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

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UNITED STATES
DEPARTMENT OF THE NAVY

FINAL ENVIRONMENTAL IMPACT STATEMENT
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United States
Department of the Navy

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COVER SHEET

RESPONSIBLE AGENCIES:
Lead Federal Agency: U.S. Department of the Navy
Cooperating Agency: U.S. Department of Energy

By participating as a cooperating agency in this Environmental Impact Statement, the Department of Energy expects to be able to adopt this Environmental Impact Statement, if appropriate, to fulfill its environmental review obligations under the National Environmental Policy Act.

TITLE: Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled cruiser, OHIO Class, and LOS ANGELES Class Naval reactor plants.

ABSTRACT: This statement describes in detail the preferred alternative - land burial of the entire reactor compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, Washington; the "no-action" alternative - protective waterborne storage for an indefinite period; disposal and reuse of subdivided portions of the reactor plant; and indefinite storage above ground at Hanford. Other alternatives examined in limited detail are sea disposal; land disposal at other sites; and permanent above ground disposal at Hanford.

Location of U.S. Department of Navy facilities considered for implementation of the preferred alternative: Puget Sound Naval Shipyard, Bremerton, Washington.

Location of U.S. Department of Energy facilities considered for implementation of the preferred alternative: Hanford Site, Benton County, Franklin County, and Grant County, Washington.

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SUMMARY

This Environmental Impact Statement analyzes the alternate ways for disposing of decommissioned, defueled reactor compartments from U.S. Navy nuclear-powered cruisers, (BAINBRIDGE, TRUXTUN, LONG BEACH, CALIFORNIA Class, and VIRGINIA Class) and LOS ANGELES Class, and OHIO Class submarines. A disposal method for the defueled reactor compartments is needed when the cost of continued operation is not justified by the ships' military capability or when the ships are no longer needed. After a nuclear-powered ship no longer has sufficient military value to justify continuing to maintain the ship or the ship is no longer needed, the ship can be: (1) placed in protective storage for an extended period followed by permanent disposal or recycling; or (2) prepared for permanent disposal or recycling. The alternatives examined in detail are the preferred alternative of land burial of the entire defueled reactor compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, Washington; the no-action alternative - protective waterborne storage for an indefinite period; disposal and reuse of subdivided portions of the reactor compartments; and indefinite storage above ground at Hanford. No new legislation is required to implement any of these alternatives. Several other alternatives are also examined in limited detail. These alternatives include sea disposal; land disposal at other sites; and permanent above ground disposal at Hanford.

In all of the alternatives considered in this Environmental Impact Statement there would be no spent nuclear fuel left in the reactor compartments. All the spent nuclear fuel would be removed before disposal. Management of the spent nuclear fuel is addressed in a separate Department of Energy National Environmental Policy Act (NEPA) document, U. S. Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, (DOE, 1995) for which the Navy is a cooperating agency. Nevertheless, there would be some other radioactive materials left within the reactor compartments. Therefore, this Final Environmental Impact Statement evaluates disposal of the reactor compartments after all the spent nuclear fuel has been removed. Recycling of the non-radioactive portion of nuclear-powered ships has been evaluated in an Environmental Assessment, and the Navy concluded that there was no significant environmental impact associated with the recycling process (USN, 1993a). Types of U.S. Navy nuclear-powered ships that are not expected to be decommissioned in the next 20 years (e.g., aircraft carriers, SEAWOLF Class submarines) are not included in this Final Environmental Impact Statement.

Navy submarine reactor plants constructed prior to the USS LOS ANGELES (SSN 688) (referred to as pre-LOS ANGELES Class submarines) share many common design characteristics with reactor plants from cruisers, OHIO Class submarines, and LOS ANGELES Class submarines. Pre-LOS ANGELES Class submarine reactor compartments are currently being disposed of at the Department of Energy Hanford Site in Eastern Washington, by Puget Sound Naval Shipyard in Bremerton, Washington consistent with the Record of Decision on disposal of decommissioned, defueled Naval submarine reactor plants (USN, 1984b). Because of the commonality of design with submarine reactor compartments from pre-LOS ANGELES Class submarines, it is feasible to use the same basic disposal method for disposal of reactor compartments from cruisers, LOS ANGELES Class submarines and OHIO Class submarines. The method currently being used for disposal of pre-LOS ANGELES Class reactor compartments, has been demonstrated to be cost effective, minimizes exposure to workers and the public, and has been used to safely package and ship over 40 reactor compartments from Puget Sound Naval Shipyard to the Hanford site for

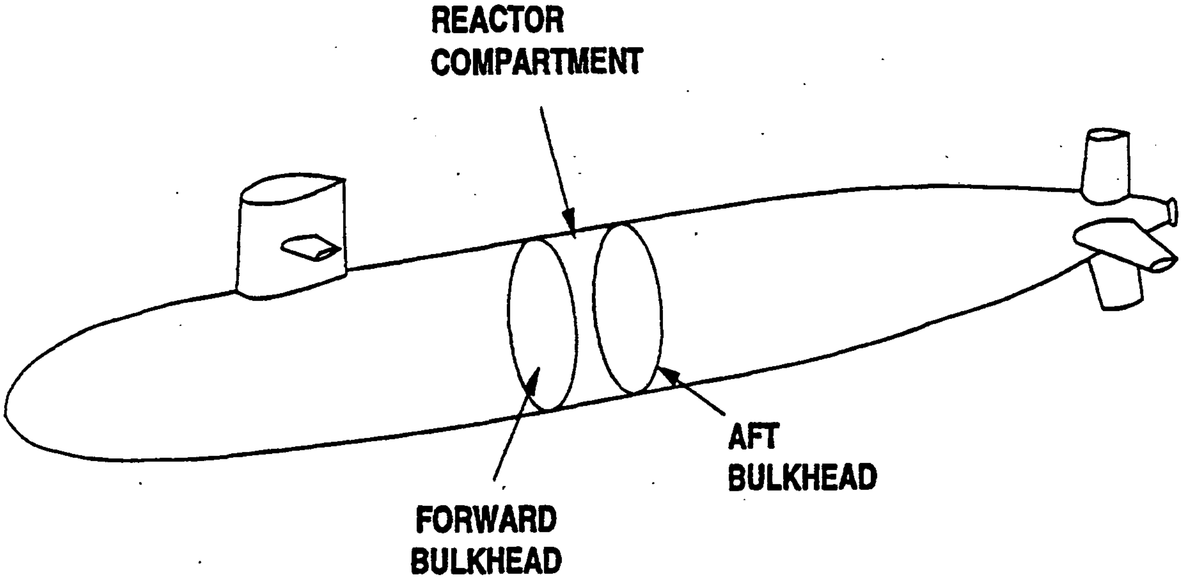

Figure S.1. Typical Submarine Reactor Compartment Location

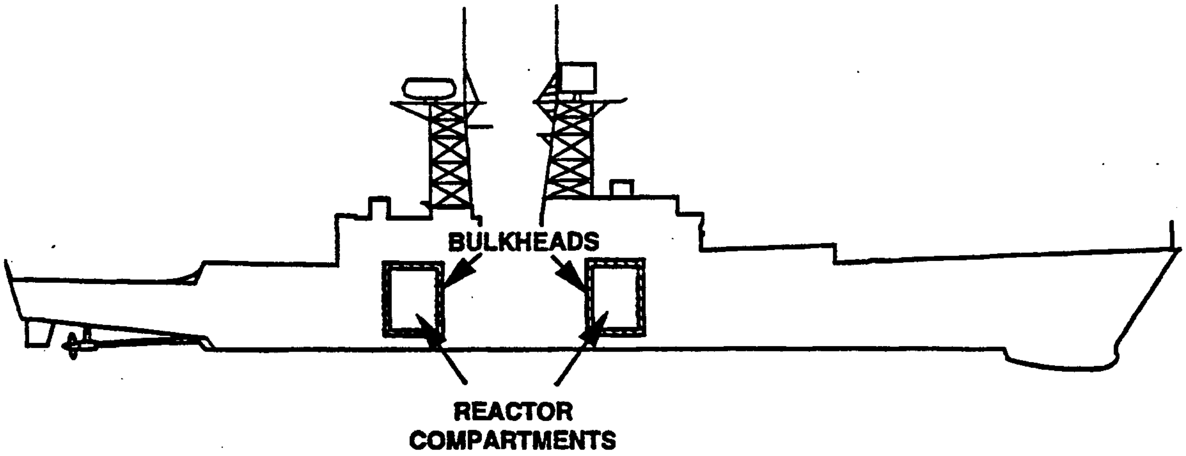

Figure S.2. Typical Cruiser Reactor Compartment Location disposal. The Navy has determined that this same basic method is the preferred alternative for disposal of reactor compartments from cruisers, LOS ANGELES Class submarines and OHIO Class submarines when compared to the other alternatives evaluated in this EIS.

1. Background

As of the end of 1994, the U.S. Navy had 99 nuclear-powered submarines and 13 nuclear-powered surface ships in operation. Today, over 40% of the Navy's principal combatants are nuclear-powered.

A nuclear-powered ship is constructed with the nuclear power plant inside a section of the ship called the reactor compartment. Figure S.1 shows a typical submarine with the location of the reactor compartment identified. Figure S.2 shows a typical cruiser with the location of the reactor compartments identified. The components of the nuclear power plant include a high-strength steel reactor vessel, heat exchanger(s) (steam generator), and associated piping, pumps, and valves. Each reactor plant contains over 100 tons of lead shielding, part of which is made radioactive by contact with radioactive material or by neutron activation of impurities in the lead.

Before a ship is taken out of service, the spent fuel is removed from the reactor pressure vessel of the ship in a process called defueling. This defueling removes all of the fuel and most of the radioactivity from the reactor plant of the ships. The fuel removed from the decommissioned ships would be handled in the same manner as that removed from ships which are being refueled and returned to service. Unlike the low-level radioactive material in defueled reactor plants, the Nuclear Waste Policy Act of 1982, as amended, requires disposal of spent fuel in a deep geological repository. Storage and disposal of spent fuel from refuelings and defuelings of nuclear-powered ships does not affect the decision of how to dispose of the defueled reactor compartments. Further, handling of spent fuel from these ships was addressed in the Programmatic Spent Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, (DOE, 1995) in which the Navy is a cooperating agency. Therefore, handling and disposal of spent fuel is not the subject of this Environmental Impact Statement.

Prior to disposal, the reactor pressure vessel, radioactive piping systems, and the reactor compartment disposal package would be sealed. Thus, they act as a containment structure for the radioactive atoms and delay the time when any of the radioactive atoms inside would be available for release to the environment as the metal corrodes. This is important because radioactivity "decays" away with time; that is, as time goes on radioactive atoms change into nonradioactive atoms. Since radioactivity decays away with time, the effect of a delay is that fewer radioactive atoms would be released to the environment. Over 99.9% of these atoms are an integral part of the metal and they are chemically just like ordinary iron, nickel, or other metal atoms. These radioactive atoms are only released from the metal as a result of the slow process of corrosion. The remaining 0.1% which is corrosion and wear products, will decay away prior to penetration of the containment structures by corrosion.

The decay of radioactive atoms produces radiation, which can cause damage to tissue if there is insufficient distance or shielding between the source and the tissue. The effects on people of radiation that is emitted during decay of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. Within kinds of radiation, the energy of the radiation varies depending on the source isotope. The more energetic radiation of a given kind, the more energy that will be absorbed, in general. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem or mrem (0.001 or 10^{-3} rem).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic process decrease the dose rate with the passage of time.

Doses are often classified into two categories: acute, which is a large dose received over a few hours or less; and chronic, which involves repeated small doses over a long time (months or years). Chronic doses are usually less harmful than acute doses because the time between exposures at low dose rates allows the body to repair damaged cells. Only chronic effects are considered here as the exposures discussed are much less than the threshold for acute effects. The most significant chronic effect from environmental and occupational radiation exposures is induction of latent cancer fatalities. This effect is referred to as latent because the cancer may take many years to develop.

Hypothetical health effects can be expressed in terms of estimated latent cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection which specifies 0.0005 latent cancer fatalities per person-rem of exposure to the public and 0.0004 latent cancer fatalities per person-rem for workers (ICRP, 1991).

To place exposure into perspective with normal everyday activities of the general public, a typical person in the United States receives 300 mrem of radiation exposure each year from natural background radiation, (NCRP, 1987). Natural background radiation is radiation that all people receive every day from the sun or from cosmic radiation, and from the natural radioactive materials that are present in our surroundings, including the rocks or soil we walk on.

2. Summary of Alternatives

a. Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

In this alternative, the reactor compartments would be prepared for shipment at Puget Sound Naval Shipyard, shipped to and buried at the Department of Energy (DOE) Hanford Site in the state of Washington. The Hanford Site is used for disposal of radioactive waste from DOE operations. The pre-LOS ANGELES Class submarine reactor compartments are placed at the Hanford Site Low Level Burial Grounds for disposal, at the 218-E-12B burial ground in the 200 East area.

The Hanford Site is a large federal government site, occupying 1450 square kilometers (560 square miles) (365,000 acres) in southeastern Washington state. In the middle of the site on the Central Plateau, approximately 210 hectares (518 acres) have been designated as the Low Level Burial Grounds. The Low Level Burial Grounds are about seven miles from the Columbia River. The Hanford Site, and in particular the 218-E-12B low level burial ground, is well suited to the permanent disposal of these reactor compartments due to (1) accessibility by barge via the Columbia River and proximity to barge off-loading facilities, (2) an arid climate, (3) excellent soil characteristics which inhibit the corrosion of metal and the migration of metals and radionuclides down through the soil, (4) the current designation of the area for disposal of low level radioactive waste and current placement of pre-LOS ANGELES class submarine reactor compartments at the 218-E-12B burial ground for disposal, (5) isolation of the 218-E-12B burial ground and all Hanford low level burial grounds from the general public, and (6) institutional controls for the management of radioactive and dangerous waste.

The disposal of the reactor compartments from the cruisers, LOS ANGELES, and OHIO Class submarines would be consistent with the pre-LOS ANGELES Class submarine reactor compartment disposal program. The land required for the burial of approximately 100 reactor compartments from the cruisers, LOS ANGELES, and OHIO Class submarines would be approximately 4 hectares (10 acres) which is similar to the land area needs for the pre-LOS ANGELES Class submarine reactor compartments. Besides the reactor compartments, the volume of mixed waste generated by this alternative is estimated to be about 1625 cubic meters (57,400 cubic feet). This mixed waste would be managed in accordance with the approved Shipyard Site Treatment Plan and associated implementing order pursuant to the Federal Facility Compliance Act.

Briefly, this alternative would involve draining the piping systems, tanks, vessels, and other components to the maximum extent practical, sealing the radioactive systems, removing the reactor compartment and enclosing it in a high integrity all-welded steel package. The reactor compartment packages would meet the Type B requirements of the Department of Transportation, the Nuclear Regulatory Commission, and the Department of Energy. Non radioactive metal, such as submarine hulls, could be recycled. The reactor compartment package would be transported by barge out of Puget Sound through the Strait of Juan de Fuca, down the Washington coast, and up the Columbia River to the Port of Benton where it would be loaded onto an overland transporter and hauled the short distance to the Department of Energy's Low Level Radioactive Waste Burial Grounds at the Department of Energy's Hanford Site near Richland, Washington.

Disposal of the reactor compartments would be in accordance with Department of Energy requirements for low level radioactive waste disposal. Disposal of the reactor compartments would be regulated by the State of Washington due to the lead shielding contained within the reactor compartments, and by the United States Environmental Protection Agency due to the small quantity of solid polychlorinated biphenyls within the reactor compartments in the form of industrial materials such as insulation, electrical cables, and rubber parts. The total volume of the reactor compartments is about 120,000 cubic meters (4,240,000 cubic feet).

An estimated cost for land burial of the reactor compartments is $10.2 million for each LOS ANGELES Class submarine reactor compartment, $12.8 million for each OHIO Class submarine reactor compartment, and $40 million for each cruiser reactor compartment. The estimated total Shipyard occupational exposure to prepare the reactor compartment disposal packages is 13 rem (approximately 0.005 additional latent cancer fatalities) for each LOS ANGELES Class submarine package, 14 rem (approximately 0.006 additional latent cancer fatalities) for each OHIO Class submarine package and 25 rem (approximately 0.01 additional latent cancer fatalities) for each cruiser package. The total estimated cost of this alternative is approximately $1,500 million and the total estimated Shipyard occupational exposure is 1508 rem (approximately 0.6 additional latent cancer fatalities). Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

b. No Action Alternative - Protective Waterborne Storage for an Indefinite Period

A ship can be placed in floating protective storage for an indefinite period. Nuclear-powered ships can also be placed into storage for a long time without risk to the environment. The ship would be maintained in floating storage. About every 15 years each ship would have to be taken out of the water for an inspection and repainting of the hull to assure continued safe waterborne storage. However, this protective storage does not provide a permanent solution for disposal of the reactor compartments from these nuclear-powered ships. Thus, this alternative does not provide permanent disposal.

The two Naval Shipyards considered for this alternative are: Puget Sound Naval Shipyard located in Bremerton, Washington and Norfolk Naval Shipyard located in Portsmouth, Virginia. These are the two Naval Shipyards with inactive nuclear ship maintenance facilities.

An estimated cost to prepare a cruiser, LOS ANGELES, or an OHIO Class submarine for protected waterborne storage and to keep it in storage for 15 years is approximately $1.6 million each. To keep a cruiser, or a LOS ANGELES, or a OHIO Class submarine in waterborne storage for an additional 15 years is estimated to cost $1.75 million each. Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

c. Disposal and Reuse of Subdivided Portions of the Reactor Plant

In general, disposal and reuse of subdivided portions of the reactor compartments would expand and build upon operations and processes in use at Naval Shipyards to overhaul ships and recycle non-radioactive portions of decommissioned ships. It would require large scale changes in terms of the numbers and size of components to be processed. Very large components, such as reactor vessels, steam generators and pressurizers, which are not removed from reactor compartments under current programs, would have to be removed, packaged and disposed of individually. In addition, the quantity of smaller components such as valves, pumps and gages to be processed would be orders of magnitude greater than under current Shipyard workloads. Compatible dismantlement processes, packaging methods, modes of transportation and disposition sites would be selected for each individual radioactive component. A massive shielded container would be needed for transport of the reactor vessel and its internal structure to the appropriate disposal site. Non-radioactive metal, such as submarine hulls, would be recycled.

The amount of waste estimated for the subdivision alternative ranged from a high of 120,000 cubic meters (4,240,000 cubic feet) to a low of 10,000 cubic meters (353,000 cubic feet) with an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). The amount of mixed waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

The cost of this alternative is estimated to be between $82.2 million and $93.6 million, per reactor compartment depending upon the estimating method used (see Appendix C). The radiological dose to workers is estimated to be between 230 and 1,115 rem per reactor compartment if accomplished immediately (0.09 to 0.45 additional latent cancer fatalities) or between 60 and 338 rem per reactor compartment (0.02 to 0.14 additional latent cancer fatalities) if deferred 10 years. Deferral of subdivision operations would not result in any significant reduction in radioactive waste volume. Deferral would require placement of inactivated ships in protected waterborne storage as described in the no action alternative. Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

d. Indefinite Storage Above Ground at Hanford

In this alternative, reactor compartments would be stored indefinitely at the Department of Energy Hanford Site. At the Hanford Site, Trench 94 in the 218-E-12B low Level Burial Ground of the 200 East area is currently used for disposal of pre-LOS ANGELES Class submarine reactor compartments. The area to the north of this trench is available for Navy use and could accommodate the storage of 100 reactor compartments.

Compartment packaging and transport methods would be identical to those for the preferred alternative. Estimated costs for packaging and transporting compartments to the storage site are identical to those for the preferred alternative. Corresponding radiation exposures are also identical. See Table S.1 for further comparison.

This alternative is similar to the preferred alternative through shipment of the reactor compartments to the 218-E-12B burial ground. However, as in the no-action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive, hazardous and PCB waste contained by the reactor compartments.

e. Other Alternatives

The following alternatives were eliminated from detailed evaluation as discussed below.

(1) Sea Disposal

Sea disposal would involve sinking the entire ship in the deep ocean. Ocean dumping of low level radioactive material is prohibited by the London Convention for 25 years (IMO, 1993). This alternative would require new legislation to implement.

(2) Land Disposal of Entire Reactor Compartments at Other Sites

The Low Level Radioactive Waste Policy Act Amendments of 1985 state the Federal Government shall be responsible for disposal of low-level radioactive waste owned or generated by the U.S. Navy as a result of the decommissioning of U.S. Navy vessels. In addition, the need to maintain control of the classified design information inherent in the reactor compartments and many of their components requires a site under Federal control. Federal nuclear waste disposal sites are located at Department of Energy Sites.

Department of Energy radioactive waste disposal sites, other than the preferred alternate site at Hanford, pose physical limitations. Disposal of the entire reactor compartment disposal package at any site is dependent on the ability to transport the package to the site. In general, the only feasible means of transportation over long distances for packages over 1000 tons and over 30 feet tall is by barge. Physical restrictions to overland transport of the packages include bridges, overhead obstructions, embankments, road load bearing capacity, and steep or narrow roads. Because of the lack of availability of a nearby barge transportation route and land transportation required over long distances, all other Department of Energy land disposal sites would be inaccessible.

(3) Permanent Above Ground Disposal at Hanford

In this alternative, cruiser, LOS ANGELES, and OHIO class reactor compartments would be placed above ground at the Hanford Site, and covered with soil, entombing the reactor compartments in a soil mound. A Resource Conservation and Recovery Act compliant closure cover would be placed over the compartments. The gentle slope of this cover would occupy more land space than if the compartments were placed below ground in a trench. The gentle slope would result in a minor recontouring of the original land surface into a natural looking gradual rise. For sites with groundwater aquifers that are non-existent or deep underground like Hanford, the resulting environmental impacts of this alternative are very similar to the preferred alternative.

3. Summary of Environmental Consequences

The preferred alternative of land burial of the entire reactor compartment at the DOE's Hanford site would result in a much lower potential for latent cancer fatalities among workers in addition to a much lower cost as compared to the subdivision alternative. The environmental consequences of the preferred alternative, the no action alternative and the alternative of indefinite storage above ground at Hanford would all be low, but the preferred alternative has the advantage of being a permanent solution whereas the other two alternatives are interim solutions that only defer the need for permanent disposition.

a. Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

(1) Shipyard Operations

Radiation exposure to Shipyard workers associated with reactor compartment disposal packaging operations to accomplish the preferred alternative has been estimated to be 1508 rem (approximately 0.6 additional latent cancer fatalities).

In all of the alternatives, the Navy would generate radioactive waste, PCB waste, and hazardous waste for disposal. However, the Navy would minimize the amount generated and any waste generated would be disposed of in accordance with applicable state and federal regulations using licensed transportation contractors and disposal sites.

(2) Transport Route

The impacts along the transport route that would be used to move reactor compartments from Puget Sound Naval Shipyard to the Hanford Site for disposal are evaluated in Appendix E. It is estimated that the preferred alternative would involve 100 reactor compartment shipments and would result in exposure to the general population of 5.8 person-rem (0.003 latent cancer fatalities). For the transportation crew it is estimated that exposure would be 5.8 person-rem (0.002 latent cancer fatalities).

In order to use the existing land transport route, six overhead power lines may need to be modified to accommodate the larger reactor compartment disposal packages under consideration in this EIS. If necessary, these modifications would only affect the sections of the power line within the immediate vicinity of the land transport route.

(3) Land Disposal Site

Approximately 4 hectares (10 acres) of land from the 218-E-12B low level burial ground in the 200 East area of the Hanford Site would be required for land disposal of the approximately 100 reactor compartment disposal packages from the cruisers, LOS ANGELES, and OHIO Class submarines. As is the case with other areas of the Hanford Site used for radioactive waste disposal, the land area used for disposal of the reactor compartment disposal packages and the surrounding buffer zone would constitute commitment of that land area and the natural resources contained therein.

The cruiser, LOS ANGELES, and OHIO Class reactor compartment disposal packages would be regulated for their radioactivity, lead, and PCB content. The release rates for these constituents are expected to be extremely small such that applicable environmental standards are not expected to be exceeded. The volume of mixed waste generated by this alternative would be less than 120,000 cubic meters (4,240,000 cubic feet). The migration of these constituents from the reactor compartments to the groundwater aquifer and to the Columbia River is also expected to be slow. For radioactivity, no short lived radionuclides are expected to be released.

b. No-Action Alternative

Shipyard Operations

Radiation exposure to the Shipyard workers associated with preparing the ships for indefinite waterborne storage following inactivation and decommissioning to accomplish the No Action alternative is estimated to be approximately 50 rem (0.02 latent cancer fatalities). This would include the first 15 years of waterborne storage maintenance operations and inspections. Because radiation exposure to the workers is primarily due to Cobalt-60 which has a half life of 5.3 years, during each 15 years storage period nearly three half lives of radioactive decay occur. As a result, exposure during the second 15 years waterborne storage period would be only 5.3 rem (0.002 latent cancer fatalities). Existing moorage capacity is adequate until after the year 2000.

c. Disposal and Reuse of Subdivided Portions of the reactor compartment

(1) Shipyard Operations

Based on results from dismantling of the Shippingport nuclear power plant and NRC projections for decommissioning of a commercial nuclear power plant, this alternative would result in from 22,500 to 109,000 rem (9.1 to 43.7 additional latent cancer fatalities) of worker radiation dose if performed immediately after decommissioning of the ships. Worker radiation dose would be reduced by about one–half for every 5 years that operations are deferred such that after a ten year deferral, worker radiation dose would be reduced to between 6,090 and 33,100 rem. (2.4 to 13.2 additional latent cancer fatalities).

(2) Transport Routes

The impacts along transportation routes that would be used to move subdivided portions of reactor compartments to disposal sites are evaluated in Appendix E. Four origin-destination cases are evaluated (Puget Sound to Hanford, Puget Sound to Savannah River, Norfolk to Hanford and Norfolk to Savannah River). Since two of the cases are for origins and destinations on the same coast and two are for origins and destinations on opposite coasts, the evaluation is considered to bound shipment of subdivided components from either of the two origins (Puget Sound and Norfolk) to any disposal site within the 48 contiguous states. It is estimated that the subdivision alternative would involve 1571 shipments and would result in exposure to the general population of 11 to 119 person-rem (0.006 to 0.060 latent cancer fatalities). For the transportation crew it is estimated that exposure would be from 12 to 96 person-rem (0.005 to 0.039 latent cancer fatalities).

(3) Disposal Sites

The amount of waste estimated for the subdivision alternative ranged from a high of 120,000 cubic meters (4,240,000 cubic feet), assuming no volume reduction, to a low of 10,000 cubic meters (353,000 cubic feet) assuming extensive volume reduction. An assumption of moderate volume reduction resulted in an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). In all three cases the amount of mixed waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

d. Indefinite Storage Above Ground at Hanford

The impacts of this alternative would be the same as for the preferred alternative as, except for actual burial at Hanford, identical actions are performed. As in the No Action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive and hazardous material contained by the reactor compartment package.

4. Comparison of Alternatives

A comparison of the preferred alternative, the no action alternative, the subdivision alternative, and the indefinite storage above ground alternative is provided in Table S.1.

Table S.1 Comparison of Alternatives

	Preferred Alternative	No Action Alternative	Subdivision[4] Alternative		Indefinite Storage Above Ground Alternative
			Immediate	10 Year Deferral	
Number of Shipments	100	0	1571	1571	100
Additional fatalities **Occupational[1]** **Public[2] (Radiological)** **Public[3] (Non-radiological)**	 0.602 0.003 0.001	 0.02 0 0	 9.1 to 43.7 0.006 0.03	 2.4 to 13.2 0.002 0.03	 0.602 0.003 0.001
Land Commitment	Approximately 10 Acres	N/A	Approximately 10 Acres		Approximately 10 Acres
Estimated Cost	$1,500,000,000 (5)	$140,000,000 for first 15 years of storage plus cost of final disposition.	$9,400,000,000 (6)		$1,500,000,000 plus caretaker cost plus cost of final disposition.

[1] Occupational fatalities consist of on-site worker and transportation worker latent cancer fatalities. Occupational latent cancer fatalities are calculated by multiplying occupational exposure in rem by 0.0004 additional latent cancer fatalities per rem.

[2] Public (Radiological) fatalities consist of radiation related latent cancer fatalities for the general population, which are calculated by multiplying estimated general population exposure in rem by 0.0005 additional latent cancer fatalities per rem. The estimated number of radiological fatalities include those associated with accidents, which account for less than 15% of the total for all of the alternatives.

[3] Public (Non-radiological) fatalities consist of fatalities from non-radiological causes related to transportation accidents (which accounts for about 90% of the risk) and transportation vehicle exhaust emissions.

[4] Values shown for the subdivision alternative are based on shipment from Puget Sound Naval Shipyard to the Hanford Site.

[5] 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.

[6] The discounted amount would be 4.3 billion dollars based on a discount rate of 4.9% over a 32 year period beginning in 1997.

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1. PURPOSE AND NEED

U.S. Navy nuclear ships are decommissioned and defueled at the end of their useful lifetime, when the cost of continued operation is not justified by their military capability, or when the ship is no longer needed. The Navy needs to disposition the reactor compartments from defueled and decommissioned cruisers, and OHIO Class and LOS ANGELES Class submarines. The number of reactor compartments under consideration by this Environmental Impact Statement is about 100. These reactor compartments are in addition to the pre-LOS ANGELES Class submarines already being disposed of under the Navy's 1984 Final Environmental Impact Statement (USN, 1984a). Newer types of U.S. Navy nuclear-powered ships that are not expected to be decommissioned in the next 20 years (e.g., aircraft carriers, SEAWOLF Class submarines) are not included in this Final Environmental Impact Statement.

1.1 Background

As of the end of 1994, the U.S. Navy had 99 nuclear-powered submarines and 13 nuclear-powered surface ships in operation. Today, over 40% of the Navy's major combatant warships are nuclear-powered.

In the late 1970's and early 1980's the Navy evaluated options for disposing of the pre-LOS ANGELES class nuclear-powered submarine reactor compartments as the ships were reaching the end of their design life. The Record of Decision issued by the Secretary of the Navy for the Navy's 1984 Final Environmental Impact Statement (USN, 1984b) stated that "Based on consideration of all current factors bearing on a disposal action of this kind contemplated, the Navy has decided to proceed with disposal of the reactor compartments by land burial." As of the end of 1994, the Navy has safely shipped 43 submarine reactor compartments to the Department of Energy's Low Level Burial Grounds at Hanford, Washington.

Today the Navy faces the necessity of downsizing the fleet to an extent that was not envisioned in the 1980's before the end of the Cold War. Over the next several years most of the nuclear-powered cruisers will be removed from service. The Navy has already removed from service USS TEXAS (CGN39), USS VIRGINIA (CGN38), USS TRUXTUN (CGN35) and USS LONG BEACH (CGN9). Some LOS ANGELES Class submarines are scheduled for removal from service as well. The Navy has removed from service USS BATON ROUGE (SSN 689), and is in the process of inactivating USS OMAHA (SSN 692), and USS CINCINNATI (SSN 693). Eventually, the Navy will also need to decommission OHIO Class submarines. Disposal of the reactor compartments from these classes of nuclear-powered ships was not considered in the 1984 Environmental Impact Statement, (USN, 1984a). Since the final submarines of the LOS ANGELES Class and OHIO Class are still under construction, the need to dispose of the ships of these classes will extend to the end of their service life, which could be in excess of 30 years.

US Navy nuclear-powered ships are defueled during inactivation and prior to transfer of the crew. The defueling process removes the nuclear fuel from the reactor pressure vessel and consequently removes most of the radioactivity from the reactor plant. Defueling is an operation routinely accomplished using established processes at shipyards qualified to perform reactor servicing work.

Removed spent fuel would be handled in accordance with either the Environmental Assessment (USN, 1993) and Finding of No Significant Impact (USN, 1994) or the U.S. Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, (DOE, 1995). A Record of Decision was issued in June 1995. Storage and disposal of spent fuel from refuelings and defuelings of nuclear-powered ships does not affect the decision of how to dispose of the defueled reactor compartments. Therefore, spent naval nuclear fuel is not included in this Environmental Impact Statement.

1.2 General Description of Reactor Compartments

The nuclear propulsion plants in United States Navy ships, while differing in size and component arrangements, are all rugged, compact, pressurized water reactors designed, constructed, and operated to exacting criteria. The nuclear components of these plants are all housed in a section of the ship called the reactor compartment. The reactor compartments all serve the same purpose but may have different shapes depending on the type of ship. For submarines, the reactor compartment is a horizontal cylinder formed by a section of the ship's pressure hull, with shielded bulkheads on each end. Cruiser reactor compartments are shielded vertical cylinders or shielded rectangular boxes deep within the ship's structure. Figures S.1 and S.2 illustrate the general location of the reactor compartments within submarines and cruisers respectively.

The propulsion plants of nuclear-powered ships remain a source of radiation even after the vessels are shut down and the nuclear fuel is removed. Defueling removes all fission products since the fuel is designed, built and tested to ensure that fuel will contain the fission products. Figure 1.1 shows a simplified schematic of a nuclear propulsion plant. 99.9% of the radioactive material that remains is an integral part of the structural alloys forming the plant components. The radioactivity was created by neutron irradiation of the iron and alloying elements in the metal components during operation of the plant. The remaining 0.1% is radioactive corrosion and wear products that have been circulated by reactor coolant, having become radioactive from exposure to neutrons in the reactor core, and then deposited on piping system internals.

A brief description of the way this equipment is used to produce energy in a nuclear reactor will help explain how the radioactivity in a ship is generated. The fuel in a reactor contains uranium atoms sealed within metal cladding. Uranium is one of the few materials capable of producing heat in a self-sustaining chain reaction. When a neutron causes a uranium atom to fission, the uranium nucleus is split into parts producing atoms of lower atomic number called fission products (Figure 1.2). When formed, the fission products initially move apart at very high speeds, but they do not travel very far, only a few thousandths of an inch, before they are stopped within the fuel cladding. Most of the heat produced in the fission process comes from stopping these fission products within the fuel and converting their kinetic energy into heat.

Radioactivity is created during fission because some of these fission products are highly radioactive when they are formed. Most of the radioactivity produced by nuclear fuel is in the fission products. The uranium fuel in naval nuclear propulsion reactor cores uses highly corrosion-resistant and highly radiation-resistant fuel and cladding. As a result, the fuel is very strong and has very high integrity. The fuel is designed, built, and tested to ensure that the fuel construction will contain and hold the radioactive fission products. Naval fuel totally contains fission products within the fuel - there is no fission product release from the fuel in normal operation.

Fissioning of uranium also produces neutrons while the nuclear power plant is operating. Most of the neutrons produced are absorbed by the atoms within the fuel and continue the chain reaction. However, some of the neutrons travel away from the fuel, go outside the fuel, and are absorbed in the metal structure which supports the fuel or in the walls of the reactor pressure vessel (Figure 1.2). Trace amounts of corrosion and wear products are carried by reactor coolant from reactor plant metal surfaces. Some of these become radioactive from exposure to neutrons.

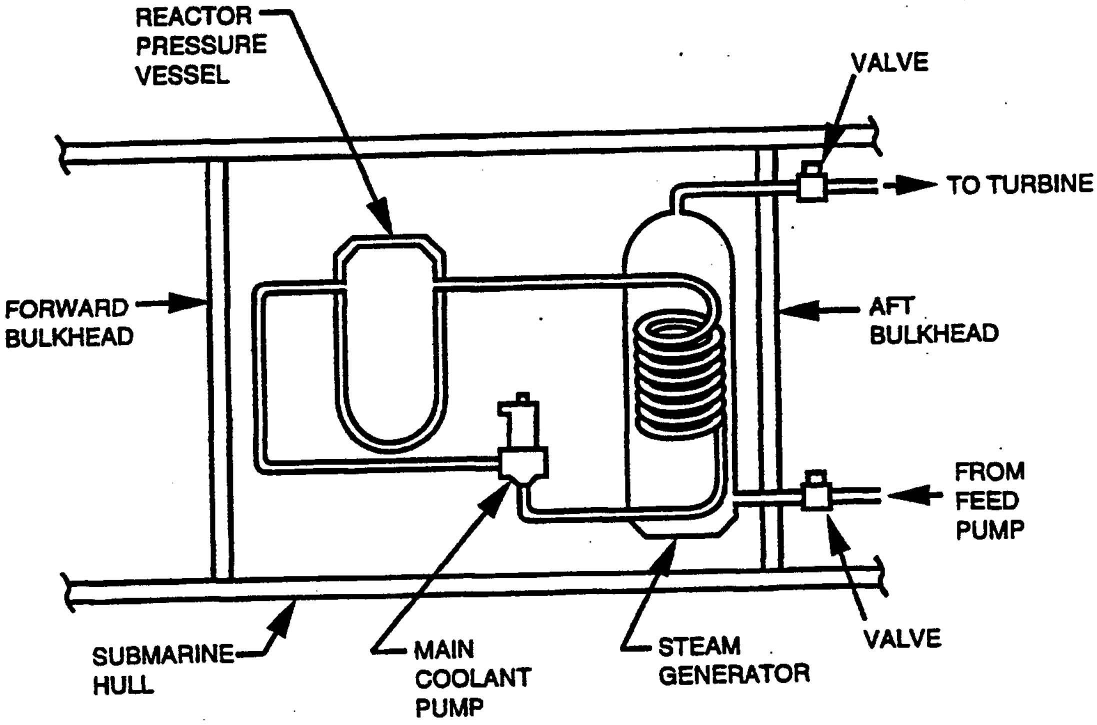


Figure 1.1. Schematic of Nuclear Propulsion Plant

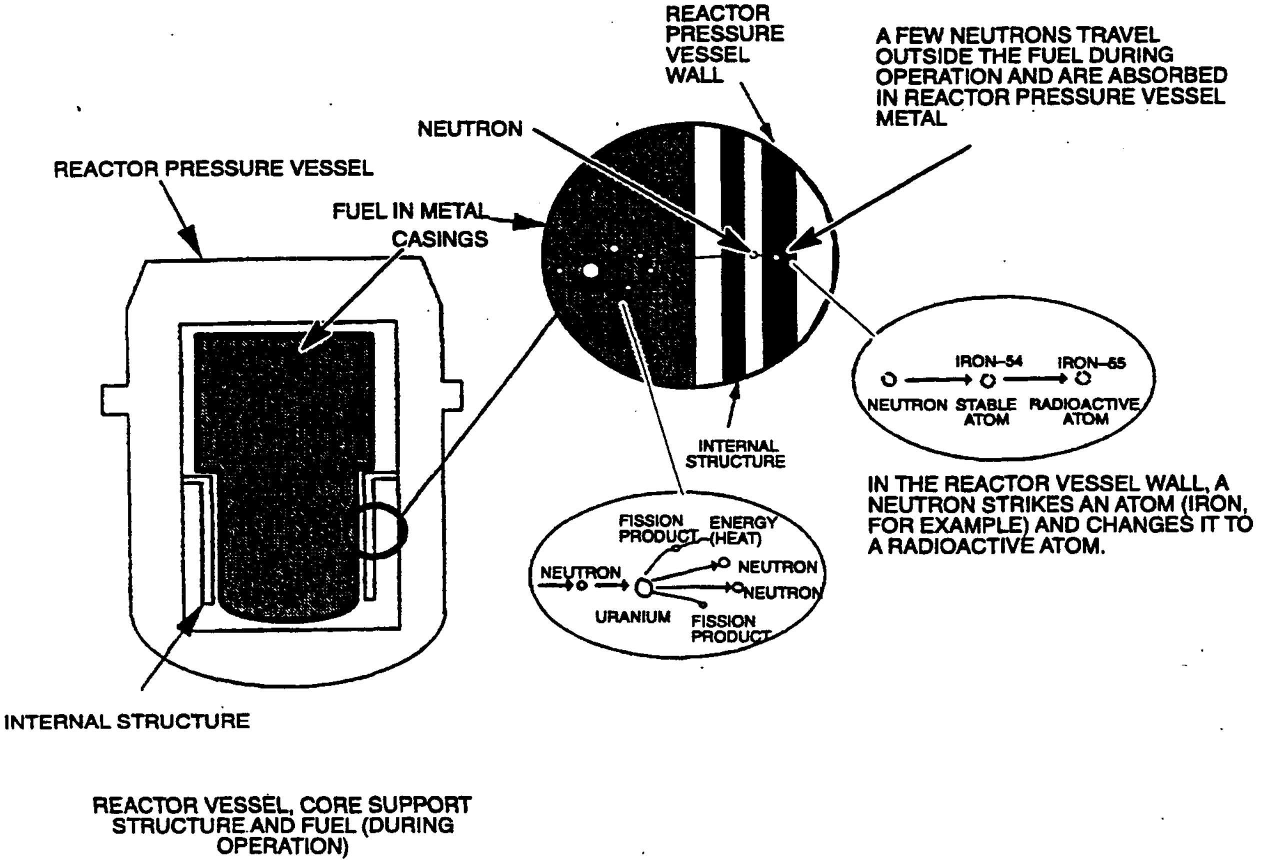


Figure 1.2. Neutron and Fission Products from Uranium Fission

Reactor coolant carries some of these radioactive products through the piping systems where a portion of the radioactivity is removed by a purification system. Most of the remaining radionuclides transported from the reactor core deposit in the piping systems. These neutrons, when absorbed in the nucleus of a nonradioactive atom like iron, can produce a radioactive atom. For example, iron-54 contains a total of 54 particles. Adding an additional neutron produces an atom containing 55 particles, called iron-55. This atom is radioactive. At some later time, it changes into a nonradioactive manganese-55 atom by releasing energy in the form of radiation (Figure 1.3). This is called radioactive decay.

