UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

PDR

CHAIRMAN

August 10, 1988

The Honorable George J. Hochbrueckner
United States House of Representatives
Washington, D. C. 20515

Dear Congressman Hochbrueckner:

I am responding to your letter of August 2, 1988, concerning the possible decommissioning of the Shoreham Nuclear Power Station.

You asked what is required by the NRC in order to complete the transfer of Long Island Lighting Company (LILCO) licenses or permits relating to Shoreham to the State of New York. Our regulatory control over a transfer of Shoreham to the State of New York will depend on the exact nature of the transaction involved. NRC has no application for transfer before it, so I cannot give you a specific answer to your question. However, I can describe what our requirements are in general terms.

Under the Atomic Energy Act (Sec. 101), no one within the United States may transfer, acquire, possess, or operate a power reactor except in accordance with a license issued by the Commission. When ownership of a licensed facility is transferred from a licensee to another person, the other person requires a license from NRC. Similarly, if operation (or any other act of possession or use) of the facility is to be undertaken by a person or organization other than the organization licensed to operate the facility, the new "operating organization" requires a license from NRC.

Sec. 184 of the Act provides also that no license and no right under any license may be transferred, assigned, or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, unless the Commission gives its consent in writing. This requirement is reflected in 10 CFR 50.80. We have had instances in which the facility remained in the ownership or possession of the original licensee but where, through corporate restructuring, control of the licensee was transferred to another corporation, such as a holding company. Such a transfer of control requires NRC approval under 10 CFR 50.80.

In the event that a licensee intends to terminate operation and decommission a facility, the licensee must apply to the Commission under 10 CFR 50.82 (see 53 FR 24051-24052, June 27,

DF01
1/1

1988) for authority to do so and obtain Commission approval of the licensee's proposed decommissioning plan. Under §50.82(f), the Commission will terminate the license if it determines that decommissioning has been performed in accordance with the approved decommissioning plan and the Commission's order authorizing decommissioning. A terminal radiation survey must also demonstrate that the facility and site are suitable for release for unrestricted use.

The NRC has not performed a detailed cost estimate for decommissioning the Shoreham Nuclear Power Station. However, we are enclosing the results of a study performed by Battelle's Northwest Laboratory for the NRC which estimates decommissioning costs for a reference 1100 MW(e) boiling water reactor. Our estimate based on this study is that decommissioning costs for plants of the Shoreham type, considering the limited operating history, would range between 65 and 105 million dollars. This estimate does not include costs associated with disposal of the irradiated fuel, site restoration, contingencies, or personnel termination. To include these and other site specific costs for a more comprehensive NRC cost estimate would require considerable expenditure of staff resources. These resources have not been expended because LILCO, in its June 1, 1988 letter to NRC, indicated its intent and desire to continue to pursue licensing of Shoreham until all contingencies in the LILCO/New York State agreement have been satisfied.

I trust this information is responsive to your request.

Sincerely,

Lando W. Zech, Jr.

Lando W. Zech, Jr.

Enclosure:
As Stated

NUREG/CR-0672
Addendum 3
1D

Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station

Technical Support for Decommissioning Matters Related to Preparation of the Final Decommissioning Rule

Manuscript Completed: May 1988
Date Published: June 1988

Prepared by G. J. Konzek, R. I. Smith

Pacific Northwest Laboratory
Richland, WA 99352

Prepared for
Materials Branch
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
NRC FIN No. B2902

ACKNOWLEDGMENTS

The authors wish to acknowledge and thank the following utility contacts who provided information that was essential to the completion of this project: Roy Keck, Art D. Kohler, David L. Whitcomb, and William C. Wolkenhauer, all of the Washington Public Power Supply System. Only through their assistance and cooperation was it possible to complete this project.

Programmatic guidance for the project was provided by Dr. Carl Feldman of the Nuclear Regulatory Commission. His input contributed significantly to the successful completion of this project.

The editorial review prior to publication was provided by David R. Payson, Pacific Northwest Laboratory.

FOREWORD
BY
NUCLEAR REGULATORY COMMISSION STAFF

The Nuclear Regulatory Commission (NRC) staff is reappraising its regulatory position relative to the decommissioning of nuclear facilities.[1] As part of this activity, the NRC has initiated two series of studies through technical assistance contracts. These contracts are being undertaken to develop information to support the preparation of new standards covering decommissioning.

The first series of studies covers the technology, safety, and costs of decommissioning reference nuclear facilities.[2-23] Light water reactors (LWRs) and fuel-cycle and nonfuel-cycle facilities are included. Facilities of current design on typical sites are selected for the studies. Separate reports are prepared as the studies of the various facilities are completed.

The second series of studies covers supporting information on the decommissioning of nuclear facilities.[24-28] This series includes an annotated bibliography on decommissioning and studies on facilitation and radiation survey methods appropriate for decommissioning, as well as an examination of regulations applicable to decommissioning.

This report contains information concerning technical support provided by Pacific Northwest Laboratory staff for decommissioning matters related to preparation of the final Decommissioning Rule by the NRC staff.

The information provided in this report on decommissioning of a reference BWR, including any comments, will be included in the record for consideration by the Commission in establishing criteria and new standards for decommissioning. Comments on this report should be mailed to:

Chief
Materials Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

REFERENCES

1. Plan for Reevaluation of NRC Policy on Decommissioning of Nuclear Facilities. 1978. NUREG-0436, REV. 1, Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C.

2. Technology, Safety and Costs of Decommissioning a Reference Nuclear Fuel Reprocessing Plant. 1977. NUREG-0278, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

3. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station. 1978. NUREG/CR-0130, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

4. Technology, Safety and Costs of Decommissioning a Reference Small Mixed Oxide Fuel Fabrication Plant. 1979. NUREG/CR-0129, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

5. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station. 1979. NUREG/CR-0130 Addendum, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

6. Technology, Safety and Costs of Decommissioning a Reference Low-Level Waste Burial Ground. 1980. NUREG/CR-0570, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

7. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. 1980. NUREG/CR-0672, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

8. Technology, Safety and Costs of Decommissioning a Reference Uranium Fuel Fabrication Plant. 1980. NUREG/CR-1266, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

9. Technology, Safety and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilities. 1981. NUREG/CR-1754, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

10. Technology, Safety and Costs of Decommissioning a Reference Low-Level Waste Burial Ground. 1981. NUREG/CR-0570 Addendum. U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

11. Technology, Safety and Costs of Decommissioning a Reference Uranium Hexafluoride Conversion Plant. 1981. NUREG/CR-1757, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

12. Technology, Safety and Costs of Decommissioning Nuclear Reactors at Multiple-Reactor Stations. 1982. NUREG/CR-1755, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

13. Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors. 1982. NUREG/CR-1756, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

14. Technology, Safety and Costs of Decommissioning Reference Light Water Reactors Following Postulated Accidents. 1982. NUREG/CR-2601, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

15. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station. 1983. NUREG/CR-0130, Addendum 2, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

16. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. 1983. NUREG/CR-0672, Addendum 1, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

17. Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors. 1983. NUREG/CR-1756 Addendum, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

18. Technology, Safety and Costs of Decommissioning Reference Independent Spent Fuel Storage Installations. 1984. NUREG/CR-2210, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

19. Technology, Safety and Costs of Decommissioning Reference Nuclear Fuel Cycle and Non Fuel Cycle Facilities Following Postulated Accidents. 1985. NUREG/CR-3293, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

20. Technology, Safety and Costs of Decommissioning Nuclear Reactors at Multiple-Reactor Stations. 1985. NUREG/CR-1755, Addendum 1, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

21. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station - Classification of Decommissioning Wastes. 1984. NUREG/CR-0130, Addendum 3, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

22. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station - Classification of Decommissioning Wastes. 1984. NUREG/CR-0672, Addendum 2, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

23. Technology, Safety and Costs of Decommissioning Reference Nuclear Fuel Cycle Facilities - Classification of Decommissioning Wastes. 1986. NUREG/CR-4519, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

24. Decommissioning of Nuclear Facilities - An Annotated Bibliography. 1979. NUREG/CR-0130, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

25. Decommissioning of Nuclear Facilities - A Review and Analysis of Current Regulations. 1979. NUREG/CR-0671, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

26. Facilitation of Decommissioning of Light Water Reactors. 1979. NUREG/CR-0569, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

27. Monitoring for Compliance with Decommissioning Termination Survey Criteria. 1981. NUREG/CR-2082, U.S. Nuclear Regulatory Commission Report by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

28. Technology and Cost of Termination Surveys Associated with Decommissioning of Nuclear Facilities. 1982. NUREG/CR-2241, U.S. Nuclear Regulatory Commission Report by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

ABSTRACT

Preparation of the final Decommissioning Rule by the Nuclear Regulatory Commission (NRC) staff has been assisted by Pacific Northwest Laboratory (PNL)[a] staff familiar with decommissioning matters. These efforts have included updating previous cost estimates developed during the series of studies on conceptually decommissioning reference licensed nuclear facilities for inclusion in the Final Generic Environmental Impact Statement (FGEIS) on decommissioning; documenting the cost updates; evaluating the cost and dose impacts of post-TMI-2 backfits on decommissioning; developing a revised scaling formula for estimating decommissioning costs for reactor plants different in size from the reference boiling water reactor (BWR) described in the earlier study; and defining a formula for adjusting current cost estimates to reflect future escalation in labor, materials, and waste disposal costs.

This report presents the results of recent PNL studies to provide supporting information in three areas concerning decommissioning of the reference BWR:

- updating the previous cost estimates to January 1986 dollars
- assessing the cost and dose impacts of post-TMI-2 backfits
- developing a scaling formula for plants different in size than the reference plant and an escalation formula for adjusting current cost estimates for future escalation.

(a) Operated for the U.S. Department of Energy by Battelle Memorial Institute.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Preparation of the final Decommissioning Rule by the NRC staff has been assisted by PNL staff familiar with decommissioning matters. These efforts have included updating previous cost estimates developed during the series of studies on conceptually decommissioning reference licensed nuclear facilities for inclusion in the Final Generic Environmental Impact Statement (FGEIS) on Decommissioning; documenting the cost updates; evaluating the cost and dose impacts of post-TMI-2 backfits on decommissioning; developing a revised scaling formula for estimating decommissioning costs for reactor plants different in size from the reference boiling water reactor (BWR) described in the earlier study;(1) and defining a formula for adjusting current cost estimates to reflect future escalation in labor, materials, and waste disposal costs.

This report presents the results of recent PNL studies to provide supporting information in the following three areas concerning decommissioning of the reference BWR:

- updating the previous cost estimates to January 1986 dollars
- assessing the cost and dose impacts of post-TMI-2 backfits
- developing a scaling formula for plants different in size than the reference plant and an escalation formula for adjusting current cost estimates for future escalation.

For consistency, the analyses for the impact of post-TMI-2 backfits follow the same basic structure, content, and study approach delineated in the original BWR study.(1)

Because of rising costs and a changing regulatory climate, the NUREG/CR-0672 generic cost estimates, originally developed in 1978 dollars, were updated to reflect 1984 cost conditions in a report prepared by PNL for the Electric Power Research Institute.(2) Using the new cost estimates as a base, revised generic cost estimates were developed for several alternatives identified to increase decommissioning costs, including additional licensing fees and extra staff to keep personnel radiation exposure below 5 rem/year.

In addition to the EPRI cost update, two addendums(3,4) to the original BWR report (NUREG/CR-0672) have been prepared which examined the effects on costs and safety of decommissioning plants 1) of being unable to dispose of wastes offsite and 2) of classifying the wastes resulting from decommissioning. This third addendum, which examines the topics listed above, was prepared in support of the FGEIS on Decommissioning and the final Decommissioning Rule.

Following this introductory chapter, a summary of the information and findings concerning the three areas of interest to this study is presented in Chapter 2. Chapter 3 contains the supporting information associated with updating the previous cost estimates to January 1986 dollars. The assessment of the cost and dose impacts of post-TMI-2 backfits on decommissioning the reference BWR is given in Chapter 4. The methodology used to develop scaling and escalation formulae for the Decommissioning Rule is presented in Chapter 5. Two appendixes to the report provide supporting information for cost updating bases and methodology (Appendix A) and revised assumptions and formulae for estimating costs as a function of plant size (Appendix B).

1.1 REFERENCES

1. H. D. Oak, G. M. Holter, W. E. Kennedy, and G. J. Konzek. 1980. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

2. R. I. Smith, G. J. Konzek, E. S. Murphy, and H. K. Elder. 1985. Updated Costs for Decommissioning Nuclear Power Facilities. EPRI NP-4012, Electric Power Research Institute Report by Pacific Northwest Laboratory, Richland, Washington.

3. G. M. Holter and E. S. Murphy. 1983. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, Addendum 1, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

4. E. S. Murphy. 1984. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, Addendum 2, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

2.0 SUMMARY

The results of this study sponsored by the U.S. Nuclear Regulatory Commission (NRC) to provide technical support for decommissioning matters related to preparation of the Final Decommissioning Rule are summarized in this chapter. The purpose of this study is to provide supporting information related to decommissioning a reference boiling water reactor (BWR), as described previously in NUREG/CR-0672. The three areas considered in this report are:

- updating the previous cost estimates to January 1986 dollars
- assessing the cost and dose impacts of post-TMI-2 backfits
- developing a scaling formula for plants different in size than the reference plant and an escalation formula for adjusting current cost estimates for future escalation.

The principal results are given, in brief, in the following paragraphs, with more complete summaries presented in subsequent sections.

