182	4	-	1,612	-	422	2,219	2,219	-	-	-	7,388	-	-	-	147,750	241	-
2b.4.7	Plant energy budget	-	-	-	-	-	-	1,726	259	1,985	1,985	-	-	-	-	-	-	-	-	-	-
2b.4.8	NRC Fees	-	-	-	-	-	-	1,228	123	1,351	1,351	-	-	-	-	-	-	-	-	-	-
2b.4.9	Emergency Planning Fees	-	-	-	-	-	-	356	36	391	-	391	-	-	-	-	-	-	-	-	-
2b.4.10	Site O&M Cost	-	-	-	-	-	-	1,541	231	1,773	1,773	-	-	-	-	-	-	-	-	-	-
2b.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	1,672	251	1,923	-	1,923	-	-	-	-	-	-	-	-	-
2b.4.12	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	421	63	484	484	-	-	-	-	-	-	-	-	-	-
2b.4.13	ISFSI Operating Costs	-	-	-	-	-	-	219	33	252	-	252	-	-	-	-	-	-	-	-	-
2b.4.14	Corporate A&G Cost	-	-	-	-	-	-	2,806	421	3,227	3,227	-	-	-	-	-	-	-	-	-	-
2b.4.15	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	300	45	345	345	-	-	-	-	-	-	-	-	-	-
2b.4.16	Security Staff Cost	-	-	-	-	-	-	22,017	3,303	25,320	25,320	-	-	-	-	-	-	-	-	-	390,738
2b.4.17	DOC Staff Cost	-	-	-	-	-	-	31,599	4,740	36,338	36,338	-	-	-	-	-	-	-	-	-	313,664
2b.4.18	Utility Staff Cost	-	-	-	-	-	-	47,961	7,194	55,156	55,156	-	-	-	-	-	-	-	-	-	582,212
2b.4	Subtotal Period 2b Period-Dependent Costs	2,004	8,137	182	4	-	1,612	113,157	19,332	144,427	141,861	2,566	-	-	7,388	-	-	-	147,750	241	1,286,614
2b.0	TOTAL PERIOD 2b COST	10,220	32,294	1,969	217	4,570	22,774	189,553	46,947	308,543	217,276	84,405	6,862	72,314	150,920	-	-	-	10,594,330	522,016	1,288,330
PERIOD 2d - Decontamination Following Wet Fuel Storage																					
Period 2d Direct Decommissioning Activities																					
2d.1.1	Remove spent fuel racks	718	64	152	7	-	1,941	-	877	3,759	3,759	-	-	-	9,093	-	-	-	577,666	1,076	-
Disposal of Plant Systems																					
2d.1.2.1	Fuel Pool Cooling and Cleanup	-	508	56	3	149	416	-	259	1,391	1,391	-	-	2,365	1,937	-	-	-	219,855	7,685	-
2d.1.2.2	HVAC (Contam)	-	396	31	3	262	168	-	184	1,044	1,044	-	-	4,161	779	-	-	-	219,040	6,045	-
2d.1.2.3	Electrical (Contam)	-	4,821	92	24	2,988	-	-	1,666	9,591	9,591	-	-	47,467	-	-	-	-	1,927,674	69,365	-
2d.1.2	Totals	-	5,726	178	30	3,399	584	-	2,109	12,025	12,025	-	-	53,993	2,716	-	-	-	2,366,569	83,095	-
2d.1.4	Scaffolding in support of decommissioning	-	680	15	0	38	10	-	180	923	923	-	-	540	48	-	-	-	27,336	11,836	-
2d.1	Subtotal Period 2d Activity Costs	718	6,470	344	37	3,436	2,535	-	3,166	16,707	16,707	-	-	54,533	11,856	-	-	-	2,971,571	96,008	-
Period 2d Additional Costs																					
2d.2.1	License Termination Survey Planning	-	-	-	-	-	-	1,532	460	1,992	1,992	-	-	-	-	-	-	-	-	-	12,480
2d.2.2	Remedial Action Surveys	-	-	-	-	-	-	815	244	1,059	1,059	-	-	-	-	-	-	-	-	11,162	-
2d.2.3	Excavation of Underground Services	-	1,855	-	-	-	-	977	610	3,442	3,442	-	-	-	-	-	-	-	-	14,000	-

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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 2d Additional Costs (continued)																					
2d.2.4	Operational Tools & Equipment	-	-	22	5	454	-	-	71	552	552	-	-	11,710	-	-	-	-	292,750	32	-
2d.2.5	Evaporation Pond Remediation	-	100	126	672	-	6,243	-	1,672	8,814	8,814	-	-	-	201,399	-	-	-	25,174,810	880	-
2d.2	Subtotal Period 2d Additional Costs	-	1,955	148	677	454	6,243	3,324	3,057	15,859	15,859	-	-	11,710	201,399	-	-	-	25,467,560	26,074	12,480
Period 2d Collateral Costs																					
2d.3.1	Process decommissioning water waste	67	-	51	34	-	161	-	84	397	397	-	-	-	436	-	-	-	26,144	85	-
2d.3.3	Small tool allowance	-	129	-	-	-	-	-	19	148	148	-	-	-	-	-	-	-	-	-	-
2d.3.4	Decommissioning Equipment Disposition	-	-	161	4	419	113	-	108	805	805	-	-	6,000	529	-	-	-	303,608	147	-
2d.3.5	Spent Fuel Capital and Transfer	-	-	-	-	-	-	19,014	2,852	21,866	-	21,866	-	-	-	-	-	-	-	-	-
2d.3.6	Security O&M	-	-	-	-	-	-	226	34	260	260	-	-	-	-	-	-	-	-	-	-
2d.3.7	Groundwater Monitoring	-	-	-	-	-	-	27	4	31	31	-	-	-	-	-	-	-	-	-	-
2d.3	Subtotal Period 2d Collateral Costs	67	129	212	39	419	274	19,267	3,101	23,507	1,641	21,866	-	6,000	965	-	-	-	329,752	232	-
Period 2d Period-Dependent Costs																					
2d.4.1	Decon supplies	39	-	-	-	-	-	-	10	49	49	-	-	-	-	-	-	-	-	-	-
2d.4.2	Insurance	-	-	-	-	-	-	341	34	375	375	-	-	-	-	-	-	-	-	-	-
2d.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2d.4.4	Health physics supplies	-	844	-	-	-	-	-	211	1,055	1,055	-	-	-	-	-	-	-	-	-	-
2d.4.5	Heavy equipment rental	-	1,179	-	-	-	-	-	177	1,355	1,355	-	-	-	-	-	-	-	-	-	-
2d.4.6	Disposal of DAW generated	-	-	77	2	-	681	-	178	938	938	-	-	-	3,122	-	-	-	62,442	102	-
2d.4.7	Plant energy budget	-	-	-	-	-	-	239	36	275	275	-	-	-	-	-	-	-	-	-	-
2d.4.8	NRC Fees	-	-	-	-	-	-	270	27	297	297	-	-	-	-	-	-	-	-	-	-
2d.4.9	Site O&M Cost	-	-	-	-	-	-	257	39	295	295	-	-	-	-	-	-	-	-	-	-
2d.4.10	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	219	33	252	252	-	-	-	-	-	-	-	-	-	-
2d.4.11	ISFSI Operating Costs	-	-	-	-	-	-	57	9	65	-	65	-	-	-	-	-	-	-	-	-
2d.4.12	Corporate A&G Cost	-	-	-	-	-	-	514	77	591	591	-	-	-	-	-	-	-	-	-	-
2d.4.13	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	78	12	90	90	-	-	-	-	-	-	-	-	-	-
2d.4.14	Security Staff Cost	-	-	-	-	-	-	2,928	439	3,367	1,078	2,290	-	-	-	-	-	-	-	-	50,228
2d.4.15	DOC Staff Cost	-	-	-	-	-	-	5,588	838	6,426	6,426	-	-	-	-	-	-	-	-	-	55,847
2d.4.16	Utility Staff Cost	-	-	-	-	-	-	9,264	1,390	10,653	9,854	799	-	-	-	-	-	-	-	-	106,667
2d.4	Subtotal Period 2d Period-Dependent Costs	39	2,023	77	2	-	681	19,753	3,508	26,083	22,929	3,154	-	-	3,122	-	-	-	62,442	102	212,741
2d.0	TOTAL PERIOD 2d COST	824	10,577	780	755	4,309	9,734	42,345	12,833	82,156	57,136	25,020	-	72,243	217,342	-	-	-	28,831,330	122,416	225,221
PERIOD 2f - License Termination																					
Period 2f Direct Decommissioning Activities																					
2f.1.1	ORISE confirmatory survey	-	-	-	-	-	-	177	53	230	230	-	-	-	-	-	-	-	-	-	-
2f.1.2	Terminate license									a											
2f.1	Subtotal Period 2f Activity Costs	-	-	-	-	-	-	177	53	230	230	-	-	-	-	-	-	-	-	-	-
Period 2f Additional Costs																					
2f.2.1	License Termination Survey	-	-	-	-	-	-	14,638	4,391	19,030	19,030	-	-	-	-	-	-	-	-	210,570	6,240
2f.2	Subtotal Period 2f Additional Costs	-	-	-	-	-	-	14,638	4,391	19,030	19,030	-	-	-	-	-	-	-	-	210,570	6,240
Period 2f Collateral Costs																					
2f.3.1	DOC staff relocation expenses	-	-	-	-	-	-	1,297	195	1,492	1,492	-	-	-	-	-	-	-	-	-	-
2f.3.2	Security O&M	-	-	-	-	-	-	314	47	361	361	-	-	-	-	-	-	-	-	-	-
2f.3.3	Groundwater Monitoring	-	-	-	-	-	-	37	6	43	43	-	-	-	-	-	-	-	-	-	-
2f.3	Subtotal Period 2f Collateral Costs	-	-	-	-	-	-	1,649	247	1,896	1,896	-	-	-	-	-	-	-	-	-	-
Period 2f Period-Dependent Costs																					
2f.4.1	Insurance	-	-	-	-	-	-	473	47	520	520	-	-	-	-	-	-	-	-	-	-
2f.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2f.4.3	Health physics supplies	-	937	-	-	-	-	-	234	1,171	1,171	-	-	-	-	-	-	-	-	-	-
2f.4.4	Disposal of DAW generated	-	-	9	0	-	77	-	20	105	105	-	-	-	351	-	-	-	7,020	11	-
2f.4.5	Plant energy budget	-	-	-	-	-	-	166	25	191	191	-	-	-	-	-	-	-	-	-	-
2f.4.6	NRC Fees	-	-	-	-	-	-	427	43	470	470	-	-	-	-	-	-	-	-	-	-
2f.4.7	Site O&M Cost	-	-	-	-	-	-	356	53	410	410	-	-	-	-	-	-	-	-	-	-
2f.4.8	ISFSI Operating Costs	-	-	-	-	-	-	79	12	91	-	91	-	-	-	-	-	-	-	-	-
2f.4.9	Corporate A&G Cost	-	-	-	-	-	-	385	58	442	442	-	-	-	-	-	-	-	-	-	-
2f.4.10	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	21	3	25	25	-	-	-	-	-	-	-	-	-	-
2f.4.11	Security Staff Cost	-	-	-	-	-	-	4,063	610	4,673	1,495	3,178	-	-	-	-	-	-	-	-	69,703
2f.4.12	DOC Staff Cost	-	-	-	-	-	-	5,684	853	6,537	6,537	-	-	-	-	-	-	-	-	-	56,576
2f.4.13	Utility Staff Cost	-	-	-	-	-	-	7,299	1,095	8,394	7,286	1,108	-	-	-	-	-	-	-	-	79,826
2f.4	Subtotal Period 2f Period-Dependent Costs	-	937	9	0	-	77	18,953	3,052	23,028	18,652	4,376	-	-	351	-	-	-	7,020	11	206,106