Reactor design and operational life of reactor plants varies somewhat between ship classes, and consequently, radioactivity within the plants will also vary. For characterizing radioactivity, cruiser, LOS ANGELES, and OHIO Class reactor plants can be categorized into five plant types as described in Appendix D. Table 1.1 provides typical radionuclide inventories for each of these plant types and identifies radionuclides that contribute greater than 1% of the total activity in the reactor plant. These radionuclides all have half lives of 100 years or less. Of this group, cobalt-60 is the predominant radionuclide and decays by a factor of two every 5.3 years. It emits penetrating gamma radiation and is the major source of radiation in the defueled reactor plant.

Of the Table 1.1 radionuclides, after 500 years, only nickel-63 remains. This radionuclide is not a major source of radiation as it emits beta particles, which are stopped by the steel structure in the reactor vessel. Longer lived radionuclides are present in reactor plants but contribute very little to the total curie content. Carbon-14, niobium-94, nickel-59, selenium-79, and technecium-99 are essentially contained within the sealed reactor vessel, concentrated in the internal structure shown on Figure 1.2. Carbon-14, like nickel-63 is a beta emitter. Nickel-59 emits weak X-rays and electrons that do not penetrate the reactor plant structure. However, because of the quantity and long half-life of this radionuclide (decays by a factor of 2 every 75,000 years), migration of this radionuclide into groundwater is theoretically possible. Niobium-94, a gamma emitter, is present in small quantity, typically less than 1 curie per plant. Even after permanent disposal, there remains a small potential for future radiation exposure to individuals from long-lived radionuclides that may eventually be released to the environment. The only mechanism for release would be through corrosion of the metal components of the reactor plant, a very slow process under any disposal option. Most of the radionuclides would decay to stable isotopes long before they could be released, and even for the longest lived radionuclides, only a small portion of the initial curie inventory would be released. Appendix B provides a more detailed discussion of this condition and the exposure that may result from potential intruder scenarios for buried reactor plants. Appendix D provides a more detailed discussion of the amount and nature of these long lived radionuclides and the method used to calculate their quantities.

The reactor compartments also contain a large amount of elemental solid lead used as shielding. Each reactor compartment contains over 100 tons of permanently installed lead shielding which would cause the reactor compartment to be regulated as dangerous waste for disposal under Washington State Dangerous Waste Regulations, Chapter 173-303 of the Washington State Administrative Code (WAC, 1993). Some shielding lead may have impurities which have become activated due to neutron activation. Decontamination of this lead by removal of radioactive impurities would not be practicable because lead used in reactor shielding is already high purity lead which was refined an extra step to minimize impurities. Radioactive lead must be disposed of as mixed radioactive and chemically hazardous waste (hereafter referred to as mixed waste).

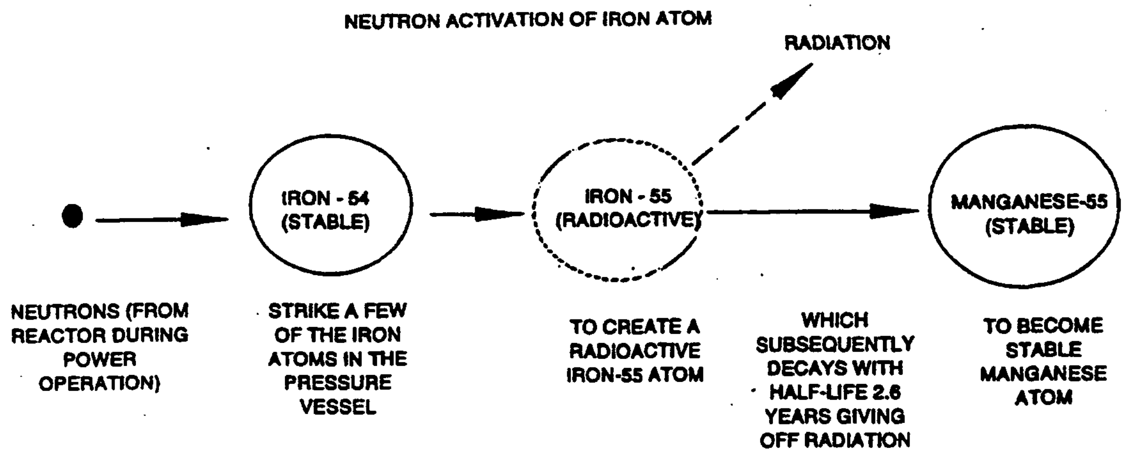


Figure 1.3. Capture Neutrons in Iron of Pressure Vessel Walls

TABLE 1.1

TYPICAL RADIOACTIVITY BY INDIVIDUAL RADIONUCLIDE PRESENT IN CRUISER, LOS ANGELES, AND OHIO CLASS DEFUELED, DECOMMISSIONED REACTOR PLANTS ONE YEAR AFTER FINAL REACTOR SHUTDOWN AND 500 YEARS LATER

Radionuclide[a]	tellurium-125m	zirconium-95/ niobium-95 [b]	cobalt-58	tantalum-182	tin-119m	iron-55	antimony-125	cobalt-60	nickel-63	All Listed Radionuclides
Half-life (years)[c]	0.16	0.18/0.10	0.19	0.32	0.81	2.69	2.77	5.27	100	NA
Radiation Emitted[c, d]	gamma, X-rays, e^-	gamma, beta $^-$	gamma, X-rays, beta$^+$, e^-	gamma, X-rays, beta$^-$, e^-	X-rays, e^-	X-rays, e^-	gamma, X-rays, beta $^-$, e^-	gamma, beta $^-$	beta $^-$	NA
Initial Radioactivity One Year After Final Shutdown (curies)										
Reactor Plant Type #1	$(5.0 \times 10^{-10})^{e}$	$(1.7/5.1 \times 10^{-2})^{e}$	1.7×10^{3}	$(1.2 \times 10^{2})^{e}$	$(4.2 \times 10^{-9})^{e}$	6.7×10^{3}	$(2.3 \times 10^{-9})^{e}$	1.2×10^{4}	2.9×10^{4}	5.0×10^{4}
Reactor Plant Type #2	$(7.8 \times 10^{-5})^{e}$	$(4.4/11 \times 10^{-3})^{e}$	4.9×10^{2}	$(9.6 \times 10)^{e}$	$(4.1 \times 10^{-4})^{e}$	1.9×10^{3}	$(3.6 \times 10^{-4})^{e}$	3.2×10^{3}	1.5×10^{4}	2.1×10^{4}
Reactor Plant Type #3	8.6×10^{2}	$2.3/4.9 \times 10^{3}$	8.4×10^{2}	1.0×10^{3}	6.8×10^{3}	8.8×10^{3}	4.0×10^{3}	1.0×10^{4}	1.9×10^{4}	5.9×10^{4}
Reactor Plant Type #4	8.2×10^{2}	$2.2/4.7 \times 10^{3}$	8.0×10^{2}	1.0×10^{3}	6.5×10^{3}	1.8×10^{4}	3.8×10^{3}	1.0×10^{4}	3.8×10^{4}	8.6×10^{4}
Reactor Plant Type #5	$(< 1 \times 10^{-6})^{e}$	$(3.8/8.2 \times 10^{-3})^{e}$	$(1.2 \times 10^{2})^{e}$	$(8.20 \times 10^{0})^{e}$	$(< 1 \times 10^{-3})^{e}$	4.0×10^{3}	$(2.0 \times 10^{-1})^{e}$	3.6×10^{3}	7.8×10^{3}	1.6×10^{4}
Radioactivity 500 Years Later (curies)[f]										
Reactor Plant Type #1	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	9.0×10^{2}	9.0×10^{2}
Reactor Plant Type #2	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	4.7×10^{2}	4.7×10^{2}
Reactor Plant Type #3	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	5.9×10^{2}	5.9×10^{2}
Reactor Plant Type #4	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	1.2×10^{3}	1.2×10^{3}
Reactor Plant Type #5	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	$(<1 \times 10^{-10})^{e}$	2.4×10^{2}	2.4×10^{2}

a: radionuclides listed represent 1% or greater of total curies at one year after shutdown for at least one plant type; long lived activity representing less than 1% of total curies at one year after shutdown are discussed in Appendix D.

b: both radionuclides are initially present at the curie contents provided, but are closely related in that a portion of the parent radionuclide decays to the daughter radionuclides.

c: KOCHER, 1981.

d: e^- represents (negatively charged) electrons emitted from orbital shells around the atomic nucleus.

e: less than 1% of total curies; provided for comparison.

f: decay constant=0.693/(half–life of radionuclide in years)

These regulations require that disposal of mixed waste be at an approved disposal site. There are presently no facilities authorized to treat and dispose of lead mixed waste separated from the reactor compartment. For reactor compartment disposal work, the lead shielding in the reactor compartment is not treated. The macroencapsulation treatment standard is already met as originally constructed and not as a result of packaging the reactor compartment.

Defueled reactor compartments may also contain several pounds of polychlorinated biphenyls (PCBs) (typically less than 10 pounds) tightly bound in the composition of solid materials such as thermal insulation, electrical cable coverings, and rubber items manufactured before PCBs were banned in the 1970s. Because the PCBs are present in materials in concentrations above 50 parts per million, the reactor compartment packages would be regulated as a toxic waste by the United States Environmental Protection Agency under the Toxic Substances Control Act (40CFR761).

1.3 Pollution Prevention

It is a national policy of the United States that, whenever feasible, pollution should be reduced at the source, recycled in an environmentally safe manner, or when pollution can not be prevented, disposal or other release to the environment should be employed only as a last resort (42 U.S.C. 1990).

U.S. Naval reactor compartments are constructed such that major components and structures last the lifetime of the plant. Removal and repair or replacement of system components is minimized through careful design, quality workmanship, and improvements through research and development projects. This has helped prevent pollution by reducing nuclear waste that would be generated if nuclear components had to be repaired or replaced and by reducing chemical or other hazardous materials that are regularly used in industrial operations. In addition, these nuclear components are compact by design which further reduces the volume of radioactive waste that must be disposed of.

Ship design efforts also support pollution prevention goals by minimizing the use of hazardous materials where consistent with safety and reliability. Where feasible, less hazardous materials are substituted for hazardous materials. Under the current disposal program for pre-LOS ANGELES Class submarines, portions of the submarine forward and aft of the reactor compartment are completely recycled, which greatly reduces the volume of waste to be disposed of. The same basic recycling processes would be used for recycling, where feasible, of non-radioactive, non-hazardous portions of cruisers, OHIO Class submarines and LOS ANGELES Class submarines.

The removal of lead from reactor compartment packages is planned within the constraint of keeping worker radiation exposure as low as reasonably achievable (ALARA) (e.g., removal of non-shielding lead). This work would constitute an additional pollution prevention activity.

2. ALTERNATIVES

The following sections discuss in detail the preferred alternative for disposal of cruiser, LOS ANGELES Class submarine, and OHIO Class submarine reactor compartments, the no-action alternative, disposal and reuse of subdivided portions of the reactor plant alternative, and indefinite storage above ground at Hanford. Costs for these alternatives are addressed in Appendix C. A comparison of the alternatives with regard to the key parameters that are different amoung the alternatives is provided in Table 2.1. Other alternatives that may be feasible but are not considered practical in the present case and have been eliminated from detailed evaluation are also discussed.

2.1 Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

In this alternative the reactor compartments would be prepared for shipment at Puget Sound Naval Shipyard, shipped to and buried at the Department of Energy Low Level Burial Grounds located at the Hanford Site in the State of Washington.

The packaging, transportation, and disposal of the cruiser and LOS ANGELES Class and OHIO Class reactor compartments would use the same proven processes that are being successfully used for the pre-LOS ANGELES Class submarine reactor compartments. These processes are designed to minimize the potential for transportation accidents, to mitigate the consequences of potential transportation accidents, to facilitate recovery if necessary, and to mitigate the impacts on the environment at the land disposal site. The following sections describe the alternative in detail.

Non-radioactive, non-hazardous material could be recycled as outlined in the Navy's June, 1993 Environmental Assessment of the Submarine Recycling Program at Puget Sound Naval Shipyard (USN, 1993a). Under the current disposal program for pre-LOS ANGELES Class submarines, portions of the submarine forward and aft of the reactor compartment are completely recycled, which greatly reduces the volume of waste to be disposed of. The same basic recycling processes would be used for recycling, where feasible, of non-radioactive, non-hazardous portions of cruisers, OHIO Class submarines and LOS ANGELES Class submarines. The total volume of the reactor compartments is about 120,000 cubic meters (4,240,000 cubic feet). Besides the reactor compartments, the volume of mixed waste generated by this alternative is estimated to be about 1,625 cubic meters (57,400 cubic feet). This mixed waste would be managed in accordance with the approved Shipyard Site Treatment Plan developed pursuant to the Federal Facilities Compliance Act.

2.1.1 Preparations for Shipment

2.1.1.1 Liquid Removal

After defueling, the piping, tanks, and fluid system components that would remain within the reactor compartment disposal package would be drained to the maximum extent practical. The system draining processes for the current pre-LOS ANGELES Class submarine reactor compartment disposal program are effective in removing to the maximum extent practical the liquid originally present in the package (PSNS, 1990b).

Radioactive liquids from the reactor plant would be either demineralized water or a solution of demineralized water and potassium chromate (a corrosion inhibitor). The demineralized water would be collected into stainless steel tanks and processed, such as pumped through a liquid processing system which consists of particulate filters, activated carbon bed filters, mixed hydrogen hydroxyl resin and colloidal removal resin beds. This process reduces radioactivity in the liquid to about 10^{-8} microcuries of gamma radioactivity per milliliter of liquid. This processed

Table 2.1 Comparison of Alternatives

	Preferred Alternative	No Action Alternative	Subdivision[4] Alternative		Indefinite Storage Above Ground Alternative
			Immediate	10 Year Deferral	
Number of Shipments	100	0	1571	1571	100
Additional fatalities					
Occupational[1]	0.602	0.02	9.1 to 43.7	2.4 to 13.2	0.602
Public[2] (Radiological)	0.003	0	0.006	0.002	0.003
Public[3] (Non-radiological)	0.001	0	0.03	0.03	0.001
Land Commitment	Approximately 4 Hectares (10 Acres)	N/A	Approximately 4 Hectares (10 Acres)		Approximately 4 Hectares (10 Acres)
Estimated Cost	$1,500,000,000 (5)	$140,000,000 for first 15 years of storage plus cost of final disposition.	$9,400,000,000 (6)		$1,500,000,000 plus caretaker cost plus cost of final disposition.

[1] Occupational fatalities consist of on-site worker and transportation worker latent cancer fatalities. Occupational latent cancer fatalities are calculated by multiplying occupational exposure in rem by 0.0004 additional latent cancer fatalities per rem.

[2] Public (Radiological) fatalities consist of radiation related latent cancer fatalities for the general population, which are calculated by multiplying estimated general population exposure in rem by 0.0005 additional latent cancer fatalities per rem. The estimated number of radiological fatalities include those associated with accidents, which account for less than 15% of the total for all of the alternatives.

[3] Public (Non-radiological) fatalities consist of fatalities from non-radiological causes related to transportation accidents (which accounts for about 90% of the risk) and transportation vehicle exhaust emissions.

[4] Values shown for the subdivision alternative are based on shipment from Puget Sound Naval Shipyard to the Hanford Site.

[5] 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.

[6] The discounted amount would be 4.3 billion dollars based on a discount rate of 4.9% over a 32 year period beginning in 1997.

liquid is then stored for reuse and the filtered radiation materials are handled, packaged, and disposed of in accordance with applicable transportation and disposal site requirements. The solution of demineralized water and potassium chromate would either be reused or managed under the approved Shipyard Site Treatment Plan developed pursuant to the Federal Facility Compliance Act.

Draining the reactor compartment to the maximum extent practicable removes about 98% of the original liquid volume. However, small amounts remain trapped in pockets of valves, pumps, tanks, vessels, and other inaccessible piping system components.

For cruiser, LOS ANGELES Class submarine, and OHIO Class submarine reactor compartments, system draining procedures would be developed based on the methodology used for the pre-LOS ANGELES Class submarine reactor compartments. Briefly, all radioactively contaminated piping systems, tanks, and vessels are drained by opening existing low point drains, or pumping and/or lancing. Non–contaminated piping systems, tanks, and voids outside of the reactor compartment are drained further by removing the system or drilling and draining. Remaining liquid in radioactively contaminated systems would not be further drained due to the large amount of radiation exposure to the Shipyard worker that would be involved without measurable benefit to the quality of the environment. Federal radiation exposure guidelines require that nuclear work be accomplished in a manner that keeps radiation exposure to workers and the public as low as reasonably achievable (ALARA) (10CFR20).

This draining methodology is effective in removing about 98% of the original liquid volume while observing the ALARA guidelines. Although equivalent liquid removal methodologies would be used, the residual liquid in the reactor vessel and piping systems would be greater than the maximum remaining in the pre–LOS ANGELES Class reactor compartments. This is due to the somewhat larger systems and components that make up the reactor plant piping, valves, tanks, and vessels. The radiological dose to the workers to remove liquid using this methodology is estimated to range between 8 rem to 20 rem (approximately 0.003 to 0.008 additional latent cancer fatalities) depending on the package type. A total dose of 1018 rem (for a total of approximately 0.4 additional latent cancer fatalities) would be received for all reactor compartments under consideration.

Removing the remaining liquid, about 2% or less, of the total volume originally present would be at a considerable cost, both in money and exposure to radiation. Any additional draining operations could only be accomplished by performing difficult draining tasks within radiation areas. Further draining of liquids from the various components would result in a considerable increase in hours that workers would be exposed to radiation.

Removal of this small quantity of residual liquid would not be warranted because the significant increase in radiation exposure to the workers would be in conflict with ALARA guidelines, and would not result in any measurable benefit to the quality of the environment.

The cost to remove the remaining liquid from the cruiser, LOS ANGELES Class and OHIO Class reactor compartments is estimated at over $5 million per reactor compartment, for a total cost of over $500 million for all reactor compartments under consideration. It is estimated that greater than 68 rem (approximately 0.03 additional latent cancer fatalities) would be required to remove the remaining liquid from each package under consideration. For all packages considered, the total radiation dose would be greater than 6,800 rem (approximately 3 additional latent cancer fatalities).

For the pre–LOS ANGELES Class submarine reactor compartment packages shipped to Hanford, a petition for exemption from land disposal restrictions for residual liquid was requested by Washington State Department of Ecology (WA, 1991). The petition was submitted in 1992 (DOE, 1992a) and will be incorporated into the Low Level Burial Grounds dangerous waste permit application documentation. The basis in the petition is the need to keep radiation exposure as low as reasonably achievable. Consistent with the pre–LOS ANGELES Class reactor compartment packages, approval from the Washington State Department of Ecology would be requested to leave the remaining liquid in the reactor compartment packages.

2.1.1.2 Radiation Exposure Reduction Practices

Access to radiation areas is controlled by posted signs and barriers. Personnel are trained in the access requirements, including the requirement to wear dosimetry devices to enter these areas. Dosimetry devices are also near the boundaries of these areas to verify that personnel outside these area do not require monitoring. Frequent radiation surveys are required using instruments which are checked before use and calibrated regularly. Areas where radiation levels are greater than 0.1 rem per hour are designated high radiation areas and are locked or guarded. Compliance with radiological control requirements is checked frequently by radiological control personnel and other personnel not affiliated with the radiological controls organization.

Maintaining personnel radiation exposures as low as reasonably achievable involves all levels of management in nuclear-powered support facilities. To evaluate the effectiveness of radiation exposure reduction programs, managers use a set of goals. Goals are set in advance to keep the dose each worker receives under certain levels and to minimize the number of workers involved. Goals are also set on the total cumulative personnel radiation dose (man–rem) for each major job, for the entire overhaul or maintenance period, and for the whole year. These goals are deliberately made hard to meet in order to encourage personnel to improve performance.

Of the various goals used, the most effective in reducing personnel radiation exposure has been the use of individual control levels which are lower than the Navy's quarterly and annual limits. Dose control levels in shipyards range from 0.5 to 2 rem for the year, depending on the amount of radioactive work scheduled, whereas 5 rem per year is the annual Navy limit. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from all radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem (NNPP, 1995b).

To achieve the benefits of lower control levels in reducing total man–rem, it is essential to minimize the number of workers permitted to receive radiation exposure. Otherwise the control levels could be met merely by adding more workers. Organizations are required to conduct periodic reviews to ensure the number of workers is the minimum for the work that has to be performed.

The following is a synopsis of the checklist which has been in use for years in maintaining personnel radiation exposure as low as reasonably achievable.

Since its inception, the Naval Nuclear Propulsion Program has stressed the reduction of personnel radiation exposure. Beginning in the 1960's, a key part of the Program's effort in this area has involved minimizing radioactive corrosion products throughout the reactor plant, which in turn has significantly contributed to reducing personnel radiation exposure. Additional measures that have been taken to reduce exposure include standardization and optimization of procedures, development of new tooling, improved use of temporary shielding, and compliance with strict contamination control measures. For example, most work involving radioactive contamination is performed in total containment. This practice minimizes the potential for spreading contamination and thus reduces work disruptions, simplifies working conditions, and minimizes the cost and exposure to clean up.

Lessons learned during radioactive work and new ways to reduce exposure developed at one organization are made available for use by other organizations in the Naval Nuclear Propulsion Program. This effort allows all of the organizations to take advantage of the experience and developments at one organization and minimizes effort.

The extensive efforts that have been taken to reduce exposure in the Naval Nuclear Propulsion Program have also had other benefits, such as reduced cost to perform radioactive work and improved reliability. Efforts such as detailed work planning, rehearsing, total containment, special tools, and standardization have resulted in increased efficiency and better access to perform maintenance with the overall result that reliability is improved and costs are reduced.

2.1.1.3 Equipment Removal and Package Containment

Piping, electrical cabling, and other components and support structure inside the ship that interfere with removal of the reactor compartment from the ship would be cut away. For the submarines, as interior structural and equipment interferences are removed, the ship's hull would be cut to remove the reactor compartment from the ship. For cruisers, the reactor compartment would be similarly separated from the ship. Cut piping would be sealed when radioactive contamination is present. The radioactive components located outside the reactor compartment package would be removed from the ship for separate disposal at licensed disposal facilities or securely placed inside the reactor compartment package.

Reusable material and equipment from the ships would be loaded onto rail cars or trucks for transport to recycling facilities. Hazardous material removed from the ships would require the necessary control for handling, shipping and disposal. Some hazardous material removed also contains radioactivity and would require control as mixed waste or radioactive–PCB waste.

Hazardous material removal for cruisers, LOS ANGELES Class and OHIO Class submarines would be similar to that accomplished for pre–LOS ANGELES Class disposal due to basic commonality in designs and materials. These materials and associated removal and disposal methods are described in the Environmental Assessment of the Submarine Recycling Program at Puget Sound Naval Shipyard (USN, 1993a). Polychlorinated biphenyl impregnated wool felt sound damping material will be removed from the reactor compartment disposal packages when present. This material could be found on the interior of the submarine hull, on bulkheads, and in other locations outside of the reactor compartment that are part of the disposal package. This material and associated PCB residue on adjacent surfaces would be removed from the reactor compartment package before disposal in accordance with EPA requirements (40CFR761). The work would be done in controlled areas by personnel wearing protective equipment. Personnel wear full body protective clothing and are supplied with breathing air. However, several pounds of PCBs (typically less than 10 pounds) might still be found tightly bound in the chemical composition of solid industrial materials widely distributed throughout the reactor compartment package such as rubber and insulation. It would not be feasible to remove these materials, and they would be left in place for disposal with the reactor compartment packages.

The removal of lead from reactor compartment packages is planned within the constraint of keeping worker radiation exposure as low as reasonably achievable (ALARA) (e.g., removal of non-shielding lead). Removed lead would be reclaimed. Lead removal work would be done in controlled areas by personnel wearing protective equipment. Permanently installed ship's shielding lead for submarine and cruiser reactor compartment disposal packages would remain.

Unlike ballast lead, lead shielding is contained by thick metal sheathing plates. Removal of all the permanent shielding lead from and structural restoration of a reactor compartment would cost between 16 to 108 million dollars depending on the ship class. Radiation exposure would be high, ranging from 585 to 1065 rem per reactor compartment (approximately 0.2 to 0.4 additional latent cancer fatalities). Retaining the lead within the reactor compartments eliminates these costs and exposures. The thick metal encapsulation meets the Resource Conservation and Recovery Act treatment standards ((40CFR268.42) Treatment Code MACRO) for disposal of radioactive lead solids, including lead shielding, as received. Work during the reactor compartment package preparation process maintains this encapsulation. No treatment of the lead shielding occurs.

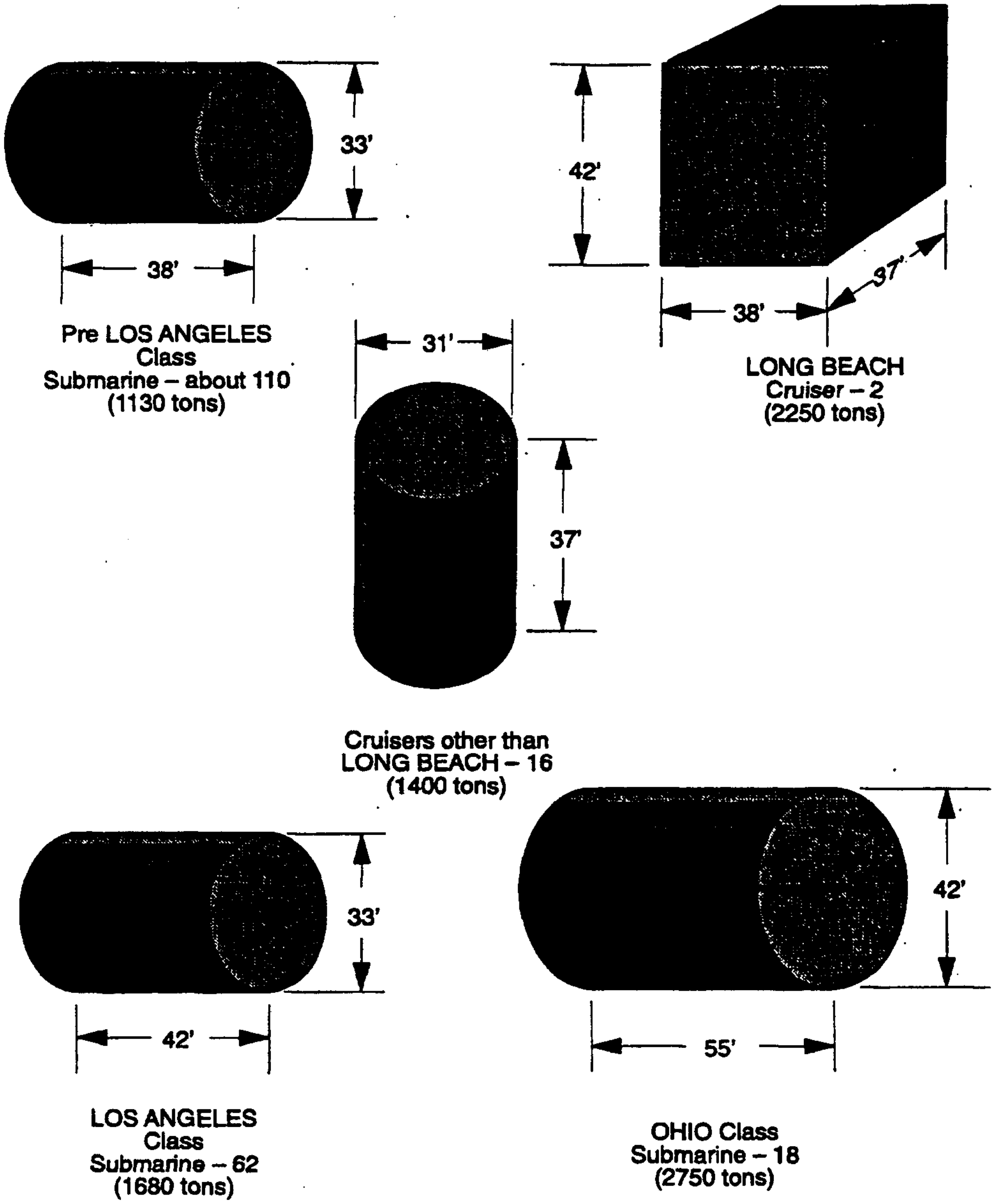
There are a variety of other hazardous materials present in small amounts in defueled reactor compartments, including silver plating on electrical contacts; silver brazing alloys; cadmium in the form of plating on fasteners and other components; chromates, amines, and ethylene glycol in small pockets of residual liquid; arsenic trioxide in glass; cyanoacrylate adhesive; and paints containing cyanide, red lead, lead napthenate, coal tar epoxy, and chromium trioxide. Preliminary investigations indicate these materials at below regulated levels for cruiser, OHIO Class submarine and LOS ANGELES Class submarine reactor compartment packages. Reactor compartments constructed before the mid-1970s also contain thousands of pounds of asbestos in the insulation on pipes and other components. This asbestos would be fully contained within the reactor compartment package, complying with the Clean Air Act regulations (40CFR61).

Containment bulkheads would be installed to the cut portions of the submarine hull to seal the reactor compartment within a disposal package. For cruisers, a containment structure would be built around the reactor compartment, enclosing it to form a disposal package. Figure 2.1 compares the size of the various reactor compartment disposal packages. While this work is occurring, the ship would be in a drydock on a combination of blocks and track mounted cradles that are designed to support and move the freed reactor compartment away from the ship. Figure 2.2 shows the conceptual sequence of these operations for submarines. Figure 2.3 shows the conceptual sequence of operations for cruisers.

The reactor compartment disposal program would be conducted and managed in accordance with all applicable federal environmental protection statutes and related Washington State and local environmental protection regulations.

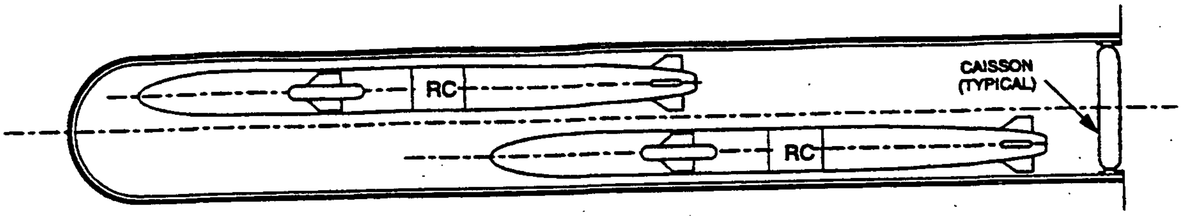
2.1.2 Transport

The Navy has transport barges that have been specially modified for transporting the pre-LOS ANGELES Class submarine reactor compartment packages. These barges are reinforced ocean-going barges. Support bulkheads have been installed to carry the reactor compartment package load in the center of the barge. Additional watertight bulkheads provide a greater number of tanks than are normally used for an ocean cargo barge. This provides added stability in the unlikely event the barge is damaged by an accident. The barges meet (a) the United States Coast Guard intact and damaged (one tank flooded) upright stability requirements (46CFR151 and 172); and (b) Navy stability requirements which require stability with two adjacent flooded tanks under storm wind and wave conditions. The barges are able to remain floating after sustaining

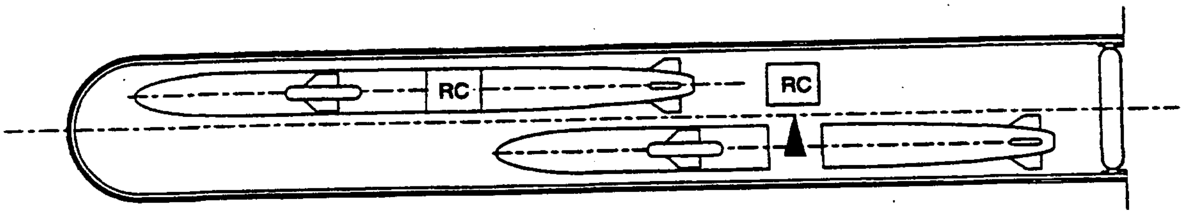


Note: Dimensions and weights are approximate. Quantities are current projections.

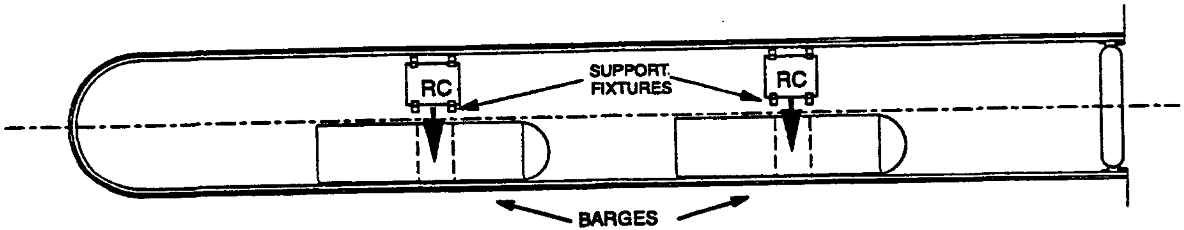
Figure 2.1. Comparison of Reactor Compartment Packages



SUBMARINES ARE PLACED IN DRYDOCK

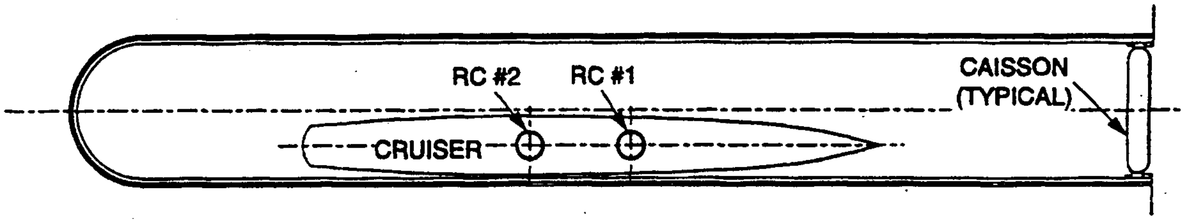


THE REACTOR COMPARTMENTS ARE CUT FROM THE SUBMARINES AND MOVED ON CRADLES AND ROLLERS TO THE SIDES OF THE DRYDOCK WHERE THEY ARE PACKAGED AND SUPPORT FIXTURES ARE INSTALLED.

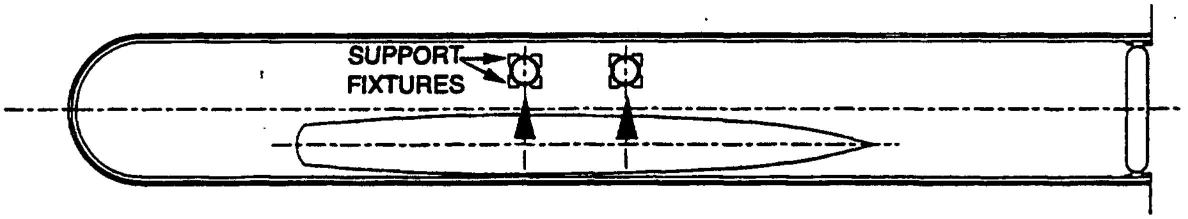


THE TWO DISPOSAL BARGES ARE PLACED IN THE DRYDOCK ALONGSIDE THE PACKAGED REACTOR COMPARTMENTS. THE BARGES ARE LOADED AND READIED FOR SHIPMENT.

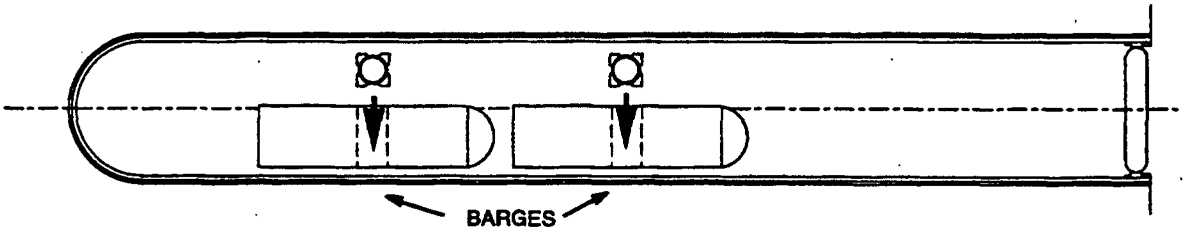
Figure 2.2. Submarine Reactor Compartment Preparation Concept



SHIP IS PLACED IN DRYDOCK AND THE REACTOR COMPARTMENTS ARE CUT FROM THE SHIP.



THE REACTOR COMPARTMENTS ARE PACKAGED AND SUPPORT FIXTURES ARE INSTALLED.



THE TWO DISPOSAL BARGES ARE PLACED IN THE DRYDOCK. THE FIRST BARGE IS LOADED, THEN THE SECOND BARGE IS MOVED INTO POSITION TO LOAD THE SECOND REACTOR COMPARTMENT PACKAGE.

Figure 2.3. Cruiser Reactor Compartment Preparation Concept

significant damage. The barges are maintained to both Navy and commercial standards and are inspected by the American Bureau of Shipping and the United States Coast Guard on a regularly scheduled basis. The same strict criteria would be used when the transport barges are used for the cruiser, LOS ANGELES Class submarine and OHIO Class submarine reactor compartment packages.

After the reactor compartment package is sealed and prepared for shipment and the remainder of the ship has been removed from the drydock, a transport barge would be placed next to the package. The package would be loaded onto the barge with hydraulic jacks to raise the package to the level of the barge deck. Support of the hydraulic jacks would be concrete keel blocks or other suitable blocking, steel plates, and timbers. These materials would also be used to provide a base for the track that would be used to move the package horizontally onto the barge deck. Jacking would be accomplished in small increments, with blocks and shims placed under the compartments as they are raised to support the compartments in case of a loss of hydraulic jacking pressure. The reactor compartments would be moved onto the barge using track mounted high capacity rollers. When in place, the reactor compartments would be welded to the steel barge deck.