Immediate dismantlement of the reference BWR is estimated to cost $131.8 million (in January 1986 dollars) under the utility-plus-contractor option or $108.9 million under a utility-only option.

Preparing the reference BWR for safe storage, safe storage for 30 years, and dismantlement after 30 years is estimated to cost a total of $131.4 million (in January 1986 dollars). Continuing care during the safe storage period is estimated to cost $120,000 per year and would continue until the facility is dismantled. The cost of deferred dismantlement, starting after intervals of 10, 30, 50 and 100 years after final shutdown, has been estimated in January 1986 dollars to be $82.2 million, $82.2 million, $48.3 million and $48 million, respectively.

Entombing the reference BWR after removing the highly activated reactor vessel internals is estimated to cost $112.8 million (in January 1986 dollars) under the utility-plus-contractor option. Entombing the reference BWR with the highly activated reactor vessel internals left in place is estimated to cost $96.9 million under the utility-plus-contractor option.

Costs of continuing care during entombment of the reference BWR are estimated to be $64,000 per year. Federal and state licensing/inspection costs are estimated to cost an additional $10,000 per year. These costs would continue until either the radioactivity can be shown to have decayed to unrestricted release levels, or until the facility is dismantled should an earlier release of the property become necessary.

No detailed estimates of cost and radiation dose are made for dismantlement of an entombed facility. However, it is anticipated that these parameters will have values similar to those for dismantlement following safe storage.

The removal, packaging, and shipment of equipment and materials that were installed in the reference plant subsequent to the TMI-2 accident and which became radioactive and/or contaminated while in service are estimated to result in additional radiation doses of about 3.1 man-rem to decommissioning workers during immediate dismantlement. The original immediate dismantlement decommissioning cost estimate could be expected to increase only slightly overall (less than 1% in January 1986 dollars), due to the slightly expanded scope of decommissioning activities associated with changes in the reference plant's characteristics.

An important part of the Decommissioning Rule developed by the NRC related to commercial power reactors is the section dealing with assurance that funds will be available for decommissioning when the time comes to accomplish that effort. The NRC has placed into the Rule a formula for estimating the amount of funds required to provide reasonable assurance of adequate funding as a function of the power rating of the reactor. Since the actual date of decommissioning for most plants is as yet undefined, an additional formula has been developed for adjusting that cost estimate to include escalation from the time the Rule was issued to the time of actual decommissioning.

2.1 STUDY BASES

For consistency, the major study bases are the same as those used in the original BWR decommissioning studies with two exceptions: 1) costs are in January 1986 dollars, and 2) occupational radiation doses to decommissioning workers shall not exceed 5 rem per person per year. It should be recognized that revisions to 10 CFR 20.101 since NUREG/CR-0672 was published in 1980 have tended to reduce annual cumulative radiation dose allowable to persons working in the nuclear industry. Under normal circumstances, the allowable quarterly radiation dose is now 1 - 1/4 rem (rather than the 3 rem per quarter dose postulated in NUREG/CR-0672 for decommissioning workers), with an annual cumulative dose of 5 rem.

2.2 UPDATED DECOMMISSIONING COSTS

All costs are given in terms of January 1986 dollars, with 25% contingencies included.

The total cost in January 1986 dollars for each of the decommissioning alternatives is summarized in Table 2.1. In addition to the values escalated from the parent documents, the costs in Table 2.1 reflect several new cost adders (i.e., predecommissioning engineering, additional staff to assure meeting the 5 rem/year dose limit for personnel, extra supplies for the additional staff, and the additional costs associated with the option of using an external contractor to conduct the decommissioning effort). These cost adders, initially developed in a PNL decommissioning cost update done in 1984 for the Electric Power Research Institute (EPRI NP-4012), are included in this analysis. Furthermore, the estimated impacts on the decommissioning cost of post-TMI-2 backfit requirements for the reference BWR, described in Chapter 4, are included in the overall totals shown in the table, where applicable.

TABLE 2.1. Summary of Updated Decommissioning Costs Estimated for the Reference BWR(a,b)

Decommissioning Option	Estimated Costs in Millions of 1986 Dollars							
	Decontamination	Preparations for Safe Storage	SAFSTOR(c)				ENTOMB(d)	
			10 Years	30 Years	50 Years	100 Years	Internals Included(e)	Internals Removed
Utility-Only (Internal) Staffing	100.9	41.0	120.8	131.4	99.9	106.1	77.3	89.6
Utility-Plus-Contractor (External) Staffing	131.8	50.9	--	--	--	--	96.9	112.8

(a) Values include the cost adders described in Section 2.2 and the effects of TMI-2 backfits, plus a 25% contingency, and are in January 1986 dollars.

(b) Values exclude cost of disposal of last core, exclude cost of demolition of nonradioactive structures, and exclude cost of deep geologic disposal of dismantled, highly activated components.

(c) The values shown for SAFSTOR include the costs of the preparations for safe storage, continuing care, and deferred dismantlement.

(d) The cost of surveillance and maintenance for the entombed structure is estimated to be about $0.064 million per year. Values listed do not include any costs for post-entombment period actions.

(e) Does not include the costs associated with the eventual removal, packaging, and disposal of the entombed radioactive materials, the demolition of the entombment structure, or demolition of the reactor building.

2.3 ESTIMATED IMPACTS OF POST-TMI-2 BACKFIT REQUIREMENTS ON THE ESTIMATED COST AND DOSE OF DECOMMISSIONING THE REFERENCE BWR

Since the original BWR decommissioning report was prepared, a number of post-TMI-2 backfit requirements have been imposed on operating nuclear power stations. These requirements were actions judged necessary by the NRC to correct or improve the safety of operation of nuclear power plants based on the experience from the accident at TMI-2. The results of analyses to examine and assess, in quantitative terms, the impact on estimated occupational doses and on decommissioning costs for all NRC-initiated post-TMI-2 plant modifications imposed on the previously studied reference BWR are summarized in the following subsections.

2.3.1 Estimated Additional Decommissioning Costs

The total additional cost in January 1986 dollars for each of the decommissioning alternatives is summarized in Table 2.2.

2.3.2 Radiation Exposure Estimates

The additional accumulated occupational radiation doses are estimated to be 3.1 man-rem for immediate dismantlement and for entombment, and about 0.28 man-rem for placing the facility in safe storage, with essentially no increase in occupational radiation dose for surveillance and maintenance staff during continuing care. Relatively little additional reduction in accumulated occupational radiation dose is estimated to result from deferring the dismantlement sequence beyond 30 years for those items identified in this backfit assessment, and virtually no reduction results from deferment beyond 50 years.

TABLE 2.2. Total Estimated Additional Costs for Possible Decommissioning Alternatives for the Reference BWR

Decommissioning Alternative	Additional Decommissioning Costs ($ thousands)[a] Number of Years After Shutdown Dismantlement is Deferred				
	0	10	30	50	100
Immediate Dismantlement	101	--	--	--	--
Preparations for:					
Safe Storage	3.8	3.8	3.8	3.8	3.8
Continuing Care	--	--	--	--	--
Deferred Dismantlement	--	58.9	58.9	3.8[b]	3.8[b]
Total Additional Cost	--	62.7	62.7	7.6	7.6
Entombment	101	101	101	101	101
Continuing Care	--	--	--	--	--
Deferred Dismantlement	--	--	--	--	--
Total Additional Cost	--	101	101	101	101[c]

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) These reduced values result from lesser amounts of contaminated materials for burial in a licensed disposal site.
(c) It is assumed that the entombed radioactive material decays to the unrestricted release level in 100 years.

The individual estimates of additional external occupational, transport, and public radiation doses for the various decommissioning alternatives are summarized in Table 2.3. The radiation dose rates are based on the maximum allowable dose rates for each shipment in exclusive-use trucks, just as analyzed in the parent study, and are thus conservatively high. The estimated additional external radiation dose for routine transportation operations for immediate dismantlement is 0.07 man-rem to transport workers and 0.007 man-rem to the general public.

Based on this study, there are no additional radiation doses to workers or to the public during the preparations for safe storage, since no additional truck shipments are contemplated.

2.3.3 Conclusions from the Backfit Analysis

The changes at the reference BWR that have resulted to date, as well as those changes anticipated to result from full implementation of post-TMI-2 regulatory requirements, will have only a minor impact on decommissioning

TABLE 2.3. Summary of Estimated Additional External Occupational, Transport, and Public Radiation Doses for Decommissioning the Reference BWR

Decommissioning Mode	Time After Reactor Shutdown (Years)	Estimated Additional Dose (man-rem)		
		Occupational	Transport Workers[a]	Public[a]
Immediate Dismantlement[b]	0	3.06	0.070	0.007
Safe Storage:[c]				
Preparations for Safe Storage[b]	0	0.28	0	0
Continuing Care	10	0	0	0
	30	0	0	0
	50	0	0	0
	100	0	0	0
Deferred Dismantlement	10	0.82	0	0
	30	0.06	0	0
	50	<0.005	0	0
	100	<0.00001	0	0
Total for Safe Storage[c] with Deferred Dismantlement in year:	10	1.1	0	0
	30	0.34	0	0
	50	0.29	0	0
	100	0.28	0	0

(a) Based on the radiation doses per shipment delineated in Table N.5-2 in NUREG/CR-0672.
(b) Total additional shipments: 1 for immediate dismantlement; zero for safe storage.
(c) Safe Storage consists of three phases: preparations for safe storage, continuing care, and deferred dismantlement.

costs and occupational radiation doses for that facility. For any given plant, however, site-specific issues will have to be addressed to assess the actual impact of the backfits on decommissioning.

One unexpected result of this assessment is the identification of the positive effect that the Technical Support Centers (TSCs), required in the aftermath of TMI-2, will eventually have on decommissioning activities. TSCs are required to provide up-to-date, as-built drawings for the purpose of emergency preparedness. The availability and use of those drawings will facilitate planning and preparation of decommissioning activities and subsequently will support implementation of those activities.

A number of plant modifications have been made for which no specifics could be obtained (and thus no quantification of potential impacts on decommissioning could be made). These modifications pertain to safeguards and/or plant security areas or equipment, and this type of information is not available without appropriate need-to-know. However, it is unlikely that these modifications would have any significant effect on the safety or cost of decommissioning.

2.4 SCALING AND ESCALATION FORMULAE DEVELOPED FOR THE DECOMMISSIONING RULE

The formulae for evaluating financial assurance for decommissioning that the NRC has placed into the Decommissioning Rule are summarized in this section.

The formulae for estimating decommissioning costs incorporate the effects of post-TMI-2 backfits, as documented in Chapter 4 of this report, and account for the situations when the utility employs an external decommissioning contractor and when the utility acts as its own decommissioning contractor. These formulae were developed using data from plants ranging in size from about 1200 MW_t to 3400 MW_t. The formula appearing in the Rule for the utility-plus-contractor option is:

Estimated BWR Decommissioning Cost = 104 + 0.009 MW_t (millions January 1986$)

where the cost for plants smaller than 1200 MW_t is set equal to the cost for a 1200-MW_t plant, and the cost for plants larger than 3400 MW_t is set equal to the cost for a 3400-MW_t plant.

This formula provides reasonable cost estimates for immediate dismantlement of reactor plants that are smaller than the reference plant examined in the original BWR decommissioning analysis (NUREG/CR-0672). Since immediate dismantlement (DECON) is generally the more expensive of the acceptable decommissioning possibilities, if funds for DECON are available, the other possibilities are also covered.

As a result of performing several cost updates over the years since 1978 (the most recent update is given in Chapter 3 of this report), it became apparent that the total cost could be divided into three principal components, as regards to cost escalation. These components are:

- Labor and other components that escalate at the same rate as labor
- Energy: electricity, fuel, and other components that escalate at the same rate as energy
- Waste Disposal: handling and burial charges at a low-level waste disposal site.

Assuming that the escalation factors for each of these components can be derived for any point in the future, relative to the 1986 data base used in the aforementioned formula used in the Decommissioning Rule, then the escalated decommissioning cost is given by:

$$\text{Estimated Cost (year X)} = \text{January 1986 Cost } (0.65\ L_x + 0.13\ E_x + 0.22\ B_x)$$

where L_x is the escalation factor for labor and related components between January 1986 and year X, E_x is the escalation factor for energy over the same period, and B_x is the escalation factor for waste disposal over the same period. L_x and E_x are to be based on regional data of the U.S. Department of Labor's Bureau of Labor Statistics. The waste disposal factor, B_x, is to be taken from NUREG-1307, a report that will be developed especially for this purpose and will contain the bases and the derived escalation factors for each disposal site operating in the U.S. at the time of issue. The report will be updated and reissued on some reasonable frequency, to provide reliable factors at any point in time.

3.0 COST UPDATING BASES, METHODOLOGY AND RESULTS

The cost adjustment factors used to update the decommissioning costs for the reference BWR to a January 1986 cost base for the Final Generic Environmental Impact Statement (FGEIS) on Decommissioning are described in detail in Appendix A of this report. The results of the application of the cost adjustment factors given in Appendix A are presented in this chapter.

3.1 APPLICATION METHODOLOGY

The application methodology consisted of a detailed review of all elements that make up each of the major cost categories given in the parent document[1] for the three decommissioning alternatives--immediate dismantlement (DECON), safe storage (SAFSTOR), and entombment (ENTOMB). The appropriate cost adjustment factors were then applied to the respective line items and the items were added to form updated cost categories for each of the decommissioning alternatives. In addition to the values escalated from the parent document, several new cost adders were included in the update. These were: predecommissioning engineering; additional staff to assure meeting the 5 rem/year dose limit for personnel; extra supplies for the additional staff; and the additional costs associated with the option of using an external contractor to conduct the decommissioning effort. These cost adders were developed in the PNL decommissioning cost update done in 1984 for the Electric Power Research Institute.[2] Furthermore, the estimated impacts of post-TMI-2 requirements on the reference BWR decommissioning costs, described in Chapter 4, are included in the overall cost update. In each case, a 25% contingency is applied to the sum of the categories to establish the estimated costs of decommissioning the reference BWR in January 1986 dollars.