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
2f.0	TOTAL PERIOD 2f COST	-	937	9	0	-	77	35,417	7,744	44,184	39,807	4,376	-	-	351	-	-	-	7,020	210,581	212,346
PERIOD 2 TOTALS		12,357	88,606	30,841	2,734	28,562	67,543	396,820	129,356	756,819	613,524	132,039	11,255	435,084	481,423	1,985	954	-	59,445,200	1,296,874	2,974,040
PERIOD 3b - Site Restoration																					
Period 3b Direct Decommissioning Activities																					
Demolition of Remaining Site Buildings																					
3b.1.1.1	Reactor	-	8,015	-	-	-	-	-	1,202	9,218	-	-	9,218	-	-	-	-	-	-	47,375	-
3b.1.1.2	Circ. Water Pumphouse	-	508	-	-	-	-	-	76	584	-	-	584	-	-	-	-	-	-	3,144	-
3b.1.1.3	Cooling Towers	-	4,545	-	-	-	-	-	682	5,227	-	-	5,227	-	-	-	-	-	-	22,238	-
3b.1.1.4	Diesel Generator Building	-	412	-	-	-	-	-	62	474	-	-	474	-	-	-	-	-	-	2,511	-
3b.1.1.5	Makeup Water Pumphouses	-	245	-	-	-	-	-	37	282	-	-	282	-	-	-	-	-	-	1,390	-
3b.1.1.6	Misc. Structures	-	7,578	-	-	-	-	-	1,137	8,714	-	-	8,714	-	-	-	-	-	-	73,226	-
3b.1.1.7	Misc. Structures 2018	-	4,207	-	-	-	-	-	631	4,838	-	-	4,838	-	-	-	-	-	-	30,966	-
3b.1.1.8	Radwaste Building	-	2,713	-	-	-	-	-	407	3,120	-	-	3,120	-	-	-	-	-	-	19,448	-
3b.1.1.9	Service Building	-	766	-	-	-	-	-	115	881	-	-	881	-	-	-	-	-	-	7,003	-
3b.1.1.10	Standby Service Water Pumphouses	-	234	-	-	-	-	-	35	269	-	-	269	-	-	-	-	-	-	1,255	-
3b.1.1.11	Technical Support Center	-	243	-	-	-	-	-	36	279	-	-	279	-	-	-	-	-	-	2,306	-
3b.1.1.12	Turbine Generator	-	8,061	-	-	-	-	-	1,209	9,270	-	-	9,270	-	-	-	-	-	-	47,709	-
3b.1.1.13	Yard Piping	-	4,206	-	-	-	-	-	631	4,837	-	-	4,837	-	-	-	-	-	-	48,931	-
3b.1.1	Totals	-	41,733	-	-	-	-	-	6,260	47,993	-	-	47,993	-	-	-	-	-	-	307,500	-
Site Closeout Activities																					
3b.1.2	BackFill Site	-	12,703	-	-	-	-	-	1,905	14,608	-	-	14,608	-	-	-	-	-	-	21,518	-
3b.1.3	Grade & landscape site	-	2,468	-	-	-	-	-	370	2,838	-	-	2,838	-	-	-	-	-	-	4,734	-
3b.1.4	Final report to NRC	-	-	-	-	-	-	82	12	95	95	-	-	-	-	-	-	-	-	-	654
3b.1	Subtotal Period 3b Activity Costs	-	56,904	-	-	-	-	82	8,548	65,535	95	-	65,440	-	-	-	-	-	-	333,752	654
Period 3b Additional Costs																					
3b.2.1	Concrete Crushing	-	2,148	-	-	-	-	12	324	2,483	-	-	2,483	-	-	-	-	-	-	9,173	-
3b.2.2	Construction Debris	-	-	-	-	-	-	6,699	1,005	7,703	-	-	7,703	-	-	-	-	-	-	-	-
3b.2.3	Landfill Closure	-	-	-	-	-	-	298	45	342	-	-	342	-	-	-	-	-	-	-	-
3b.2.4	Underground Wells	-	-	-	-	-	-	771	116	887	-	-	887	-	-	-	-	-	-	-	-
3b.2.5	Security Barriers	-	-	-	-	-	-	334	50	384	-	-	384	-	-	-	-	-	-	-	-
3b.2	Subtotal Period 3b Additional Costs	-	2,148	-	-	-	-	8,113	1,539	11,799	-	-	11,799	-	-	-	-	-	-	9,173	-
Period 3b Collateral Costs																					
3b.3.1	Small tool allowance	-	383	-	-	-	-	-	57	440	-	-	440	-	-	-	-	-	-	-	-
3b.3.2	Spent Fuel Capital and Transfer	-	-	-	-	-	-	436	65	502	-	502	-	-	-	-	-	-	-	-	-
3b.3.3	Security O&M	-	-	-	-	-	-	843	127	970	-	660	310	-	-	-	-	-	-	-	-
3b.3.4	Groundwater Monitoring	-	-	-	-	-	-	100	15	115	115	-	-	-	-	-	-	-	-	-	-
3b.3	Subtotal Period 3b Collateral Costs	-	383	-	-	-	-	1,380	264	2,027	115	1,161	751	-	-	-	-	-	-	-	-
Period 3b Period-Dependent Costs																					
3b.4.1	Insurance	-	-	-	-	-	-	1,268	127	1,395	1,395	-	-	-	-	-	-	-	-	-	-
3b.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3b.4.3	Heavy equipment rental	-	5,980	-	-	-	-	-	897	6,877	-	-	6,877	-	-	-	-	-	-	-	-
3b.4.4	Plant energy budget	-	-	-	-	-	-	223	33	256	-	-	256	-	-	-	-	-	-	-	-
3b.4.5	NRC ISFSI Fees	-	-	-	-	-	-	498	50	547	-	547	-	-	-	-	-	-	-	-	-
3b.4.6	Site O&M Cost	-	-	-	-	-	-	554	83	638	-	-	638	-	-	-	-	-	-	-	-
3b.4.7	ISFSI Operating Costs	-	-	-	-	-	-	212	32	244	-	244	-	-	-	-	-	-	-	-	-
3b.4.8	Corporate A&G Cost	-	-	-	-	-	-	546	82	628	-	-	628	-	-	-	-	-	-	-	-
3b.4.9	Security Staff Cost	-	-	-	-	-	-	10,905	1,636	12,541	-	8,528	4,013	-	-	-	-	-	-	-	187,072
3b.4.10	DOC Staff Cost	-	-	-	-	-	-	15,119	2,268	17,387	-	-	17,387	-	-	-	-	-	-	-	141,440
3b.4.11	Utility Staff Cost	-	-	-	-	-	-	10,678	1,602	12,280	-	2,984	9,296	-	-	-	-	-	-	-	113,360
3b.4	Subtotal Period 3b Period-Dependent Costs	-	5,980	-	-	-	-	40,004	6,809	52,793	1,395	12,303	39,095	-	-	-	-	-	-	-	441,872
3b.0	TOTAL PERIOD 3b COST	-	65,415	-	-	-	-	49,579	17,161	132,155	1,605	13,465	117,085	-	-	-	-	-	-	342,925	442,526
PERIOD 3c - Fuel Storage Operations/Shipping																					
Period 3c Collateral Costs																					
3c.3.1	Spent Fuel Capital and Transfer	-	-	-	-	-	-	30,314	4,547	34,861	-	34,861	-	-	-	-	-	-	-	-	-
3c.3.2	Security O&M	-	-	-	-	-	-	1,399	210	1,609	-	1,609	-	-	-	-	-	-	-	-	-
3c.3.3	Groundwater Monitoring	-	-	-	-	-	-	2,211	332	2,542	2,542	-	-	-	-	-	-	-	-	-	-
3c.3	Subtotal Period 3c Collateral Costs	-	-	-	-	-	-	33,924	5,089	39,012	2,542	36,470	-	-	-	-	-	-	-	-	-

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 3c Period-Dependent Costs																					
3c.4.1	Insurance	-	-	-	-	-	-	28,060	2,806	30,866	-	30,866	-	-	-	-	-	-	-	-	-
3c.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3c.4.4	NRC ISFSI Fees	-	-	-	-	-	-	14,835	1,483	16,318	-	16,318	-	-	-	-	-	-	-	-	-
3c.4.5	Site O&M Cost	-	-	-	-	-	-	1,725	259	1,983	-	1,983	-	-	-	-	-	-	-	-	-
3c.4.6	ISFSI Operating Costs	-	-	-	-	-	-	4,689	703	5,392	-	5,392	-	-	-	-	-	-	-	-	-
3c.4.7	Corporate A&G Cost	-	-	-	-	-	-	2,994	449	3,443	-	3,443	-	-	-	-	-	-	-	-	-
3c.4.8	Security Staff Cost	-	-	-	-	-	-	164,159	24,624	188,782	-	188,782	-	-	-	-	-	-	-	-	2,851,067
3c.4.9	Utility Staff Cost	-	-	-	-	-	-	57,333	8,600	65,933	-	65,933	-	-	-	-	-	-	-	-	621,222
3c.4	Subtotal Period 3c Period-Dependent Costs	-	-	-	-	-	-	273,795	38,924	312,719	-	312,719	-	-	-	-	-	-	-	-	3,472,289
3c.0	TOTAL PERIOD 3c COST	-	-	-	-	-	-	307,718	44,013	351,731	2,542	349,189	-	-	-	-	-	-	-	-	3,472,289
PERIOD 3d - GTCC shipping																					
Period 3d Direct Decommissioning Activities																					
Nuclear Steam Supply System Removal																					
3d.1.1.1	Vessel & Internals GTCC Disposal	-	-	1,000	-	-	6,695	-	1,254	8,949	8,949	-	-	-	-	-	-	1,633	319,745	-	-
3d.1.1	Totals	-	-	1,000	-	-	6,695	-	1,254	8,949	8,949	-	-	-	-	-	-	1,633	319,745	-	-
3d.1	Subtotal Period 3d Activity Costs	-	-	1,000	-	-	6,695	-	1,254	8,949	8,949	-	-	-	-	-	-	1,633	319,745	-	-
Period 3d Collateral Costs																					
3d.3.1	Security O&M	-	-	-	-	-	-	12	2	14	14	-	-	-	-	-	-	-	-	-	-
3d.3.2	Groundwater Monitoring	-	-	-	-	-	-	2	0	2	2	-	-	-	-	-	-	-	-	-	-
3d.3	Subtotal Period 3d Collateral Costs	-	-	-	-	-	-	14	2	16	16	-	-	-	-	-	-	-	-	-	-
Period 3d Period-Dependent Costs																					
3d.4.1	Insurance	-	-	-	-	-	-	24	2	27	27	-	-	-	-	-	-	-	-	-	-
3d.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3d.4.4	NRC ISFSI Fees	-	-	-	-	-	-	9	1	10	-	10	-	-	-	-	-	-	-	-	-
3d.4.5	Site O&M Cost	-	-	-	-	-	-	1	0	2	2	-	-	-	-	-	-	-	-	-	-
3d.4.6	ISFSI Operating Costs	-	-	-	-	-	-	4	1	5	-	5	-	-	-	-	-	-	-	-	-
3d.4.7	Corporate A&G Cost	-	-	-	-	-	-	3	0	3	3	-	-	-	-	-	-	-	-	-	-
3d.4.8	Security Staff Cost	-	-	-	-	-	-	142	21	164	164	-	-	-	-	-	-	-	-	-	2,472
3d.4.9	Utility Staff Cost	-	-	-	-	-	-	50	7	57	57	-	-	-	-	-	-	-	-	-	539
3d.4	Subtotal Period 3d Period-Dependent Costs	-	-	-	-	-	-	233	33	267	252	14	-	-	-	-	-	-	-	-	3,010
3d.0	TOTAL PERIOD 3d COST	-	-	1,000	-	-	6,695	247	1,290	9,232	9,217	14	-	-	-	-	-	1,633	319,745	-	3,010
PERIOD 3e - ISFSI Decontamination																					
Period 3e Additional Costs																					
3e.2.1	Decommissioning of ISFSI	-	493	136	4	-	1,600	2,740	1,243	6,215	6,215	-	-	-	7,330	-	-	-	364,041	18,240	2,369
3e.2	Subtotal Period 3e Additional Costs	-	493	136	4	-	1,600	2,740	1,243	6,215	6,215	-	-	-	7,330	-	-	-	364,041	18,240	2,369
Period 3e Period-Dependent Costs																					
3e.4.1	Insurance	-	-	-	-	-	-	101	25	127	127	-	-	-	-	-	-	-	-	-	-
3e.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3e.4.4	Security Staff Cost	-	-	-	-	-	-	355	89	443	443	-	-	-	-	-	-	-	-	-	6,239
3e.4.5	Utility Staff Cost	-	-	-	-	-	-	468	117	585	585	-	-	-	-	-	-	-	-	-	4,733
3e.4	Subtotal Period 3e Period-Dependent Costs	-	-	-	-	-	-	924	231	1,154	1,154	-	-	-	-	-	-	-	-	-	10,971
3e.0	TOTAL PERIOD 3e COST	-	493	136	4	-	1,600	3,663	1,474	7,370	7,370	-	-	-	7,330	-	-	-	364,041	18,240	13,340
PERIOD 3f - ISFSI Site Restoration																					
Period 3f Additional Costs																					
3f.2.1	Demolition of ISFSI	-	4,278	-	-	-	-	771	757	5,806	-	-	5,806	-	-	-	-	-	-	50,158	160
3f.2	Subtotal Period 3f Additional Costs	-	4,278	-	-	-	-	771	757	5,806	-	-	5,806	-	-	-	-	-	-	50,158	160
Period 3f Collateral Costs																					
3f.3.1	Small tool allowance	-	62	-	-	-	-	-	9	71	-	-	71	-	-	-	-	-	-	-	-
3f.3	Subtotal Period 3f Collateral Costs	-	62	-	-	-	-	-	9	71	-	-	71	-	-	-	-	-	-	-	-
Period 3f Period-Dependent Costs																					
3f.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3f.4.3	Heavy equipment rental	-	115	-	-	-	-	-	17	132	-	-	132	-	-	-	-	-	-	-	-