The barge would be towed from Puget Sound Naval Shipyard using a large American Bureau of Shipping certified ocean-going tug. The tow would be accompanied by appropriate vessels such as a second similar backup tug and a Navy or Coast Guard escort vessel. River tugs would be used on the Columbia River. Qualified pilots would be used on all restricted waterways in Puget Sound, when crossing the Columbia River bar, and on the Columbia River. Shipments would be scheduled to avoid the less favorable Pacific Ocean winter weather. Figure 2.4 is a photograph of a pre-LOS ANGELES Class reactor compartment on a transport barge. The reactor compartments covered by this EIS would be transported in a similar manner.

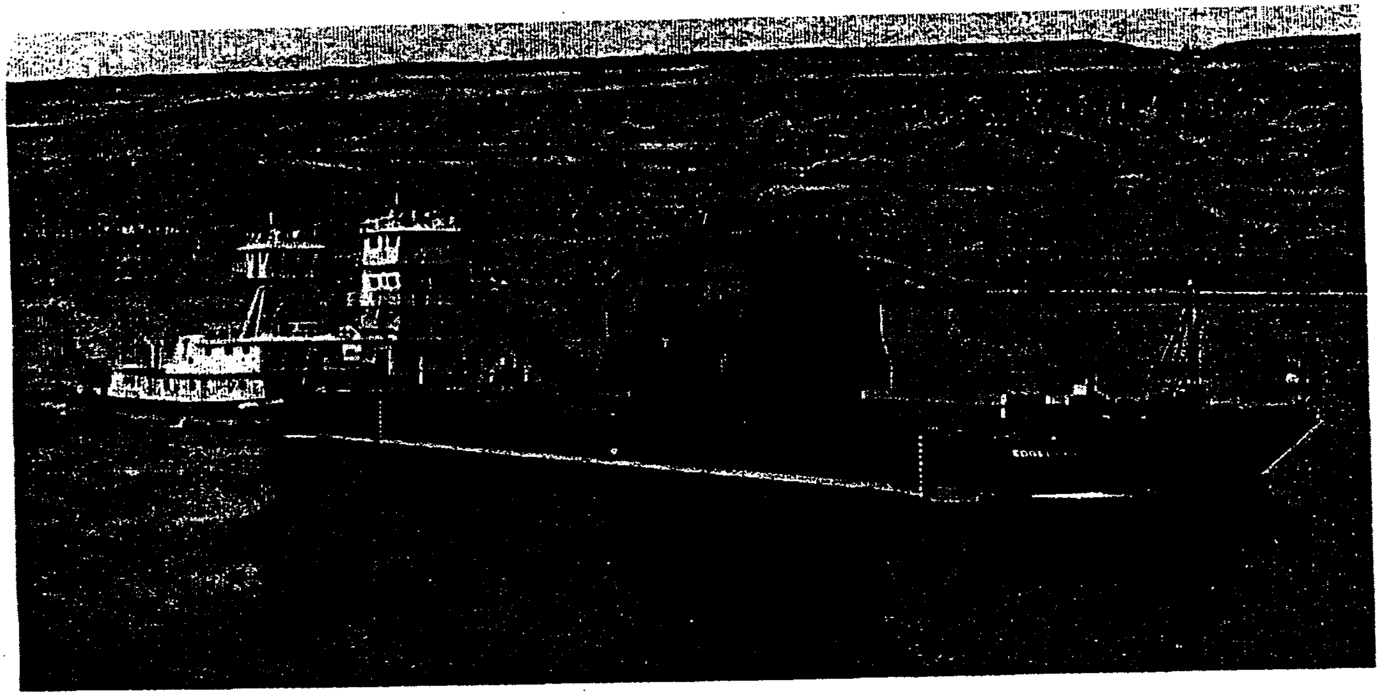


Figure 2.4. Pre-LOS ANGELES Class Reactor Compartment on a Transport Barge, Columbia River

The transport route for the cruiser, LOS ANGELES Class and OHIO Class submarine reactor compartment disposal packages would be the same as that used for the pre-LOS ANGELES Class disposal packages. The waterborne portion of the route follows the normal deep-water shipping lanes from the Shipyard, through Rich Passage, past Restoration Point, and northerly through Puget Sound. The route is then westerly through the Strait of Juan De Fuca (in U.S. territorial waters), and southerly down the Washington coast to the mouth of the Columbia River. The route is then up the Columbia River, following the shipping channel used for the regular transport of commercial cargo. The river route passes through the navigation locks at the Bonneville, The Dalles, John Day, and McNary dams to the Port of Benton at river mile 342.8. Figure 2.5 is a map showing the waterborne transport route. The time from Shipyard departure to arrival at the Port of Benton would be approximately three days.

To ensure that the reactor compartment packages cross the Columbia River bar on an incoming tide, departure times from Puget Sound Naval Shipyard would be calculated to arrive at that time. The ocean-going tugs would be replaced with river tugs at Vancouver, Washington for passing through the navigation locks at Bonneville, The Dalles, John Day, and McNary dams. The waterborne portion of the transport route ends at the Port of Benton, river mile 342.8.

The most restrictive overhead obstructions along the route are on the Columbia River in the Pasco-Kennewick area where there are two fixed bridges and one power line that cross the river between Pasco and Kennewick. Pasco's South 10th Ave. bridge (the cable bridge) at river mile 328.4 has a vertical clearance of 17 meters (56 feet) starting at the north bridge pier and extending south for 176 meters (578 feet) with the McNary pool height at 104 meters (340 feet). It is the most limiting overhead obstruction on the waterborne transport route. This would provide adequate clearance for the taller LONG BEACH packages and OHIO Class submarine packages to transit under the bridge while staying well within charted navigable waters. The Highway 395 bridge at river mile 330.1 has a vertical clearance of over 17.5 meters (58 feet) with the McNary pool height at 104 meters (340 feet) and therefore does not pose a problem.

115 kV Benton County Public Utility District (PUD) power lines cross the Columbia River approximately 180 to 275 meters (200 to 300 yards) upstream of the cable bridge. The lowest point on the power lines is 25 meters (82 feet) above the water with the McNary pool elevation at 104 meters (340 feet) above mean sea level. This would provide over 10 meters (30 feet) of clearance above the reactor compartment packages covered by this EIS.

Upon arrival at the Port of Benton the barge would be placed in the slip. Water would be added to the barge compartments in a controlled sequence to ground the barge firmly on the gravel slip bottom. Once grounded, the deck of the barge would be against and level with the top of the sill at the landward (west) end of the slip. Figure 2.6 shows a plan view of the barge slip. The slip bottom would be prepared to receive the barge under required permits such as from the Army Corps of Engineers, the Washington State Department of Fisheries, the Washington State Department of Ecology, and the City of Richland, Community Development Department. River water level would be monitored to ensure it does not affect the barge during the off-loading.

The welds holding the reactor compartment package to the barge would be cut, and the reactor compartment would be jacked up and placed upon four steel columns. Jacking would be in small increments with safety cribbing blocks and shims temporarily placed under the load to support the compartment if hydraulic jack pressure were lost. A transport vehicle would then be driven onto the barge and under the package. A multiple wheel high-capacity trailer specially designed for heavy loads would be used. Figure 2.7 shows an off-loading arrangement concept. The package would be attached to the transport vehicle using welded attachments. The time required to off-load the package from the barge would be 24-36 hours from the time the barge is docked.

2.1.3 Land Transport Route

The transport route currently used for the pre-LOS ANGELES class packages would be used for the cruiser, LOS ANGELES Class and OHIO Class packages as well. The route begins at the Port of Benton barge slip just south of the Hanford Site on the west bank of the Columbia River.

From the barge slip the route consists of the gravel access ramp at the barge slip and a short section of C Avenue to the Hanford Site border at Horn Rapids Road. From there, a 1.6 kilometer (one mile) stretch of well compacted gravel roadway angles northwest across the desert and intersects Route 4S just south of the 300 Area. This section of the transport route could be changed to account for any currently unidentified use of that portion of the Hanford Site. The route is north and northwest for approximately 19 kilometers (12 miles) along Route 4S, a well maintained four lane paved highway, to the Wye Barricade. Only one half the width of the highway would be needed to transport the reactor compartments along Route 4S except for three areas where the entire width of the pavement would be needed to maneuver around traffic lights. From the Wye Barricade, the transport route is north for approximately 10 kilometers (six miles) to the old Hanford Town Site on Route 2S. The transport route then turns west on Route 11A for about 10 kilometers (six miles) to a short access road (Canton Avenue) which leads to the north east corner of the 200 East Area where the proposed land disposal site would be located. Figure 2.8 shows the Hanford Site map and landhaul transport route.

Because of the increased dimensions of some of the cruiser and OHIO Class submarine packages, at approximately six locations at the Hanford Site, Bonneville Power Administration electrical lines may need to be modified in order to provide the safe clearance prescribed by the utility companies for energized transmission lines. The Navy will coordinate this work with Bonneville Power Administration. The work would be confined to the immediate vicinity of the towers along the roadway and would have minimal impact on the desert environment. This route has no bridges or overpasses which would block movement of a very large and heavy package. The time in transit along the landhaul route is expected to be about 12 hours.

The time to transport a package between the Port of Benton and the Wye Barricade along the transport route would be approximately 4-6 hours. This section of the highway is open to the public. Transport arrangements would be made to afford safety to other drivers. For example, transport could be scheduled to avoid heavy use of the roadway, travel could be restricted to one side of the four lane highway, or pilot cars could be used to provide safe escort around the package. Beyond the Wye-Barricade the roadway could be closed to general traffic for the 4-6 hour transit from the Wye Barricade to the 200 East Area. Traffic could be routed around on Route 4 - South.

Transport trailers used to haul pre-LOS ANGELES Class reactor compartments are of modular construction. Each module is approximately six feet wide with two steerable dollies each with four high capacity tires. Modules are available in lengths of four, six and eight rows of wheels each. Modules are typically bolted together end to end and side to side to provide an adequate number of wheels to carry the intended load and keep the load per tire to levels the road can accept. For disposal packages considered by this EIS, trailer modules would be assembled to provide enough wheels to properly distribute the load. Figure 2.9 is a photograph of a pre-LOS ANGELES Class reactor compartment disposal package on a modular trailer.

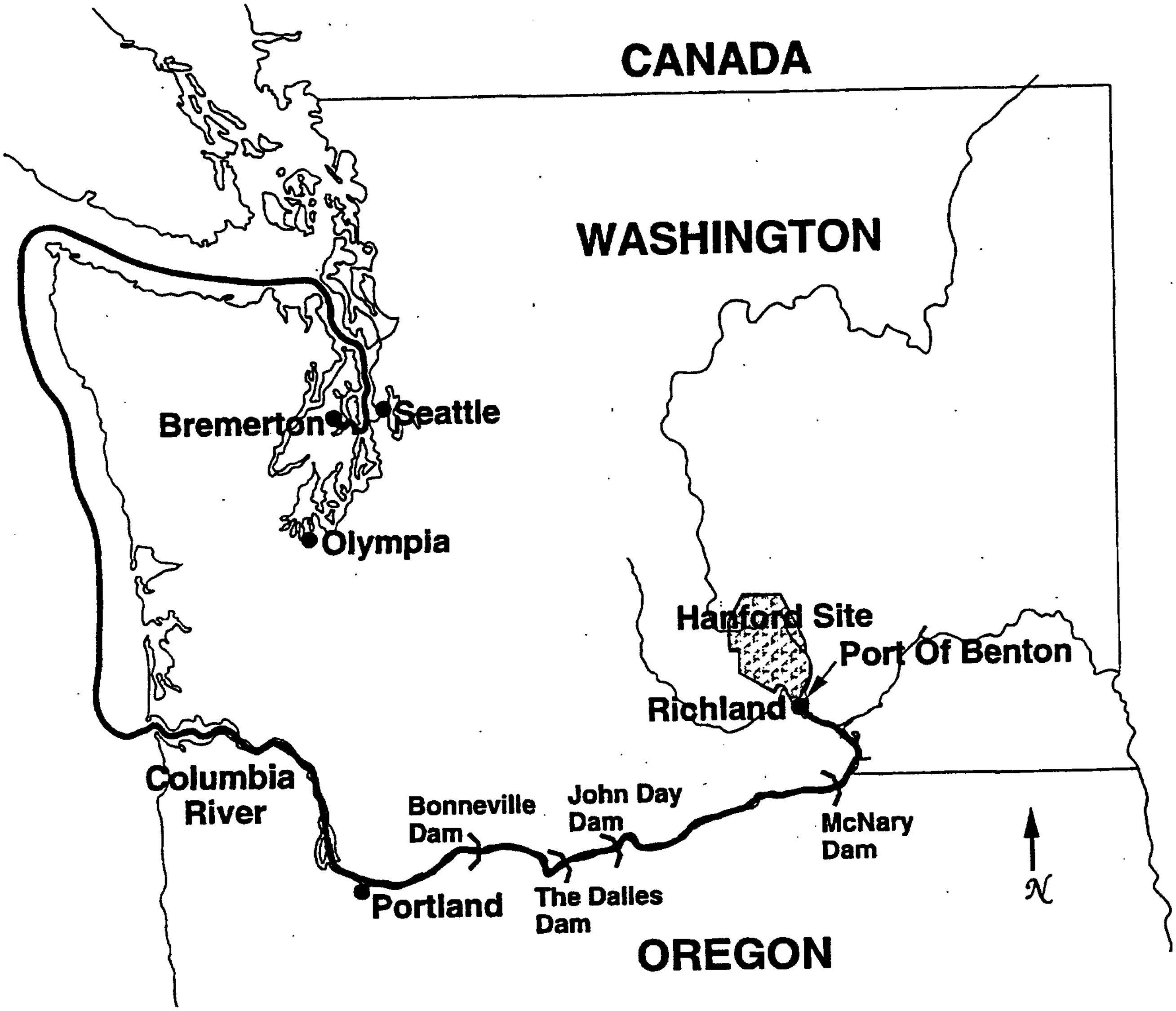


Figure 2.5. Reactor Compartment Disposal Transport Route

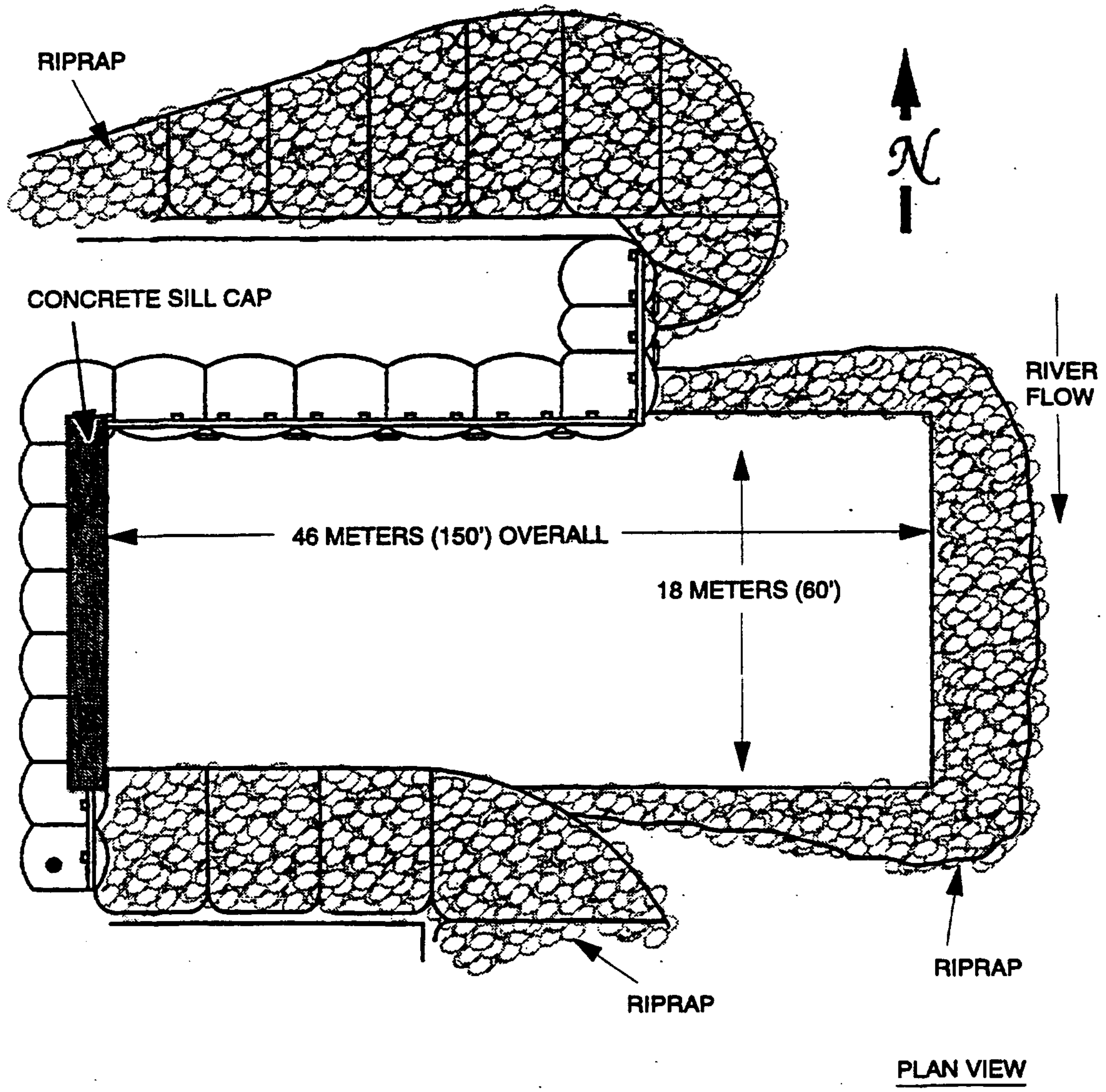


Figure 2.6. Port of Benton Barge Slip

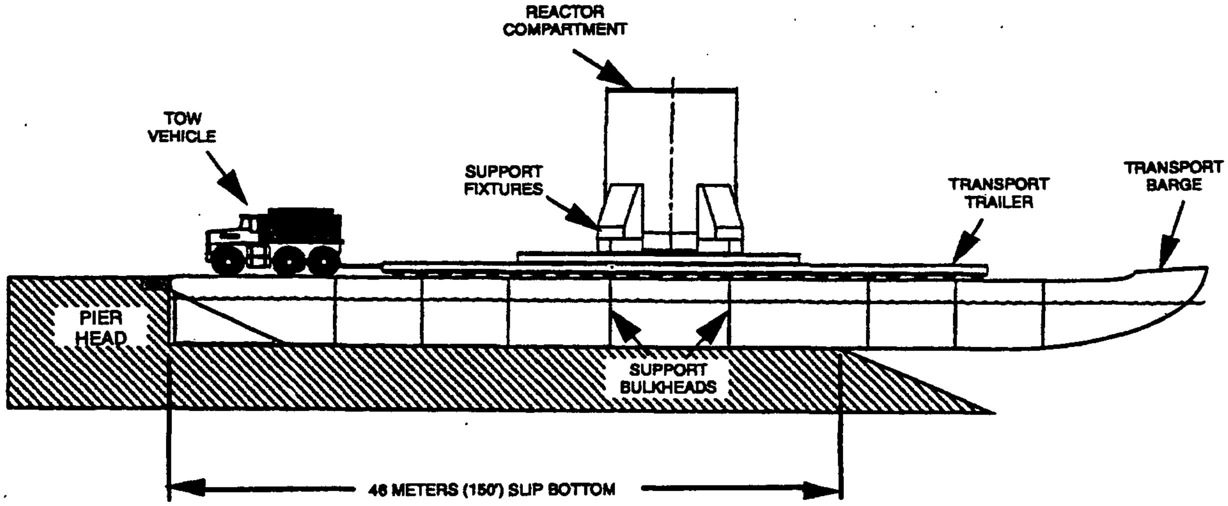


Figure 2.7. Port of Benton Cruiser Package Off-loading Concept

2.1.4 Land Disposal Site

The Hanford Site is located in the southeastern corner of the State of Washington, about 30 miles east of Yakima and immediately north of Richland. The 218-E-12B Low Level Burial Ground is situated near the center of the Hanford Site within the 200 East area.

The Low Level Burial Grounds at Hanford are currently being used for the disposal of solid radioactive wastes similar to the contents of the reactor compartments considered in this statement. The burial grounds of the 200 East and 200 West Areas are situated in an isolated area in the Central Plateau region about seven miles from the Columbia River.

The burial ground area immediately north of Trench 94 is available for Navy use. This area could accommodate expansion of Trench 94 or construction of a second reactor compartment disposal trench of adequate size to hold the approximately 100 reactor compartments considered in this EIS. Trench 94 is sufficiently deep (about 53 feet) to accommodate reactor compartment packages from cruisers and later classes of submarines.

Expanding Trench 94 approximately 60 meters (200 feet) to the north would provide adequate additional trench space for 100 reactor compartments. The existing ramp into Trench 94 could be used. Transport equipment size and configuration would also have a bearing on the final arrangement of the disposal packages in the trench. Figure 2.10 is a conceptual design of the expansion of Trench 94. Figure 2.11 shows the pre-LOS ANGELES Class reactor compartments in Trench 94 as of the end of 1994.

Likewise, a separate trench could be constructed to the north of Trench 94 which could use the existing access ramp. The ramp would have to be widened at the base to allow access to this separate trench. Since the minimum length of the ramp is restricted by the limits on the maximum allowed slope, there would be an advantage to using the existing ramp. A new ramp constructed expressly for the new trench would extend too far north and would interfere with the road and power lines along the north edge of the 200 East Area. The ramp would extend beyond the 200 East Area parameter fence and would require relocation of the power lines and closure or rerouting of the road. Construction of a new ramp would also require a new gate be constructed and would involve disturbing approximately one hectare (two acres) of land outside the existing 200 East Area boundary. If it became necessary to construct a new access ramp, the area could be restored after closure of the trench and would not constitute a commitment of irreversible resources. Figure 2.12 shows a conceptual design of a new trench which would utilize the existing ramp.

The new trench would occupy approximately 4 hectares (10 acres) of the 218-E-12B Low Level Burial Ground which is about the same size as Trench-94.

Currently the area to the north of Trench 94 is partially covered by the spoil pile from the excavation of Trench 94. Part of the spoil pile would have to be moved to allow room for either expansion of Trench 94 or construction of a separate trench. More of the spoil material would have to be moved to provide space for construction of a separate trench than for the expansion scenario. This is because a separate trench would extend approximately 140 meters (450 feet) north of the north wall of Trench-94 and expanding Trench 94 would extend only 75 meters (250 feet) north of the existing north trench wall.

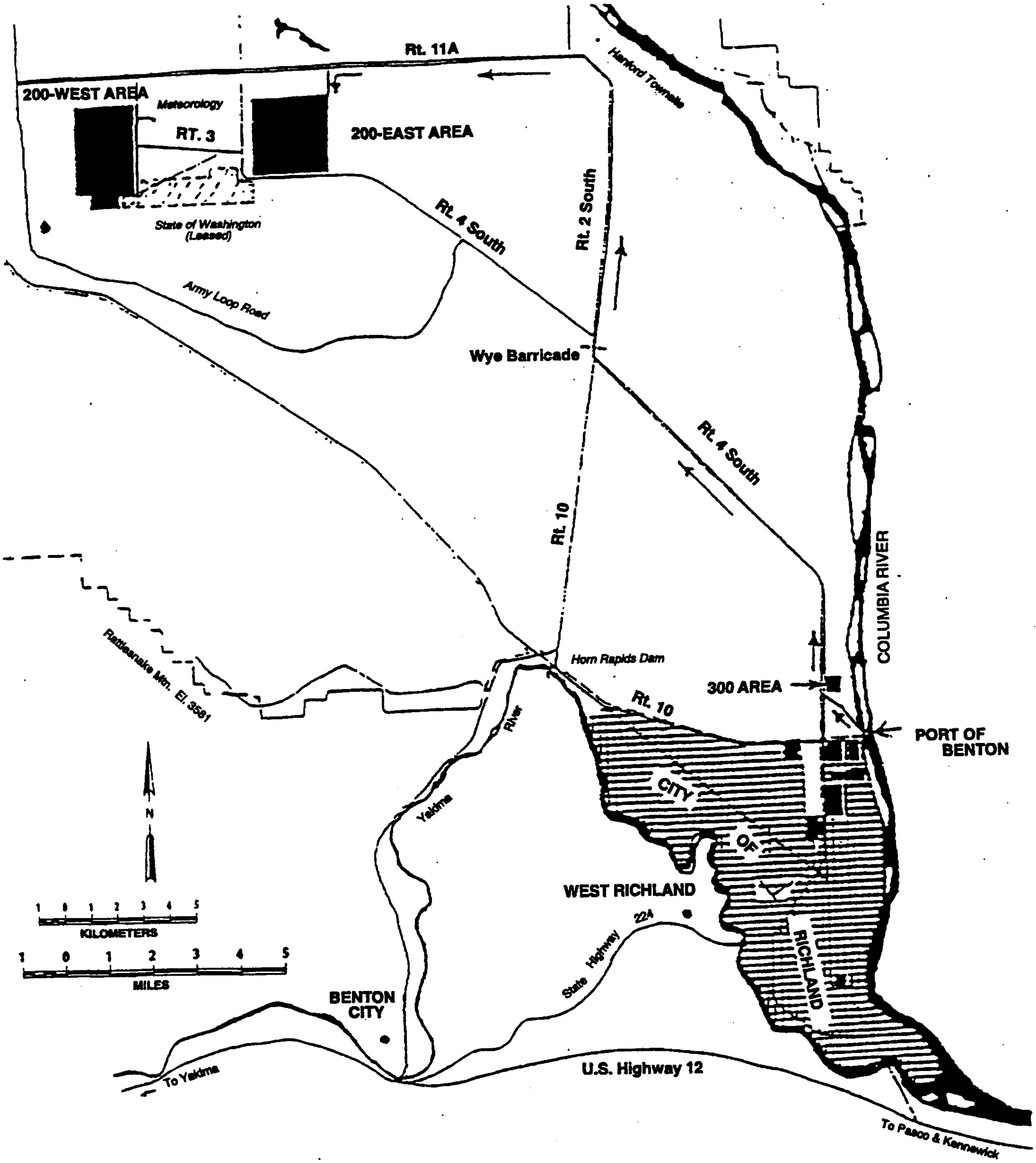


Figure 2.8. Hanford Site Transport Route

Construction operations for either of the trench options would be basically the same. Movement of material would be primarily with scrapers, bulldozers, and graders. Exhaust emissions, noise and dust normally associated with this type of work would be confined to the construction site and would not have any affect beyond the duration of the work. Watering would be used to control dust. An estimated time to accomplish the excavation would be three to six months of continuous work. Because it would be several miles distance to any area accessible to the public, there would be no affect on the general population.

The quantity of material to be excavated to expand Trench 94 would be approximately 320,000 cubic meters (415,000 cubic yards). Construction of a separate trench would involve the removal of approximately 590,000 cubic meters (770,000 cubic yards) of material. This does not include relocation of the existing spoil pile, which could require movement of roughly 50 percent more material for either option. Back-fill would be with native soils prepared (graded) to enhance corrosion performance of the reactor compartments.

It may be feasible to use the existing trench space more efficiently by placing reactor compartments closer together within Trench 94. Currently, pre-LOS ANGELES Class reactor compartments are placed roughly on 15 meter (50 foot) by 15 meter (50 foot) grids with an approximate 230 square meter (2500 square foot) area of trench floor claimed per reactor compartment. This area could be reduced substantially freeing up enough additional floor space to accommodate the cruiser, and LOS ANGELES and OHIO Class reactor compartments. It is expected that existing reactor compartments in Trench 94 would not have to be relocated. The need for trench expansion or the construction of a new trench would be eliminated under this option. However, some minor excavation at areas along the edges of Trench 94 may be required to facilitate this closer spacing of reactor compartments.

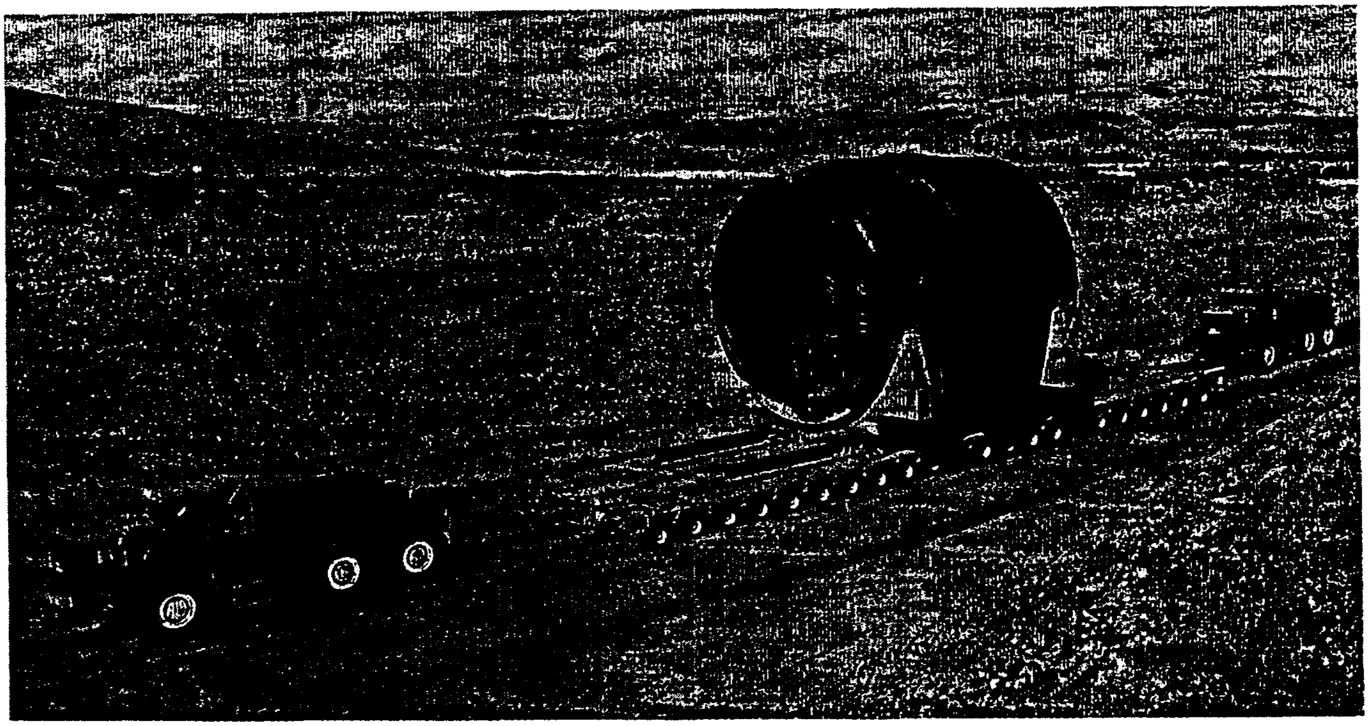


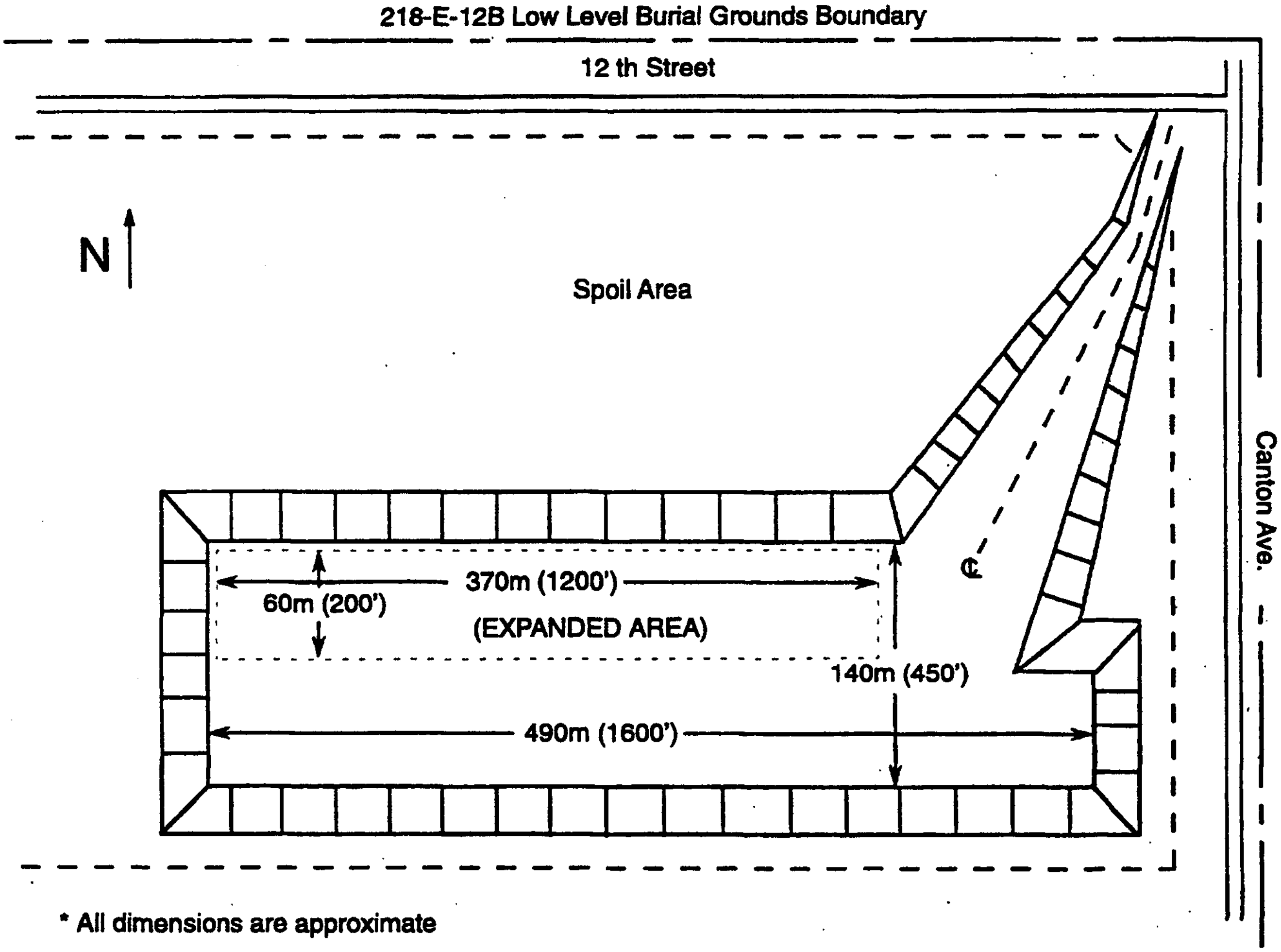
Figure 2.9. Pre-LOS ANGELES Class Reactor Compartment on a Transport Trailer, Hanford Site

2.1.5 Applicable Regulatory Considerations

The following sections discuss the applicable regulations for management, packaging, transport, and disposal of reactor compartments from cruisers, and LOS ANGELES and OHIO Class submarines.

2.1.5.1 Shipyard Preparations Prior to Transport

The applicable regulations for the reactor compartment disposal program at the Shipyard include the Clean Air Act, the Clean Water Act, Toxic Substances Control Act, and the Resource Conservation and Recovery Act (RCRA). The Puget Sound Air Pollution Control Agency has regulatory authority for the Clean Air Act. The Washington State Department of Ecology has regulatory authority over RCRA issues. The EPA has regulatory authority over PCB issues.



* All dimensions are approximate

Figure 2.10. Conceptual Expansion of Trench 94

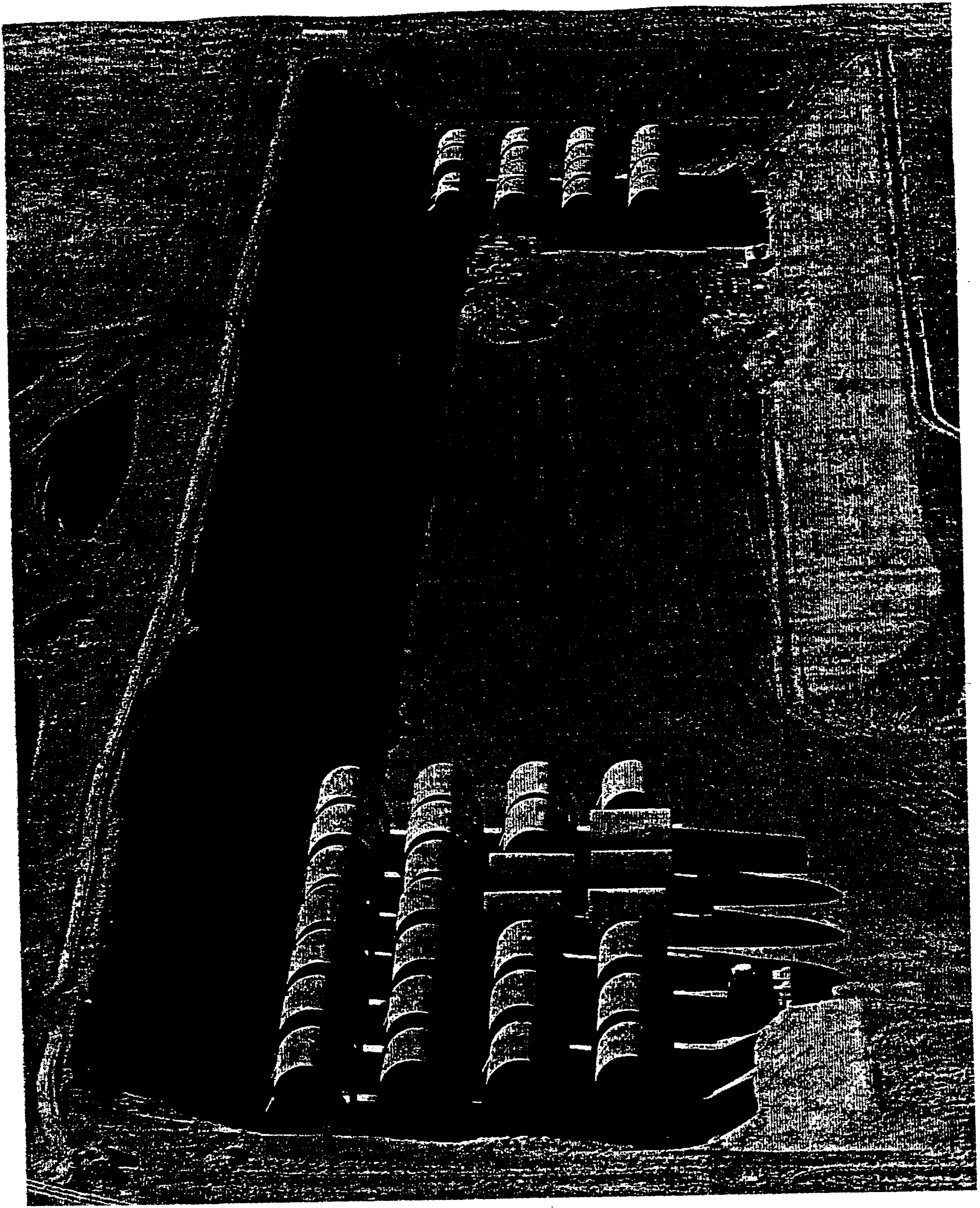
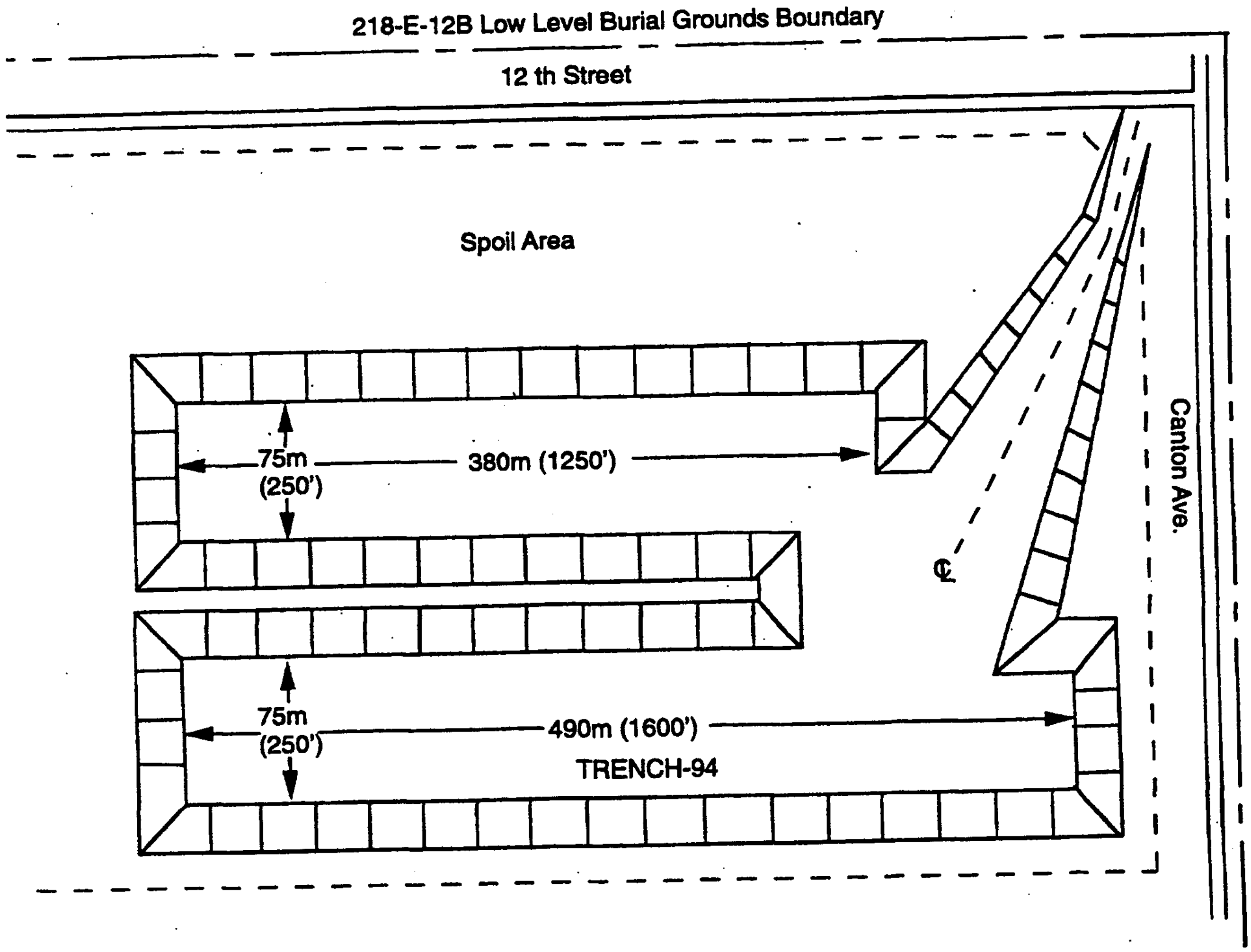


Figure 2.11. Pre-LOS ANGELES Class Reactor Compartments in Trench 94, Sept. 1994



* All dimensions are approximate

Figure 2.12. Conceptual Design of Second Disposal Trench

The Shipyard has National Pollutant Discharge Elimination System (NPDES) permit number WA-000206-2, which specifies discharge limitations for certain constituents as well as stipulates monitoring requirements. Any drydock discharges would be constrained by this permit.

