

DECOMMISSIONING COST STUDY
for the
WOLF CREEK GENERATING STATION



prepared for the

Wolf Creek Nuclear Operating Corporation

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

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APPROVALS

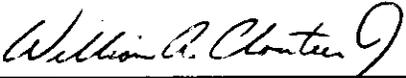
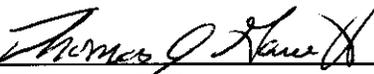
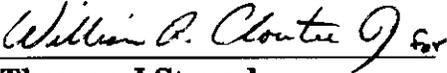
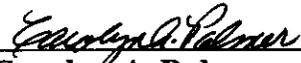
Project Manager	 _____ William A. Cloutier, Jr.	<u>8-26-99</u> Date
Project Engineer	 _____ Thomas J. Garrett	<u>8-26-99</u> Date
Technical Manager	 _____ Thomas J Strnad	<u>8-26-99</u> Date
Quality Assurance Manager	 _____ Carolyn A. Palmer	<u>8/26/99</u> Date

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REVISION LOG

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EXECUTIVE SUMMARY

This study evaluates the different decommissioning alternatives for the Wolf Creek Generating Station following the final cessation of plant operations. The associated estimates of cost were prepared for Wolf Creek Nuclear Operating Corporation by TLG Services, Inc. (TLG). The projected costs to decommission the station are estimated in 1999 dollars at \$467.2 million for the DECON alternative, \$590.4 million for the SAFSTOR alternative and \$671.0 million for the ENTOMB alternative. Cost and schedule summaries are provided in a summary table at the end of this section. The major contributors to the overall decommissioning costs are labor and radioactive waste disposal. The costs are based on several key assumptions, including regulatory requirements, contingency provisions, the disposal of low-level radioactive waste, the management of high-level radioactive waste, and the need for site restoration. A complete discussion of the strategic assumptions is presented in Section 3.

A detailed accounting of the major contributors to the cost of decommissioning is reported in Section 6 of the report. Schedules of annual expenditures are provided in Section 3, with the detailed activity costs, waste volumes, and removal man-hours provided in Appendix C. The current cost estimates include the continued operation of the Fuel Building's fuel storage pool as an interim wet storage facility for approximately five years after license expiration. During the five-year period, the Department of Energy (DOE) will complete the transfer of the residual spent fuel inventory to a federal facility.

Alternatives and Regulations

The Nuclear Regulatory Commission (NRC) provided general decommissioning guidance in the rule adopted on June 27, 1988.¹ 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 three decommissioning alternatives as being acceptable to the NRC - DECON, SAFSTOR, and ENTOMB.

DECON was 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

¹ 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+), June 27, 1988.

property to be released for unrestricted use shortly after cessation of operations." ²

SAFSTOR was 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." ³ Decommissioning is required to be completed within 60 years, although longer time periods will be considered when necessary to protect public health and safety.

ENTOMB was defined as "the alternative in which radioactive contaminants are encased in a structurally long-lived material, such as concrete; the entombed structure is appropriately maintained and continued surveillance is carried out until the radioactive material decays to a level permitting unrestricted release of the property." ⁴ As with the SAFSTOR alternative, decommissioning is currently required to be completed within 60 years, although longer time periods will also be considered when necessary to protect public health and safety. This requirement has limited the practicality of this alternative at commercial reactors that generate significant amounts of long-lived radioactive material.

[Note: On April 3, 1997, the NRC requested from staff its view on the viability of entombment as a decommissioning option. The Staff Requirements Memorandum directed the staff to identify the technical requirements and regulatory actions that would be necessary for entombment to become a viable option, if entombment was not deemed practicable. 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 staff's findings are summarized in SECY-99-187, issued on July 19, 1999.]

In 1996, the NRC published revisions to the 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. The amendments allow for greater public participation and

² Ibid. Page FR24022, Column 3.

³ Ibid.

⁴ Ibid. Page FR24023, Column 2.

better define the transition process from operations to decommissioning. A draft regulatory guide (DG-1067), issued in June of 1997, further describes 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 estimate follow the general guidance and sequence in the amended regulations.

Methodology

The methodology used to develop the decommissioning cost estimates for the Wolf Creek Generating Station follows the basic approach originally presented in the cost estimating guidelines⁵ 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 study reflect site-specific costs, as well as the latest available information about worker productivity in decommissioning.

This estimate reflects lessons learned from the Shippingport Station Decommissioning Project, completed in 1989, and the decommissioning of the Cintichem reactor, hot cells and associated facilities, completed in 1997, as well as from TLG's involvement in the decommissioning planning and engineering for the Pathfinder, Shoreham, Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee and San Onofre-1 nuclear units.

An activity duration critical path is used to determine the total decommissioning program schedule required for calculating the carrying costs which include program management, administration, field engineering, equipment rental, quality assurance, and security. This systematic approach for assembling decommissioning estimates has ensured a high degree of confidence in the reliability of the resulting costs.

Contingency

Consistent with industry 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." ⁶ The cost elements in this estimate are

⁵ T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986.

⁶ Project and Cost Engineers' Handbook, Second Edition, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York, p. 239.

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 estimate, does not account for price escalation and inflation in the cost of decommissioning over the remaining operating life of the unit.

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

Low-Level Radioactive Waste Disposal

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 Disposal Act" in 1980 and its Amendments of 1985⁷, the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

Kansas is a member of the five-state Central Interstate Compact, formed in response to the waste legislation. The development of a regional facility, however, was halted with the denial of US Ecology's license application for the construction and operation of a facility in Boyd County, Nebraska by Nebraska regulators. While the generators in the five contiguous states are current able to access the disposal facility in Barnwell, South Carolina, the situation is expected to be much different in the future. The capacity of the Barnwell Low-Level Radioactive Waste Management Disposal Facility is limited and the State of South Carolina is currently pursuing alternatives to conserve and restrict its use. Therefore, it is reasonable to assume that additional disposal capacity will be required to support reactor decommissioning, particularly for the isolation of the more highly radioactive material that is not suitable for disposal elsewhere. This analysis further presumes that new disposal facilities would be available by the time the Wolf Creek Generating Station ceases operation in 2025.

The plant components, equipment, and structural material removed, as well as the debris generated in the decontamination and dismantling of the Wolf Creek Generating Station will be characterized prior to disposal. For purposes of this

⁷ "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, 1/15/86.

estimate, material requiring controlled disposal is assumed to be routed to a licensed facility located within the central state region. The rate schedule for the currently operating Barnwell facility is used as a proxy for a regional site. Its rates are comparable with disposal projections for proposed facilities.

High-Level Waste

Congress passed the "Nuclear Waste Policy Act"⁸ in 1982, assigning the responsibility for disposal of spent nuclear fuel created by the commercial nuclear generating plants to the DOE. This legislation also created a Nuclear Waste Fund to cover the cost of the program, which is funded by the sale of electricity from nuclear reactors, and an estimated equivalent for assemblies irradiated prior to April 1983. The target date for startup of the Federal Waste Management System was originally 1998.

Since the original legislation, the DOE has announced several delays in the program schedule. Operation of DOE's yet-to-be constructed geologic repository is currently scheduled for the year 2010. The agency has no plans for receiving spent fuel from the nuclear plant sites prior to this date.

For cost estimating purposes, it is assumed that DOE would be able to take receipt of the spent fuel generated prior to the cessation of operations. The final core discharge would remain in wet storage for approximately five years following plant shutdown. Interim storage of the assemblies is dictated by DOE's transport system requirements for decay heat.

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 will substantially damage power block structures, potentially weakening the footings and structural supports. Prompt demolition after license termination is clearly the most appropriate and cost-effective option. 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 on site is more efficient and less costly than if the process were deferred. Experience at shutdown generating stations has shown that plant facilities quickly degrade without continual maintenance, adding additional expense and creating potential hazards to the public, as well as to the demolition work force. Consequently, this study assumes

⁸ "Nuclear Waste Policy Act of 1982 and Amendments," U.S. Department of Energy's Office of Civilian Radioactive Management, 1982.

that site structures will be removed to a nominal depth of three feet below the local grade level whenever possible. The site will then be graded and stabilized.

Recommendations

In most situations, the DECON alternative is the preferred mode of decommissioning. This alternative is favored because it eliminates the costs for care taking and prevents the site from becoming a potential long-term safety hazard. More importantly, the individuals familiar with the operation of the nuclear facility are available to support the dismantling effort; plant systems and services are fully functional; structural integrity is intact; and the licensee has a comprehensive management organization available to oversee/conduct the orderly decontamination and termination of the NRC site licenses. The DECON alternative is a valid and cost-effective option; it is also the least expensive option prior to any "time-value of money" considerations.

The construction of barriers and the general decontamination of plant areas in preparation for long-term storage do not necessarily alleviate the need for continued surveillance. Therefore, commitment is required to maintain essential site services and prevent the deterioration of the facilities. Maintenance would be required on security systems, area lighting, and on-site facilities supporting the fuel storage activity. These facilities can include power centers, administrative offices, and fuel transfer/repackaging facilities. Active supporting systems and components include plant fire protection, site drainage/monitoring and sewage, plant transformers and switchyard, plant grounding and lightning protection, communications, liquid collection, sampling and processing, seismic monitoring, etc. The NRC's review of currently dormant facilities has resulted in a general increase in the level of maintenance the agency is requiring, as well as a greater on-site presence by the licensee. As a result, estimates for the care taking of a dormant facility have increased significantly from earlier projections.

Summary

The DECON alternative involves removal of all radioactive material from the site following permanent shutdown. The facility operator may then have unrestricted use of the site with no further requirement for a license. This study also assumes that the remainder of the plant systems and structures on site, not previously removed in support of license termination, are dismantled and the site restored. For comparison, the SAFSTOR and ENTOMB decommissioning alternatives are also evaluated.

This study provides estimates for decommissioning Wolf Creek Generating Station under current regulatory requirements. The estimates are based on present-day costs and available technology. The schedule and sequence of decommissioning activities

for the alternatives are identified in Section 4. Cost summaries are provided in Section 6, with additional detail provided in Appendix C.

COST AND SCHEDULE ESTIMATE SUMMARY

	Costs 99\$ (thousands)	Schedule (months)
DECON		
Preparations	60,578	18
Decommissioning	360,367	65
Site Restoration	46,245	26
	<u>467,190</u>	<u>109</u>
SAFSTOR		
Preparations	40,295	18
52.6 year Maintenance *	146,749	632
Delayed Decommissioning	356,699	70
Site Restoration	46,701	26
	<u>590,444</u>	<u>746</u>
ENTOMB		
Preparations	52,419	18
Entombment Operations	218,446	57
48.4 year Maintenance *	102,806	581
Delayed Decommissioning	250,665	64
Site Restoration	46,708	26
	<u>671,044</u>	<u>746</u>

* Dormancy durations were adjusted so that license termination is accomplished within the required performance period of 60 years.

1. INTRODUCTION

This cost estimate analysis, prepared by TLG Services, Inc., (TLG) is designed to provide the Wolf Creek Nuclear Operating Corporation (WCNOC) with sufficient information to prepare financial planning documents required by the Nuclear Regulatory Commission (NRC). It is not an engineering analysis, but a cost estimate prepared in advance of the detailed preparations required to carry out the decommissioning of the Wolf Creek Generating Station.

1.1 OBJECTIVE OF STUDY

The objective of this study is to prepare an estimate of the cost, schedule, and waste volume generated to decommission the nuclear unit at Wolf Creek, including all common and supporting facilities. For the purposes of this study, the final shutdown date (license expiration) is projected as March 11, 2025. This date is forty years from issuance of the operating license.

1.2 SITE DESCRIPTION

Wolf Creek Generating Station is located approximately 3.5 miles northeast of the town of Burlington, in Coffey County, Kansas, approximately 75 miles southwest of Kansas City, Kansas. The site is on the east side of a man-made lake formed by impounding Wolf Creek. The station is an 1150 MWe (nominal) pressurized water reactor plant with supporting facilities. The Wolf Creek Generating Station was designed and constructed under the standardization program - Standardized Nuclear Unit Power Plant System.

Westinghouse Electric Company designed the Nuclear Steam Supply Steam System (NSSS). The NSSS consists of a pressurized water reactor with four independent primary coolant loops, each of which contains a reactor coolant pump and a steam generator. An electrically heated pressurizer and connecting piping complete the system. The NSSS is rated at a thermal power level of 3579 MWt (3565 MWt reactor core plus 14 MWt for reactor coolant pumps) with a corresponding turbine-generator gross output of 1214 MWe. The system is housed within a containment structure, a pre-stressed, post-tensioned concrete structure with cylindrical wall, a hemispherical dome, and a flat foundation slab. The wall and dome form a pre-stressed post-tensioned system. The inside surface of the structure is covered with a carbon steel liner, providing a leak tight membrane.

The Power Conversion System converts heat produced in the reactor to electrical energy. This system converts the thermal energy of the steam into

mechanical shaft power and then into electrical energy. The turbine-generator at Wolf Creek Generating Station is a tandem-compound, six-flow, four element, 1800-rpm unit. The unit consists of one high pressure and three low-pressure turbine elements driving a directly coupled generator. The turbine is operated in a closed feedwater cycle that condenses the steam; the feedwater is returned to the steam generators. Heat rejected in the main condensers is removed by the Circulating Water system.

The circulating waste system supplies cooling water from the plant's cooling water source to the main condenser, condensing the steam exhausted from the turbine. A large cooling lake provides the heat sink required for removal of waste heat in the power plant's thermal cycle.

1.3 REGULATORY GUIDANCE

The NRC provided decommissioning guidance in the rule "General Requirements for Decommissioning Nuclear Facilities," June 27, 1988. [1]* This rule amended NRC regulations to set forth technical and financial criteria for decommissioning licensed nuclear 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 licensee 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," [2] which provided guidance to the licensees of nuclear facilities on 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 amendments.

The rule defined three decommissioning alternatives as being acceptable to the NRC: DECON, SAFSTOR, and ENTOMB. It also placed limits on the time allowed to complete the decommissioning process. For SAFSTOR, 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. The guidelines for ENTOMB are similar, providing the NRC with both sufficient leverage and flexibility to ensure that these deferred options are only used in situations where it is reasonable and consistent with the definition of decommissioning. At the conclusion of a 60-year dormancy period (or longer for ENTOMB if the NRC approves such a case), the site would still require significant remediation to meet the conditions for release and license termination.

* Annotated references for citations in Sections 1-6 are provided in Section 7.

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 recent rulemaking permitting the release of a site for controlled use, the NRC has re-evaluated this 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. Consequently, while this study evaluates the ENTOMB alternative under existing regulations, the results may be significantly different if the required rulemaking is enacted. [Note: The staff's findings and accompanying analysis is provided in SECY-99-187, issued on July 19, 1999.]

In 1996 the NRC published revisions to the general requirements for decommissioning nuclear power plants.^[3] When the decommissioning regulations were adopted in 1988, it was assumed that the majority of licensees would decommission at the end of the operating license life. Since that time, several licensees have permanently and prematurely ceased operations without having submitted a decommissioning plan. In addition, these licensees requested exemptions from certain operating requirements as being unnecessary once the reactor is defueled. Each case has been 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 new amendments allow for greater public participation and better define the transition process from operations to decommissioning.

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

1.3.1 Nuclear Waste Policy Act

Congress passed the Nuclear Waste Policy Act⁽⁴⁾ in 1982, assigning the responsibility for disposal of spent nuclear fuel from the commercial nuclear generating plants to the Department of Energy (DOE). Two permanent disposal facilities were envisioned as well as an interim facility. To recover the cost of permanent spent fuel disposal, this legislation created a Nuclear Waste Fund through which money was to be collected from the consumers of the electricity generated by commercial nuclear power plants. The date targeted for start-up of the Federal Waste Management System was 1998.

After pursuing a national site selection process, the Act was amended in 1987 to designate Yucca Mountain, Nevada, as the only site to be evaluated for geologic disposal of high-level waste. Also in 1987, the DOE announced a five-year delay in the opening date for the repository, from 1998 to 2003. Two years later, in 1989, an additional 7-year delay was announced, primarily due to problems in obtaining the required permits from the state of Nevada to perform the required characterization of the site. There is a strong potential for additional delays.

Utilities have responded to this impasse by initiating legal action and constructing supplemental storage as a means of maintaining operating margins. On November 14, 1997, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision in Northern States Power Company, et al., v. U.S. Department of Energy. In the decision, the Court reaffirmed its earlier Indiana Michigan ruling that the DOE has an unconditional obligation to begin disposal of the utilities' spent nuclear fuel by January 31, 1998. Since the agency was not in default at the time the decision was issued, the court declined to prescribe "remedies" in the likely event the DOE failed to uphold its obligation. More recently, the U.S. Court of Federal Claims has ruled in favor of Yankee Atomic Power Company in its damage claim. However, even with the ruling, the DOE's position has remained unchanged. The agency continues to maintain that its delayed performance is unavoidable because it does not have an operational repository and does not have authority to provide storage in the interim. Consequently, the DOE has no plans to receive spent fuel before the year 2010.

It is assumed, for purposes of this cost estimate, that the DOE will be able to accept the majority of the spent fuel generated at the Wolf Creek Generating Station prior to the cessation of operations in the year 2025.

The residual assemblies, including the final core discharge, are assumed to be removed from the plant site within the first five years following shutdown. This duration is consistent with the fuel's heat decay requirements specified in the Standard Contract.

1.3.2 Low-Level Radioactive Waste Policy Amendments Act

Congress passed the "Low-Level Radioactive Waste Disposal Act" in 1980, declaring the states as being ultimately responsible for the disposition of low-level radioactive waste generated within their own borders. The federal law encouraged the formation of regional groups or compacts to implement this objective safely, efficiently and economically, and set a target date of 1986. With little progress, the "Amendments Act" of 1985^[5] extended the target, with specific milestones and stiff sanctions for non-compliance.

Kansas is a member of the five-state Central Interstate Compact, formed in response to the waste legislation. The development of a regional facility, however, was halted with the denial of US Ecology's license application for the construction and operation of a facility in Boyd County, Nebraska by Nebraska regulators. While the generators in the five contiguous states are current able to access the disposal facility in Barnwell, South Carolina, the situation is expected to be much different in the future. The capacity of the Barnwell Low-Level Radioactive Waste Management Disposal Facility is limited and the State of South Carolina is currently pursuing alternatives to conserve and restrict its use. Therefore, it is reasonable to assume that additional disposal capacity will be required to support reactor decommissioning, particularly for the isolation of the more highly radioactive material that is not suitable for disposal elsewhere. This analysis further presumes that new disposal facilities would be available by the time the Wolf Creek Generating Station ceases operation in 2025.

The plant components, equipment, and structural material removed, as well as the debris generated in the decontamination and dismantling of the Wolf Creek Generating Station will be characterized prior to disposal. For purposes of this estimate, material requiring controlled disposal is assumed to be routed to a licensed facility located within the central state region. The rate schedule for the currently operating Barnwell facility is used as a proxy for a regional site. Its rates are comparable with disposal projections for proposed facilities.

1.3.3 Radiological Criteria for License Termination

In 1997, 10 CFR 20, Subpart E, "Radiological Criteria for License Termination,"^[6] was published. This subpart provided radiological criteria for releasing a facility for unrestricted use. The criteria specifically defined a basis [Total Effective Dose Equivalent (TEDE) not to exceed 25 mrem per year to an average member of a critical group] by which levels of acceptable established residual radioactivity can be established, provided that residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA).

This subpart provides a well-defined license termination criteria, but does create uncertainties in predicting the total disposal volume of slightly contaminated materials (such as soil and silt which may require removal and disposal). The volume of contaminated soil/silt required to be decontaminated or disposed of may vary significantly, depending on the levels of soil contamination, the radioactive isotopes causing the contamination, and the geographic distribution of the contamination.

2. DECOMMISSIONING ALTERNATIVES

Cost studies were developed to decommission the Wolf Creek Generating Station for each of the approved decommissioning alternatives: DECON, SAFSTOR and ENTOMB. The duration of dormancy selected for the SAFSTOR and ENTOMB alternatives was based upon the maximum allowable interval (60 years) between cessation of operations and termination of the site license. Although the three alternatives differ with respect to technique, process, cost, and schedule, they attain the same result: removal of all regulated radioactive material from the site and ultimate release of the site for unrestricted and/or alternative use.

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, these 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.

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 remove spent fuel from the site; such costs are funded through the surcharge on electrical generation (1 mill/kWhr). However, the study does recognize the constraints imposed by the spent fuel residing on site during the decommissioning process.

The conceptual approach that the Nuclear Regulatory Commission (NRC or Commission) has chosen in their amended regulations is to divide 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 Phase I, 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 would then be prohibited from reactor operation. Within two years of notification to cease reactor operations, the licensee is required to provide a Post Shutdown Decommissioning Activities Report (PSDAR). This report would provide a description of the licensee's planned decommissioning activities, a corresponding schedule and an estimate of expected costs. The PSDAR would also address whether environmental impacts associated with the proposed decommissioning scenario have already

been considered in previously prepared environmental statement(s). Ninety days following the NRC's receipt of the PSDAR, the licensee can initiate certain decommissioning activities without specific NRC approval, under a modified 10 CFR §50.59 review process. The proposed rule would permit the licensee to expend/recover up to 3% of the generic decommissioning cost for planning, with an additional 20% available following the 90-day waiting period and certification of permanent defueling. Remaining funds would be available to the licensee with submittal of a detailed, site-specific cost estimate.

The second phase identified by the NRC in their proposed rule addresses licensed activities during a storage period, applicable to the dormancy phases of the deferred decommissioning alternatives, SAFSTOR and ENTOMB. Phase III pertains to the activities involved in license termination. The submittal of an application to terminate the license, along with a termination plan, marks the commencement of this phase. The termination plan would contain a detailed site characterization (i.e., location, type and amount of radioactivity) a description of any remaining dismantling activities to be accomplished, detailed plans for a final survey and the planned end use of the site. An updated cost to complete would be required along with the reporting of any new or altered environmental consequences.

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. The organization required to manage the intended decommissioning activities is assembled from available plant staff and outside resources, as required. This staffing transition process includes retraining of selected plant staff. Preparations include the planning for permanent defueling of the reactor, revision of technical specifications appurtenant to the operating conditions and requirements, a characterization of the facility and major components, and the development of the PSDAR.

Engineering and Planning

Prior to the commencement of decommissioning operations, the licensee will certify the permanent cessation of operations and the removal of fuel from the reactor vessel. The PSDAR, required within two years of the notice to cease operations, provides a description of the licensee's planned decommissioning activities, a timetable, and the associated financial requirements of the 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, i.e., without specific 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 Greater-than-Class C waste (GTCC, as defined under 10 CFR §61). 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 Commission is proposing to include the following additional criteria for use of the 10 CFR §50.59 process in decommissioning: the proposed activity must not 1) foreclose release of the site for possible unrestricted use, 2) significantly increase decommissioning cost, 3) cause any significant environmental impact, or 4) violate the terms of the licensee's existing license. Consequently, activity specifications, cost-benefit and safety analyses, work packages and procedures, etc., must be assembled in support of the proposed decontamination and dismantling activities, and in conjunction with the development of the PSDAR.

The decommissioning program outlined in the PSDAR will be designed to accomplish the required tasks within the As-Low-As-Reasonably-Achievable (ALARA as defined in 10 CFR §20) guidelines 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.

The NRC recognizes that the existing operational technical specifications will need to be 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 will need to be considered, with an environmental report on specific and unique concerns required to be submitted to the NRC for consideration and possible preparation of an environmental impact statement.

Much of the work in preparing the PSDAR is also relevant to the development of the detailed engineering plans and procedures. This work includes, but is not limited to:

1. Site preparation plans for the proposed decommissioning activities;

2. Detailed procedures and sequences for removal of systems and components;
3. Evaluation of the disposition alternatives for the reactor vessel and its internals;
4. Plans for decontamination of structures and systems;
5. Design/procurement and testing of tooling and equipment;
6. Identification/selection of specialty contractors;
7. Procedures for removal and disposal of radioactive materials; and
8. Sequential planning of activities to minimize conflicts with simultaneous tasks.

Site Preparations

The following activities are initiated following final plant shutdown and in preparation for actual decommissioning activities.

1. Prepare site support and storage facilities, as required.
2. Isolate spent fuel storage services and fuel handling systems located in the Fuel Building from the rest of power block such that decommissioning operations can commence on the balance of the plant. Existing plant personnel in accordance with existing operating technical specifications may carry out this activity. Decommissioning operations are assumed to be scheduled around the Fuel Building, to the greatest extent possible, such that the overall project schedule is optimized. DOE's cooling requirement for fuel transport is approximately five years. Therefore, decommissioning operations for the Fuel Building cannot be expected to begin prior to five years after the cessation of plant operations. The assemblies are assumed to be transferred to a DOE facility once the spent fuel decays to the point that it meets the heat load criteria.
3. Clean all plant areas of loose contamination and process all liquid and solid wastes.

4. Conduct radiation surveys of work areas. Characterize major components (including the reactor vessel and its internals), and assay internal system contamination and biological shield activation.
5. Correlate survey data and normalize for development of packaging and transportation procedures.
6. Determine transport and disposal container requirements for activated materials and/or hazardous materials, including shielding and stabilization. Fabricate or procure such containers.
7. Develop procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radwaste including DAW, resins, filter media, metallic and non-metallic components generated in decommissioning, site security and emergency programs, and industrial safety.

Following submittal of the PSDAR and certification of permanent removal of fuel from the reactor vessel, the licensee may commence major decommissioning activities (under certain conditions). Unlimited access to the decommissioning fund will require the preparation of a detailed site-specific cost estimate for submittal to the NRC. In addition, a licensee termination plan, submitted, as a supplement to the FSAR or equivalent, needs to be prepared at least two years prior to the license termination date.

2.1.2 Period 2 - Operations

Decommissioning Activities

For the DECON alternative, significant decommissioning activities involve the following steps:

1. Construct temporary facilities and modify existing storage facilities to support the dismantling activities. These may include additional changing rooms and contaminated laundry facilities for increased work force, establishment of laydown areas to facilitate equipment removal and preparation for off-site transfer, the upgrade of roads to facilitate hauling and transportation, and modifications to the Reactor Building to facilitate access of large/heavy equipment.

