COST ANALYSIS
for
FINAL ENVIRONMENTAL IMPACT STATEMENT
ON THE
DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER,
OHIO,
AND
LOS ANGELES CLASS NAVAL REACTOR PLANTS

Appendix C

Table of Contents

List of Tables

1. INTRODUCTION

This appendix provides information on the estimated costs associated with the reasonable alternatives. Economic costs and radiation exposures are both considered. These factors are important to decide which alternatives should be considered further and which alternatives should be considered most appropriate for disposal of decommissioned, defueled reactor compartments from cruisers, LOS ANGELES, and OHIO Class submarines in a safe and environmentally acceptable manner.

The reasonable alternatives discussed in detail in this appendix are:

- Preferred alternative of land burial of the entire reactor compartment at the Department of Energy low level waste burial ground at Hanford, WA.
- No-Action alternative of protective waterborne storage for an indefinite period.
- Disposal and reuse of subdivided portions of the reactor plant alternative.
- Indefinite storage above ground at Hanford alternative.

Alternatives not discussed in detail because they are not considered reasonable are:

- Sea disposal alternative.
- Permanent above ground disposal at Hanford alternative.
- Land disposal at other sites alternative.

The costs associated with the preferred alternative of land burial of the entire reactor compartment at the Department of Energy low level waste burial ground at Hanford, WA. would include the shipyard efforts to prepare the reactor compartment disposal package for transportation and disposal, contractor services to transport the reactor compartment disposal package to Hanford, and the Hanford activities to accept the reactor compartment disposal package for disposal.

Indefinite waterborne storage would be an alternative to disposal, but does not provide an ultimate means of disposal. Maintenance of proper storage conditions during the indefinite waterborne storage period would incur significant costs. Storage would be in a naval inactive nuclear ship moorage facility at either Norfolk Naval Shipyard or Puget Sound Naval Shipyard. Indefinite waterborne storage would include those preparation actions necessary to assure storage in a safe and environmentally acceptable manner. Periodic actions required during storage would include monitoring the decaying radiation levels and maintenance of essential storage conditions.

For the disposal and reuse of subdivided portions of the reactor plant alternative the non-reusable material would be disposed of in a safe and environmentally acceptable manner. The options within this alternative vary depending on prompt action or delay to allow some radionuclides to decay away, thus reducing the general area radiation exposure levels. For this analysis a delay of 10 years was analyzed, consistent with the safe storage (SAFESTOR) alternative of commercial nuclear reactor plant studied by the NRC (NRC, 1988).

Indefinite storage above ground at Hanford would be an alternative to disposal, but as with waterborne storage, would not provide an ultimate means of disposal. The alternative would involve all the actions for packaging and transportation as described in the preferred alternative except for the disposal trench activities, which would be replaced with storage activities; such as, paint maintenance, etc.

2. BACKGROUND

The costs of disposal consist of two elements:

a. Radiation exposure to the general population, transport workers, and to shipyard workers.

b. Economic costs that would be incurred to accomplish the disposals.

As discussed in the body of this environmental impact statement, the estimated radiation dose that would be received by the general population and the hypothetical maximally exposed individual would be quite small when compared to natural background radiation for all of the reasonable alternatives evaluated. The estimated radiation dose to the shipyard workers from the subdivide and reuse alternative may be excessive when compared to the other alternatives. These estimated doses should be considered as a basis for selecting an alternative since they indicate that some of the alternatives can not adequately safeguard the worker from significant exposure.

The estimated economic costs range from a total program cost of about $1.53 billion for the preferred alternative to a total program cost of about $9.36 billion for the disposal and reuse of subdivided portions of the reactor plant alternative. The totals should be considered an effective basis for comparing relative cost of the alternatives.

3. DISCUSSION OF COST

Monetary values are in constant 1994 fiscal year dollars. These estimates are not budget quality, but rather a rough order-of-magnitude cost estimate based on experience, engineering concepts, or available data from a variety of technical sources. The values presented are for comparison purposes only, since the actual cost could be influenced by factors not foreseeable during development of this EIS; such as: (1) promulgation of changes to existing policies and/or regulations, (2) man-day rate changes, (3) new technological developments, (4) different environmental considerations, (5) work controls, (6) different occupational safety and health regulations, and (7) transportation requirements.

3.1 Preferred Alternative of Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Ground at Hanford, WA.

The most significant cost associated with this alternative would be the shipyard effort for preparation for disposal. Very little new capital equipment or other one-time items would be needed to support this alternative, except that overhead power lines on the Hanford Site transport route may need to be raised. The significant costs associated with this alternative are shipyard efforts to (1) remove residual liquids to the maximum extent practicable, (2) reactor compartment packaging for transportation and disposal, and (3) associated engineering and services. The engineering and services description encompasses a wide variety of shipyard related costs, such as; electrical services, industrial supplies, project management personnel, special tooling, etc. Table C-1 summarizes the significant costs associated with this alternative.