2.1.5.2 Normal Conditions of Transport

Transportation would meet the requirements for normal conditions of transport as specified in 10CFR71 (Packaging and Transportation of Radioactive Materials) and 49CFR171-179 (Hazardous Material Regulations). The requirements of 10CFR71 involve evaluating the reactor compartment disposal package containment structure under: (1) free drop striking the surface in a position for which maximum damage is expected; (2) puncture; (3) temperature influences; (4) external pressure (reduced and increased); (5) water spray; and (6) vibration conditions. These requirements are more restrictive than those of 49CFR171-179.

An engineering analysis of the reactor compartment package designs will be performed to assess the performance of these designs under the hypothetical accident scenarios discussed above. The analysis results will then be compared with the specific requirements for normal transport listed in 10CFR71.51. Package designs based on this analysis will ensure that 10CFR71 requirements are met. Actual physical testing of reactor compartment packages would be impractical due to weight and size considerations and is not required by 10CFR71.

For the containment structure of the reactor compartment disposal package, the free drop scenario is considered the most limiting of all the normal conditions of transport. If the reactor compartment disposal package were to fall 0.3 meters (one foot) as specified by 10CFR71.71(c)(7), the containment structure would deform locally in the affected area of impact. This minor deformation would not affect the integrity of the containment of the reactor compartment disposal package. Additionally, during jacking operations, safety cribbing would be used that was capable of supporting the package if hydraulic jacking pressure were lost.

Package integrity is assessed by evaluating the impact condition as specified by 10CFR71.71(c)(10), which involves striking an area of the exposed surface, considered to be the most vulnerable to puncture, with a six kilogram (13-pound) steel cylinder, 3.2 cm (1 1/4 inches) in diameter, dropped from a height of one meter (40 inches). The potential impact energy from the 6 kilogram (13-pound) steel cylinder would have no effect on the exposed surface; therefore, no puncture of the exterior packaging would occur.

Temperature effects, such as subjecting packages to an ambient temperature of 38°C (100°F) in direct sunlight as specified in 10CFR71.71(c)(1), are analyzed. The maximum internal temperature has been estimated at approximately 150°C (300°F) for the internal structures of the reactor vessel. The maximum package outer surface temperature has been estimated at approximately 38°C (100°F). These elevated temperatures are considerably less than normal service temperatures of the reactor compartment; thus, there would be no damage to the reactor compartment disposal package. The associated pressure increase would be well within the design capability of the reactor compartment disposal package therefore, no damage would occur. Additionally, if a pressure were applied as specified by 10CFR71.71(c)(3) & (4), there would be no affect to the reactor compartment disposal package. This determination is based on the methods used to fabricate the reactor compartment disposal package; such as, using thick steel plates which are fully welded to form the exterior containment structure.

The method of fabricating the containment structure results in a closed and sealed package. The thick, fully welded, steel containment structure would prevent any water from entering the reactor compartment disposal package when subjected to a water spray sufficiently heavy to keep the entire exposed surface continuously wet for 30 minutes (10CFR71.71.(c)(6)). Additionally, the reactor compartment disposal package would be tested for leaks prior to shipment to confirm the integrity of the containment structure. 10CFR71.71(C)(2) specifies that the integrity of the reactor compartment disposal package containment structure be maintained when subjected to an ambient temperature of -40°C (-40°F).

During normal transport, packages are subjected to vibrations over a broad spectrum of frequencies. The vibrations incurred in transporting the reactor compartment disposal package under normal conditions of transport would occur at frequencies that are less than the natural frequencies of the reactor compartment and reactor compartment components. Therefore, it is expected that no resonance and no damage to the reactor compartment disposal package would occur due to vibration (10CFR71.71(c)(5)).

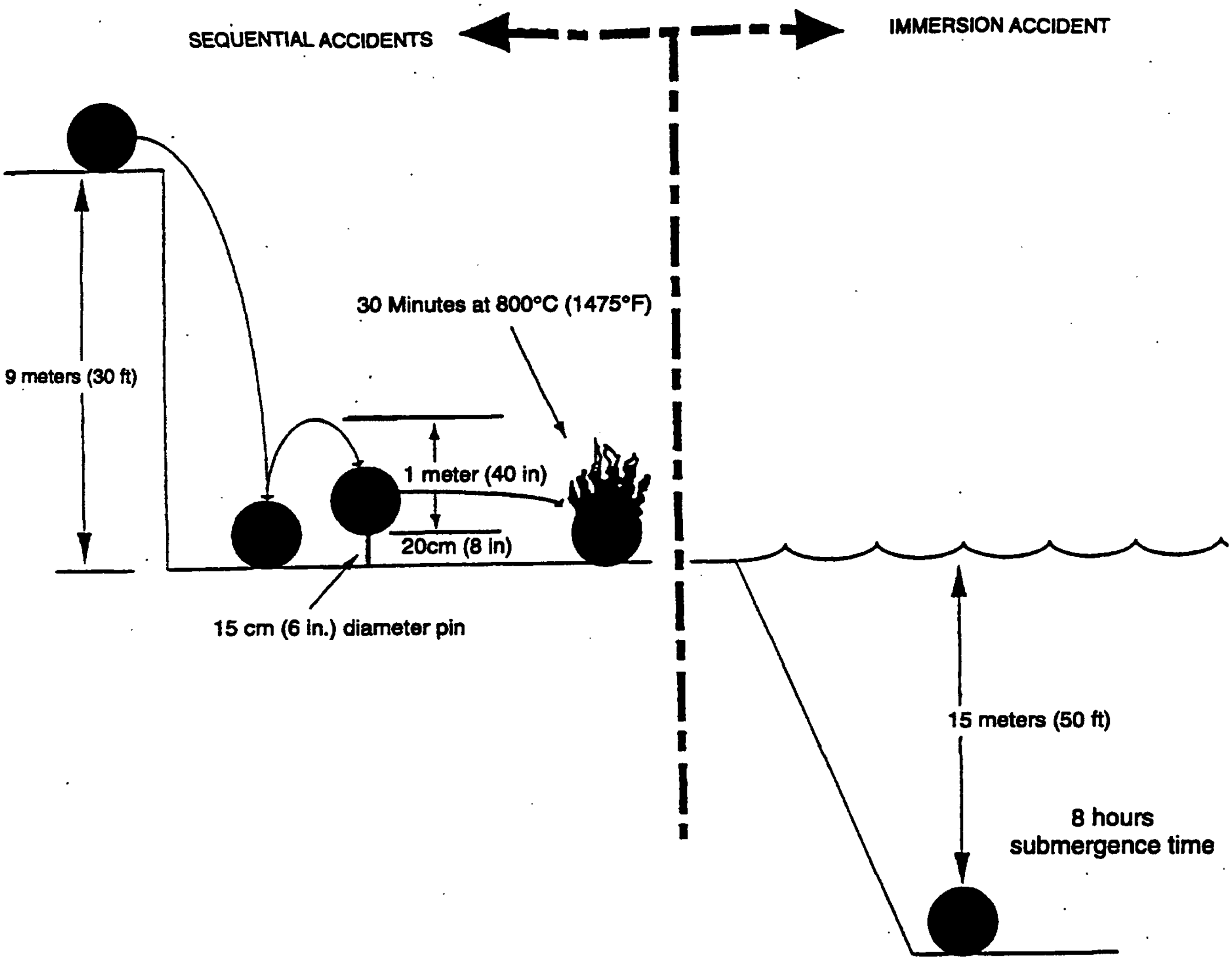
Due to the need for sailors to live on the ships during operation, reactor compartments are designed to attenuate radiation levels outside of the reactor compartment to extremely low levels. The external surface radiation levels for the normal conditions of transportation of the cruisers and LOS ANGELES Class and OHIO Class submarines are expected to be a fraction of the 200 mrem per hour on contact limit allowed under 49CFR173. For reactor compartment disposal packages, radiation levels would typically be less than one mrem per hour on contact, except for isolated spots. The reactor compartment packages would be surveyed prior to shipment to determine radiation levels. Past experience shows the highest levels for isolated spots has been 30 mrem per hour on contact. There would be no removable or fixed radioactive contamination on the outside of the package.

2.1.5.3 Hypothetical Accident Conditions

The reactor compartment disposal packages will be designed to meet the transportation requirements for hypothetical accident conditions of transport as specified by 10CFR71.73. These requirements involve evaluating the reactor compartment disposal package shipping containment structure under a 9 meter (30 feet) free drop onto an unyielding surface, puncture by a 15 cm (6 inch) bar, and 800°C (1475°F) fire for 30 minutes. Immersion in 15 meters (50 feet) of water is considered as a separate accident. The results are compared with 10CFR71.51(a)(2) requirements. Figure 2.13 depicts the sequential hypothetical accident scenario of 10CFR71.73.

The conditions of an unyielding surface and a 9 meter (30 foot) drop would not be encountered along the transport route for the package weight being considered. Also, the regulatory assumption that the 15 cm (6 inch) steel bar is mounted on an essentially unyielding surface would not be encountered. However, the containment structure of the package would be designed and constructed so the 10CFR71.51 requirements would not be exceeded by the sequential accidents.

An undamaged package is required to be analyzed for immersion under a head of water of at least 15 meters (50 feet) for a period of not less than eight hours, as specified by 10CFR71.73(c)(5). As a result of the engineering analysis work discussed previously and the design of the reactor compartment packages, the packages will not deform under this immersion and not exceed the radioactive material release requirements of 10 CFR71.51.



Note: Representative accident sequence - NOT DRAWN TO SCALE

Figure 2.13. Hypothetical Accident Scenario Specified by 10CFR71.73

The submarine hull and new containment bulkheads for the LOS ANGELES Class and OHIO Class submarines would make up the outer containment boundary for the reactor compartment disposal packages. The cruisers' reactor plants are contained within the shielded structural bulkheads of the ships' reactor compartments. Although these bulkheads are designed to accommodate normal and emergency ship's operating conditions including the ability to withstand battle shock, they do not have the larger design margins provided by a submarine's high-strength pressure hull. Therefore, the cruiser reactor compartments require a containment structure to be fabricated around the reactor compartment to meet the Type B package criteria in 10CFR71.

In both cases, the thick, fully-welded, steel containment structure would be designed, constructed, and prepared so that the packaging will prevent the release of the radioactivity in excess of the limits specified in 10CFR71 for normal transportation and hypothetical accident conditions.

It is important to note that even though the reactor compartment disposal packages would contain quantities of radioactivity, see Table 1.1, requiring the Type B level of containment for transportation, the majority of the radioactivity (approximately 99.9%) is in the form of neutron activated structural metal components contained within the reactor vessel. Only the surface-deposited activated corrosion products, the remaining 0.1% of the radioactivity, could potentially become available for release.

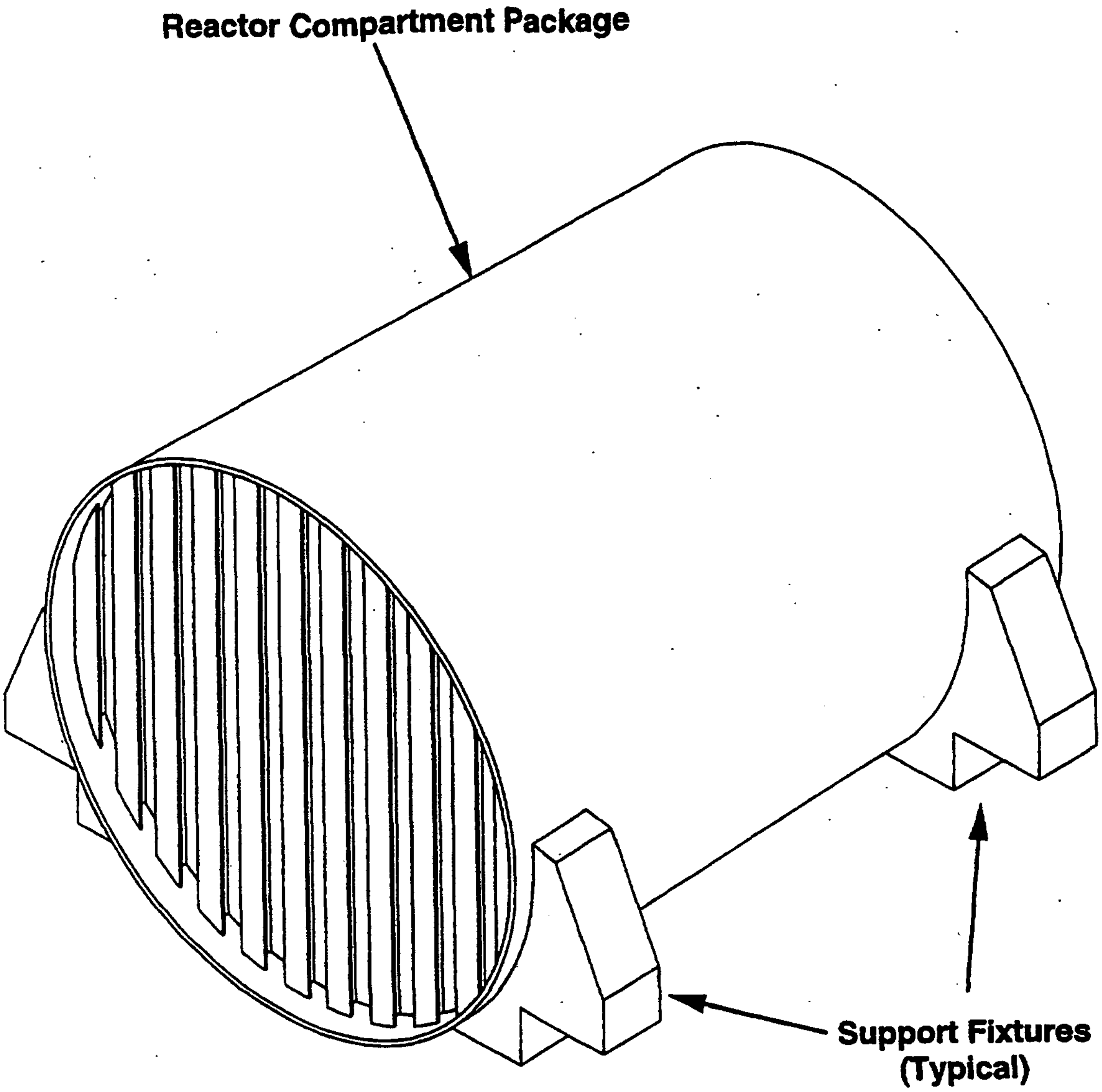
The same proven principles used to safely and successfully transport the pre-LOS ANGELES reactor compartment packages would be adapted for the cruisers and LOS ANGELES and OHIO Class reactor compartments. Figure 2.14 shows the conceptual design of a typical LOS ANGELES or OHIO Class submarine reactor compartment disposal package and Figures 2.15 and 2.16 show the conceptual design of typical cruiser reactor compartment disposal packages. As shown on the Figures, structural support fixtures would be welded to the package to facilitate moving it horizontally and vertically. In all cases, the thick, fully-welded, steel containment structure would prevent the release of the package contents in excess of the specified limits for normal transportation and hypothetical accident conditions.

2.1.5.4 Disposal

Land disposal at the Hanford Site 218-E-12B Low Level Burial Grounds would be regulated by State and Federal agencies. The United States Department of Energy would manage the disposal of the radioactive material contained in the reactor compartment packages under Department of Energy Order 5820.2A, Radioactive Waste Management (DOE, 1988). The Washington State Department of Ecology would regulate the reactor compartment disposal packages as a dangerous waste under Washington Administrative Code (WAC) 173-303, Dangerous Waste Regulations (WAC, 1993) due to the quantity of permanent lead shielding present.

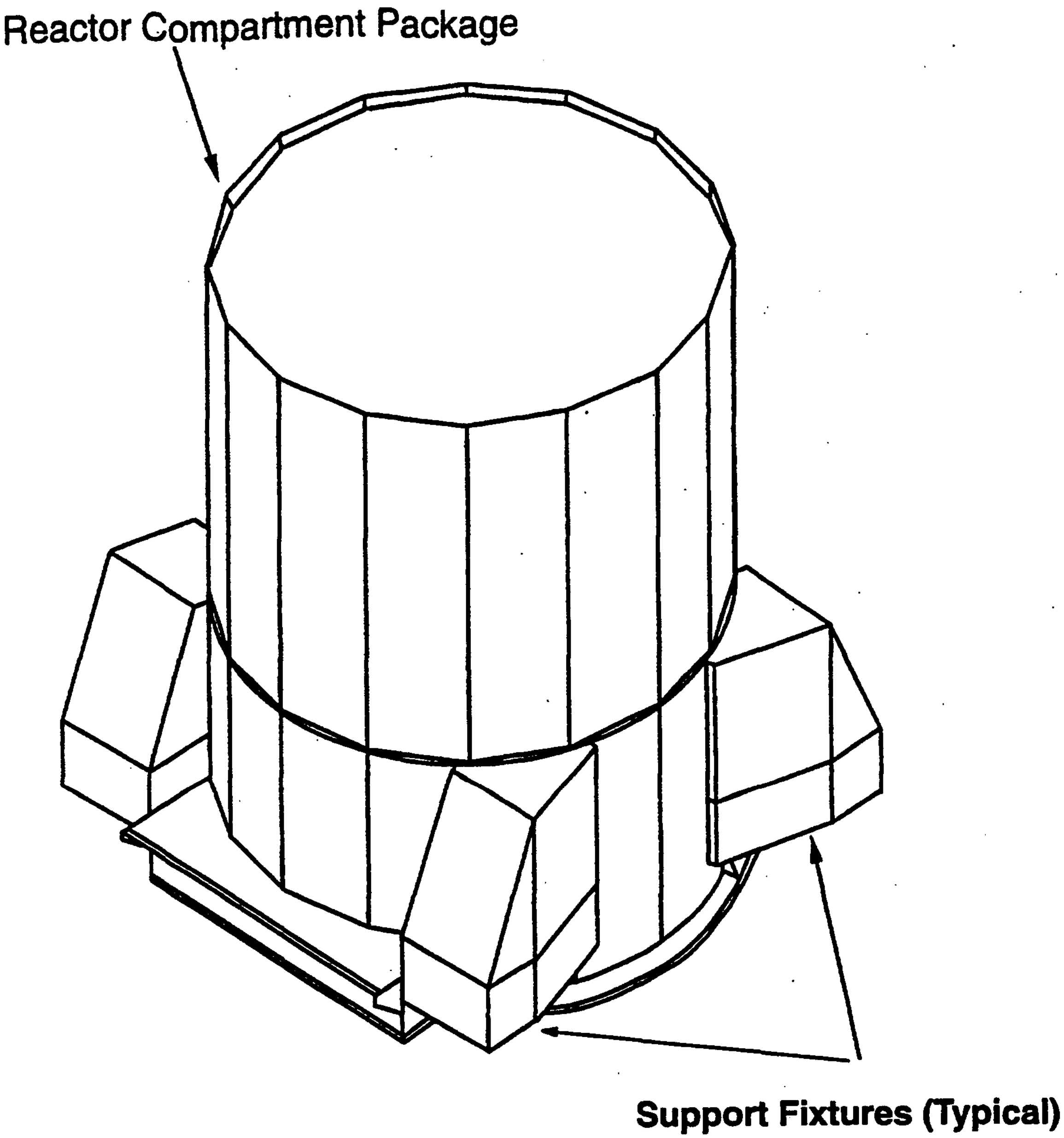
Polychlorinated biphenyls (PCB) in concentrations greater than 50 parts per million would be regulated by the United States Environmental Protection Agency (EPA) under the Toxic Substances Control Act, Title 40 of the Code Federal Regulations, Part 761.75 (40CFR761.75). Asbestos would be properly contained to meet local (Benton-Franklin Counties Air Pollution Control Authority), State (WAC 173-303), and Federal (40CFR61) requirements.

Sections 173-303-280 through 173-303-283 of the Washington Administrative Code (WAC, 1993) describe the Washington state requirements for facilities which store, treat, or dispose of dangerous wastes and which must be permitted by the State. The disposal of reactor compartments from defueled, decommissioned cruisers, LOS ANGELES Class submarines, and OHIO Class Submarines at the 218-E-12B Low Level Burial Ground would be regulated under these sections.



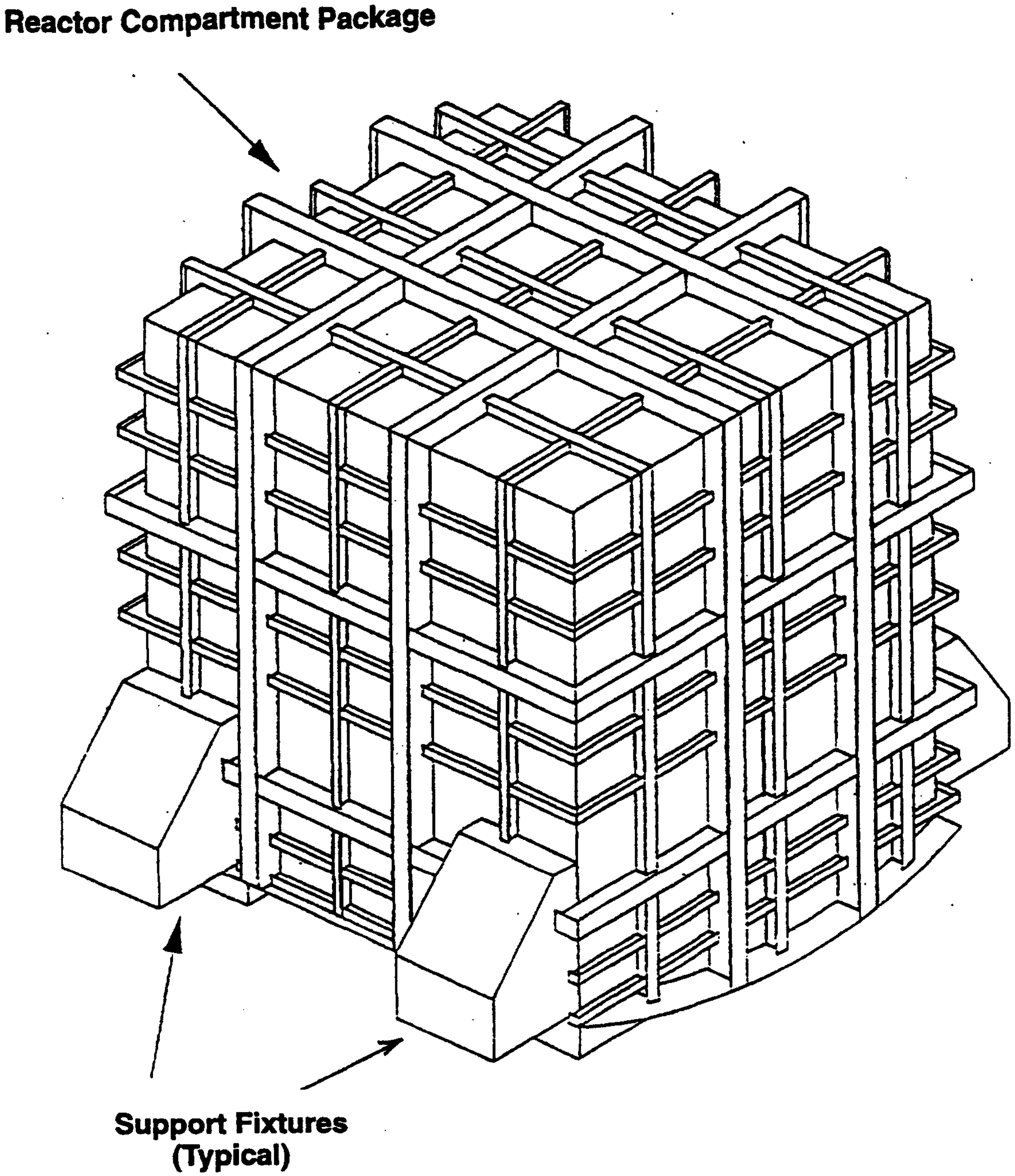
Note: Package size would be approximately 42 feet long by 33 feet diameter for the LOS ANGELES Class and approximately 55 feet long by 42 feet diameter for the OHIO Class.

Figure 2.14. Conceptual LOS ANGELES or OHIO Class Submarine Reactor Compartment Disposal Package



Note: Package size would be approximately 31 feet diameter by 37 feet high.

Figure 2.15. **Conceptual Cruiser Reactor Compartment Disposal Package (Except LONG BEACH)**



Note: Package size would be approximately 38 feet by 37 feet by 42 feet high.

Figure 2.16. Conceptual Cruiser Reactor Compartment Disposal Package for the Cruiser LONG BEACH

2.2 No Action Alternative - Indefinite Waterborne Storage

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 work required to prepare the ships for indefinite waterborne storage in a safe and environmentally acceptable manner. After inactivation, the ship would be placed in waterborne storage. The existing facilities for waterborne storage of nuclear-powered ships are at Puget Sound Naval Shipyard and Norfolk Naval Shipyard.

The preparation for storage work would include removing fluids, removing militarily useful 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.

The alternative of taking no permanent disposal action can be selected and successfully applied. The Navy's 1984 EIS (USN, 1984a) determined that protective waterborne storage could be safely done. This determination was supported by a discussion of the measures taken in storing seven defueled, decommissioned Naval nuclear submarines to ensure that no radiological concern existed or would exist for many years as long as periodic hull maintenance is performed. Three of these seven submarines have been in waterborne storage for over 15 years. Drydocking for hull maintenance has been performed as necessary. The 1984 conclusion was that the protective waterborne storage option is considered satisfactory as an interim measure; however, maintenance will be an increasing responsibility for the Navy as the ships age and the number of inactivated ships increases. Protective storage is not a permanent solution to the disposal problem. If no permanent alternative is available, the "no action" alternative will occur by default.

The disadvantage of this option is that it only delays ultimate permanent disposal. The potential benefit would be lower radiation exposure to shipyard workers preparing the package for final disposal. A delay of 50 to 100 years would reduce the total radiation dose to shipyard workers to less than one rem per package (approximately 0.0004 additional latent cancer fatalities) in preparing the package for land disposal. At the end of protective storage, the radioactive inventory, primarily radionuclides such as nickel-63 and nickel-59, would still require permanent disposal of the reactor compartments as radioactive waste.

Although delaying disposal could potentially allow the development of some new technology to deal with the disposal of radioactivity, there is nothing presently on the horizon that would hold the promise of a more cost effective, environmentally safe disposal method for reactor compartments.

2.2.1 Moorage Facility Requirements

There are two areas designated by the Navy as inactive nuclear-powered ship moorage facilities. Norfolk Naval Shipyard maintains the designated inactive nuclear ship moorage facility on the east coast and Puget Sound Naval Shipyard maintains the facility on the west coast. These facilities have specific services and equipment to provide a safe, secure moorage for temporary storage of inactivated defueled nuclear-powered ships. The Norfolk Naval Shipyard moorage facility, with minor modifications and dredging, would be capable of handling up to twelve ships depending on the type and size. The Puget Sound Naval Shipyard morage facility has a capacity of about 35 ships depending on the classes involved.

The inactive ship nuclear mooring facilities at both Norfolk Naval Shipyard and Puget Sound Naval Shipyard would be adequate to handle the cruisers and submarines inactivated until after the year 2000.

At Norfolk Naval Shipyard, dredging would be required prior to berthing the ships considered by this EIS. Sediment buildup in the Norfolk area is about three inches per year. Periodic maintenance dredging would be required during the storage period to prevent grounding during low tides. At Puget Sound Naval Shipyard, water depths are adequate to berth the ships considered by this EIS without dredging. Since sediment buildup in the Puget Sound Naval Shipyard area is less than approximately one foot per 50 years, maintenance dredging is an insignificant factor.

2.3 Disposal and Reuse of Subdivided Portions of the Reactor Plant

2.3.1 Description of Alternative

This alternative would involve the dismantlement of the entire ship, including the reactor compartment and the reactor plant, into smaller sections. Reusable components and materials would be recycled to the extent feasible. Components and materials would be processed according to regulations applicable at the time of disposition. The amount of waste estimated for the subdivision alternative ranged from a high 120,000 cubic meters (4,240,000 cubic feet) to a low of 10,000 cubic meters (353,000 cubic feet) with an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). The amount of mixed waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

Operations could begin immediately after defueling and decommissioning while the ship was still in drydock. They also could be performed after protected waterborne storage for an indefinite period following defueling and decommissioning. Periods of storage preceding operations would allow radionuclides to decay, thereby reducing radiation exposure to shipyard workers.

Puget Sound Naval Shipyard and Norfolk Naval Shipyard are the sites being considered for performing subdivision operations. One or both of these sites would be used if this alternative is selected because they are the two largest Naval Shipyards, can handle all classes of ships under consideration in this EIS, have Naval Inactive Ship Maintenance Facilities (NISMF) and would perform most of the defuelings.

The basic operations would be accomplished in drydock. The arrangement would be similar to the arrangement shown in Figure 2.17. The ship would be floated into a flooded drydock and lowered onto keel blocks as the water is drained from the drydock. Subsequent operations would take place either with the reactor compartment attached to or separated from the rest of the ship. Enclosures would be installed and openings made into the reactor compartment. Components and materials would be removed from the reactor compartment and transferred to appropriate locations within the shipyard for further disassembly or processing if necessary. When no longer needed for environmental control of radioactive and hazardous materials, the enclosures would be removed and the reactor compartment structure and hull would be dismantled.

2.3.2 Basic Facilities and Operations Required to Support Alternative

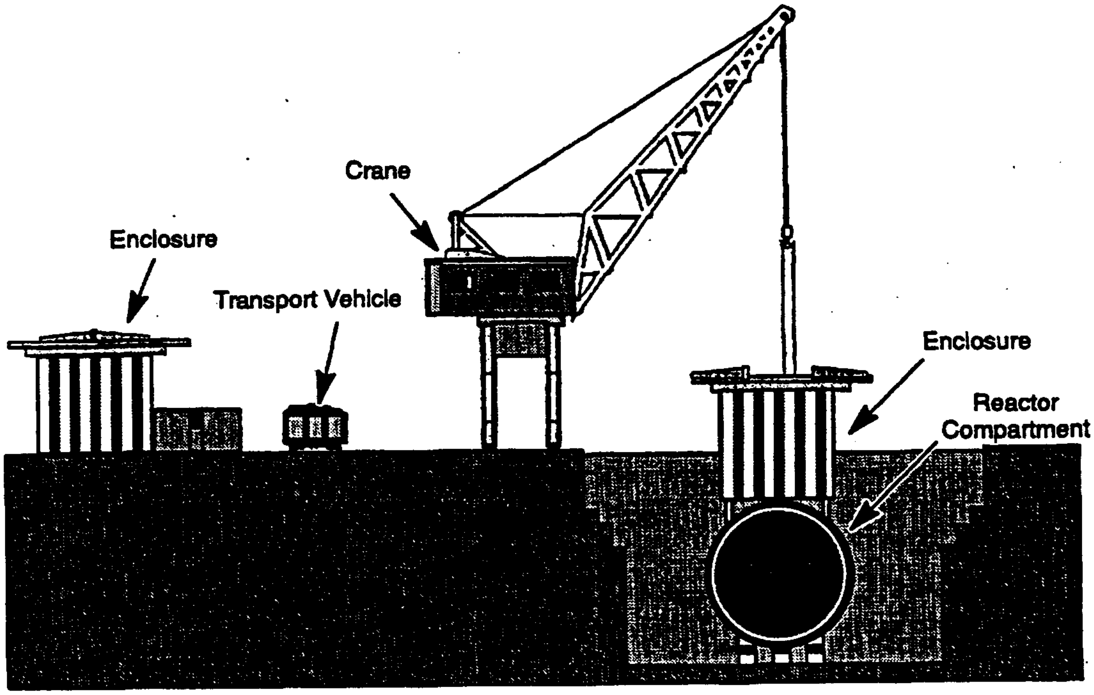
The operations required to support the subdivision alternative would require removal of the reactor plant systems, such as the fluid systems and electrical systems. Lead shielding would be removed. The reactor compartment structure and hull would be dismantled. Large components would be packaged individually for shipment and disposal while smaller items would be packaged in drums or other bulk containers. The operations and processes needed to accomplish the subdivision alternative would be expanded from those currently in use at Naval shipyards to overhaul ships. The number and size of components to be processed would be on a larger scale. Large components, such as reactor pressure vessels, steam generators and pressurizers, which are not removed from reactor compartments under current programs, would have to be removed, packaged and disposed of individually. The large quantity of smaller components, such as valves, pumps and gages would have to be removed, packaged and disposed of separately. The magnitude of this disposal effort would be at least 10 times that of current programs.

Basically, the physical operations would involve mechanical disassembly of components, machine cutting of metal, flame cutting of metal, removal of insulation, packaging of material and handling of material. Operations, in general, would be keyed to removal of the major components such as the reactor vessel, steam generators, pressurizer and main coolant pumps. Prior to removal of each major component, cables, piping, cat walks and other structures that would cause interference would be removed. Radiological considerations, together with differences in reactor compartment arrangements and component sizes and weights, would affect the specific way that each reactor plant is dismantled.

Most items to be removed would be within the capacity of existing shipyard portal cranes. However, in some cases reactor vessels, which are the heaviest components, exceed the capacity of the largest portal cranes at the Shipyards being considered for this work. Also, in the normal installed position, radiation from the reactor vessel is attenuated by lead shielding attached to the shield tank that surrounds the lower part of the reactor vessel. Therefore, it would be advantageous to remove the reactor vessel and primary shield tank as a unit to take advantage of the shielding provided by the tank and thereby reduce radiation exposure to shipyard workers. The combined weight of the reactor vessel and tank would exceed the capacity of even the largest shipyard portal cranes. Therefore, either a crane with sufficient lifting capacity would be obtained or transfer of the reactor vessel and tank for shipment would be accomplished by means of jacking and blocking. It would also be advantageous to add concrete to the primary shield tank to provide further shielding in which case the weight to be handled would be even greater.

Although some large components, such as reactor pressure vessels and steam generators, would be too large to ship by truck or by rail, none of the components would be too large to ship by barge. Department of Energy disposal sites at Hanford, Washington and Savannah River, South Carolina are accessible by truck, rail or barge. Operations would take place in a drydock or pierside. Subdividing the reactor plant and processing of the pieces would require appropriate containment to protect shipyard workers and the environment from radioactive materials and hazardous materials exposed during processing.

One or more enclosures would be placed over or around the reactor compartment for removal of components and materials. Moveable roofs, or other means of access, would be provided as necessary for transporting components and material out of the reactor compartment. The enclosure would incorporate a controlled ventilation system designed to prevent discharge of hazardous or radioactive particulates to the environment. Access would be provided from the enclosure to the reactor compartment interior. Methods would be established to ensure that hazardous materials exiting the enclosure would be properly identified for subsequent disposition. In addition to facilities for general disassembly of components and segregation of materials, special facilities would be provided for handling of radioactive material, PCB bearing material, lead and asbestos. Reusable material and equipment would be loaded onto rail cars or trucks for transport to recycling facilities. Cranes as well as trucks and rail cars would be utilized for transport of components.



Note: LOS ANGELES Class reactor compartment is shown. Approximate diameter is 33 feet.

Figure 2.17. Conceptual Arrangement for Drydock Operations

This alternative would generate (1) asbestos, toxic, hazardous, radioactive and mixed wastes, (2) equipment that could be salvaged and reused, (3) metal and other materials that could be reused or sold for reuse and (4) non-hazardous solid waste. Work involving hazardous materials would be carried out by trained people using appropriate personnel protective equipment, in accordance with occupational safety and health regulatory requirements. The method of disposition would vary according to the nature of the material. Items that were radioactive, but not otherwise toxic or hazardous, would be packaged to meet the DOT requirements at 49CFR170 through 189 and applicable DOE orders and disposal site requirements. Mixed waste, which is waste that is radioactive in addition to being hazardous, would be processed in accordance with an approved shipyard site treatment plan and Section 3021(b) of the Resource Conservation and Recovery Act, as amended. Radioactive PCB waste, which is a regulated PCB article in addition to being radioactive, would be processed for storage in accordance with 40CFR761 and applicable Navy directives.

Non-radioactive, non-hazardous materials could be recycled as outlined in the Navy's June, 1993 Environmental Assessment of the Submarine Recycling Program at Puget Sound Naval Shipyard (USN, 1993a). Under the current disposal program for pre-LOS ANGELES Class submarines, portions of the submarine forward and aft of the reactor compartment are completely recycled, which greatly reduces the volume of waste to be disposed of. The same basic recycling processes would be used for recycling, where feasible, of non-radioactive, non-hazardous portions of cruisers, OHIO Class submarines and LOS ANGELES Class submarines including non-radioactive, non-hazardous portions of the reactor compartments. There is limited disposal capacity for mixed waste and radioactive PCB waste which might result from reactor compartment disposal work. Mixed waste would require treatment in accordance with appropriate treatment standards before disposal or else would require placement in retrievable storage until a mixed waste treatment and/or disposal site became available. Similarly, radioactive PCB waste would require storage until sufficient treatment or disposal capacity became available.