2. Design and fabricate shielding in support of removal and transportation activities as well as contamination control envelopes; specify/procure specialty tooling and remotely operated equipment. Modify the refueling facilities to support segmentation activities and prepare rigging for segmentation and extraction of heavy components, including the reactor vessel and its internals.
3. Procure (lease or purchase) required shipping canisters, cask liners, and Industrial Packages (IPs) from suppliers.
4. Conduct decontamination of components and piping systems as required to control (minimize) worker exposure. Remove, package, and dispose of all piping and components that are no longer essential to support decommissioning operations.
5. Remove control rod drive housings and the head service structure from reactor vessel head and package for controlled disposal.
6. Segment reactor vessel closure head and vessel flange for shipment in cask liners. Load overpack liners into shielded casks or place in shielded vans for transport.
7. Segment upper internals assemblies; package segments in shielded casks. These operations are performed remotely by cutting equipment located under water in the refueling facilities. Package and dispose of items that meet 10 CFR §61 "Class C" criteria or less.
8. Disassemble/segment remaining reactor internals in shielded casks. The operations are also conducted under water using remotely operated tooling and contamination controls. Package and dispose of items that meet 10 CFR §61 "Class C" criteria or less.
9. Package 10 CFR §61 GTCC components into fuel assembly-sized containers for handling and storage along with the spent fuel assemblies. Transfer GTCC containers to the fuel handling facilities or suitable storage location.
10. Segment/section the reactor vessel, placing segments into shielded containers. The operation is performed remotely in air using a contamination control envelope. Sections are placed in

containers stored under water (for example in an isolated area of the refueling canal or spent fuel pool) using a remote or shielded crane. Transport the containers using shielded truck casks.

11. Remove the reactor coolant pumps. The reactor coolant pumps are sealed with steel plate so as to serve as their own containers. Package the piping in standard containers. Ship piping and pumps for controlled disposal.
12. Remove systems and associated components as they become non-essential to the vessel removal operation, related decommissioning activities, or worker health and safety (e.g., waste collection and processing systems, electrical and ventilation systems, etc.).
13. Maintain station diesel generator operation to provide emergency power to the spent fuel cooling and cleanup systems during the required heat decay phase for the last core off load. The fuel handling equipment, supporting the transfer of the assemblies off site, may also require the station diesel generators to be available.
14. Remove activated concrete biological shield and accessible contaminated concrete (excluding steam generator and pressurizer cubicles). If dictated by the steam generator and pressurizer removal scenarios, remove those portions of the associated cubicles necessary for access and component extraction.
15. Remove steam generators and pressurizer for shipment and controlled disposal. Decontaminate exterior surfaces, as required, and seal-weld openings (nozzles, inspection hatches, and other penetrations). These components can serve as their own burial containers provided that all penetrations are properly sealed and the internal contaminants are stabilized. Add steel shields to those external areas of the steam generators to meet transportation limits and regulations.

License Termination

The preparation of a termination plan is required at least two years prior to the anticipated date of license termination. 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 any reuse of the site, an updated cost estimate to complete the decommissioning, and any associated environmental concerns. The NRC will publish notice of a receipt of the plan and make the plan available for public comment. A local hearing will also be scheduled. Plan approval may be subject to conditions and limitations as deemed appropriate by the NRC. The licensee may then commence with the final remediation of site facilities and services, including the following activities:

1. Remove steel liners from the refueling canal, and containment, including any contaminated concrete behind liners, and route for controlled disposition.
2. Remove contaminated equipment and material from all the remaining auxiliary structures. Remediate until radiation surveys indicate that the structure can be released for unrestricted access.
3. Remove contaminated equipment and material from the fuel handling facility following the transfer of all residual spent fuel off-site. Remediate fuel handling facility area until radiation surveys indicate that the structure can be released for unrestricted access.
4. Decontaminate remaining site buildings and facilities with residual contaminants. Remove all remaining low-level radioactive waste. Material removed in the decontamination and dismantling of the nuclear unit will be routed to an on-site central processing area. Material certified to be free of contamination would be released for unrestricted disposition, e.g., for scrap or general disposal. Contaminated material will be characterized and segregated for additional on-site decontamination, off-site processing (if available), and/or packaging for controlled disposal at the regional low-level radioactive waste disposal facility.
5. Remediate those site areas that contain concentrations of radionuclides exceeding NRC release limits.
6. Remove remaining components, equipment, and plant services in support of the area release survey(s).

7. Conduct final radiation survey to ensure that all radioactive materials in excess of permissible residual levels have been remediated in accordance with "Radiological Criteria for License Termination," 62 Federal Register 39058 July 21, 1997. The survey may coincide with final NRC site inspection. These activities are scheduled at the end of Period 2, the operations phase.

Incorporated into the License Termination Plan, the Final Survey Plan details the radiological surveys to be performed once the decontamination activities are completed. The Final Survey Plan is developed using the guidance provided by the Multi-Agency Radiation and Site Investigation Manual (MARSSIM), which was issued in December 1997 in final form as NUREG-1575. This document delineates the statistical approaches to survey design and data interpretation acceptable to the Environmental Protection Agency (EPA) and the NRC. It also identifies state-of-the-art, commercially available, instrumentation and procedures for conducting radiological surveys. Using this guideline ensures that the surveys' design and implementation are conducted in a manner that provides a high degree of confidence that 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 final termination of the license.

The NRC will terminate the 10 CFR §50 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.

2.1.3 Period 3 - Site Restoration

Site restoration activities may begin following completion of decommissioning operations. Efficient removal of the contaminated materials and verification that residual radionuclide concentrations are below the NRC limits will typically result in substantial damage to many of the structures. Blasting, coring, drilling, scarification (surface removal), and the other decontamination activities will substantially damage power block structures including the Reactor, Auxiliary, Fuel and Radwaste buildings. Verifying that subsurface radionuclide concentrations meet NRC site release requirements may 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.

Prompt dismantling of site structures is clearly the most appropriate and cost-effective option. 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 on site is more efficient and less costly than if the process were deferred. Site facilities quickly degrade without continual maintenance, adding additional expense and creating potential hazards to the public as well as to future workers. Abandonment creates a breeding ground for vermin infestation as well as other biological hazards.

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

1. Perform demolition of the remaining portions of the containment structure and interior portions of the Reactor Building. Internal floors below grade level are removed, from the lower levels upward, using controlled blasting techniques. Clean concrete rubble produced by demolition activities is used to backfill voids. Excess material is trucked off site for disposal as construction debris.
2. Remove remaining buildings using conventional demolition techniques for above ground structures.
3. Prepare the final dismantling program report.

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 SAFSTOR period), with structures maintained in a sound condition. Systems not required to operate in support of 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 is 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 - SAFSTOR Operations

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 the staffing transition plan, the organization required to manage the intended decommissioning program is assembled from available plant staff and outside resources. Preparations 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 program outlined in the PSDAR will be designed to accomplish the required tasks within the ALARA guidelines for protection of personnel from exposure to radiation hazards. It also addresses the continued protection of the health and safety of the public and the environment.

The NRC recognizes that the existing operational technical specifications will require review and modifications to reflect plant conditions and the safety concerns associated with permanent cessation of operations. The environmental impact associated with the planned decommissioning activities must be considered; an environmental report

on those concerns not already assessed must be submitted to the NRC for consideration and possible preparation of an environmental impact statement.

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

1. Isolate spent fuel storage services and fuel handling systems located in the fuel handling facility from the power block so that safe-storage operations may commence on the balance of the plant. Plant personnel in accordance with existing operating technical specifications may carry out this activity. Activities are assumed to be scheduled around the fuel handling systems to the greatest extent possible. The final core discharge will be stored in the existing spent fuel pool until transferred off-site.
2. Drain/de-energize/secure all non-contaminated systems not required to support dormancy operations.
3. Dispose of contaminated filter elements and resin beds not required for processing wastes from decontamination activities.
4. Drain reactor vessel; leaving internals in place.
5. Drain, de-energize, and secure all contaminated systems. Decontaminate systems as required for future maintenance and inspection.
6. Prepare lighting and alarm systems whose continued use is required. De-energize and/or secure portions of fire protection, electric power, and Heating, Ventilation, and Air Conditioning (HVAC) systems whose continued use is not required.
7. Clean loose surface contamination from building access pathways.
8. Perform an interim radiation survey of plant; post warning signs as appropriate.
9. Erect physical barriers and/or secure all access to radioactive or contaminated areas, except as required for controlled access, i.e., inspection and maintenance.
10. Install security and surveillance monitoring equipment and relocate security fence around secured structures, as required.

11. Delay the demolition of those structures located outside the secured area until after the termination of the license.

2.2.2 Period 2 - SAFSTOR 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 alternative SAFSTOR. After an optional 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 termination plan (described in Section 2.1.2), thereby initiating the third phase.

Activities required during the planned dormancy period for the SAFSTOR alternative include a 24-hour guard 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, and routine service. This work force will maintain the structures in a safe condition, provide adequate lighting, heating, and ventilation, and perform periodic preventive maintenance on essential site services.

An environmental surveillance program is carried out during the dormancy period to ensure that potential releases of radioactive material to the environment are 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. Security is provided by the security fence, sensors, alarms, surveillance equipment, etc., which must be maintained in good condition for the duration of this period. Fire and radiation alarms are also to be monitored and maintained. While remote surveillance is an option, it does not offer the immediate response time of a physical presence.

Variations in the length of the dormancy period are expected to have little effect upon the quantities of radioactive wastes generated from system and structure removal operations. While there will be a decrease in the contamination levels present on all surfaces due to radioactive decay over an increased dormancy duration, it is not expected that any material that is non-releasable at the time of shutdown will decay to a releasable state over the permissible time frame (i.e., 60 years maximum). It is not possible to make any further assumptions concerning contamination levels without detailed characterization information.

Given the levels of radioactivity and spectrum of radionuclides expected from forty years of plant operation, no plant process system identified as being contaminated upon final shutdown will become releasable due to the decay period alone (i.e., there is no significant reduction in waste volume in delaying decommissioning). In fact, SAFSTOR estimates can show a slight increase in the total projected waste volume, due primarily to initial preparation activities for placing the unit in safe-storage, as well as from follow-up housekeeping tasks over the caretaking period for the station.

The delay in decommissioning yields lower working area radiation levels. As such, the difference between the prompt and delayed scenarios is moderated by reduced ALARA controls for the SAFSTOR's lower occupational exposure potential. Because this alternative provides a period of decay for the residual radioactive material, lower radiation fields are encountered than with the DECON alternative. Some of the dismantling activities may employ manual techniques rather than remote procedures. Thus, dismantling operations may be simplified for some tasks. However, this study does not attempt to quantify this effect, because it would have an immaterial impact on overall costs.

2.2.3 Periods 3 and 4 - Deferred Decommissioning

A termination plan must be prepared at least two years prior to the anticipated date of license termination. Submitted as a supplement to the FSAR, or equivalent, the plan must include a site characterization, description of the remaining dismantling activities, plans for site remediation, detailed plans 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 publish notice of a receipt of the plan and make the plan available for public comment. A local hearing will also be scheduled. Plan

approval will be subject to any conditions and limitations deemed appropriate by the NRC. The licensee may then commence with the final remediation of site facilities and plant services.

Although the initial radiation levels due to ^{60}Co will decrease significantly 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 SAFSTOR. Portions of the biological 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.

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 for activities and the writing of activity specifications and detailed 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, as well as 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 SAFSTOR scenarios is the absence, in the latter, of any constraint on the availability of the fuel handling facilities for decommissioning. The timing for the SAFSTOR scenario is such that the spent fuel inventory has been removed from the site prior to the initiation of decontamination and dismantling activities, eliminating a significant scheduling hindrance. Any GTCC material generated in the segmentation of the reactor vessel internals is assumed to be directly routed to the DOE's geological facility without the need to provide for interim storage on site.

Incorporated into the License Termination Plan, the Final Survey Plan details the radiological surveys to be performed once the decontamination activities are completed. The Final Survey Plan is developed using the guidance provided by the Multi-Agency Radiation and Site Investigation Manual (MARSSIM), as discussed in Section 2.1.2. 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 final termination of the license. The NRC will terminate the license if it determines that site remediation has been performed in accordance with the license termination plan, and the terminal radiation survey and associated documentation demonstrate that the facility is suitable for release.

2.2.4 Period 5 - Site Restoration

Following completion of decommissioning operations, site-restoration activities may begin. Dismantling of the site structures is clearly the most appropriate and cost-effective option as described in Section 2.1.3. Unless site structures have been well maintained during the dormancy period, the cost to dismantle site facilities can be more costly than reported by this study. The basis for the dismantling cost in the SAFSTOR scenario is consistent with that described in Section 2.1.3 for DECON, presuming the removal of structures and site facilities to a nominal depth of three feet below grade and the limited restoration of the site.

2.3 ENTOMB

This alternative deals with creation of an entombment structure within the Reactor Building to serve as an additional barrier, preventing inadvertent or deliberate contact with, and intrusion into, the reactor vessel and internals, reactor coolant pumps, steam generators, and piping. This structure uses the existing concrete where possible. New concrete is added as necessary to provide a sealed reinforced concrete barrier around the primary system, preventing personnel access. Radioactive material exterior to this boundary is either relocated within the entombment structure, or removed and packaged for off-site disposal. The decontaminated structures and systems and all other site structures and systems remain intact until after the dormancy period. At that time all remaining radioactive material within the entombment structure is removed and disposed of in a controlled manner.

2.3.1 Period 1 - ENTOMB Preparations

As described in Section 2.1, notification would be provided to the NRC certifying the permanent cessation of operations and the removal of fuel from the reactor vessel. The licensee would then be prohibited from re-initiating reactor operation. Within two years of notification to cease reactor operations, the licensee is required to provide a PSDAR. This report would provide a description of the licensee's planned decommissioning activities, a corresponding schedule and an estimate of expected costs. The PSDAR would also address whether environmental impacts associated with the proposed decommissioning scenario differ from those already considered in previously prepared environmental statement(s). Ninety days following the NRC's receipt of the PSDAR, the licensee can initiate certain decommissioning activities without specific NRC approval, under a modified 10 CFR §50.59 review process.

The proposed program outlined in the PSDAR will be designed to accomplish the required tasks within the As-Low-As-Reasonably-Achievable (ALARA as defined in 10 CFR §20) guidelines 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.

The Commission recognizes that the existing operational technical specifications will need to be 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 will need to be considered with an environmental report on those concerns (not already assessed) required to be submitted to the NRC for consideration. This could include the possible preparation of an environmental impact statement.

The goal of this decommissioning method is to confine the highly radioactive or contaminated components (e.g., the reactor vessel and its internals) within concrete structures, which are integral with the primary containment and other designated portions of the Reactor Building. This alternative includes the removal and disposal of all fuel assemblies, solid and liquid wastes, and any remaining radioactive materials, components, and structural materials exterior to the entombment structure(s). The engineering and planning requirements for this alternative are similar to those described for the DECON alternative. However, the PSDAR should include descriptions for monitoring the structures/facility and the environment, with associated

reports, security requirements, and any other activities necessary during the dormancy period.

Site preparations for ENTOMB include most of the activities previously described for the DECON alternative. However, because ENTOMB is not as extensive as DECON, plant support and storage facility requirements may be less. Except for draining and drying of the reactor coolant system, only minimal work is performed on any component(s) within the entombment boundary prior to the dormancy period.

Liquid and solid wastes are processed and removed and plant radiation surveys are conducted. The entombment activity is initiated approximately ninety days following the submittal of the PSDAR.

2.3.2 Period 2 - ENTOMB Operations

The activities necessary to accomplish the entombment requirements are as follows:

1. Drain/de-energize/secure non-contaminated systems not required to support decommissioning operations.
2. Isolate the existing spent fuel storage and handling facilities in the Fuel Building from the power block such that decommissioning operations can commence. Plant personnel in accordance with existing operating technical specifications may carry out this activity. Decommissioning operations are assumed to be scheduled around the Fuel Building to the greatest extent possible such that the overall project schedule is optimized.
3. Dispose of contaminated filter elements and resin beds not required for processing wastes from decontamination activities.
4. Drain reactor vessel and the reactor coolant piping. Cut, cap, and seal weld all piping at the entombment boundary interface.
5. Drain/de-energize/secure contaminated systems. Decontaminate, as required, and remove portions of these systems located outside entombment boundary. Package, ship, and bury removed systems; isolate remaining systems, if required, at the entombment boundary. Certain components may be moved or stored within the entombment structure.

6. Prepare lighting and security alarm systems required for continued use. De-energize and/or secure sections of the fire protection, electric power, and HVAC systems not required for continued use.
7. Remove all large contaminated components external to the entombment boundary(s). Where feasible, these components are decontaminated (in-situ if possible, and therefore not removed) and released; otherwise the components are boxed/packaged and shipped off site for processing or for disposal as low specific activity (LSA) waste.
8. Complete the entombment barrier(s) by capping and sealing all openings and penetrations with concrete.
9. Structural surfaces exterior to the entombment barrier should be cleaned/decontaminated to unrestricted levels. Equipment and normal personnel access hatches located outside the entombment barrier boundary remain operational with controlled access procedures implemented.
10. An entombment structure pressure equalization line, equipped with an absolute filter should be installed.
11. Decommission all radioactive structures external to the entombment boundary and remove all radioactive materials for shipping and burial. As an alternative, selected contaminated material and non-combustible wastes may be transferred for storage within the entombment structure. Decontaminated structures other than the Reactor Building may remain intact with accesses properly secured against unauthorized entry.
12. Install security and surveillance monitoring equipment and relocate the security fence around structures containing radioactive material as required.
13. Perform final radiation survey of plant and post warning signs as appropriate.

Sections of the site outside the controlled area may be restored. All other site structures may remain intact.

2.3.3 Period 3 - ENTOMB Dormancy

Activities required during the planned dormancy period, for the ENTOMB alternative, include routine inspection, preventive and corrective maintenance on safety systems, maintenance of structural integrity, and an environmental and radiation monitoring program. Equipment maintenance, inspection and routine servicing may also be distributed over a quarterly period in such a manner that all portions of the plant are inspected and maintained throughout the dormancy period.

An environmental surveillance program is carried out during the dormancy period to ensure that potential releases of radioactivity to the environment are detected and controlled. Appropriate emergency procedures should be established and initiated for releases that exceed prescribed limits. The environmental surveillance program is generally a modified/abbreviated version of that in effect during normal plant operations.

Security during the dormancy period is primarily conducted to prevent unauthorized entry and to protect the public from the consequences of their own actions. Security detection and notification systems used during plant operations are augmented by the installation of audible alarms. Additionally, silent alarms may be installed to alert off-site security personnel to trespass and fire. It is assumed that the licensee will maintain a minimal manned security presence at the site. These personnel can provide periodic site checks and prompt response to alarms. Liaison with local law enforcement agencies is maintained and their assistance requested as necessary.

Security fences, monitoring and alarm and surveillance systems must be maintained in good condition for the duration of this period. The facility is secured; exterior doors will be locked and alarmed for intrusion. Security personnel monitor fire and radiation alarms.

The second phase identified by the NRC, in their proposed rule, addresses licensed activities during a storage period and is applicable to the dormancy phases of the deferred decommissioning alternatives, SAFSTOR and ENTOMB. After an optional period of storage (up to 60 years after permanent cessation of operations), the proposed rule would require that the licensee submit an application to terminate the license along with a termination plan, initiating the third phase. The termination plan would contain a detailed site characterization, i.e.,

location, type and amount of radioactivity, a description of any remaining dismantling activities to be accomplished, detailed plans for a final survey and the planned end-use of the site. An updated cost to complete the decommissioning would be required along with a report of any new or altered environmental consequences.

2.3.4 Periods 4 and 5 - Deferred Decommissioning

At the conclusion of the dormancy period for the ENTOMB alternative, remaining structures will be completely dismantled. Essentially, the dismantling operations described in the DECON scenario are performed.

At least two years prior to the anticipated date of license termination, a termination plan is required to be prepared. Submitted as a supplement to the FSAR, or equivalent, the plan must include a site characterization, description of the remaining dismantling activities, plans for site remediation, detailed plans for the final radiation survey, designation of the end-use of the site, an updated cost estimate to complete, and any associated environmental concerns. The NRC will notice the receipt of the plan and make the plan available for public comment. A local hearing will also be scheduled. Plan 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 plant services.

Prior to the commencement of decommissioning operations, preparations are undertaken to reactivate the site and prepare for decommissioning. Preparations include engineering and planning, a detailed site characterization, as well as the assembly of a decommissioning management organization. Final planning for activities and writing of activity specifications and detailed procedures are also initiated.

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, as well as the follow-on decontamination and dismantling processes are detailed in Section 2.1.1 and 2.1.2. The primary difference between the sequences anticipated for the DECON and ENTOMB scenarios is the focus on the entombment boundary, i.e., decontamination and site remediation activities will be restricted to the Reactor Building. Any GTCC material generated in the segmentation of the reactor vessel internals is assumed to be routed to DOE's geological facility, without the need to provide for interim storage on-site.

The Commission will terminate the license if it determines that site remediation has been performed in accordance with the license termination plan and the terminal radiation survey and associated documentation demonstrates that the facility is suitable for release. Once the requirements are satisfied, the NRC can terminate the 10 CFR §50 license for the nuclear unit.

2.3.5 Period 6 - Site Restoration

Following completion of decommissioning operations, site-restoration activities may begin. Dismantling of the site structures is clearly the most appropriate and cost-effective option as described in Section 2.1.3. Unless site structures have been well maintained during the dormancy period, the cost to dismantle site facilities can be more costly than reported in this estimate. The basis for the dismantling cost in the ENTOMB scenario is consistent with that described in Section 2.1.3 for DECON, presuming the removal of structures and site facilities to a nominal depth of three feet below grade and the limited restoration of the site.

3. COST ESTIMATE

The site-specific cost estimate prepared for decommissioning the nuclear unit considers the unique features of the site, including the nuclear steam supply system, power generation system, support services, site buildings, and ancillary facilities. The basis of the estimate, and its sources of information, methodology, site-specific considerations, assumptions, and total costs are described in this section.

3.1 BASIS OF ESTIMATE

The current estimate was developed using the basic design information originally generated for the 1993 decommissioning study. For example, a detailed accounting of the plant inventory was generated for the 1993 study. Components were inventoried from the mechanical and electrical piping and instrument diagrams. Estimates of concrete volume, steel quantities, and plant areas to be addressed in remediation of the site were developed from plant general arrangement drawings, structural details, and construction design documents. This information was reviewed for the 1999 estimate and updated, as required.

The site-specific considerations and assumptions used in the 1993 estimate were also revisited. Modifications were incorporated where new information was available or experience from ongoing decommissioning programs dictated an alteration.

3.2 METHODOLOGY

The methodology used to develop this cost estimate follows the basic approach originally presented in the AIF/NESP-036 study report, "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,"^[7] and the US DOE "Decommissioning Handbook."^[8] These documents present a unit cost factor method for estimating decommissioning activity costs, which simplifies the estimating calculations. Unit cost factors for concrete removal (\$/cubic yard), steel removal (\$/ton), and cutting costs (\$/inch) were developed using local labor rates provided by WCNO. The activity-dependent costs were estimated with the item quantities (cubic yards, tons, inches, etc.) developed from plant drawings and inventory documents. The unit cost factors used in this study reflect the site-specific costs, as well as the latest available information on worker productivity in decommissioning. Lessons learned from the Shippingport Station Decommissioning Project, completed in 1989, the decommissioning of the Cintichem reactor, hot cells and associated facilities, completed in 1997, and TLG's involvement in the

decommissioning planning and engineering for the Pathfinder, Shoreham, Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee and San Onofre-1 nuclear units are reflected within this estimate.

The unit cost factor method provides a demonstrable basis for establishing reliable cost estimates. The detail of activities provided in the unit cost factors for activity time, labor costs (by craft), and equipment and consumable costs provides assurance that cost elements have not been omitted. These detailed unit cost factors, coupled with the plant-specific inventory of piping, components and structures, provide a high degree of confidence in the reliability of the cost estimates.

Work Difficulty Factors (WDFs) were assigned to each unit cost factor set, 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 15%
- Protective Clothing Factor 10% to 30%

These factors and their associated range of values were developed in conjunction with the Atomic Industrial Forum's Guideline Study. The factors (and their suggested application) are discussed in more detail in this publication.

An activity duration critical path was used to determine the total decommissioning program schedule. The program schedule is used to determine the period-dependent costs for program management, administration, field engineering, equipment rental, quality assurance, and security. The study used typical salary and hourly rates for personnel associated with period-dependent costs for the region in which the station is located. Costs for the conventional removal of components/structures relied upon information available from "Building Construction Cost Data," published by R. S. Means.^[9] Examples of unit cost factor development are presented in the AIF/NESP-036 study. Appendix A presents the detailed development of a typical site-specific unit cost factor. Appendix B provides the values contained within one set of factors developed for the Wolf Creek Generating Station analyses.

3.3 FINANCIAL COMPONENTS OF THE COST MODEL

TLG's proprietary decommissioning cost model, DECCER, is composed of a number of distinct cost line items. These direct expenditures, however, do not comprise the total cost to accomplish the project goal, i.e., license termination and site restoration.

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, labor stoppages, etc. 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 monies to cover these types of expenses.

In addition to the routine uncertainties that contingency addresses, 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 of these uncertainties 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." This cost study, however, 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 are revisited periodically and addressed through repeated revisions or updates of the base estimate.

3.3.1 Contingency

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"^[10] 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 estimate are based upon ideal conditions and maximum efficiency; therefore, consistent with industry practice, a contingency factor has been applied. 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 percentage contingency in each category. It should be noted that contingency, as used in this estimate, does not account for price escalation and inflation in the cost of decommissioning over the remaining operating life of the unit.

The use and role of contingency within decommissioning estimates is not a "safety factor issue." Safety factors provide additional security and address situations that may never occur. Contingency funds are expected to be fully expended throughout the program. They also provide assurance that sufficient funding is available to accomplish the intended tasks. Some of the rationale for (and need to incorporate) contingency within any estimate is offered in the following discussion. An estimate without contingency, or from which contingency has been removed, can disrupt the orderly progression of events and jeopardize a successful conclusion to the decommissioning process.

The most technologically challenging task in decommissioning a commercial nuclear station will be the disposition of the reactor vessel and internal components, which have become highly radioactive after a lifetime of exposure to radiation produced in the core. The disposition of these highly radioactive components forms the basis for the critical path (schedule) for decommissioning operations. Cost and schedule are interdependent and any deviation in schedule has a significant impact on cost for performing a specific activity.