Table C
Columbia Generating Station
DECON Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 3f Period-Dependent Costs (continued)																					
3f.4.4	Plant energy budget	-	-	-	-	-	-	18	3	21	-	-	21	-	-	-	-	-	-	-	-
3f.4.5	Security Staff Cost	-	-	-	-	-	-	141	21	162	-	-	162	-	-	-	-	-	-	-	2,479
3f.4.6	Utility Staff Cost	-	-	-	-	-	-	154	23	178	-	-	178	-	-	-	-	-	-	-	1,539
3f.4	Subtotal Period 3f Period-Dependent Costs	-	115	-	-	-	-	314	64	493	-	-	493	-	-	-	-	-	-	-	4,018
3f.0	TOTAL PERIOD 3f COST	-	4,455	-	-	-	-	1,085	831	6,370	-	-	6,370	-	-	-	-	-	-	50,158	4,178
PERIOD 3 TOTALS		-	70,362	1,136	4	-	8,294	362,293	64,768	506,857	20,734	362,668	123,455	-	7,330	-	-	1,633	683,786	411,323	3,935,342
TOTAL COST TO DECOMMISSION		16,873	161,801	32,209	3,037	28,562	82,949	889,129	217,879	1,432,439	794,924	497,388	140,127	435,084	490,071	3,483	954	1,633	60,329,040	1,740,145	8,059,945

TOTAL COST TO DECOMMISSION WITH 17.94% CONTINGENCY:	**$1,432,439**	**thousands of 2018 dollars**
TOTAL NRC LICENSE TERMINATION COST IS 55.49% OR:	**$794,924**	**thousands of 2018 dollars**
SPENT FUEL MANAGEMENT COST IS 34.72% OR:	**$497,388**	**thousands of 2018 dollars**
NON-NUCLEAR DEMOLITION COST IS 9.78% OR:	**$140,127**	**thousands of 2018 dollars**
TOTAL LOW-LEVEL RADIOACTIVE WASTE VOLUME BURIED (EXCLUDING GTCC):	**494,508**	**cubic feet**
TOTAL GREATER THAN CLASS C RADWASTE VOLUME GENERATED:	**1,633**	**cubic feet**
TOTAL SCRAP METAL REMOVED:	**148,969**	**tons**
TOTAL CRAFT LABOR REQUIREMENTS:	**1,740,145**	**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
A cell containing " - " indicates a zero value

APPENDIX D

DETAILED COST ANALYSIS

SAFSTOR

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
PERIOD 0a - Pre-Shutdown Early Planning																					
Period 0a Direct Decommissioning Activities																					
Period 0a Collateral Costs																					
0a.3.1	Site Restoration Study	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
0a.3	Subtotal Period 0a Collateral Costs	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
0a.0	TOTAL PERIOD 0a COST	-	-	-	-	-	-	4,348	652	5,000	-	-	5,000	-	-	-	-	-	-	-	-
PERIOD 1a - Shutdown through Transition																					
Period 1a Direct Decommissioning Activities																					
1a.1.1	SAFSTOR site characterization survey	-	-	-	-	-	-	547	164	711	711	-	-	-	-	-	-	-	-	-	-
1a.1.2	Prepare preliminary decommissioning cost	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
1a.1.3	Notification of Cessation of Operations									a											
1a.1.4	Remove fuel & source material									n/a											
1a.1.5	Notification of Permanent Defueling									a											
1a.1.6	Deactivate plant systems & process waste									a											
1a.1.7	Prepare and submit PSDAR	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1a.1.8	Review plant dwgs & specs.	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
1a.1.9	Perform detailed rad survey									a											
1a.1.10	Estimate by-product inventory	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.11	End product description	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.12	Detailed by-product inventory	-	-	-	-	-	-	79	12	91	91	-	-	-	-	-	-	-	-	-	629
1a.1.13	Define major work sequence	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
1a.1.14	Perform SER and EA	-	-	-	-	-	-	164	25	189	189	-	-	-	-	-	-	-	-	-	1,299
1a.1.15	Prepare/submit Defueled Technical Specifications	-	-	-	-	-	-	397	59	456	456	-	-	-	-	-	-	-	-	-	3,143
1a.1.16	Perform Site-Specific Cost Study	-	-	-	-	-	-	264	40	304	304	-	-	-	-	-	-	-	-	-	2,095
1a.1.17	Prepare/submit Irradiated Fuel Management Plan	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
Activity Specifications																					
1a.1.18.1	Prepare plant and facilities for SAFSTOR	-	-	-	-	-	-	260	39	299	299	-	-	-	-	-	-	-	-	-	2,061
1a.1.18.2	Plant systems	-	-	-	-	-	-	220	33	253	253	-	-	-	-	-	-	-	-	-	1,746
1a.1.18.3	Plant structures and buildings	-	-	-	-	-	-	165	25	190	190	-	-	-	-	-	-	-	-	-	1,307
1a.1.18.4	Waste management	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1a.1.18.5	Facility and site dormancy	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
1a.1.18	Total	-	-	-	-	-	-	857	129	986	986	-	-	-	-	-	-	-	-	-	6,791
Detailed Work Procedures																					
1a.1.19.1	Plant systems	-	-	-	-	-	-	63	9	72	72	-	-	-	-	-	-	-	-	-	496
1a.1.19.2	Facility closeout & dormancy	-	-	-	-	-	-	63	10	73	73	-	-	-	-	-	-	-	-	-	503
1a.1.19	Total	-	-	-	-	-	-	126	19	145	145	-	-	-	-	-	-	-	-	-	999
1a.1.20	Procure vacuum drying system	-	-	-	-	-	-	5	1	6	6	-	-	-	-	-	-	-	-	-	42
1a.1.21	Drain/de-energize non-cont. systems									a											
1a.1.22	Drain & dry NSSS									a											
1a.1.23	Drain/de-energize contaminated systems									a											
1a.1.24	Decon/secure contaminated systems									a											
1a.1	Subtotal Period 1a Activity Costs	-	-	-	-	-	-	2,894	516	3,410	3,410	-	-	-	-	-	-	-	-	-	18,599
Period 1a Collateral Costs																					
1a.3.1	Security O&M	-	-	-	-	-	-	1,167	175	1,342	1,342	-	-	-	-	-	-	-	-	-	-
1a.3.2	Groundwater Monitoring	-	-	-	-	-	-	8	1	9	9	-	-	-	-	-	-	-	-	-	-
1a.3	Subtotal Period 1a Collateral Costs	-	-	-	-	-	-	1,175	176	1,351	1,351	-	-	-	-	-	-	-	-	-	-
Period 1a Period-Dependent Costs																					
1a.4.1	Insurance	-	-	-	-	-	-	3,199	320	3,519	3,519	-	-	-	-	-	-	-	-	-	-
1a.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1a.4.3	Health physics supplies	-	521	-	-	-	-	-	130	651	651	-	-	-	-	-	-	-	-	-	-
1a.4.4	Heavy equipment rental	-	546	-	-	-	-	-	82	628	628	-	-	-	-	-	-	-	-	-	-
1a.4.5	Disposal of DAW generated	-	-	15	0	-	133	-	35	183	183	-	-	-	610	-	-	-	12,190	20	-
1a.4.6	Plant energy budget	-	-	-	-	-	-	1,114	167	1,281	1,281	-	-	-	-	-	-	-	-	-	-
1a.4.7	NRC Fees	-	-	-	-	-	-	1,141	114	1,255	1,255	-	-	-	-	-	-	-	-	-	-
1a.4.8	Emergency Planning Fees	-	-	-	-	-	-	917	92	1,008	-	1,008	-	-	-	-	-	-	-	-	-
1a.4.9	Site O&M Cost	-	-	-	-	-	-	746	112	858	858	-	-	-	-	-	-	-	-	-	-
1a.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	810	121	931	-	931	-	-	-	-	-	-	-	-	-

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 1a Period-Dependent Costs (continued)																					
1a.4.11	ISFSI Operating Costs	-	-	-	-	-	-	106	16	122	-	122	-	-	-	-	-	-	-	-	-
1a.4.12	Corporate A&G Cost	-	-	-	-	-	-	2,035	305	2,340	2,340	-	-	-	-	-	-	-	-	-	-
1a.4.13	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	29	4	33	33	-	-	-	-	-	-	-	-	-	-
1a.4.14	Security Staff Cost	-	-	-	-	-	-	15,858	2,379	18,236	18,236	-	-	-	-	-	-	-	-	-	299,315
1a.4.15	Utility Staff Cost	-	-	-	-	-	-	33,583	5,037	38,621	38,621	-	-	-	-	-	-	-	-	-	422,240
1a.4	Subtotal Period 1a Period-Dependent Costs	-	1,067	15	0	-	133	59,537	8,915	69,667	67,606	2,061	-	-	610	-	-	-	12,190	20	721,555
1a.0	TOTAL PERIOD 1a COST	-	1,067	15	0	-	133	63,606	9,607	74,428	72,367	2,061	-	-	610	-	-	-	12,190	20	740,154
PERIOD 1b - SAFSTOR Limited DECON Activities																					
Period 1b Direct Decommissioning Activities																					
Decontamination of Site Buildings																					
1b.1.1.1	Reactor	6,423	-	-	-	-	-	-	3,212	9,635	9,635	-	-	-	-	-	-	-	-	91,230	-
1b.1.1.2	Radwaste Building	608	-	-	-	-	-	-	304	911	911	-	-	-	-	-	-	-	-	9,507	-
1b.1.1.3	Turbine Generator	809	-	-	-	-	-	-	405	1,214	1,214	-	-	-	-	-	-	-	-	12,666	-
1b.1.1	Totals	7,840	-	-	-	-	-	-	3,920	11,760	11,760	-	-	-	-	-	-	-	-	113,403	-
1b.1	Subtotal Period 1b Activity Costs	7,840	-	-	-	-	-	-	3,920	11,760	11,760	-	-	-	-	-	-	-	-	113,403	-
Period 1b Additional Costs																					
1b.2.1	Spent fuel pool isolation	-	-	-	-	-	-	12,000	1,800	13,800	13,800	-	-	-	-	-	-	-	-	-	-
1b.2	Subtotal Period 1b Additional Costs	-	-	-	-	-	-	12,000	1,800	13,800	13,800	-	-	-	-	-	-	-	-	-	-
Period 1b Collateral Costs																					
1b.3.1	Decon equipment	999	-	-	-	-	-	-	150	1,148	1,148	-	-	-	-	-	-	-	-	-	-
1b.3.2	Process decommissioning water waste	258	-	184	125	-	586	-	313	1,467	1,467	-	-	-	1,589	-	-	-	95,345	310	-
1b.3.4	Small tool allowance	-	135	-	-	-	-	-	20	155	155	-	-	-	-	-	-	-	-	-	-
1b.3.5	Security O&M	-	-	-	-	-	-	190	28	218	218	-	-	-	-	-	-	-	-	-	-
1b.3.6	Groundwater Monitoring	-	-	-	-	-	-	11	2	12	12	-	-	-	-	-	-	-	-	-	-
1b.3	Subtotal Period 1b Collateral Costs	1,257	135	184	125	-	586	201	513	3,001	3,001	-	-	-	1,589	-	-	-	95,345	310	-
Period 1b Period-Dependent Costs																					
1b.4.1	Decon supplies	1,872	-	-	-	-	-	-	468	2,340	2,340	-	-	-	-	-	-	-	-	-	-
1b.4.2	Insurance	-	-	-	-	-	-	156	16	172	172	-	-	-	-	-	-	-	-	-	-
1b.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1b.4.4	Health physics supplies	-	677	-	-	-	-	-	169	846	846	-	-	-	-	-	-	-	-	-	-
1b.4.5	Heavy equipment rental	-	135	-	-	-	-	-	20	155	155	-	-	-	-	-	-	-	-	-	-
1b.4.6	Disposal of DAW generated	-	-	20	0	-	175	-	46	241	241	-	-	-	802	-	-	-	16,034	26	-
1b.4.7	Plant energy budget	-	-	-	-	-	-	275	41	316	316	-	-	-	-	-	-	-	-	-	-
1b.4.8	NRC Fees	-	-	-	-	-	-	162	16	178	178	-	-	-	-	-	-	-	-	-	-
1b.4.9	Emergency Planning Fees	-	-	-	-	-	-	42	4	47	-	47	-	-	-	-	-	-	-	-	-
1b.4.10	Site O&M Cost	-	-	-	-	-	-	184	28	212	212	-	-	-	-	-	-	-	-	-	-
1b.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	200	30	230	-	230	-	-	-	-	-	-	-	-	-
1b.4.12	ISFSI Operating Costs	-	-	-	-	-	-	26	4	30	-	30	-	-	-	-	-	-	-	-	-
1b.4.13	Corporate A&G Cost	-	-	-	-	-	-	502	75	577	577	-	-	-	-	-	-	-	-	-	-
1b.4.14	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	36	5	41	41	-	-	-	-	-	-	-	-	-	-
1b.4.15	Security Staff Cost	-	-	-	-	-	-	2,508	376	2,884	2,884	-	-	-	-	-	-	-	-	-	46,715
1b.4.16	Utility Staff Cost	-	-	-	-	-	-	8,281	1,242	9,523	9,523	-	-	-	-	-	-	-	-	-	104,114
1b.4	Subtotal Period 1b Period-Dependent Costs	1,872	812	20	0	-	175	12,372	2,541	17,792	17,485	306	-	-	802	-	-	-	16,034	26	150,829
1b.0	TOTAL PERIOD 1b COST	10,969	946	204	126	-	761	24,572	8,774	46,353	46,047	306	-	-	2,391	-	-	-	111,379	113,739	150,829
PERIOD 1c - Preparations for SAFSTOR Dormancy																					
Period 1c Direct Decommissioning Activities																					
1c.1.1	Prepare support equipment for storage	-	499	-	-	-	-	-	75	573	573	-	-	-	-	-	-	-	-	3,000	-
1c.1.2	Install containment pressure equal. lines	-	50	-	-	-	-	-	8	58	58	-	-	-	-	-	-	-	-	700	-
1c.1.3	Interim survey prior to dormancy	-	-	-	-	-	-	733	220	953	953	-	-	-	-	-	-	-	-	9,450	-
1c.1.4	Secure building accesses									a											
1c.1.5	Prepare & submit interim report	-	-	-	-	-	-	31	5	35	35	-	-	-	-	-	-	-	-	-	244
1c.1	Subtotal Period 1c Activity Costs	-	549	-	-	-	-	764	307	1,619	1,619	-	-	-	-	-	-	-	-	13,150	244