The locations of radioactive items on board Naval nuclear-powered ships are clearly established through surveys conducted throughout the operational life of the ship, by surveys conducted before, during, and after maintenance work and by surveys conducted as part of the decommissioning process. In addition, surveys would be conducted before, during and after subdivision operations.

Work on radioactive items would take place in specially controlled areas with methods in effect to prevent radioactivity from being spread to uncontrolled areas. Items within such a controlled area would be considered potentially radioactive and would be subjected to radiological surveys prior to being released for unrestricted handling.

Radioactive items that would require disposal would be evaluated to determine if they were hazardous in addition to being radioactive. If so, they would be considered mixed waste or radioactive-PCB waste and would be processed accordingly.

Mixed wastes would first be collected in designated accumulation areas. Then they would be processed to segregate the radioactive, hazardous, non-recyclable, non-radioactive, non-hazardous and recyclable components to the extent practicable. The mixed waste that remained after processing would be packaged and shipped to an appropriate mixed waste treatment or disposal site. Similarly, radioactive waste, hazardous waste and non-recyclables that resulted from processing would be packaged and shipped to appropriate disposal sites.

In addition, to reduce the overall volume of waste metal from the subdivision alternative, some of the radioactive metals could be recycled using recently licensed foundry technology. The Navy has used this technology to process some Navy radioactive waste metals. In December of 1993, Norfolk Naval Shipyard awarded a contract for processing of radioactive waste, which included provisions for recycling of radioactively contaminated metals by foundry melting. The amount of metal involved was estimated to be 300,000 pounds. The contract precluded processing of mixed waste, transuranics, and Class B and Class C waste per 10CFR61.

2.3.3 Applicable Regulatory Considerations

Portions of the reactor plant which would be transported for final disposition would be packaged to meet all applicable U.S. Department of Transportation requirements for packaging of hazardous materials for transport as set forth in 49CFR173.

Items would also be packaged to meet applicable U.S. Nuclear Regulatory Commission regulations (10CFR71) for packaging and transportation of radioactive material. In addition, they would be packaged to meet applicable U.S. Environmental Protection Agency solid waste regulations of 40 CFR et seq. Any additional requirements of the disposal site operator, including those imposed by State government, would also be met.

Applicable regulations for the reactor compartment disposal program at the shipyards include the Clean Air Act, the Clean Water Act, Toxic Substances Control Act, and the Resource Conservation and Recovery Act (RCRA).

At Puget Sound Naval Shipyard, the Puget Sound Air Pollution Control Agency has regulatory authority for the Clean Air Act. At Norfolk Naval Shipyard, this function is assumed by Region 6 of the Virginia Department of Environmental Quality. The Washington State Department of Ecology has regulatory authority over RCRA issues. For Norfolk Naval Shipyard, this function is retained by the EPA. The Shipyards have national Pollutant Discharge Elimination System (NPDES) permits, which specify discharge limitations for certain constituents as well as stipulating monitoring requirements. Any drydock discharges would be constrained by these permits.

The EPA has regulatory authority over PCB issues at the shipyards. Toxic or hazardous wastes and wastes that contain asbestos or PCBs would be disposed of at sites authorized to accept those wastes in accordance with 40CFR240 et seq. and 40CFR700 et seq. as applicable.

The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary) which are run by Naval Hospital Bremerton. Personnel may also be taken to Harrison Memorial Hospital as needed.

The shipyard maintains two fire stations with approximately 50 personnel. The shipyard has a fire department that is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard has a security force of approximately 177 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Bremerton Naval Complex.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

2.3.4 As Low as Reasonably Achievable (ALARA) Considerations

Radiation exposure to both shipyard workers and the public would be reduced by approximately one-half for every five years that operations are deferred because cobalt-60, which would be the primary source of exposure from 1 to 100 years after reactor shutdown, has a relatively short half-life of 5.3 years. After about 100 years, niobium-94 dominates the radiation dose to workers or personnel in the vicinity (NRC, 1991). In its evaluation of radiation exposure to personnel performing disposal of large commercial pressurized water power plants, the Nuclear Regulatory Commission estimated that, after 10 years worker exposure would be reduced to 55% of the exposure for immediate decommissioning, (NRC, 1988, Table 4.3-2). For Naval reactor compartments, however, the proportion of exposure to prepare for storage (which is constant regardless of how far in the future subdivision takes place) relative to the overall exposure for disposal is lower than for commercial reactors. Therefore, the overall exposure for disposal using the subdivision alternative could be reduced, after ten years to about 27% of the exposure for immediate subdivision.

The reason that deferral reduces exposure is straightforward. Radioactive isotopes that are mainly beta emitters or have very short half-lives do not contribute significantly to the personnel radiation dose associated with the subdivision alternative. Because beta radiation is weakly penetrating, it can be easily shielded and mainly presents a hazard if ingested or inhaled. Precautions to preclude ingestion or inhalation are implemented during all stages of work.

Radiation dose to workers would be kept as low as reasonably achievable through detailed planning, use of work processes that result in reduced personnel exposure, and installation of temporary shielding.

2.4 Indefinite Storage Above Ground at Hanford

In this alternative, reactor compartment packages would be stored above ground indefinitely at the Department of Energy Hanford Site. Compartment packaging and transport methods would be the same as those for the preferred alternative. The reactor compartments would be placed on foundations, similar to the current placement of pre-LOS ANGELES Class reactor compartments in Trench 94. However, for storage, there would be no intent to landfill the compartments for disposal as is planned for Trench 94. For storage, the surface coatings (paint) on the exterior of the compartments and the compartment foundations would be maintained as needed.

As in the no action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive and hazardous material contained by the reactor compartment.

The total volume of the reactor compartments is about 120,000 cubic meters (4,240,000 cubic feet). Besides the reactor compartments, the volume of mixed waste generated by this alternative is estimated to be about 1,625 cubic meters (57,400 cubic feet).

2.4.1 Storage Land Area Requirements

Storage of 100 reactor compartments would require an area of about 4 hectares (10 acres). The area within the 218-E-12B burial ground, immediately north of Trench 94 is considered in this EIS for the Hanford Site above ground storage alternative. Trench 94 is currently used for disposal of pre-LOS ANGELES Class submarine reactor compartments with 43 such compartments having been placed in the trench as of the end of 1994, Figure 2.11. The area to the north of this trench is available for Navy use and could accommodate the storage of 100 reactor compartments. Use of other areas on the Central Plateau of the Hanford site would entail extending the current landhaul route by up to 30%. Figure 2.18 shows conceptually how 100 reactor compartments could be arranged for storage at 218-E-12B.

Sites outside of Hanford were not considered for this alternative. Among the other radioactive material management and storage sites owned by the Federal Government, only the Hanford site would be accessible by barge shipments of reactor compartments. The physical access limitations of the other potential sites are discussed in previous sections.

Figure 2.19 is a sketch of a typical submarine reactor compartment placed on foundations for above ground storage.

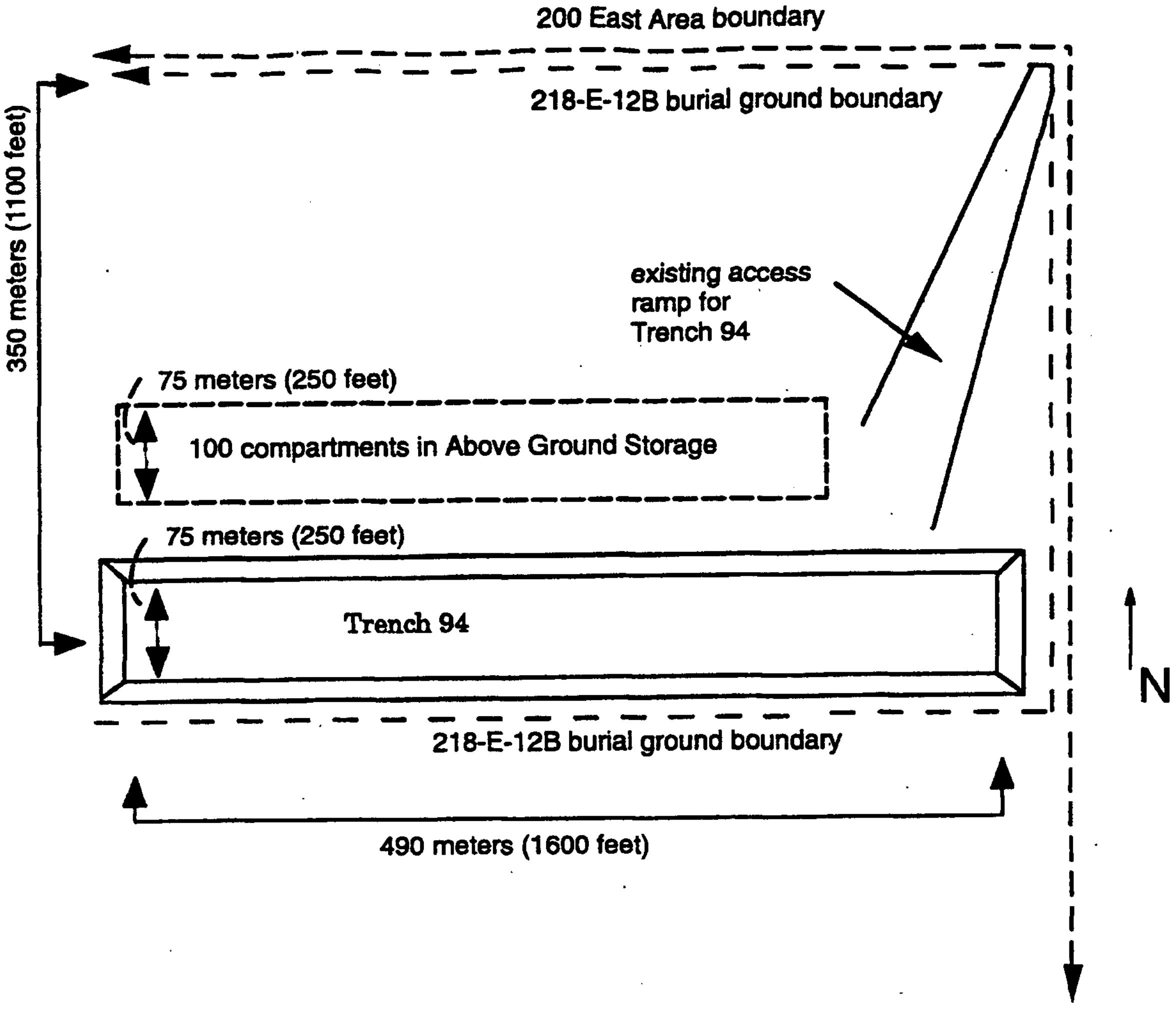
2.4.2 Applicable Regulatory Considerations

Packaging and shipping requirements for storage would be the same as for the preferred alternative (Section 2.1.5.1). Requirements provided by Title 49 "Transportation" of the Code of Federal Regulations do not differentiate between the transportation of hazardous and radioactive waste for storage or disposal. The same transport route through the Hanford Site used for the preferred alternative would be utilized to transport reactor compartments to an above ground storage site.

2.4.2.1 Federal Resource Conservation and Recovery Act and Washington State Dangerous Waste Regulations

The State of Washington has been delegated authority to implement a portion of the Federal Resource Conservation and Recovery Act. This is accomplished pursuant to the federal program by regulations promulgated in chapter 173-303 Dangerous Waste Regulations of the Washington Administrative Code (WAC), WAC 173-303. These regulations provide dangerous waste storage facility requirements. Because of the quantity of lead shielding present in the reactor compartment disposal packages, the Washington State Department of Ecology would regulate the reactor compartment disposal packages as a dangerous waste under the Washington State Administrative Code (WAC) 173-303, Dangerous Waste Regulations (WAC, 1993).

The area north of Trench 94 meets the facility siting criteria of the WAC 173-303 part 282. Hydrogeological characteristics for this area have been defined by Pacific Northwest Laboratory (PNL, 1992, PNL, 1994a). The thick and strong structure of the cruiser, LOS ANGELES, and OHIO Class reactor compartments would serve the same function as a dangerous waste storage facility described in WAC 173-303. Shielding lead in the compartments is in a solid elemental form and thus is not readily soluble in water. The lead is jacketed in steel canning. The reactor compartment packages provide their own containment. In the arid climate of the Hanford Site, with periodic maintenance of surface coatings (paint) and foundation structures, the compartments in storage would retain their structural integrity indefinitely with no migration of lead or radioactivity occurring.



* All Dimensions are Approximate

Figure 2.18. Conceptual Arrangement of 100 Reactor Compartments in Above Ground Storage at 218-E-12B Burial Ground.

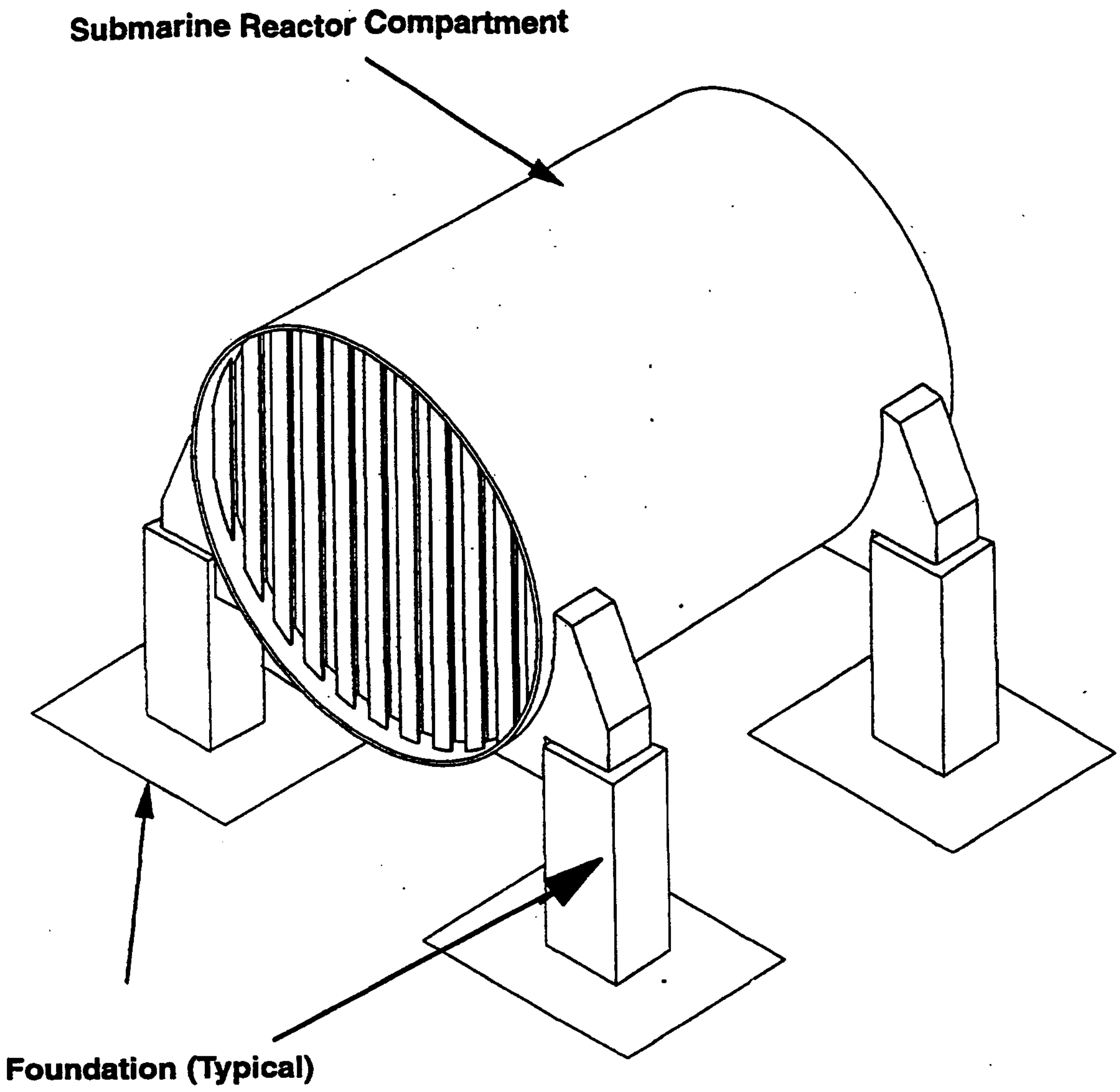


Figure 2.19. Typical Submarine Reactor Compartment Placed on Foundations for Above Ground Storage

Part 72 of WAC 173-303 provides a mechanism for Ecology to approve alternate means of meeting storage facility requirements. Such approval would be necessary in order to store cruiser, LOS ANGELES Class and OHIO Class reactor compartments above ground at 218-E-12B. This approval would involve demonstrating reactor compartment packages provide functional equivalence to hazardous waste storage requirements (e.g., a storage facility with a sloped floor and leak detection/containment system) as well as requirements for a fire protection system. The 218-E-12B burial ground already has a groundwater monitoring system around its perimeter that complies with the Resource Conservation and Recovery Act.

2.4.2.2 Toxic Substances Control Act

Cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments may contain solid polychlorinated biphenyls in industrial materials at levels equal to or greater than 50 ppm, causing these compartments to be regulated by the Environmental Protection Agency under the Toxic Substances Control Act (TSCA) at 40CFR761. Requirements for chemical waste storage facilities under TSCA are similar to those provided by WAC 173-303 and generally can be satisfied by meeting or showing equivalence to the requirements provided by WAC 173-303.

A justification for indefinite storage under TSCA storage requirements could be based on the functional equivalence of the compartments to the storage facility required.

2.4.2.3 Asbestos

Asbestos is regulated in the workplace, in removal operations, and in the air, land, and water environments. There shall be no discharge of visible emission to the outside air during the collection, processing, packaging, or transportation of any asbestos containing material (40CFR61.150(a)).

2.5 Other Alternatives

The preferred, no action, disposal and reuse of subdivided portions of the reactor plant, and indefinite storage above ground at Hanford alternatives are considered to cover all reasonable implementable alternatives at the present time. Other approaches that may be feasible for certain waste disposal operations but are not considered practical in the present case or different from other alteratives have been eliminated from detailed evaluation as discussed in the following sections.

2.5.1 Sea Disposal

A detailed evaluation of sea disposal is contained in the Navy's 1984 Final Environmental Impact Statement (FEIS) for Disposal of Decommissioned Defueled Naval Submarine Reactor Compartments (USN, 1984a). The 1984 FEIS concluded that sea disposal could be performed in an environmentally safe manner with no significant adverse effect. However, the 1984 Record of Decision (USN, 1984b) noted that Congress passed an amendment which restricted the issuance of permits for sea disposal of radioactive material and required Congressional approval before such a permit could be issued. Furthermore, the Environmental Protection Agency stated that additional regulations may be required before a permit request could be reviewed. Also, in November 1993, the U.S. voted along with the majority of other signatories to the London Convention (IMO, 1972) to ban sea disposal of low level radioactive waste subject to a scientific review in 25 years (IMO, 1993). Therefore, the sea disposal alternative is currently precluded by the London Convention.

Sea disposal would not be a viable alternative until after 2018 (1993 plus 25 years), and then only pending favorable results from the scientific reviews resulting from the London Convention. An interim storage method such as described in the no-action alternative would be a necessary part of this alternative. If this alternative were employed, preparations for ocean disposal would be made at one of the shipyards normally servicing nuclear-powered naval ships. The reactor vessel would be sealed by welding following defueling. The ship would be towed to the disposal location and sunk in a controlled flooding operation. The reactor compartment would be allowed to flood as the ship descended to the ocean bottom. This would preclude crushing the reactor compartment bulkheads by the extreme pressure at the depths considered for disposal. When the ship came to rest on the ocean bottom, it would be intact. The additional containment of radioactive material provided by the intact reactor compartment is not crucial to the safety of the sea disposal alternative. This is because almost all of the radioactive material is also contained within the thick pressure vessel and is an integral part of the metal components.

Although there is no technical basis for expecting that retrieval or further containment of an ocean-disposed ship would ever become necessary, methods for doing so have been examined and found to be technically feasible. They are described in Appendix M of the 1984 FEIS (USN, 1984a).

Over a period of time, radioactive material would be released as the ship and nuclear plant system components slowly corrode away. Since the radioactive atoms would be inside the sealed reactor vessel, many years would elapse before corrosion could free radioactive material from the metal. During this time most of the radioactivity would decay to stable isotopes.

In the evaluation of sea disposal presented in the 1984 FEIS (USN, 1984a), it was assumed that 100 submarines were sunk at a single location at a rate of three ships per year. These ships were then assumed to corrode and release radioactive materials to the ocean. The transport of radioactive material through the oceans included the effects of ocean currents, eddies, and water temperature and density variations, mixing in the water layers nearest the bottom, settling out of particles through the water column, etc. The same assumptions are made for purposes of this EIS. Possible radiological doses to members of the general public were extrapolated from doses calculated for the 1984 FEIS.

Doses were extrapolated for realistic assumptions and for very conservative assumptions; for example, that all the rusted particles were carried off by the water and none of them settled to the bottom.

Baseline radionuclide content was taken from Table 1-1 of the 1984 FEIS, which gives radionuclide quantities for one typical pre-LOS ANGELES class submarine at six months after final reactor shutdown. For purposes of extrapolation, the Table 1-1 values were adjusted for a total of 100 submarines at 365 days after final shutdown. Baseline values for dose commitments corresponding to disposal of 100 pre-LOS ANGELES were taken from Tables J-2, J-16 and J-17 of the 1984 FEIS, which provide estimated radiation exposures due to various radionuclides under various conditions for disposal of 100 submarines at a rate of three submarines per year. The exposures listed in the tables vary linearly with the number of curies of a given radionuclide.

Comparative radionuclide content for about 100 reactor compartments from cruiser, OHIO Class and LOS ANGELES Class submarines was developed from data generated by government laboratory computer models. Then linear extrapolations were made for each of the three conditions evaluated by first calculating the dose commitment for each radionuclide expected to be present in the cruisers, OHIO Class and LOS ANGELES Class submarines. The dose commitment for each radionuclide listed in Table J-12, Table J-16 and Table J-17 was multiplied by the ratio of the comparative value to the baseline value. Then the dose commitments for each radionuclide were summed to arrive at an overall dose commitment.

Extrapolation yields a dose of 2×10^{-11} mrem per year to the typical affected person. For example, this person is assumed to eat all of his seafood from ocean fish caught at the fishing ground nearest the disposal site. This radiological dose is less than one ten-trillionth of the average annual dose received from background radiation. Extrapolation for the very conservative assumptions gives a result of less than 0.0005 mrem per year of exposure, or less than 2 millionths of normal dose from background radiation.

To provide a "worst case" estimate for this environmental impact statement, possible radiological dose was extrapolated from the "worst case" estimate provided in the Navy's 1984 Final Environmental Impact Statement (USN, 1984a). That value was calculated assuming that at some time in the future a person might eat a very large amount of seafood (145 pounds a year) all of which had somehow been caught at the deep ocean disposal site. Even with such a hypothetical shortcut of the food chain, extrapolation indicates that this person would receive a whole body dose of less than 20 mrem per year. This is not considered to be an actual consequence of sea disposal but has been included to show that even a hypothetical short cut in the food chain would not result in significant exposure to any individual.

The sea disposal analysis for the pre-LOS ANGELES Class submarines did not consider removal or disposal of PCBs from the ship hulls and components. The Environmental Protection Agency regulates the handling and disposal of PCBs and PCB waste (40CFR761). Some of the ships covered by this EIS may contain PCB bearing material in concentrations above the 50 ppm limit requiring controlled disposal specified by 40CFR761.60. This material would have to be dealt with per 40CFR761 and 40CFR229 (EPA's ocean disposal regulations) before the ship could be disposed of by sinking at sea. To gain access to the PCB bearing material, equipment and structural material would have to be removed from the ships. If a ship were to be disposed of at sea, the structure of the ship would have to be restored to a degree that would allow the ship to be towed to the disposal site and sunk.

2.5.2 Land Disposal of Entire Reactor Compartments at Other Sites

Disposal sites other than the DOE Hanford Site have been considered for land disposal of the entire reactor compartment. The Low Level Radioactive Waste Policy Act Amendments of 1985 state the Federal Government shall be responsible for disposal of low-level radioactive waste owned or generated by the U.S. Navy as a result of the decommissioning of U.S. Navy vessels. In addition, the need to maintain control of the classified design information inherent in the reactor compartments requires a site under Federal control. Federal nuclear waste disposal sites are located at Department of Energy Sites. In the Navy's 1984 EIS (USN, 1984a), DOE radioactive waste disposal sites other than Hanford were evaluated. The Savannah River DOE Site was the only other site which was considered practicable.

The physical limitations imposed by the size and weight of the reactor compartment packages considered by this EIS would require that the disposal sites be accessible by barge shipment with an unobstructed land transportation route to the final disposal area the same as with the pre-LOS ANGELES Class submarine reactor compartment disposal program.

The Savannah River Site was evaluated in the Navy's 1984 EIS and it was concluded that the site was barely accessible by a barge loaded with a pre-LOS ANGELES Class reactor compartment. The limiting factors were shallow areas of the river that would require dredging and two bridges across the river that would require that the barge be ballasted down to transit under them.

The reactor compartments considered in this EIS are one and one half to two and one half times heavier and physically larger than the pre-LOS ANGELES Class submarine packages. The National Oceanic and Atmospheric Administration nautical charts numbers 11514 and 11515, Savannah River, show areas where the river depth is seven feet at low water. The chart also shows a fixed bridge at river mile 61.3 which has a vertical clearance of 38 feet at low water. The draft of a barge loaded with a LOS ANGELES Class reactor compartment package is expected to be greater than seven feet and the height above the water line would be approximately 41 feet. Cruiser and OHIO Class reactor compartments are taller than LOS ANGELES Class reactor compartments. The physical constraints up the Savannah River transit route would be insurmountable for the larger reactor compartment disposal packages covered by this EIS which would make the Savannah River Site inaccessible as a disposal site. As a result, the Hanford Site is the only site available for land disposal of the entire defueled reactor compartment.

2.5.3 Permanent Above Ground Disposal at the Hanford Site

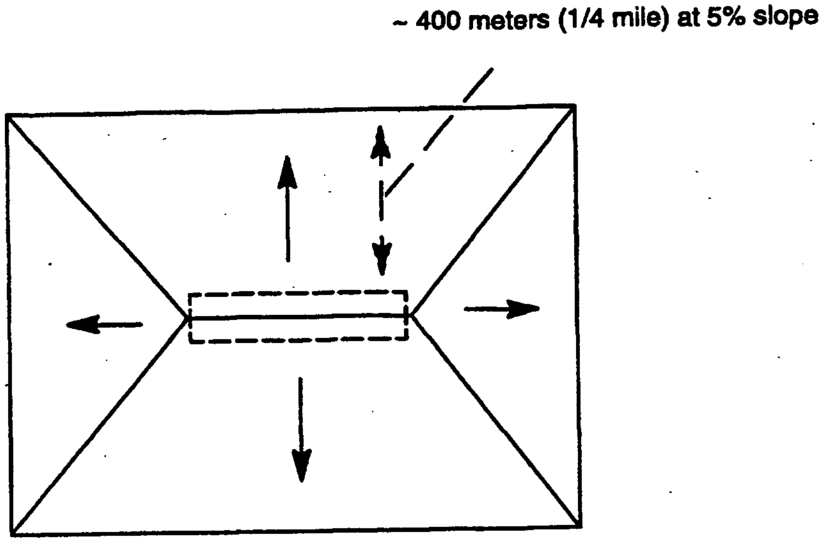
In this alternative, cruiser, LOS ANGELES Class, and OHIO Class submarine reactor compartments would be placed above ground at the Hanford Site, covered with soil, and entombed in a soil mound.

The State of Washington has been delegated authority to implement a portion of the Federal Resource Conservation and Recovery Act. This is accomplished pursuant to the federal program by regulations promulgated in chapter 173-303 Dangerous Waste Regulations of the Washington Administrative Code (WAC), WAC 173-303. Because of the quantity of lead shielding present in the reactor compartment disposal packages, the Washington State Department of Ecology would regulate the reactor compartment disposal packages as a dangerous waste under the Washington State Administrative Code (WAC) 173-303, Dangerous Waste Regulations (WAC, 1993). The cruiser, LOS ANGELES Class, and OHIO Class submarine reactor compartments may also contain solid polychlorinated biphenyls in industrial materials at levels equal to or greater than 50 ppm, and thus be regulated as a toxic waste by the Environmental Protection Agency under the Toxic Substances Control Act. The implementing regulations for polychlorinated biphenyls are codified at Title 40 Code of Federal Regulations Part 761 (40CFR761). Permanent disposal of these reactor compartments must comply with requirements for land disposal of hazardous waste specified by the above regulations.

Part 665 of WAC 173-303 provides requirements for the disposal of dangerous waste by landfill. Disposal by landfill as defined in section 040 of the WAC 173-303 includes disposal in or on land. The regulations for disposal of polychlorinated biphenyls (40CFR761) specify the requirements for chemical waste landfills. Compliance with the WAC 173-303 requirements generally satisfies TSCA requirements. The alternative of permanent above ground disposal at Hanford, with entombment in a soil mound, would be subject to these requirements as well. The applicable regulations require that upon closure, an engineered cover be placed over the disposal site to divert surface precipitation away from the buried waste.

The EPA technical guidance document for Resource Conservation and Recovery Act compliant closure covers recommends a multilayer cover design with a uniform surface slope of between 3 and 5 percent (after allowance for settlement) (Golder, 1992). This gentle slope reduces the potential for cover erosion. Figure 2.20 shows a conceptual arrangement of a Resource Conservation Recovery Act compliant engineered cover over an above ground disposal site for the reactor compartments.

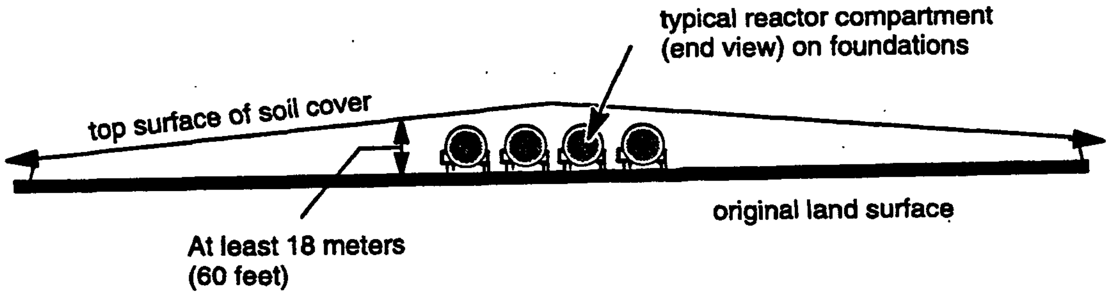
In order to maintain the minimum 5 meter (16 feet) burial depth specified in 10CFR61 for near surface disposal of radioactive waste, the peak of this cover would be at least 18 meters (60 feet) above ground surface. Maintaining the gentle 5% slope along the entire slope of the cover from peak to original land grade, for erosion control, would result in a the cover extending almost 400 meters (1/4 mile) in each direction from the reactor compartments. Total area occupied by the cover would be around 100 hectares (240-250 acres). This area could potentially encompass less disturbed shrub-steppe environment at Hanford. Large quantities of soil would also be required to create this structure (on the order of 6E6 cubic meters). The end result would be a recontouring of the land surface into a gradual rise that would be natural looking but represent a new feature on the landscape. Disposal facility closure requirements in WAC 173-303 discuss returning the facility to the natural appearance of the surrounding land. For sites with groundwater aquifers that are deep or partially non-existent, like Hanford, this alternative is essentially the same as the preferred alternative except that more land space would be occupied by the above ground cover due to the increased height of this cover over the existing grade of the land.



Arrows show direction of slope (3-5%)

Dashed lines show outline of array of 100 compartments

OVERHEAD VIEW



CROSS SECTION VIEW
(across narrow dimension of compartment array)

Figure 2.20. **Conceptual Arrangement of Resource Conservation Recovery Act Compliant Engineered Cover over Above Ground Disposal Site**

3. AFFECTED ENVIRONMENT

3.1 Preferred Alternative

The existing environment of the preferred alternative includes the Puget Sound Naval Shipyard where the reactor compartment disposal packages would be prepared for shipment, the waterborne transport route between the Shipyard and the barge off-load site at the Port of Benton, Richland, Washington, the landhaul transport route on the Hanford Site, and the proposed Hanford land disposal site.

3.1.1 Shipyard

The Puget Sound region lies in the northwest corner of Washington State as shown on Figure 3.1. The region is defined by the Olympic Mountain Range to the west and the Cascade Mountain Range to the east. The lowlands contrast dramatically with the mountains, with numerous channels, bays, and inlets on the inland sea that is Puget Sound. The Puget Sound Naval Shipyard is located inside the city limits of Bremerton, Washington at 47° 33′ 30″ north latitude and 122° 38′ 8″ west longitude. Bremerton is located in Kitsap County on the Sinclair Inlet 22 kilometers (14 miles) across Puget Sound west of Seattle and about 32 kilometers (20 miles) straight line distance northwest of Tacoma. Topography in the Bremerton area is characterized by rolling hills with an elevation range from sea level to +60 meters (+200 feet) above mean sea level (msl) in West Bremerton and ranging up to +90 meters (+300 feet) above msl in East Bremerton (area east of Port Washington Narrows). The predominant native vegetation in the area are douglas fir, cedar, and hemlock. Within a distance of 40 to 65 kilometers (25 to 40 miles) in a westerly direction from Bremerton, the Olympic Mountains rise to elevations of 1200 to 2100 meters (4,000 to 7,000 feet). The higher peaks are covered with snow most of the year and there are several glaciers on Mount Olympus (elevation 2,425 meters (7,954 feet)). In an easterly direction and within a distance of 96 kilometers (60 miles), the Cascade Range rises to average elevations of 1,200 to 2,100 meters (5,000 to 7,000 feet) with snowcapped peaks in excess of 3,050 meters (10,000 feet).

Puget Sound Naval Shipyard is the largest activity of the Bremerton Naval Complex, which also includes the Fleet and Industrial Supply Center, Puget Sound and Naval Sea Systems Command Detachment, and Planning and Engineering for Repair/Alteration of Aircraft Carriers. Tenant activities include Naval Inactive Ship Maintenance Facility, Naval Reserve Center, and the Defense Printing Service.

Bremerton Naval Complex includes a total of approximately 539 hectares (1,347 acres) consisting of uplands and submerged lands. Puget Sound Naval Shipyard has 130 hectares (327 acres) of upland and is highly developed. Puget Sound Naval Shipyard also owns about 135 hectares (338 acres) of submerged tidelands. The waterfront dry dock area is the high–security portion of the shipyard where most production takes place. It includes production shops, administration, and some public works and supply functions. The upland area of the Shipyard is the military support area which provides services to military personnel, including housing, retail goods and services, recreation, counseling, dental care, and other support services. The industrial support area in the southwestern portion of the shipyard includes several piers for homeported ships and inactive fleet, the power plant, warehouses, steel yard, public works shops, and parking.

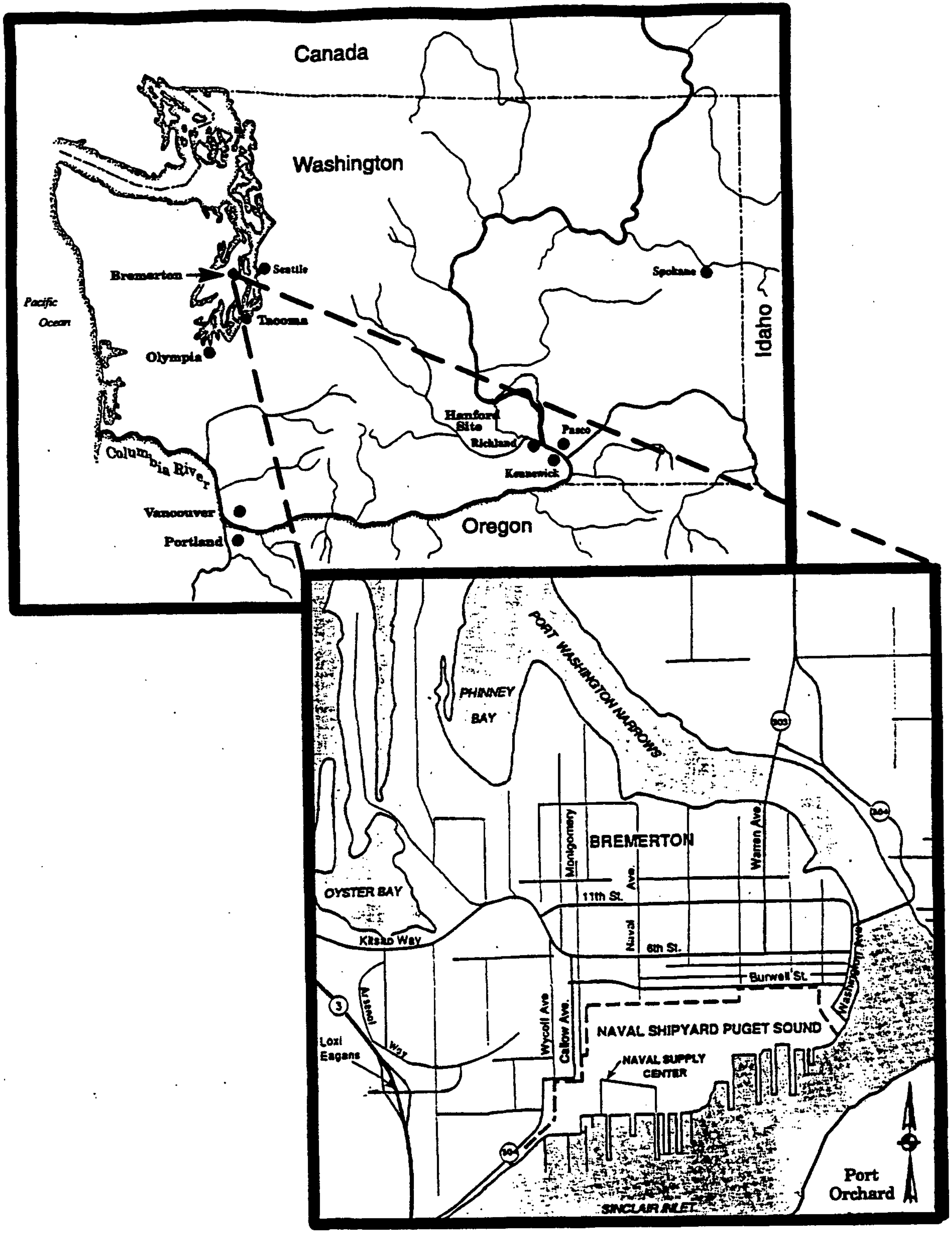


Figure 3.1. General Site Location, Puget Sound Naval Shipyard

The operations to prepare the reactor plants for shipment would be accomplished within the controlled industrial area of the Shipyard. This area consists of the facilities involved in ship overhaul, repair, dry docking, and conversions. The area is bounded by Decatur Avenue on the north, the waterfront on the south, the Fleet Industrial Supply Center on the west, and the main gate on the east. The area is industrialized with the land area typically covered with structures or paving. There would be no significant changes in the uses of this area of the Shipyard from the industrial operations that have been conducted there for several decades.