Disposition of the reactor vessel internals involves the underwater cutting of complex components that are highly radioactive. Costs are based upon optimum segmentation, handling, and packaging scenarios. The schedule is primarily dependent upon the turnaround time for the heavily shielded shipping casks, including preparation, loading, and decontamination of the containers for transport. The number of casks required is a function of the pieces generated in the segmentation activity, a value calculated on optimum performance of the tooling employed in cutting the various subassemblies. The risk and uncertainties associated with this task are that the expected optimization may not be achieved, resulting in delays and additional program costs. For this reason, contingency must be included to mitigate the consequences of the expected inefficiencies inherent in this complex activity, along with related concerns associated with specialty tooling modifications and repairs, field changes, discontinuities in the coordination of plant services, system failure, water clarity, lighting, computer-controlled cutting software

corrections, etc. Experience in decommissioning other plants in the past has shown that many of these problem areas have occurred during, and in support of, the segmentation process. Contingency dollars are an integral part of the total cost to complete this task. Exclusion of this component puts at risk a successful completion of the intended tasks and, potentially, subsequent related activities.

The following list is a composite of some of the activities, assembled from past decommissioning programs, in which contingency dollars were needed to respond to, compensate for, and/or provide adequate funding of decontamination and dismantling tasks:

Incomplete or Changed Conditions:

- Unavailable/incomplete operational history that led to a recontamination of a work area, because a sealed cubicle (incorrectly identified as being non-contaminated) was breached without controls.
- Surface coatings covering contamination that, due to an incomplete characterization, required additional cost and time to remediate.
- Additional decontamination, controlled removal, and disposition of previously undetected (although at some sites, suspected) contamination due to access gained to formerly inaccessible areas and components.

Adverse Working Conditions:

- Lower than expected productivity due to high temperature environments, resulting in a change in the working hours (shifting to cooler periods of the day) and additional manpower.
- Confined space, low-oxygen environments where supplied air was necessary and additional safety precautions prolonged the time required to perform required tasks.

Maintenance, Repairs and Modifications

- Facility refurbishment required to support site operations, including those needed to provide new site services, as well as to maintain the integrity of existing structures.

- Damage control, repair, and maintenance from bird nestings and their fouling of equipment and controls.
- Building modification, i.e., re-supporting of floors to enhance loading capacity for heavily shielded casks.
- Roadway upgrades on site to handle heavier and wider loads; roadway rerouting, excavation, and reconstruction.
- Requests for additional safety margins by a vendor.
- Requests to analyze accident scenarios beyond those defined by the removal scenario (requested by the NRC to comply with “total scope of regulation”).
- Additional collection of site runoff and processing of such due to disturbance of natural site contours and drainage.
- Concrete coring for removal of embedments and internal conduit, piping, and other potentially contaminated material not originally identified as being contaminated.
- Modifications required to respond to higher than expected worker exposure, water clarity, water disassociation, and hydrogen generation from high temperature cutting operations.
- Additional waste containers needed to accommodate cutting particulates (fines), inefficient waste geometries, and excess material.

Labor

- Turnover of personnel, e.g., craft and health physics. Replacement of labor is costly, involving additional training, badging, medical exams, and associated processing procedures. Recruitment costs are incurred for more experienced personnel and can include relocation and living expense compensation.
- Additional personnel required to comply with NRC mandates and requests.

- Replacement of personnel due to non-qualification and/or incomplete certification (e.g., welders).

Schedule

- Schedule slippage due to a conflict in required resources, i.e., the licensee was forced into a delay until prior (non-licensee) commitments of outside resources were resolved.
- Rejection of material by NRC inspectors, requiring refabrication and causing program delays in activities required to be completed prior to decommissioning operations.

Weather

- Weather-related delays in the construction of facilities required to support site operations (with compensation for delayed mobilization made to vendor).

The cost model incorporates considerations for items such as those described above, generating contingency dollars (at varying percentages of total line-item cost) with every activity. The purpose of the contingency is to allow for the costs of high probability program problems occurring in the field where the occurrence, duration, and severity cannot be accurately predicted, and so their associated costs have not been included in the basic estimate. Past decommissioning experience has shown that unforeseeable elements of cost are almost certain to occur in the field and may have a cumulative impact. In the study for the Wolf Creek Generating Station, TLG examined the major activity-related problems (decontamination, segmentation, equipment handling, packaging, transport, and waste disposal) that necessitate a contingency. Individual activity contingencies ranged from 10% to 75%, depending on the degree of difficulty judged to be appropriate from TLG's actual decommissioning experience. The contingency values used in this study are as follows.

Decontamination	50%
Contaminated Component Removal	25%
Contaminated Component Packaging	10%
Contaminated Component Transport	15%
Low-Level Radioactive Waste Disposal	25%

Reactor Segmentation	75%
NSSS Component Removal	25%
Reactor Waste Packaging	25%
Reactor Waste Transport	25%
Reactor Vessel Component Disposal	50%
Non-Radioactive Component Removal	15%
Heavy Equipment and Tooling	15%
Supplies	25%
Engineering	15%
Energy	15%
License Termination Survey	30%
Construction	15%
Fees	10%
Insurance	10%
Taxes (Property)	10%
Staffing	15%

The overall contingency, when applied to the appropriate components of the estimate on a line item basis, results in averages of approximately 18-21% for the three decommissioning alternatives.

3.3.2 Financial Risk

Financial risk refers to the possibility and associated probabilities of certain events occurring that could increase or decrease costs for decommissioning.

Included within the category of financial risk are:

- Transition activities and costs: ancillary expenses associated with eliminating 50% to 80% of the site labor force shortly after the cessation of plant operations, added cost for worker separation packages throughout the decommissioning program, state- 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, state and local hearings, etc.

- 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), or variations in plant inventory, or configuration not indicated by the as-built drawings.
- Regulatory changes, e.g., affecting worker health and safety, site release criteria, waste transportation, and disposal.
- Policy decisions altering federal and state commitments, e.g., in the ability to accommodate certain waste forms for disposition, or in the timetable for such.
- Pricing changes for basic inputs, such as labor, energy, materials, and burial. Some of these inputs may vary slightly (e.g.; -10% to +20%); burial could vary from -50% to +200% or more.

It has been TLG's experience that the results of a risk analysis, when compared with the base case estimate for decommissioning, indicate that the chances of the base decommissioning estimate's being too high is a low probability, and the chances that the estimate is too low is a much higher probability. This is mostly due to the pricing uncertainty for low-level radioactive waste burial, and to a lesser extent due to schedule increases from changes in plant conditions and to pricing variations in the cost of labor (both craft and staff). TLG did not perform a risk analysis for this study and therefore the estimates in this report do not include any increase as a result of any risk analysis performed for WCNO or any other TLG client.

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 Disposition

The last core off-load of used fuel will be stored in the spent fuel pool for approximately five years after the cessation of plant operations. The

spent fuel caretaking costs include storage pool maintenance, security, and associated operating expenses. The decommissioning scenario has been constructed to minimize the restraints imposed by continued spent fuel storage and shipment. The spent fuel assemblies stored in the spent fuel pool will be transferred to the DOE, in accordance with the existing contract within approximately five years from the cessation of plant operations. Once the pool is emptied, the spent fuel storage and handling facilities are available for decommissioning.

3.4.2 Reactor Vessel and Internal Components

The reactor pressure vessel and reactor internal components are segmented for disposal in shielded transportation casks. Segmentation and packaging of the internals' packages are performed in the refueling canal where a turntable and remote cutter will be 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 Department of Transportation (DOT) regulations dictate segmentation and packaging methodology. All packages must meet the current physical and radiological limitations and regulations. Cask shipments will be made in DOT-approved, currently available, truck casks.

The dismantling of reactor internals will generate radioactive waste generally unsuitable for shallow land disposal (GTCC). Although the material is not classified as high-level waste, the DOE has indicated it will accept title to this waste for disposal at the future high-level waste repository. However, the DOE has not yet established an acceptance criteria or a disposition schedule for this material, and numerous questions remain as to the ultimate disposal cost and waste form requirements. As such, for purposes of this study, the GTCC waste has been packaged and disposed of as high-level waste, at a cost equivalent to that envisioned for the spent fuel.

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 due to several contributing factors, as discussed below.

The concept of intact disposal is not new. The DOE had shipped the Shippingport reactor as an integrated package from the plant site in

western Pennsylvania by barge to Washington State for disposal. In addition, the controls, methods, and techniques proposed by PGE for transport of the reactor vessel were similar to those used by US Navy for reactor compartment shipments. The logistics had also been demonstrated in the disposition of the Trojan steam generators and pressurizer, which followed the same route. The location of the Trojan Nuclear Plant 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 nature 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 Wolf Creek Generating Station ceases operation. Future viability of this option will depend upon the ultimate location of the disposal site, as well as, the site licensee's ability to accept highly radioactive packages and effectively isolate them from the environment.

3.4.3 Steam Generators and Other Large System Components

The following discussion deals with the one-piece removal and disposition of the steam generators, but the techniques involved are also applicable to other large components, such as heat exchangers and component coolers. The steam generators' size and weight, as well as their configuration and limited access in the Reactor Building itself, place constraints on the intact removal of these components. Determination of the removal strategy requires several different considerations, including 1) rigging and modifications to the Reactor Building to maneuver and extract the generators from the structure, and 2) the component preparations needed to transport the generators to a disposal site.

The generators will be rigged for removal, disconnected from the surrounding piping and supports, and maneuvered into the open area where they will be lowered onto a dolly. The dolly will allow the lower end of the steam generator to rotate through the equipment hatch opening as it is being lowered. Once the steam generator has been lowered to the horizontal position, nozzles and other openings will be welded closed, and it will be filled with low-density cellular concrete for stabilization of the internal contamination and to satisfy burial ground packaging requirements. When this stage has been completed, the generator will be rigged out of the building and transferred to a multi-wheeled transporter and moved to an on-site steam generator processing area. The final package preparation includes the welding of steel shielding plates to the outside surface to meet DOT transportation regulations, if required. The generators will be loaded onto a heavy-duty flatcar for rail transport to the regional burial facility.

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

3.4.4 Transportation Methods

For the purposes of the cost estimate, it was assumed that the low-level radioactive waste produced in the decontamination and dismantling of the nuclear unit will be moved overland by truck, shielded van, railcar and/or multi-wheeled transporter. Transport costs for material requiring controlled disposal assumed a regional disposal site approximately 700 miles from the plant site as the final destination.

3.4.5 Low-Level Radioactive Waste Disposal

The plant components, equipment, and structural material removed, as well as the debris generated in the decontamination and dismantling of the Wolf Creek Generating Station will be characterized prior to disposal. For purposes of this estimate, material requiring controlled disposal is assumed to be routed to a licensed facility located within the central state region. The rate schedule for the currently operating Barnwell facility is used as a proxy for a regional site. Its rates are comparable with disposal projections for proposed facilities.

The rate structure at the Barnwell facility is based upon the density of the packaged waste. An average density of the waste stream, generated from the decontamination and dismantling of the Wolf Creek Generating Station, was estimated from the plant components and structural materials inventoried, and the packaging configurations used for controlled disposal. The average packaged density of the Wolf Creek Generating Station waste stream is approximately 87 pounds per cubic foot. At a unit disposal rate of \$4.84 per pound, this equates to a volumetric charge of \$421.08 per cubic foot. This value was used to estimate the cost of disposal of the Wolf Creek Generating Station decommissioning waste stream.

3.4.6 Site Conditions Following Decommissioning

A final radiation survey will be conducted to ensure that all radioactive materials in excess of permissible residual levels have been remediated in accordance with "Radiological Criteria for License Termination," 62 Federal Register 39058, July 21, 1997. This survey may coincide with final NRC site inspection.

The NRC will terminate the 10 CFR §50 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 typically will end at this point. Local building codes, state environmental regulations, and the Owner's own future plans for the site will dictate the next step in the decommissioning process. TLG assumed the total removal of all plant systems and all non-essential above-grade structures from the site. These non-radiological costs are included in the total cost of decommissioning.

3.5 ASSUMPTIONS

The following are the major assumptions made in the development of the cost estimates for decommissioning the Wolf Creek Generating Station.

3.5.1 Estimating Basis

1. The estimate is performed in accordance with the methodology described in the AIF/NESP-036 study and the assumptions delineated in the previous 1993 study unless otherwise noted.

2. Decommissioning costs are reported in the year of projected expenditure; however, the values are provided in 1999 dollars for the current estimate. Costs are not inflated or escalated over the period of performance.

3.5.2 Labor Costs

1. WCNOC will continue to provide site operations support, including decommissioning program management, licensing, radiological protection, and site security. The supervisory staff needed to oversee the labor subcontractors, consultants, and specialty contractors relied upon to perform the work envisioned in the decontamination and dismantling effort will be subcontracted.
2. Utility staffing requirements will vary with the level of effort associated with the various phases of the project. Once the decommissioning program commences, the operations staff will be reduced to only those staff positions necessary to support the decommissioning program.
3. The staffing levels assumed in this estimate reflect the management provisions experienced at other decommissioning projects recently completed and currently underway.
4. A Decommissioning Operations Contractor (DOC) will be hired to provide contract management of the decommissioning labor force and to subcontract such engineering services as activity specifications, detailed procedures, detailed activation analyses, structural modifications, etc.
5. The craft labor required to decontaminate and dismantle the nuclear unit will be acquired through standard site contracting practices. Representative salary and craft labor rates for site administration, operations, construction, and maintenance personnel were used as a cost basis.

3.5.3 Design Conditions

1. 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., cesium-137, strontium-90, or transuranics) has been

prevented from reaching levels exceeding those that permit the major NSSS components to be shipped under current DOT regulations and to be buried within the requirements of 10 CFR §61.

2. The estimated curie contents of the vessel and internal components were derived from those listed in NUREG/CR-3474.^[11] Actual estimates were derived from the curie/gram values in NUREG/CR-3474 and adjusted for the different mass of the Wolf Creek Generating Station components, operating life, and periods of decay. Additional short-lived isotopes were derived from NUREG/CR-0130 ^[12] and NUREG/CR-0672 ^[13] and benchmarked to the long-lived values from NUREG/CR-3474.

3.5.4 Waste Processing and Disposal

1. The disposal costs for the reactor pressure vessel and internals are based on remote in-place segmentation, packaging in casks with shielding, and shipping by truck to the burial ground. A maximum normal road weight limit of 80,000 pounds is assumed for all truck shipments, including cask shipments. This includes vessel segment(s), supplementary shielding, cask tie-downs, and tractor trailer. The maximum curies per shipment assumed permissible are based upon the license limits of available shielded shipping casks. The number and curie content of vessel segments are selected to meet these limits.
2. This study estimates that there will be some radioactive waste generated which is greater than 10 CFR §61 Class C quantities, resulting from disposal of the highly activated sections of the reactor vessel internals. This waste will most likely be disposed of as high-level waste in the DOE's deep geological repository unless an alternative solution is approved by the NRC. The cost of disposal, unlike that for the spent fuel, is not covered by the DOE's 1 mill/kWhr surcharge and has been estimated from equivalent disposal costs for spent nuclear fuel.
3. Compactible dry active waste, such as booties, glove liners, respirator filter cartridges, shipping containers, radiological controls, survey materials, etc. are assumed to be drummed and compacted to 10% of their original volume.

4. Material requiring controlled disposal is assumed to be routed to a regional disposal site at a distance of approximately 700 miles from the plant site.

3.5.5 Transportation

1. Contaminated piping, components, and structural material other than the highly activated reactor vessel and internal components will qualify as LSA-I, LSA-II or LSA-III or Surface Contaminated Object, SCO-I or SCO-II, as described in Title 49 of the Code of Federal Regulations.^[14] The contaminated materials will be packaged in Industrial Packages (IP-I, IP-II, or IP-III) for transport unless demonstrated to qualify as their own shipping containers. The reactor vessel and internal components are expected to be transported as Type B, in accordance with 10 CFR §71. It is conceivable that the reactor, due to its limited specific activity, could qualify as LSA-II or LSA-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.
2. Truck transport assumes a maximum normal road weight limit of 80,000 pounds for all shipments, with the exception of the overweight shielded casks. Rates for shipping radioactive wastes are provided by Tri-State Motor Transit in published tariffs for this cargo.^[15]
3. Transport of 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 number of curies per shipment assumed permissible is based upon the license limits of available shielded shipping casks. The number and curie content of vessel and internal segments are selected to meet these limits.
4. The number of cask shipments out of the Reactor Building is expected to average three every two weeks. Non-cask shipments will be limited to three per week.

3.5.6 Spent Fuel

1. For the basis of this cost study, the DOE is assumed to begin accepting commercial spent fuel at its geologic repository in 2010. With the exception of the final core discharge, the majority of spent fuel generated from plant operations is assumed to be transferred to a DOE facility prior to the cessation of operations in 2025.
2. The residual inventory of spent fuel assemblies, including the final core discharge, will be transferred to a DOE facility within approximately five years following the cessation of plant operations, i.e., by the end of year 2030.

3.5.7 General

1. The existing plant equipment is considered obsolete and suitable for scrap as deadweight quantities only. WCNOG will make economically reasonable efforts to salvage equipment following final plant shutdown. This estimate does not attempt to quantify the value that WCNOG may realize based upon those efforts.
2. Scrap generated during decommissioning is not included as a salvage credit line item in this study. It is difficult to estimate the potential salvage value of a decommissioned nuclear power plant for the following reasons:
 - The acceptability of nuclear plant equipment to potential salvage equipment buyers is highly speculative, regardless of the ability to free release this material.
 - Much of the equipment at a nuclear plant, especially from older units, is too specific to that plant to be of use to potential salvage buyers.
 - The cost for removal of equipment to a configuration that is attractive to a salvage dealer is variable. Dismantling techniques assumed for equipment by TLG for this estimate are not consistent with removal techniques required for salvage (resale) of equipment. Yankee Rowe experience 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.

For these reasons, it has generally been considered that the salvage value inherent in free-releasable nuclear plant equipment is sufficient to pay for the cost of removing of this equipment from the site, (i.e., clean equipment that has been removed from its installed location and placed in a laydown area is considered to be removed from the site at no additional charge by salvage dealers). This assumption is an implicit recognition of scrap value in the disposal of clean metallic waste at no cost to the project.

3. For estimating purposes, non-essential plant systems are assumed to be de-energized. Off site electrical power will be provided to support decommissioning operations.
4. Current plant staffing will remove all items of furniture, tools, mobile equipment (such as forklifts, trucks, bulldozers, and other similar mobile equipment), and other such items of personal property owned by WCNOG that will be easily removed without the use of special equipment at no cost or credit to the project.
5. Existing warehouses will be cleared out of non-essential material and remain for use by WCNOG and its subcontractors. The warehouses may be dismantled as they become unnecessary to the decommissioning program.
6. Current WCNOG staffing perform the following activities at no cost or credit to the project during the first six months of the planning period:
 - Fuel oil tanks will be emptied; tanks will be cleaned by flushing or steam cleaning as required prior to disposal.
 - Acid and caustic tanks will be emptied.
 - Lubricating and transformer oils will be drained and removed from site by a waste disposal vendor.
7. The decommissioning activities will be performed in accordance with the current regulations assumed to be in place at the time of

decommissioning. Changes in current regulations may have a cost impact on decommissioning.

8. Material and equipment costs for conventional demolition and/or construction activities were taken from R.S. Means Construction Cost Data.
9. ALARA planning is considered in the costs for engineering and planning, and in the development of activity specifications and detailed procedures. Changes to 10 CFR §20 worker exposure limits may impact the decommissioning cost and project schedule. The study follows the principles of ALARA through the use of work duration adjustment factors, which incorporate such items as radiological protection instruction, mock-up training, and the use of respiratory protection and personnel protective clothing. These items lengthen a task's duration, which increases the costs and lengthens the overall schedule.
10. The premiums for nuclear liability and property insurance are phased out upon the final decontamination of the site and the termination of the 10 CFR §50 license. Costs for continuing coverage during the decommissioning period are based upon current operating premiums and the status of the spent fuel.
11. Property tax payments will continue throughout decommissioning.
12. The perimeter fence and in-plant security barriers will be moved as appropriate to conform with the Security Plan in force during the various stages in the project.
13. Identified site structures will be removed while their non-contaminated subgrade foundations remain in place. Holes will be drilled in each of the foundation basemats to allow for natural drainage. Building foundations will be backfilled and the site will be graded such that the site will have a final contour consistent with adjacent surroundings.
14. Piping and electrical manholes, as well as vertical pump structures and sumps, will be backfilled with a suitable earthen material and abandoned. Culverts, head walls and stone rip-rap will remain in place to allow natural drainage.

15. The existing electrical switchyard and the transmission towers will remain after decommissioning in support of the utility's electrical transmission and distribution system. Other structures that will remain are the Main Dam, cooling lake, Makeup Water Discharge Structure (west side of lake), and the Eisenhower Learning Center.
16. Road and parking areas with asphalt or concrete surfacing will be broken up and the material used as backfill on site. Road and parking area base material will remain in place. All gravel road and parking areas remain in place and the area will be covered with fill.
17. Non-contaminated underground piping (except the service water and circulating water piping) will be abandoned without special considerations. Accessible circulating and service water piping will be removed/collapsed and backfilled to eliminate the potential for collapse after the site is released for unrestricted access.
18. No significant quantities of asbestos, industrial solvents, chromated water, lead, or mercury are expected to be present on site at the time of decommissioning.

3.6 COST ESTIMATE SUMMARY

Summaries of the decommissioning costs and annual expenditures are provided in Tables 3.1, 3.2, and 3.3. The schedules are based upon the costs reported in Appendix C. The following should be considered when reviewing these tables:

- "Decon" as used in the headings of these tables, refers to decontamination activities, as opposed to the NRC term DECON, which refers to the prompt removal decommissioning scenario.
- "Total" as used in the headings of these tables, is the sum of Decon, Remove, Pack, Ship, Bury, and Contingency, as well as other miscellaneous items not listed (such as engineering and preparations).
- The subtotal reported for the major cost categories does not include contingency, which is reported in a separate column.

- “Other” includes different types of costs that are not easily categorized. In most of the engineering preparatory activities the “Other” cost is strictly engineering labor; however, “Other” also includes taxes, insurance, energy, and regulatory fees.

TABLE 3.1
SCHEDULE OF ANNUAL DECON EXPENDITURES
(1999 dollars)

Year	Period			Totals
	1 Planning	2 Decommissioning	3 Site Restoration	
2025	31,315,579			31,315,579
2026	29,262,351	23,852,503		53,114,854
2027		76,950,359		76,950,359
2028		75,982,091		75,982,091
2029		74,624,044		74,624,044
2030		74,758,759		74,758,759
2031		33,542,057		33,542,057
2032		657,550	19,779,697	20,437,247
2033			21,418,665	21,418,665
2034			5,046,589	5,046,589
	60,577,930	360,367,364	46,244,951	467,190,245

TABLE 3.2
SCHEDULE OF ANNUAL SAFSTOR EXPENDITURES
(1999 dollars)

Year	Period 1 Preparations	Period 2 Dormancy	Period 3 Preparations	Period 4 Decommissioning	Period 5 Site Restoration	Totals
2025	21,772,478					21,772,478
2026	18,522,862	2,211,405				20,734,267
2027-2078		143,734,743				143,734,743
2079		803,201	20,757,665			21,560,866
2080			29,274,865	14,586,656		43,861,521
2081				83,189,522		83,189,522
2082				82,430,997		82,430,997
2083				81,403,317		81,403,317
2084				43,462,986		43,462,986
2085				1,592,586	17,577,772	19,170,358
2086					21,631,445	21,631,445
2087					7,491,313	7,491,313
	40,295,340	146,749,350	50,032,530	306,666,065	46,700,530	590,443,815

TABLE 3.3
SCHEDULE OF ANNUAL ENTOMBMENT EXPENDITURES
(1999 DOLLARS)

Year	Period 1 Preparations	Period 2 Entombment	Period 3 Dormancy	Period 4 Preparations	Period 5 Decommissioning	Period 6 Site Restoration	Totals
2025	26,906,667						26,906,667
2026	25,512,423	14,390,675					39,903,097
2027		46,431,790					46,431,790
2028		46,559,001					46,559,001
2029		46,431,790					46,431,790
2030		46,566,113					46,566,113
2031		18,066,731	1,158,534				19,225,265
2032-2078			99,774,972				99,774,972
2079			1,872,197	2,917,073			4,789,270
2080				28,711,192			28,711,192
2081				11,797,685	40,515,799		52,313,484
2082					65,434,809		65,434,809
2083					64,040,101		64,040,101
2084					35,655,972		35,655,972
2085					1,592,543	17,580,467	19,173,009
2086						21,634,762	21,634,762
2087						7,492,462	7,492,462
	52,419,090	218,446,100	102,805,703	43,425,950	207,239,223	46,707,690	671,043,756

4. SCHEDULE ESTIMATE

The schedule for the decommissioning scenarios considered in this study follows the sequence presented in the AIF/NESP-036 study, with minor changes to reflect recent experience and site-specific constraints. In addition, the scheduling has been revised to reflect the spent fuel turnover (to the DOE) requirements at shutdown.

Figure 4.1 presents a schedule for the DECON decommissioning alternative; the assumptions supporting this schedule are listed in Section 4.1. The key activities listed in the schedule do not reflect a one-to-one correspondence with those activities in the Appendix C cost table, but reflect dividing some activities for clarity and combining others for convenience. The schedule was prepared using the "Microsoft Project 98" computer software. [16]

4.1 SCHEDULE ESTIMATE ASSUMPTIONS

The schedule estimate 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 durations used in the precedence network reflect the actual man-hour estimates from the cost table in Appendix C, 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.

- All work except vessel and internals removal activities is performed during an 8-hour workday, 5 days per week with no overtime. There are eleven paid holidays per year.
- The Fuel Building will continue to serve as the spent fuel storage/transfer facility until such time that all spent fuel has been removed from site. The Fuel Building is expected to operate for approximately five years after the cessation of operations.
- Reactor and internals removal activities are performed by using separate crews for different activities working on different shifts, with a corresponding backshift charge for the second shift.
- Multiple crews work parallel activities to the maximum extent possible, consistent with optimum efficiency, adequate access for cutting, removal and laydown space, and with the stringent safety measures necessary during demolition of heavy components and structures.

- For plant systems removal, the systems with the longest removal durations in areas on the critical path are considered to determine the duration of the activity.
- A period of 3 months is allowed to complete final site survey activities followed by a 6-month duration allowing for completion of the NRC review process.

4.2 PROJECT SCHEDULE

The period-dependent costs presented in Appendix C are based upon the durations developed in the schedule for each decommissioning alternative. 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 was used as the basis for determining the period-dependent costs.

Project timelines for the DECON, SAFSTOR and ENTOMB alternatives are shown in this section as Figure 4.2. Milestone dates are based on a 40-year plant operating life from the issuance of the operating license, a five-year wet storage period for the last core discharge, and a maximum deferral of sixty years for license termination (SAFSTOR and ENTOMB) and final site release.