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															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 1c Collateral Costs																					
1c.3.1	Process decommissioning water waste	205	-	146	100	-	466	-	248	1,164	1,164	-	-	-	1,262	-	-	-	75,693	246	-
1c.3.3	Small tool allowance	-	5	-	-	-	-	-	1	5	5	-	-	-	-	-	-	-	-	-	-
1c.3.4	Security O&M	-	-	-	-	-	-	189	28	218	218	-	-	-	-	-	-	-	-	-	-
1c.3.5	Groundwater Monitoring	-	-	-	-	-	-	12	2	14	14	-	-	-	-	-	-	-	-	-	-
1c.3	Subtotal Period 1c Collateral Costs	205	5	146	100	-	466	202	279	1,402	1,402	-	-	-	1,262	-	-	-	75,693	246	-
Period 1c Period-Dependent Costs																					
1c.4.1	Insurance	-	-	-	-	-	-	156	16	172	172	-	-	-	-	-	-	-	-	-	-
1c.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1c.4.3	Health physics supplies	-	193	-	-	-	-	-	48	241	241	-	-	-	-	-	-	-	-	-	-
1c.4.4	Heavy equipment rental	-	135	-	-	-	-	-	20	155	155	-	-	-	-	-	-	-	-	-	-
1c.4.5	Disposal of DAW generated	-	-	4	0	-	33	-	9	45	45	-	-	-	150	-	-	-	3,006	5	-
1c.4.6	Plant energy budget	-	-	-	-	-	-	275	41	316	316	-	-	-	-	-	-	-	-	-	-
1c.4.7	NRC Fees	-	-	-	-	-	-	162	16	178	178	-	-	-	-	-	-	-	-	-	-
1c.4.8	Emergency Planning Fees	-	-	-	-	-	-	42	4	47	-	47	-	-	-	-	-	-	-	-	-
1c.4.9	Site O&M Cost	-	-	-	-	-	-	118	18	136	136	-	-	-	-	-	-	-	-	-	-
1c.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	200	30	230	-	230	-	-	-	-	-	-	-	-	-
1c.4.11	ISFSI Operating Costs	-	-	-	-	-	-	26	4	30	-	30	-	-	-	-	-	-	-	-	-
1c.4.12	Corporate A&G Cost	-	-	-	-	-	-	502	75	577	577	-	-	-	-	-	-	-	-	-	-
1c.4.13	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	36	5	41	41	-	-	-	-	-	-	-	-	-	-
1c.4.14	Security Staff Cost	-	-	-	-	-	-	2,504	376	2,880	2,880	-	-	-	-	-	-	-	-	-	46,640
1c.4.15	Utility Staff Cost	-	-	-	-	-	-	8,281	1,242	9,523	9,523	-	-	-	-	-	-	-	-	-	104,114
1c.4	Subtotal Period 1c Period-Dependent Costs	-	328	4	0	-	33	12,302	1,904	14,571	14,264	306	-	-	150	-	-	-	3,006	5	150,754
1c.0	TOTAL PERIOD 1c COST	205	881	150	100	-	498	13,268	2,490	17,592	17,285	306	-	-	1,412	-	-	-	78,699	13,401	150,998
PERIOD 1 TOTALS		11,174	2,894	369	226	-	1,393	101,446	20,871	138,373	135,699	2,674	-	-	4,412	-	-	-	202,269	127,159	1,041,982
PERIOD 2a - SAFSTOR Dormancy with Wet Spent Fuel Storage																					
Period 2a Direct Decommissioning Activities																					
2a.1.1	Quarterly Inspection									a											
2a.1.2	Semi-annual environmental survey									a											
2a.1.3	Prepare reports									a											
2a.1.4	Bituminous roof replacement	-	-	-	-	-	-	442	66	508	508	-	-	-	-	-	-	-	-	-	-
2a.1.5	Maintenance supplies	-	-	-	-	-	-	623	156	778	778	-	-	-	-	-	-	-	-	-	-
2a.1	Subtotal Period 2a Activity Costs	-	-	-	-	-	-	1,065	222	1,287	1,287	-	-	-	-	-	-	-	-	-	-
Period 2a Collateral Costs																					
2a.3.1	Spent Fuel Capital and Transfer	-	-	-	-	-	-	84,928	12,739	97,667	-	97,667	-	-	-	-	-	-	-	-	-
2a.3.2	Security O&M	-	-	-	-	-	-	3,081	462	3,543	2,250	1,293	-	-	-	-	-	-	-	-	-
2a.3.3	Groundwater Monitoring	-	-	-	-	-	-	200	30	230	230	-	-	-	-	-	-	-	-	-	-
2a.3	Subtotal Period 2a Collateral Costs	-	-	-	-	-	-	88,209	13,231	101,441	2,480	98,960	-	-	-	-	-	-	-	-	-
Period 2a Period-Dependent Costs																					
2a.4.1	Insurance	-	-	-	-	-	-	2,544	254	2,798	2,798	-	-	-	-	-	-	-	-	-	-
2a.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2a.4.3	Health physics supplies	-	838	-	-	-	-	-	209	1,047	1,047	-	-	-	-	-	-	-	-	-	-
2a.4.4	Disposal of DAW generated	-	-	23	1	-	201	-	53	277	277	-	-	-	923	-	-	-	18,457	30	-
2a.4.5	Plant energy budget	-	-	-	-	-	-	894	134	1,028	1,028	-	-	-	-	-	-	-	-	-	-
2a.4.6	NRC Fees	-	-	-	-	-	-	1,053	105	1,158	1,158	-	-	-	-	-	-	-	-	-	-
2a.4.7	Emergency Planning Fees	-	-	-	-	-	-	691	69	760	-	760	-	-	-	-	-	-	-	-	-
2a.4.8	Site O&M Cost	-	-	-	-	-	-	1,112	167	1,279	1,039	239	-	-	-	-	-	-	-	-	-
2a.4.9	Spent Fuel Pool O&M	-	-	-	-	-	-	3,247	487	3,734	-	3,734	-	-	-	-	-	-	-	-	-
2a.4.10	ISFSI Operating Costs	-	-	-	-	-	-	425	64	489	-	489	-	-	-	-	-	-	-	-	-
2a.4.11	Corporate A&G Cost	-	-	-	-	-	-	1,588	238	1,827	1,485	342	-	-	-	-	-	-	-	-	-
2a.4.12	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	60	9	69	69	-	-	-	-	-	-	-	-	-	-
2a.4.13	Security Staff Cost	-	-	-	-	-	-	40,737	6,111	46,848	29,748	17,099	-	-	-	-	-	-	-	-	758,675
2a.4.14	Utility Staff Cost	-	-	-	-	-	-	27,762	4,164	31,926	25,956	5,970	-	-	-	-	-	-	-	-	329,540
2a.4	Subtotal Period 2a Period-Dependent Costs	-	838	23	1	-	201	80,112	12,065	93,239	64,606	28,633	-	-	923	-	-	-	18,457	30	1,088,215
2a.0	TOTAL PERIOD 2a COST	-	838	23	1	-	201	169,386	25,518	195,967	68,373	127,593	-	-	923	-	-	-	18,457	30	1,088,215

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
PERIOD 2b - SAFSTOR Dormancy with Dry Spent Fuel Storage																					
Period 2b Direct Decommissioning Activities																					
2b.1.1	Quarterly Inspection									a											
2b.1.2	Semi-annual environmental survey									a											
2b.1.3	Prepare reports									a											
2b.1.4	Bituminous roof replacement	-	-	-	-	-	-	5,243	786	6,029	6,029	-	-	-	-	-	-	-	-	-	-
2b.1.5	Maintenance supplies	-	-	-	-	-	-	7,384	1,846	9,230	9,230	-	-	-	-	-	-	-	-	-	-
2b.1	Subtotal Period 2b Activity Costs	-	-	-	-	-	-	12,627	2,633	15,260	15,260	-	-	-	-	-	-	-	-	-	-
Period 2b Collateral Costs																					
2b.3.1	Spent Fuel Capital and Transfer	-	-	-	-	-	-	49,764	7,465	57,228	-	57,228	-	-	-	-	-	-	-	-	-
2b.3.2	Security O&M	-	-	-	-	-	-	2,006	301	2,307	579	1,728	-	-	-	-	-	-	-	-	-
2b.3.3	Groundwater Monitoring	-	-	-	-	-	-	2,377	357	2,733	2,733	-	-	-	-	-	-	-	-	-	-
2b.3	Subtotal Period 2b Collateral Costs	-	-	-	-	-	-	54,146	8,122	62,268	3,312	58,956	-	-	-	-	-	-	-	-	-
Period 2b Period-Dependent Costs																					
2b.4.1	Insurance	-	-	-	-	-	-	30,166	3,017	33,183	16,591	16,591	-	-	-	-	-	-	-	-	-
2b.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2b.4.3	Health physics supplies	-	4,820	-	-	-	-	-	1,205	6,026	6,026	-	-	-	-	-	-	-	-	-	-
2b.4.4	Disposal of DAW generated	-	-	129	3	-	1,147	-	300	1,579	1,579	-	-	-	5,257	-	-	-	105,144	171	-
2b.4.5	Plant energy budget	-	-	-	-	-	-	5,299	795	6,093	6,093	-	-	-	-	-	-	-	-	-	-
2b.4.6	NRC Fees	-	-	-	-	-	-	11,856	1,186	13,042	6,521	6,521	-	-	-	-	-	-	-	-	-
2b.4.7	Site O&M Cost	-	-	-	-	-	-	1,854	278	2,132	1,734	399	-	-	-	-	-	-	-	-	-
2b.4.8	ISFSI Operating Costs	-	-	-	-	-	-	5,040	756	5,797	-	5,797	-	-	-	-	-	-	-	-	-
2b.4.9	Corporate A&G Cost	-	-	-	-	-	-	7,630	1,145	8,775	7,134	1,641	-	-	-	-	-	-	-	-	-
2b.4.10	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	370	56	426	426	-	-	-	-	-	-	-	-	-	-
2b.4.11	Security Staff Cost	-	-	-	-	-	-	235,502	35,325	270,828	67,978	202,850	-	-	-	-	-	-	-	-	4,449,236
2b.4.12	Utility Staff Cost	-	-	-	-	-	-	136,978	20,547	157,524	128,067	29,457	-	-	-	-	-	-	-	-	1,583,034
2b.4	Subtotal Period 2b Period-Dependent Costs	-	4,820	129	3	-	1,147	434,696	64,609	505,405	242,149	263,256	-	-	5,257	-	-	-	105,144	171	6,032,270
2b.0	TOTAL PERIOD 2b COST	-	4,820	129	3	-	1,147	501,470	75,363	582,933	260,721	322,212	-	-	5,257	-	-	-	105,144	171	6,032,270
PERIOD 2c - SAFSTOR Dormancy without Spent Fuel Storage																					
Period 2c Direct Decommissioning Activities																					
2c.1.1	Quarterly Inspection									a											
2c.1.2	Semi-annual environmental survey									a											
2c.1.3	Prepare reports									a											
2c.1.4	Bituminous roof replacement	-	-	-	-	-	-	113	17	130	130	-	-	-	-	-	-	-	-	-	-
2c.1.5	Maintenance supplies	-	-	-	-	-	-	159	40	198	198	-	-	-	-	-	-	-	-	-	-
2c.1	Subtotal Period 2c Activity Costs	-	-	-	-	-	-	271	57	328	328	-	-	-	-	-	-	-	-	-	-
Period 2c Collateral Costs																					
2c.3.1	Security O&M	-	-	-	-	-	-	200	30	230	230	-	-	-	-	-	-	-	-	-	-
2c.3.2	Groundwater Monitoring	-	-	-	-	-	-	51	8	59	59	-	-	-	-	-	-	-	-	-	-
2c.3	Subtotal Period 2c Collateral Costs	-	-	-	-	-	-	251	38	289	289	-	-	-	-	-	-	-	-	-	-
Period 2c Period-Dependent Costs																					
2c.4.1	Insurance	-	-	-	-	-	-	405	41	446	446	-	-	-	-	-	-	-	-	-	-
2c.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2c.4.3	Health physics supplies	-	97	-	-	-	-	-	24	122	122	-	-	-	-	-	-	-	-	-	-
2c.4.4	Disposal of DAW generated	-	-	3	0	-	23	-	6	31	31	-	-	-	104	-	-	-	2,080	3	-
2c.4.5	Plant energy budget	-	-	-	-	-	-	114	17	131	131	-	-	-	-	-	-	-	-	-	-
2c.4.6	NRC Fees	-	-	-	-	-	-	232	23	255	255	-	-	-	-	-	-	-	-	-	-
2c.4.7	Site O&M Cost	-	-	-	-	-	-	25	4	28	28	-	-	-	-	-	-	-	-	-	-
2c.4.8	Corporate A&G Cost	-	-	-	-	-	-	90	13	103	103	-	-	-	-	-	-	-	-	-	-
2c.4.9	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	8	1	9	9	-	-	-	-	-	-	-	-	-	-
2c.4.10	Security Staff Cost	-	-	-	-	-	-	1,986	298	2,284	2,284	-	-	-	-	-	-	-	-	-	31,884
2c.4.11	Utility Staff Cost	-	-	-	-	-	-	1,559	234	1,793	1,793	-	-	-	-	-	-	-	-	-	18,599
2c.4	Subtotal Period 2c Period-Dependent Costs	-	97	3	0	-	23	4,419	661	5,203	5,203	-	-	-	104	-	-	-	2,080	3	50,483
2c.0	TOTAL PERIOD 2c COST	-	97	3	0	-	23	4,942	756	5,820	5,820	-	-	-	104	-	-	-	2,080	3	50,483
PERIOD 2 TOTALS		-	5,756	154	3	-	1,371	675,797	101,637	784,719	334,914	449,805	-	-	6,284	-	-	-	125,681	205	7,170,967