3.2 ESTIMATED DECOMMISSIONING COSTS

Immediate dismantlement of the reference BWR is estimated to cost $131.8 million under the utility-plus-contractor option. The major contributors to the total cost of immediate dismantlement are summarized in Table 3.1. The cost for shipment and disposal of radioactive materials is about 34% of the total decommissioning cost. About 30% of the total decommissioning cost is due to utility staff labor (i.e., the cost categories of Staff Labor plus Additional Staff Needed to Reduce Average Annual Dose to 5 rem per year, shown in Table 3.1). Approximately 22% of the total decommissioning cost is due to the use of an external decommissioning contractor. Energy, supplies, and special tools and equipment costs constitute about 7%, 3%, and 3%, respectively, of the total dismantlement cost.

Preparing the reference BWR for safe storage is estimated to cost $50.9 million under the utility-plus-contractor option. The major contributors to the total cost of preparations for passive safe storage are summarized in Table 3.2. About 44% of the total cost of preparations for safe storage is

TABLE 3.1. Summary of Estimated Costs for Immediate Dismantlement of the Reference BWR (millions of 1986 dollars)

Cost Category	Estimated Costs ($ millions)[a,b]		Percent of Total
Disposal of Radioactive Materials			
Activated Materials Disposal	7.248		
Contaminated Internals Disposal	23.483		
Radioactive Waste Disposal[c]	4.549		
Total Disposal Costs		35.280	33.5
Staff Labor		28.098	26.7
Energy		7.071	6.7
Special Tools and Equipment		3.226	3.1
Miscellaneous Supplies		2.974	2.8
Specialty Contractors		0.570	0.5
Nuclear Insurance		1.520	1.4
License Fees		0.112	0.1
Cost Adders[d]			
Additional Staff Needed to Reduce Average Annual Dose to 5 rem/year		3.520	3.3
Use of External Decommissioning Contractor		16.880	16.0
Predecommissioning Engineering by an External Contractor		5.920	5.6
Supplies for Extra Staff		0.160	0.2
Post-TMI-2 Impacts by an External Contractor		0.080	0.1
Subtotal		105.411	100.0
25% Contingency		26.353	
Total, Immediate Dismantlement Costs		131.764	

(a) Costs adjusted to January 1986.
(b) Number of figures shown is for computational accuracy and does not imply precision to the nearest thousand dollars.
(c) Includes both wet solid wastes and dry solid wastes.
(d) See text for details concerning this category.

TABLE 3.2. Summary of Estimated Costs for Preparations for Safe Storage of the Reference BWR (millions of 1986 dollars)

Cost Category	Estimated Costs ($ millions)(a,b)	Percent of Total
Disposal of Radioactive Materials	3.757	9.2
Staff Labor	18.006	44.2
Energy	4.229	10.4
Special Tools and Equipment	0.562	1.4
Miscellaneous Supplies	2.178	5.4
Specialty Contractors	0.314	0.8
Nuclear Insurance	0.950	2.3
License Fees	0.084	0.2
Cost Adders(c)		
Additional Staff Needed to Reduce Average Annual Dose to 5 rem/year	0	0
Use of External Decommissioning Contractor	7.040	17.3
Predecommissioning Engineering by an External Contractor	3.600	8.8
Supplies for Extra Staff	0	0
Post-TMI-2 Impacts by an External Contractor	Negligible	--
Subtotal	40.720	100.0
25% Contingency	10.180	
Total, Preparations for Safe Storage Costs	50.900	

(a) Costs adjusted to January 1986.
(b) Number of figures shown is for computational accuracy and does not imply precision to the nearest thousand dollars.
(c) See text for details concerning this category.

due to utility staff labor. The external contractor contributes about 26% of the total cost. Disposal of radioactive wastes, energy, and supplies contribute about 9.2%, 10.4%, and 5.4%, respectively, to the total cost.

The cost of continuing care during safe storage of the reference BWR is estimated tc be about $120,000 per year.

The cost of deferred dismantlement, starting after intervals of 10, 30, 50 and 100 years after final reactor shutdown, is estimated in January 1986 dollars to be $82.2 million, $82.2 million, $48.3 million and $48 million, respectively. The lesser cost after 100 years is the result of having less contaminated material for packaging, shipment, and burial due to decay of the residual radionuclides.

Entombing the reference BWR via the scenario that calls for the remova and disposal of reactor vessel internals is estimated to cost $112.8 million under the utility-plus-contractor option. The major contributors tc the total cost of entombment are summarized in Table 3.3. About 34% of the total is due to utility staff labor (i.e., the cost categories of Staff Labor plus Additional Staff Needed to Reduce Average Annual Dose to 5 mrem per year, shown in Table 3.3). The external contractor labor accounts for about 26% of the total cost for this scenario. Disposal of radioactive materials, energy, and special tools and equipment contribute 22.8%, 8.4%, and 3.6%, respectively, to the total cost.

With the reactor internals left in place, which is really a form of hardened safe storage, entombment of the reference BWR is estimated to cost about $97 million (see Table 3.3).

The cost of continuing care during entombment of the reference BWR is estimated to be about $74,000 per year for either or the aforementioned scenarios, which includes an estimated $10,000 per year for various federal and state licensing/inspection costs.

Because of the many variables involved, PNL made no firm estimate of the costs for possible deferred dismantlement of the entombment structure. However, these costs are anticipated to be at least of the same order of magnitude as those discussed previously for deferred dismantlement of the reference BWR after a period of safe storage.

TABLE 3.3. Summary of Estimated Costs for Entombment of the Reference BWR (millions of 1986 dollars)

Cost Category	Entombment (with internals) Estimated Costs ($ millions)(a,b)	Entombment (with internals) Percent of Total	Entombment (internals removed)(c) Estimated Costs ($ millions)(a,b)	Entombment (internals removed)(c) Percent of Total
Disposal of Radioactive Materials				
Neutron-Activated Materials	N/A		7.259	
Contaminated Materials	9.491		8.796	
Radioactive Wastes(d)	4.549		4.549	
Total Disposal Costs	14.040	18.1	20.604	22.8
Staff Labor	27.198	35.1	26.952	32.1
Energy	7.557	9.7	7.557	8.4
Special Tools and Equipment	1.388	1.8	3.226	3.6
Miscellaneous Equipment	2.974	3.8	2.974	3.3
Specialty Contractors	0.275	0.4	0.275	0.3
Nuclear Insurance	1.520	2.0	1.520	1.7
License Fees	0.086	0.1	0.066	0.1
Cost Adders(e)				
Additional Staff Needed to Reduce Average Annual Dose to 5 rem/year	2.160	2.8	1.840	2.0
Use of External Decommissioning Contractor	14.240	18.4	17.040	18.9
Predecommissioning Engineering by an External Contractor	5.920	7.6	6.000	6.6
Supplies for Extra Staff	0.080	0.1	0.080	~0.1
Post-TMI-2 Impacts by an External Contractor	0.080	0.1	0.080	~0.1
Subtotals	77.516	100.0	90.234	100.0
25% Contingencies	19.379		22.559	
Total, Entombment Costs	96.895		112.793	
Annual Continuing Care Costs	0.074		0.074	

(a) Costs adjusted to January 1986.
(b) Number of figures shown is for computational accuracy and does not imply precision to the nearest thousand dollars.
(c) For this entombment scenario, dismantlement will eventually be required.
(d) Includes both wet solid wastes and dry solid wastes.
(e) See text for details concerning this category.

3.3 REFERENCES

1. H. D. Oak, G. M. Holter, W. E. Kennedy, and G. J. Konzek. 1980. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

2. R. I. Smith, G. J. Konzek, E. S. Murphy, and H. K. Elder. 1985. Updated Costs for Decommissioning Nuclear Power Facilities. EPRI NP-4012, Electric Power Research Institute Report by Pacific Northwest Laboratory, Richland, Washington.

4.0 ESTIMATED IMPACTS OF POST-TMI-2 REQUIREMENTS AND OTHER SELECTED REGULATORY CHANGES ON DECOMMISSIONING OF THE REFERENCE BOILING WATER REACTOR

Since the original BWR decommissioning report(1) was prepared, a number of post-TMI-2 backfit requirements have been imposed on operating nuclear power stations. These requirements were actions judged necessary by the NRC to correct or improve the safety of operation of nuclear power plants based on the experience from the accident at TMI-2.

Examined and assessed in quantitative terms in this chapter are all NRC-initiated post-TMI-2 plant modifications imposed on the previously studied reference BWR, whether mandated (as in a rule, regulation, or order) or committed to by the licensee (originating in a generic letter or IE Bulletin, for example), for their impact on estimated decommissioning costs and occupational radiation doses. The purpose of this examination was to provide the NRC decision-makers with pertinent information concerning the effects of those backfit requirements and associated regulatory changes on decommissioning. The results of these analyses also make a useful addition to the already existing decommissioning data base and increases its general applicability.

The study results are summarized in Section 4.1. The study approach taken is presented in Section 4.2. The analyses are based on the reference BWR nuclear power plant reported in NUREG/CR-0672.(1) The sources of information used in the analyses are discussed in Section 4.3, and the detailed results of the analyses are given in Section 4.4.

4.1 SUMMARY OF STUDY RESULTS

The results of this study to assess the impacts on decommissioning of post-TMI-2 requirements and other changes in the regulatory climate are summarized in this section. The principal results are given, in brief, in the following paragraphs, with more details presented in subsequent sections.

4.1.1 Study Bases

For consistency, the major study bases are the same as those used in the original BWR decommissioning study with one exception--costs are in January 1986 dollars. The results obtained in this study are specific to these major bases and to the specific assumptions that are derived from them. Applying these results to situations with conditions different from those in this study could produce erroneous conclusions. However, without additional evidence/information, more refined analyses are not expected to significantly change the results of this study.

4.1.2 Additional Decommissioning Costs Associated with Backfit Assessment

All additional costs associated with this backfit assessment are given in January 1986 dollars, with 25% contingencies included.

Immediate dismantlement of the reference BWR is estimated to cost an additional $100,800 based on this backfit assessment.

It is assumed for purposes of this backfit assessment that virtually all of the contaminated materials identified in this study for immediate dismantlement require offsite disposal for entombment as well. It is further assumed that the removal, packaging, and transport of those materials is accomplished in a manner similar to that postulated for immediate dismantlement. The costs, schedules, and manpower estimates also are anticipated to be similar to those estimated for immediate dismantlement. Thus, the total additional cost associated with this backfit assessment for entombment is about $101,000, including a 25% contingency. No increase in costs associated with con[illegible]re activities is anticipated to result based on this backfit assessment.

Preparing the reference BWR for safe storage is estimated to cost an additional $3,800. Deactivation and tagging of the additional valves and equipment that were identified in this study are estimated to require about two days. No increase in costs associated with continuing care activities is anticipated to result based on this backfit assessment.

The additional costs of deferred dismantlement following safe storage of the reference BWR for intervals of 10, 30, 50 and 100 years after final shutdown are estimated in January 1986 dollars to be $58,900, $58,900, $3,800, and $3,800, respectively. The lesser costs after the longer intervals are the result of having less of the contaminated materials identified in this study for shipment and disposal due to decay of the radionuclides.

The total estimated additional costs in constant 1986 dollars for each of the decommissioning alternatives are summarized in Table 4.1.

4.1.3 Additional Decommissioning Radiation Doses Associated with Backfit Assessment

Estimates of additional accumulated occupational radiation doses associated with this backfit assessment are briefly described in the following paragraphs. Included are the additional occupational doses and the additional radiation doses received by transport workers and by the general public as a result of transporting the increased amount of radioactive materials identified in this study to disposal sites.

The individual estimates of additional occupational, transport worker, and public radiation doses for the various decommissioning alternatives are summarized in Table 4.2. Additional accumulated occupational radiation doses are estimated to be 3.1 man-rem for immediate dismantlement and for entombment, and about 0.28 man-rem for placing the facility in safe storage, with essentially no increase in occupational radiation dose for surveillance and maintenance staff during continuing care. Deferring the dismantlement sequence beyond 30 years for those items identified in this backfit assessment results

TABLE 4.1. Summary of Estimated Additional Costs for Possible Decommissioning Alternatives for the Reference BWR

Decommissioning Alternative	Additional Decommissioning Costs ($ thousands)(a) Number of Years After Shutdown Dismantlement is Deferred 0	10	30	50	100
Immediate Dismantlement	101	--	--	--	--
Preparations for:					
Safe Storage	3.8	3.8	3.8	3.8	3.8
Continuing Care	--	--	--	--	--
Deferred Dismantlement	--	58.9	58.9	3.8(b)	3.8(b)
Total Additional Cost	--	62.7	62.7	7.6	7.6
Entombment	101	101	101	101	101
Continuing Care	--	--	--	--	--
Deferred Dismantlement	--	--	--	--	--
Total Additional Cost	--	101	101	101	101(c)

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) These reduced values result from lesser amounts of contaminated materials for burial in a licensed disposal site.
(c) It is assumed that the entombed radioactive material decays to the unrestricted release level in 100 years.

in relatively little reduction in accumulated occupational radiation dose, and virtually no reduction results from deferment beyond 50 years. The estimated additional external radiation dose from transport operations for immediate dismantlement is 0.07 man-rem to transport workers and 0.007 man-rem to the general public.