FIGURE 4.1

DECON ACTIVITY SCHEDULE

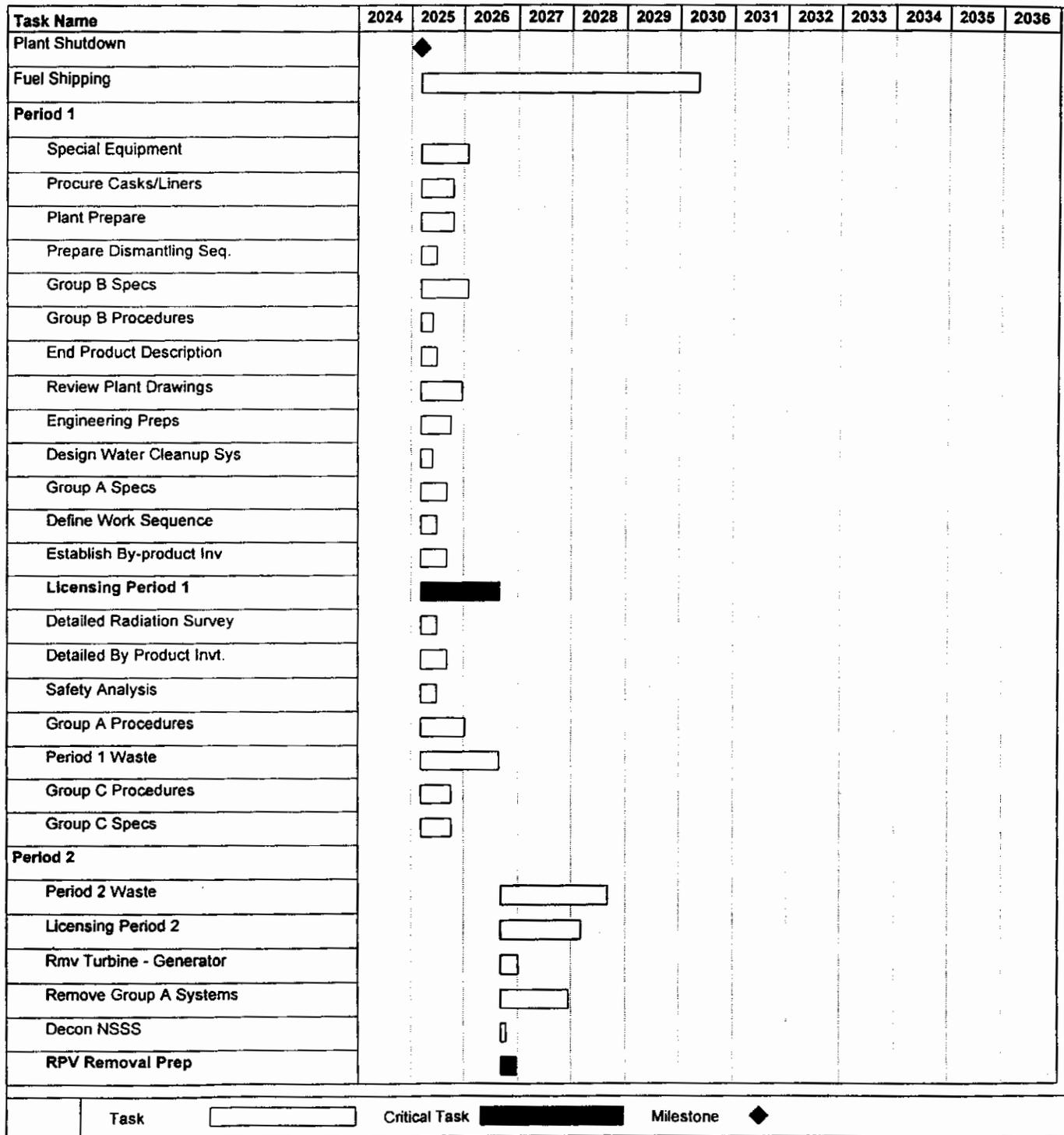


FIGURE 4.1
DECON ACTIVITY SCHEDULE
(continued)

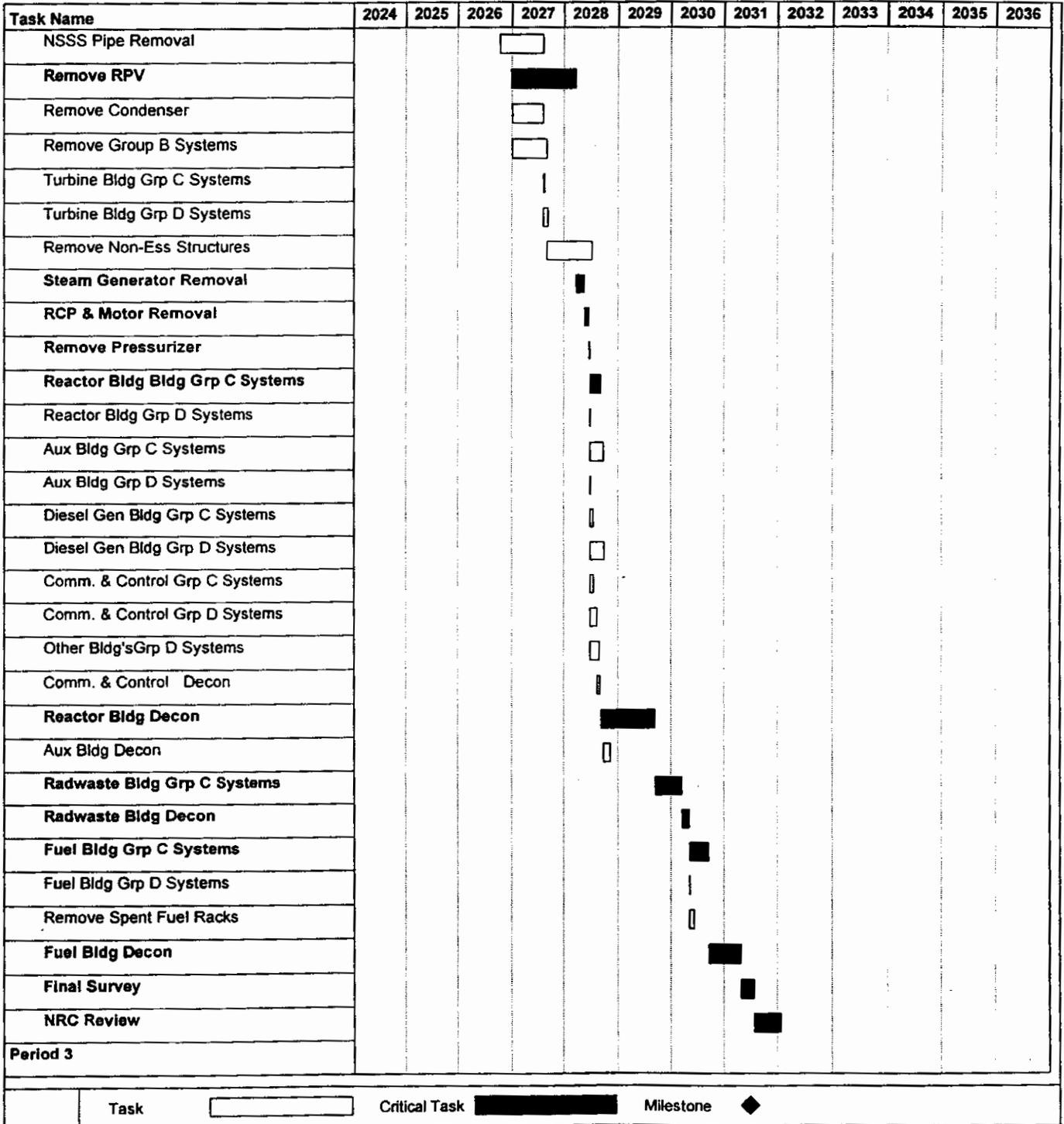


FIGURE 4.1
DECON ACTIVITY SCHEDULE
(continued)

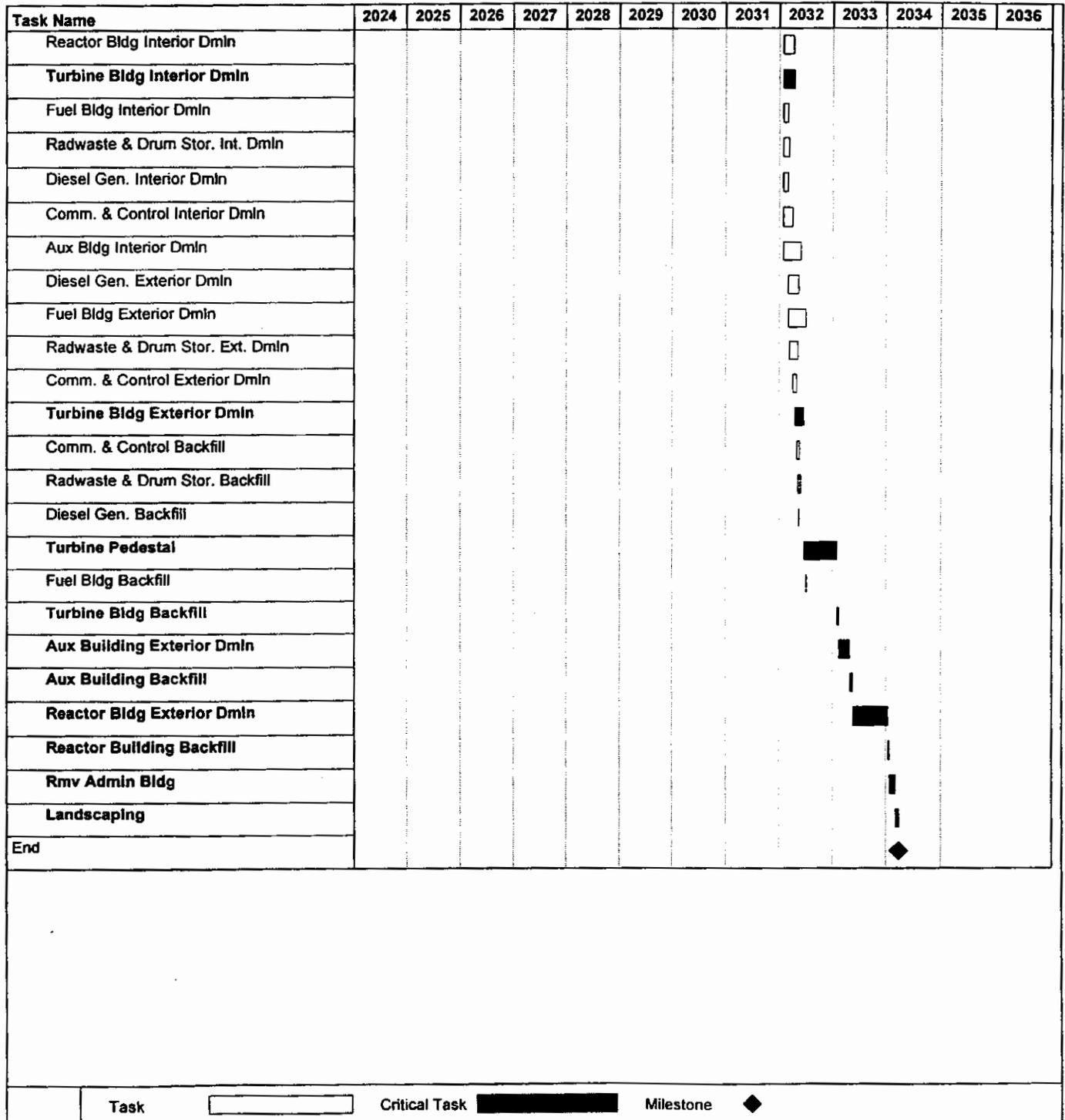
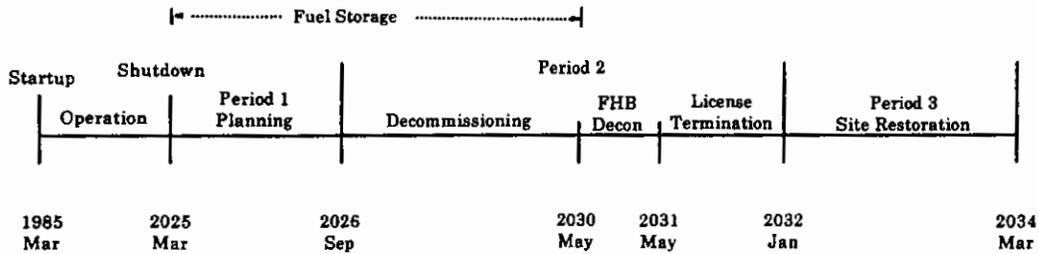
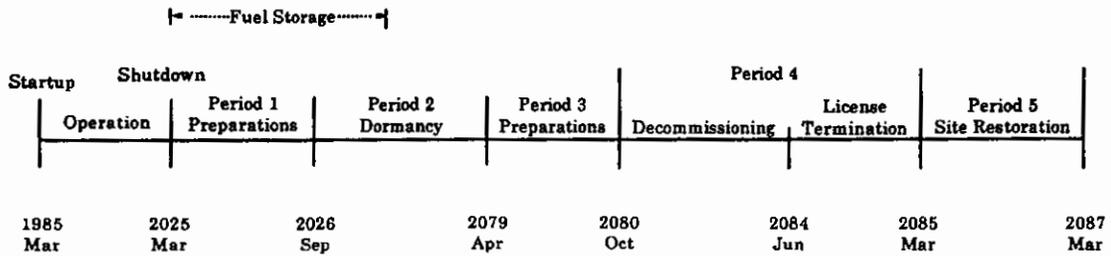


FIGURE 4.2
DECOMMISSIONING TIMELINES

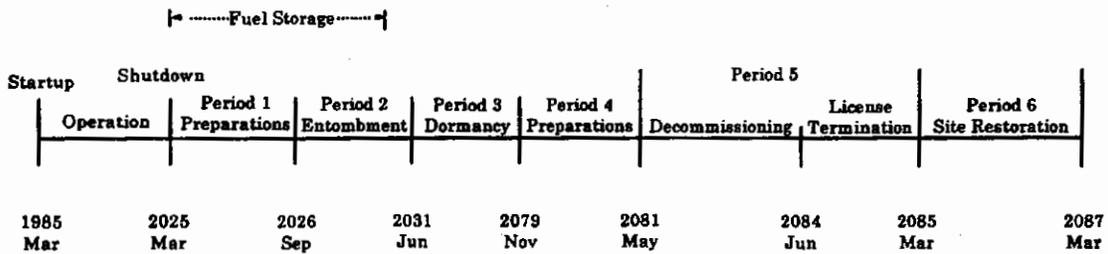
DECON



SAFSTOR



ENTOMB



NOT TO SCALE

5. RADIOACTIVE WASTES

The goal of the decommissioning program is the removal of all radioactive material from the site that would restrict its future use, and termination of the NRC license for the site. This currently requires the remediation of all radioactive material at the site in excess of applicable legal limits. Under the Atomic Energy Act,^[17] 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, 10 CFR §61 controls the burial of low-level radioactive material and 10 CFR §71 defines radioactive material.

The volumes of radioactive waste generated during the various decommissioning activities at the site are shown on a line-item basis in Appendix C and summarized in Table 5.1. The quantified waste volume summaries shown in Table 5.1 are consistent with 10 CFR §61 classifications. The volumes are calculated based on the gross container dimensions; for those components serving as their own waste container, (i.e., steam generators and pressurizer) the volume is calculated based upon the displaced volume of the component.

Most of the materials being transported for controlled burial are categorized as Low Specific Activity (LSA) or Surface Contaminated Objects (SCO) materials containing Type A quantities, as defined in 49 CFR §173-178. Shipping containers are required to be Industrial Packages (IP-1 or IP-2). 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, penetrations, etc.

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. The steam generators are presumed to be shipped intact for disposal.

No process system that contains/handles radioactive substances at shutdown is presumed to meet material release criteria by decay alone, i.e., systems radioactive at shutdown will still be radioactive in a deferred decommissioning alternative due to the presence of long-lived radionuclides. While the dose rates decrease with time, radionuclides such as ¹³⁷Cs will still control the disposition requirements.

The waste volume generated in the decontamination and dismantling of the Wolf Creek Generating Station is primarily generated during Period 2 of DECON and Period 4 of SAFSTOR and Periods 2 & 5 of ENTOMB. Contaminated and activated material will be characterized on site. Components with low levels of removable surface contamination will be decontaminated on site to the maximum extent possible. Heavily contaminated components and activated materials are generally routed for controlled disposal after on-site volume reduction.

The low-level radioactive waste generated in the decontamination and dismantling of the Wolf Creek Generating Station will be characterized prior to disposal. Material requiring controlled disposal including contaminated concrete rubble and dry active waste (DAW), will be transported to a regional low-level waste burial facility.

TABLE 5.1

DECOMMISSIONING RADIOACTIVE WASTE BURIAL SUMMARY

	Waste Class ¹	Volume (Cubic feet)
DECON ALTERNATIVE		
	A	208,647
	B	13,880
	C	884
	>C	649
Total		224,060
SAFSTOR ALTERNATIVE		
	A	215,314
	B	5,997
	C	884
	>C	649
Total		222,844
ENTOMB ALTERNATIVE		
	A	216,644
	B	9,458
	C	884
	>C	649
Total		227,635

¹ Waste is classified according to the requirements as delineated in Title 10 of the Code of Federal Regulations, Part 61.55

6. RESULTS

The projected costs to decommission the Wolf Creek Generating Station, presuming the use of the DECON alternative, including the five-year operation of the Fuel Building as an interim wet fuel storage facility, and the restoration of the site is estimated to be \$467.2 million in 1999 dollars. SAFSTOR and ENTOMB costs are \$590.4 million and \$671.0 million, respectively. The costs reflect the site-specific features of the Wolf Generating Creek Generating Station, the local cost of labor, the DOE's schedule for spent fuel receipt, and a projected cost for low-level radioactive waste disposal. An analysis of the major activities contributing to the total cost for the DECON, SAFSTOR and ENTOMB decommissioning alternatives is provided in Tables 6.1, 6.2 and 6.3, respectively. Appendix C contains a detailed list of costs by "activity description" for each decommissioning alternative.

Staffing, including management and utility transition expenses, security and health physics combine with the removal labor cost to represent the majority of the cost to decommission a nuclear station. This is a direct result of the labor-intensive nature of the decommissioning process, as well as the management controls required to ensure a safe and successful program. Low-level radioactive waste disposal (burial) represents the next largest cost component. Packaging and transportation costs are most sensitive to the waste volume generated in the decontamination and dismantling process, the volume reduction achieved, transport regulations for low-level radioactive waste, as well as the final destination (i.e., distance to the disposal site). "Other" costs include property taxes, engineering costs, energy, insurance and fees.

In most situations, the DECON alternative is the preferred mode of decommissioning. This alternative is favored because it eliminates the costs for care taking and prevents the site from becoming a potential long-term safety hazard. More importantly, the individuals familiar with the operation of the nuclear facility are available to support the dismantling effort, plant systems and services are fully functional, structural integrity is intact, and the licensee has a comprehensive management organization available to oversee/conduct the orderly decontamination and termination of the NRC licenses for the site. The DECON alternative is a valid and cost-effective option; it is also the least expensive option prior to any time value of money calculations.

Although deferred decommissioning alternatives do have some advantages, the construction of barriers and the general decontamination of plant areas in preparation of long-term storage does not alleviate the need for continued surveillance nor substantially lessen the potential of an uncontrolled release of

radioactivity to the environment. Active ventilation of contaminated areas is the only assurance that radionuclide releases are monitored, contained and treated. The structural integrity of facilities will need to be maintained so as to support eventual decontamination and dismantling activities. Dehumidification will inhibit corrosion and debonding of materials within these structures. Continued operation of the plant's essential service systems counters the "advantages" offered by the deferred decommissioning scenarios. While remote surveillance is an option, it does not offer the immediate response time of a manned presence at a site. It is expected that a full-time preventive and corrective maintenance staff will be needed to maintain essential site services and address the deterioration of the site facilities.

The NRC has become increasingly concerned over the maintenance, or lack of maintenance, at shutdown facilities. As such, the decommissioning estimates for placing a facility in dormancy have become increasingly more costly. The commitment to maintain fuel storage support facilities at the site during the first five years following the cessation of plant operations is stipulated by DOE's transfer policy irrespective of the intended decommissioning plans for the facility. This will require the continued operation of several plant systems and a cognizant operations staff. Considerable progress in the decontamination and dismantling (of systems and facilities non-essential to spent fuel storage) can be made during the initial wet storage period in a program such as DECON. By comparison, at the conclusion of the transfer activity and the placement of the facility into safe-storage (SAFSTOR), the physical plant is relatively unchanged, deferring the cleanup and dismantling of the facility to a later time.

The care taking of a dormant facility has also become more costly. The NRC's review of current comparable facilities has resulted in a general increase in the level of maintenance required, as well as an increase in the on-site presence of the owners/operators of the sites. Currently, licensees are required to complete the decommissioning process (culminating in the termination of the NRC site licenses), within a period of 60 years. This translates into an available safe-storage period of approximately 50 years during which the owner/operator would continue to maintain the property, replace roofing, repair and upgrade surveillance and monitoring systems, lighting and communication equipment, rainwater collection, sampling and treatment equipment, etc. At the conclusion of this phase, release of the facility from the jurisdiction of the NRC will still require remediation of the property. The 50- to 60-year delay in decommissioning will not dramatically alter the cleanup requirements, i.e., the quantities of waste to be remediated will be comparable to those addressed in the DECON alternative. Although the radiation levels within the plant will have decreased substantially over the period of decay, the presence of long-lived radioisotopes will control the removal and disposal techniques used in the decontamination and dismantling of plant systems and facilities. As such, the cost

savings in postponing decommissioning are relatively small and the risk that regulatory and waste disposal requirements will become more restrictive, relatively high.

The commonality of the costs associated with the disposal of spent fuel for any of the decommissioning alternatives along with the required care taking of the site and relative minimal saving in deferred remediation costs has resulted in SAFSTOR and ENTOMB cost estimates exceeding those for a comparable DECON alternative (in the same year's dollars). The magnitude of the differential is dependent upon the length of the dormancy, care taking and other utility housekeeping costs, e.g., taxes, insurance and fees.

Due to the presence of long-lived radioisotopes at commercial nuclear reactors, ENTOMB is not generally considered a practical decommissioning option. The NRC has recognized the difficulties with the alternative and stated in the supplementary information to its decommissioning rule ^[1] that the "use of ENTOMB by a licensee would be carefully evaluated by the NRC according to the requirements of the rule before its use is permitted."

Typically, when the ENTOMB alternative is evaluated in funding comparisons, the duration of the program is limited (for consistency) to that permitted for SAFSTOR, i.e., 60 years, although durations up to 100 years could be considered by the NRC. However, the radioisotopes at commercial units exhibit some relatively long-lived elements such as Cesium-137, such that significant savings in the waste stream generated from decommissioning operations are not realized until much later.

The objective of the alternative (the decay of residual radioactivity to a level permitting unrestricted release of the property) can be met under certain conditions. The scenario constructed for ENTOMB of a commercial nuclear facility requires the removal, at a minimum, of the reactor vessel and internal components (due to their geologic decay periods), prior to the entombment activity. It also presumes that any and all contaminated material, outside of the designated entombment boundary will either be disposed of, or relocated, within the entombment boundary. Typically, this "boundary" is confined to the Reactor Building although multiple structures can be employed.

This study provides an estimate for decommissioning the site under current requirements based on present-day costs and available technology. Individual costs associated with decommissioning activities have increased at rates greater than that of general inflation. For example, there has been significant volatility in the issues and policies surrounding waste disposal, i.e., the access to and the cost of low-level radioactive waste disposal sites has been both unpredictable and has escalated at

rates historically greater than inflation (over the past ten years). The government's high-level waste program has experienced a series of delays that have impeded the prompt decommissioning of the commercial reactors retired to date. Waste disposal has become the primary driver in the escalation of decommissioning costs. It is therefore appropriate that this cost estimate be reviewed periodically.

TABLE 6.1
SUMMARY OF DECOMMISSIONING COST CONTRIBUTORS
DECON ALTERNATIVE

Work Category	Cost 99\$ (thousand)	Percent of Total Costs
Decontamination	12,327	2.6%
Removal	84,876	18.2%
Packaging	7,567	1.6%
Transportation	3,859	0.8%
Low-Level Radioactive Waste Burial	157,024	33.6%
Staffing	158,102	33.8%
Taxes	608	0.1%
Engineering	12,772	2.7%
Energy	10,124	2.2%
Insurance	2,211	0.5%
NRC and EP Fees	2,843	0.6%
Site Characterization	1,519	0.3%
License Termination Survey	8,729	1.9%
Miscellaneous Support Equip & Supplies	4,628	1.0%
Total	467,190	100.0%

* Column may not add due to rounding

TABLE 6.2

SUMMARY OF DECOMMISSIONING COST CONTRIBUTORS

SAFSTOR ALTERNATIVE

Work Category	Cost 99\$ (thousand)	Percent of Total Costs
Decontamination	9,604	1.6%
Removal	82,451	14.0%
Packaging	7,166	1.2%
Transportation	3,462	0.6%
Low-Level Radioactive Waste Burial	148,199	25.1%
Staffing	246,753	41.8%
Taxes	4,181	0.7%
Engineering	17,462	3.0%
Energy	16,389	2.8%
Insurance	9,507	1.6%
NRC and EP Fees	15,163	2.6%
Site Characterization	2,253	0.4%
License Termination Survey	8,729	1.5%
Miscellaneous Support Equip & Supplies	19,125	3.2%
Total	590,444	100.0%

* Column may not add due to rounding

TABLE 6.3

SUMMARY OF DECOMMISSIONING COST CONTRIBUTORS

ENTOMB ALTERNATIVE

Work Category	Cost 99\$ (thousand)	Percent of Total Costs
Decontamination	10,818	1.6%
Removal	89,150	13.3%
Packaging	7,776	1.2%
Transportation	3,653	0.5%
Low-Level Radioactive Waste Burial	150,708	22.5%
Staffing	321,904	48.0%
Taxes	4,181	0.6%
Engineering	20,898	3.1%
Energy	12,762	1.9%
Insurance	9,506	1.4%
NRC and EP Fees	15,558	2.3%
Site Characterization	2,135	0.3%
License Termination Survey	8,729	1.3%
Miscellaneous Support Equip & Supplies	13,268	2.0%
Total	671,044	100.0%

* Column may not add due to rounding

7. REFERENCES

1. 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+), June 27, 1988.
2. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.159, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors," August, 1990.
3. 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 (p39278+), July 29, 1996.
4. "Nuclear Waste Policy Act of 1982 and Amendments," U.S. Department of Energy's Office of Civilian Radioactive Management, 1982.
5. "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, January 15, 1986.
6. U.S. Code of Federal Regulations, Title 10, Part 20, Subpart E, "Radiological Criteria for License Termination", Federal Register, Volume 62, Number 139 (p39058t), July 21, 1997.
7. T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May, 1986.
8. W.J. Manion and T.S. LaGuardia, "Decommissioning Handbook," U.S. Department of Energy, DOE/EV/10128-1, November, 1980.
9. "Building Construction Cost Data 1999," Robert Snow Means Company, Inc., Kingston, Massachusetts.
10. Project and Cost Engineers' Handbook, Second Edition, p. 239, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York.
11. 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.