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
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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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
PERIOD 3a - Reactivate Site Following SAFSTOR Dormancy																					
Period 3a Direct Decommissioning Activities																					
3a.1.1	Prepare preliminary decommissioning cost	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
3a.1.2	Review plant dwgs & specs.	-	-	-	-	-	-	243	36	280	280	-	-	-	-	-	-	-	-	-	1,927
3a.1.3	Perform detailed rad survey									a											
3a.1.4	End product description	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
3a.1.5	Detailed by-product inventory	-	-	-	-	-	-	69	10	79	79	-	-	-	-	-	-	-	-	-	545
3a.1.6	Define major work sequence	-	-	-	-	-	-	397	59	456	456	-	-	-	-	-	-	-	-	-	3,143
3a.1.7	Perform SER and EA	-	-	-	-	-	-	164	25	189	189	-	-	-	-	-	-	-	-	-	1,299
3a.1.8	Perform Site-Specific Cost Study	-	-	-	-	-	-	264	40	304	304	-	-	-	-	-	-	-	-	-	2,095
Activity Specifications																					
3a.1.9.1	Re-activate plant & temporary facilities	-	-	-	-	-	-	390	58	448	403	-	45	-	-	-	-	-	-	-	3,088
3a.1.9.2	Plant systems	-	-	-	-	-	-	220	33	253	228	-	25	-	-	-	-	-	-	-	1,746
3a.1.9.3	Reactor internals	-	-	-	-	-	-	375	56	432	432	-	-	-	-	-	-	-	-	-	2,975
3a.1.9.4	Reactor vessel	-	-	-	-	-	-	344	52	395	395	-	-	-	-	-	-	-	-	-	2,724
3a.1.9.5	Sacrificial shield	-	-	-	-	-	-	26	4	30	30	-	-	-	-	-	-	-	-	-	210
3a.1.9.6	Moisture separators/reheaters	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
3a.1.9.7	Reinforced concrete	-	-	-	-	-	-	85	13	97	49	-	49	-	-	-	-	-	-	-	670
3a.1.9.8	Main Turbine	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
3a.1.9.9	Main Condensers	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
3a.1.9.10	Pressure suppression structure	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
3a.1.9.11	Drywell	-	-	-	-	-	-	85	13	97	97	-	-	-	-	-	-	-	-	-	670
3a.1.9.12	Plant structures & buildings	-	-	-	-	-	-	165	25	190	95	-	95	-	-	-	-	-	-	-	1,307
3a.1.9.13	Waste management	-	-	-	-	-	-	243	36	280	280	-	-	-	-	-	-	-	-	-	1,927
3a.1.9.14	Facility & site closeout	-	-	-	-	-	-	48	7	55	27	-	27	-	-	-	-	-	-	-	377
3a.1.9	Total	-	-	-	-	-	-	2,360	354	2,714	2,473	-	241	-	-	-	-	-	-	-	18,701
Planning & Site Preparations																					
3a.1.10	Prepare dismantling sequence	-	-	-	-	-	-	127	19	146	146	-	-	-	-	-	-	-	-	-	1,006
3a.1.11	Plant prep. & temp. svces	-	-	-	-	-	-	3,300	495	3,795	3,795	-	-	-	-	-	-	-	-	-	-
3a.1.12	Design water clean-up system	-	-	-	-	-	-	74	11	85	85	-	-	-	-	-	-	-	-	-	587
3a.1.13	Rigging/Cont. Cntrl Envlps/tooling/etc.	-	-	-	-	-	-	2,300	345	2,645	2,645	-	-	-	-	-	-	-	-	-	-
3a.1.14	Procure casks/liners & containers	-	-	-	-	-	-	65	10	75	75	-	-	-	-	-	-	-	-	-	515
3a.1	Subtotal Period 3a Activity Costs	-	-	-	-	-	-	9,485	1,423	10,907	10,666	-	241	-	-	-	-	-	-	-	30,781
Period 3a Additional Costs																					
3a.2.1	Site Characterization	-	-	-	-	-	-	6,705	2,011	8,716	8,716	-	-	-	-	-	-	-	-	30,500	10,852
3a.2	Subtotal Period 3a Additional Costs	-	-	-	-	-	-	6,705	2,011	8,716	8,716	-	-	-	-	-	-	-	-	30,500	10,852
Period 3a Collateral Costs																					
3a.3.1	Security O&M	-	-	-	-	-	-	318	48	366	366	-	-	-	-	-	-	-	-	-	-
3a.3.2	Groundwater Monitoring	-	-	-	-	-	-	50	8	58	58	-	-	-	-	-	-	-	-	-	-
3a.3	Subtotal Period 3a Collateral Costs	-	-	-	-	-	-	368	55	424	424	-	-	-	-	-	-	-	-	-	-
Period 3a Period-Dependent Costs																					
3a.4.1	Insurance	-	-	-	-	-	-	397	40	436	436	-	-	-	-	-	-	-	-	-	-
3a.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3a.4.3	Health physics supplies	-	455	-	-	-	-	-	114	569	569	-	-	-	-	-	-	-	-	-	-
3a.4.4	Heavy equipment rental	-	546	-	-	-	-	-	82	628	628	-	-	-	-	-	-	-	-	-	-
3a.4.5	Disposal of DAW generated	-	-	13	0	-	112	-	29	155	155	-	-	-	514	-	-	-	10,287	17	-
3a.4.6	Plant energy budget	-	-	-	-	-	-	1,114	167	1,281	1,281	-	-	-	-	-	-	-	-	-	-
3a.4.7	NRC Fees	-	-	-	-	-	-	350	35	385	385	-	-	-	-	-	-	-	-	-	-
3a.4.8	Site O&M Cost	-	-	-	-	-	-	478	72	550	550	-	-	-	-	-	-	-	-	-	-
3a.4.9	Corporate A&G Cost	-	-	-	-	-	-	1,243	186	1,430	1,430	-	-	-	-	-	-	-	-	-	-
3a.4.10	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	29	4	33	33	-	-	-	-	-	-	-	-	-	-
3a.4.11	Security Staff Cost	-	-	-	-	-	-	3,664	550	4,214	4,214	-	-	-	-	-	-	-	-	-	65,000
3a.4.12	Utility Staff Cost	-	-	-	-	-	-	21,146	3,172	24,318	24,318	-	-	-	-	-	-	-	-	-	257,920
3a.4	Subtotal Period 3a Period-Dependent Costs	-	1,001	13	0	-	112	28,421	4,451	33,998	33,998	-	-	-	514	-	-	-	10,287	17	322,920
3a.0	TOTAL PERIOD 3a COST	-	1,001	13	0	-	112	44,979	7,940	54,045	53,804	-	241	-	514	-	-	-	10,287	30,517	364,553