The general meteorological conditions of the Puget Sound area are typical of a marine climate, since the prevailing air currents at all elevations are from the Pacific Ocean. The relatively cool summers, mild winters, and wetness characteristic of a marine climate are enhanced by the presence of Puget Sound. The area tends toward damp, cloudy conditions much of the year. The Cascade Range to the east serves as a partial barrier to the temperature extremes of the continental climate of eastern Washington. Extreme weather conditions, such as thunderstorms, tornados, etc., rarely occur in the Puget Sound area.

The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary) which are run by Naval Hospital Bremerton. Personnel may also be taken to Harrison Memorial Hospital as needed.

The shipyard maintains two fire stations with approximately 50 personnel. The shipyard has a fire department that is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard has a security force of approximately 177 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Bremerton Naval Complex.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

In accordance with the Clean Air Act and the required State Implementation Plan for achieving nationwide air quality goals, air pollution control in the State of Washington is a coordinated effort by the Department of Ecology and various single or multi–county local air pollution control authorities. The State is divided into intrastate Air Quality Control Regions (AQCRs). Each AQCR has the responsibility for developing its point and area source emissions inventory and for analyzing and reporting on air quality monitoring data within its jurisdiction. The Puget Sound Air Pollution Control Agency has the delegated authority for enforcement of the Clean Air Act in the area encompassing the Shipyard (Kitsap County). The Code of Federal Regulations, Title 40, part 81, designates this area as being in attainment of national standards for suspended particulate matter and sulfur dioxide. Air quality with respect to ozone, carbon–monoxide, and nitrogen dioxide has not been classified but is considered to be in attainment. Puget Sound Naval Shipyard is not located in an area where degradation of air quality is severely restricted under the prevention of significant deterioration (PSD) regulations of Title 40, part 52.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk as defined by the Uniform Building Code (UBC, 1991). Puget Sound Naval Shipyard is located in a Zone 3 as defined by the Uniform Building Code (UBC,1991). The largest probable earthquake which could be expected in the Central Puget Sound area could have a magnitude of up to 7.5 on the Richter scale. There have been approximately 200 earthquakes since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude in the region near Olympia (approximately 65 kilometers (40 miles) from Bremerton) in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale).

There is no known fault line within 915 meters (3000 feet) of the Bremerton Naval Complex; however, two known fault traces have been identified in Kitsap County. The Kingston-Bothell trace, in the northern portion of the county, and the Seattle-Bremerton trace, located a few miles north of Bremerton. There has been no known surface faulting in conjunction with earthquakes in the Shipyard vicinity. Recently published studies have noted that a large earthquake is believed to have occurred less than 1100 years ago on a fault line referred to as the "Seattle Fault", (SCIENCE, 1992a), which stretches from east of Seattle and terminates near Bainbridge Island on the western shores of Puget Sound. The magnitude of this large earthquake was estimated at 7 or larger on the Richter scale. The magnitude and occurrence of the earthquake are based on carbon dating of trees believed to have slid into Lake Washington from landslides, sediments deposited at two sites north of Seattle on the Puget Sound believed to be from a tsunami, and a sudden 7-meter uplift of Restoration Point on Bainbridge Island, located approximately 3 to 5 kilometers (2 to 3 miles) east, north-east of the Shipyard. All of these phenomena are believed to have been induced by the earthquake, (SCIENCE, 1992a; SCIENCE, 1992b). The studies also noted that a repeat of a similar earthquake would cause extremely strong shaking, tsunamis in the Puget Sound, and ground uplift and subsidence over large populated areas, particularly in the Seattle metropolitan area.

As noted in the studies, a wide variety of effects were attributed to the earthquake in far reaching areas of the Puget Sound Lowlands, from the Olympic Mountains to Lake Washington east of Seattle. These studies however, did not note any effect in Sinclair Inlet or in the vicinity of the shipyard. Additionally, the Shipyard has had the seismic design work for the Water Pit Facility reevaluated. This reevaluation considered the shallow fault referred to in the recently published studies and concluded that the fault was not close enough or well established enough to constitute any significant hazard to the facility. Additional details are provided in the Seismic Design Study for the Water Pit Facility at Puget Sound Naval Shipyard, (STUDY, 1978).

Puget Sound Naval Shipyard and Sinclair Inlet lie within the usual and accustomed fishing area of the Suquamish Tribe. The Tribe is entitled to take up to one-half of the fish passing through the Sinclair Inlet, including hatchery produced fish. Historically the area has been of cultural significance to the Tribe, who depend on the quantity and quality of its resources for a livelihood (USN, 1994a).

3.1.1.1 Socioeconomic Background Information for the Puget Sound Region

This region is defined as encompassing Kitsap County (which contains Puget Sound Naval Shipyard) and adjacent countries (mainly Clallam, Mason, Pierce and Jefferson Counties). Although population growth in the State of Washington was increasing at 5.5% in 1992, population growth in Kitsap County averaged 12% between 1990 and 1994 making it the eighth fastest growing in the state. This growth has largely been due to the development of a retail center in

Silverdale. Growth in the City of Bremerton during the same period averaged 3%. Projected growth for the next 20 years is 91,000 (or 43%); 19,000 of which is projected to occur in the City of Bremerton.

Based on U.S. Bureau of the Census, Statistical Abstract of the United States (1993, 113th edition, Washington D.C.), the ethnic makeup of the county was 87.4% (183,951) White, 2.8% (5,971) Black, 1.7% (3,545) American Indian/Eskimo/Aleut, 4.7% ((9,948) Asian/Pacific Islander and 3.4% (7,115) Hispanic. Unemployment rate for last 5 years averaged 5.6% - 1 percent less than the state as a whole. In January 1994, unemployment was 5.9% vs 6.8% statewide.

Due to lengthy experience with the Shipyard, City of Bremerton planning allows for plus or minus ten percent shift in total Shipyard (military and civilian), due to Shipyard workload changes and the types of ships traditionally in overhaul or in port. Beyond this expected shift, a change of one worker at the Shipyard results in a 6 person population change in the City and surrounding region. (Source: a report prepared by the Office of Economic Adjustment, ODS, in February 1976 titled The Trident Impact on Kitsap County. The forecast in this report for 1985 (166,000) was close to actuals for that year (168,000).

Regional infrastructure is generally adequate for current projected growth. This includes transportation, health care, schools, fire protection, water supply, power supply, solid waste collection and treatment, wastewater treatment, storm water collection, and recreational facilities.

It is postulated that a change of one worker in the Shipyard (greater than the ±10% threshold) will result in a change in need for 2.6 housing units. (Source: this multiplier was extrapolated from a report prepared by the Office of Economic Adjustment, ODS, in February 1976 titled The Trident Impact on Kitsap County.) The current supply of single-family and mobile home lots is falling short of consumption. Over the past four years, 1.33 lots were used to every lot created. According to the 1990 U.S. Census, projected housing demand in the County is 3,100 units average per year for the next three years. In order to meet a critical Government housing shortage, the Navy is building 400 housing units for local Navy families.

3.1.1.2 Socioeconomic Background Information for the Norfolk Virginia Region

Based on U.S. Bureau of the Census, Statistical Abstract of the United States (1993, 113th edition, Washington D.C.), population increased from 1990 to 1993 by 1.5%. The ethnic makeup of this population was 58.3% (841,269) White, 33.6% (484,848) Black, 3% (43,290) American Indian/Eskimo/Aleut, 2.3% (33,189) Asian/Pacific Islander and 2.8% (40,404) Hispanic. This contrasts with population growth of 3.1% in the State of Virginia.

3.1.1.3 Ecological Resources

Vegetation and wildlife on Puget Sound Naval Shipyard are limited to "open spaces", noncontiguous, undeveloped areas. Most of these areas have been disturbed and are currently landscaped with native and ornamental trees and shrubs. Due to the extensive industrial nature of the shipyard, its resident bird community is characterized by "urban species" with numerous glaucous–winged gulls (Laurus glaucescens) inhabiting the waterfront area. Current populations of mammals at the shipyard are extremely limited. The lack of suitable habitat restricts the population of reptiles and amphibians. The majority of the shipyard is developed and covered with an impervious surface.

The shoreside of the shipyard consists primarily of riprap, concrete bulkheads, and old wooden piers. Marine vegetation along the shipyard shoreline consists primarily of sea lettuce (Ulva lactuca), rockweed (Fuchus distichus), and debris of algae that has been carried inshore. Juvenile Pacific Salmon (Oncorhvnchus spp.) migrate near–shore from mid March to mid June. Pacific herring (Clupea harengus) also mill in the vicinity of the Shipyard from mid January to mid April.

The bald eagle (Haliaeetus leucocephalus), a listed species under the Endangered Species Act may be found in the Bremerton Area from about the end of October to the end of March. Trees suitable for perching and roosting are found in the non–industrialized area at the shipyard, but not near the waterfront. No eagles have been reported nesting on the shipyard. Several marine mammal species may be found in Puget Sound waters including the gray whale (Eschrichtius robustus) and humpbacked whale (Megaptera novaeangliae), both endangered, and the killer whale (Ordinus orca), a protected marine mammal.

Additional discussion of the Ecological Resources of the Shipyard and surroundings can be found in Volume 1, Appendix D, Section 4.1.1.9 of the Final Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (DOE, 1995).

3.1.2 Waterborne Transport Route

The waterborne transport route follows the normal shipping lanes from Puget Sound Naval Shipyard, through Rich Passage, past Restoration Point, and northerly through the Puget Sound. The route is then westerly through the Strait of Juan De Fuca (in U.S. territorial waters), past Cape Flattery, and down the Washington coast to the mouth of the Columbia River. The route is then up the Columbia River, following the shipping channel used for the regular transport of commercial cargo. The river route passes through the navigation locks at the Bonneville, The Dalles, John Day, and McNary dams to the Port of Benton at river mile 342.8. Figure 2.5 is a map showing waterborne transport route.

A Final Environmental Impact Statement (FEIS) prepared by the National Oceanic and Atmospheric Administration (NOAA) evaluated establishment of the Olympic National Marine Sanctuary off the Northern Washington State coast (NOAA, 1993). NOAA has requested the U.S. Coast Guard to submit a request to establish an Area To Be Avoided (ATBA) which would limit vessel traffic from the shoreline to 25 nautical miles off the Olympic Peninsula.

The Columbia River is the fourth largest river in North America. Several large hydroelectric dams and navigation locks have been constructed on the Columbia River and Snake River, one of the major tributaries of the Columbia River, between the 1930s and 1970s. This system of dams and locks allows movement of large commercial tug and barge shipments on the Columbia and Snake Rivers. The Columbia-Snake River system provides a variety of resources for public and private use. Major economic activities include transportation, agriculture, electric power generation, fisheries, and recreation. The 465-mile (748-km) Columbia-Snake inland waterway represents a key part of the economics of the Pacific Northwest region. In 1990, over 26.5 million tons (23.9 million metric tons) of goods were exported from Columbia River deep water ports.

The Army Corps of Engineers has issued a Draft Environmental Impact Statement (ACoE, 1994) which accomplished a System Operation Review that evaluates various options for operating the Columbia River system. The formal listings in November 1991 and April 1992 of the Snake River Sockeye salmon as endangered and the spring/summer, and fall chinook salmon as threatened under the Endangered Species Act (ESA) have significant implication on the future operation of the Columbia River system. The ESA requires development of plans to help threatened and endangered species to recover. The ESA makes survival and restoration of the three salmon stocks an overriding issue in the preparation of the Columbia River system operation plan, and places significant restraints on system operation. No changes to the operations of the river system have been identified to date that would affect shipments of reactor compartments via the normal shipping channel and navigation locks.

The identified System Operation Review actions for control of the Columbia River System would not have a direct impact on prime or unique agricultural lands; direct impact would be confined to the reservoirs. Since reactor compartment shipments on the Columbia River would observe all controls imposed to control the river, there would be no direct impacts to prime or unique agricultural lands from the reactor compartment shipments as well. Shipments along the saltwater portion of the transportation route would not have an impact on prime or unique agricultural lands since by the location of the shipping route no farm lands would be encountered.

Reactor compartment shipments would not have a direct impact on wetlands or floodplains along the transportation route. Shipments would be along normal ocean shipping lanes and river channels, and be a small part of the normal ocean and Columbia River traffic. Shipments would observe all controls imposed to control the river and river traffic. Shipments would use the same off-loading facilities at the Port of Benton already in use for the current pre-LOS ANGELES Class reactor compartment disposal program. At this facility, river banks slope steeply into the water with little riparian vegetation. Water levels at the Port of Benton fluctuate daily and seasonally. This fluctuation tends to inhibit the formation of stable wetland environments.

Overhead clearances were evaluated along the waterborne transport route from Puget Sound Naval Shipyard to the Port of Benton at Richland, Washington. This evaluation determined that there were no overhead obstructions on the Columbia River that would pose an interferrence problem for the shipments covered by this EIS.

The drafts of the shipping barges for the cruiser, LOS ANGELES and OHIO Class reactor compartment disposal packages would not pose a problem for shipping. The shallowest river depths encountered are about 5 meters (15 feet) near the barge slip at the Port of Benton. The depth in the barge slip can be adjusted through the control of river flow at the up stream dam (Priest Rapids Dam) and the pool height at the down stream dam (McNary Dam) for docking barges of different drafts. This is routinely done for docking barges for the pre-LOS ANGELES Class disposal program.

The Hanford Reach, approximately 82 kilometers (51 miles) of the Columbia River that flows past or through the Hanford Site, has been the subject of a Comprehensive River Study and Environmental Impact Statement under Public Law 100-605, The Hanford Reach Act. The study and Final EIS (DOI, 1994) identified as the preferred alternative the designation of a National Wildlife Refuge and a National Wild and Scenic River. Area to be designated would be between river mile 346.5 and upstream 80 kilometers (49.5 miles) to river mile 396. The Port of Benton is located below the lower end of the study area at river mile 342.8. Therefore reactor compartment shipment and off-loading operations would be downstream of and not within the proposed National Wildlife Refuge and National Wild and Scenic River area of the Hanford Reach.

3.1.3 Land Disposal Site

The preferred land disposal site is the 218-E-12B Burial Ground located in the northeast corner of the 200 East Area of the U.S. Department of Energy's Hanford Site in southeastern Washington State. Figures 3.2 and 3.3 depict the Hanford Site and the location of the 218-E-12B Burial Ground.

3.1.3.1 Background

The Hanford Site is a 1450 square kilometer (560 square mile), mostly undisturbed area of relatively flat shrub-steppe desert lying within the Pasco Basin of the Columbia Plateau, a semi-arid region in the rain shadow of the Cascade Mountain Range. The Saddle Mountains form the northern boundary of the site. The Columbia River flows through the northern part of the site and forms part of its eastern boundary. The Yakima River forms part of the southern boundary. The City of Richland bounds the site on the southeast. The site contains numerous plant and animal species adapted to the region's semi-arid environment. More information on site ecology can be found in the Hanford Site National Environmental Policy Act (NEPA) Characterization (PNL, 1994b). This document does not identify any endangered species indigenous to the 200 East Area. Areas on the northern and southwestern edge of the site, totaling 665 square kilometers (257 square miles), have been designated as ecology and wildlife reserves/refuges and game management areas. Adjoining lands to the west, north, and east of the site are principally range and agricultural land. The Tri-Cities of Richland, Kennewick, and Pasco to the southeast constitute the nearest population center with a combined incorporated population of 100,600 as of 1993 (PNL, 1994b). About 376,000 people live within an 80-kilometer (50 mile) radius of the center of the Hanford Site according to the 1990 census (DOE, 1992b).

In prehistoric and historic times, the Hanford Reach of the Columbia River was heavily populated by Native Americans of various tribal affiliations. The Chamnapum band of the Yakama tribe dwelt along the Columbia River from south of Richland upstream to Vantage. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum bands to fish the Hanford Reach and some inhabited the east bank of the Columbia River. Walla Walla and Umatilla people also made periodic visits to the area to fish (PNL, 1994b).

The Hanford Site, is located on lands ceded to the U.S. Government by the Yakama and Umatilla Indians and near lands ceded to the U.S. Government by the Nez Perce Indians. The Yakama Indian Nation and the Confederated Tribes of the Umatilla have large reservations to the west and southeast of the Site, respectively, and the Nez Perce reservation is in Idaho. Treaties in 1855 established the reservations and provided the basis and compensation under which the remainder of the lands were ceded to the United States. Figure 3.4 is a map of the ceded lands and reservations of the nearby Indian tribes. As part of the 1855 treaties, the tribes, in common with citizens of the Territory, may fish in their usual and accustomed places. The treaty also provides, for hunting, gathering of roots and berries, and pasturing stock on open and unclaimed lands. The land occupied by the Hanford Site has not been considered open and unclaimed (DOE, 1987). Descendants of the Chamnapum band still live near the Hanford Reach at Priest Rapids, and others have been incorporated into the Yakama and Umatilla Reservations. The Washane, or Seven Drums religion, which has ancient roots and had its start at the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs (central Oregon), and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in ceremonies performed by tribe members (PNL, 1994b). There are other Indian

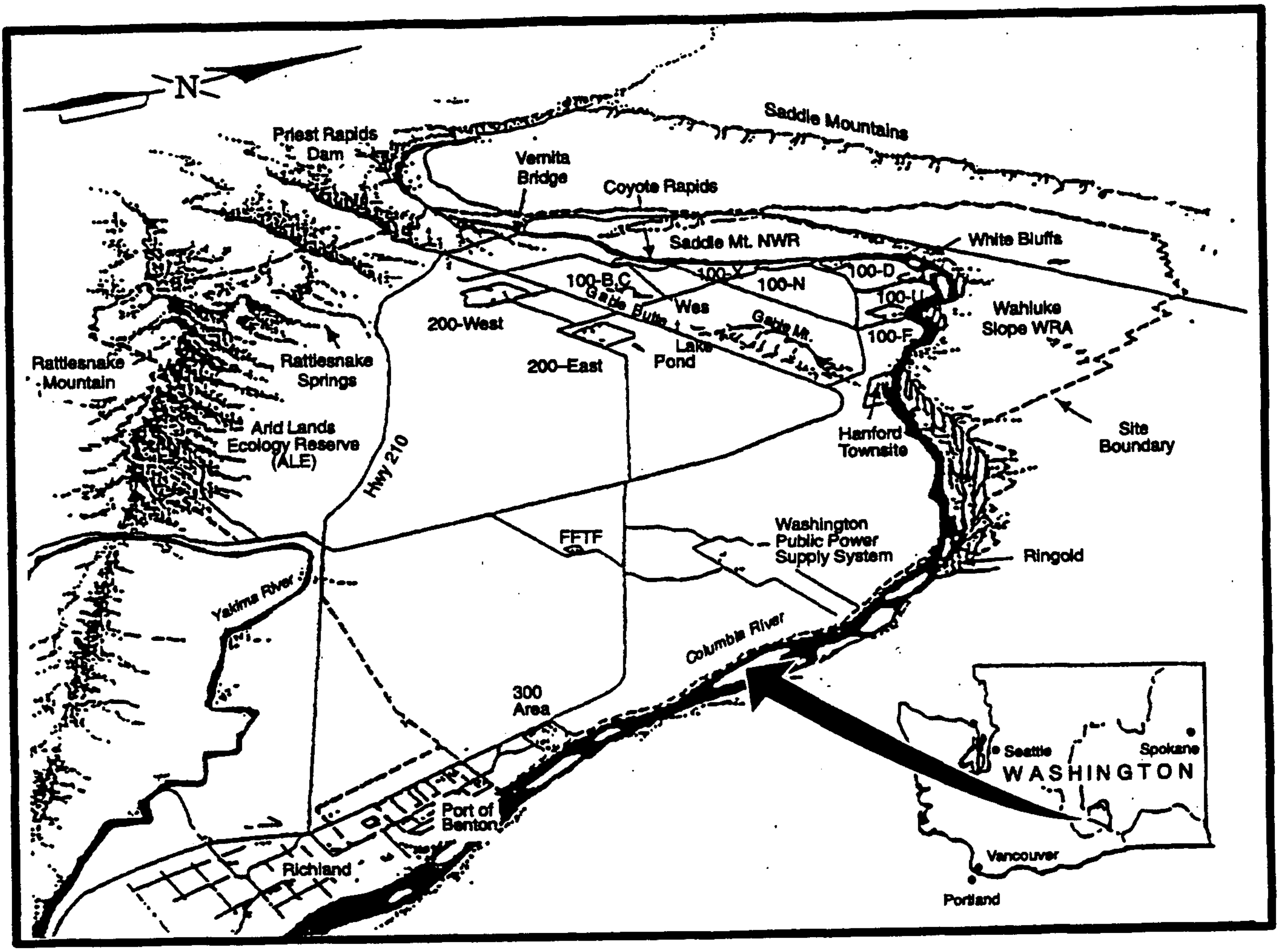


Figure 3.2. Overview of the Hanford Site

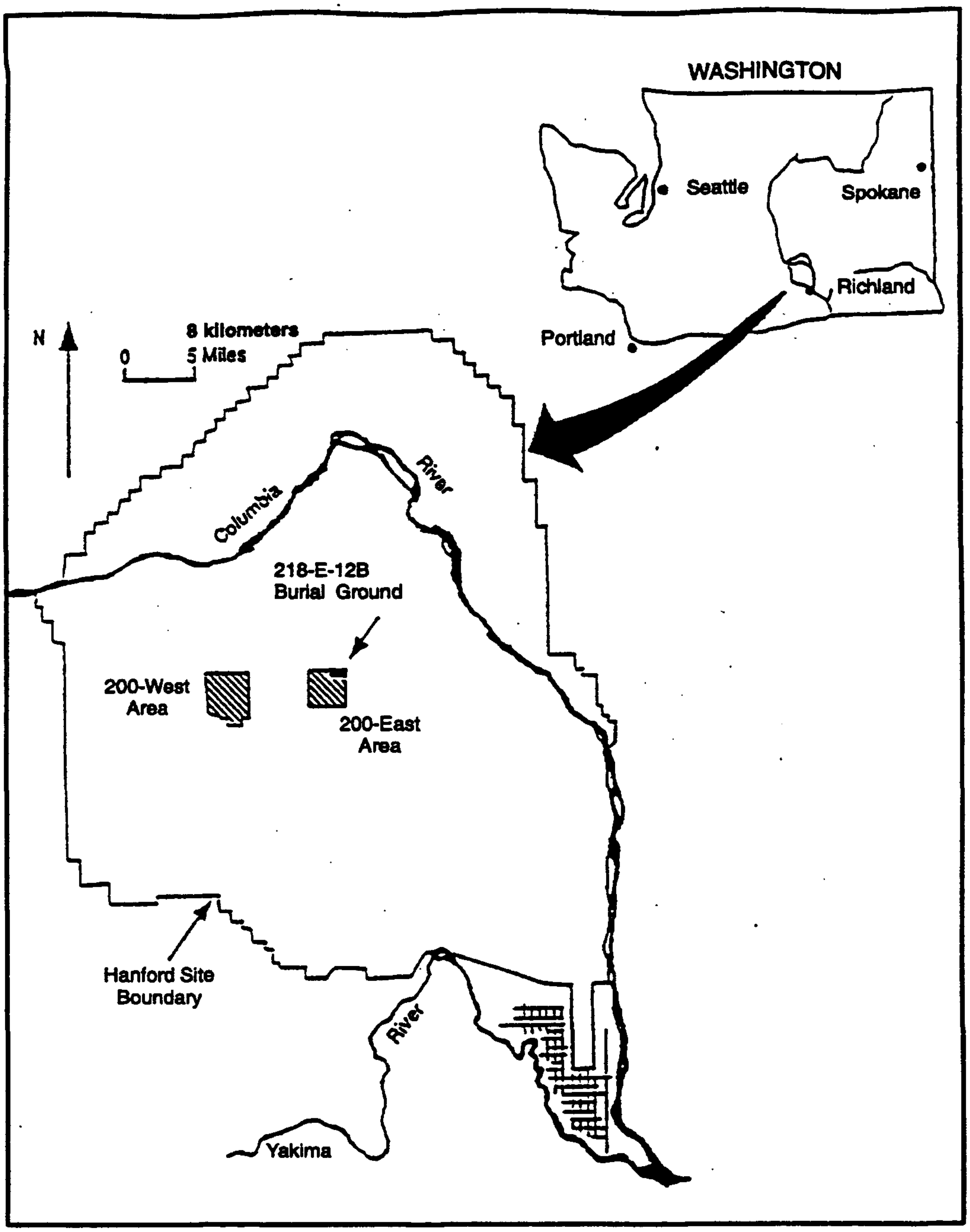


Figure 3.3. Location of the 218-E-12B Burial Ground

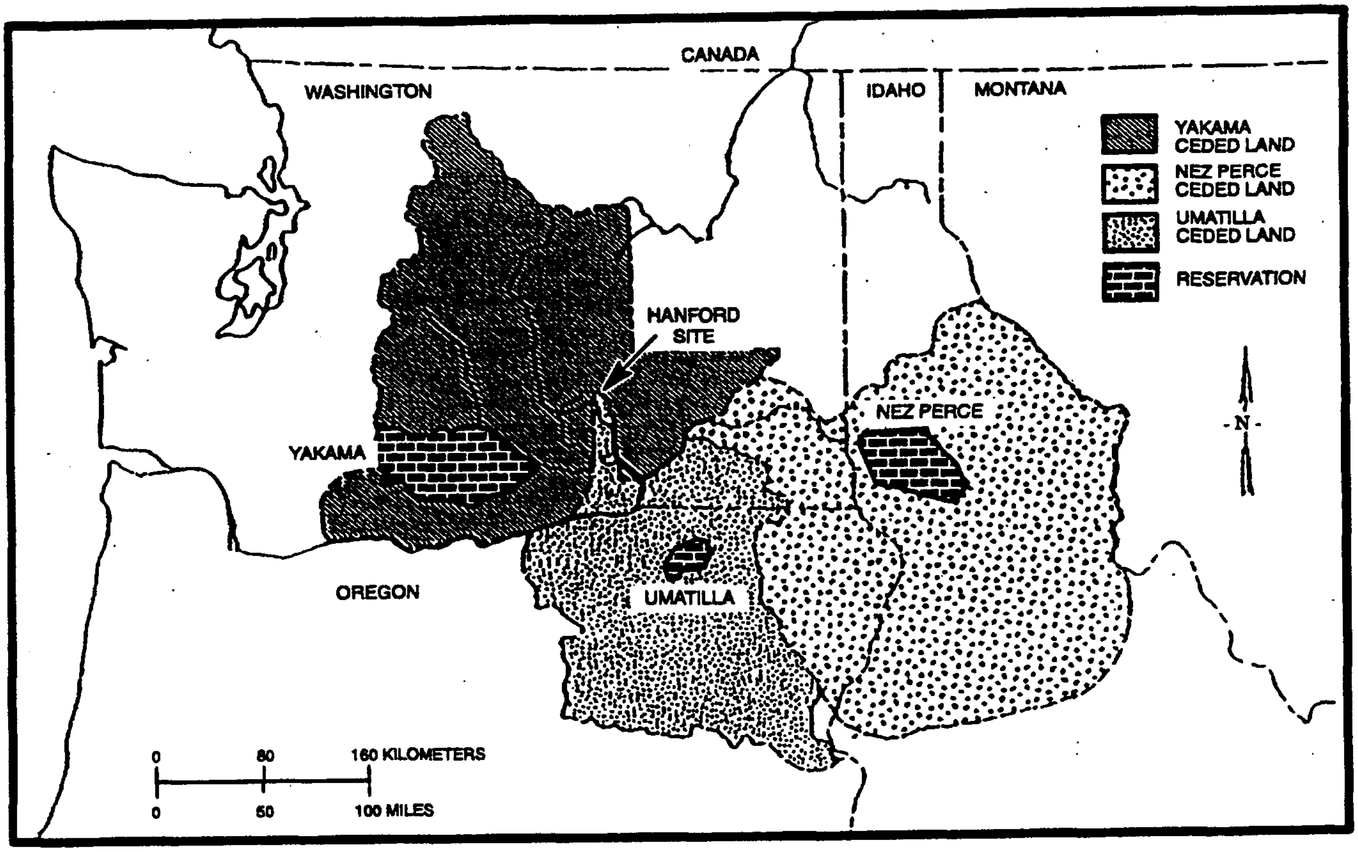


Figure 3.4. Ceded Lands and Reservations of Nearby Indian Tribes

tribes in the area whose ceded lands did not include any portion of the Hanford Site but who may make use of the Columbia River downstream of the Hanford Site for fishing (e.g., Warm Springs) (DOE, 1987). Additionally, the Wanapum band, a non federally recognized tribe living adjacent to the Hanford Site, has cultural and religious interests protected by the American Religious Act and is regularly consulted by the Department of Energy.

The Hanford Site contains numerous, well-preserved archaeological sites representing both the prehistoric and historic periods. Gable Butte and Gable Mountain, located about 3 to 5 miles to the north and east of the 218-E-12B burial ground, are some of the sites considered sacred to the Native Americans who originally inhabited the Hanford Site. However, no archaeological sites or areas of Native American interest are identified within the 200 East Area in the 1994 Hanford Site NEPA Characterization Document (PNL, 1994b). Archaeological surveys have been conducted of all undeveloped portions of this area. Historic resources from the Manhattan Project and Cold War eras include buildings and structures located in the 200 East Area. These buildings have been evaluated for National Register of Historic Places eligibility, however, these buildings are not located within or adjacent to the 218-E-12B burial ground. For additional discussion of the Hanford Site with respect to the 1855 treaties and Native American use, refer to the Environmental Impact Statement, Hanford Reach of the Columbia River, Final - June 1994 (DOI, 1994).

The Department of Energy's Native American Policy commits the Department of Energy to consult with tribal governments to assure the tribal rights and concerns are considered prior to the Department of Energy taking actions, making decisions, or implementing programs that may affect tribes. The Department of Energy has cooperative agreements with the Yakama Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce, which provide financial assistance to the tribes for providing comment for, and participating in Hanford related decisions.

In accordance with the Clean Air Act and the required State Implementation Plan for achieving nationwide air quality goals, air pollution control in the State of Washington is a coordinated effort by the Department of Ecology and various single or multi–county local air pollution control authorities. The State is divided into intrastate Air Quality Control Regions (AQCRs). Each AQCR has the responsibility for developing its point and area source emissions inventory and for analyzing and reporting on air quality monitoring data within its jurisdiction. Authority for enforcement of the Clean Air Act in the Area of the Hanford Site is shared by the Washington State Department of Ecology and the Benton County Clean Air Authority. The Code of Federal Regulations, Title 40, part 81 designates this area as being in attainment of national standards for suspended particulate matter and sulfur dioxide, however, suspended particulate in diameters of 10 micrometers or less occasionally exceeds national standards due in large part to natural events in the arid climate/ecology of the Pasco Basin. Air quality with respect to ozone, carbon–monoxide, and nitrogen dioxide has not been classified but is considered to be in attainment. The Hanford Site is not located in an area where degradation of air quality is severely restricted under the prevention of significant deterioration (PSD) regulations of Title 40, part 52.

3.1.3.2 Existing Land Use

In early 1943, the U.S. Army Corps of Engineers selected the Hanford Site as the location for reactor and chemical separation facilities for the production of plutonium for use in nuclear weapons. The site was used for this purpose until the recent decision to cease plutonium production. The work at Hanford is now primarily directed toward decommissioning the production facilities, disposal of the wastes, and environmental remediation actions. Environmental remediation actions are being accomplished under the Federal Facility Agreement and Consent Order signed by the Washington State Department of Ecology, the U.S. Environmental Protection Agency, and the U.S. Department of Energy (ECOLOGY, EPA, and DOE, 1989).

Land at the Hanford Site has not been used for farming since the site was established. Abandoned fields are found in areas along the Columbia River and highland areas along the western edge of the site (PNL, 1994b). About 6% of the Hanford Site is occupied by widely spaced clusters of Department of Energy processing facilities, nuclear reactors, and other industrial buildings located along the shoreline of the Columbia River and at several locations in the interior of the site. The industrial buildings are interconnected by roads, railroads, and utilities such as electrical transmission lines.

The Hanford Site also contains waste storage and waste disposal facilities. These facilities include buried tanks containing high-level radioactive defense wastes and burial grounds containing solid and radioactive wastes. Planning and preparations are underway for the disposal of mixed wastes (both hazardous and radioactive). The Washington Public Power Supply System operates a power generating reactor, WNP-2, near the Columbia River on the southeast portion of the site. Industrial and scientific activity at Hanford has a dominant role in the socioeconomics of the Tri-Cities.

Environmental impact statements and planning documents have been issued over the last decade which characterize site ecology, waste storage and disposal practices, site contamination, proposed corrective actions, and related environmental, historical, archeological, endangered species, and cumulative impacts (e.g., DOE, 1987, DOE, 1991, DOE, 1992a, DOE, 1992b PNL, 1994b). The results of ongoing environmental compliance monitoring at onsite and off-site locations are published yearly (PNL, 1994c). Because of these studies, the Hanford Site's characteristics are well documented.

3.1.3.3 Low Level Burial Grounds

The Low-Level Burial Grounds is a section of the Hanford Site used for land disposal of wastes. The Low-Level Burial Grounds cover a total area of approximately 210 hectares (518 acres), divided into eight burial grounds located in the Site's 200 East and 200 West areas. The 200 East Area is located near the center of the Hanford Site about 11 kilometers (seven miles) from the Columbia River, on a plateau about 183 meters (600 feet) above mean sea level. The 200 East area also contains reactor fuel chemical separation processing facilities that are currently inactive. Located in the northeast corner of the 200 East area is burial ground 218-E-12B. The 218-E-12B burial ground began receiving waste in 1967 and currently consists of over 80 existing or planned trenches covering 70 hectares (173 acres). These trenches contain mixed waste, low-level waste, and transuranic waste. A system of Resource Conservation and Recovery Act compliant ground water monitoring wells is in place around the 218-E-12B burial ground.

Trench 94 of the 218-E-12B burial ground is used for the disposal of decommissioned, defueled pre-LOS ANGELES class submarine reactor compartments. Trench 94, which has been in operation since 1986, contained 43 submarine reactor compartment disposal packages by October, 1994, and has a capacity for approximately 120 packages. The reactor compartment packages currently in Trench 94 are regulated as a mixed waste because they contain radioactivity, essentially as activated metal, and solid lead shielding (regulated by the State of Washington).

They are also regulated for small quantities of solid polychlorinated biphenyls (PCBs) bound within industrial materials at a concentration greater than 50 parts per million (regulated by the EPA under the Toxic Substances Control Act). The reactor compartment packages may also contain asbestos in the form of component insulation and parts. The asbestos would be fully contained within the welded reactor compartment which meets local (Benton-Franklin countries Air Pollution Control Authority), State, and Federal disposal requirements.

A portion of the 218-E-12B burial ground to the north of Trench 94 is available for use by the Navy. This area is classified as "disturbed/facilities" on vegetation/land use maps for the Hanford Site provided by the 1994 Hanford Site NEPA Characterization (PNL, 1994b). The area is not in a native condition, having been covered with excavation spoils from Trench 94 for a number of years. Grasses have recently established themselves on limited areas of the spoils. Surrounding areas to the south and west are also disturbed with backfilled trenches and spoil piles. Pockets of shrub-steppe are present to the south but not adjacent to the burial ground. Less disturbed shrub-steppe lands border the burial ground to the north and east. The shrub-steppe lands are typically vegetated with a sagebrush/cheatgrass cover. A further detailed discussion of 200 East area ecology can be found in PNL, 1994b.

3.1.3.4 Endangered Species

The U.S. Fish and Wildlife Service lists the American peregrine falcon (Falco peregrinus) as endangered; and the bald eagle (Haliaeetus leucocephalus) as a threatened animal species on the Hanford Site (PNL, 1994c). The American peregrine falcon is not known to nest on the Hanford Site and its presence is as casual migrant. The bald eagle also has not been known to nest on the Hanford Site; however, it is a regular winter resident mainly foraging for dead salmon and preying upon waterfowl along the Columbia River, with occasional foraging flights onto the Hanford Site and in the last few years there have been several nesting attempts. The Washington State Wildlife Department also lists animal species in three categories: sensitive, threatened, and endangered. Listed species that are known to occur or thought to have a potential to occur on the Hanford Site are discussed in depth in Volume 1, Appendix A of the Department of Energy Programmatic Spent Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (DOE, 1995).

None of the plants occurring at Hanford are included on the federal list of endangered and threatened species, but there are four plant species which are candidates for consideration for future listing; Columbia milk-vetch (Astragalus columbianus), Hoover's desert parsley (Lomatium tuberosum) Columbia yellowcress (Rorippa columbiae) and Northern wormwood (Artemisisa campestris ssp. borealis var. wormskioldii), (WA, 1994). However, none of these species are indigenous to the 200 East area. The total number of insect species known to exist on the Hanford Site probably exceeds 600 with grasshoppers and darkling beetles among the most conspicuous groups (PNL, 1994b).

Washington State has listed several plant species as "sensitive" which probably could occur on the dryland areas of the Hanford Site; Dense sedge (Carex), Gray cryptantha (Cryptantha leucophea), Shining flatsedge (Cyperus rivularis), Piper's daisy (Erigeron piperianus), Southern mudwort (Limosella acaulis), and False-pimpernel (Lindernia anagallidea), (DOE, 1995). It is unlikely that these plant species could be impacted since the 218-E-12B Low Level Burial Ground is not in a native state. Spoils from any additional excavation that might be conducted at the 218-E-12B burial ground would also likely be placed in already disturbed areas within the Low Level Burial Grounds.

3.1.3.5 Floodplains/Wetlands

Floodplain and wetland environmental review requirements are provided in Section 404 of the Clean Water Act and Executive Orders 11990 and 11988. The Department of Energy has published regulations in 10CFR1022 on compliance with these requirements. Definitions of floodplains and wetlands from 10CFR1022 and an analysis of the flood potential of the Columbia River can be found in DOE 1992b. Based on the subject discussion in DOE 1992b, the 218-E-12B burial ground does not meet the definition of wetlands or floodplains of 10CFR1022. In addition, the land transport route for the reactor compartments would not impact floodplains or wetlands. This route traverses dry, upland areas of the Hanford Site and would not impact floodplains or wetlands. This route traverses dry, upland areas of the Hanford Site and would be the same route currently used for the pre-LOS ANGELES Class reactor compartment disposal program.

3.1.3.6 Seismicity

The 218-E-12B burial ground, and the Hanford Site in general, are located on the Central Columbia Plateau, a region of low to moderate seismicity. For purposes of structural design, the Hanford Site is rated seismic Zone 2B by the Uniform Building Code. Estimates for the earthquake potential of structures and zones in the Central Columbia Plateau have been developed during licensing of nuclear power plants at the Hanford Site. The largest estimated maximum magnitude was 6.5 on the Richter Scale for a seismic event originating along the Rattlesnake-Wallula alignment, which passes along the southwest boundary of the Hanford Site. This geologic feature is over 16 kilometers (10 miles) from the 218-E-12B burial ground at the closest point. A maximum magnitude of 5.0 on the Richter Scale was estimated for a closer structure, Gable Mountain. The potential risk associated with the Gable Mountain seismic event dominated risks associated with other potential sources considered. A further discussion of this work is presented in DOE 1995.

Historical earthquake magnitudes at the Hanford Site are considerably less than estimated maximums. While seismic activity above magnitude 3.0 on the Richter Scale has occurred in the Central Columbia Plateau, activity above 3.5 on the Richter Scale is most commonly found around the northern and western portions of the plateau with a few such events occurring around the Oregon border. The largest recorded earthquake on the entire Columbia Plateau was the magnitude 5.75 on the Richter Scale Milton-Freewater earthquake of 1936 (DOE, 1987). However, this location is over 80 kilometers (50 miles) southeast of the 218-E-12B burial ground. The majority of seismic activity closer to the 218-E-12B burial ground occurs as shallow earthquake swarms not associated with known geologic structures. These swarms typically involve numerous quakes of magnitude generally less than 2.0 on the Richter Scale (DOE, 1989b). Seismic activity and related phenomena such as liquefaction, fault rupture, and subsidence are not believed to be events that could plausibly and directly cause a release of waste from DOE facilities (DOE, 1992b).