Since no additional truck shipments are contemplated, there are no additional radiation doses to workers or to the public resulting from post-TMI-2 backfits during the preparations for safe storage.

4.1.4 Conclusions and Recommendations

Based upon the results of this study, it appears that the changes that have already resulted, as well as those changes anticipated to result from full implementation of post-TMI-2 regulatory requirements at the reference BWR, will have only a minor impact on decommissioning costs and occupational radiation doses. Site-specific issues will have to be addressed in every other case where precise assessments of the exact extent of the impact on decommissioning are desired. For example, the license conditions for plants licensed before January 1, 1979, vary in both scope and content. After

TABLE 4.2. Summary of Estimated Additional External Occupational, Transport, and Public Radiation Doses for Decommissioning the Reference BWR

Decommissioning Mode	Time After Reactor Shutdown (Years)	Estimated Additional Dose (man-rem)		
		Occupational	Transport Workers[(a)]	Public[(a)]
Immediate Dismantlement[(b)]	0	3.06	0.070	0.007
Safe Storage:[(c)]				
Preparations for Safe Storage[(b)]	0	0.28	0	0
Continuing Care	10	0	0	0
	30	0	0	0
	50	0	0	0
	100	0	0	0
Deferred Dismantlement	10	0.82	0	0
	30	0.06	0	0
	50	<0.005	0	0
	100	<0.00001	0	0
Total for Safe Storage[(c)] with Deferred Dismantlement in year:	10	1.1	0	0
	30	0.34	0	0
	50	0.29	0	0
	100	0.28	0	0

(a) Based on the radiation doses per shipment delineated in Table N.5-2 in NUREG/CR-0672.

(b) Total additional shipments: 1 for immediate dismantlement; zero for safe storage.

(c) Safe Storage consists of three phases: preparations for safe storage, continuing care, and deferred dismantlement.

January 1, 1979, inclusion of a fire protection program (including a fire hazards analysis) in the Final Safety Analysis Report became a prerequisite for licensing. Plant modifications resulting from such analyses apparently varied widely. It is known that at some plants such modifications have been extensive, including rerouting of cable, affixing fire retardant materials, installation of new conduits, and provision of improved barriers as well as the addition of pumps and other equipment. To identify all the practical aspects involved in such assessments will require an in-depth study of each plant, since each reactor and its respective site are unique. Thus, cost and occupational dose estimates for post-TMI-2 requirements (and other regulatory adjustments) for the single BWR examined in this study may not represent the circumstances at all BWR stations.

One unexpected result of this assessment is the identification of the positive effect that the technical support centers (TSCs) required in the aftermath of TMI-2 will eventually have on decommissioning activities. TSCs are required to provide up-to-date, as-built drawings for the purpose of emergency preparedness. The availability of those drawings will facilitate planning and preparation of decommissioning activities and subsequently will support implementation of those activities.

It should be noted that a number of plant modifications have been made for which no specifics could be obtained (and thus no quantification of potential impacts on decommissioning could be made). These modifications pertain to safeguards and/or plant security areas or equipment, and this type of information is not available without appropriate need-to-know. However, it is unlikely that these modifications would have any significant effect on the safety or cost of decommissioning.

An emerging area of change that was identified concerns the steadily increasing costs associated with the burial of radwastes and the concomitant efforts at volume reduction by nuclear power plant operators. Whether such efforts are done by a contractor or by the addition of new equipment at the plant itself, an increase in the inventory of contaminated materials, in the form of outdated original equipment, could result. In many cases, this equipment may lie unused at the plant for years until the plant is decommissioned. Then, it must be accounted for.

4.2 STUDY OBJECTIVE, APPROACH, ALTERNATIVES, BASES AND ASSUMPTIONS

This section contains brief descriptions of the study objective, approach, decommissioning alternatives, and bases and assumptions.

4.2.1 Study Objective

The primary objective of this study is to examine post-TMI-2 backfits and assess their potential impacts on decommissioning cost and dose estimates previously developed for the reference BWR.[1] Development of this information is necessary in order to provide NRC decision-makers with the pertinent information they need concerning those impacts on decommissioning.

4.2.2 Technical Approach

A methodology was developed to guide the acquisition and assessment of the data concerning post-TMI-2 backfit impacts on the decommissioning estimates previously developed for the reference BWR.[1]

The study methodology, which is designed to provide direction for data gathering, proper use of the literature, and careful evaluation of information, is shown in Figure 4.1. The first step in the process was to acquire background material on the reference BWR by consulting the literature. Coinciding with that task were contacts (initially arranged by the respective NRC

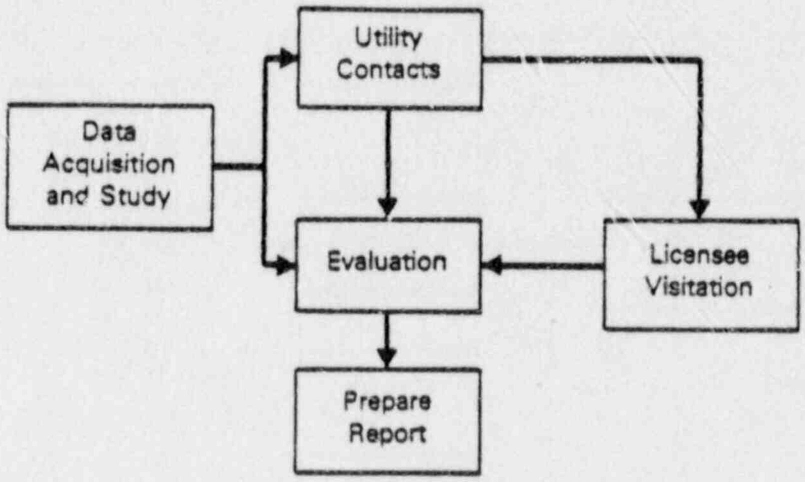

FIGURE 4.1. Post-TMI-2 Backfit Impacts Study Methodology

project manager) with the utility that operates the reference reactor involved in the study. The final step included visits to the utility headquarters and the reference reactor site to meet with cognizant utility staff and to gather appropriate backfit information.

4.2.3 Decommissioning Alternatives

The three decommissioning alternatives evaluated in the reference BWR study are examined again in this study to estimate the additional costs and radiation doses that may result from implementation of post-TMI-2 backfits. These alternatives are defined briefly below.

- Immediate Dismantlement (DECON) - The station is decontaminated and the radioactive materials are removed shortly after final reactor shutdown. Upon completion, the nuclear license is terminated and the property is released for unrestricted use.
- Safe Storage with Deferred Dismantlement (SAFSTOR) - The radioactively contaminated materials and contaminated areas are decontaminated or secured and the structures and equipment are maintained as necessary to ensure the protection of the public from the residual radioactivity. During the period of safe storage, use of the property remains limited by the nuclear license. Eventual dismantlement is necessary for unrestricted release and license termination.
- Entombment (ENTOMB) - The radioactively contaminated materials and contaminated areas are decontaminated and the nonreleasable materials are confined within a monolithic structure that provides integrity to ensure the protection of the public from the entombed radioactivity for a period of sufficient length to permit the decay of the radioactivity to unrestricted release levels. During the

period of entombment, the property is maintained as necessary and remains restricted in use by the nuclear license.

4.2.4 Study Bases and Assumptions

The study is intended to provide decommissioning information useful to NRC decision-makers. In addition, the information will provide the basis for developing current cost and occupational dose estimates for decommissioning the reference plant. The study bases are:

- Costs are in January 1986 dollars.
- All other applicable bases and assumptions necessary to the conduct of this study are the same as those used in the original NUREG report (see Reference 1 for details).

4.3 SOURCES OF INFORMATION

A manual literature search was conducted to obtain information associated with post-TMI-2 backfits. For example, the WNP-2 responses (through December 1985) to 60 regulatory issues resulting from TMI-2 contained in their Final Safety Analysis Report (FSAR) Appendix B[(2)] were examined. Government reports, technical journals, conference proceedings, etc. were examined for information relative to the reference BWR. A computer-based licensee event report (LER) search was conducted for the licensee's plant. Although the LERs were not viewed in the same context as other more clearly defined post-TMI-2 backfits, they were nonetheless examined and assessed for their potential impact on decommissioning costs since they often reveal modifications to the plant. Where those modifications involved equipment, components, and/or materials that would eventually become radioactive and/or contaminated, they were assessed for their impact on decommissioning as well.

The utility visitation was a very significant part of the study, though limited in scope in terms of actual time spent with utility representatives. The NRC is cognizant of the criticism focusing on the regulatory burden on licensees. Therefore, initial discussions were conducted between the licensee and their respective NRC project manager. Subsequently, PNL staff contacted the cognizant utility staff identified by the NRC project manager, meetings were conducted, and the information gathering process was carried out.

4.3.1 Licensee Visitation

The visitation itself involved an introductory conference with utility representatives representing finance, licensing, and/or decommissioning planning. Topics covered included: 1) the purpose and objectives of this study; 2) a brief review of their decommissioning plans; 3) a discussion focusing on understanding differences between various decommissioning cost estimates by others; and 4) arrangements for responsible utility staff to provide backfit information to PNL.

The discussions were kept informal to facilitate development of backfit information specific to the study. This effort was quite productive as meaningful, pertinent backfit information was obtained. Some of the information secured on the utility visit was not available from other sources.

4.3.2 Discussion Concerning Information Sources Used in this Study

As previously mentioned, the primary objective of this study is to examine post-TMI-2 backfits for their potential impact on decommissioning. If a plant modification is needed for a facility to comply with a license, an NRC rule or order, or to conform with a written commitment by the licensee, it will probably show up in the utility's record system (either as a backfit or possibly as a design change).

Backfitting is defined as a modification of or addition to systems, structures, components, or design of a facility; or the design approval or manufacturing license for a facility; or to the procedures or organization required to design, construct, or operate a facility; any of which may result from a new or amended provision in the NRC rules or the imposition of a regulatory staff position interpreting the Commission rules that is either new or different from a previously applicable staff position after: (i) The date of issuance of the construction permit for the facility for facilities having construction permits issued after October 21, 1985; or, (ii) Six months before the date of docketing of the operating license application for the facility for facilities having construction permits issued before October 21, 1985; or (iii) The date of issuance of the operating license for the facility for facilities having operating licenses; or, (iv) The date of issuance of the design approval under 10 CFR Part 50, Appendices M, N, or O.[3]

Generic backfitting is governed by the Committee to Review Generic Requirements process. On the other hand, plant-specific backfitting is governed by NRC staff manual chapter 0514, which encompasses power reactors. Plant-specific backfitting is different from generic backfitting in that the former involves the imposition on a licensee of positions unique to a particular plant, whereas generic backfitting involves the imposition of the same or similar positions on two or more plants. In the case of generic backfitting, additional guidance on the subject to the licensee is provided via generic letters,[a] since a systematic and documented analysis is required to be done by the NRC for any generic backfit it seeks to impose.

(a) Generic letters are issued by the NRC Office of Nuclear Reactor Regulation, Division of Licensing. They are used to transmit information to, and obtain information from reactor licensees, applicants, and/or equipment suppliers regarding matters of safety, safeguards, or environmental significance. Generic letters usually either 1) provide information thought to be important in assuring continued safe operation of facilities, or 2) request information on a specific schedule that would enable regulatory decisions to be made regarding the continued safe operation of facilities. They have been a significant means of communicating with licensees on a number of important issues, the resolutions of which have contributed to improved quality of design and operation.

The examination and assessment of information contained in generic letters concerning backfits led into other records-keeping systems that revealed areas with the potential for additional information on various kinds of changes to the reference plant. For example, the LERs include a detailed narrative description of potentially significant safety events. These reports are initiated by the licensee. By describing in detail the event and the planned corrective action, the LER system provides the basis for the careful study of events or conditions that might lead to serious accidents. For the purpose of this study, the "planned corrective action" feature of the LERs (and the followup correspondence associated with that action) was examined for the reference plant to assess any potential impacts on decommissioning. About 270 LERs were examined for the WNP-2 plant (the reference BWR), which corresponds roughly to most of the LERs produced for the plant since commercial operation began.

In all cases, the subsequent identification of any change that might impact on decommissioning was investigated further, including examination of plant annual reports[a] and discussions with plant engineering and/or licensing staff. In some cases, as-built drawings were obtained from which estimates of volumes of contaminated and/or radioactive wastes were subsequently made. For the most part, best estimates concerning material quantities were based upon discussions with utility staff and upon engineering judgment. Records associated with most material quantities and with all occupational exposures associated with installation activities were generally unavailable. Therefore, estimates concerning occupational exposures presented in this study rely on the composite values developed for the reference plant contained in the parent document.[1]

4.4 RESULTS OF THE BACKFIT IMPACT ASSESSMENT FOR THE REFERENCE BWR

This section contains the results of the backfit impact assessment for the reference nuclear power plant, including estimates of the additional decommissioning costs and occupational doses resulting from the post-TMI-2 requirements imposed on the licensee to date by the NRC as well as other selected changes resulting from adjustments in the regulatory climate. The results are based upon the information sources previously discussed in Section 4.3.

The WNP-2 responses (through December 1985) to 60 regulatory issues resulting from TMI-2 are contained in their FSAR Appendix B.[2] This backfit assessment is not intended to encompass a technical discussion of all 60 regulatory issues and responses, and that level of detail is not included. The 60 requirements are lumped into fewer categories for simplicity and are presented in Table 4.3 to show the broad spectrum of issues covered therein.