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
PERIOD 3b - Decommissioning Preparations																					
Period 3b Direct Decommissioning Activities																					
Detailed Work Procedures																					
3b.1.1.1	Plant systems	-	-	-	-	-	-	250	38	288	259	-	29	-	-	-	-	-	-	-	1,983
3b.1.1.2	Reactor internals	-	-	-	-	-	-	212	32	243	243	-	-	-	-	-	-	-	-	-	1,676
3b.1.1.3	Remaining buildings	-	-	-	-	-	-	71	11	82	21	-	62	-	-	-	-	-	-	-	566
3b.1.1.4	CRD housings & NIs	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
3b.1.1.5	Incore instrumentation	-	-	-	-	-	-	53	8	61	61	-	-	-	-	-	-	-	-	-	419
3b.1.1.6	Removal primary containment	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
3b.1.1.7	Reactor vessel	-	-	-	-	-	-	192	29	221	221	-	-	-	-	-	-	-	-	-	1,521
3b.1.1.8	Facility closeout	-	-	-	-	-	-	63	10	73	36	-	36	-	-	-	-	-	-	-	503
3b.1.1.9	Sacrificial shield	-	-	-	-	-	-	63	10	73	73	-	-	-	-	-	-	-	-	-	503
3b.1.1.10	Reinforced concrete	-	-	-	-	-	-	53	8	61	30	-	30	-	-	-	-	-	-	-	419
3b.1.1.11	Main Turbine	-	-	-	-	-	-	110	16	126	126	-	-	-	-	-	-	-	-	-	872
3b.1.1.12	Main Condensers	-	-	-	-	-	-	110	17	127	127	-	-	-	-	-	-	-	-	-	875
3b.1.1.13	Moisture separators & reheaters	-	-	-	-	-	-	106	16	122	122	-	-	-	-	-	-	-	-	-	838
3b.1.1.14	Radwaste building	-	-	-	-	-	-	144	22	166	149	-	17	-	-	-	-	-	-	-	1,144
3b.1.1.15	Reactor building	-	-	-	-	-	-	144	22	166	149	-	17	-	-	-	-	-	-	-	1,144
3b.1.1	Total	-	-	-	-	-	-	1,731	260	1,991	1,801	-	190	-	-	-	-	-	-	-	13,718
3b.1	Subtotal Period 3b Activity Costs	-	-	-	-	-	-	1,731	260	1,991	1,801	-	190	-	-	-	-	-	-	-	13,718
Period 3b Collateral Costs																					
3b.3.1	Decon equipment	999	-	-	-	-	-	-	150	1,148	1,148	-	-	-	-	-	-	-	-	-	-
3b.3.2	DOC staff relocation expenses	-	-	-	-	-	-	1,297	195	1,492	1,492	-	-	-	-	-	-	-	-	-	-
3b.3.3	Pipe cutting equipment	-	1,200	-	-	-	-	-	180	1,380	1,380	-	-	-	-	-	-	-	-	-	-
3b.3.4	Security O&M	-	-	-	-	-	-	157	24	180	180	-	-	-	-	-	-	-	-	-	-
3b.3.5	Groundwater Monitoring	-	-	-	-	-	-	25	4	28	28	-	-	-	-	-	-	-	-	-	-
3b.3	Subtotal Period 3b Collateral Costs	999	1,200	-	-	-	-	1,479	552	4,229	4,229	-	-	-	-	-	-	-	-	-	-
Period 3b Period-Dependent Costs																					
3b.4.1	Decon supplies	36	-	-	-	-	-	-	9	45	45	-	-	-	-	-	-	-	-	-	-
3b.4.2	Insurance	-	-	-	-	-	-	205	21	226	226	-	-	-	-	-	-	-	-	-	-
3b.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3b.4.4	Health physics supplies	-	247	-	-	-	-	-	62	309	309	-	-	-	-	-	-	-	-	-	-
3b.4.5	Heavy equipment rental	-	269	-	-	-	-	-	40	310	310	-	-	-	-	-	-	-	-	-	-
3b.4.6	Disposal of DAW generated	-	-	7	0	-	63	-	16	86	86	-	-	-	287	-	-	-	5,738	9	-
3b.4.7	Plant energy budget	-	-	-	-	-	-	549	82	632	632	-	-	-	-	-	-	-	-	-	-
3b.4.8	NRC Fees	-	-	-	-	-	-	173	17	190	190	-	-	-	-	-	-	-	-	-	-
3b.4.9	Site O&M Cost	-	-	-	-	-	-	236	35	271	271	-	-	-	-	-	-	-	-	-	-
3b.4.10	Corporate A&G Cost	-	-	-	-	-	-	613	92	705	705	-	-	-	-	-	-	-	-	-	-
3b.4.11	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	14	2	16	16	-	-	-	-	-	-	-	-	-	-
3b.4.12	Security Staff Cost	-	-	-	-	-	-	1,807	271	2,078	2,078	-	-	-	-	-	-	-	-	-	32,055
3b.4.13	DOC Staff Cost	-	-	-	-	-	-	5,756	863	6,619	6,619	-	-	-	-	-	-	-	-	-	57,442
3b.4.14	Utility Staff Cost	-	-	-	-	-	-	10,428	1,564	11,992	11,992	-	-	-	-	-	-	-	-	-	127,193
3b.4	Subtotal Period 3b Period-Dependent Costs	36	517	7	0	-	63	19,781	3,076	23,479	23,479	-	-	-	287	-	-	-	5,738	9	216,690
3b.0	TOTAL PERIOD 3b COST	1,034	1,717	7	0	-	63	22,991	3,887	29,699	29,509	-	190	-	287	-	-	-	5,738	9	230,409
PERIOD 3 TOTALS		1,034	2,718	20	0	-	175	67,970	11,827	83,744	83,313	-	431	-	801	-	-	-	16,026	30,526	594,962
PERIOD 4a - Large Component Removal																					
Period 4a Direct Decommissioning Activities																					
Nuclear Steam Supply System Removal																					
4a.1.1.1	Recirculation System Piping & Valves	37	169	46	2	96	232	-	138	721	721	-	-	935	989	-	-	-	131,253	3,019	-
4a.1.1.2	Recirculation Pumps & Motors	15	52	17	2	179	323	-	130	718	718	-	-	2,569	2,137	-	-	-	211,420	1,167	-
4a.1.1.3	CRDMs & NIs Removal	57	1,192	708	6	-	1,094	-	671	3,728	3,728	-	-	-	5,536	-	-	-	325,500	18,886	-
4a.1.1.4	Reactor Vessel Internals	184	6,661	12,554	355	-	2,184	364	9,462	31,764	31,764	-	-	-	2,306	2,880	281	-	492,796	30,840	1,392
4a.1.1.5	Vessel & Internals GTCC Disposal	-	-	-	-	-	6,695	-	1,004	7,699	7,699	-	-	-	-	-	-	1,633	319,745	-	-
4a.1.1.6	Reactor Vessel	-	9,175	2,944	145	-	10,788	364	13,102	36,518	36,518	-	-	-	31,738	-	-	-	1,999,216	30,840	1,392
4a.1.1	Totals	294	17,248	16,269	511	275	21,315	728	24,508	81,148	81,148	-	-	3,504	42,706	2,880	281	1,633	3,479,929	84,752	2,784
Removal of Major Equipment																					
4a.1.2	Main Turbine/Generator	-	595	4,116	94	11,682	-	-	2,327	18,813	18,813	-	-	167,480	-	-	-	-	7,536,607	9,015	-
4a.1.3	Main Condensers	-	1,318	2,180	50	6,189	-	-	1,483	11,220	11,220	-	-	88,729	-	-	-	-	3,992,800	20,173	-

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Disposal of Plant Systems																					
4a.1.5.1	Auxiliary and Process Steam	-	154	-	-	-	-	-	23	177	-	-	177	-	-	-	-	-	-	2,639	-
4a.1.5.2	Circulating Water	-	1,161	-	-	-	-	-	174	1,335	-	-	1,335	-	-	-	-	-	-	19,825	-
4a.1.5.3	Closed Cooling Water	-	1,037	-	-	-	-	-	155	1,192	-	-	1,192	-	-	-	-	-	-	17,273	-
4a.1.5.4	Condensate and Feedwater	-	1,442	724	34	1,539	5,751	-	2,107	11,596	11,596	-	-	24,453	26,830	-	-	-	2,704,511	23,149	-
4a.1.5.5	Condensate Supply	-	1,494	189	12	864	1,440	-	884	4,883	4,883	-	-	13,733	6,730	-	-	-	986,119	22,635	-
4a.1.5.6	Containment Atmosphere Control	-	34	-	-	-	-	-	5	39	-	-	39	-	-	-	-	-	-	581	-
4a.1.5.7	Contain Aux and Process Steam	-	81	6	0	19	36	-	33	175	175	-	-	297	166	-	-	-	22,812	1,184	-
4a.1.5.8	Emergency Chilled Water-Control	-	124	-	-	-	-	-	19	143	-	-	143	-	-	-	-	-	-	2,059	-
4a.1.5.9	Extraction Steam and Heater Vents	-	941	78	7	571	510	-	457	2,564	2,564	-	-	9,069	2,380	-	-	-	520,115	14,180	-
4a.1.5.10	Gas and Air Removal	-	324	25	2	186	165	-	153	854	854	-	-	2,948	769	-	-	-	168,730	4,862	-
4a.1.5.11	Heater Drains	-	438	86	4	218	577	-	295	1,618	1,618	-	-	3,466	2,666	-	-	-	312,401	6,641	-
4a.1.5.12	Heating Hot Water and Chilled Water (RCA	-	196	-	-	-	-	-	29	226	-	-	226	-	-	-	-	-	-	3,280	-
4a.1.5.13	Heating Hot Water and Chilled Water	-	42	-	-	-	-	-	6	48	-	-	48	-	-	-	-	-	-	732	-
4a.1.5.14	Heating Steam	-	50	-	-	-	-	-	7	57	-	-	57	-	-	-	-	-	-	799	-
4a.1.5.15	HVAC (Clean)	-	340	-	-	-	-	-	51	391	-	-	391	-	-	-	-	-	-	5,914	-
4a.1.5.16	Main and Exhaust Steam	-	850	103	7	587	727	-	494	2,768	2,768	-	-	9,329	3,396	-	-	-	595,351	12,974	-
4a.1.5.17	Main Steam	-	626	62	5	456	386	-	328	1,863	1,863	-	-	7,244	1,797	-	-	-	409,126	9,510	-
4a.1.5.18	Main Steam Iso. Valve Leakage Control	-	4	0	0	0	1	-	1	6	6	-	-	7	4	-	-	-	566	52	-
4a.1.5.19	Off Gas Processing	-	506	45	3	223	313	-	243	1,332	1,332	-	-	3,539	1,455	-	-	-	236,769	7,543	-
4a.1.5.20	Plant Makeup Water Treatment	-	66	-	-	-	-	-	10	76	-	-	76	-	-	-	-	-	-	1,126	-
4a.1.5.21	Plant Service Water	-	96	-	-	-	-	-	14	110	-	-	110	-	-	-	-	-	-	1,567	-
4a.1.5.22	Post Accident Sampling	-	40	2	0	7	11	-	14	73	73	-	-	111	49	-	-	-	7,709	604	-
4a.1.5.23	Primary Containment Cooling	-	88	16	1	107	97	-	64	373	373	-	-	1,701	449	-	-	-	97,867	1,352	-
4a.1.5.24	Primary Containment N2 Inerting	-	69	6	0	10	33	-	27	145	145	-	-	156	149	-	-	-	16,105	953	-
4a.1.5.25	Radwaste - Condensate Demin	-	472	60	3	200	421	-	260	1,416	1,416	-	-	3,183	1,956	-	-	-	254,565	7,092	-
4a.1.5.26	Sanitary Waste	-	79	-	-	-	-	-	12	91	-	-	91	-	-	-	-	-	-	1,374	-
4a.1.5.27	Standby Liquid Control	-	34	3	0	13	20	-	16	86	86	-	-	207	93	-	-	-	14,414	498	-
4a.1.5.28	Standby Service Water	-	471	119	5	196	801	-	360	1,951	1,951	-	-	3,111	3,694	-	-	-	364,594	6,734	-
4a.1.5.29	Steam and Liquid Sampling	-	218	26	2	175	172	-	127	721	721	-	-	2,786	804	-	-	-	164,482	3,203	-
4a.1.5.30	Turbine Oil Purification	-	394	-	-	-	-	-	59	453	-	-	453	-	-	-	-	-	-	6,408	-
4a.1.5.31	Under Vessel Neutron Monitoring	-	35	2	0	2	20	-	14	75	75	-	-	38	93	-	-	-	7,474	538	-
4a.1.5	Totals	-	11,905	1,552	86	5,374	11,480	-	6,443	36,840	32,502	-	4,338	85,377	53,479	-	-	-	6,883,710	187,282	-
4a.1.6	Scaffolding in support of decommissioning	-	2,414	58	1	151	41	-	642	3,307	3,307	-	-	2,161	191	-	-	-	109,346	41,900	-
4a.1	Subtotal Period 4a Activity Costs	294	33,480	24,175	742	23,671	32,835	728	35,403	151,328	146,990	-	4,338	347,250	96,376	2,880	281	1,633	22,002,390	343,123	2,784
Period 4a Additional Costs																					
4a.2.1	Remedial Action Surveys	-	-	-	-	-	-	2,224	667	2,891	2,891	-	-	-	-	-	-	-	-	30,468	-
4a.2.2	Asbestos Abatement	-	-	-	-	-	-	1,000	150	1,150	1,150	-	-	-	-	-	-	-	-	-	-
4a.2	Subtotal Period 4a Additional Costs	-	-	-	-	-	-	3,224	817	4,041	4,041	-	-	-	-	-	-	-	-	30,468	-
Period 4a Collateral Costs																					
4a.3.1	Process decommissioning water waste	5	-	10	7	-	33	-	13	68	68	-	-	-	88	-	-	-	5,288	17	-
4a.3.3	Small tool allowance	-	398	-	-	-	-	-	60	458	412	-	46	-	-	-	-	-	-	-	-
4a.3.4	Security O&M	-	-	-	-	-	-	467	70	536	536	-	-	-	-	-	-	-	-	-	-
4a.3.5	Groundwater Monitoring	-	-	-	-	-	-	73	11	84	84	-	-	-	-	-	-	-	-	-	-
4a.3	Subtotal Period 4a Collateral Costs	5	398	10	7	-	33	540	154	1,147	1,101	-	46	-	88	-	-	-	5,288	17	-
Period 4a Period-Dependent Costs																					
4a.4.1	Decon supplies	106	-	-	-	-	-	-	27	133	133	-	-	-	-	-	-	-	-	-	-
4a.4.2	Insurance	-	-	-	-	-	-	610	61	671	671	-	-	-	-	-	-	-	-	-	-
4a.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a.4.4	Health physics supplies	-	2,555	-	-	-	-	-	639	3,194	3,194	-	-	-	-	-	-	-	-	-	-
4a.4.5	Heavy equipment rental	-	3,121	-	-	-	-	-	468	3,589	3,589	-	-	-	-	-	-	-	-	-	-
4a.4.6	Disposal of DAW generated	-	-	158	4	-	1,403	-	367	1,931	1,931	-	-	-	6,429	-	-	-	128,582	210	-
4a.4.7	Plant energy budget	-	-	-	-	-	-	1,551	233	1,784	1,784	-	-	-	-	-	-	-	-	-	-
4a.4.8	NRC Fees	-	-	-	-	-	-	839	84	923	923	-	-	-	-	-	-	-	-	-	-
4a.4.9	Site O&M Cost	-	-	-	-	-	-	701	105	806	806	-	-	-	-	-	-	-	-	-	-
4a.4.10	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	598	90	687	687	-	-	-	-	-	-	-	-	-	-
4a.4.11	Corporate A&G Cost	-	-	-	-	-	-	1,837	276	2,112	2,112	-	-	-	-	-	-	-	-	-	-
4a.4.12	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	213	32	245	245	-	-	-	-	-	-	-	-	-	-
4a.4.13	Security Staff Cost	-	-	-	-	-	-	5,371	806	6,177	6,177	-	-	-	-	-	-	-	-	-	95,274
4a.4.14	DOC Staff Cost	-	-	-	-	-	-	20,853	3,128	23,980	23,980	-	-	-	-	-	-	-	-	-	210,365
4a.4.15	Utility Staff Cost	-	-	-	-	-	-	31,105	4,666	35,771	35,771	-	-	-	-	-	-	-	-	-	381,096
4a.4	Subtotal Period 4a Period-Dependent Costs	106	5,676	158	4	-	1,403	63,677	10,980	82,004	82,004	-	-	-	6,429	-	-	-	128,582	210	686,735