7. REFERENCES
(continued)

12. 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.
13. 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.
14. U.S. Department of Transportation, Section 49 of the Code of Federal Regulations, "Transportation," Parts 173 through 178, 1996.
15. Tri-State Motor Transit Company, published tariffs, Interstate Commerce Commission (ICC), Docket No. MC-109397 and Supplements, 1999.
16. "Microsoft Project 98", Microsoft Corporation, Redmond, WA, 1997.
17. "Atomic Energy Act" of 1954," (68 Stat. 919).

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 packing area.

2. CALCULATIONS

Act ID	Activity Description	Activity Duration	Critical Duration
<hr style="border-top: 1px dashed black;"/>			
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 in plastic, send to packing area	<u>60</u>	<u>60</u>
	Totals (Activity/Critical)	355	255
 Duration adjustment(s):			
	+ Respiratory protection adjustment (50% of critical duration)		128
	+ Radiation/ALARA adjustment (33.95833% of critical duration)		<u>87</u>
	Adjusted work duration		470
	+ Protective clothing adjustment (30% of adjusted duration)		<u>141</u>
	Productive work duration		611
	+ Work break adjustment (8.33 % of productive duration)		<u>51</u>
	Total work duration min		662 min

***** Total duration = 11.033 hr *****

**APPENDIX A
(continued)**

3. LABOR REQUIRED

Crew	Number	Duration (hr)	Rate (\$/hr)	Cost
Laborers	3.00	11.033	\$15.86	\$524.95
Craftsmen	2.00	11.033	\$26.43	\$583.20
Foreman	1.00	11.033	\$29.07	\$320.73
General Foreman	0.25	11.033	\$31.33	\$86.42
Fire Watch	0.05	11.033	\$15.86	\$8.75
Health Physics Technician	1.00	11.033	\$34.14	<u>\$376.67</u>
Total labor cost				\$1900.72

4. EQUIPMENT & CONSUMABLES COSTS

Equipment Costs	none
Consumables/Materials Costs	
-Blotting paper 50 @ \$0.36 sq ft {2}	\$18.00
-Plastic sheets/bags 50 @ \$0.08/sq ft {3}	\$4.00
-Gas torch consumables 1 @ \$6.21/hr x 1 hr {1}	<u>\$6.21</u>
Subtotal cost of equipment and materials	\$28.21
Overhead & profit on equipment and materials @ 14.900%	<u>\$4.20</u>
Total costs, equipment & material	\$32.41
TOTAL COST Removal of contaminated heat exchanger <3000 pounds:	\$1,933.13
Total labor cost:	\$1,900.72
Total equipment/material costs:	\$32.41
Total adjusted exposure man-hours incurred:	45.472
Total craft labor man-hours required per unit:	80.541

**APPENDIX A
(continued)**

5. NOTES AND REFERENCES

1. Durations are shown in minutes. The integrated duration accounts for those activities that can be performed in conjunction with other activities, indicated by the alpha designator of the concurrent activity. This results in an overall decrease in the sequenced duration.
2. Work difficulty factors were developed in conjunction with the AIF program to standardize decommissioning cost studies and are delineated in the "Guidelines" study (Vol. 1, Ch. 5).
3. Adjusted for regional material costs for Emporia, Kansas.
4. References:
 1. R.S. Means (1999) Division 016 Section 420-6360 pg 23
 2. McMaster-Carr Ed. 105
 3. R.S. Means (1999) Division 015 Section 602-0200 pg 17

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	0.19
Removal of clean pipe 0.25 to 2 inches diameter, \$/linear foot	2.40
Removal of clean pipe >2 to 4 inches diameter, \$/linear foot	2.93
Removal of clean pipe >4 to 8 inches diameter, \$/linear foot	5.98
Removal of clean pipe >8 to 14 inches diameter, \$/linear foot	11.25
Removal of clean pipe >14 to 20 inches diameter, \$/linear foot	14.63
Removal of clean pipe >20 to 36 inches diameter, \$/linear foot	21.53
Removal of clean pipe >36 inches diameter, \$/linear foot	25.57
Removal of clean valves >2 to 4 inches	30.45
Removal of clean valves >4 to 8 inches	59.84
Removal of clean valves >8 to 14 inches	112.51
Removal of clean valves >14 to 20 inches	146.33
Removal of clean valves >20 to 36 inches	215.28
Removal of clean valves >36 inches	255.74
Removal of clean pipe hangers for small bore piping	12.99
Removal of clean pipe hangers for large bore piping	44.59
Removal of clean pumps, <300 pound	99.84
Removal of clean pumps, 300-1000 pound	284.46
Removal of clean pumps, 1000-10,000 pound	1,119.14
Removal of clean pumps, >10,000 pound	2,157.27
Removal of clean pump motors, 300-1000 pound	120.24
Removal of clean pump motors, 1000-10,000 pound	467.03
Removal of clean pump motors, >10,000 pound	1,050.85
Removal of clean turbine-driven pumps < 10,000 pound	1,292.34
Removal of clean turbine-driven pumps > 10,000 pounds	2,886.12

**APPENDIX B
(continued)**

Unit Cost Factor	Cost/Unit(\$)
Removal of clean PWR turbine-generator	71,112.04
Removal of clean heat exchanger <3000 pound	605.68
Removal of clean heat exchanger >3000 pound	1,524.96
Removal of clean feedwater heater/deaerator	4,279.05
Removal of clean moisture separator/reheater	8,771.53
Removal of clean PWR main condenser	196,621.39
Removal of clean tanks, <300 gallons	129.96
Removal of clean tanks, 300-3000 gallon	409.58
Removal of clean tanks, >3000 gallons, \$/square foot surface area	3.52
Removal of clean electrical equipment, <300 pound	54.92
Removal of clean electrical equipment, 300-1000 pound	195.76
Removal of clean electrical equipment, 1000-10,000 pound	391.52
Removal of clean electrical equipment, >10,000 pound	947.57
Removal of clean electrical transformers < 30 tons	658.07
Removal of clean electrical transformers > 30 tons	1,895.13
Removal of clean standby diesel-generator, <100 kW	672.16
Removal of clean standby diesel-generator, 100 kW to 1 MW	1,500.30
Removal of clean standby diesel-generator, >1 MW	3,105.94
Removal of clean electrical cable tray, \$/linear foot	5.15
Removal of clean electrical conduit, \$/linear foot	2.25
Removal of clean mechanical equipment, <300 pound	54.92
Removal of clean mechanical equipment, 300-1000 pound	195.76
Removal of clean mechanical equipment, 1000-10,000 pound	391.52
Removal of clean mechanical equipment, >10,000 pound	947.57
Removal of clean HVAC equipment, <300 pound	54.92

APPENDIX B
(continued)

Unit Cost Factor	Cost/Unit(\$)
Removal of clean HVAC equipment, 300-1000 pound	195.76
Removal of clean HVAC equipment, 1000-10,000 pound	391.52
Removal of clean HVAC equipment, >10,000 pound	947.57
Removal of clean HVAC ductwork, \$/pound	0.41
Removal of contaminated instrument and sampling tubing, \$/linear foot	0.72
Removal of contaminated pipe 0.25 to 2 inches diameter, \$/linear foot	16.30
Removal of contaminated pipe >2 to 4 inches diameter, \$/linear foot	29.81
Removal of contaminated pipe >4 to 8 inches diameter, \$/linear foot	50.43
Removal of contaminated pipe >8 to 14 inches diameter, \$/linear foot	96.90
Removal of contaminated pipe >14 to 20 inches diameter, \$/linear foot	117.09
Removal of contaminated pipe >20 to 36 inches diameter, \$/linear foot	164.34
Removal of contaminated pipe >36 inches diameter, \$/linear foot	194.91
Removal of contaminated valves >2 to 4 inches	141.10
Removal of contaminated valves >4 to 8 inches	247.33
Removal of contaminated valves >8 to 14 inches	484.50
Removal of contaminated valves >14 to 20 inches	615.24
Removal of contaminated valves >20 to 36 inches	821.71
Removal of contaminated valves >36 inches	974.57
Removal of contaminated pipe hangers for small bore piping	48.59
Removal of contaminated pipe hangers for large bore piping	149.16
Removal of contaminated pumps, <300 pound	436.06
Removal of contaminated pumps, 300-1000 pound	1,004.88
Removal of contaminated pumps, 1000-10,000 pound	3,140.35
Removal of contaminated pumps, >10,000 pound	7,619.97
Removal of contaminated pump motors, 300-1000 pound	434.65

APPENDIX B
(continued)

Unit Cost Factor	Cost/Unit(\$)
Removal of contaminated pump motors, 1000-10,000 pound	1,283.40
Removal of contaminated pump motors, >10,000 pound	2,878.47
Removal of contaminated turbine-driven pumps < 10,000 pounds	3,850.75
Removal of contaminated turbine-driven pumps > 10,000 pounds	8,782.12
Removal of contaminated heat exchanger <3000 pound	1,933.13
Removal of contaminated heat exchanger >3000 pound	5,593.54
Removal of contaminated tanks, <300 gallons	728.92
Removal of contaminated tanks, >300 gallons, \$/square foot	14.21
Removal of contaminated electrical equipment, <300 pound	388.18
Removal of contaminated electrical equipment, 300-1000 pound	811.64
Removal of contaminated electrical equipment, 1000-10,000 pound	1,557.03
Removal of contaminated electrical equipment, >10,000 pound	3,065.04
Removal of contaminated electrical cable tray, \$/linear foot	24.14
Removal of contaminated electrical conduit, \$/linear foot	30.69
Removal of contaminated mechanical equipment, <300 pound	375.17
Removal of contaminated mechanical equipment, 300-1000 pound	898.47
Removal of contaminated mechanical equipment, 1000-10,000 pound	1,723.82
Removal of contaminated mechanical equipment, >10,000 pound	3,065.04
Removal of contaminated HVAC equipment, <300 pound	375.17
Removal of contaminated HVAC equipment, 300-1000 pound	898.47
Removal of contaminated HVAC equipment, 1000-10,000 pound	1,723.82
Removal of contaminated HVAC equipment, >10,000 pound	3,065.04
Removal of contaminated HVAC ductwork, \$/pound	1.56
Removal/plasma arc cut of contaminated thin metal components, \$/linear in.	1.73
Additional decontamination of surface by washing, \$/square foot	3.58

**APPENDIX B
(continued)**

Unit Cost Factor	Cost/Unit(\$)
Decontamination of large components, \$/square foot	17.03
Decontamination rig hook-up and flush	3,181.92
Chemical flush of components/systems, \$/gallon	7.29
Removal of clean standard reinforced concrete, \$/cubic yard	83.76
Removal of grade slab concrete, \$/cubic yard	112.51
Removal of clean concrete floors, \$/cubic yard	153.39
Removal of sections of clean concrete floors, \$/cubic yard	483.23
Removal of clean heavily rein concrete w/#9 rebar, \$/cubic yard	119.56
Removal of contaminated heavily rein concrete w/#9 rebar, \$/cubic yard	1,002.16
Removal of clean heavily rein concrete w/#18 rebar, \$/cubic yard	152.23
Removal of contaminated heavily rein concrete w/#18 rebar, \$/cubic yard	1,329.65
Removal heavily rein concrete w/#18 rebar & steel embedments, \$/cu yd	217.53
Removal of below-grade suspended floors, \$/square foot	153.39
Removal of clean monolithic concrete structures, \$/cubic yard	418.27
Removal of contaminated monolithic concrete structures, \$/cu yd	1,000.53
Removal of clean foundation concrete, \$/cubic yard	327.88
Removal of contaminated foundation concrete, \$/cubic yard	931.70
Explosive demolition of bulk concrete, \$/cubic yard	16.97
Removal of clean hollow masonry block wall, \$/cubic yard	41.17
Removal of contaminated hollow masonry block wall, \$/cubic yard	148.87
Removal of clean solid masonry block wall, \$/cubic yard	41.17
Removal of contaminated solid masonry block wall, \$/cubic yard	148.87
Backfill of below-grade voids, \$/cubic yard	11.29
Removal of subterranean tunnels/voids, \$/linear foot	64.37
Placement of concrete for below-grade voids, \$/cubic yard	64.57

APPENDIX B
(continued)

Unit Cost Factor	Cost/Unit(\$)
Excavation of clean material, \$/cubic yard	1.94
Excavation of contaminated material, \$/cubic yard	22.25
Excavation of submerged concrete rubble, \$/cubic yard	6.44
Removal of clean concrete rubble, \$/cubic yard	57.83
Removal of contaminated concrete rubble, \$/cubic yard	17.08
Removal of building by volume, \$/cubic foot	0.14
Removal of clean building metal siding, \$/square foot	0.66
Removal of contaminated building metal siding, \$/square foot	2.40
Removal of standard asphalt roofing, \$/square foot	0.90
Removal of transite panels, \$/square foot	1.09
Scarifying contaminated concrete surfaces (drill & spall)	7.06
Scabbling contaminated concrete floors, \$/square foot	1.03
Scabbling contaminated concrete walls, \$/square foot	3.96
Scabbling contaminated ceilings, \$/square foot	39.56
Scabbling structural steel, \$/square foot	3.35
Removal of clean overhead cranes/monorails < 10 ton capacity	283.31
Removal of contaminated overhead cranes/monorails < 10 ton capacity	871.37
Removal of clean overhead cranes/monorails >10-50 ton capacity	679.94
Removal of contaminated overhead cranes/monorails >10-50 ton capacity	2,090.56
Removal of polar cranes > 50 ton capacity, each	2,883.50
Removal of gantry cranes > 50 ton capacity, each	11,844.54
Removal of structural steel, \$/pound	0.16
Removal of clean steel floor grating, \$/square foot	1.47
Removal of contaminated steel floor grating, \$/square foot	4.94
Removal of clean free-standing steel liner, \$/square foot	5.28

**APPENDIX B
(continued)**

Unit Cost Factor	Cost/Unit(\$)
Removal of contaminated free-standing steel liner, \$/square foot	16.42
Removal of clean concrete-anchored steel liner, \$/square foot	2.64
Removal of contaminated concrete-anchored steel liner, \$/square foot	19.09
Placement of scaffolding in clean areas, \$/square foot	2.79
Placement of scaffolding in contaminated areas, \$/square foot	7.07
Landscaping with topsoil, \$/acre	13,835.99
Cost of CPC B-88 LSA box & preparation for use	645.15
Cost of CPC B-25 LSA box & preparation for use	691.04
Cost of CPC B-12V 12 gauge LSA box & preparation for use	527.25
Cost of CPC B-144 LSA box & preparation for use	2,994.33
Cost of LSA drum & preparation for use	62.28
Cost of cask liner for CNSI 14-195 cask	6,348.22
Cost of cask liner for CNSI 8-120A cask (resins)	4,276.61
Cost of cask liner for CNSI 8-120A cask (filters)	4,276.61
Decontamination of surfaces with vacuuming, \$/square foot	0.31

APPENDIX C

DETAILED DECOMMISSIONING COST REPORTS:

TABLE C-1: DECON

TABLE C-2: SAFSTOR

TABLE C-3: ENTOMB

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

ID Number	Activity Description	Decom	Remove	Pack	Ship	Burril	Other	Contingency	Total	NRC		LLW site		GTCC			
										LicTerm	Resoure	A C/P	B C/P	C C/P	CE	Hours	
PERIOD 1																	
1	Prepare preliminary decommissioning cost										150						
2	Notification of Cessation of Operations																
3	Remove fuel & source material																
4	Notification of Permanent Deueling																
5	Decontaminate plant systems & process waste																
6	Prepare and submit PSDAR										230						
7	Review plant deags & specs.																
8	Perform detailed rad survey																
9	Estimate by-product inventory																
10	End product description																
11	Detailed by-product inventory																
12	Define major work sequences																
13	Perform DER and EA																
14	Perform Site-Specific Cost Study																
15	Prepare/submit License Termination Plan																
16	Receive NRC approval of termination plan																
Activity Specifications																	
17.1	Plant & temporary facilities																
17.2	Plant systems																
17.3	NSSS Decontamination Flush																
17.4	Reactor internals																
17.5	Reactor vessel																
17.6	Biological shield																
17.7	Steam generators																
17.8	Reinforced concrete																
17.9	Turbine & condenser																
17.10	Plant structures & buildings																
17.11	Waste management																
17.12	Facility & site closure																
17	Total																
Planning & Site Preparations																	
18	Prepare dewatering sequence																
19	Plant prep. & temp. svcs																
20	Design water clean-up system																
21	Rigging/CCE/cooling/etc.																
22	Procure cranes/lifters & containers																
Detailed Work Procedures																	
23.1	Plant systems																
23.2	NSSS Decontamination Flush																
23.3	Vessel head																
23.4	Reactor internals																
23.5	Remaking buildings																
23.6	CRD cooling assembly																
23.7	CRD housings & ICI tubes																
23.8	Incore instrumentation																
23.9	Reactor vessel																
23.10	Facility closure																
23.11	Missile shields																
23.12	Biological shield																
23.13	Steam generators																
23.14	Reinforced concrete																
23.15	Turbine & condensers																
23.16	Auxiliary building																
23.17	Reactor building																
23	Total																
24	Decom primary loop																
										642							
										321	964						
										4,110	3,391	719					
										964	964						
										800							

Columns may not add due to rounding

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LJW site			GTCC Craft Labor		
												A CF	B CF	C CF	CP	CP	Hours
Period 1 Additional Costs																	
25	Site Characterization Survey	-	-	-	-	-	-	1,169	351	1,519	-	-	-	-	-	-	-
Subtotal Period 1 Activity Costs																	
		842	-	-	-	-	-	15,793	2,865	19,301	18,062	1,239	-	-	-	-	600
Period 1 Undistributed Costs																	
1	Decon equipment	487	-	-	-	-	-	-	73	560	560	-	-	-	-	-	-
2	Decon supplies	29	-	-	-	-	-	-	7	37	37	-	-	-	-	-	-
3	DOC staff relocation expenses	-	678	-	-	-	-	-	102	780	780	-	-	-	-	-	-
4	Process liquid waste	88	-	-	190	2,359	-	-	895	3,651	3,651	-	-	5,801	-	-	240
5	Insurance	-	-	-	-	-	961	-	98	1,079	1,079	-	-	-	-	-	-
6	Property taxes	-	-	-	-	-	-	82	9	101	101	-	-	-	-	-	-
7	Health physics supplies	185	-	-	-	-	-	-	46	231	231	-	-	-	-	-	-
8	Heavy equipment rental	208	-	-	-	-	-	-	31	239	239	-	-	-	-	-	-
9	Small tool allowance	0	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-
10	Disposal of DAW generated	-	-	233	9	1,592	-	-	415	2,219	2,219	-	-	3,709	-	-	10,086
11	Plant energy budget	-	-	-	-	-	2,462	-	369	2,832	2,832	-	-	-	-	-	-
12	NRC Fees	-	-	-	-	-	343	-	38	421	421	-	-	-	-	-	-
13	Emergency Planning Fees	-	-	-	-	-	182	-	18	167	167	-	-	-	-	-	-
14	Site Security Cost	-	-	-	-	-	1,502	-	225	1,727	1,727	-	-	-	-	-	-
Subtotal Undistributed Costs Period 1																	
		605	1,071	-	552	199	3,920	5,571	2,124	14,043	14,043	-	-	3,709	5,801	-	10,328
Staff Costs																	
	DOC Staff Cost	-	-	-	-	-	-	5,348	802	6,150	6,150	-	-	-	-	-	-
	Utility Staff Cost	-	-	-	-	-	-	18,334	2,750	21,084	21,084	-	-	-	-	-	-
TOTAL PERIOD 1 COST																	
		1,248	1,071	-	552	199	3,920	48,046	8,642	60,578	59,539	1,239	-	3,709	5,801	-	11,138
PERIOD 2																	
Nuclear Steam Supply System Removal																	
26.1	Reactor Coolant Piping	90	152	-	-	-	-	-	248	1,106	1,106	-	-	1,534	-	-	9,615
26.2	Pressurizer Refill Tank	15	76	-	6	280	-	-	93	454	454	-	-	618	-	-	3,619
26.3	Reactor Coolant Pumps & Motors	46	42	28	103	1,054	-	-	315	1,588	1,588	-	-	2,504	-	-	3,725
26.4	Pressurizer	22	26	4	25	998	-	-	271	1,346	1,346	-	-	2,369	-	-	1,852
26.5	Steam Generators	191	3,243	-	1,177	18,812	-	-	5,905	30,521	30,521	-	-	33,824	-	-	12,456
26.6	CFRMA/Ch/Service Structure Removal	78	50	53	17	1,543	-	-	444	2,184	2,184	-	-	3,665	-	-	4,490
26.7	Reactor Vessel Internals	59	1,001	-	427	4,984	-	-	4,437	13,962	13,962	-	-	1,310	471	884	17,066
26.8	Vessel & Internals GTCC Disposal	-	-	-	-	-	-	-	2,173	18,659	18,659	-	-	5,371	1,965	-	32,954
26.9	Reactor Vessel	136	4,327	230	375	7,442	-	-	7,186	19,866	19,866	-	-	50,965	2,436	884	85,777
26	Totals	635	6,317	3,849	2,186	50,206	-	-	21,073	87,576	87,576	-	-	17,313	-	-	9,382
27 Remove spent fuel rods																	
		201	20	-	11	7,290	-	-	1,995	9,507	9,507	-	-	-	-	-	-
Removal of Major Equipment																	
28	Main Turbine/Generator	-	72	-	-	-	-	-	11	83	-	83	-	-	-	-	3,091
29	Main Condensers	-	242	-	-	-	-	-	36	278	-	278	-	-	-	-	10,143
Disposal of Plant Systems																	
30.1	AB - Main Steam	-	118	-	-	-	-	-	18	136	-	136	-	-	-	-	5,678
30.2	AB - Main Steam RCA	-	64	-	8	433	-	-	128	635	635	-	-	1,028	-	-	2,713
30.3	AC - Main Turbine	-	118	-	-	-	-	-	18	135	-	135	-	-	-	-	5,719
30.4	AD - Condensate	-	130	-	-	-	-	-	19	149	-	149	-	-	-	-	9,161
30.5	AE - Feedwater	-	89	-	-	-	-	-	13	102	-	102	-	-	-	-	4,278
30.6	AF - Feedwater Heaters, Dm & Vnt	-	110	-	-	-	-	-	16	126	-	126	-	-	-	-	5,419
30.7	AK - Condensate Demineralizer	-	40	-	-	-	-	-	6	46	-	46	-	-	-	-	1,953
30.8	AL - Auxiliary Feedwater	-	17	-	-	-	-	-	3	20	-	20	-	-	-	-	845
30.9	AN - Demineralized Wtr Storage & Idr	-	32	-	-	-	-	-	5	37	-	37	-	-	-	-	1,588
30.10	AO - Demineralized Wtr Strg & Idr RCA	-	12	-	0	21	-	-	8	41	-	41	-	-	-	-	471
30.11	AP - Condensate Storage & Transfer	-	37	-	-	-	-	-	5	43	-	43	-	-	-	-	1,663
30.12	AQ - Condensate & Feedwater Chem Addn	-	10	-	-	-	-	-	2	12	-	12	-	-	-	-	484