(a) The annual reports contain, together with other licensee information, a section devoted to plant modifications and design changes. Equipment, components, and/or other materials that had been or were scheduled to be installed in radiation zones were carefully examined for their potential impact later during decommissioning.

TABLE 4.3. Summary of Regulatory Items Associated with Post-TMI-2 Action Plan Requirements for the Reference BWR

Regulatory Items
Technical Support Center
Emergency Operations Center
Emergency Feedwater System Upgrade
Abnormal Transient Operator Guidelines and TMI-Related Training and Drilling
Emergency Planning
Reactor Coolant System Vents
Shift Technical Advisor Training
Safety Parameter Display System
Safety and Relief Valve Testing
Reactor Coolant System and Containment Atmosphere Sampling
Safety Grade Reactor Trip
Small Break Loss-of Coolant Accident Analyses
Plant Shielding Review
Reactor Vessel Level Instrumentation
Containment Pressure Instrumentation
Containment Hydrogen Monitor
Hydrogen Purge System
Reactor Vessel Thermal Shock Report
Control Room Habitability Improvements

Information found in FSAR Appendix B, the WNP-2 Annual Reports, generic letters, and LERs, together with discussions with WNP-2 engineering staff, were carefully assessed to identify those plant modifications and design changes subsequent to the TMI-2 accident that could potentially have an impact on decommissioning. Included in this category are equipment, components, and/or materials that had been or are scheduled to be installed in the near-term in radiation zones (i.e., in those plant areas whereby such entities will probably become contaminated or radioactive during the plant's remaining lifetime and thus become prime candidates for removal during decommissioning). Table 4.4 lists the equipment, piping, valves, and other items that are estimated to eventually have an impact on decommissioning of the reference plant.

4.4.1 Estimated Additional Costs for Decommissioning the Reference BWR

The estimated additional costs for decommissioning the reference BWR via the three decommissioning alternatives described previously in Section 4.2.3 are presented in the following subsections. The costs include a 25% contingency and are adjusted to January 1986 dollars in all cases.

4.4.1.1 Estimated Additional Costs for Immediate Dismantlement

The estimated additional costs for immediate dismantlement are summarized and totaled in Table 4.5. It can be seen from the table that the total additional cost associated with this backfit assessment for immediate dismantlement is about $101,000, including a 25% contingency.

TABLE 4.4. Summary of Information Regarding Additional Potentially Contaminated Materials at the Reference BWR

System or Location	Description of Material(a)	Number of Units(b)	Length, m	Mass, kg	Estimated Number of Disposable Containers (rounded up)(c)
Post-Accident Sampling System	Piping, 3/4-in. s/s	453	793	709	1
	Valves	66	NA(d)	92	<0.2
	Pumps	6	NA	138	<0.1
	Hanger Supports	255	NA	561	1
	Display Panel	2	NA	909	2(e)
	Insulation Material and Heat Wrap	NA	NA	90	1
	Miscellaneous	NA	NA	90	<0.5
CRD Maintenance Room	Piping, 2-1/2-in.	44	76	740	0.2
	Valves	8	NA	182	<0.1
	Skid (filter and pump)	1	NA	455	0.3
	Tank	1	NA	614	1(f)
Pre-Moisture Separator Reheater	Piping, 8-in. c/s	35	61	2,728	1.4
	Valves	12	NA	588	0.2
	Drain Tank	2	NA	2,086	2(g)
Miscellaneous	Instrumentation in Containment	NA	NA	227	2(h)
	Fire Protection Materials	NA	NA	1,061	0.5
Totals		855	930	11,270	7 + 7(i)

(a) Obtained or estimated from information supplied by Washington Public Power Supply System.
(b) A piping unit consists of a piece 1.75 meters in length.
(c) Assumed to be 1.2-m by 1.2-m by 2.4-m metal boxes, unless otherwise indicated.
(d) NA means not applicable.
(e) Packaged as their own containers, 0.6 m by 1.2 m by 1.8 m each.
(f) Packaged as its own container, 0.9 m by 0.9 m by 6.1 m.
(g) Packaged as their own containers, 0.8-m diameter by 2.7-m each.
(h) These containers are 55-gal drums.
(i) These seven containers represent self-contained disposable containers on which openings or surfaces are capped or covered and seal-welded.

TABLE 4.5. Summary of Estimated Additional Costs for Immediate Dismantlement of the Reference BWR

Cost Category	Estimated Costs, \$[a,b]
Disposal of Contaminated Materials	58,914
Staff Labor	40,165
Special Tools and Equipment	NA[c]
Miscellaneous Supplies	1,705
Total, Immediate Dismantlement Costs	100,784

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) The number of figures shown is for computational accuracy and does not imply precision to that many significant figures.
(c) NA means not applicable; see text for discussion.

Detailed cost data for the individual cost categories shown in Table 4.5 are presented and discussed in the following subsections.

Costs for Disposal of Contaminated Materials. The contaminated materials listed in Table 4.4 are anticipated to be removed from various locations within the reactor building, the radwaste and control building, and the turbine generator building. For example, the post-accident sampling system has piping, components, and valves at various elevations in the reactor building (including a minimal amount within primary containment) and in the radwaste and control building. An estimated one additional overweight truck shipment is required to transport the contaminated materials to a shallow-land burial facility, where they will occupy an estimated 36 m^3 of space. The total disposal cost (see Table 4.6) for these additional contaminated materials from the immediate dismantlement of the reference BWR is estimated at about \$59,000, including a 25% contingency.

Costs for Staff Labor. The estimated additional costs for staff labor attributable to this backfit assessment during immediate dismantlement are shown in Table 4.7. The estimated staff labor requirements shown in the table are based on a task-by-task analysis to determine the man-years of effort required to remove and package all of the materials previously given in Table 4.4. The same basic assumptions made in developing the staff labor estimates given in the original study (see Section I.2.4, Reference 1) are utilized here. It is assumed that the laborer and craftsmen shown in Table 4.7 are hired from the local union hall and that they are adequately trained on-site for the decommissioning work.

TABLE 4.6. Summary of Estimated Costs for Disposal of Additional Contaminated Materials from the Reference BWR[a]

Description:	All materials shown in Table 4.4
Estimated Mass, kg[b]:	11,270
Number of Disposable Containers[c]:	14[d]
Container Costs, $[e]:	15,000
Number of Shipments[f]:	1
Transport Costs, $[g]:	4,320
Handling Costs, $:	0
Burial Volume, m^3:	36
Burial Cost, $[h]:	39,594
Total Disposal Cost, $[i]:	58,914

(a) Values include 25% contingency and are in January 1986 dollars.
(b) Obtained or estimated from information supplied by Washington Public Power Supply System.
(c) Assumed to be 1.2-m by 1.2-m by 2.4-m metal boxes, unless otherwise indicated.
(d) Seven of these containers are self-contained disposable containers on which the openings or surfaces are capped or covered and seal-welded.
(e) Based on information in Section M.2 of Appendix M, Reference 1, and escalated to January 1986 dollars.
(f) Assumed to be overweight shipment.
(g) Based on Table M.4-4 of Reference 1 and escalated to January 1986 dollars.
(h) Based on Table M.5-1 of Reference 1 and escalated to January 1986 dollars; based on an assumed container surface dose rate of <0.20 R/hr.
(i) The number of figures shown is for computational accuracy and dose not imply precision to that many significant figures.

Costs for Special Tools and Equipment for Immediate Dismantlement. The inventory of special tools and equipment given in Table I.3-9, Reference 1, is considered adequate to accommodate the additional decommissioning tasks attributable to this backfit assessment.

Costs for Additional Miscellaneous Supplies. The additional miscellaneous supplies needed to accomplish the decommissioning tasks attributable to this backfit assessment include anticontamination clothing, cleaning and

TABLE 4.7. Estimated Costs for Staff Labor During Immediate Dismantlement of the Reference BWR

Position	Total Staff Labor Required (man-years)	Total Staff Labor Costs ($)[a,b,c]
Decommissioning Workers		
Crew Leader[d]	0.117	8,728
Utility Operator[d]	0.117	6,343
Laborer	0.117	6,060
Craftsman	0.167	13,160
H.P. Technician[d]	0.117	5,874
Totals	0.635	40,165

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) Calculated as the product of the estimated staff labor requirements shown above (based on a task-by-task analysis) and the corresponding data given in Table M.1-1 of Reference 1, and escalated to January 1986 dollars.
(c) The number of figures shown is for computational accuracy and does not imply precision to that many significant figures.
(d) One additional trained person is maintained for the time period shown above to meet the additional requirements associated with this task.

contamination control supplies (chemical agents, sweeping compounds, rags, mops, and plastic bags and sheeting), expendable hand tools, and cutting and welding supplies (saw blades, torch gas, and welding rod). The total estimated cost for these additional miscellaneous supplies during immediate dismantlement of the reference BWR is about $1,700 (see Table 4.8). Individual costs shown in the table are estimated by determining the average cost of the respective items per man-year for the original decommissioning worker staff, then multiplying that cost by the additional number of man-years estimated to accomplish the decommissioning tasks identified in this backfit assessment, and then escalating the costs to January 1986 dollars.

4.4.1.2 Estimated Additional Costs for Entombment

PNL considered two approaches to entombment in the parent study on decommissioning the reference BWR[1]--entombment with the reactor vessel internals removed (scenario 1) and entombment with the reactor vessel internals in place (scenario 2). The latter scenario is really a form of hardened safe storage since eventually dismantlement is necessary. For both entombment scenarios,

TABLE 4.8. Estimated Costs for Additional Miscellaneous Supplies During Immediate Dismantlement of the Reference BWR

Item	Estimated Costs, $[a,b]
Anticontamination Clothing[c]	580
Cleaning and Contamination Control Supplies	739
Hand Tools	257
Cutting and Welding Supplies	129
Total	1,705

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) The number of figures shown is for computational accuracy and does not imply precision to that many significant figures.
(c) Estimated at four changes per day per decommissioning worker.

dismantlement of the reference facility outside the entombment structure is carried out in a manner similar to immediate dismantlement, with the difference being that as much as possible of the contaminated equipment and material is placed in the entombment structure (see Figure K.1-1, Reference 1, for details) rather than being packaged and shipped to offsite disposal. However, the amount of contaminated material that can be entombed inside the primary containment vessel, in either entombment scenario, is limited by the free and easily-filled volume available for use within the vessel.

Examination of the analysis performed in the parent document[1] reveals that a volume utilization efficiency for storage within the primary containment vessel of 50% was assumed. This resulted in roughly 33% of all contaminated material, in either scenario, requiring packaging and shipment to offsite disposal. It is beyond the scope of this study to optimize the storage, but this should be considered during the planning of any actual entombment project.

Based on the aforementioned discussion, it is assumed for purposes of this backfit assessment that virtually all of the contaminated materials listed previously in Table 4.4 require offsite disposal. It is further assumed that the removal, packaging, and transport of those materials is accomplished in a manner similar to that which was previously described for immediate dismantlement. The costs, schedules, and manpower estimates also are anticipated to be similar to those previously estimated for immediate dismantlement. Thus, the total additional cost associated with this backfit assessment for entombment is about $101,000, including a 25% contingency (see Table 4.5 for details).

No increase in costs associated with continuing care activities is anticipated to result based on this backfit assessment.

4.4.1.3 Estimated Additional Costs for Preparations for Safe Storage

Deactivation and tagging of valves and equipment (see Table 4.4 for details) are estimated to require about two days. The estimated additional costs for preparations for safe storage for these activities are summarized in Table 4.9. It can be seen from the table that the total additional cost associated with this backfit assessment is about $3,800, including a 25% contingency.

4.4.1.4 Estimated Additional Costs for Deferred Dismantlement

The cost of deferred dismantlement of the reference BWR has previously been estimated assuming that dismantlement takes place starting at intervals of 10, 30, 50, and 100 years after reactor shutdown. These estimates are developed in Appendix J.7 of Reference 1, together with the costs for continuing care. Continuing care costs of the reference BWR are not anticipated to be affected based on this backfit assessment.

The total costs of deferred dismantlement are affected only slightly because of the increased quantity of contaminated materials (see Table 4.4 for details) that must be removed. However, the additional costs due to this increase in the contaminated materials inventory could be expected to decrease for dismantlement at 50 years or later just as they were judged to do so in

TABLE 4.9. Summary of Estimated Additional Costs for Preparations for Safe Storage of the Reference BWR

Cost Category	Estimated Costs, $(a,b)
Disposal of Contaminated Materials	Negligible
Staff Labor	3,509
Special Tools and Equipment	Negligible
Miscellaneous Supplies	294
Total, Preparations for Safe Storage Costs	3,803

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) The number of figures shown is for computational accuracy and does not imply precision to that many significant figures.

the parent document.(1) This lower disposal cost is because of the lesser quantities of contaminated materials for burial, due to decay of the radionuclides.

It is assumed that the radioactive contamination of the piping systems, tanks, pools, etc. is primarily ^{60}Co. Thus, for safe storage periods of less than fifty years (~10 half-lives of ^{60}Co), the material remains radioactively contaminated to levels greater than those that would permit unrestricted use of the material. After 50 years of decay, it is assumed that the radioactive contamination on the bulk of the formerly contaminated material has decayed to levels that are indistinguishable from the natural radioactivity in the environment, and can be either salvaged for scrap value, buried in a landfill or left in the structures.