3.1.3.7 Geology/Groundwater

The 218-E-12B burial ground is underlain by the slightly alkaline gravelly sands, sands, and sandy gravels of the Hanford Formation. Thin discontinuous bands of finer silty sediment are interspersed in the formation but these do not represent a significant portion of the Hanford Formation. The Hanford Formation sediments are glaciofluvial from the Pleistocene age and, under the 218-E-12B burial ground, rest directly atop the basaltic lava of the Miocene Columbia River Basaltic flows. A complex Miocene Basalt structure exists under the burial ground which has a profound effect on its hydrology. The geology and hydrology under the 218-E-12B burial ground are described in detail in Estimation of the Release and Migration of Lead through Soils and Groundwater at the Hanford Site 218-E-12B Burial Ground (PNL, 1992). In general, groundwater occurs under the burial ground in both unconfined and confined aquifers, with the confined (deeper) aquifers bounded above by relatively impermeable basalt layers and the unconfined (uppermost) aquifer lying at the interface between the Hanford Formation and the underlying basalt. The depth to the unconfined (uppermost) aquifer under the burial ground is approximately 61 meters (200 feet). The relatively impermeable Miocene Basalts project above the water table to the east/northeast and west/northwest of the burial ground with a lower basalt divide connecting these higher areas across/under the burial ground. The divide surface slopes southward under the burial ground. Measurements of the unconfined aquifer taken under the 218-E-12B burial ground indicate thicknesses of around 1 meter (3 feet), increasing quickly in thickness to 2.5 meters (8 feet) outside the area of the burial ground (PNL, 1992).

Recharge of the unconfined aquifer under the Hanford Site occurs from natural and artificial sources. Natural recharge occurs from precipitation at higher elevations bordering the Site, run-off from intermittent streams on the western margin of the Hanford Site, and from the Yakima River on the southwestern boundary of the Site. The Columbia River recharges the unconfined aquifer near the river during high water stages (PNL, 1994c). These sources are not adjacent to the 218-E-12B burial ground. The unconfined aquifer receives little, if any, recharge directly from precipitation that falls on vegetated areas of the Hanford site because of a high rate of evapotranspiration from native soil and vegetation. Surface precipitation may contribute recharge where soils are coarse textured and bare of vegetation (PNL, 1994c). Recharge rates of 0.5 cm/yr and 5 cm/yr have been used at the Hanford Site to model recharge to the unconfined aquifer from the current arid climate and potentially wetter conditions (DOE, 1987; DOE, 1992b). The effect of such low recharges and the good drainage provided by the Hanford Formation sediment is actually observed in the form of a low moisture content in the Hanford Formation at the 200 East Area (1-5% by weight for the sandy gravely sediment that predominates at the 218-E-12B burial ground) (PNL, 1992).

The B-ponds, a series of unlined, interconnected, waste water disposal ponds, are located about 3 kilometers (2 miles) southeast of the 218-E-12B burial ground. Recharge from these ponds and from other now deactivated sources of artificial recharge has raised the local water table by as much as 9 meters (30 feet) compared to the preexisting condition (PNL, 1994b). As the B-ponds are decommissioned and this source of recharge ceases, water tables are expected to drop. Groundwater modeling conducted by Pacific Northwest Laboratory for the 218-E-12B burial ground (PNL, 1992) suggests that in the absence of artificial recharge from the B-pond, under current climate conditions, the unconfined aquifer will recede southward and not be present under the burial ground and perhaps a majority of the 200 East Area.

Hanford formation sediments underlying the 218-E-12B burial ground exhibited a strong tendency to adsorb (immobilize) lead and a lesser although still significant, adsorption of nickel from groundwater in site specific testing (PNL, 1992, PNL, 1994a). Solubilities of these constituents in the groundwater itself were also found to be fairly low at about 0.3 ppm for lead and 2 ppm for nickel. In addition, the sediments at Trench 94 possess low chloride levels and high resistivity (over 30,000 ohm-cm)(NFESC, 1993). These conditions provide a corrosion resistant environment, that inhibits the transport of metals from the 218-E-12B burial ground.

3.1.3.8 Environmental Monitoring

Monitoring of the atmosphere, ground water, Columbia River water, foodstuffs, plants, animals, and soil is conducted routinely at locations on and off the Hanford Site by the Pacific Northwest Laboratory. A detailed discussion of monitoring methods, locations, and collected data is provided in the Hanford Environmental Report which is published yearly. Results from 1993 monitoring, with emphasis on the 218-E-12B burial ground and surrounding 200 East Area, are discussed below (PNL, 1994c).

Air monitoring showed consistently detectable levels of ^{90}Sr, ^{137}Cs, uranium, ^{239}Pu and ^{240}Pu in the 200 East and 200 West Areas. However, measured levels of these detected radionuclides are low, resulting in a combined radiological dose of less than 0.05 mrem/yr for these radionuclides. Average concentrations of ^{129}I in the air were elevated at the Hanford Site boundary relative to distant locations indicating the potential for migration off-site. However, measured concentrations in the air on-site result in low radiological doses (less than 0.001 mrem/yr for ^{129}I). Potential sources of ^{129}I exist at the 200 East Area associated with the Plutonium and Uranium Extraction (PUREX) facility, about 1-2 miles south of the 218-E-12B burial ground.

Columbia River monitoring showed that concentrations of ^{3}H, ^{129}I, and Uranium were higher at locations downstream of the Hanford Site than upstream. The observed increase statistically indicated a contribution from the Hanford Site. However, the measured concentrations of these radionuclides in the river remained well below Environmental Protection Agency and State of Washington drinking water standards.

Federal drinking water standards for beta particle and photon radioactivity from man-made radionuclides are based on a maximum 4 mrem per year dose. These standards, provided in the Code of Federal Regulations Title 40 "Environment" part 141 (40CFR141), are applied to public and DOE drinking water systems. This limit is not applied to the Hanford Site in general. DOE order 5400.5 "Radiation Protection of the Public and the Environment" limits the effective public dose from routine DOE activities to 100 mrem per year from all pathways combined. Where the Hanford Site Environmental Report for Calender Year 1993 (PNL, 1994c) references federal standards, these are included in the summary of groundwater monitoring results from PNL 1994c which is provided below.

Groundwater monitoring showed that ^{3}H is widespread through the 200 East Area at concentrations greater than the 20,000 pCi/L federal drinking water standards. Localized areas of ^{90}Sr exist at concentrations greater than the 8 pCi/L federal standard. ^{99}Tc, ^{129}I, and ^{137}Cs are also present at levels exceeding federal drinking water standards (i.e., 900 pCi/L, 1 pCi/L, and 200 pCi/L, respectively). A large groundwater plume of ^{3}H originated from the PUREX Facility, located about 1-2 miles south of the 218-E-12B burial ground. This plume has reached the Columbia River to the east/south east, the historical direction of groundwater flow in this area. An ^{129}I plume originated from the PUREX area with concentrations over the 1 pCi/L federal drinking water standard extending for many miles beyond the 200 East Area to the south east. Measured ^{60}Co levels in Hanford Site groundwater were at or below the detection limit of 20 pCi/L. One well in the 200 East Area had measured levels of ^{60}Co from 37 to 66 pCi/L, still below the federal drinking water standard of 100 pCi/L. ^{137}Cs and ^{60}Co are strongly absorbed in soil and thus normally immobile in Hanford soil (i.e., migration through soil via groundwater is slow). However, cyanide bearing compounds were present in the waste streams at Hanford that contained ^{60}Co. The cyanide compounds can form complexes with the ^{60}Co reducing soil adsorption.

Groundwater monitoring in 1993 identified eight hazardous chemicals at levels above applicable federal drinking water standards at Hanford: nitrate, cyanide, fluoride, chromium, carbon tetrachloride, chloroform, trichloroethylene, and tetrachloroethylene. The chlorinated organic compounds form distinct plumes under the 200 West Area as they are associated with production facilities in that area, but are not found under the 200 East Area. Nitrate plumes are present under the 200 East Area, coincident with ^{3}H plumes as a common source existed for both at the PUREX facility. Chromium is found in the 200 East Area at concentrations greater than federal drinking water standards (100 μg/L with a more restrictive Washington State limit at 50 μg/L). However, filtered samples tend to be below the federal drinking water standards. This suggests that the chromium is not truly solubilized in the water but is rather present as a fine suspended particulate that is removed by the filtration. Contamination from metal particulate generated by well construction and installation has been suggested as a possible source of the chromium found (PNL, 1994c). Polychlorinated biphenyls have not been detected in groundwater samples.

The submarine reactor compartments at the 218-E-12B burial ground are not a current or historic source for any of the radionuclides or hazardous chemicals identified by Hanford Site monitoring.

The general direction of groundwater movement in the unconfined aquifer under the Hanford Site can be inferred from the spread of ^{3}H and nitrate contamination since these constituents are mobile in groundwater. ^{3}H and nitrate plume maps for the Hanford Site show movement in directions skirting around and away from the 218-E-12B burial ground (extreme northeast corner of the 200 East Area)(PNL, 1994c, DOE 1989b). This effect is likely due to the subsurface basalt, structure which forms a divide under the burial ground, effectively shunting groundwater flow around this region.

Radiation doses to the general public from Hanford operations during 1993 are calculated and discussed in the Hanford Site Environmental Report for Calender Year 1993 (PNL, 1994c). The Maximally Exposed Individual (MEI or MI) is a hypothetical person who lives at a particular location and has a postulated lifestyle such that it is unlikely that other members of the public would receive higher doses. The location selected for the MI can vary from year to year depending on the relative importance of the several sources of radioactive effluents released to the air and to the Columbia River from Hanford facilities. Releases of ^{220}Rn and ^{222}Rn from the 300 Area in 1993 resulted in the MI for 1993 being located 1.5 km directly across the Columbia River from the 300 Area, different than past MI locations (Ringold and Riverview areas on the east side of the Columbia River). The calculated effective dose potentially received by the 1993 MI was 0.03 mrem/yr, up from 0.02 mrem/yr from 1992. The following exposure pathways were included in the calculation of this MI dose: inhalation of and submersion in air downwind of the Site, consumption of foods contaminated by radionuclides deposited on the ground from airborne materials and by irrigation with water from the Columbia River, direct exposure to radionuclides deposited on the ground, consumption of drinking water derived from the Columbia River, consumption of fish taken from the Columbia River, and external radiation during recreation activities on the Columbia River and its shoreline. Doses to the MI were calculated with the GENII computer code. The collective effective dose to the population living within 80 kilometers (50 miles) of the site was also estimated at 0.4 person-rem, compared with 0.8 person-rem estimated for 1992. The 0.03 mrem/year MI dose and the 0.4 person-rem collective dose for 1993 can be compared with the 300 mrem and 110,000 person-rem received annually by an average individual and by the surrounding population respectively, as the result of naturally occurring radiation (PNL, 1994c). The submarine reactor compartments in Trench 94 do not contribute to these doses.

3.2 No Action Alternative

3.2.1 Puget Sound Naval Shipyard

Puget Sound Naval Shipyard is the largest activity of the Bremerton Naval Complex, which also includes the Fleet and Industrial Supply Center, Puget Sound and Naval Sea Systems Command Detachment, and Planning Engineering for Repair/Alteration of Aircraft Carriers. Tenant activities include Naval Inactive Ship Maintenance Facility (NISMF), Naval Reserve Center, and the Defense Printing Service. Refer to Section 3.1.1 for more detailed information on Puget Sound Naval Shipyard. Figure 3.1 provides a shipyard vicinity map.

Puget Sound Naval Shipyard is the designated location on the West coast for storage of inactivated nuclear-powered ships. The Shipyard's inactive nuclear ship moorage facility will accommodate about 35 pre-LOS ANGELES Class Submarines. This facility could be used to berth approximately 32 LOS ANGELES Class submarines with space for three larger ships, either cruisers or OHIO Class submarines or a combination of both. Other combinations of cruiser, LOS ANGELES Class submarines and OHIO Class submarines are possible however it should be noted that, due to space requirements, approximately two LOS ANGELES Class submarines can be moored in the space required for one cruiser or OHIO Class submarine.

3.2.2 Norfolk Naval Shipyard

Norfolk Naval Shipyard is located in the Tidewater region in the South East corner of Virginia on the Southern Branch of the Elizabeth River. The shipyard is contiguous with the city of Portsmouth and occupies approximately 480 hectares (1200 acres). The shipyard is centrally located in a highly developed urban industrialized area. Six cities are within 24 kilometers (15 miles) of the shipyard: Portsmouth, Chesapeake, Norfolk, Virginia Beach, Hampton and Newport News, and Suffolk.

The Shipyard is centrally located in relation to the six-city population centers that comprise the Tidewater region. At the time of the 1990 census, approximately 1.5 million persons resided within a 80 kilometers (50 mile) radius of the shipyard. The six-city metropolitan area houses most of this population. The shipyard was founded in 1767 under the British flag and is currently a highly developed ships servicing and repair center and was authorized to perform naval nuclear propulsion work in 1963.

The shipyard is divided internally into a controlled industrial area and non-industrial area. All of the piers, drydocks, and work facilities accomplishing naval nuclear propulsion plant work are within the controlled industrial area. The shipyard includes over 500 administrative, industrial, and support structures and four miles of shoreline. Norfolk Naval Shipyard is the designated storage area on the East coast for inactive nuclear-powered ships. The current area at Norfolk Naval Shipyard designated for storage of decommissioned nuclear-powered ships would be capable of berthing eight to twelve ships made up of a combination of cruisers, and LOS ANGELES Class submarines.

The seismic risk related to structural damage for Norfolk Naval Shipyard is defined as Zone 1 by the Uniform Building Code (UBC, 1991). No major faults underlie the Tidewater region and the region is considered aseismic (SCIENCE, 1969).

Summer winds are predominantly from the south and southwest at Norfolk Naval Shipyard, pulling large amounts of moisture up from the Gulf of Mexico. During the summer months, afternoon thunderstorms due to daytime heating of the near surface air are very common. Large areas of high pressure frequently stall just east of the southern coast. These "Bermuda Highs" can lead to extended periods of hot, humid weather with very little precipitation other than scattered thunderstorms. Thunderstorms occasionally spawn isolated tornadic activity throughout the region. Although locally destructive, the tornados move through the area rapidly along with storm centers.

Tropical cyclones of hurricane force are a probability in the Norfolk area. Tropical cyclones that pass within 180 nautical miles of the Norfolk area are considered a threat. Statistically, 1.6 tropical cyclones a year pose a threat to the Norfolk area. Because of the high latitude (37° N), most of these storms recurve from a westerly track to a more northerly track accelerating their forward movement as they do. This tends to move the cyclones away from the Norfolk area. Cyclones that stay on a westerly or northwesterly track tend to weaken as they move overland. Norfolk Naval Shipyard, located on the Southern fork of the Elizabeth River, is situated so that it is not susceptible to any significant wind generated waves from any direction. There are no long fetches of water that would result in significant wind generated waves. Norfolk Naval Shipyard is a recommended safe moorage location for small craft during gale force winds. The greatest threat at Norfolk Naval Shipyard from tropical cyclones is storm surge which can add several feet to the height of the usual tide. Action must be taken for ships moored in the area so storm surge possibilities will not break the mooring lines.

In accordance with the Clean Air Act and the required State Implementation Plan for achieving nationwide air quality goals, air pollution control in the State of Virginia is a coordinated effort directed by the Department of Environmental Quality via regional authorities within the state. The State is divided into intrastate Air Quality Control Regions (AQCRs). Each AQCR has the responsibility for developing its point and area source emissions inventory and for analyzing and reporting on air quality monitoring data within its jurisdiction. The Hampton Roads Intrastate Air Quality Control Region (Region 6) has the delegated authority for enforcement of the Clean Air Act in the area encompassing the Shipyard. The Code of Federal Regulations, Title 40, part 81 designates this area as being in attainment of national standards for suspended particulate matter and sulfur dioxide, however, a moderate nonattainment designation is given for ozone. Air quality with respect to carbonmonoxide and nitrogen dioxide has not been classified but is considered to be in attainment. Norfolk Naval Shipyard is not located in an area where degradation of air quality is severely restricted under the prevention of significant deterioration (PSD) regulations of Title 40, part 52.

The U.S. Fish and Wildlife Service lists the following species as endangered (E) or threatened (T) in the South Hampton Roads area from Suffolk eastward: Loggerhead turtle (T); Bald eagle (E); Peregrine falcon (E); Piping plover (T); Red-cockaded woodpecker (E); Eastern cougar (E); Dismal Swamp Southeastern shrew (T); and Northeastern beach tiger beetle (T). The exact location of specific habitats could not be located; however, surveys of the area have not identified any habitat on shipyard property. Additionally, there are no marine mammals that are routinely found within the lower Chesapeake Bay or its tributaries including the shipyard property. Past sounding records in the Norfolk Naval Shipyard area have indicated sedimentation at the rate of three inches per year. Ships in inactive status must be dry-docked about every 15 years for hull preservation. Therefore, dredge depths would be established below the minimum required for the ships in storage to allow maintenance dredging to be done when the ships are removed from storage for hull preservation work.

3.3 Disposal and Reuse of Subdivided Portions of the Reactor Plant

3.3.1 Operations Sites

The sites affected by this alternative are Puget Sound Naval Shipyard and Norfolk Naval Shipyard. Existing environments of those sites are discussed in the subsections for the following alternatives: the preferred alternative and the no-action alternative.

3.3.2 Disposal Sites

For purposes of evaluation, the primary disposal sites for waste from the subdivision alternative are considered to be the Department of Energy's Hanford Site in the State of Washington and the Department of Energy's Savannah River Site in the State of South Carolina. However, at the actual time for disposition of wastes generated from the subdivision alternative, disposition at other authorized sites would not be precluded. Some classified components may be able to undergo a declassification process prior to disposal at sites not controlled by D.O.E. Other classified components cannot be declassified or would require cost and personnel exposure to declassify.

3.3.2.1 Hanford Site

The existing environment of the Hanford Site is discussed in the preferred alternative subsection of this section.

3.3.2.2 Savannah River Site.

The following site information has been summarized from the Final F-Canyon Environmental Impact Statement for the Department of Energy Savannah River Site (DOE, 1994b).

The Savannah River Site (SRS) is on the Aiken Plateau of the Upper Atlantic Coastal Plain about 40 kilometers (25 miles) southeast of the Fall Line that separates the Atlantic Coastal Plain from the Piedmont, Figure 3.5.

A recent study of available geophysical evidence identified six faults under the SRS. Two major earthquakes have occurred within 300 kilometers (186 miles) of the SRS. The first was the Charleston, South Carolina, earthquake of 1886, which had an estimated Richter scale magnitude of 6.8 and occurred approximately 145 kilometers (90 miles) from the site. The second major earthquake was the Union County, South Carolina, earthquake of 1913, which had an estimated Richter scale magnitude of 6.0 and occurred about 160 kilometers (99 miles) from the Site. Several earthquakes have occurred inside the SRS boundary in recent years. One occurred on June 8, 1985, another occurred on August 5, 1988 and yet another occurred on August 8, 1993. They had local Richter scale magnitudes of 2.6, 2.0, and 3.2, respectively.

Five principal tributaries of the Savannah River drain almost all of the SRS. The Savannah River, which forms the boundary between the States of Georgia and South Carolina, supplies potable water to several municipalities (Savannah, Georgia; Beaufort County, South Carolina and Jasper County, South Carolina).

Groundwater is a domestic, municipal, and industrial water source throughout the Upper Coastal Plain. The groundwater beneath the SRS flows slowly toward the SRS streams and swamps and into the Savannah River at rates ranging from inches per year to several hundred feet per year.

Based on SRS data collected from onsite meteorological towers for the 5-year period from 1987 to 1991, maximum wind direction frequencies are from the northeast and west-southwest and the average wind speed is 3.8 meters per second (8.5 miles per hour). The average annual temperature at the SRS is 18°C (64°F). The atmosphere in the SRS region is unstable approximately 56 percent of the time, neutral 23 percent of the time, and stable about 21 percent of the time. The SRS experiences an average of 55 thunderstorm days per year with 50 percent of them occurring in June, July and August. From 1954 to 1983, 37 reported tornadoes occurred in a 1-degree square of latitude and longitude that includes the SRS. This frequency of occurrence is equivalent to an average of about one tornado per year. Since operations began at the SRS in 1953, nine tornadoes have been confirmed on or near the site. From 1700 to 1992, 36 hurricanes occurred in South Carolina, resulting in an average frequency of about one hurricane every 8 years. Because the SRS is about 160 kilometers (100 miles) inland the winds associated with hurricanes have usually diminished below hurricane force [i.e., equal to or greater than a sustained wind speed of 33.5 meters per second (75 miles per hour)] before reaching the SRS.

At present, SRS does not perform onsite ambient air quality monitoring. State agencies operate ambient air quality monitoring sites in Barnwell and Aiken Counties in South Carolina, and in Richmond County in Georgia. The counties, which are near SRS, are in compliance with National Ambient Air Quality Standards for particulate matter, lead, ozone, sulfur dioxide, nitrogen oxides, and carbon monoxide. The South Carolina Department of Health and Environmental Control has the delegated authority for enforcement of the Clean Air Act in the area encompassing the Savannah River Site. The Code of Federal Regulations, Title 40, part 81 designates this area as being in attainment of national standards for suspended particulate matter and sulfur dioxide. Air quality with respect to ozone, carbon–monoxide and nitrogen dioxide has not been classified but is considered to be in attainment. The Savannah River Site is not located in an area where degradation of air quality is severely restricted under the prevention of significant deterioration (PSD) regulations of Title 40, part 52.

3.4 Indefinite Storage Above Ground at Hanford

The affected environment for this alternative is the same as that for the preferred alternative, which is discussed previously.

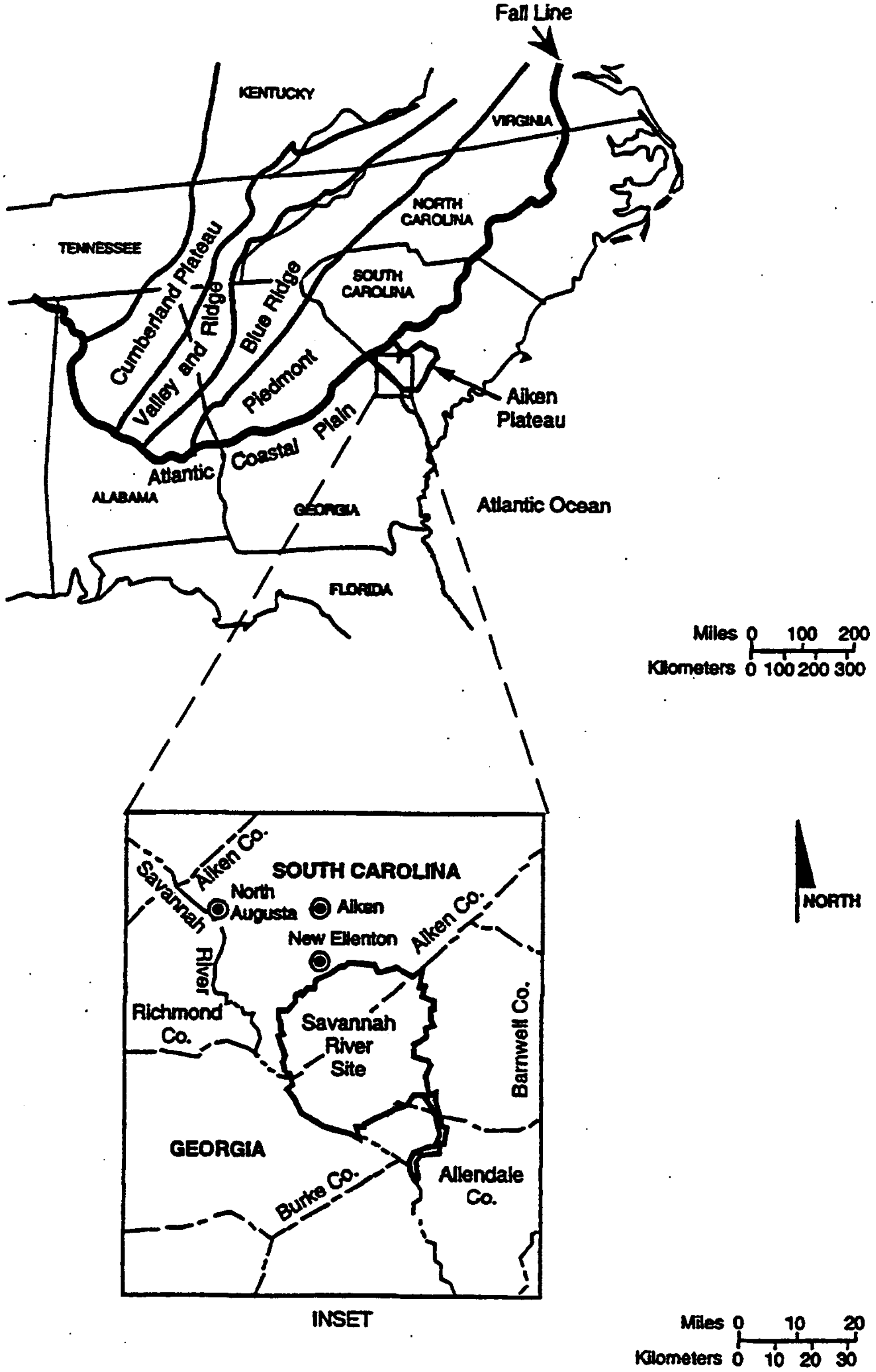


Figure 3.5. General Location of the Savannah River Site

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4. ENVIRONMENTAL CONSEQUENCES

4.1 General

The following sections discuss the potential environmental consequences associated with the alternatives of land disposal of the reactor compartment at the Department of Energy Low Level Burial Grounds at Hanford, WA; the no action alternative; the disposal and reuse of subdivided portions of the reactor compartment alternative; and the indefinite storage above ground at Hanford alternative. Potential environmental consequences from disposal of reactor compartments from cruisers and OHIO Class and LOS ANGELES Class submarines relate to radionuclides and to toxic and hazardous materials such as asbestos, polychlorinated biphenyls (PCBs), lead and chromates found in compartments. The measures that would be employed by the Navy to protect its own workers from potential hazards during disposal work would be protective of off site personnel and the environment as well.

The decay of radioactive atoms produces radiation, which can cause damage to tissue if there is insufficient distance or shielding between the source and the tissue. The effects on people of radiation that is emitted during decay of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. Within kinds of radiation, the energy of the radiation varies depending on the source isotope. The more energetic radiation of a given kind, the more energy that will be absorbed, in general. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem or mrem (0.001 or 10^{-3} rem).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic process decrease the dose rate with the passage of time.

Doses are often classified into two categories: acute, which is a large dose received over a few hours or less; and chronic, which involves repeated small doses over a long time (months or years). Chronic doses are usually less harmful than acute doses because the time between exposures at low dose rates allows the body to repair damaged cells. Only chronic effects are considered here as the exposures discussed are much less than the threshold for acute effects. The most significant chronic effect from environmental and occupational radiation exposures is induction of latent cancer fatalities. This effect is referred to as latent because the cancer may take many years to develop.

Hypothetical health effects can be expressed in terms of estimated latent cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection which specifies 0.0005 latent cancer fatalities per person-rem of exposure to the public and 0.0004 latent cancer fatalities per person-rem for workers (ICRP, 1991).

To place exposure into perspective with normal everyday activities of the general public, a typical person in the United States receives 300 mrem of radiation exposure each year from natural background radiation, (NCRP, 1987). Natural background radiation is radiation that all people receive every day from the sun or from cosmic radiation, and from the natural radioactive materials that are present in our surroundings, including the rocks or soil we walk on.

The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce, to as low as reasonably achievable, the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows a 5 rem dose for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational dose received by each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation dose associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The control of radiation exposure to Shipyard workers is further discussed in the annual report NT-94-2 "Occupational Radiation Exposure from U.S. Naval Nuclear Plants and their Support Facilities" issued by the Department of the Navy. In 1991, researchers from the Johns Hopkins University in Baltimore, MD completed a comprehensive epidemiological study of the health of workers at eight shipyards that service nuclear-powered ships, including Puget Sound Naval Shipyard and Norfolk Naval Shipyard. This study of 70,730 Shipyard workers covering a period of 24 years, did not show any cancer links with radiation exposure at these Shipyards, (MATANOSKI, 1991). Additionally, a National Academy of Science report states that there is a possibility that there may be no risks from exposure comparable to external natural background radiation (BEIR, 1990).

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

Public exposure resulting from activities within Naval Shipyards would be negligible. As discussed in the annual report NT–95–1 "Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear Powered Ships and their Support Facilities" issued by the Department of the Navy, procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear–powered ships and their support facilities have been effective in protecting the environment and health and safety of the general public. Independent radiological environmental monitoring performed by the U.S. Environmental Protection Agency and states have confirmed the adequacy of these procedures. These procedures have ensured that no member of the public has received measurable radiation exposure as a result of current operations of the Naval Nuclear Propulsion Program (NNPP, 1995a).

Regarding non radiological health hazards, the Navy complies with the Navy Occupational Safety and Health requirements, which have been approved by the Occupational Safety and Health Administration. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the industrial nature of work at Naval Shipyards, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to chemical hazards and where appropriate are placed into medical surveillance programs for these chemical hazards.

The process for identification and protection of historic sites provided in the National Historic Preservation Act (36CFR800) applies to all alternatives. The extent of effort required to complete the process will vary depending on the alternative selected. For the Hanford Site, previously performed archaeological surveys have not identified archaeological or historic sites located in the 200 East area (DOE 1992b, PNL, 1994b). One such survey included an area north of Trench 94 that forms a portion of the area available for placement of additional reactor compartments (PNL, 1990). This condition reduces the possibility that historic sites could be impacted by the Hanford alteratives. However, prior to implementation of any of the alternatives involving Department of Energy Sites, cultural resource, biological, and ecological surveys will be performed as applicable.

In accordance with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," most of the actions contemplated by this final EIS would result in no significant environmental, human health, or economic effects on surrounding populations, including any minority or low-income populations that may exist in the areas. However, the subdivide and reuse alternative may result in significant human health effects to workers, who are neither disproportionately minority or low income.

4.2 Potential Effects of Primary Hazardous Materials found in Reactor Compartments

4.2.1 Asbestos (USN, 1993a)

Asbestos is a general term that applies to a variety of naturally occurring mineral silicates, e.g., chrysotile, amosite, crocidolite, tremolite, anthophylite, and actinolite. Asbestos is generally a fibrous material whose primary chemical and physical properties are resistance to combustion, good thermal and electrical resistance, tensile strength, and fair chemical resistance.

Asbestos is a health hazard when there is the potential for personnel exposure to its airborne fibers. The primary potential asbestos exposure hazard resulting from disposal of reactor compartments would be occupational exposure to the workers removing or handling asbestos, or disturbing asbestos in the course of other work. Other potential hazards would exist for the general population in the Shipyard of disposal site vicinity in the event of asbestos release.

The link between exposure to asbestos and certain illnesses has been well established by epidemiological and other studies. Studies have been conducted on persons occupationally exposed, families of these persons, and persons residing in areas where asbestos is mined. Increased rates of lung cancer, pleural and peritoneal mesothelioma, and gastrointestinal cancer have been directly tied to exposure. Mesothelioma is a rare cancer of the thin membrane lining the chest and abdomen. Also, asbestosis is a disabling fibrotic lung disease whose only known cause is exposure to asbestos. The above maladies generally occur long after initial exposure, generally in about 20 years. There are no known acute health problems caused by asbestos exposure.

Asbestos is regulated in the work place, in removal operations, and in the air, land, and water environments. There shall be no discharge of visible emission to the outside air during the collection, processing, packaging, or transportation of any asbestos containing material (40CFR61.150(a)).

4.2.2 Polychlorinated Biphenyls (USN, 1993a)

Polychlorinated Biphenyls (PCBs) were developed in the 1880s, but were not widely used until the 1930s. They were first regulated as toxic substances in 1976, Their primary physical and chemical characteristics are thermal stability, resistance to oxidation, resistance to bases and acids, and excellent dielectric qualities. They are soluble in organic solvents but their solubility in water is extremely low. PCBs persist and bioaccumulate in the environment. In 1980, the EPA determined an average biaoaccumulation factor of 31,200 times the ambient water concentration in freshwater fish and shellfish.

The effects of PCBs can be summarized with the following points:

They are readily absorbed through the gastrointestinal and respiratory systems, and skin.

They may initially concentrate in the liver, blood, and muscle mass in mammals.

The major metabolic products of PCBs are phenolic derivatives or dihydrodiols, which may be formed through pathways with arene oxide intermediates or by direct hydroxylation. The susceptibility of individual PCB congeners to metabolism is a function of the number of chlorines present on the biphenyl and their arrangement. Biphenyls that have one or more pairs of adjacent unsubstituted carbons are more rapidly metabolized than those that do not.

PCBs that are readily metabolized are also rapidly excreted in the urine and bile. Excretion in urine is most prominent for the least chlorinated, while bile becomes the more significant route of excretion for more highly chlorinated congeners.

Those congeners most refractory (resistant) to metabolism accumulate for increasing periods of time in fatty tissues. Highly chlorinated congeners are accumulated almost indefinitely.

PCBs can be transferred either transplacentally or in breast milk.

Non human primates may retain PCBs more efficiently than rodents.

A single PCB isomer, 4-chlorobiphenyl, has been found to be highly mutagenic. Mutagenicity decreased with increasing chlorination.

High levels of PCBs are carcinogenic in rodents. Several animal studies have resulted in reports that PCBs produce a carcinogenic response, and that they enhance carcinogenic activities of other substances. The National Institute for Occupational Safety and Health (NIOSH) and EPA consider PCBs to be animal carcinogens and suspected human carcinogens. PCBs were classified as carcinogenic by the International Agency for Research on Cancer.

PCBs are regulated both for use and disposal (40CFR761). Generally, there are no Federal restrictions when PCB concentration is less than 50 parts per million (40CFR761.60(a)).

Potential PCB exposure risk would occur during removal of felt sound damping material, when present. PCBs will be encountered less frequently, if at all, on the later classes of ships due to the ban on production of PCB manufacturing effectively established by Congress in 1976.

4.2.3 Lead (USN, 1993a)

Lead is metal whose primary chemical and physical properties are high density, high malleability, and high corrosion resistance. Health effects from lead fall into three categories: (a) alimentary, (b) neuromuscular, (c) encephalic. The alimentary effect is the most common, and is characterized by abdominal discomfort and pain, joint and muscle pain, vomiting, irritability, and various gastrointestinal symptoms. In the neuromuscular type, less severe gastrointestinal symptoms usually are present, accompanied by increased joint and muscle pain and muscular weakness. Encephalic effect is the most severe, and usually occurs following rapid, heavy lead ingestion. Symptoms range from headache and dizziness to coma and death.

Potential lead exposure risk occurs during reactor compartment disposal work if fine lead particles become dislodged from solid pieces and become airborne, or if vapors are emitted during cut-out and removal, thus leading to the potential for subsequent inhalation or ingestion.

Lead is regulated in the work place and in the water environment.

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

4.3.1 Shipyard

4.3.1.1 Facilities

Puget Sound Naval Shipyard routinely conducts ship overhaul and repair work including docking, defueling and decommissioning of nuclear-powered naval vessels in the Controlled Industrial Area. Although the ships and their reactor compartments would be larger for cruiser, LOS ANGELES and OHIO Class submarines, the operations for the pre-LOS ANGELES submarine inactivation, defueling, and decommissioning program would apply. No new facilities would be required to support the reactor compartment disposal packaging work.

4.3.1.2 Preparations for Shipment

The reactor compartment disposal packaging work would involve draining fluid systems, cutting and sealing piping, removal of components, and installation of packaging materials and handling fixtures. Some of this work would involve occupational radiation exposure to Shipyard employees working in the gamma radiation fields of the reactor compartment.

The total radiation dose for the preferred alternative of preparing a cruiser reactor compartment for shipment to a land disposal site is expected to be about 25 rem (approximately 0.01 additional latent cancer fatalities). Similarly, the dose incurred in preparing LOS ANGELES and OHIO reactor compartments is expected to be 13 rem and 14 rem respectively (approximately 0.005 and 0.006 additional latent cancer fatalities respectively) total per reactor compartment. This dose would be to workers who are trained for work in radiation areas.

The average occupational dose for each radiological worker in the Shipyard work force is less than one-fifth of a rem (200 mrem) per year. For comparison, the radiation dose a typical person in the United States receives each year from natural background radiation is three-tenths of a rem (300 mrem). The work to prepare the cruiser, LOS ANGELES and OHIO Class submarine reactor compartments for any of the alternatives would be similar to and supplement work routinely being performed at Puget Sound Naval Shipyard and Norfolk Naval Shipyard to overhaul, maintain, or inactivate ships and submarines, and to prepare pre-LOS ANGELES Class submarine reactor compartments for disposal. It would not cause a significant increase to the average radiation exposure of persons in the Shipyard work force. Individual worker exposure is strictly controlled to not exceed the federally established dose limits (5 rem per year to the total body).

Processes used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public. Independent radiological environment monitoring performed by the Environmental Protection Agency and states have confirmed the adequacy of these processes. These processes have ensured that no member of the general public has received measurable radiation exposure as a result of current operations of the Naval Nuclear Propulsion Program (NNPP, 1995a).

Some cruiser and LOS ANGELES and OHIO Class submarine reactor compartment preparation work would involve working with hazardous materials. For example, PCB impregnated sound damping material would be removed when present. PCBs will be encountered less frequently, if at all, on the later classes of ships due to the ban on production of PCB manufacturing effectively established by Congress in 1976. All work involving hazardous materials would be carried out by trained people using appropriate personal protective equipment, in accordance with occupational safety and health regulatory requirements. Wastes generated in the Shipyard would be recycled or disposed of in accordance with applicable state and federal regulations using licensed transportation contractors and disposal sites.

Shipyard work practices and processes performed in connection with the preferred alternative would be in accordance with applicable Shipyard directives to minimize the discharge of air pollutants from the industrial procedures. These activities would be performed such that the emission standards established by the Puget Sound Air Pollution Control Agency would not be violated.

Mixed waste would require treatment in accordance with appropriate treatment standards before disposal or else would require placement in retrievable storage until a mixed waste disposal site became available. Similarly, radioactive PCB waste would require storage until sufficient treatment or disposal capacity became available. Typically, the waste generated would either be a solid (e.g., a piece of lead), a solid with a hazardous material tightly bound within its matrix as part of the formulation (e.g., PCB in paint chips, rubber gaskets, or insulation), sound damping felt, or solidified liquid (e.g., processed potassium chromate solution). Management of these wastes would not result in unauthorized exposures to workers or unpermitted releases to the environment.

4.3.2 Transport

The preferred alterative would involve transport of approximately 100 reactor compartments from Puget Sound Naval Shipyard to the Hanford Site for disposal. The water and land transportation of the cruiser, LOS ANGELES Class, and OHIO Class submarine reactor compartments would use the same proven processes that are being safely and successfully used to transport the pre-LOS ANGELES Class submarine reactor compartments. These processes are designed to minimize the potential for transportation accidents, to mitigate the consequences of potential accidents, and to facilitate recovery if necessary. The estimated impacts from transport of the reactor compartments are evaluated in Appendix E.

4.3.2.1 Radiation Exposure from Normal Condition of Transport

For normal conditions of transport (incident free), transport of 100 reactor compartment packages is estimated to result in exposure to the general population of 5.8 person-rem (0.0029 latent cancer fatalities), and the maximum exposed individual in the general population is estimated to receive 0.12 person-rem (0.000061 latent cancer fatalities). Exposure to the transportation crew for 100 shipments is estimated to be 5.79 person-rem (0.00232 latent cancer fatalities) and the maximum exposed transportation worker is estimated to receive 0.636 person-rem (0.000254 latent cancer fatalities). Non-radiological fatalities are estimated to be 0.000418.