An additional cost could be incurred if the ships are temporarily stored pierside for an indefinite period of time. For an initial 15 year storage period, the total cost for the preferred alternative would be approximately $1.67 billion, a $140,000,000 increase.

Preferred Alternative of Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Ground at Hanford, WA. (Per Reactor Plant)

TABLE C-1

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS (1)			
• Engineering, Management, Labor, and Support Services	$6,876,000	$8,770,000	$27,945,000
• Water Removal	$1,310,000	$1,750,000	$1,980,000
• Packaging	$1,014,000	$1,217,000	$7,465,000
TRANSPORTATION	$480,000	$480,000	$480,000
TRENCH	$253,000	$253,000	$253,000
Per reactor plant	$9,933,000	$12,470,000	$38,123,000
Total per class	$615,846,000	$224,460,000	$686,214,000
Total program cost	$1,526,520,000 (2)		

(1) The cost to dispose of a LOS ANGELES Class reactor compartment was considered to be the same as the actual cost to dispose of the most common type pre-LOS ANGELES Class reactor compartment. This is because of similarity in size and configuration. The cost estimates for OHIO Class and cruiser reactor compartments were adjusted upward due to differences in size and plant configuration.

(2) The discounted amount would be 0.7 billion dollars based on a discount rate of 4.9% over a 32 year period beginning in 1997.

3.2 The "No-Action" Alternative - Protective Waterborne Storage for an Indefinite Period

The closest reasonable approach to the "No-Action" alternative would involve actions that would be considered prudent to provide protection of the public safety and to prevent unacceptable environmental consequences. This alternative would include the work which must be accomplished to prepare them for indefinite waterborne storage in a safe and environmentally acceptable manner. Preparation for storage would include removing fluids, removing strategic equipment, blanking sea connections, ensuring the preservation of containment barriers such as the hull, and installing fire and flooding alarms. Equipment and materials would be available for salvage. Periodically it would be necessary to move each ship into drydock for hull maintenance. Table C-2 summarizes the costs associated with this alternative.

The "No-Action" Alternative - Protective Waterborne Storage for an Indefinite Period

TABLE C-2

	Per Ship Cost for a 15 year cycle
WATERBORNE STORAGE PREPARATIONS	
• Hull Blanking	$715,000
• Hull preservation	$140,000
STORAGE	
• Maintenance	$750,000(1)
Total per ship cost	$1,605,000(2)
Total Program cost for first 15 years of storage	$142,845,000

(1) Based on $50,000 per year maintenance cost at Puget Sound Naval Shipyard.

(2) For additional 15 year storage periods the cost is estimated at $1.75 million per ship.

3.3 Disposal and Reuse of Subdivided Portions of the Reactor Plant

This alternative would include removal of reusable equipment; separating the reactor plant and reactor plant support systems from the ship; preparing the reactor plant and reactor plant support systems for disposal or storage; and, transportation to the disposal site.

The complete dismantlement of a nuclear reactor plant has been accomplished by the Department of Energy for the Shippingport Station. The Nuclear Regulatory Commission (NRC) also has studied the cost of decommissioning commercial nuclear reactor plants and published that information in a Generic Environmental Impact Statement, (NRC, 1988). The Navy utilized both the estimated and actual cost information published on the Shippingport decommissioning and the generic costs outlined by the NRC to decommission a commercial nuclear reactor plant to establish a baseline for dismantlement of naval nuclear reactor plants.

The NRC in 10CFR50.75 provides the following equation to determine the minimum amounts required to demonstrate reasonable assurance of funds for decommissioning by reactor type and power level, P (in MWt), of commercial nuclear power plants. The NRC limits the usage of the equation to plants with a power level between 1200 and 3400 MWt; for plants smaller than 1200 MWt, the NRC specifies using 1200 MWt for P. The maximum thermal output of a naval nuclear propulsion is below 1200 MWt; therefore:

Cost = 75 + 0.0088P (in millions of January 1986 dollars)
= $85.56 million per reactor plant

The estimated cost to dismantle approximately one hundred reactor plants is about $8.5 billion based on the NRC equation. However, it is important to note that there is a large uncertainty associated with the actual cost to dismantle a reactor plant.

The NRC, in NUREG-0586 (NRC, 1988), studied the technology, safety, and cost of decommissioning a commercial pressurized water reactor plant. The DECON (immediate dismantlement of the plant) alternative studied by the NRC is comparable to subdividing naval nuclear reactor plants. The NRC estimated that immediate removal and disposal of all radioactivity to release of the commercial nuclear reactor plant complex for unrestricted use would cost, in 1986 dollars, between $88.7 million (for utility staffing) and $103.5 million (for utility plus contractor staffing). The NRC estimating method is based on the guidance provided by the NRC in NUREG-CR-0130, (NRC, 1978).