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON. DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decom	Remove	Pack	Ship	Overhaul	Other	Contingency	Total	NRC LicTerm	Site Restora	LLW mls A GPF B GPF C GPF	GTCC CrsR Labor Hours
30.13 AX	Acid Feed	15							2	18	18		753
30.14	Auxiliary Bldg Non-System Specific	131		3	2	182			61	409	409	456	5,400
30.15	Auxiliary Bldg Non-System Specific RCA	810		31	16	1,063			631	3,181	3,181	4,020	33,378
30.16	Reactor Coolant	147		13	8	798			239	1,204	1,204	1,895	6,177
30.17	BG - Chemical & Volume Control	523		37	23	2,278			1,001	4,450	4,450	5,411	40,222
30.18	BL - Reactor Makeup Water	183		10	6	605			194	978	978	1,438	6,743
30.19	BH - Steam Generator Blowdown	378		16	10	998			347	1,747	1,747	2,365	15,807
30.20	BN - Stored Retaining Water Storage	195		21	13	1,265			369	1,663	1,663	3,005	8,120
30.21	CA - Steam Seal	9							1	11	11		461
30.22	CB - Main Turbine Lube Oil	27							4	31	31		1,207
30.23	CC - Generator Hydrogen & CO2	4							1	5	5		200
30.24	CD - Generator Seal Oil	6							1	7	7		260
30.25	CE - Steator Cooling Water	5							1	6	6		244
30.26	CF - Lube Oil Strg, Xler & Purification	17							3	20	20		865
30.27	CG - Condenser Air Removal	14							2	16	16		625
30.28	CH - Main Turbine Control Oil	27							4	32	32		1,219
30.29	CI - Chlorination	12							2	14	14		573
30.30	CO - Carbon Dioxide	3							0	3	3		136
30.31	CW - Circulating Water	158							24	183	183		7,860
30.32	CZ - Caustic Acid	2							0	2	2		106
30.33	Control Bldg Non-System Specific	217		9	4	472			174	877	877	1,121	8,942
30.34	Control Bldg Non-System Specific Ch	702							105	806	806		26,076
30.35	DA - Circulating Water System	160							24	184	184		7,932
30.36	DM - Equipment Drains	26							4	30	30		1,227
30.37	DN - Equipment Drains RCA	105		45	32	3,138			820	4,138	4,138	7,451	45,518
30.38	DO - Diesel Oil	1							0	1	1		48
30.39	EA - Service Water	53							8	61	61		2,600
30.40	EB - Closed Cooling Water	26							4	30	30		1,291
30.41	EC - Fuel Pool Cooling & Cleanup	263		13	8	783			265	1,343	1,343	1,863	10,932
30.42	EF - Essential Service Water	59							9	68	68		2,956
30.43	EG - Essential Service Water RCA	59		5	3	273			84	423	423	646	2,493
30.44	EO - Component Cooling Water	98							15	113	113		4,873
30.45	EQ - Component Cooling Water RCA	48		4	2	246			15	372	372	582	1,926
30.46	EJ - Residual Heat Removal	274		20	12	1,212			375	1,893	1,893	2,878	11,615
30.47	EM - High Pressure Coolant Injection	186		6	4	401			148	748	748	852	7,797
30.48	EN - Containment Spray	140		10	6	575			161	911	911	1,365	5,813
30.49	EP - Accumulator Safety Injection	103		6	4	390			124	627	627	925	4,294
30.50	FA - Auxiliary Steam Generator	11							2	13	13		556
30.51	FB - Auxiliary Steam	43							6	50	50		2,132
30.52	FC - Auxiliary Steam RCA	57		3	2	153			53	267	267	363	2,353
30.53	FE - Auxiliary Turbines	28							4	32	32		1,315
30.54	FE - Auxiliary Steam Chemical Addition	2							0	3	3		110
30.55	FO - Fuel Oil	10							1	11	11		498
30.56	FP - Fire Protection	78							12	90	90		3,828
30.57	FP - Fire Protection RCA	215		21	12	1,173			351	1,771	1,771	2,796	8,750
30.58	FQ - Fuel Bldg Non-System Specific	68		1	1	77			37	184	184	184	2,804
30.59	FQ - Fuel Bldg Non-System Specific RCA	429		13	7	727			291	1,468	1,468	1,728	17,820
30.60	GA - Plant Heating	39							6	45	45		1,964
30.61	GA - Plant Heating RCA	73		2	1	130			51	258	258	309	2,093
30.62	GB - Central Chilled Water	37							6	43	43		1,856
30.63	GB - Central Chilled Water RCA	17		1	0	33			13	64	64	76	697
30.64	GD - East Side Wtr Pumps Bldg HVAC	6							1	8	8		365
30.65	GE - Turbine Bldg HVAC	98							15	112	112		4,321
30.66	GF - Miscellaneous Building HVAC	31							5	36	36		1,380
30.67	GG - Fuel Building HVAC	185		14	8	803			250	1,260	1,260	1,907	6,621
30.68	GH - Refractory Building HVAC	132		9	5	521			195	832	832	1,237	4,738
30.69	GH - Control Building HVAC	140							21	161	161		6,151
30.70	GL - Auxiliary Building HVAC	336		19	11	1,095			361	1,622	1,622	2,599	11,966
30.71	GM - Diesel Generator Building HVAC	25							4	29	29		1,115
30.72	GN - Containment Cooling	380		29	17	1,669			518	2,613	2,613	3,944	14,361
30.73	GP - Containment Integrated Leak Rate Test	25		2	1	114			35	177	177	272	981

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LLW atg			GTCC			Cra Labor Hours
												A	B	C	C	F	CF	
30.74	GR - Containment Atmospheric Control	-	10	4	2	233	-	61	310	310	-	-	553	-	-	-	399	
30.75	GS - Containment Hydrogen Control	-	42	3	2	159	-	51	255	255	-	-	377	-	-	-	1,759	
30.76	OT - Containment Puffing HVAC	-	86	8	4	444	-	134	676	676	-	-	1,053	-	-	-	3,335	
30.77	MA - Gaseous Radwaste	-	209	11	7	730	-	237	1,194	1,194	-	-	1,733	-	-	-	6,567	
30.78	HB - Liquid Radwaste	612	497	28	19	1,845	-	897	3,899	3,899	-	-	4,363	-	-	-	43,656	
30.79	HC - Solid Radwaste	-	275	18	11	1,105	-	349	1,758	1,758	-	-	2,824	-	-	-	11,481	
30.80	HD - Decontamination	-	56	4	2	248	-	76	384	384	-	-	563	-	-	-	2,271	
30.81	HE - Boron Recycle	319	291	14	9	677	-	454	1,964	1,964	-	-	2,063	-	-	-	24,053	
30.82	HF - Secondary Liquid Waste	526	563	33	21	2,065	-	832	4,162	4,162	-	-	4,950	-	-	-	42,890	
30.83	HY - Hydrogen	-	5	-	-	-	-	1	6	6	-	-	-	-	-	-	237	
30.84	IE - Emergency Fuel Oil	-	28	-	-	-	-	4	32	32	-	-	-	-	-	-	1,274	
30.85	KA - Compressed Air and Instrument	-	129	-	-	-	-	19	148	148	-	-	-	-	-	-	6,301	
30.86	KB - Breathing Air	-	22	-	-	-	-	3	25	25	-	-	-	-	-	-	1,098	
30.87	KC - Fire Protection	-	151	-	-	-	-	23	173	173	-	-	-	-	-	-	7,488	
30.88	KD - Fire Protection RCA	-	348	27	15	1,509	-	469	2,365	2,365	-	-	3,583	-	-	-	14,143	
30.89	KE - Domestic Water	-	36	-	-	-	-	5	41	41	-	-	-	-	-	-	1,776	
30.90	KE - Fuel Hdg & Stig Reactor Vssl Serv	-	9	3	2	179	-	48	241	241	-	-	428	-	-	-	377	
30.91	KH - Service Gas	-	14	-	-	-	-	2	16	16	-	-	-	-	-	-	662	
30.92	KJ - Standby Diesel Engine	-	147	-	-	-	-	22	169	169	-	-	-	-	-	-	6,781	
30.93	LA - Sanitary Drains	-	6	-	-	-	-	1	7	7	-	-	-	-	-	-	294	
30.94	LA - Sanitary Drains RCA	-	21	1	55	-	-	19	98	98	-	-	132	-	-	-	640	
30.95	LB - Roof Drains	-	28	-	-	-	-	4	30	30	-	-	-	-	-	-	1,276	
30.96	LB - Roof Drains RCA	-	111	7	4	414	-	133	669	669	-	-	863	-	-	-	4,464	
30.97	LC - Yard Drains	-	2	-	-	-	-	0	2	2	-	-	-	-	-	-	86	
30.98	LD - Chemical & Detergent Waste	64	66	2	1	145	-	86	366	366	-	-	344	-	-	-	98	
30.99	LE - Oil Waste	-	52	-	3	312	-	11	562	562	-	-	741	-	-	-	5,272	
30.100	LF - Oil Waste RCA	-	130	5	3	312	-	11	562	562	-	-	741	-	-	-	2,574	
30.101	LF - Floor & Equipment Drains	-	997	37	22	2,234	-	615	4,106	4,106	-	-	5,308	-	-	-	5,269	
30.102	MT - Nitrogen	-	3	-	-	-	-	0	4	4	-	-	-	-	-	-	159	
30.103	OX - Oxygen	-	4	-	-	-	-	1	4	4	-	-	-	-	-	-	173	
30.104	RM - Process Sampling & Analysis	-	72	3	200	-	-	19	346	346	-	-	474	-	-	-	2,976	
30.105	Radwaste Bldg Non-System Specific	-	236	5	3	236	-	68	698	698	-	-	748	-	-	-	9,758	
30.106	Radwaste Bldg Non-System Specific RCA	-	1,477	52	26	2,855	-	1,092	5,501	5,501	-	-	6,760	-	-	-	60,803	
30.107	Reactor Bldg Non-System Specific	-	142	2	1	124	-	67	337	337	-	-	295	-	-	-	5,874	
30.108	Reactor Bldg Non-System Specific RCA	-	691	20	11	1,120	-	506	2,548	2,548	-	-	2,660	-	-	-	36,466	
30.109	SJ - Nuclear Sampling	-	38	2	1	135	-	44	220	220	-	-	320	-	-	-	1,596	
30.110	BT - Sewage Treatment	-	49	-	-	-	-	7	56	56	-	-	-	-	-	-	2,332	
30.111	SW - Screen Wash	-	14	-	-	-	-	2	16	16	-	-	-	-	-	-	631	
30.112	SZ - Service Air	-	39	-	-	-	-	6	45	45	-	-	-	-	-	-	1,941	
30.113	Turbine Bldg Non-System Specific	-	334	-	-	-	-	50	384	384	-	-	384	-	-	-	15,405	
30.114	VA - I&C Shop HVAC	-	3	-	-	-	-	0	4	4	-	-	-	-	-	-	141	
30.115	VB - I&C Shop HVAC	-	2	-	-	-	-	0	2	2	-	-	-	-	-	-	85	
30.116	VC - Health Physics Computer Room HVAC	-	4	-	-	-	-	1	5	5	-	-	-	-	-	-	202	
30.117	VH - Health Physics Computer Room HVAC	-	5	-	-	-	-	1	6	6	-	-	-	-	-	-	245	
30.118	VJ - Circ Water & Makeup Water Cornis	-	1	-	-	-	-	0	1	1	-	-	-	-	-	-	51	
30.119	VJ - Shop Bldg Machine Shop Area Vent	-	2	-	-	-	-	0	2	2	-	-	-	-	-	-	92	
30.120	VS - Active Bldg HVAC	-	5	-	-	-	-	1	6	6	-	-	-	-	-	-	236	
30.121	VT - Tech Support Building HVAC	-	2	-	-	-	-	0	2	2	-	-	-	-	-	-	79	
30.122	VV - Misc Bldg HVAC	-	3	-	-	-	-	0	3	3	-	-	-	-	-	-	123	
30.123	VW - Waste Water Treatment Ventilation	-	1	-	-	-	-	0	1	1	-	-	-	-	-	-	48	
30.124	WD - Domestic Water	-	19	-	-	-	-	3	21	21	-	-	-	-	-	-	919	
30.125	WG - Gland Water & Motor Cooling Water	-	12	-	-	-	-	2	13	13	-	-	-	-	-	-	597	
30.126	WL - Cooling Lake Makeup & Blowdown	-	15	-	-	-	-	2	18	18	-	-	-	-	-	-	740	
30.127	WM - Makeup Demineralizer	-	82	-	-	-	-	12	94	94	-	-	-	-	-	-	3,971	
30.128	WS - Plant Services Water	-	67	-	-	-	-	10	77	77	-	-	-	-	-	-	3,305	
30.129	WS - Plant Services Water RCA	-	35	7	4	373	-	103	521	521	-	-	685	-	-	-	1,491	
30.130	WT - Waste Water Treatment	-	16	-	-	-	-	2	16	16	-	-	-	-	-	-	780	
30.131	WZ - Waste Water Treatment	-	5	-	-	-	-	1	6	6	-	-	-	-	-	-	240	
30.132	YZ - Radioactive Liquid Waste	-	13	-	-	-	-	2	15	15	-	-	-	-	-	-	603	
30.132	YZ and Non-System Specific	2,109	10,336	670	395	39,967	-	14,857	74,334	69,736	4,598	-	94,818	-	-	-	787,547	
30 Totals		-	2,213	16	8	1,078	-	828	4,141	4,141	-	-	2,560	-	-	-	76,127	
31	Erect scaffolding for systems removal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LLW like			GTCC Craft Labor			
												A CF	B CF	C CF	A CF	B CF	C CF	
Decommissioning of Site Buildings																		
32.1	Reactor	646	440	89	55	5,117	-	1,730	8,078	8,078	-	12,153	-	-	-	-	41,778	
32.2	Auxiliary	377	52	34	20	2,033	-	716	3,232	3,232	-	4,828	-	-	-	-	16,471	
32.3	Communication Corridor - Contaminated	8	0	1	0	36	-	13	80	80	-	87	-	-	-	-	332	
32.4	Fuel Building	415	374	25	13	1,116	-	584	2,527	2,527	-	2,640	-	-	-	-	30,186	
32.5	Hot Machine Shop	12	-	1	0	42	-	17	71	71	-	89	-	-	-	-	446	
32.6	Robocasts	201	19	17	10	885	-	355	1,586	1,586	-	2,338	-	-	-	-	8,443	
32.7	Radwaste Drum Storage	23	1	2	1	103	-	36	187	187	-	244	-	-	-	-	920	
32.8	Radwaste Storage Building	56	-	4	3	241	-	80	396	396	-	572	-	-	-	-	2,202	
32	Totals	1,740	887	171	104	9,972	-	3,543	18,117	18,117	-	22,971	-	-	-	-	100,778	
34	Terminate license	-	-	-	-	-	110	33	142	142	-	-	-	-	-	-	-	
Note 1																		
Period 2 Additional Costs																		
35	License Termination Survey	-	-	-	-	-	8,605	1,982	8,587	8,587	-	-	-	-	-	-	-	118,092
36	Curie Surcharge (Excluding RPV)	-	-	-	-	2,888	-	722	3,610	3,610	-	-	-	-	-	-	-	
Subtotal Period 2 Activity Costs																		
4,688			29,288	4,865	2,713	111,102	6,715	45,016	204,376	199,417	4,959	188,756	2,436	884	649	1,171,917		
Period 3 Undistributed Costs																		
1	Decon equipment	487	-	-	-	-	-	73	560	560	-	-	-	-	-	-	-	-
2	Decon supplies	769	-	-	-	-	-	187	987	987	-	-	-	-	-	-	-	-
3	DOC staff relocation expenses	-	678	-	-	-	-	102	780	780	-	-	-	-	-	-	-	-
4	Process liquid waste	586	-	254	322	2,460	-	963	4,807	4,807	-	-	5,843	-	-	-	830	
5	Insurance	-	-	-	-	-	930	84	1,031	1,031	-	-	-	-	-	-	-	
6	Property taxes	-	-	-	-	-	330	33	362	326	36	-	-	-	-	-	-	
7	Health physics supplies	-	3,371	-	-	-	-	843	4,214	4,214	-	-	-	-	-	-	-	
8	Heavy equipment rental	-	6,100	-	-	-	-	1,215	9,315	8,383	931	-	-	-	-	-	-	
9	Small tool allowance	-	355	-	-	-	-	53	408	367	41	-	-	-	-	-	-	
10	Pipe cutting equipment	-	787	-	-	-	-	118	905	905	-	-	-	-	-	-	-	
11	Decon 10	1,023	-	-	-	-	-	153	1,176	1,176	-	-	-	-	-	-	-	
12	Disposal of DAW generated	-	-	836	34	5,610	-	1,481	7,970	7,970	-	-	13,323	-	-	-	36,238	
13	Decommissioning Equipment Disposition	-	-	-	13	1,204	-	305	1,543	1,543	-	-	2,859	-	-	-	778	
14	Plant energy budget	-	-	21	-	-	6,272	941	7,213	6,491	721	-	-	-	-	-	-	
15	NRC Fees	-	-	-	-	-	1,890	168	1,848	1,848	-	-	-	-	-	-	-	
16	Emergency Planning Fees	-	-	-	-	-	370	37	407	407	-	-	-	-	-	-	-	
17	Site Security Cost	-	-	-	-	-	8,515	1,277	9,792	9,792	-	-	-	-	-	-	-	
18	LLRW Processing Equipment	-	-	-	-	-	350	52	402	402	-	-	-	-	-	-	-	
Subtotal Undistributed Costs Period 2																		
2,888			13,291	1,110	369	9,274	18,454	8,136	53,521	51,791	1,730	16,162	5,843	-	-	-	37,648	
Staff Costs																		
-	DOC Staff Cost	-	-	-	-	-	30,199	4,530	34,728	34,728	-	-	-	-	-	-	-	-
-	UIRKY Staff Cost	-	-	-	-	-	58,906	8,836	67,742	67,742	-	-	-	-	-	-	-	-
TOTAL PERIOD 2																		
7,573			42,879	5,965	3,082	130,377	114,274	66,818	360,367	353,678	6,689	204,938	8,279	884	649	1,509,783		
PERIOD 3																		
Demolition of Remaining Site Buildings																		
37.1	Reactor	-	3,196	-	-	-	-	479	3,676	-	3,676	-	-	-	-	-	75,822	
37.2	Access Vaults	-	12	-	-	-	-	2	14	-	14	-	-	-	-	-	174	
37.3	Administration	-	148	-	-	-	-	22	170	-	170	-	-	-	-	-	4,198	
37.4	Auxiliary	-	2,716	-	-	-	-	407	3,123	-	3,123	-	-	-	-	-	59,349	
37.5	Auxiliary Boiler	-	-	-	-	-	-	3	22	-	22	-	-	-	-	-	587	
37.6	Chlorine Storage	-	15	-	-	-	-	2	17	-	17	-	-	-	-	-	378	
37.7	Circ Water Pump Enclosure	-	4	-	-	-	-	1	4	-	4	-	-	-	-	-	181	
37.8	Circ Water Travel Screen Enclosure	-	3	-	-	-	-	1	4	-	4	-	-	-	-	-	169	
37.9	Circulating Water Discharge Structure	-	114	-	-	-	-	17	131	-	131	-	-	-	-	-	1,838	
37.10	Circulating Water Intake & Screenhouse	-	232	-	-	-	-	35	287	-	287	-	-	-	-	-	1,908	
37.11	Communication Corridor - Clean	-	787	-	-	-	-	118	905	-	905	-	-	-	-	-	20,542	
37.12	Communication Corridor - Contaminated	-	26	-	-	-	-	4	30	-	30	-	-	-	-	-	668	
37.13	Covered Walkways	-	8	-	-	-	-	1	9	-	9	-	-	-	-	-	332	

TABLE C-1
WOLF CREEK NUCLEAR STATION
DECON, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

ID Number	Activity Description	Decom	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LLW site			GTCC C/F	Crar Labor Hours
												A.C.F.	R.C.F.	G.C.F.		
Demolition of Remaining Site Buildings (continued)																
37.14	Diesel Generator	-	272	-	-	-	-	41	313	-	313	-	-	-	-	6,119
37.15	E.S.W.S. Pumphouse	-	330	-	-	-	-	50	380	-	380	-	-	-	-	2,778
37.16	ESWS Valve House	-	10	-	-	-	-	2	12	-	12	-	-	-	-	243
37.17	Fuel Building	-	1,231	-	-	-	-	165	1,416	-	1,416	-	-	-	-	27,061
37.18	GOB - Administration Building	-	218	-	-	-	-	32	248	-	248	-	-	-	-	5,397
37.19	Hot Machine Shop	-	15	-	-	-	-	2	17	-	17	-	-	-	-	484
37.20	M.M.O. Building	-	157	-	-	-	-	24	181	-	181	-	-	-	-	3,483
37.21	Miscellaneous Site Foundations	-	315	-	-	-	-	47	362	-	362	-	-	-	-	7,228
37.22	Miscellaneous Site Structures	-	911	-	-	-	-	137	1,047	-	1,047	-	-	-	-	20,240
37.23	New Covered Walkway	-	8	-	-	-	-	1	7	-	7	-	-	-	-	148
37.24	New Misc Structures	-	45	-	-	-	-	7	52	-	52	-	-	-	-	1,362
37.25	Oil Separator and Waste Tank	-	2	-	-	-	-	0	2	-	2	-	-	-	-	48
37.26	Rachwitz	-	1,115	-	-	-	-	167	1,283	-	1,283	-	-	-	-	24,007
37.27	Radioactive Drum Storage	-	154	-	-	-	-	23	177	-	177	-	-	-	-	3,857
37.28	Radioactive Storage Building	-	83	-	-	-	-	12	95	-	95	-	-	-	-	2,362
37.29	Security/Guardhouse	-	35	-	-	-	-	5	40	-	40	-	-	-	-	672
37.30	Site Diesel Generator	-	3	-	-	-	-	0	3	-	3	-	-	-	-	60
37.31	Support Complex - Tool Room	-	24	-	-	-	-	4	27	-	27	-	-	-	-	695
37.32	Toolhouse Building	-	2,552	-	-	-	-	383	2,935	-	2,935	-	-	-	-	87,807
37.33	Turbine Pedestal	-	551	-	-	-	-	83	633	-	633	-	-	-	-	10,928
37.34	Waste Water Treatment	-	15	-	-	-	-	2	18	-	18	-	-	-	-	438
37 Totals		-	15,322	-	-	-	-	2,266	17,821	-	17,821	-	-	-	-	369,341
Site Close																
38	Remove Rubble	-	5,308	-	-	-	-	766	6,104	-	6,104	-	-	-	-	12,575
39	Grade & landscape site	-	1,328	-	-	-	-	189	1,527	-	1,527	-	-	-	-	6,028
40	Final report to NRC	-	-	-	-	-	-	156	23	178	-	-	-	-	-	-
Subtotal Period 3 Activity Costs		-	21,959	-	-	-	-	1,566	3,317	25,432	179	25,253	-	-	-	389,944
Period 3 Undistributed Costs																
1	Insurance	-	-	-	-	-	-	92	9	101	-	-	-	-	-	-
2	Property taxes	-	-	-	-	-	-	132	13	145	-	-	-	-	-	-
3	Heavy equipment rental	-	3,016	-	-	-	-	452	3,469	-	3,469	-	-	-	-	-
4	Small tool allowance	-	122	-	-	-	-	16	141	-	141	-	-	-	-	-
5	Plant energy budget	-	-	-	-	-	-	89	10	78	-	-	-	-	-	-
6	Site Security Cost	-	-	-	-	-	-	1,065	160	1,225	-	-	-	-	-	-
Subtotal Undistributed Costs Period 3		-	3,138	-	-	-	-	1,358	663	5,159	101	5,058	-	-	-	-
Staff Costs																
DOC Staff Cost		-	-	-	-	-	-	8,961	1,344	10,305	-	10,305	-	-	-	-
Utility Staff Cost		-	-	-	-	-	-	4,951	666	5,349	4,814	535	-	-	-	-
TOTAL PERIOD 3		-	26,097	-	-	-	-	15,126	6,022	46,248	5,094	41,151	-	-	-	389,944
TOTAL COST TO DECOMMISSION		8,820	68,747	6,817	3,281	124,297	174,446	81,082	467,190	418,112	49,078	268,647	13,880	884	849	1,610,836

Total cost to decommission with 21.00% contingency: \$ 487,190,245

Total NRC license termination cost is 89.50% or \$ 418,111,921
Non-nuclear demolition cost is 10.51% or \$ 49,078,339

Total LLW site release volume buried 223,411 cubic feet
Total 10CFR91 greater than class C waste buried 646 cubic feet

Total scrap metal released from Callaway Plant 32,280 tons
Total civil labor requirements 1,610,835 person hours

Note: "0" indicates costs less than \$500
Note 1: This activity is performed by the decommissioning staff following plant shutdown; the costs for this are included in this period's staff cost.
Note 2: This activity, while performed after final plant shutdown, is considered part of operations and therefore no decommissioning costs are included for this activity.

TABLE C-2
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

Comments may not add due to rounding

II) Number	Activity Description	Person	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LLW site BOP	ACF	CF	GTCC CP	Crst Labor Hours
PERIOD 1: Mobilizing Activities																
1	SAFSTOR site characterization survey						278	84	362	362						
2	Prepare preliminary decommissioning cost						130	20	150	150						
3	Notification of cessation of Operations								Note 1							
4	Remove fuel & source material								Note 1							
5	Notification of Permanent Dismantling								Note 1							
6	Dismantle plant systems & process vessels						200	30	230	230						
7	Prepare and submit PSDAR						130	20	150	150						
8	Review plant design & specs.								Note 1							
9	Perform detailed rad survey						100	15	115	115						
10	Estimate by-product inventory						100	15	115	115						
11	Final product description						190	23	213	213						
12	Detailed by-product inventory						100	15	115	115						
13	Define major work sequence						310	47	357	357						
14	Perform SER and EA						500	75	575	575						
15	Perform Site-Specific Cost Study						410	61	471	471						
16	Prepare/submit License Termination Plan								Note 1							
17	Receive NRC approval of termination plan															
Activity Specifications																
18.1	Prepare plant and facilities for SAFSTOR						482	74	556	568						
18.2	Plant systems						417	63	479	479						
18.3	Plant structures and buildings						312	47	359	359						
18.4	Waste management						200	30	230	230						
18.5	Facility and site dormancy						200	30	230	230						
18 Total							1,621	243	1,864	1,864						
Detailed Work Procedures																
19.1	Plant systems						473	71	544	544						
19.2	Facility closeout & dormancy						120	18	138	138						
19 Total							593	89	682	682						
20	Process vacuum drying system						10	2	12	12						
21	Drain/bleed/energize non-cont. systems								Note 1							
22	Drain & dry NSSS								Note 1							
23	Drain/bleed/energize contaminated systems								Note 1							
24	Decommission contaminated systems								Note 1							
Decommissionation of Site Buildings																
25.1	Reactor	568						259	896	896						23,794
25.2	Auxiliary	297						148	445	445						12,361
25.3	Communication Combs - Contaminated	7						3	10	10						273
25.4	Fuel Building	390						195	585	585						14,201
25.5	Hot Machine Shop	8						4	12	12						340
25.6	Radiation	198						79	237	237						6,562
25.7	Radwaste Drum Storage	18						9	27	27						741
25.8	Radwaste Storage Building	45						23	68	68						1,874
25 Totals		1,521						761	2,282	2,282						60,166
26	Prepare support equipment for storage		287					43	330	330						3,000
27	Install containment pressure equal. lines		19					3	21	21						700
28	Initial survey prior to dormancy						324	48	372	372						
29	Secure building accesses								Note 1							
30	Prepare & submit interim report						58	9	67	67						
Subtotal Period 1 Activity Costs		1,521	306				5,014	1,600	8,442	8,442						83,888

TABLE C-2
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1998 Dollars)

ID Number	Activity Description	Decom	Remove	Pack	Skip	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	A CF	LLW site B CF	CCF	OTCC CF	Craft Labor Hours	
Period 1 Undistributed Costs																	
1	Decom equipment	487	-	-	-	-	-	73	560	560	-	-	-	-	-	-	
2	Decom supplies	713	-	-	-	-	-	176	882	882	-	-	-	-	-	-	
3	Process liquid waste	234	-	62	116	729	-	333	1,484	1,484	-	-	1,730	-	-	340	
4	Insurance	-	-	-	-	-	981	96	1,079	1,079	-	-	-	-	-	-	
5	Property taxes	-	-	-	-	-	92	8	101	101	-	-	-	-	-	-	
6	Health physics supplies	332	-	-	-	-	-	83	416	416	-	-	-	-	-	-	
7	Small tool allowance	21	-	-	-	-	-	3	24	24	-	-	-	-	-	-	
8	Disposal of DAW generated	-	-	233	9	1,562	-	415	2,219	2,219	-	3,709	-	-	-	10,089	
9	Plant energy budget	-	-	-	-	-	2,464	370	2,833	2,833	-	-	-	-	-	-	
10	NRC Fees	-	-	-	-	-	383	38	421	421	-	-	-	-	-	-	
11	Emergency Planning Fees	-	-	-	-	-	152	15	167	167	-	-	-	-	-	-	
12	Site Security Cost	-	-	-	-	-	1,402	225	1,727	1,727	-	-	-	-	-	-	
	Subtotal Undistributed Costs Period 1	1,454	354	295	125	2,290	5,573	1,841	11,932	11,932	-	3,709	1,730	-	-	10,428	
Staff Costs																	
	Utility Staff Cost	-	-	-	-	-	17,323	2,598	19,922	19,922	-	-	-	-	-	-	-
	TOTAL COST TO SAFSTOR	2,976	689	295	126	2,290	27,910	6,040	40,296	40,296	-	3,709	1,730	-	-	74,294	
Total cost to SAFSTOR with 17.63% contingency: \$ 40,295,340																	
Total SAFSTOR radwaste volumes buried 5,439 cubic feet																	
Total craft labor requirements 74,284 person hours																	