The same basic activities that are performed during immediate dismantlement are also performed during deferred dismantlement. It is assumed that a work force of essentially the same size as was used in immediate dismantlement is needed for deferred dismantlement, and for approximately the same duration.

A convenient way to estimate the additional costs incurred for deferred dismantlement, based on this backfit assessment, after periods of safe storage of various lengths is to examine only those cost parameters that are different from immediate dismantlement. The manpower costs are assumed to be the same as for immediate dismantlement. The major difference in cost identified in this study concerns the cost of disposal of contaminated material.

The estimates of the additional volumes of contaminated material that must be packaged and shipped for burial when dismantlement is performed starting immediately and starting at 10, 30, 50 and 100 years after reactor shutdown are given in Table 4.10, together with their respective estimated disposal costs. The estimated additional volumes given in the table are summarized from information discussed previously in this section. The total additional volume of contaminated material, as previously presented in Table 4.4, is assumed to remain constant through 30 years but to have decreased to $<0.4\ m^3$ by 50 years and thereafter based on engineering judgment.

Essentially no additional volume of contaminated material is attributable to the preparations for safe storage as determined by this study; thus no disposal cost is assigned to it in Table 4.10.

Using the additional volumes of contaminated materials and their respective estimated disposal costs listed in Table 4.10 for the different time periods, it can be seen that after about 50 years, additional deferred dismantlement costs associated with those additional contaminated materials are reduced by about $55,000.

In summary, the <u>total</u> cost of deferred dismantlement could be expected to increase by about $59,000 when dismantlement starts at either 10 or 30 years after reactor shutdown. Deferred dismantlement at 50 years or more after

TABLE 4.10. Estimated Additional Volumes and Costs of Contaminated Material Disposed of During the Various Decommissioning Options for the Reference BWR

Decommissioning Option	Option Starts (Years after Shutdown)	Estimated Burial Volume, m^3 Contaminated Material	Estimated Disposal Costs, $[a]
Immediate Dismantlement	0	36	58,914[b]
Preparations for Safe Storage	0	--	--
Deferred Dismantlement	10	36	58,914
	30	36	58,914
	50	<0.4	3,828[c]
	100	<0.4	3,828

(a) Values include a 25% contingency and are in January 1986 dollars.
(b) Based on Table 4.6.
(c) Based on: 1) one legal-weight truck shipment of two disposable containers (1.2-m by 1.2-m by 2.4-m metal boxes) to a low-level waste burial ground; 2) information in Appendix M, Reference 3, escalated to January 1986 dollars; and 3) Table M.5-1, Reference 1, for assumed container surface dose rates of <0.20 R/hr.

reactor shutdown is estimated to result in an increase of about $3,800. In any case, the increase in the total cost of deferred dismantlement is attributable to the increase in the volume of contaminated materials as determined by this backfit assessment.

4.4.2 Estimated Additional External Occupational Radiation Doses for Decommissioning the Reference BWR

Detailed estimates are made of the external occupational radiation doses that are accumulated by the workers used to accomplish the decommissioning tasks attributable to this backfit assessment during immediate dismantlement of the reference BWR. The estimates are based on a task-by-task analysis to determine the man-hours of effort required in radiation-zone work and the anticipated dose rates associated with each task for all labor categories. The same basic assumptions made in developing the occupational radiation dose estimates given in the original study (see Section I.4, Reference 1) are used here.

Estimates of the additional occupational radiation doses for decommissioning the reference BWR via three decommissioning alternatives are presented in the following subsections.

4.4.2.1 Estimated Additional External Occupational Radiation Doses for Immediate Dismantlement

The estimated total dose for each task (within each building) is corrected for radioactive decay with a decay factor calculated using the half-life of ^{60}Co and the midpoint of the timeline for the given task as it is accomplished within the reactor building/primary containment, turbine generator building, and the radwaste and control building. For the purpose of this study, the approximate timeline selected to accomplish the decommissioning tasks attributable to this backfit assessment falls between the twentieth and the twenty-fourth months (after shutdown) of the original immediate dismantlement schedule. The reason for this selection is that this period roughly corresponds to the piping and equipment removal activities scheduled to take place in all three of the buildings (see Figure I.2-4, Reference 1, for details).

The results of these analyses, including decay corrections, are presented in Table 4.11. The total corrected additional external occupational radiation dose is about 3 man-rem.

TABLE 4.11. Estimated Additional Occupational Radiation Doses for Immediate Dismantlement of the Reference BWR

Position	Estimated Occupational Exposure (man-hr)/Corrected Dose (man-rem)(a)			Totals	
	Reactor/ Primary Containment	T-G Building	RW&C Building	Exposure (man-hr)	Corrected Dose(b) (man-rem)
Decommissioning Workers					
Supervisors(c)	42/0.2883	13/0.0376	7/0.0188	62	0.3447
Utility Operators and Laborers	183/1.2404	59/0.1356	30/0.3530	272	1.7290
Craftsmen	141/0.1936	45/0.1417	24/0.2030	210	0.5383
H.P. Technicians	50/0.3604	16/0.0463	8/0.0461	74	0.4528
Totals	416/2.0827	133/0.3612	69/0.6209	618	3.0648

(a) The decay factors used in these analyses for the reactor building/primary containment, the turbine generator building, and the radwaste and control building are 0.858, 0.851, and 0.769, respectively.
(b) The number of significant figures shown is for computational accuracy and does not imply precision to the nearest millirem.
(c) Includes shift engineers, crew leaders, craft supervisors, and senior health physics technicians.

4.4.2.2 Estimated Additional External Occupational Radiation Doses for Entombment

As previously discussed, this backfit assessment is based on the same manpower assumptions used for immediate dismantlement. In addition, the overall schedule and sequence of tasks also are essentially unchanged from those described previously for immediate dismantlement. Therefore, based on the scenarios postulated for entombment in the parent study(1) and the radiation doses previously estimated in this study for immediate dismantlement, the estimated additional external occupational radiation dose is anticipated to remain unchanged, at about 3 man-rem, by performing entombment rather than a dismantlement (see Table 4.11 for details).

4.4.2.3 Estimated Additional External Occupational Radiation Doses for Preparations for Safe Storage

As previously mentioned in Section 4.4.1, two additional days of effort were allocated for the deactivation and tagging of valves and equipment. For the crew size envisioned, it is estimated that this equates to an additional 56 hours of radiation zone work, which results in a total corrected additional occupational dose of about 0.28 man-rem.

During the continuing care period, the external occupational radiation dose of the surveillance and maintenance staff is not anticipated to be significantly affected by the additional equipment and materials identified in this study.

4.4.2.4 Estimated Additional External Occupational Radiation Doses for Deferred Dismantlement

The same basic activities that are performed during immediate dismantlement (see Table 4.11 for details) are also performed during deferred dismantlement. It is assumed that a work force of essentially the same size as was used in immediate dismantlement (see Section 4.4.1 for details) is needed for deferred dismantlement, and for approximately the same time duration.

For this study it is assumed that the additional amounts of occupational radiation dose accumulated by the decommissioning workers is controlled largely by the radiation levels of ^{60}Co throughout the plant. Thus, if a given task performed immediately after shutdown caused a radiation dose of N_0, that same task performed t years later during deferred dismantlement would cause a dose of $N(t) = N_0e^{-\lambda t}$, where λ is the decay constant for ^{60}Co in years.

Since one of the key assumptions for deferred dismantlement is that essentially all of the same jobs would be performed in approximately the same way as for immediate dismantlement, using the same techniques and equipment, the occupational radiation dose accumulated during deferred dismantlement, including those jobs concerning this backfit assessment, would be proportional to that accumulated during immediate dismantlement (see Table 4.11), reduced by the relative reduction of the radioactivity levels of ^{60}Co over the safe storage period. Therefore, to estimate the additional external occupational dose for deferred dismantlement, a simple reduction of the immediate dismantlement dose in proportion to the decay of ^{60}Co over the safe storage period is a reasonable and conservative approach. These estimates are given in Table 4.12 for dismantlement starting 10, 30, 50 and 100 years after reactor shutdown. After 100 years, essentially all of the remaining radioactivity is contained only in the activated reactor vessel components, and the occupational radiation dose associated with this backfit assessment is extremely small.

TABLE 4.12. Estimated Additional External Occupational Radiation Doses for Deferred Dismantlement of the Reference BWR[(a)]

Decommissioning Mode	Years After Final Reactor Shutdown	Estimated Additional Dose (man-rem)
Immediate Dismantlement	0	3.06
Deferred Dismantlement	10	0.82
	30	0.06
	50	<0.005
	100	<0.00001

(a) Man-rem estimates derived from Table 4.11.

4.4.3 Estimated Additional Radiation Doses from Routine Transportation Tasks

The same basic assumptions made in developing the estimated accumulated radiation dose from truck transport of radioactive wastes in NUREG/CR-0672, Section N.5 of Appendix N, are used in this study. The estimated routine doses from truck transport of the additional contaminated materials identified in this backfit assessment from immediate dismantlement and from preparations for safe storage are listed in Table 4.13. These radiation dose rates are based on the maximum allowable dose rates for each shipment in exclusive-use trucks, as analyzed in the parent study, and are thus conservatively high. The estimated additional external radiation dose for routine transportation operations for immediate dismantlement is 0.0703 man-rem to transport workers and 0.0068 man-rem to the general public.

Based on this study, there are no additional radiation doses to workers or to the public during the preparations for safe storage, since no additional truck shipments are contemplated.

TABLE 4.13. Estimated Additional Accumulated Radiation Doses from Truck Transport of Radioactive Wastes from the Reference BWR

Mode	Group	Radiation Dose per Shipment,(a) (man-rem)	Estimated Additional Total Dose (man-rem)
Immediate Dismantlement(b)	Truck Drivers	0.067	0.067
	Garagemen	0.0033	0.0033
	Total		0.0703
	Onlookers	0.005	0.005
	General Public	0.0018	0.0018
	Total		0.0068
Preparations for Safe Storage(b)	Truck Drivers	0	0
	Garagemen	0	0
	Total		0
	Onlookers	0	0
	General Public	0	0
	Total		0

(a) Based on Table M.5-2 in NUREG/CR-0672.
(b) Total additional shipments: 1 for immediate dismantlement; zero for safe storage.

4.5 REFERENCES

1. H. D. Oak, G. M. Holter, W. E. Kennedy, and G. J. Konzek. 1980. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

2. Washington Public Power Supply System. 1982. WPPSS Nuclear Project No. 2 Final Safety Analysis Report. Appendix B, "WNP-2 Response to Regulatory Issues Resulting from TMI-2." Richland, Washington.

3. U.S. Code of Federal Regulations. 1985. Title 10, Part 50.109, "Backfitting," Superintendent of Documents, Government Printing Office, Washington, D.C.

4. U.S. Code of Federal Regulations. 1982. Title 10, Part 50.48, "Fire Protection," Superintendent of Documents, Government Printing Office, Washington, D.C.

5.0 DEVELOPMENT OF SCALING AND ESCALATION FORMULAE FOR THE DECOMMISSIONING RULE

A necessary part of the Decommissioning Rule developed by the NRC, related to commercial power reactors, is the section dealing with assurance that funds will be available for decommissioning when the time comes to accomplish that effort. To provide reasonable assurance of adequate funding, the NRC has placed into the Rule a formula for estimating the amount of funds required as a function of the power rating of the reactor. Since the actual date of decommissioning for most plants is as yet undefined, an additional formula has been developed for adjusting the cost estimate to include escalation from the time the Rule was issued to the time of actual decommissioning. The bases and methodology used in developing these formulae are presented in this chapter.

5.1 DEVELOPMENT OF SCALING FORMULAE FOR ESTIMATING DECOMMISSIONING COSTS OF BWRs DIFFERENT IN SIZE FROM THE REFERENCE BWR

In the original analyses of decommissioning a reference BWR,[1] a methodology was developed for estimating the costs of decommissioning plants with smaller power output than the reference plant. This methodology was based on the assumption that essentially all of the decommissioning costs were proportional to the size of the principal components of the plant (e.g., the reactor vessel, turbine condenser, etc.). Subsequent analyses have suggested that only the waste disposal costs should be proportional to the size of the major components, and that the other costs (principally labor and materials) should be nearly independent of the plant size. These revised assumptions and formulae for estimating costs for plants smaller than the reference plant were initially documented in a letter (R. I. Smith to C. Feldman, 11/12/86), which is presented in Appendix B. Since that letter was written, small adjustments to the cost estimates have been made to include the effects of post-TMI-2 backfits, as documented in Chapter 4 of this report. The development of these revised scaling formulae is presented here for completeness.

The smallest conventional BWR examined in the original scaling analysis for BWRs was the Vermont Yankee station, with a thermal rating of 1593 MW_t, and a derived scaling factor of 0.648. The reference reactor (WNP-2) had a thermal rating of 3320 MW_t and a scaling factor of 1.0. To develop a new scaling relationship, it was necessary to recalculate the cost estimate for the Vermont Yankee reactor, as shown in Table 5.1.