The NRC method provides a basis for comparison, but may not be directly applicable to dismantlement of naval nuclear reactor plants due to the differences in reactor plant construction techniques; such as: large and spread out complex (commercial) versus small and compact compartment (naval), concrete secondary containment structure (commercial) versus metal secondary containment structure (naval). Furthermore, the NRC estimate is based on several factors which are not included in the other cost estimates in this appendix, such as: spent fuel removal and management; Nuclear Insurance; etc. To be consistent with the other cost estimates in this appendix in terms of scope of work, $21.22 million (23.92%) has been subtracted from the $88.7 million for an estimated total cost per reactor plant of $67.48 million in 1986 dollars. Adjusting to 1994 dollars, results in an estimated per reactor plant total of $82.19 million and $8.22 billion for the approximately one hundred reactor plants.

A reasonable comparison can be made to the Department of Energy's decommissioning of the Shippingport Atomic Power Station. The total cost for the Shippingport Atomic Power Station decommissioning project was $91.3 million. However, this included activities not included in the other alternatives, such as: Decommissioning Operations Contractor Fee; Home office Support costs; etc: To be consistent with the other cost estimates in this appendix in terms of scope of work, $7.223 million (7.91%) has been subtracted from the $91.3 million for an estimated total cost per reactor plant of $84.08 million in 1989 dollars. Adjusting to 1994 dollars, results in an estimated per reactor plant total of $93.63 million and $9.36 billion for the approximately one hundred reactor plants. The discounted amount for 100 reactor compartments would be 4.3 billion dollars based on a discount rate of 4.9% over a 32 year period.

3.4 Indefinite Storage Above Ground at Hanford

This alternative would include the same operations as the preferred alternative excluding the burial operations, but includes cost such as paint maintenance. Storage costs would depend ultimately on the length of spent time in storage; however, the additional cost to store the packages would likely be less than 1% of the total program.

4. DISCUSSION OF RADIATION DOSE

The preferred alternative estimates are based on historical measurements made during pre-LOS ANGELES Class submarine disposals adjusted for the plant types and if temporary water-borne storage is utilized. The land disposal and reuse of subdivided portions of the reactor plant alternative estimated dose values are based on the values determined by the Nuclear Regulatory Commission for decommissioning commercial nuclear power plants and experience from Shippingport Atomic Power Station. The Indefinite on Surface Storage at Hanford alternative would incur the same exposure as the preferred alternative without temporary waterborne storage; therefore, a table listing exposure estimates for this alternative is not provided. Furthermore, the "No-Action" alternative would not result in any significant exposure to the workers or the the public; therefore, a table listing exposure estimates for this alternative is also not provided.

Preferred Alternative of Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Ground at Hanford, WA, Exposure Estimates (rem)

TABLE C-3

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS			
• Water Removal	8	9	20
• Packaging	0.4	0.4	3
• Services	4.6	4.6	2
Total per reactor plant	13	14	25
Total per class of ship	806	252	450
Total program dose	1,508		
Latent fatal cancers Per class of ship	0.32	0.1	0.18
Total Program	0.6		

Subdivision Option
On-Site Occupational Exposure Estimates (rem)
Shippingport Based Estimate/Immediate

TABLE C-4A

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS • Subdivision Operations	230	230	230
Total per reactor plant	230	230	230
Total per class of ship	14,260	4,140	4,140
Total program exposure	22,540		
Latent fatal cancers Per class of ship	5.7	1.7	1.7
Total Program	9.1		

Subdivision Option
On-Site Occupational Exposure Estimates (rem)
Shippingport Based Estimate/10 Year Deferral

TABLE C-4B

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS • Subdivision Operations • Maintenance Operations	61.7 0.3	61.7 0.2	61.7 1.2
Total per reactor plant	62.0	61.9	62.9
Total per class of ship	3,844	1,114	1,132
Total program exposure	6,090		
Latent fatal cancers Per class of ship	1.5	0.4	0.5
Total Program	2.4		

Subdivision Option
On-Site Occupational Exposure Estimates (rem)
NRC Based Estimate/Immediate Disposal

TABLE C-4C

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS • Subdivision Operations[1]	1,115	1,115	1,115
Total per reactor plant	1,115	1,115	1,115
Total per class of ship	69,130	20,070	20,070
Total program exposure	109,270		
Latent fatal cancers Per class of ship	27.7	8.0	8.0
Total Program	43.7		

[1]Occupational exposure estimates are based on NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Table 4.3-2.

Subdivision Option
On-Site Occupational Exposure Estimates (rem)
NRC Based Estimate/10 Year Deferral

TABLE C-4D

	LOS ANGELES	OHIO	CRUISERS
DISPOSAL PREPARATIONS • Subdivision Operations[1]	338	338	338
Total per reactor plant	338	338	338
Total per class of ship	20,956	6,084	6,084
Total program exposure	33,124		
Latent fatal cancers Per class of ship	8.4	2.4	2.4
Total Program	13.2		

[1]Occupational exposure estimates are based on NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Table 4.3-2.

REFERENCES

NRC, 1978 — Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station, U.S. Nuclear Regulatory Commission, NUREG/CR-0130.

NRC, 1988 — Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, U.S. Nuclear Regulatory Commission, nureg-0586, August 1988.