TABLE C-3
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1998 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRCLicTerm	Site Restore	LLW site B CP	C CP	OTCC CP	Cash Labor Hours		
PERIOD 2: Safstor Annual Maintenance Cost																	
1	Quarterly inspection																
2	Semi-annual environmental survey																
3	Prepare reports																
4	Health physics supplies						48	12	60	60							
5	Insurance						131	13	144	144							
6	Property lease						61	6	67	67							
7	Deposit of consolidated solid waste					43		11	55	55					28		
8	Reinforce roof replacement											102					
9	Maintenance supplies						57	8	65	65							
10	Plant energy budget						103	28	129	129							
11	NRCLicTerm						128	19	149	149							
12	Emergency Planning Fees						211	21	232	232							
13	Site Security Cost						7	1	8	8							
14	Site maintenance staff						328	49	377	377							
							1,308	196	1,501	1,501							
	PERIOD 2 ANNUAL MAINTENANCE TOTALS					43	2,381	363	2,788	2,788		102			28		
Total cost SAFSTOR demeracy with		52,6375	years equals	\$	146,749,350												
Total site radioactive volume buried																5,364	cubic feet

TABLE C-2
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	ACF	LLW site B/CF	G/CF	OTCC CF	Craft Labor Hours
PERIOD 4																
Nuclear Steam Supply System Removal																
18.1	Reactor Coolant Piping	82	139		10	20		241	1,138	1,138		1,534				6,753
18.2	Pressurizer Relief Tank	14	69		4	6		90	443	443		618				3,260
18.3	Reactor Coolant Pumps & Motors	42	38		28	103		312	1,577	1,577		2,504				3,409
18.4	Pressurizer	15	20		1,154	996		2,170	3,343	3,343		33,624				12,456
18.5	Steam Generators	139	3,248		1,117	18,612		5,896	30,484	30,484		3,865				4,200
18.6	CRDMs/Chassis Structures Removal	69	1,135		53	1,177		3,457	2,182	2,182		1,441				15,156
18.7	Reactor Vessel Internals	50	1,521		2,397	300		2,173	16,659	16,659		5,371		884		32,644
18.8	Reactor Vessel	124	4,311		230	375		6,083	16,398	16,398		51,126		884		81,685
18.9	Reactor Vessel	572	9,397		3,916	2,103		19,323	82,301	82,301		17,313				8,574
18	Total	185	20		50	11		1,927	9,482	9,482						
19 Remove spent fuel rods																
Removal of Major Equipment																
20	Main Turbine/Generator	72						11	83		83					3,091
21	Main Condensers	242						36	278		278					10,143
Disposal of Plant Systems																
22.1	AS - Main Steam		118			433		18	136		136					5,878
22.2	AS - Main Steam RCA		64					126	635		635					2,715
22.3	AC - Main Turbine		118					19	149		149					5,710
22.4	AD - Condensate		130					13	102		102					6,161
22.5	AE - Feedwater		89					16	126		126					4,279
22.6	AF - Feedwater Hot Extraction, Dm & Vnt		110					6	46		46					5,419
22.7	AK - Condensate Demineralizer		40					3	20		20					1,953
22.8	AL - Auxiliary Feedwater		17					5	37		37					845
22.9	AM - Demineralized Wt Storage & rfr		32					6	41		41					1,588
22.10	AN - Demineralized Wt Sg & Jtr RCA		37					5	33		33					471
22.11	AO - Condensate Storage		15					2	12		12					1,663
22.12	AO - Condensate & Feedwater Chem Addition		15					2	18		18					484
22.13	AX - Acid Feed		119			152		78	395		395					733
22.14	Auxiliary Bldg Non-System Specific		810			1,653		631	3,181		3,181					33,371
22.15	Auxiliary Bldg Non-System Specific RCA		132			746		235	1,165		1,165					5,325
22.16	BB - Reactor Coolant		148					898	3,511		3,511					19,965
22.17	BG - Chemical & Volume Control		148					190	959		959					6,060
22.18	BL - Reactor Makeup Water		344			996		338	1,704		1,704					14,277
22.19	BM - Steam Generator Blowdown		177					365	1,640		1,640					7,335
22.20	BN - Screened Makeup Water Storage		27					1	11		11					481
22.21	BO - Makeup Water		4					1	5		5					1,207
22.22	CB - Main Turbine Lube Oil		4					1	7		7					200
22.23	CC - Generator Hydrogen & CO2		6					1	6		6					244
22.24	CD - Generator Seal Oil		5					1	6		6					825
22.25	CE - Stator Cooling Water		17					3	20		20					665
22.26	CF - Lube Oil Sg, Xtr & Purification		14					2	16		16					1,219
22.27	CG - Condenser Air Removal		27					4	32		32					573
22.28	CH - Main Turbine Control Oil		12					2	14		14					156
22.29	CI - Chlorination		3					0	3		3					7,860
22.30	CO - Carbon Dioxide		3					24	193		193					108
22.31	CP - Cooling Water		193					2	872		872					6,842
22.32	CZ - Cooling Water		2					177	808		808					29,915
22.33	Control Bldg Non-System Specific		217			472		105	608		608					1,227
22.34	Control Bldg Non-System Specific Ch		702					24	184		184					4,519
22.35	DA - Circulating Water System		180					4	30		30					48
22.36	DM - Equipment Drains		28					4	4,139		4,139					2,600
22.37	DN - Equipment Drains RCA		165			3,138		820	1,314		1,314					9,887
22.38	DO - Diesel Oil		1					0	1		1					2,966
22.39	EA - Service Water		53					8	61		61					4,873
22.40	EB - Closed Cooling Water		28					8	30		30					1,929
22.41	EC - Fuel Pool Cooling & Cleanup		240			793		261	1,314		1,314					10,516
22.42	ED - Fuel Pool Cooling Water		59					9	68		68					3,613
22.43	EE - Essential Service Water RCA		66					84	423		423					3,596
22.44	EF - Essential Service Water		68			273		17	372		372					1,929
22.45	EG - Component Cooling Water RCA		68					7	62		62					2,873
22.46	EJ - Residual Heat Removal RCA		249			2,452		368	1,862		1,862					10,516
22.47	EM - High Pressure Coolant Injection		170			1,212		144	725		725					7,035
22.48	EN - Containment Spray		140			401		181	911		911					5,813
22.49	EP - Accumulator Safety Injection		94			390		122	616		616					3,596
22.50	FA - Auxiliary Steam Generator		11					2	13		13					2,132
22.51	FB - Auxiliary Steam		43					6	50		50					2,353
22.52	FC - Auxiliary Steam RCA		29			153		53	267		267					1,315
22.53	FD - Auxiliary Turbines		2					4	32		32					498
22.54	FE - Auxiliary Steam Chemical Addition		2					0	3		3					
22.55	FO - Fuel Oil		10					1	11		11					

Columns may not add due to rounding

TABLE C-2
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1998 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decom	Remove	Peak	Ship	Burial	Other	Contingency	Total	NRC Lifeform	Site Restore	A CF	Liability BCF	C CF	OTCC CF	Craft Labor Hours
23	Erect scaffolding for systems removal	-	2,062	-	16	-	-	793	3,977	3,977	-	-	2,560	-	-	70,217
Decommissioning of Site Buildings																
24.1	Reactor	590	399	-	89	5,117	-	1,691	7,942	7,942	-	-	12,153	-	-	37,873
24.2	Reactor	345	47	-	20	2,033	-	699	3,177	3,177	-	-	4,828	-	-	14,904
24.3	Communication Corridor - Contaminated	6	0	-	1	36	-	13	59	59	-	-	87	-	-	301
24.4	Fuel Building	377	339	-	25	1,116	-	557	2,427	2,427	-	-	2,649	-	-	27,388
24.5	Hot Machine Shop	11	1	-	1	42	-	16	70	70	-	-	99	-	-	404
24.6	Radiation Drum Storage	184	17	-	10	965	-	348	1,558	1,558	-	-	2,339	-	-	7,640
24.7	Rehearsal Drum Storage	21	1	-	2	103	-	37	164	164	-	-	244	-	-	632
24.8	Rehearsal Storage Building	53	4	-	3	241	-	66	388	388	-	-	572	-	-	1,985
24	Totals	1,589	804	-	171	9,872	-	3,446	15,786	15,786	-	-	22,871	-	-	81,325
25	ORISE confirmatory survey	-	-	-	-	-	-	33	142	142	-	-	-	-	-	-
26	Terminate license	-	-	-	-	-	-	-	Note 1	-	-	-	-	-	-	-
Period 4 Additional Costs																
27	License Termination Survey	-	-	-	-	189	-	6,605	1,982	8,587	-	-	-	-	-	119,082
28	Cuts Surcharge (Excluding RPV)	-	-	-	-	-	-	42	211	211	-	-	-	-	-	-
Subtotal Period 4	Activity Costs	2,348	28,331	4,825	2,620	105,165	6,715	41,239	181,240	186,281	4,959	188,887	2,227	884	649	1,048,639
Period 4 Unallocated Costs																
1	Decom equipment	487	-	-	-	-	-	73	560	560	-	-	-	-	-	-
2	Decom supplies	769	-	-	-	-	-	102	872	872	-	-	-	-	-	-
3	DOC staff relocation expenses	-	678	-	-	-	-	382	1,780	1,780	-	-	2,039	-	-	401
4	Professional fees	300	-	-	73	859	-	50	1,282	1,282	-	-	-	-	-	-
5	Insurance	-	-	-	-	-	498	27	548	548	-	-	-	-	-	-
6	Property taxes	-	-	-	-	-	287	27	293	293	-	-	-	-	-	-
7	Health physics supplies	-	2,958	-	-	-	-	740	3,698	3,698	29	-	-	-	-	-
8	Heavy equipment rental	6,620	-	-	-	-	-	993	7,613	7,613	761	-	-	-	-	-
9	Small tool allowance	312	-	-	-	-	-	47	359	359	36	-	-	-	-	-
10	Pipe capping equipment	787	-	-	-	-	-	118	905	905	-	-	-	-	-	-
11	Disposal of DAW generated	-	-	-	677	4,542	-	1,207	6,453	6,453	-	-	10,786	-	-	29,339
12	Decommissioning Equipment Deposition	-	-	-	21	1,204	-	305	1,543	1,543	-	-	-	-	-	778
13	Plant energy budget	-	-	-	-	-	3,823	543	4,416	4,416	417	-	-	-	-	-
14	NRC Fee	-	-	-	-	-	1,378	138	1,516	1,516	-	-	-	-	-	-
15	Site Security Cost	-	-	-	-	-	5,142	899	6,041	6,041	-	-	-	-	-	-
16	LRPV Processing Equipment	-	-	-	-	-	1,301	195	1,496	1,496	-	-	-	-	-	-
Subtotal Unallocated Costs Period 4		1,556	11,355	771	177	6,805	12,859	5,991	39,311	38,068	1,243	13,646	2,039	-	-	30,517
Staff Costs																
	DOC Staff Cost	-	-	-	-	-	24,342	3,851	27,993	27,993	-	-	-	-	-	-
	Utility Staff Cost	-	-	-	-	-	41,845	6,277	48,122	48,122	-	-	-	-	-	-
TOTAL PERIOD 4		3,901	39,686	5,595	2,797	111,770	88,760	57,158	306,666	300,484	8,202	202,552	4,266	864	649	1,079,306
PERIOD 5																
Demolition of Remaining Site Buildings																
29.1	Reactor	-	3,198	-	-	-	-	479	3,676	-	3,676	-	-	-	-	73,822
29.2	Access Vaults	-	12	-	-	-	-	2	14	-	14	-	-	-	-	174
29.3	Administration	-	148	-	-	-	-	22	170	-	170	-	-	-	-	4,198
29.4	Auxiliary	-	2,716	-	-	-	-	407	3,123	-	3,123	-	-	-	-	59,348
29.5	Auxiliary Boiler	-	19	-	-	-	-	3	22	-	22	-	-	-	-	587
29.6	Chlorine Storage	-	15	-	-	-	-	2	17	-	17	-	-	-	-	379
29.7	Circ Water Pump Enclosure	-	4	-	-	-	-	1	4	-	4	-	-	-	-	181
29.8	Circ Water Pump Screen Enclosure	-	3	-	-	-	-	1	4	-	4	-	-	-	-	169
29.9	Cracking Water Storage Structure	-	114	-	-	-	-	17	131	-	131	-	-	-	-	1,908
29.10	Cracking Water Storage Structure	-	232	-	-	-	-	35	267	-	267	-	-	-	-	1,908
29.11	Communication Corridor - Clean	-	787	-	-	-	-	118	905	-	905	-	-	-	-	20,542
29.12	Communication Corridor - Contaminated	-	26	-	-	-	-	4	30	-	30	-	-	-	-	608
29.13	Covered Walkway	-	8	-	-	-	-	1	9	-	9	-	-	-	-	332
29.14	Diesel Generator	-	272	-	-	-	-	41	313	-	313	-	-	-	-	6,119
29.15	E.S.W.S. Pumphouse	-	330	-	-	-	-	50	380	-	380	-	-	-	-	2,778
29.16	ESMS Valve House	-	10	-	-	-	-	2	12	-	12	-	-	-	-	243
29.17	Fuel Building	-	1,231	-	-	-	-	185	1,416	-	1,416	-	-	-	-	27,061
29.18	GOB - Administration Building	-	216	-	-	-	-	32	248	-	248	-	-	-	-	5,397
29.19	Hot Machine Shop	-	15	-	-	-	-	2	17	-	17	-	-	-	-	464
29.20	M.M.O. Building	-	157	-	-	-	-	24	181	-	181	-	-	-	-	3,483
29.21	Miscellaneous Site Foundations	-	315	-	-	-	-	47	362	-	362	-	-	-	-	7,228
29.22	Miscellaneous Site Structures	-	911	-	-	-	-	137	1,047	-	1,047	-	-	-	-	20,240
29.23	New Covered Walkway	-	6	-	-	-	-	1	7	-	7	-	-	-	-	148
29.24	New Rec. Structure	-	45	-	-	-	-	7	52	-	52	-	-	-	-	1,382
29.25	Old Rec. Structure and Waste Tank	-	1,115	-	-	-	-	187	1,263	-	1,263	-	-	-	-	24,007
29.26	Radiation Drum Storage	-	154	-	-	-	-	23	177	-	177	-	-	-	-	3,857
29.27	Rehearsal Drum Storage	-	83	-	-	-	-	12	95	-	95	-	-	-	-	2,382
29.28	Rehearsal Storage Building	-	35	-	-	-	-	5	40	-	40	-	-	-	-	672
29.29	Security/Guardhouse	-	3	-	-	-	-	0	3	-	3	-	-	-	-	80
29.30	Site Diesel Generator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE C-3
WOLF CREEK NUCLEAR STATION
SAFSTOR, DECOMMISSIONING COST ESTIMATE
(Thousands of 1988 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	BNip	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	ACF	LLW site BCF	CCF	OTCC CP	Craft Labor Hours
Demolition of Remaining Site Buildings (continued)																
29.31	Support Complex - Tool Room	-	24	-	-	-	-	4	27	-	27	-	-	-	-	695
29.32	Turbine Building	-	2,352	-	-	-	-	333	2,835	-	2,835	-	-	-	-	87,607
29.33	Waste Ponds	-	91	-	-	-	-	633	633	-	633	-	-	-	-	10,928
29.34	Waste Water Treatment	-	15	-	-	-	-	2	16	-	16	-	-	-	-	438
29	Total	-	15,332	-	-	-	-	2,398	17,621	-	17,621	-	-	-	-	369,341
Site Closeout Activities																
30	Remove Rubble	-	5,308	-	-	-	-	786	6,104	-	6,104	-	-	-	-	12,575
31	Grade & landscape site	-	1,328	-	-	-	-	199	1,527	-	1,527	-	-	-	-	8,028
32	Final report to NRC	-	-	-	-	-	156	23	179	-	-	-	-	-	-	-
	Subtotal Period 5 Activity Costs	-	21,959	-	-	-	156	3,317	25,432	179	25,253	-	-	-	-	389,944
Period 5 Undistributed Costs																
1	Insurance	-	-	-	-	-	82	9	101	101	-	-	-	-	-	-
2	Property taxes	-	-	-	-	-	132	13	145	-	145	-	-	-	-	-
3	Heavy equipment rental	-	3,047	-	-	-	42	42	3,491	-	3,491	-	-	-	-	-
4	Small equipment rental	-	-	-	-	-	18	18	141	-	141	-	-	-	-	-
5	Plant energy budget	-	122	-	-	-	59	8	181	-	181	-	-	-	-	-
6	Site Security Cost	-	-	-	-	-	1,063	160	1,225	-	1,225	-	-	-	-	-
	Subtotal Undistributed Costs Period 5	-	3,169	-	-	-	1,344	686	5,179	101	5,078	-	-	-	-	-
Staff Costs																
	DOC Staff Cost	-	-	-	-	-	8,960	1,344	10,304	-	10,304	-	-	-	-	-
	Utility Staff Cost	-	-	-	-	-	5,031	755	5,785	5,207	579	-	-	-	-	-
	TOTAL PERIOD 5	-	28,128	-	-	-	18,491	6,882	48,701	5,487	41,214	-	-	-	-	389,944
	TOTAL COST TO DECOMMISSION	6,877	68,771	6,157	2,345	117,890	294,832	85,162	890,444	641,751	48,883	216,314	6,897	884	649	1,656,141
Total cost to decommission with 19.21% contingency: \$ 890,443,815																
Total NRC license termination cost is 91.75% or \$ 541,761,165																
Non-nuclear demolition cost is 8.25% or \$ 48,682,638																
Total LLW site radwaste volume buried 222,194 cubic feet																
Total 10CFR61 greater than class C volume buried 649 cubic feet																
Total scrap metal released from Callaway Plant 32,290 tons																
Total craft labor requirements 1,555,141 person hours																

Note: "0" indicates costs less than \$500

Note 1: This activity is performed by the decommissioning staff following plant shutdown; the costs for this are included in this period's staff cost.

Note 2: This activity, while performed after final plant shutdown, is considered part of operations and therefore no decommissioning costs are included for this activity.

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	A CF	LAW site B CF	C CF	GTCC CP	Crack Labor Hours
Period 1 Undistributed Costs (continued)																
8	Disposal of DAW generated	-	-	233	9	1,562	-	415	2,219	2,219	-	-	-	-	-	10,088
9	Plant energy budget	-	-	-	-	-	1,831	275	2,106	2,106	-	-	-	-	-	-
10	NRC Fees	-	-	-	-	-	383	38	421	421	-	-	-	-	-	-
11	Emergency Planning Fees	-	-	-	-	-	152	167	167	167	-	-	-	-	-	-
12	Site Security Cost	-	-	-	-	-	1,502	225	1,727	1,727	-	-	-	-	-	-
	Subtotal Undistributed Costs Period 1	818	861	258	58	1,854	4,940	1,437	10,023	10,023	-	-	3,709	885	-	10,224
Staff Costs																
	DOC Staff Cost	-	-	-	-	-	5,348	802	6,150	6,150	-	-	-	-	-	-
	Utility Staff Cost	-	-	-	-	-	10,334	2,750	21,084	21,084	-	-	-	-	-	-
	TOTAL PERIOD 1 COST	818	861	258	58	1,854	41,770	7,003	52,419	51,688	731	-	3,709	885	-	10,224
PERIOD 2																
Disposal of Plant Systems																
External to Entombment Barrier																
25.1	AB - Main Steam RCA	-	64	8	4	433	-	128	635	635	-	-	1,028	-	-	2,713
25.2	AN - Demineralized Wtr Strg & xtr RCA	-	12	0	21	8	-	61	41	41	-	-	40	-	-	471
25.3	Auxiliary Bldg Non-System Specific	-	131	3	102	456	-	61	409	409	-	-	456	-	-	5,400
25.4	Auxiliary Bldg Non-System Specific RCA	-	810	31	1,603	3,181	-	631	3,181	3,181	-	-	4,020	-	-	33,378
25.5	BG - Chemical & Volume Control	587	523	37	23	2,278	-	1,001	4,450	4,450	-	-	5,411	-	-	40,222
25.6	BL - Reactor Makeup Water	-	163	10	6	605	-	194	978	978	-	-	1,438	-	-	6,743
25.7	BM - Steam Generator Blowdown	-	378	18	10	998	-	347	1,747	1,747	-	-	2,365	-	-	15,907
25.8	BN - Saturated Reboiler Water Storage	-	195	21	13	1,285	-	369	1,863	1,863	-	-	3,005	-	-	6,120
25.9	Control Bldg Non-System Specific	-	217	9	4	472	-	174	877	877	-	-	1,121	-	-	8,942
25.10	DM - Equipment Dring & Clean	-	105	45	32	3,138	-	620	4,139	4,139	-	-	7,451	-	-	45,119
25.11	EC - Fuel Pool Cooling & Clean	-	283	13	8	793	-	268	1,343	1,343	-	-	1,863	-	-	10,892
25.12	EF - Essential Service Water RCA	-	58	5	3	273	-	84	423	423	-	-	648	-	-	1,829
25.13	EG - Component Cooling Water RCA	-	46	4	2	245	-	74	372	372	-	-	562	-	-	11,615
25.14	EJ - Residual Heat Removal	-	274	20	12	1,212	-	375	1,893	1,893	-	-	2,878	-	-	7,787
25.15	EM - High Pressure Coolant Injection	-	166	6	4	401	-	148	748	748	-	-	952	-	-	5,613
25.16	EN - Containment Spray	-	140	10	6	575	-	181	911	911	-	-	1,385	-	-	2,353
25.17	FP - Fire Protection RCA	-	57	3	2	153	-	53	267	267	-	-	2,786	-	-	2,804
25.18	FP - Fire Protection RCA	-	215	21	12	1,173	-	351	1,771	1,771	-	-	2,786	-	-	17,820
25.19	Fuel Bldg Non-System Specific	-	66	1	77	727	-	37	184	184	-	-	309	-	-	2,963
25.20	Fuel Bldg Non-System Specific RCA	-	429	13	7	2,727	-	281	1,488	1,488	-	-	1,728	-	-	8,877
25.21	GA - Plant Heating RCA	-	73	2	1	130	-	51	258	258	-	-	78	-	-	6,821
25.22	GB - Central Chilled Water RCA	-	17	0	33	84	-	84	84	84	-	-	1,907	-	-	4,738
25.23	GG - Fuel Building HVAC	-	165	14	8	803	-	250	1,260	1,260	-	-	1,237	-	-	11,988
25.24	GH - Radwaste Building HVAC	-	338	9	521	1,822	-	361	1,822	1,822	-	-	2,598	-	-	3,355
25.25	GL - Auxiliary Building HVAC	-	25	2	1	114	-	134	879	879	-	-	1,053	-	-	4,856
25.26	GP - Containment Improped Leak Rate Test	-	208	8	4	444	-	89	1,194	1,194	-	-	1,733	-	-	11,461
25.27	GT - Containment Pure HVAC	-	697	29	19	1,845	-	597	3,089	3,089	-	-	2,624	-	-	24,063
25.28	HA - Gaseous Radwaste	612	275	18	11	1,105	-	349	1,758	1,758	-	-	2,865	-	-	14,143
25.29	HB - Liquid Radwaste	-	36	4	2	246	-	76	384	384	-	-	583	-	-	6,400
25.30	HC - Solid Radwaste	-	291	14	9	877	-	434	1,964	1,964	-	-	2,083	-	-	14,143
25.31	HD - Decontamination	319	563	33	21	2,085	-	932	4,162	4,162	-	-	3,583	-	-	4,484
25.32	HE - Boron Recycle	528	348	27	15	1,509	-	489	2,365	2,365	-	-	132	-	-	5,272
25.33	HF - Secondary Liquid Waste	-	21	1	95	98	-	19	98	98	-	-	983	-	-	5,268
25.34	KC - Fire Protection RCA	-	111	7	4	414	-	133	869	869	-	-	344	-	-	41,435
25.35	LA - Sanitary Drains RCA	-	64	2	1	145	-	88	386	386	-	-	502	-	-	2,078
25.36	LB - Roof Drains RCA	-	130	5	3	312	-	115	562	562	-	-	5,300	-	-	60,803
25.37	LD - Chemical & Delugent Waste	-	997	37	22	2,224	-	815	4,106	4,106	-	-	748	-	-	39,496
25.38	LE - Oily Waste RCA	-	72	3	200	474	-	69	346	346	-	-	2,965	-	-	1,491
25.39	LF - Floor & Equipment Drains	-	236	5	3	315	-	139	898	898	-	-	6,780	-	-	5,874
25.40	RM - Process Sampling & Analysis	-	1,477	52	28	2,655	-	1,092	5,501	5,501	-	-	2,600	-	-	25,448
25.41	Radwaste Bldg Non-System Specific	-	142	1	124	337	-	506	2,548	2,548	-	-	865	-	-	1,589
25.42	Radwaste Bldg Non-System Specific RCA	-	891	20	11	1,120	-	44	220	220	-	-	320	-	-	1,491
25.43	Reactor Bldg Non-System Specific	-	35	7	4	373	-	103	521	521	-	-	865	-	-	553,110
25.44	Reactor Bldg Non-System Specific RCA	-	11,647	612	360	36,540	-	13,217	64,485	64,485	-	-	86,777	-	-	-
25.45	WS - Plant Services Water RCA	2,109	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Totals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	A CF	LAW site B CF	CCF	GTCC CP	Craft Labor Hours
20	Erect scaffolding for systems removal		1,901	13	6	853		691	3,464	3,464		2,026				64,487
Decommissioning of Site Buildings																
External to Entombment Barrier																
27.1	Auditory	377	52		34	2,033		716	3,232	3,232		4,828				16,471
27.2	Communication Corridor - Contaminated	8	0		1	36		13	60	60		87				332
27.3	Fuel Building	415	374	25	13	1,116		564	2,527	2,527		2,648				30,186
27.4	Hot Machine Shop	12			1	42		17	71	71		99				448
27.5	Radwaste	201	19	17	10	985		355	1,566	1,566		2,339				8,443
27.6	Radwaste Drum Storage	23	1	2	1	103		38	187	187		244				920
27.7	Radwaste Storage Building	58	1	4	3	241		90	398	398		572				2,202
27	Totals	1,094	447	82	48	4,555		1,813	8,039	8,039		10,818				59,001
28	Prepare support equipment for storage		144					22	165	165						1,500
29	Mobile sys & comp. at entombment body		53					8	61	61						2,600
30	Construct entombment barriers		358					54	412	412						7,549
31	Install containment pressure equal. lines		18					3	21	21						700
32	Interim survey prior to ENTOMB dominance						195	59	254	254						
33	Secure building accesses								Note 1							
34	Prepare and submit interim report						120	18	138	138						
Rack Removal																
35	Remove spent fuel racks	201	20		11	7,290		1,935	9,507	9,507		17,313				9,362
Subtotal Period 2 Activity Costs																
		3,404	14,569	757	426	49,238	315	17,818	66,547	66,547		116,934				697,709
Period 2 Undistributed Costs																
1	Decon equipment	487						73	560	560						
2	Decon supplies	516						129	646	646						
3	DOC staff relocation expenses	678						102	780	780						
4	Process liquid waste	497		231	281	2,200		864	4,073	4,073			5,225			708
5	Insurance						906	91	997	997						
6	Property taxes						291	29	320	320						
7	Health physics supplies	2,215						554	2,769	2,769						
8	Heavy equipment rental	2,763						414	3,177	3,177						
9	Small tool allowance	226						34	260	260						
10	Pipe cutting equipment	787						118	905	905						
11	Disposal of DAW generated			739	30	4,859		1,318	7,046	7,046		11,777				32,034
12	Pilot energy budget							5,588	6,437	6,437						
13	NRC Fees							1,465	1,634	1,634						
14	Emergency Planning Fees							370	407	407						
15	Site Security Cost							7,381	8,489	8,489						
16	LURW Processing Equipment							350	402	402						
Subtotal Undistributed Costs Period 2																
		1,500	6,869	970	311	7,159	18,382	5,910	36,902	36,902		11,777	5,225			32,743
Staff Costs																
DOC Staff Cost																
Utility Staff Cost																
							27,163	4,074	31,237	31,237						
							53,704	8,050	61,760	61,760						
TOTAL PERIOD 2 COST																
		4,904	21,255	1,727	737	59,398	97,563	35,858	218,446	218,446		128,711	5,225			730,452
TOTAL COST TO ENTOMB																
		5,822	22,119	1,985	793	58,262	139,334	42,862	270,865	270,865	731	132,420	5,819			740,678