TABLE 5.1. Revised Estimated Decommissioning Costs for WNP-2 and Vermont Yankee Reactors (millions of January 1986 dollars)

Reactor Site	Waste Disposal	Scaling Factor	Other Costs	External Contractor	Utility Only	Utility Plus Contractor
WNP-2	44.201	1.00	64.694	22.972	108.895	131.867
Vermont Yankee	44.201	0.648	64.694	22.972	93.336	116.308

To develop the revised scaling formulae, the cost estimates given in Table 5.1 were inserted into two linear equations having two unknown coefficients and the equations were solved for the unknown coefficients.

$$A + B(3320\ MW_t) = \$131.867, \quad A = B(1593\ MW_t) = \$116.308$$

$$B = 9.00 \times 10^{-3}\ \text{Million}\ \$/MW_t, \quad A = \$101.956\ \text{million (Utility + Contractor)}$$
$$A = \$78.985\ \text{million (Utility-only)}$$

Thus, the BWR scaling equation for decommissioning costs becomes:

$$\text{Total Cost (millions 1986\$)} = (101.956 + 0.0090\ \{\text{Plant}\ MW_t\})$$

when the utility employs an external decommissioning contractor, and

$$\text{Total Cost (millions 1986\$)} = (78.985 + 0.0090\ \{\text{Plant}\ MW_t\})$$

when the utility acts as its own decommissioning contractor.

These equations were developed using data from plants ranging from about 1200 MW_t to 3400 MW_t, and are only assumed to be applicable within that range. For plants smaller than 1200 MW_t, the value calculated at 1200 MW_t should be used, a conservative assumption. For plants greater than 3400 MW_t, the value calculated at 3400 MW_t should be used.

Subsequently, in the development of the Decommissioning Rule, some additional conservatism has been added to the constant terms in the above equations. As a result, the equation appearing in the Rule is:

$$\text{Estimated BWR Decommissioning Cost} = 104 + 0.009\ MW_t\ \text{(millions January 1986\$)}$$

Where the cost for plants smaller than 1200 MWt is set equal to the cost for a 1200-MW_t plant, and the cost for plants larger than 3400 MW_t is set equal to the cost for a 3400-MW_t plant.

This equation is believed to represent an adequate approach to estimating the amount of funds that should be available to provide reasonable assurance that decommissioning of a BWR station can be performed at the appropriate time. This equation is applicable to cost estimates for immediate dismantlement for reactor plants that are smaller than the reference plant examined in the original BWR decommissioning analysis.(1) Since immediate dismantlement (DECON) is generally the more expensive of the acceptable decommissioning possibilities, if funds for DECON are available, the other possibilities are also covered.

5.2 DEVELOPMENT OF A COST ESCALATION FORMULA FOR DECOMMISSIONING COSTS

The cost estimate for decommissioning the reference BWR was developed in 1978 dollars initially. Because of the significant amount of escalation that has occurred since that time, it has been necessary to periodically update the estimated cost to reflect increases in the various components of that cost, with the results of the most recent update given in Chapter 3 of this report. As a result of performing several cost updates over the years since 1978, it became apparent that the total cost could be divided into three principal components, as regards to cost escalation. These components are:

- Labor and other components that escalate at the same rate as labor
- Energy: electricity, fuel, and other components that escalate at the same rate as energy
- Waste Disposal: handling and burial charges at a low-level waste disposal site.

Assuming that the escalation factors for each of these components can be derived for any point in the future, relative to the 1986 data provided in this report, then the escalated decommissioning cost is given by:

$$\text{Estimated Cost (Year X)} = [\text{January 1986 Cost}]\ [A\ L_X + B\ E_X + C\ B_X]$$

where A, B, and C are fractions of the total cost in January 1986 dollars that are attributable to labor, energy, and burial, respectively, and sum to 1.0. The factors L_X, E_X, and B_X are defined below.

L_X = [labor cost escalation from 1986 to Year X]

E_X = [energy cost escalation from 1986 to Year X]

B_X = [disposal cost escalation from 1986 to Year X]
or
[disposal cost in Year X / disposal cost in 1986]

Evaluation of L_X and E_X for years subsequent to 1986 are left to the licensees, based on the national consumer price indices and on local conditions at a given site. Evaluation of B_X is to be provided to the licensees via NUREG-1307, a report to be issued periodically by the U.S. NRC, which will contain the disposal rate schedules for each radioactive waste disposal site operating in the U.S. at the time of report issuance, and values of B_X applicable to each operating site. Evaluation of the coefficients A, B, and C is illustrated in the following tables and paragraphs.

The distribution of total disposal costs between container cost, transportation cost, and burial cost is illustrated in Table 5.2, with the costs given in January 1986 dollars, based on the original estimates given in NUREG/CR-0672.(1)

TABLE 5.2. Distribution of Radioactive Waste Disposal Costs into Components that Escalate Proportional to Labor, Energy, and Burial Costs

NUREG/CR-0672 Reference Table	Type of Waste	Costs in Millions of January 1986 Dollars		
		Container Costs	Transportation Costs	Burial Costs
I.3-3	Activated Materials	0.67	1.51	5.07
I.3-4	Contaminated Materials	4.89	2.80	15.80
I.3-5	Radwaste	0.95	1.72	1.80
Subtotals		6.50	6.02	22.67
Contingency (25%)		1.65	1.51	5.67
Totals		8.15	7.53	28.34

Evaluation of the coefficients A, B, and C in the decommissioning cost escalation formula is presented here for the reference BWR. This evaluation is based on information presented in Chapter 3 of this report and on Table 5.2, above. The cost components that escalate similarly are grouped together in Table 5.3. The sum of those grouped costs is divided by the total cost of decommissioning to obtain the fraction of the total cost attributable to that group of components.

The analysis presented in Table 5.3 has shown the values of A, B, and C to be 0.66, 0.12, and 0.22, respectively. A similar analysis for the reference PWR has yielded values of 0.64, 0.14, and 0.22, respectively. In view of the uncertainties and contingencies on these values, and considering that the values of the coefficients for both the PWR and the BWR are so similar, it has been concluded that the best estimates for the coefficients are the averages of the PWR and BWR values:

$\bar{A} = 0.65$ $\quad\quad$ $\bar{B} = 0.13$ $\quad\quad$ $\bar{C} = 0.22$

TABLE 5.3. Derivation of the Coefficients A, B, and C in the Decommissioning Cost Escalation Formula

Cost Category	Millions of January 1986 Dollars	Coefficient Derivation	Data Source
Labor	35.98		Table 3.1
Equipment	4.03		"
Supplies	3.71		"
Decommissioning Contractor	21.1		"
Insurance	1.9		"
Added Staff	4.4		"
Added Supplies	0.2		"
Specialty Contractor	0.71		"
Pre-engineering	7.4		"
Post-TMI Backfits	0.1		"
Surveillance	--		--
Fees	0.14	A = 86.95/131.7	"
Containers	8.14		Table 5.2
Subtotal	86.95	A = 0.66	
Energy	8.84	B = 16.38/131.7	Table 3.1
Transportation	7.54		Table 5.2
Subtotal	16.38	B = 0.12	
Burial	28.34	C = 28.34/131.7	Table 5.2
Total	131.7	C = 0.22	

Note: All costs include a 25% contingency.

5.3 REFERENCES

1. H. D. Oak, G. M. Holter, W. E. Kennedy, and G. J. Konzek. 1980. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

COST UPDATING BASES AND METHODOLOGY

APPENDIX A

COST UPDATING BASES AND METHODOLOGY

Cost adjustment factors used to update decommissioning costs to a January 1986 cost base for the Final Generic Environmental Impact Statement (FGEIS) on Decommissioning are contained in the following letter to Dr. Carl Feldman (NRC) from Richard I. Smith (PNL).

Battelle
Pacific [illegible]
P.O. Box [illegible]
[illegible]
Telephone [illegible]
Telex 15-[illegible]

June 25, 1986

Dr. Carl Feldman
Chemical Engineering Branch
Division of Engineering Technology
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Feldman:

Enclosed are the marked-up draft of Chapter 14, NON-FUEL-CYCLE NUCLEAR FACILITIES, for the Generic EIS on Decommissioning, and a brief summary of the bases and methodology used in updating the cost estimates contained in Chapter 14. This same bases and methodology is being applied to updating the remaining chapters of the GEIS, and these chapters will be forwarded to you as they are completed.

In addition, we reviewed the text of Chapter 14 and offer a few minor suggestions for revisions where we thought a revision might clarify a point. These suggestions are also marked on the enclosed draft text.

If you have any questions about any of this material, please call me.

Sincerely,

Richard I. Smith, PE
Staff Engineer

Enclosures

RIS:sb

COST UPDATING BASES AND METHODOLOGY

E. S. Murphy and G. J. Konzek

Cost adjustment factors used to update decommissioning costs to a January 1986 cost base are shown in Table 1. The rationale for these cost adjustment factors is given in the following paragraphs.

Table 1. Adjustment Factors for Updating Costs to a January 1986 Cost Base

Cost Category	Cost Adjustment Factor Applied To	
	1978 Costs	1981 Costs
Staff Labor	1.6	1.3
Equipment	1.6	1.2
Miscellaneous Supplies	1.6	1.2
Energy		
Electricity	1.9	1.4
Fuel Oil	2.1	0.9
Specialty Contractors	1.6	1.3
Regulatory Fees	See rationale	See rationale
Insurance	1.9	1.5
Waste Management		
Containers	See rationale	See rationale
Transportation	1.8	1.3
Burial	See rationale	See rationale

Staff Labor. Cost adjustment factors for staff labor were determined by using the January 1985 Handy Whitman Index of Public Utility Construction Costs. Average values, determined by averaging cost escalation factors for building trades labor for the six regions of the United States defined by the Handy-Whitman index, were used in making comparisons between 1978 or 1981 and 1986.

Equipment. Equipment costs were escalated based on national average cost escalation values for capital equipment obtained from the U.S. Department of Labor publication, "Producer Prices and Price Indexes."

Miscellaneous Supplies. Cost adjustment factors used for miscellaneous supplies are the same as those used for equipment.

Electricity. Costs of electricity were escalated based on national average values of the electric power index in the U.S. Department of Labor publication, "Producer Prices and Price Indexes."

Fuel Oil. Costs of fuel oil were escalated based on national average values of the index for No. 2 fuel oil in the U.S. Department of Labor publication, "Producer Prices and Price Indexes." The price index shows a decline in the price of fuel oil between January 1981 and January 1986.

Specialty Contractors. Specialty contractor costs are primarily costs associated with labor and equipment. The same cost escalation factors were used for specialty contractor labor and equipment as were used for facility licensee labor and equipment.

Regulatory Fees. Fees charged for licensing services performed by the NRC are on a cost recovery basis as defined in 10 CFR Part 170. For these cost updates it is assumed that licensee submittals are of a quality such that one NRC staff-year is required to accomplish the appropriate reviews, operational surveillance, and termination inspections, with an estimated cost in 1986 dollars of about $120,000.

Insurance. Based on telephone discussions with American National Insurers (ANI) representatives and with Oregon State University personnel who operate a research reactor, 1978 insurance premiums were escalated by a factor 1.9 and 1981 premiums were escalated by a factor of 1.5.

Containers. Insofar as possible, container costs were updated using actual 1986 costs determined by telephone contact with a supplier. For cases where this was not practicable, 1978 container costs were escalated by a factor of

1.6 and 1981 container costs were escalated by a factor of 1.2. (These are the same escalation factors used to update equipment costs.)

Transportation. Per a telephone call to Tri-State Motor Transit Company on May 27, 1986, it was determined that the 1986 cost of a legal-weight, exclusive-use truck shipment employing a single driver is $1.89/mile for a shipment from Raleigh, North Carolina to Hanford. The 1978 cost of a similar shipment was $1.03/mile, and the 1981 cost was $1.42/mile. These values were used to establish transportation cost adjustment factors.

Low-Level Waste Burial. Current rate schedules for disposal of radioactive waste were obtained from both U.S. Ecology and Chem-Nuclear Systems, Inc. The two companies use different bases for determining surcharges, and, therefore, their rate schedules are not directly comparable. Chem Nuclear's charges appear to be slightly higher than those of U.S. Ecology. Waste disposal costs in the original decommissioning studies were based on U.S. Ecology rate schedules. Cost adjustment factors were therefore obtained by comparisons of 1978 and 1981 U.S. Ecology rate schedules with the current U.S. Ecology rate schedule.

Waste disposal cost escalation factors are larger than escalation factors for any other cost category. For example, for the disposal of steel drums or wood boxes with surface dose rates <0.2 R/hr, the escalation factor is 9.4 for adjustment of disposal costs from the early-1978 base to the January 1986 base, and 2.9 for the adjustment of disposal costs from the early-1981 base to the January 1986 base. Waste disposal cost escalation factors for different categories of waste depend on several parameters including type of waste container, quantity of radioactive material in the container, and package weight. Waste disposal cost escalation factors were therefore determined on a case-by-case basis.

APPENDIX B

REVISED ASSUMPTIONS AND FORMULAE FOR ESTIMATING COSTS AS A FUNCTION OF PLANT SIZE

APPENDIX B

REVISED ASSUMPTIONS AND FORMULAE FOR ESTIMATING COSTS AS A FUNCTION OF PLANT SIZE

For purposes of developing upper-bound estimates of costs for immediate dismantlement of reactor plants different in size from the reference BWR, scaling analyses were performed and overall scaling factors (OSFs) were developed. The initial results of these analyses are contained in the following letter to Dr. Carl Feldman (NRC) from Richard I. Smith (PNL). In addition, the letter also presents the cost escalation factors from 1984 to 1986 that were developed in PNL's cost update for the Electric Power Research Institute[a] and subsequently utilized as an integral part of the cost base for the NRC's Generic Environmental Impact Statement (GEIS) on Decommissioning. It should be recognized that since the letter was written, small adjustments to the cost estimates have been made to include the effects of post-TMI-2 backfits as documented in Chapter 4 of this report. Development of the revised scaling factors is presented in Chapter 5 of this report.