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
4a.0	TOTAL PERIOD 4a COST	406	39,555	24,343	753	23,671	34,270	68,169	47,354	238,520	234,136	-	4,384	347,250	102,894	2,880	281	1,633	22,136,260	373,817	689,519
PERIOD 4b - Site Decontamination																					
Period 4b Direct Decommissioning Activities																					
4b.1.1	Remove spent fuel racks	650	64	145	7	679	291	-	531	2,368	2,368	-	-	9,740	1,364	-	-	-	524,954	1,076	-
Disposal of Plant Systems																					
4b.1.2.1	Chemical Feed	-	140	-	-	-	-	-	21	161	-	-	161	-	-	-	-	-	-	2,364	-
4b.1.2.2	Chemical Waste Processing	-	226	-	-	-	-	-	34	260	-	-	260	-	-	-	-	-	-	3,810	-
4b.1.2.3	Containment Instrument Air	-	161	-	-	-	-	-	24	185	-	-	185	-	-	-	-	-	-	2,734	-
4b.1.2.4	Control and Service Air	-	124	-	-	-	-	-	19	143	-	-	143	-	-	-	-	-	-	2,045	-
4b.1.2.5	Control Rod Drive	-	692	73	2	45	416	-	291	1,520	1,520	-	-	714	1,892	-	-	-	152,886	9,219	-
4b.1.2.6	Demineralized Water	-	161	-	-	-	-	-	24	185	-	-	185	-	-	-	-	-	-	2,659	-
4b.1.2.7	Diesel Oil and Misc	-	215	-	-	-	-	-	32	247	-	-	247	-	-	-	-	-	-	3,550	-
4b.1.2.8	Equip Drain Sys. - Reactor Bldg	-	1,169	102	4	24	917	-	536	2,752	2,752	-	-	389	4,294	-	-	-	288,753	16,678	-
4b.1.2.9	Equip and Floor Drains - Radwaste	-	130	17	1	15	137	-	71	371	371	-	-	242	639	-	-	-	50,672	1,906	-
4b.1.2.10	Equip and Floor Drains -Turbine	-	1,194	104	4	26	931	-	546	2,806	2,806	-	-	415	4,359	-	-	-	294,033	17,039	-
4b.1.2.11	Fire Protection (RCA)	-	270	-	-	-	-	-	40	310	-	-	310	-	-	-	-	-	-	4,459	-
4b.1.2.12	Fire Protection (Non RCA)	-	108	-	-	-	-	-	16	124	-	-	124	-	-	-	-	-	-	1,853	-
4b.1.2.13	Fire Protection-Well Water Pumphouse 2	-	124	-	-	-	-	-	19	142	-	-	142	-	-	-	-	-	-	1,989	-
4b.1.2.14	Floor Drain System-Reactor Bldg	-	88	11	0	2	82	-	44	228	228	-	-	39	381	-	-	-	25,991	1,238	-
4b.1.2.15	Fuel Pool Cooling and Cleanup	-	460	56	3	149	416	-	247	1,331	1,331	-	-	2,365	1,937	-	-	-	219,855	6,872	-
4b.1.2.16	HPCS and LPCS	-	307	107	5	248	759	-	315	1,741	1,741	-	-	3,932	3,520	-	-	-	385,684	4,786	-
4b.1.2.17	HVAC Chilled Water-Radwaste	-	685	52	4	274	362	-	309	1,686	1,686	-	-	4,358	1,687	-	-	-	284,719	10,007	-
4b.1.2.18	HVAC (Contam)	-	356	31	3	262	168	-	174	993	993	-	-	4,161	779	-	-	-	219,040	5,397	-
4b.1.2.19	Misc Drains Vents and Sealing	-	412	63	3	74	523	-	251	1,325	1,325	-	-	1,168	2,443	-	-	-	203,128	6,156	-
4b.1.2.20	Non-Radioactive Drains	-	1,290	-	-	-	-	-	194	1,484	-	-	1,484	-	-	-	-	-	-	22,270	-
4b.1.2.21	Nuclear Boiler Recirculation	-	239	114	4	104	804	-	288	1,552	1,552	-	-	1,655	3,715	-	-	-	306,385	3,619	-
4b.1.2.22	Potable Hot and Cold Water	-	81	-	-	-	-	-	12	93	-	-	93	-	-	-	-	-	-	1,406	-
4b.1.2.23	Radwaste - Equipment Drain Processing	-	308	44	2	104	331	-	180	968	968	-	-	1,650	1,541	-	-	-	165,506	4,675	-
4b.1.2.24	Radwaste - Floor Drain Processing	-	172	26	1	55	188	-	101	543	543	-	-	866	871	-	-	-	91,149	2,592	-
4b.1.2.25	Radwaste Disposal-Solids Handling	-	172	26	1	55	188	-	101	543	543	-	-	866	871	-	-	-	91,149	2,592	-
4b.1.2.26	Reactor Core Isolation Cooling	-	335	56	2	65	467	-	216	1,141	1,141	-	-	1,039	2,179	-	-	-	181,063	5,080	-
4b.1.2.27	Reactor Water Cleanup	-	212	26	1	22	182	-	104	547	547	-	-	343	838	-	-	-	67,976	3,084	-
4b.1.2.28	Residual Heat Removal	-	912	303	11	316	2,286	-	879	4,707	4,707	-	-	5,020	10,615	-	-	-	884,321	14,143	-
4b.1.2.29	Electrical (Clean)	-	3,068	-	-	-	-	-	460	3,528	-	-	3,528	-	-	-	-	-	-	49,651	-
4b.1.2.30	Electrical (Contam)	-	4,357	92	24	2,988	-	-	1,550	9,011	9,011	-	-	47,467	-	-	-	-	1,927,674	61,947	-
4b.1.2	Totals	-	18,168	1,301	73	4,827	9,158	-	7,100	40,628	33,765	-	6,862	76,689	42,562	-	-	-	5,839,983	275,820	-
4b.1.3	Scaffolding in support of decommissioning	-	3,621	87	2	226	61	-	964	4,961	4,961	-	-	3,241	286	-	-	-	164,019	62,851	-
Decontamination of Site Buildings																					
4b.1.4.1	Reactor	5,836	4,880	411	79	2,931	9,586	-	7,027	30,750	30,750	-	-	46,566	80,241	-	-	-	5,714,518	150,159	-
4b.1.4.2	Radwaste Building	616	412	32	7	-	1,166	-	707	2,940	2,940	-	-	-	9,955	-	-	-	470,232	14,452	-
4b.1.4.3	Turbine Generator	815	544	40	9	22	1,444	-	913	3,788	3,788	-	-	351	12,328	-	-	-	596,295	19,206	-
4b.1.4	Totals	7,267	5,836	483	95	2,953	12,196	-	8,647	37,478	37,478	-	-	46,917	102,524	-	-	-	6,781,044	183,817	-
4b.1.5	Prepare/submit License Termination Plan	-	-	-	-	-	-	217	32	249	249	-	-	-	-	-	-	-	-	-	1,716
4b.1.6	Receive NRC approval of termination plan									a											
4b.1	Subtotal Period 4b Activity Costs	7,918	27,689	2,017	177	8,686	21,706	217	17,275	85,684	78,821	-	6,862	136,588	146,736	-	-	-	13,310,000	523,564	1,716
Period 4b Additional Costs																					
4b.2.1	License Termination Survey Planning	-	-	-	-	-	-	1,532	460	1,992	1,992	-	-	-	-	-	-	-	-	-	12,480
4b.2.2	Remedial Action Surveys	-	-	-	-	-	-	3,400	1,020	4,421	4,421	-	-	-	-	-	-	-	-	46,584	-
4b.2.3	Operational Tools & Equipment	-	-	22	5	454	-	-	71	552	552	-	-	11,710	-	-	-	-	292,750	32	-
4b.2.4	Excavation of Underground Services	-	1,855	-	-	-	-	977	610	3,442	3,442	-	-	-	-	-	-	-	-	14,000	-
4b.2.5	Decommissioning of ISFSI	-	493	136	4	-	1,600	3,663	1,474	7,370	7,370	-	-	-	7,330	-	-	-	364,041	18,240	15,856
4b.2.6	Underground Storage Tanks	-	-	-	-	-	-	191	29	220	220	-	-	-	-	-	-	-	-	-	-
4b.2.7	Evaporation Pond Remediation	-	100	126	672	-	6,243	-	1,672	8,814	8,814	-	-	-	201,399	-	-	-	25,174,810	880	-
4b.2	Subtotal Period 4b Additional Costs	-	2,448	284	681	454	7,843	9,765	5,336	26,810	26,810	-	-	11,710	208,728	-	-	-	25,831,600	79,736	28,336
Period 4b Collateral Costs																					
4b.3.1	Process decommissioning water waste	14	-	28	19	-	89	-	35	185	185	-	-	-	240	-	-	-	14,411	47	-
4b.3.3	Small tool allowance	-	595	-	-	-	-	-	89	685	685	-	-	-	-	-	-	-	-	-	-
4b.3.4	Decommissioning Equipment Disposition	-	-	161	4	419	113	-	108	805	805	-	-	6,000	529	-	-	-	303,608	147	-
4b.3.5	Security O&M	-	-	-	-	-	-	713	107	820	820	-	-	-	-	-	-	-	-	-	-