Total cost to ENTOMBMENT with 18.80% contingency: \$ 270,865,200
 Total ENTOMBMENT radwaste volume buried 138,339 cubic feet
 Total craft labor requirements 740,678 person hours

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1999 Dollars)

ID Number	Activity Description	Decom	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	LAW site		GTCC CP	Crnk Labor Hours
												ACF	BCF		
PERIOD 4															
1	Review plant design & specs.							20	150						
2	Perform detailed rad survey								Note 1						
3	End product description							5	37						
4	Detailed by-product inventory							23	173						
5	Define major work sequence							100	115						
6	Perform SER and EA							47	357						
7	Perform Site-Specific Cost Study							75	575						
8	Presubmittal License Termination Plan							61	471						
9	Receive NRC approval of termination plan								Note 1						
Activity Specifications															
10.1	Receive NRC approval of termination plan							63	479		48				
10.2	Plant systems							107	817						
10.3	Reactor internals							86	748						
10.4	Reactor vessel							50	58						
10.5	Biological shield							312	359						
10.6	Steam generators							24	184		92				
10.7	Reinforced concrete							312	359		178				
10.8	Plant structures & buildings							460	529		529				
10.9	Waste management							80	104		52				
10.10	Facility & site closure							14	104		52				
10	Total							3,181	474		3,284				
Planning & Site Preparations															
11	Prepare dismantling sequence							298	2,289						
12	Plant prep. & temp. events							21	161						
13	Design water clean-up system							108	830						
14	Repair/CCS/stockpile/c.							18	141						
15	Procure castellers & containers														
Detailed Work Procedures															
16.1	Plant systems							71	544		54				
16.2	Vessel head							36	288						
16.3	Reactor internals							250	288						
16.4	Remaining buildings							20	155		118				
16.5	CRD cooling assembly							15	115						
16.6	CRD housings & ICI tubes							100	115						
16.7	Incore instrumentation							100	115						
16.8	Reactor vessel							363	54		417				
16.9	Facility closure							120	138		69				
16.10	Missile shields							45	52						
16.11	Biological shield							120	138						
16.12	Steam generators							460	529		529				
16.13	Reinforced concrete							100	115		58				
16.14	Auxiliary building							273	314		283				
16.15	Reactor building							41	314		283				
16	Total							3,162	474		3,637				
Period 4 Additional Costs															
17	Site Characterization							351	1,519						
Subtotal Period 4 Activity Costs								12,089	1,990		13,357				
Period 4 Undistributed Costs															
1	DOC staff relocation expenses		678												
2	Insurance						187								
3	Property taxes						92								
4	Health physics supplies		183												
5	Heavy equipment rental		437												
6	Plant energy budget						847								
7	MRC Fees						383								
8	Site Security Cost						1,070								
Subtotal Undistributed Costs Period 4			1,298				2,579		587		4,443				

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC LicTerm	Site Restore	A C/P	LLW site B C/P	C C/P	GTCC C/P	Crash Labor Hours
Staff Costs																
	DOC Staff Cost	-	-	-	-	-	5,348	862	6,150	6,150	-	-	-	-	-	8,753
	Utility Staff Cost	-	-	-	-	-	18,299	2,445	18,744	18,744	-	-	-	-	-	3,280
TOTAL PERIOD 4 COST																
		-	1,298	-	-	-	36,324	5,804	43,428	42,695	731	-	-	-	-	3,409
PERIOD 5																
Nuclear Steam Supply System Removal																
18.1	Reactor Containment Piping	82	138	10	20	646	-	241	1,138	1,138	-	1,534	-	-	-	8,753
18.2	Pressurizer Relief Tank	14	69	4	6	200	-	90	443	443	-	618	-	-	-	3,280
18.3	Reactor Coolant Pumps & Motors	42	38	28	103	1,054	-	312	1,577	1,577	-	2,504	-	-	-	3,409
18.4	Pressurizer	20	26	4	25	898	-	270	1,343	1,343	-	2,389	-	-	-	1,778
18.5	Steam Generators	173	3,243	1,193	1,177	18,812	-	5,996	30,494	30,494	-	33,824	-	-	-	12,456
18.6	CRDMs/Cl/Servico Structure Removal	69	49	53	17	1,543	-	440	2,172	2,172	-	3,665	-	-	-	4,208
18.7	Reactor Vessel Internals	50	1,521	2,397	380	3,907	-	3,813	12,067	12,067	-	1,441	262	884	-	15,156
18.8	Vessel & Internals GTCC Disposal	124	4,311	230	375	14,486	-	2,173	18,659	18,659	-	5,371	1,965	-	-	32,844
18.9	Reactor Vessel	572	9,397	3,918	2,103	46,879	-	19,319	82,268	82,268	-	51,128	2,227	864	-	81,865
18	Totals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Removal of Major Equipment																
19	Main Turbine/Generator	-	72	-	-	-	-	11	83	83	-	-	-	-	-	3,091
20	Main Condensers	-	242	-	-	-	-	36	278	278	-	-	-	-	-	10,143
Disposal of Plant Systems																
21.1	AB - Main Steam	-	118	-	-	-	-	18	136	136	-	-	-	-	-	5,878
21.2	AC - Main Turbine	-	118	-	-	-	-	18	136	136	-	-	-	-	-	5,719
21.3	AD - Condensate	-	130	-	-	-	-	19	149	149	-	-	-	-	-	6,161
21.4	AE - Feedwater	-	86	-	-	-	-	13	102	102	-	-	-	-	-	4,279
21.5	AF - Feedwater Htr Exdrtn, Dm & Vht	-	110	-	-	-	-	16	126	126	-	-	-	-	-	5,419
21.6	AK - Condensate Demineralizer	-	40	-	-	-	-	6	46	46	-	-	-	-	-	1,953
21.7	AL - Auxiliary Feedwater	-	17	-	-	-	-	3	20	20	-	-	-	-	-	845
21.8	AN - Demineralized Wtr Storage & Htr	-	32	-	-	-	-	5	37	37	-	-	-	-	-	1,588
21.9	AP - Condensate Storage & Transfer	-	37	-	-	-	-	6	43	43	-	-	-	-	-	1,863
21.10	AQ - Condensate & Feedwater Chem Addn	-	10	-	-	-	-	2	12	12	-	-	-	-	-	484
21.11	AX - ACG Feed	-	15	-	-	-	-	2	18	18	-	-	-	-	-	753
21.12	BB - Reactor Coolant	-	132	-	8	768	-	235	1,165	1,165	-	1,695	-	-	-	5,525
21.13	CA - Steam Seal	-	9	-	-	-	-	1	11	11	-	-	-	-	-	481
21.14	CB - Main Turbine Lubes Oil	-	27	-	-	-	-	4	31	31	-	-	-	-	-	1,207
21.15	CC - Generator Hydrogen & CO2	-	4	-	-	-	-	1	5	5	-	-	-	-	-	200
21.16	CD - Generator Seal Oil	-	6	-	-	-	-	1	7	7	-	-	-	-	-	260
21.17	CE - Steator Cooling Water	-	5	-	-	-	-	1	6	6	-	-	-	-	-	244
21.18	CF - Lube Oil Strp, Xtr & Purification	-	17	-	-	-	-	3	20	20	-	-	-	-	-	826
21.19	CG - Condensate Air Removal	-	14	-	-	-	-	2	16	16	-	-	-	-	-	665
21.20	CH - Main Turbine Air Removal	-	27	-	-	-	-	4	32	32	-	-	-	-	-	1,219
21.21	CL - Chlorination	-	12	-	-	-	-	2	14	14	-	-	-	-	-	573
21.22	CO - Carbon Dioxide	-	3	-	-	-	-	0	3	3	-	-	-	-	-	136
21.23	CW - Circulating Water	-	159	-	-	-	-	24	183	183	-	-	-	-	-	7,860
21.24	CZ - Caustic Acid	-	2	-	-	-	-	0	2	2	-	-	-	-	-	108
21.25	Control Bldg Non-System Specific Ch	-	702	-	-	-	-	105	808	808	-	-	-	-	-	29,078
21.26	DA - Circulating Water System	-	180	-	-	-	-	24	184	184	-	-	-	-	-	7,932
21.27	DM - Equipment Drains	-	28	-	-	-	-	4	30	30	-	-	-	-	-	1,227
21.28	DO - Diesel Oil	-	1	-	-	-	-	0	1	1	-	-	-	-	-	48
21.29	EA - Service Water	-	53	-	-	-	-	6	61	61	-	-	-	-	-	2,600
21.30	EB - Closed Cooling Water	-	59	-	-	-	-	4	60	60	-	-	-	-	-	1,291
21.31	EF - Essential Service Water	-	28	-	-	-	-	8	30	30	-	-	-	-	-	2,956
21.32	EG - Component Cooling Water	-	98	-	-	-	-	15	113	113	-	-	-	-	-	4,873
21.33	EP - Accumulator Safety Injection	-	94	-	-	-	-	122	616	616	-	-	-	-	-	3,890
21.34	FA - Auxiliary Steam Generator	-	11	-	4	390	-	2	13	13	-	-	-	-	-	550
21.35	FB - Auxiliary Steam	-	43	-	-	-	-	8	50	50	-	-	-	-	-	2,132
21.36	FC - Auxiliary Turbines	-	28	-	-	-	-	4	32	32	-	-	-	-	-	1,315
21.37	FE - Auxiliary Steam Chemical Addition	-	2	-	-	-	-	0	3	3	-	-	-	-	-	110
21.38	FD - Fuel Oil	-	10	-	-	-	-	1	11	11	-	-	-	-	-	488
21.39	FP - Fire Protection	-	78	-	-	-	-	12	90	90	-	-	-	-	-	3,828
21.40	GA - Plant Heating	-	38	-	-	-	-	8	45	45	-	-	-	-	-	1,964
21.41	GB - Central Chilled Water	-	37	-	-	-	-	6	43	43	-	-	-	-	-	1,856
21.42	GD - Essntl Srvc Wtr Pumps Bldg HVAC	-	6	-	-	-	-	9	15	15	-	-	-	-	-	365
21.43	GE - Turbine Bldg HVAC	-	99	-	-	-	-	15	112	112	-	-	-	-	-	4,321

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

Columns may not add due to rounding

Item Number	Activity Description	Decom	Remove	Pack	Ship	Burial	Other	Contingency	Total	NUC J.cterm	Site Restoro	A CF	LLW site B CF	C CF	GTCC CF	Craft Labor Hours
21.44	GF - Miscellaneous Building HVAC	-	31	-	-	-	-	5	36	-	36	-	-	-	-	1,340
21.45	OK - Control Building HVAC	-	140	-	-	-	-	21	161	-	161	-	-	-	-	6,151
21.46	GM - Diesel Generator Building HVAC	-	25	-	-	-	-	4	29	-	29	-	-	-	-	1,115
21.47	GN - Diesel Generator Building HVAC	-	348	-	-	1,669	-	510	2,572	2,572	-	3,994	-	-	-	12,887
21.48	GR - Containment Cooling	-	9	-	2	233	-	61	309	309	-	553	-	-	-	364
21.49	GS - Containment Atmospheric Control	-	39	-	2	158	-	50	251	251	-	377	-	-	-	1,599
21.50	HT - Hydrogen	-	5	-	-	-	-	1	6	-	6	-	-	-	-	237
21.51	JE - Emergency Fuel Oil	-	28	-	-	-	-	4	32	-	32	-	-	-	-	1,274
21.52	KA - Compressed Air and Instrument	-	129	-	-	-	-	19	149	-	149	-	-	-	-	6,301
21.53	KB - Breathing Air	-	22	-	-	-	-	3	25	-	25	-	-	-	-	1,088
21.54	KC - Fire Protection	-	151	-	-	-	-	23	173	-	173	-	-	-	-	7,488
21.55	KD - Domestic Water	-	36	-	-	-	-	5	41	-	41	-	-	-	-	1,776
21.56	KE - Fuel Hdg & Sng Reactor Vent Serv	-	8	-	-	-	-	48	240	240	-	426	-	-	-	343
21.57	KH - Service Gas	-	14	-	3	179	-	2	189	-	189	-	-	-	-	682
21.58	KJ - Standby Diesel Engine	-	147	-	-	-	-	22	169	-	169	-	-	-	-	6,781
21.59	LA - Sanitary Drains	-	6	-	-	-	-	1	7	-	7	-	-	-	-	294
21.60	LB - Roof Drains	-	26	-	-	-	-	4	30	-	30	-	-	-	-	1,278
21.61	LC - Yard Drains	-	2	-	-	-	-	0	2	-	2	-	-	-	-	88
21.62	LE - Oil Waste	-	52	-	-	-	-	6	59	-	59	-	-	-	-	2,574
21.63	MT - Nitrogen	-	3	-	-	-	-	0	4	-	4	-	-	-	-	159
21.64	OX - Oxygen	-	4	-	-	-	-	4	4	-	4	-	-	-	-	173
21.65	ST - Sewerage Treatment	-	49	-	-	-	-	7	56	-	56	-	-	-	-	2,332
21.66	BW - Screen Wash	-	14	-	-	-	-	18	18	-	18	-	-	-	-	631
21.67	SZ - Service Air	-	39	-	-	-	-	45	45	-	45	-	-	-	-	1,941
21.68	Turbine Bldg Non-System Specific	-	334	-	-	-	-	60	384	-	384	-	-	-	-	15,405
21.69	VA - IBC Shop HVAC	-	3	-	-	-	-	0	4	-	4	-	-	-	-	141
21.70	VB - IBC Shop HVAC	-	2	-	-	-	-	0	2	-	2	-	-	-	-	95
21.71	VC - Health Physics Computer Room HVAC	-	4	-	-	-	-	1	5	-	5	-	-	-	-	202
21.72	VH - CFC Water & Makeup Water Scrub	-	5	-	-	-	-	1	6	-	6	-	-	-	-	245
21.73	VJ - Shop Bldg Machine Shop Area Vent	-	1	-	-	-	-	0	1	-	1	-	-	-	-	51
21.74	VL - Shop Building HVAC	-	2	-	-	-	-	0	2	-	2	-	-	-	-	92
21.75	VS - Admin Bldg HVAC	-	5	-	-	-	-	1	6	-	6	-	-	-	-	238
21.76	VT - Tech Support Building HVAC	-	2	-	-	-	-	0	2	-	2	-	-	-	-	79
21.77	WV - Misc Bldg HVAC	-	3	-	-	-	-	0	3	-	3	-	-	-	-	123
21.78	WY - Waste Water Treatment Ventilation	-	1	-	-	-	-	0	1	-	1	-	-	-	-	48
21.79	WD - Domestic Water	-	10	-	-	-	-	3	21	-	21	-	-	-	-	919
21.80	WG - Gland Water & Motor Cooling Water	-	12	-	-	-	-	2	13	-	13	-	-	-	-	587
21.81	WL - Cooling Lake Makeup & Blowdown	-	15	-	-	-	-	2	18	-	18	-	-	-	-	740
21.82	WM - Makeup Demineralizer	-	82	-	-	-	-	12	94	-	94	-	-	-	-	3,871
21.83	WS - Plant Services Water	-	07	-	-	-	-	10	77	-	77	-	-	-	-	3,565
21.84	WT - Waste Water Treatment	-	16	-	-	-	-	2	18	-	18	-	-	-	-	760
21.85	WZ - Radioactive Liquid Waste	-	5	-	-	-	-	1	6	-	6	-	-	-	-	240
21.86	Yard Non-System Specific	-	13	-	-	-	-	2	15	-	15	-	-	-	-	603
21 Totals		-	4,827	-	57	34	3,427	1,625	9,772	5,174	4,588	8,140	-	-	-	211,662
22	Erect scaffolding for systems removal	-	284	-	3	2	225	128	643	643	-	535	-	-	-	10,406
Decommissioning of Site Buildings																
23.1	Reactor	590	388	89	55	5,117	-	1,891	7,942	7,942	-	-	-	-	-	37,873
23 Totals		590	388	89	55	5,117	-	1,891	7,942	7,942	-	-	-	-	-	37,873
24	ORIS condormatory survey	-	-	-	-	-	110	33	142	142	-	-	-	-	-	-
25	Tennessee license	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Period 5 Additional Costs																
26	License Termination Survey	-	-	-	-	-	6,005	1,982	6,587	6,587	-	-	-	-	-	119,092
27	Curie Surcharge (Excluding RPV)	-	-	-	-	169	-	42	211	211	-	-	-	-	-	-
Subtotal Period 5 Activity Costs		1,163	15,022	4,068	2,194	55,918	6,715	24,867	109,946	104,887	4,959	71,953	2,227	884	649	473,971
Period 5 Undistributed Costs																
1	Decom equipment	487	-	-	-	-	-	73	560	560	-	-	-	-	-	-
2	Decom supplies	335	-	-	-	-	-	84	419	419	-	-	-	-	-	-
3	DOC stifer education expenses	-	876	-	-	-	-	102	780	780	-	-	-	-	-	-
4	Process liquid waste	193	-	47	88	552	-	252	1,133	1,133	-	1,312	-	-	-	256
5	insurance	-	-	-	-	-	429	43	471	471	-	-	-	-	-	-
6	Property taxes	-	-	-	-	-	23	23	256	230	26	-	-	-	-	-
7	Health physics supplies	-	1,543	-	-	-	-	386	1,929	1,829	-	-	-	-	-	-

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

ID Number	Activity Description	Decon	Remove	Pack	Ship	Berial	Other	Contingency	Total	NRC LicTerm	Site Restore	LJW site		GTCC CF	Craft Labor Hours	
												ACF	BCF			
Period 6 Undistributed Costs (continued)																
8	Heavy equipment rental		5,776					866	6,643	5,978	664					
9	Small tool allowance		127					118	146	132	15					
10	Pipe cutting equipment		787					118	905	905						
11	Deposit of DAW generated			560		3,963		1,063	5,631	5,631					25,601	
12	Decommissioning Equipment Deposition			21		1,204		305	1,543	1,543			9,412		778	
13	Plant energy budget						1,064	285	2,259	2,033	228		2,859			
14	MFC Fees						1,167	119	1,306	1,306						
15	Site Security Cost						5,124	769	5,893	5,893						
16	LLRW Processing Equipment						1,100	185	1,286	1,286						
	Subtotal Undistributed Costs Period 6	1,015	6,912	656	125	5,720	10,037	4,672	31,136	30,208	930		12,271	1,312	26,636	
Staff Costs																
	DOC Staff Cost						21,164	3,178	24,362	24,362						
	Utility Staff Cost						36,342	5,451	41,793	41,793						
	TOTAL PERIOD 6	2,177	23,933	4,776	2,319	61,638	74,278	38,168	207,239	201,350	5,860		84,225	3,639	864	649
PERIOD 6																
Dismantling of Remaining Site Buildings																
28.1	Reactor		3,196					479	3,676		3,676					73,622
28.2	Access Vaults		12					2	14		14					174
28.3	Administration		148					22	170		170					4,196
28.4	Auxiliary		2,716					407	3,123		3,123					59,349
28.5	Auxiliary Boiler							3	22		22					587
28.6	Chemical Storage		15					2	17		17					379
28.7	Chlorine Storage							1	4		4					181
28.8	Chlorine Pump Enclosure							1	4		4					169
28.9	Circulating Water Discharge Structure		114					17	131		131					1,638
28.10	Circulating Water Intake & Screenhouse		232					35	267		267					1,809
28.11	Communication Building - Chain		787					118	905		905					20,842
28.12	Communication Corridor - Contaminated		26					4	30		30					666
28.13	Covered Walkways		6					1	9		9					332
28.14	Diesel Generator		272					41	313		313					8,119
28.15	E.S.V. 8. Pumphouse		330					50	380		380					2,778
28.16	ESVS Value House		10					2	12		12					243
28.17	Fuel Building		1,231					165	1,416		1,416					27,061
28.18	GOB - Administration Building		216					32	248		248					5,397
28.19	Hot Melches Shop		15					2	17		17					464
28.20	M.M.O. Building		157					24	181		181					3,463
28.21	Miscellaneous Site Foundations		315					47	362		362					7,228
28.22	Miscellaneous Site Structures		911					137	1,047		1,047					20,240
28.23	New Covered Walkway		6					1	7		7					146
28.24	New Misc Structures		45					7	52		52					1,362
28.25	Oil Separator and Waste Tank		2					0	2		2					48
28.26	Rachasse		1,115					167	1,283		1,283					24,007
28.27	Refractive Drum Storage		154					23	177		177					3,857
28.28	Refractive Storage Building		83					12	95		95					2,382
28.29	Security/Quarantoon		35					5	40		40					672
28.30	Site Diesel Generator		3					0	3		3					60
28.31	Support Complex - Tool Room		24					4	27		27					695
28.32	Turbine Building		2,552					383	2,935		2,935					87,807
28.33	Turbine Pedestal		591					83	633		633					10,928
28.34	Waste Water Treatment		15					2	16		16					438
28 Totals			15,322					2,298	17,621		17,621					369,341
Site Closeout Activities																
29	Remove Rubble		5,308					798	6,104		6,104					12,575
30	Grade & landscape site		1,328					199	1,527		1,527					8,028
31	Final report to NRC						156	23	179		179					
	Subtotal Period 6 Activity Costs		21,959				156	3,317	25,432	179	25,253					359,944
Period 6 Undistributed Costs																
1	Insurance						92	9	101		101					
2	Property taxes						132	13	145		145					

TABLE C-3
WOLF CREEK GENERATING STATION
ENTOMBMENT, DECOMMISSIONING COST ESTIMATE
(Thousands of 1989 Dollars)

Columns may not add due to rounding

ID Number	Activity Description	Decon	Remove	Pack	Ship	Burial	Other	Contingency	Total	NRC		LLW site		GTCC		Craft Labor Hours	
										Lit-Term	Restore	A CF	B CF	CF	CF		
Period 6 Undistributed Costs (continued)																	
3	Heavy equipment rental	-	3,047	-	-	-	-	457	3,504	-	3,504	-	-	-	-	-	-
4	Small tool allowance	-	122	-	-	-	-	16	141	-	141	-	-	-	-	-	-
5	Plant energy budget	-	-	-	-	-	62	6	71	-	71	-	-	-	-	-	-
6	Site Security Cost	-	-	-	-	-	1,065	160	1,225	-	1,225	-	-	-	-	-	-
	Subtotal Undistributed Costs Period 6	-	3,169	-	-	-	1,351	667	5,186	101	5,085	-	-	-	-	-	-
Staff Costs																	
	DOC Staff Cost	-	-	-	-	-	6,960	1,344	10,304	-	10,304	-	-	-	-	-	-
	Utility Staff Cost	-	-	-	-	-	5,031	755	5,785	5,207	576	-	-	-	-	-	-
	TOTAL PERIOD 6	-	25,128	-	-	-	16,497	6,083	48,708	6,447	41,231	-	-	-	-	-	389,944
	TOTAL COST TO DECOMMISSION	7,639	72,478	6,711	3,111	119,830	366,330	105,825	671,044	622,471	48,573	216,644	864	849	649	1,631,227	
Total cost to decommission with 18.72% contingency: \$ 671,043,756																	
Total NRC license termination cost is 92.76% or \$ 622,471,086																	
Non-nuclear demolition cost is 7.24% or \$ 48,572,650																	
Total LLW site radioactive volume buried 229,696 cubic feet																	
Total 10CFR61 greater than class C volume buried 649 cubic feet																	
Total scrap metal released from Callaway Plant 32,290 tons																	
Total craft labor requirements 1,631,227 person hours																	

Note: "0" indicates costs less than \$500

Note 1: This activity is performed by the decommissioning staff following plant shutdown; the costs for this are included in this period's staff cost.

Note 2: This activity, while performed after final plant shutdown, is considered part of operations and therefore no decommissioning costs are included for this activity.