(a) R. I. Smith, G. J. Konzek, E. S. Murphy, and H. K. Edler. 1985. Updated Costs for Decommissioning Nuclear Power Facilities. EPRI NP-4012, Electric Power Research Institute Report by Pacific Northwest Laboratory, Richland, Washington.

November 12, 1986

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

Dr. Carl Feldman
Materials Branch
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Carl:

In response to your request, we have examined the updated costs for decommissioning the reference PWR and BWR as developed for the GEIS, and have made further adjustments which include the cost adders developed in our EPRI cost update (EPRI NP-4012) for pre-decommissioning engineering, additional staff to assure meeting the 5 Rem/year dose limit for personnel, extra supplies for the additional staff, and the additional costs associated with utilizing an external contractor to conduct the decommissioning effort. These adders have been escalated from 1984 to 1986. Engineering and staff labor was escalated by a factor of 1.02 from the 1984 values, while the extra supplies were escalated by a factor of 1.04. Since the external contractor costs are essentially all staff labor, these costs were escalated by a factor of 1.02. All values include a 25% contingency. The results are presented in Table 1.

Table 1. Immediate Dismantlement Costs in Millions of 1986 Dollars

Reactor Type	GEIS Value	Pre-D&D Engrng.	Extra Staff	Extra Supplies	External[a] Contrtr.	Utility Only	Utility+ Contrtr.
PWR	73.608	5.610	7.527	1.248	14.740	87.993	102.733
BWR	98.564	5.610	4.412	0.208	22.972	108.794	131.766

(a) Includes incremental cost (1.836) of utilizing an external contractor for pre-decommissioning analyses.

SCALING ANALYSIS

For purposes of developing an upper-bound estimate of costs for immediate dismantlement of reactor plants smaller than the reference plants, assume that all costs (staff labor, equipment, supplies, etc.) except waste disposal are independent of plant size, and that the scaling factors developed in the NUREG/CR-0130 Addendum and in the NUREG/CR-0672 Appendix O are applicable to just the disposal costs. This analysis will be limited to plants with thermal power ratings greater than 1200 MW_t. Using the 1986 GEIS cost updates for the reference plants, as given in the table above, the portion of those costs that are due to waste disposal, the overall scaling factors from the previous scaling analyses, and the escalated cost adders from Table 1, above, the results shown in Table 2 are obtained:

Battelle

Table 2. Immediate Dismantlement Costs For Plants Smaller Than The Reference PWR and BWR, Based On Previously-Derived Overall Scaling Factors

Reactor	Waste Disposal	Scaling Factor	Remaining Costs	Escalated Adders	Utility Only	Utility + Contractor
R E Ginna	39.434	0.518	34.174	14.385	68.986	83.726
Trojan	39.434	1.000	34.174	14.385	87.993	102.733
Ver. Yankee	44.100	0.648	54.464	10.230	93.271	116.243
WNP-2	44.100	1.000	54.464	10.230	108.794	131.766

Using the results from Table 2, a set of linear equations can be derived for the scaling of the immediate dismantlement costs for plants in the 1200 to 3500 MW_t range.

PWR: $Cost = 57.756 + 8.640 \times 10^{-3} [MW_t]$ Utility Only
$Cost = 72.495 + 8.640 \times 10^{-3} [MW_t]$ Utility + Contractor

BWR: $Cost = 78.948 + 8.986 \times 10^{-3} [MW_t]$ Utility Only
$Cost = 101.924 + 8.986 \times 10^{-3} [MW_t]$ Utility + Contractor

For the reference plants, the thermal power ratings used in developing these equations are PWR (3500 MW_t), BWR (3320 MW_t). The thermal power ratings of the other plants used in developing the overall scaling factors are given in the respective NUREG/CR reports.

I trust this information will be adequate and appropriate for your use in developing the final decommissioning rule. If you have any questions about any of the material presented in this letter, please call me.

Sincerely,

Dick

Richard I Smith, P.E.
Staff Engineer
Waste Systems and Transportation

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1 REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)
NUREG/CR-0672
Addendum 3

2 TITLE AND SUBTITLE
Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station: Technical Support for Decommissioning Matters Related to Preparation of the final Decommissioning Rule

3 LEAVE BLANK

4 DATE REPORT COMPLETED
MONTH: May YEAR: 1988

5 AUTHOR(S)
G. J. Konzek and R. I. Smith

6 DATE REPORT ISSUED
MONTH: June YEAR: 1988

7 PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Pacific Northwest Laboratory
Richland, Washington 99352

8 PROJECT/TASK/WORK UNIT NUMBER

9 FIN OR GRANT NUMBER
B2902

10 SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Materials Branch
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

11a TYPE OF REPORT

b PERIOD COVERED (Inclusive dates)

12 SUPPLEMENTARY NOTES

13 ABSTRACT (200 words or less)

Preparation of the final Decommissioning Rule by the Nuclear Regulatory Commission (NRC) staff has been assisted by Pacific Northwest Laboratory (PNL) staff familiar with decommissioning matters. These efforts have included updating previous cost estimates developed during the series of studies of conceptually decommissioning reference licensed nuclear facilities for inclusion in the Final Generic Environmental Impact Statement (FGEIS) on Decommissioning; documenting the cost updates; evaluating the cost and dose impacts of post-TMI-2 backfits on decommissioning; performing revised scaling factor analyses concerning reactor plants different in size from the reference BWR described in the earlier studies; and determining the formula for adjusting current cost estimates to reflect escalation in labor, materials, and waste disposal costs. This report presents supporting information in three of the aforementioned areas concerning decommissioning the reference BWR: 1) updating the previous cost estimates to January 1986 dollars, 2) assessing the cost and dose impacts of post-TMI-2 backfits, and 3) developing scaling and escalation formula.

14 DOCUMENT ANALYSIS – a KEYWORDS/DESCRIPTORS

b IDENTIFIERS/OPEN-ENDED TERMS

15 AVAILABILITY STATEMENT
Unlimited

16 SECURITY CLASSIFICATION
(This page) Unclassified
(This report) Unclassified

17 NUMBER OF PAGES

18 PRICE

November 12, 1986

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

Dr. Carl Feldman
Materials Branch
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Carl:

In response to your request, we have examined the updated costs for decommissioning the reference PWR and BWR as developed for the GEIS, and have made further adjustments which include the cost adders developed in our EPRI cost update (EPRI NP-4012) for pre-decommissioning engineering, additional staff to assure meeting the 5 Rem/year dose limit for personnel, extra supplies for the additional staff, and the additional costs associated with utilizing an external contractor to conduct the decommissioning effort. These adders have been escalated from 1984 to 1986. Engineering and staff labor was escalated by a factor of 1.02 from the 1984 values, while the extra supplies were escalated by a factor of 1.04. Since the external contractor costs are essentially all staff labor, these costs were escalated by a factor of 1.02. All values include a 25% contingency. The results are presented in Table 1.

Table 1. Immediate Dismantlement Costs in Millions of 1986 Dollars

Reactor Type	GEIS Value	Pre-D&D Engrng.	Extra Staff	Extra Supplies	External[(a)] Contrtr.	Utility Only	Utility+ Contrtr.
PWR	73.608	5.610	7.527	1.248	14.740	87.993	102.733
BWR	98.564	5.610	4.412	0.208	22.972	108.794	131.766

(a) Includes incremental cost (1.836) of utilizing an external contractor for pre-decommissioning analyses.

SCALING ANALYSIS

For purposes of developing an upper-bound estimate of costs for immediate dismantlement of reactor plants smaller than the reference plants, assume that all costs (staff labor, equipment, supplies, etc.) except waste disposal are independent of plant size, and that the scaling factors developed in the NUREG/CR-0130 Addendum and in the NUREG/CR-0672 Appendix O are applicable to just the disposal costs. This analysis will be limited to plants with thermal power ratings greater than 1200 MW_t. Using the 1986 GEIS cost updates for the reference plants, as given in the table above, the portion of those costs that are due to waste disposal, the overall scaling factors from the previous scaling analyses, and the escalated cost adders from Table 1, above, the results shown in Table 2 are obtained:

Battelle

Table 2. Immediate Dismantlement Costs For Plants Smaller Than The Reference PWR and BWR, Based On Previously-Derived Overall Scaling Factors

Reactor	Waste Disposal	Scaling Factor	Remaining Costs	Escalated Adders	Utility Only	Utility + Contractor
R E Ginna	39.434	0.518	34.174	14.385	68.986	83.726
Trojan	39.434	1.000	34.174	14.385	87.993	102.733
Ver. Yankee	44.100	0.648	54.464	10.230	93.271	116.243
WNP-2	44.100	1.000	54.464	10.230	108.794	131.766

Using the results from Table 2, a set of linear equations can be derived for the scaling of the immediate dismantlement costs for plants in the 1200 to 3500 MW_t range.

PWR: $\text{Cost} = 57.756 + 8.640 \times 10^{-3} [MW_t]$ Utility Only
$\text{Cost} = 72.495 + 8.640 \times 10^{-3} [MW_t]$ Utility + Contractor

BWR: $\text{Cost} = 78.948 + 8.986 \times 10^{-3} [MW_t]$ Utility Only
$\text{Cost} = 101.924 + 8.986 \times 10^{-3} [MW_t]$ Utility + Contractor

For the reference plants, the thermal power ratings used in developing these equations are PWR (3500 MW_t), BWR (3320 MW_t). The thermal power ratings of the other plants used in developing the overall scaling factors are given in the respective NUREG/CR reports.

I trust this information will be adequate and appropriate for your use in developing the final decommissioning rule. If you have any questions about any of the material presented in this letter, please call me.

Sincerely,

Dick

Richard I Smith, P.E.
Staff Engineer
Waste Systems and Transportation

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)
NUREG/CR-0672
Addendum 3

2. TITLE AND SUBTITLE
Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station: Technical Support for Decommissioning Matters Related to Preparation of the final Decommissioning Rule

3. LEAVE BLANK

4. DATE REPORT COMPLETED
MONTH: May YEAR: 1988

5. AUTHOR(S)
G. J. Konzek and R. I. Smith

6. DATE REPORT ISSUED
MONTH: June YEAR: 1988

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Pacific Northwest Laboratory
Richland, Washington 99352

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER
B2902

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Materials Branch
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

11a. TYPE OF REPORT

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

Preparation of the final Decommissioning Rule by the Nuclear Regulatory Commission (NRC) staff has been assisted by Pacific Northwest Laboratory (PNL) staff familiar with decommissioning matters. These efforts have included updating previous cost estimates developed during the series of studies of conceptually decommissioning reference licensed nuclear facilities for inclusion in the Final Generic Environmental Impact Statement (FGEIS) on Decommissioning; documenting the cost updates; evaluating the cost and dose impacts of post-TMI-2 backfits on decommissioning; performing revised scaling factor analyses concerning reactor plants different in size from the reference BWR described in the earlier studies; and determining the formula for adjusting current cost estimates to reflect escalation in labor, materials, and waste disposal costs. This report presents supporting information in three of the aforementioned areas concerning decommissioning the reference BWR: 1) updating the previous cost estimates to January 1986 dollars, 2) assessing the cost and dose impacts of post-TMI-2 backfits, and 3) developing scaling and escalation formula.

14. DOCUMENT ANALYSIS – a. KEYWORDS/DESCRIPTORS

b. IDENTIFIERS/OPEN-ENDED TERMS

15. AVAILABILITY STATEMENT
Unlimited

16. SECURITY CLASSIFICATION
(This page)
Unclassified
(This report)
Unclassified

17. NUMBER OF PAGES

18. PRICE

GEORGE J. HOCHBRUECKNER
1ST DISTRICT, NEW YORK

COMMITTEES:
ARMED SERVICES
MERCHANT MARINE
AND FISHERIES
SCIENCE, SPACE, AND TECHNOLOGY

Congress of the United States
House of Representatives
Washington, DC 20515

1008 LONGWORTH HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-3826

DISTRICT OFFICES:
3771 NESCONSET HIGHWAY
SUITE 213
CENTEREACH, NY 11720
(516) 689-6767

BAGSHAW OFFICE BUILDING
437 EAST MAIN STREET
RIVERHEAD, NY 11901
(516) 727-2152

August 2, 1988

The Honorable Lando W. Zech
Chairman
Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, D.C. 20555

Dear Mr. Chairman:

I need some assistance from the Commission relative to the possible decommissioning of the Shoreham nuclear power plant.

As you know, the Long Island Lighting Company (LILCO) and the State of New York have an agreement as of June 16, 1988 that is intended to result in the permanent closing and decommissioning of Shoreham. I have two questions for you relating to future actions pursuant to this agreement.

First, I need to know exactly what is required by the Nuclear Regulatory Commission in order to complete the transfer of all LILCO licenses or permits relating to Shoreham to the State of New York. Under the terms of the LILCO-New York State agreement, LILCO consents to transfer all ownership and licenses associated with Shoreham to the Long Island Power Authority (LIPA). Please advise me on what is required, from the NRC's point of view, in order to execute this transfer, with the result being LIPA's full ownership of the Shoreham nuclear power plant and all licenses and permits assigned to that plant.

Second, I would like to request that the NRC provide a cost estimate for decommissioning Shoreham in its current condition. I understand that Shoreham has operated at 5% power for approximately 60 hours. Therefore, its decommissioning costs, particularly in the area of decontamination, would differ dramatically from the costs associated with plants that have operated with a full power license for a number of years.

Since I am presently scheduled to meet with Governor Cuomo on Friday, August 5, I would appreciate a response by the close of business Thursday, August 4. Thank you for your assistance.

Sincerely,

George Hochbrueckner

George J. Hochbrueckner
Member of Congress