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Period 4b Collateral Costs (continued)																					
4b.3.6	Groundwater Monitoring	-	-	-	-	-	-	112	17	129	129	-	-	-	-	-	-	-	-	-	-
4b.3	Subtotal Period 4b Collateral Costs	14	595	189	23	419	202	825	356	2,624	2,624	-	-	6,000	769	-	-	-	318,019	194	-
Period 4b Period-Dependent Costs																					
4b.4.1	Decon supplies	2,016	-	-	-	-	-	-	504	2,521	2,521	-	-	-	-	-	-	-	-	-	-
4b.4.2	Insurance	-	-	-	-	-	-	933	93	1,026	1,026	-	-	-	-	-	-	-	-	-	-
4b.4.3	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4b.4.4	Health physics supplies	-	4,045	-	-	-	-	-	1,011	5,057	5,057	-	-	-	-	-	-	-	-	-	-
4b.4.5	Heavy equipment rental	-	4,919	-	-	-	-	-	738	5,657	5,657	-	-	-	-	-	-	-	-	-	-
4b.4.6	Disposal of DAW generated	-	-	192	4	-	1,705	-	446	2,348	2,348	-	-	-	7,815	-	-	-	156,307	255	-
4b.4.7	Plant energy budget	-	-	-	-	-	-	1,872	281	2,153	2,153	-	-	-	-	-	-	-	-	-	-
4b.4.8	NRC Fees	-	-	-	-	-	-	1,282	128	1,410	1,410	-	-	-	-	-	-	-	-	-	-
4b.4.9	Site O&M Cost	-	-	-	-	-	-	1,072	161	1,232	1,232	-	-	-	-	-	-	-	-	-	-
4b.4.10	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	914	137	1,051	1,051	-	-	-	-	-	-	-	-	-	-
4b.4.11	Corporate A&G Cost	-	-	-	-	-	-	2,651	398	3,049	3,049	-	-	-	-	-	-	-	-	-	-
4b.4.12	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	325	49	374	374	-	-	-	-	-	-	-	-	-	-
4b.4.13	Security Staff Cost	-	-	-	-	-	-	8,212	1,232	9,444	9,444	-	-	-	-	-	-	-	-	-	145,671
4b.4.14	DOC Staff Cost	-	-	-	-	-	-	31,075	4,661	35,737	35,737	-	-	-	-	-	-	-	-	-	312,319
4b.4.15	Utility Staff Cost	-	-	-	-	-	-	45,341	6,801	52,142	52,142	-	-	-	-	-	-	-	-	-	550,055
4b.4	Subtotal Period 4b Period-Dependent Costs	2,016	8,965	192	4	-	1,705	93,678	16,641	123,202	123,202	-	-	-	7,815	-	-	-	156,307	255	1,008,045
4b.0	TOTAL PERIOD 4b COST	9,949	39,697	2,682	885	9,558	31,456	104,485	39,607	238,319	231,457	-	6,862	154,298	364,049	-	-	-	39,615,930	603,748	1,038,098
PERIOD 4f - License Termination																					
Period 4f Direct Decommissioning Activities																					
4f.1.1	ORISE confirmatory survey	-	-	-	-	-	-	177	53	230	230	-	-	-	-	-	-	-	-	-	-
4f.1.2	Terminate license									a											
4f.1	Subtotal Period 4f Activity Costs	-	-	-	-	-	-	177	53	230	230	-	-	-	-	-	-	-	-	-	-
Period 4f Additional Costs																					
4f.2.1	License Termination Survey	-	-	-	-	-	-	14,638	4,391	19,030	19,030	-	-	-	-	-	-	-	-	210,570	6,240
4f.2	Subtotal Period 4f Additional Costs	-	-	-	-	-	-	14,638	4,391	19,030	19,030	-	-	-	-	-	-	-	-	210,570	6,240
Period 4f Collateral Costs																					
4f.3.1	DOC staff relocation expenses	-	-	-	-	-	-	1,297	195	1,492	1,492	-	-	-	-	-	-	-	-	-	-
4f.3.2	Security O&M	-	-	-	-	-	-	129	19	148	148	-	-	-	-	-	-	-	-	-	-
4f.3.3	Groundwater Monitoring	-	-	-	-	-	-	37	6	43	43	-	-	-	-	-	-	-	-	-	-
4f.3	Subtotal Period 4f Collateral Costs	-	-	-	-	-	-	1,464	220	1,683	1,683	-	-	-	-	-	-	-	-	-	-
Period 4f Period-Dependent Costs																					
4f.4.1	Insurance	-	-	-	-	-	-	310	31	341	341	-	-	-	-	-	-	-	-	-	-
4f.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4f.4.3	Health physics supplies	-	934	-	-	-	-	-	234	1,168	1,168	-	-	-	-	-	-	-	-	-	-
4f.4.4	Disposal of DAW generated	-	-	9	0	-	76	-	20	104	104	-	-	-	347	-	-	-	6,948	11	-
4f.4.5	Plant energy budget	-	-	-	-	-	-	166	25	191	191	-	-	-	-	-	-	-	-	-	-
4f.4.6	NRC Fees	-	-	-	-	-	-	427	43	470	470	-	-	-	-	-	-	-	-	-	-
4f.4.7	Site O&M Cost	-	-	-	-	-	-	356	53	410	410	-	-	-	-	-	-	-	-	-	-
4f.4.8	Corporate A&G Cost	-	-	-	-	-	-	355	53	408	408	-	-	-	-	-	-	-	-	-	-
4f.4.9	US Ecology Washington Site Availability Charge	-	-	-	-	-	-	21	3	25	25	-	-	-	-	-	-	-	-	-	-
4f.4.10	Security Staff Cost	-	-	-	-	-	-	1,112	167	1,278	1,278	-	-	-	-	-	-	-	-	-	18,600
4f.4.11	DOC Staff Cost	-	-	-	-	-	-	5,684	853	6,537	6,537	-	-	-	-	-	-	-	-	-	56,576
4f.4.12	Utility Staff Cost	-	-	-	-	-	-	6,699	1,005	7,704	7,704	-	-	-	-	-	-	-	-	-	73,626
4f.4	Subtotal Period 4f Period-Dependent Costs	-	934	9	0	-	76	15,131	2,486	18,636	18,636	-	-	-	347	-	-	-	6,948	11	148,803
4f.0	TOTAL PERIOD 4f COST	-	934	9	0	-	76	31,410	7,150	39,579	39,579	-	-	-	347	-	-	-	6,948	210,581	155,043
PERIOD 4 TOTALS		10,354	80,186	27,034	1,638	33,229	65,802	204,064	94,111	516,418	505,172	-	11,246	501,548	467,290	2,880	281	1,633	61,759,140	1,188,146	1,882,659
PERIOD 5b - Site Restoration																					
Period 5b Direct Decommissioning Activities																					
Demolition of Remaining Site Buildings																					
5b.1.1.1	Reactor	-	8,015	-	-	-	-	-	1,202	9,218	-	-	9,218	-	-	-	-	-	-	47,375	-
5b.1.1.2	Circ. Water Pumphouse	-	508	-	-	-	-	-	76	584	-	-	584	-	-	-	-	-	-	3,144	-
5b.1.1.3	Cooling Towers	-	4,545	-	-	-	-	-	682	5,227	-	-	5,227	-	-	-	-	-	-	22,238	-

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			
Demolition of Remaining Site Buildings (continued)																					
5b.1.1.4	Diesel Generator Building	-	412	-	-	-	-	-	62	474	-	-	474	-	-	-	-	-	-	2,511	-
5b.1.1.5	Makeup Water Pumphouses	-	245	-	-	-	-	-	37	282	-	-	282	-	-	-	-	-	-	1,390	-
5b.1.1.6	Misc. Structures	-	7,578	-	-	-	-	-	1,137	8,714	-	-	8,714	-	-	-	-	-	-	73,226	-
5b.1.1.7	Misc. Structures 2018	-	4,207	-	-	-	-	-	631	4,838	-	-	4,838	-	-	-	-	-	-	30,966	-
5b.1.1.8	Radwaste Building	-	2,713	-	-	-	-	-	407	3,120	-	-	3,120	-	-	-	-	-	-	19,448	-
5b.1.1.9	Service Building	-	766	-	-	-	-	-	115	881	-	-	881	-	-	-	-	-	-	7,003	-
5b.1.1.10	Standby Service Water Pumphouses	-	234	-	-	-	-	-	35	269	-	-	269	-	-	-	-	-	-	1,255	-
5b.1.1.11	Technical Support Center	-	243	-	-	-	-	-	36	279	-	-	279	-	-	-	-	-	-	2,306	-
5b.1.1.12	Turbine Generator	-	8,061	-	-	-	-	-	1,209	9,270	-	-	9,270	-	-	-	-	-	-	47,709	-
5b.1.1.13	Yard Piping	-	4,206	-	-	-	-	-	631	4,837	-	-	4,837	-	-	-	-	-	-	48,931	-
5b.1.1	Totals	-	41,733	-	-	-	-	-	6,260	47,993	-	-	47,993	-	-	-	-	-	-	307,500	-
Site Closeout Activities																					
5b.1.2	BackFill Site	-	12,703	-	-	-	-	-	1,905	14,608	-	-	14,608	-	-	-	-	-	-	21,518	-
5b.1.3	Grade & landscape site	-	2,468	-	-	-	-	-	370	2,838	-	-	2,838	-	-	-	-	-	-	4,734	-
5b.1.4	Final report to NRC	-	-	-	-	-	-	82	12	95	95	-	-	-	-	-	-	-	-	-	654
5b.1	Subtotal Period 5b Activity Costs	-	56,904	-	-	-	-	82	8,548	65,535	95	-	65,440	-	-	-	-	-	-	333,752	654
Period 5b Additional Costs																					
5b.2.1	Concrete Crushing	-	2,148	-	-	-	-	12	324	2,483	-	-	2,483	-	-	-	-	-	-	9,173	-
5b.2.2	Construction Debris	-	-	-	-	-	-	6,699	1,005	7,703	-	-	7,703	-	-	-	-	-	-	-	-
5b.2.3	Demolition of ISFSI	-	4,278	-	-	-	-	771	757	5,806	-	-	5,806	-	-	-	-	-	-	50,158	160
5b.2.4	Landfill Closure	-	-	-	-	-	-	298	45	342	-	-	342	-	-	-	-	-	-	-	-
5b.2.5	Underground Wells	-	-	-	-	-	-	771	116	887	-	-	887	-	-	-	-	-	-	-	-
5b.2.6	Security Barriers	-	-	-	-	-	-	334	50	384	-	-	384	-	-	-	-	-	-	-	-
5b.2	Subtotal Period 5b Additional Costs	-	6,425	-	-	-	-	8,884	2,296	17,605	-	-	17,605	-	-	-	-	-	-	59,331	160
Period 5b Collateral Costs																					
5b.3.1	Small tool allowance	-	441	-	-	-	-	-	66	508	-	-	508	-	-	-	-	-	-	-	-
5b.3.2	Security O&M	-	-	-	-	-	-	346	52	398	-	-	398	-	-	-	-	-	-	-	-
5b.3.3	Groundwater Monitoring	-	-	-	-	-	-	100	15	115	115	-	-	-	-	-	-	-	-	-	-
5b.3	Subtotal Period 5b Collateral Costs	-	441	-	-	-	-	446	133	1,021	115	-	906	-	-	-	-	-	-	-	-
Period 5b Period-Dependent Costs																					
5b.4.2	Property taxes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5b.4.3	Heavy equipment rental	-	5,980	-	-	-	-	-	897	6,877	-	-	6,877	-	-	-	-	-	-	-	-
5b.4.4	Plant energy budget	-	-	-	-	-	-	223	33	256	-	-	256	-	-	-	-	-	-	-	-
5b.4.5	Site O&M Cost	-	-	-	-	-	-	554	83	638	-	-	638	-	-	-	-	-	-	-	-
5b.4.6	Corporate A&G Cost	-	-	-	-	-	-	391	59	450	-	-	450	-	-	-	-	-	-	-	-
5b.4.7	Security Staff Cost	-	-	-	-	-	-	2,984	448	3,431	-	-	3,431	-	-	-	-	-	-	-	49,920
5b.4.8	DOC Staff Cost	-	-	-	-	-	-	15,119	2,268	17,387	-	-	17,387	-	-	-	-	-	-	-	141,440
5b.4.9	Utility Staff Cost	-	-	-	-	-	-	7,897	1,184	9,081	-	-	9,081	-	-	-	-	-	-	-	81,120
5b.4	Subtotal Period 5b Period-Dependent Costs	-	5,980	-	-	-	-	27,167	4,972	38,119	-	-	38,119	-	-	-	-	-	-	-	272,480
5b.0	TOTAL PERIOD 5b COST	-	69,751	-	-	-	-	36,579	15,950	122,280	210	-	122,070	-	-	-	-	-	-	393,083	273,294
PERIOD 5 TOTALS		-	69,751	-	-	-	-	36,579	15,950	122,280	210	-	122,070	-	-	-	-	-	-	393,083	273,294
TOTAL COST TO DECOMMISSION		22,562	161,305	27,577	1,868	33,229	68,741	1,090,204	245,048	1,650,534	1,059,307	452,479	138,748	501,548	478,787	2,880	281	1,633	62,103,120	1,739,120	10,963,860

Table D
Columbia Generating Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 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				Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
															Class A Cu. Feet	Class B Cu. Feet	Class C Cu. Feet	GTCC Cu. Feet			

TOTAL COST TO DECOMMISSION WITH 17.44% CONTINGENCY:	**$1,650,534**	**thousands of 2018 dollars**
TOTAL NRC LICENSE TERMINATION COST IS 64.18% OR:	**$1,059,307**	**thousands of 2018 dollars**
SPENT FUEL MANAGEMENT COST IS 27.41% OR:	**$452,479**	**thousands of 2018 dollars**
NON-NUCLEAR DEMOLITION COST IS 8.41% OR:	**$138,748**	**thousands of 2018 dollars**
TOTAL LOW-LEVEL RADIOACTIVE WASTE VOLUME BURIED (EXCLUDING GTCC):	**481,947**	**cubic feet**
TOTAL GREATER THAN CLASS C RADWASTE VOLUME GENERATED:	**1,633**	**cubic feet**
TOTAL SCRAP METAL REMOVED:	**148,002**	**tons**
TOTAL CRAFT LABOR REQUIREMENTS:	**1,739,120**	**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
A cell containing " - " indicates a zero value

APPENDIX E

DETAILED COST ANALYSIS

ISFSI

Table E
Columbia Generating Station
ISFSI Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Description	Removal Costs	Packaging Costs	Transport Costs	LLRW Disposal Costs	Other Costs	Total Costs	Burial Volume Class A (cubic feet)	Craft Hours	Oversight and Contractor Hours
Decommissioning Contractor									
Planning (characterization, specs and procedures)	-	-	-	-	397	397	-	-	1,216
Decontamination (overpack disposition)	493	136	4	1,600	-	2,232	7,330	3,234	-
License Termination (radiological surveys)	-	-	-	-	1,829	1,829	-	15,006	-
Subtotal	**493**	**136**	**4**	**1,600**	**2,226**	**4,458**	**7,330**	**18,240**	**1,216**
Supporting Costs									
NRC and NRC Contractor Fees and Costs	-	-	-	-	514	514	-	-	1,153
Insurance	-	-	-	-	101	101	-	-	-
Property Taxes	-	-	-	-	-	-	-	-	-
Security Staff Cost	-	-	-	-	355	355	-	-	8,758
Oversight Staff	-	-	-	-	468	468	-	-	4,729
Subtotal	**-**	**-**	**-**	**-**	**1,437**	**1,437**	**-**	**-**	**14,640**
Total (w/o contingency)	**493**	**136**	**4**	**1,600**	**3,663**	**5,896**	**7,330**	**18,240**	**15,856**
Total (w/25% contingency)	**616**	**170**	**5**	**2,000**	**4,579**	**7,370**			

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)