4.3.2.2 Accident Scenarios

For hypothetical accident conditions depicted in Figure 2.13, exposure to the general population is estimated to be 0.186 person-rem (0.0000929 latent cancer fatalities) when both the probability and severity of an accident are considered. For non-radiological accidents, there are similarly estimated to be 0.000947 fatalities. Assuming an accident actually does happen, the maximum consequences are estimated to be 0.835 rem (0.000418 latent cancer fatalities) to a maximum exposed individual and a collective dose to the exposed population of 4,430 person-rem (2.22 latent cancer fatalities).

4.3.2.3 Waterborne Transport

The precautions currently in use for the pre-LOS ANGELES Class submarine reactor compartments, which would be continued for cruiser and later class submarine reactor compartment shipments, would insure that the probability of an accident is extremely small. Only experienced commercial towing contractors would be used, with the advantage of employing people experienced in the work and the route, using regularly operated and maintained equipment. Two tugs would be used, a primary tug for the tow and a backup tug traveling along with the shipment to take over in case of a problem with the primary tug. Fully crewed, American Bureau of Shipping certified, commercial ocean going tugs would be specified for the tow from the Shipyard to the Portland - Vancouver area on the Columbia River. These would be twin engine and twin propulsion unit vessels, with more power than would be normally employed for an equivalent sized cargo barge of a similar capacity. Two pusher type river tugs with full crews and more than adequate power, one primary and one backup, would be specified by the contract for the Columbia River above the Portland - Vancouver area. This would maximize maneuverability and control of the barge.

All towing operations, including the route to be followed, operating procedures, and casualty procedures, would be in accordance with a formal tow plan developed by a private contractor and approved by the Navy. Puget Sound's normal shipping lanes would be used to the maximum extent possible to minimize the potential for collision or inadvertent grounding. Shipments would not be scheduled when weather conditions are not favorable. Licensed ship pilots would be used in Puget Sound and on the Columbia River. Licensed Columbia River Bar pilots would be used when crossing the Columbia River Bar.

The barges that would be used are part of the disposal program for pre-LOS ANGELES Class submarine reactor compartments. These barges, when loaded with one of the heavier reactor compartment packages covered by this EIS, would have a draft of up to about 3 meters (nine feet). The Columbia River navigation channel is maintained for vessels with drafts up to 4.5 meters (14 feet). The barge length and width would be well within the capacity of the four navigation locks. Overhead clearances on the Columbia River have been evaluated and there are none that would pose an interference problem for the transit following the pre-existing plans for raising of the Benton County Public Utilities District power lines at Kennewick - Pasco. The barge would be equipped with flooding alarms. A backup towing bridle and tow line would be installed on the barge with a trailing retrieval line behind the barge on the ocean transit portion for bringing the backup towing gear aboard the tug if the primary towing gear were lost.

Each of the barges proposed for use is highly compartmented (12 or more watertight compartments) and is designed to maintain its upright stability with any two compartments flooded. The welds attaching the reactor compartment package to the barge would be strong enough to hold the weight of the reactor compartment even if capsized. The barges meet (a) the United States Coast Guard intact and damaged (one tank flooded) upright stability requirements (46CFR151 and 172); and (b) Navy stability requirements which require stability with two adjacent flooded tanks under storm wind and wave conditions. The barges are able to remain floating after sustaining sugnificant damage. A barge sinking would take an extreme collision scenario. Breach of the reactor compartment package due to collision is not considered a credible event because the reactor compartment would sit well back from the edge of the barge and the exterior of the package would be designed to withstand severe accidents.

As an added safety and security measure, a Navy or Coast Guard escort vessel would accompany each tow. Coast Guard security personnel would be stationed aboard the escort vessel. The role of security personnel would be primarily to protect people and other boats. The escort vessel could act as an independent communication base. Shipyard personnel familiar with the towing procedures and radiological processes would accompany the tow to monitor the operations and provide assistance and advice to the tug captains if needed.

A Final Environmental Impact Statement (FEIS) prepared by the National Oceanic and Atmospheric Administration (NOAA) evaluated establishment of the Olympic National Marine Sanctuary off the Northern Washington State coast (NOAA, 1993). Existing reactor compartment shipments through the marine sanctuary area were described in the NOAA EIS as well as the reason for them and the extensive precautions taken to ensure that these barge shipments are made safely. The NOAA EIS preferred alternative was not to specifically regulate vessel traffic at the time of the sanctuary designation due to the preexisting shipping practices having the desired effect of minimizing risk to the Sanctuary. Continuation of the same prudent shipping practices for future reactor compartment shipments would have no adverse impact on the Marine Sanctuary.

In the extremely unlikely event of sinking, the proposed package designs could potentially be breached due to water pressure. However, the reactor vessel, components, and piping that contain radioactivity are designed to withstand much higher pressures and battle shock, and would continue to provide a barrier to the release of radioactivity. Only a small fraction of the tightly adhering radioactivity deposited on the piping and component internals would be exposed to the environment. This amount of radioactivity would have such a low concentration when deposited in sediment or in the surrounding volume of water as to have virtually no environmental consequences.

This conclusion is confirmed by the radiological monitoring of the USS THRESHER and USS SCORPION submarines which were lost in the deep Atlantic Ocean in 1963 and 1968, respectively. These were extreme accidents causing breakup of the ship. Water, sediment, marine life and debris sampling was conducted in 1965, 1977, 1983, and 1986 at the USS THRESHER site (KAPL, 1993), and in 1968, 1979, and 1986 at the SCORPION site (KAPL, 1993a). Sediment sampling found very low concentrations of cobalt-60 which were determined to be from the reactor compartment piping systems. The amount of cobalt-60 radioactivity in these samples was small compared to the naturally occurring radioactivity in these sediments. From these samples, the total cobalt-60 activity in the sediment was estimated to be less than 0.001 curie for either site. No radioactivity above background levels due to naturally occurring radioisotopes or fallout from weapons testing was observed in any of the marine life samples analyzed. Water samples showed no detectable radioactivity, except for the naturally occurring radioactivity from isotopes such as Potassium-40 found in sea water. Thus, even the worst case reactor compartment transportation accident would have a negligible impact.

There would be no environmental consequences from a breached reactor compartment package with regard to the non-radiological constituents. This is based on the fact that nearly all the non-radiological constituents (PCBs, lead, chromium, iron, etc) are in a solid (insoluble) state. However, residual potassium chromate solution that cannot be drained and asbestos could be potentially released. In the unlikely event the potassium chromate solution is released to the environment, its concentration would be reduced by the surrounding water to negligible amounts. Asbestos, if present, could be disturbed in an accident and portions of the disturbed asbestos might mix with water entering through the breach. Any asbestos that eventually escaped would be expected to eventually settle out of the water and become incorporated into the sediment.

It would be the Navy's intention to recover a sunken package, and a number of engineered features would be provided to facilitate location and salvage. A buoy would be attached to the barge designed to float to the surface to mark its location. An emergency position indicating radio beacon (EPIRB) would float to the surface and transmit a distress signal on a frequency monitored by the National Transportation Safety Board. Heavy cables or other attachments would be installed on the exterior of the package before shipment to allow the attachment of salvage gear to raise the sunken package using commercial or Navy owned heavy lift ships if refloating the barge is not possible. The barge and package could be raised as a unit, or cut apart by divers for separate recovery, without any impact on the environment.

4.3.2.4 Port of Benton

The package would be off-loaded from the barge at a barge slip at the Port of Benton adjacent to the Hanford Site on the Columbia River. The river water level must be controlled during the off-load to assure the barge remains stable. This would be accomplished by adjustment of the McNary Dam pool level down stream of the barge slip and the flow rate from the up stream dam, Priest Rapids Dam.

The existing Port of Benton facilities would be used for off-loading. These off-loading operations would involve the use of mechanical equipment and vehicles at an existing facility intended for this kind of work. This work would not adversely affect the quality of the river or shore environment. The barge slip facility is currently used for pre-LOS ANGELES Class shipments and is periodically inspected both above and below water. Maintenance work is controlled under the provisions of required permits such as an Army Corps of Engineers permit, and permits from the Washington State Department of Ecology, the Washington State Department of Fisheries and the City of Richland Community Development Department to protect river quality.

4.3.2.5 Land Transport Route

Land transportation would involve moving the transport vehicle over existing roads. Individual transport vehicle wheel loads would be about twice those of commercial trucks, contributing to the need to perform routine maintenance of the roadway. This would involve no additional impact beyond road maintenance routinely accomplished at the site. Because of the increased dimensions of some of the larger cruiser and submarine packages, at approximately six locations on the Hanford Site, Bonnevile Power Administration electrical lines may need to be modified to provide the safe clearance prescribed by the utilities for energized transmission lines. This would involve adding sections to existing power line support towers or adding additional towers. The Navy will coordinate this work with Bonneville Power Administration. The work would be confined to the immediate vicinity of the towers along the roadway. Some minor straightening of the curve in the road at the Port of Benton is also contemplated to accommodate the larger transporter configurations that would likely be employed for heavier loads.

The transport vehicles that would be specified are designed to transport heavy loads and are very stable. The disposal package would be welded to the transporter. The overland transit would be coordinated by Hanford Site transportation personnel. Pilot cars would provide an escort and assure a clear roadway for the transporter, minimizing the potential for collision by other vehicles due to the slow (about 5 mph) movement of the transport. Train traffic would be curtailed during the land transport on the Hanford Site (the rails crossing the route are only used by the Hanford Site and the usage is on an infrequent basis at limited speeds). Even if there were a collision, the package, which would be designed and certified to withstand more severe hypothetical accidents, would retain its integrity.

4.3.3 Hanford Site

The Hanford Site is located in the southeastern corner of the State of Washington, about 50 kilometers (30 miles) east of Yakima and three miles north of Richland. The 218-E-12B Low Level Burial Ground is situated near the center of the Hanford Site. The nearest barge slip is located at the Port of Benton, which is on the north edge of Richland and just south of the 300 Area of the Hanford Site, approximately 42 kilometers (26 miles) from the 218-E-12B burial grounds.

The Low Level Burial Grounds at Hanford are currently being used for the disposal of solid radioactive wastes similar to the contents of the reactor compartments considered in this Environmental Impact Statement. The burial grounds of the 200 Areas are situated in an isolated area in the Central Plateau region about 11 kilometers (seven miles) from the Columbia River.

The Hanford Future Site Uses Working Group had broad representation from federal, tribal, state and local governments with jurisdictional interests in Hanford, and from agricultural, labor, local cities, environmental, and public interest groups. The working group was charged with the task of articulating a range of visions for future use of the Hanford Site and discussing the implications of those visions.

The Final Report of the Hanford Future Site Uses Working Group, (REPORT, 1992) discussed possible future uses for the 200 Areas at Hanford. This report listed findings and recommendations concerning cleanup limits at the Hanford Site. The Working Group acknowledged "the existing obligations at the Hanford Site to dispose of submarine reactor compartments and commercial Low Level Waste (in accordance with the Northwest Low-Level Radioactive Waste Compact) at the US Ecology site on the state-leased lands in this area. Fulfillment of these obligations is assumed when considering other future use options for the Central Plateau."

Additionally, this report stated that "Waste management, storage and disposal activities in the 200 Area and immediate vicinity should be concentrated within the 200 Area whenever feasible to minimize the amount of land devoted to or contaminated by waste management activities. When bringing wastes to the area, adverse effects should be minimized, especially to currently uncontaminated areas of the Central Plateau."

The preferred alternative of this Environmental Impact Statement does not conflict with the findings and recommendations concerning the 200 Area listed in the Final Report of the Hanford Future Site Uses Working Group (REPORT, 1992). The 200 East Area would not need to be expanded to dispose of the reactor compartments from the cruiser, LOS ANGELES and OHIO Class submarines. Further, there would not be a conflict with the proposed use of the land between 200 East and 200 West Areas for disposal of Hanford cleanup wastes.

4.3.3.1 Extreme Natural Phenomena

The 1987 Final Environment Impact Statement on Disposal of Hanford Defense High Level, Transuranic and Tank Wastes (DOE, 1987) analyzed in detail the natural phenomena considered credible to occur and to have an adverse impact on the Hanford Site. The analysis and conclusions with respect to the 218-E-12B Low Level Burial Ground in the 200 East Area are summarized in this document.

4.3.3.1.1 Flooding

The analysis of the 1987 Final Environment Impact Statement on Disposal of Hanford Defense High Level, Transuranic and Tank Wastes (DOE, 1987) considered flooding scenarios for a variety of conditions; i.e., influences from the Columbia and Yakima Rivers, 25 % and 50 % instantaneous destruction of the center section of the Grand Coulee Dam, and flash flooding of the Cold Creek drainage area.

Maximum Columbia River floods of historical record occurred in 1894 and 1948, with flows of 21,000 m^3/sec and 19,600 m^3/sec, respectively. The likelihood of floods of this magnitude recurring has been reduced by the construction of several flood control/water storage dams upstream of the Hanford Site. The probable maximum flood (the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions reasonably possible in the region) would produce a flow of 40,000 m^3/sec. This flood would not affect the 200 East and West Areas. Similarly, it was determined that waters of a 100-year flood (13,000 m^3/sec) would also have no effect on the 218-E-12B Low Level Burial Ground.

The development of irrigation reservoirs within the Yakima River Basin has considerably reduced the flood potential of the river. It was concluded that the lands susceptible to a 100-year flood on the Yakima River are limited to areas near the southern sections of the Hanford Site and these waters would not reach the 218-E-12B Low Level Burial Ground. Additionally, much of the Yakima River is physically separated from the Hanford Site by Rattlesnake Mountain. This topographic barrier prevents potential flooding of the Yakima River from reaching the Low Level Burial Grounds.

A 50 % instantaneous breach of the Grand Coulee Dam center section would create a maximum flow of 227,000 m^3/sec, for a brief duration, with flood elevations of 143 to 148 meters (469 to 486 feet) above mean sea level in the 100 Areas. Normal river elevations within the Hanford Site range from 120 meters (394 feet) near Vernita (Northwest corner) to 104 meters (341 feet) near the 300 Area (Southeast corner). However, the 218-E-12B Low Level Burial Ground, at an average elevation of 180 meters (590 feet) above mean sea level, would not be reached by the 50 % breach of Grand Coulee Dam.

Potential for flash flooding from the Cold Creek drainage area was also examined and the estimated a maximum flood depth of 2.3 meters (7.5 feet) for the southwestern part of the 200 Areas. This estimated flood depth is not sufficient to reach the 218-E-12B Low Level Burial Ground.

4.3.3.1.2 Earthquakes

Seismic activity and related phenomena are not identified to be of a magnitude that would have significant effects on 218-E-12B burial ground operations.

4.3.3.1.3 Other

An average of ten thunderstorms occur each year. The probability of a tornado striking a point at the Hanford Site was documented as $4\text{x}10^{-6}$ per year or 1 in 250,000 per year (DOE, 1987). There have been no documented violent tornadoes for the region surrounding Hanford. Although locally destructive, the tornadoes would move through the area rapidly along with the storm centers and are not expected to be capable of inflicting damage to the reactor compartments.

Other natural phenomena are considered not possible or not capable of inflicting damage to the reactor compartments when disposed of at Hanford.

4.3.3.2 Radiological Impacts

4.3.3.2.1 Radiation Exposure Upon Disposal

There is little risk of radiation exposure to anyone in the general public during movement to the burial ground, actual burial, or after burial. This is because radiation outside the reactor compartment package would be well below the federal limits and the package would have been welded shut at the shipyard to prevent entry. After burial, direct radiation at the land surface would be insignificant (i.e., below detectable levels) due to the low contact radiation fields on the package and the shielding effect of the soil cover.

Over 99.9 % of the radioactivity associated with the reactor compartments from the cruisers, and LOS ANGELES Class and OHIO Class submarines is in the form of radioactive atoms metallurgically bound into the matrix of irradiated metal structural components of the heavy walled pressure vessel and its internal components. These atoms are an inseparable part of the metal and they are chemically just like the rest of the iron, nickel, or other metal atoms in the reactor compartment. These radioactive atoms can only be released from the metal as a result of the slow process of corrosion.

The remaining 0.1 % of the radioactive material that remains in the defueled, decommissioned reactor compartments is wear product activity. The wear product was carried by the primary system through the reactor vessel where it became activated. The activated wear product was then deposited as an adherent film on interior surfaces of the reactor pressure vessel, primary piping, pumps, and steam generator during reactor operation.

4.3.3.2.1.1 Corrosion Performance

High strength (HT/HS) carbon steels, and very high tensile strength nickel alloyed (HY-80), steels would form the exterior of Reactor Compartment Disposal Packages and provide containment for activity within the compartment. Corrosion Resistant Steel (CRES) 304 and Inconel A600 nickel-iron-chromium alloys are present inside the compartments, and would contain most of the actual radioactivity in a compartment as activated metal. Site specific corrosion studies have been conducted to characterize the corrosion of these metal alloys in Hanford Soils (NCEL, 1992, NIST, 1992, DOE, 1992a, NFESC, 1993).

The soil environment around a buried metal component is a significant factor in determining the corrosion performance of the component. Soil at the 218-E-12B burial ground is a typical mix of sandy-gravel, sand, and gravely sand found in the Hanford Formation. The soil is dry (moisture content of 1-5% by weight), well drained, slightly alkaline (pH of 8.2), and low in chlorides at 0.08 milligram equivalents per 100 grams soil or about 30 ppm. Soil resistivity at the 218-E-12B burial ground is high, measured as greater than 30,000 ohm-cm (PNL, 1992, NFESC, 1993). These conditions, coupled with the average site rainfall of 16 centimeters per year (6.3 inches per year) minimize corrosion.

The corrosion studies showed that corrosion rates for carbon steels in the Hanford soil would be low, with an expected average pitting corrosion rate of 0.0025 centimeters per year (0.001 inch per year), and an expected average general corrosion rate of 0.0005 centimeters per year (0.0002 inch per year). The maximum pitting corrosion rate predicted was 0.0089 centimeters per year (0.0035 inch per year), with a corresponding maximum general corrosion rate of 0.0015 centimeters per year (0.0006 inch per year).

These corrosion rates were based on a comparison to actual test data from underground storage tanks exhumed at the Hanford Site as well as available data from National Institute of Standards (NIST) test sites with soil conditions approximating those at Hanford.

The actual corrosion values for compartment structure are expected to be less than these predictions. The studies were based on test data for open hearth carbon steel which is somewhat less corrosion resistant than the HT/HS carbon steel and HY-80 steel typically forming the exterior of reactor compartments. In addition, no credit was taken for the protective cover that will be installed over the trenches to minimize moisture in the soil. Even under these conservative assumptions, it was estimated that the first potential generation of leachate could not occur for at least 600 years, after general corrosion results in failure of endplates allowing soil to enter (DOE, 1992a). The reactor compartment disposal packages for the cruisers, LOS ANGELES, and OHIO class submarines will be as robust, composed of similar alloys, and as such would exhibit similar corrosion performance as the pre-LOS ANGELES class submarines.

Upper limit corrosion rates expressed in milligrams of metal alloy weight loss per square decimeter of surface per year, for HY-80, CRES 304, and A600 Inconel alloys present in Naval Reactor Compartments, were also estimated for the 218-E-12B burial ground (NFESC, 1993). These corrosion rates are as follows: for HY-80 - 70 milligrams per square decimeter per year, for CRES 304 - 0.02 milligrams per square decimeter per year, and for A600 Inconel alloy - 0.01 milligrams per square decimeter per year.

The estimated rates were based on a study of sites where NIST corrosion test data was available. For the subject alloys, an NIST site was selected based on soil characteristics that were considered similar to the compartment burial site; for example, sites with well drained, dry, alkaline soil, and low chlorides were considered most suitable. Alloy test data from the selected site was adjusted for the high soil resistivity of soil at the 218-E-12B burial ground (30,000 ohm-cm plus).

Actual weight loss rates for the CRES 304 and A600 Inconel alloys are expected to be much lower than the low rates already estimated. In the 218-E-12B burial ground environment, corrosion may not initiate on CRES and it is likely that corrosion would not initiate (at all) on the Inconel alloy (NFESC, 1993).

4.3.3.2.1.2 Site Specific Migration Studies, Radionuclides

Pacific Northwest Laboratory estimated the release and migration of nickel through soils and groundwater at the Hanford Site 218-E-12B burial ground (PNL, 1994a). This study considered the disposal of a group of 120 large metal components (i.e., reactor compartments) at the burial ground as a potential nickel radionuclide source due to the presence of metal alloys inside the compartments that contain activated nickel (nickel-59 and nickel-63). The number of compartments considered was based on the existing capacity of the burial trench at 218-E-12B dedicated for reactor compartment disposal (Trench 94). However, compartments were modeled with average quantities of nickel alloy and activated nickel based on total inventories in pre-LOS ANGELES, LOS ANGELES, and OHIO reactor compartments and all cruiser reactor compartments. If the preferred alternative for disposal of cruiser, LOS ANGELES, and OHIO reactor compartments was selected, Trench 94 could receive cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments as well as or in lieu of pre-LOS ANGELES Class submarine reactor compartments which are currently being placed in the trench. This would fill the trench to its current capacity of 120 compartments. Additional capacity would be required for remaining compartments being disposed of (bounded 220 compartments combining the pre-LOS ANGELES Classes with the about 100 reactor compartments considered in this final EIS).

Potential concentrations of nickel-59 and nickel-63 resulting in the underlying aquifer from reactor compartment disposal were estimated as well as migration times for such concentrations to occur. Resulting radiological doses to persons using the aquifer were also calculated. The release and migration of total elemental nickel from the compartments was also estimated in order to accurately predict migration times to the aquifer.

Figure 4.1 shows the basic migration model for the nickel migration study. The TRANSS computer code, a one dimensional streamtube model (PNL, 1986a), was employed to predict migration through the soil, the compartments and in the aquifer itself. A Hanford Site aquifer model which incorporates site data and the Coupled Fluid, Energy, and Solute Transport (CFEST) computer code (PNL, 1982) was employed to provide required data for TRANSS. Geologic, geochemistry, and geohydraulic data inputs for these codes were obtained from available literature and from laboratory testing using actual 218-E-12B burial ground soil samples. The GENII computer code (the Hanford Environmental Radiation Dosimetry Software System) (PNL, 1988) was employed to calculate exposure.

The amount of precipitation falling on the site that would infiltrate through the soil to the buried compartments and downwards to the aquifer (recharge) was modeled at 0.5 centimeters per year (0.2 inches per year) for the current arid climate condition. A postulated wetter condition was also modeled with a recharge rate 10 times greater than that used for the current climate. The soil column from compartments to aquifer was modeled at 45 meters (approximately 150 feet) of thickness based on site measurements from the floor of the current excavation (Trench 94). This soil thickness represents the minimum distance from the compartments to the aquifer expected for disposal of reactor compartments at the 218-E-12B burial ground.

Nickel radionuclides were modeled as activated constituents of Corrosion Resistant Steel (CRES) 304 and Inconel Alloy 600 inside the compartments. Upper limit corrosion rates for these alloys when buried at the 218-E-12B burial ground were identified by the Naval Facilities Engineering Service Center at 0.01 milligrams alloy corroded per square decimeter of alloy surface per year (0.01 $mg/dm^2/yr$) (2.05E-7 $lb/ft^2/yr$) for the Inconel and 0.02 $mg/dm^2/yr$ (4.09E-7 $lb/ft^2/yr$) for the CRES (NFESC 1993). This corrosion study also identified that corrosion may not initiate on the

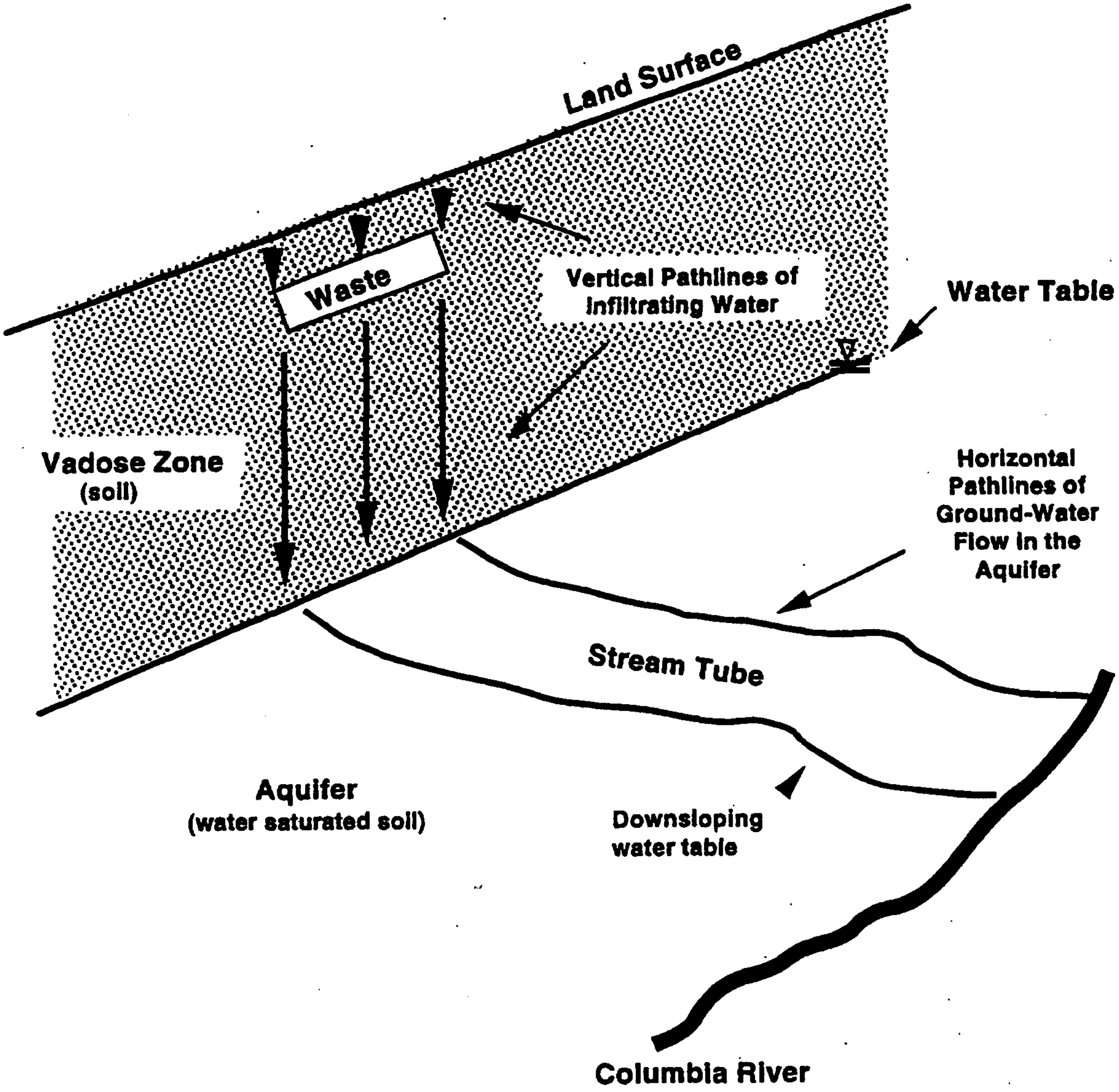


Figure 4.1. Basic Migration Model Including Depiction of the Streamtube Approach to Transport in the Underlying Aquifer

Inconel alloy at all after burial. Corrosion of these alloys would allow radionuclides to be transported if sufficient water were available in the soil to dissolve the corrosion products. Nickel-63 would decay to negligible levels in the magnitude of 1×10^{-10} picocuries per liter prior to reaching the aquifer even under the postulated wetter condition.

The 120 compartments considered were modeled in a compact rectangular array (the planned configuration for Trench 94), Figure 4.2. The TRANSS model effectively treated this array as a single large nickel source, Figure 4.1. Consequently, each compartment in the array was modeled with an average nickel alloy and nickel-59 content (per alloy). Quantities were averaged from the total inventory of Inconel Alloy 600, CRES 304, and nickel-59 in pre-LOS ANGELES, LOS ANGELES, and OHIO reactor compartments and all cruiser reactor compartments. The average nickel-59 content (per alloy) per compartment was coupled to the corrosion rates estimated for the CRES and Inconel 600 alloys and surface area terms for these alloys to estimate the quantity of nickel-59 released per compartment by corrosion. No credit was taken for the containment provided by the compartments. Nickel-59 release rates calculated by this method were also conservative if only pre-LOS ANGELES class compartments were disposed of at the 218-E-12B burial ground as these compartments contain a lower concentration of nickel-59 (in nickel alloy) than modeled by the average quantities determined for the nickel migration study (PNL, 1994a).

HY-80 steel alloy forms part of the exterior containment structure of most reactor compartments and contains non-radioactive nickel. This alloy was considered to be less corrosion resistant than the CRES 304 and Inconel alloys and recharge water contacting the compartments could become chemically saturated with dissolved nickel due to non-radioactive nickel released from the corrosion of the HY-80 steel alloy. The release of radioactive and non-radioactive nickel by corrosion would occur simultaneously, competing for the available capacity of the water to hold dissolved nickel (solubility). In order to conservatively predict nickel-59 transport, the migration model was configured to allow all nickel-59 released by CRES and Inconel corrosion to preferentially dissolve with the non-radioactive nickel making up the balance of the groundwater's nickel solubility. Even so, non-radioactive nickel occupied over 99.9% of the groundwater's dissolved nickel capacity (solubility) with this modeling approach. The solubility concentration of nickel in Hanford groundwater was determined initially by computer code and verified by laboratory experiments for estimating nickel migration.

Batch and flow-through column laboratory experiments with 218-E-12B soils showed that nickel dissolved in the groundwater (solubilized nickel) would be adsorbed in soil under the compartments, retarding the movement of nickel towards the aquifer. Radioactive nickel was considered to be adsorbed at the same rate as non-radioactive nickel; however, on a mass basis, virtually all solubilized nickel would be non-radioactive and thus occupy most available soil adsorption sites. Nickel adsorption was modeled using a Freundlich adsorption isotherm. This mathematical equation, dating from 1926, predicts adsorption from non-linear data and was considered appropriate for use in this study.

Iron and chromium (from steel alloys) would not be sufficiently soluble in a form that could compete with nickel for soil adsorption sites. Laboratory tests were conducted to determine the competitive effect of lead released from lead shielding in the compartment on nickel adsorption. These tests demonstrated that nickel adsorption was not influenced by the presence of lead at levels expected in the groundwater as a consequence of migration from the compartments.

The nickel released from each compartment was considered to migrate vertically downward, carried along through the soil by the groundwater which dissolved the nickel. Adsorption, as discussed previously, would delay the arrival of this nickel at the aquifer. Upon arrival at the aquifer, this larger body of water, modeled as a streamtube by the TRANSS code, would carry the nickel away from the burial ground.

For the nickel migration study, all nickel released from the 120 compartment array was modeled as entering a single hypothetical streamtube of width equal to the diagonal of this rectangular array is 461 meters (1513 feet) consistent with CFEST predictions of flow in the aquifer under the site in a general northerly direction for the future wetter condition, and the absence of an aquifer directly under the site under the current climate condition without artificial recharge, (groundwater would contact bedrock under the site and move southward through unsaturated sediment along the bedrock surface until entering the aquifer). Flow within the aquifer for the current climate conditions is predicted to be generally east to southeastward toward the Columbia river (Figures 4.1 and 4.2).

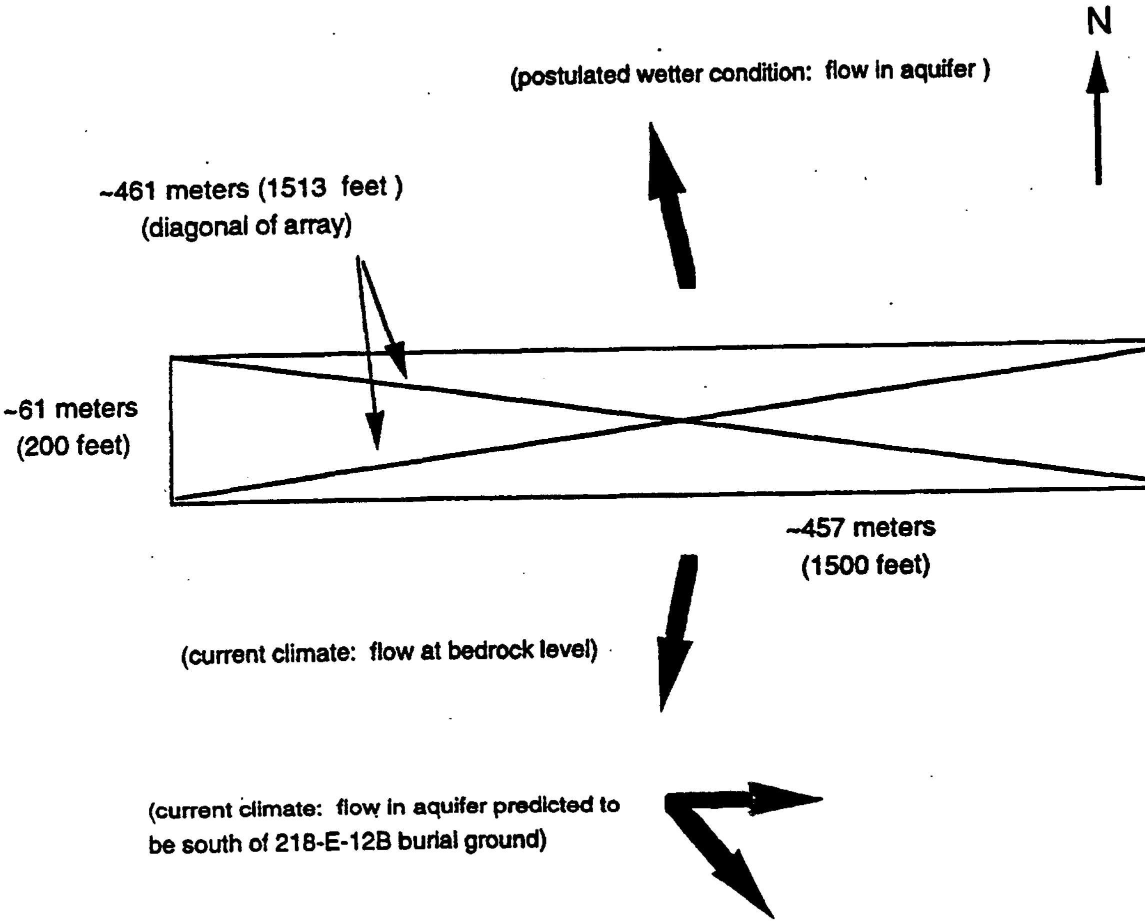
A complex geologic pattern is present in the basalt bedrock under the 218-E-12B burial ground. Although flow is predicted to be southerly across the diagonal of the array for the current climate case, the CFEST computer code does not model the exact contour or extent of "dry" bedrock under the burial ground, causing the predicted flow direction to be less certain than for the wetter condition modeled. Flow in alternate directions would reduce the width of the tube and the volume of water in the aquifer streamtube. As a result, predicted concentrations in the streamtube for the current climate condition would increase. The range of possible streamtube widths varies from the current 461 meters (1513 feet) down to 61 meters (200 feet) for a west to east flow direction, which although unlikely, could potentially occur if the aquifer did not recede to south of the burial ground and was still present under the site.

Streamtube depth of 2.5 to 5 meters (8.2 to 16.4 feet) were used to model the current and wetter condition, respectively. The modeling did not allow mixing of water between the streamtube and adjacent water at locations downgradient (downstream) of the burial ground (i.e., no dissipation of the nickel plume by spreading out).

Resulting concentrations of nickel and radioactive nickel for the 461 meter wide streamtube were estimated for the Columbia River and for hypothetical wells tapping the streamtube at 100 meters (330 feet) and 5000 meters (16,400 feet) from the burial ground (100 meter and 5000 meter wells, respectively). Radiological doses for a maximally exposed individual, identified as a farmer using the aquifer water at the site (100 meter well), and future downriver populations using Columbia River water were calculated based on predicted radioactive nickel concentrations.

In Title 10 of the Code of Federal Regulations, the U.S. Nuclear Regulatory Commission limit for nickel-59 in water effluent released to unrestricted areas is $3x10^{-4}$ microcuries per milliliter (equivalent to 300,000 picocuries per liter) (10CFR20). This requirement defines an unrestricted area as having no access controls for protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters.

Under current climate conditions, nickel-59 was not predicted to migrate to the 100 meter well for 800,000 years. Transit time through the soil column between compartments and aquifer accounted for almost all of this time, within 1000 years. Peak concentrations of nickel-59 in the aquifer at the 100 meter well occurred shortly after 800,000 years and were estimated at 0.007 picocuries per liter (and 0.009 milligrams per liter), respectively.



Note: Upper arrow shows predicted direction of flow in the aquifier under Trench 94 for the postulated wetter condition. Lower arrows show predicted movement of water under current climate (at bedrock level under Trench 94 and within the aquifer predicted to be south of the 218-E-12B burial ground). Directions are from CFEST based modeling based on orientation of Trench 94, 218-E-12B.

Figure 4.2. Overhead View of Trench 94 Hanford Site 218-E-12B Burial Ground

Under the postulated wetter condition (10 times current recharge assumed), nickel-59 was not predicted to migrate to the 100 meter well for about 66,000 years. Peak concentrations of nickel-59 in the aquifer at the 100 meter well occurred at 68,000 years and were estimated at 2.0 picocuries per liter, respectively. A 2.0 picocurie per liter concentration represents 0.0007% of the Nuclear Regulatory Commission limit discussed above.

The dose to a maximally exposed individual resulting from nickel-59 in the aquifer was calculated as 3.3×10^{-6} mrem/yr for the current climate condition and 0.00097 mrem/yr for the postulated wetter condition. These doses were calculated from all exposure pathways based on a farmer drawing water for irrigation, animal consumption, and human consumption at a well 100 meters downstream of the site. Exposure through the drinking water pathway alone results in a lower dose than provided above. In Title 40 "Environment" of the Code of Federal Regulations, the Environmental Protection Agency limits exposure from drinking water at a 2 liter/day (0.53 gallon/day) consumption to 4 mrem per year (40CFR141). The entire maximally exposed individual dose is less than 0.025% of the 4 mrem per year Environmental Protection Agency limit.

For the postulated wetter condition, nickel-59 (and nickel) was not predicted to reach the Columbia River for about 260,000 years. The dose to the maximally exposed downriver person was calculated at 1.8×10^{-10} mrem per year. This dose can be compared to the 0.02 mrem per year dose resulting from Hanford Site operations in 1993, which was calculated in the 1993 Hanford Environmental Report (PNL, 1994c) under similar assumptions for a maximally exposed individual.

The Environmental Protection Agency, under the National Primary Drinking Water Standards provides a Maximum Contaminant Level (MCL) of 0.1 milligrams per liter for nickel in community and non-community water systems serving 25 or more people (40CFR141). The Environmental Protection Agency states that drinking water which meets this standard should be considered safe with respect to nickel (40CFR141). For exposure via drinking water, the Environmental Protection Agency also has advised that a higher 0.35 milligrams per liter concentration of nickel represents a level at which adverse effects would not be anticipated to occur for a lifetime of exposure of adults (ATSDR, 1988). From the nickel migration study (PNL, 1994a), predicted total elemental nickel concentrations for the aquifer streamtube ranged from 0.009 to 0.051 mg/L depending on the recharge condition (i.e., current and wetter, respectively). These peak concentrations were predicted to occur at the same times as for nickel-59. Total elemental nickel concentrations in the Columbia River ranged from 1.8×10^{-9} to 2.2×10^{-8} mg/L as derived from predictions of peak nickel flux to the river and a river flow rate of 100 trillion liters/year (about 112,000 cfs) assumed by Pacific Northwest Laboratory. All predicted total nickel concentrations, which are below both standards discussed above, were based on a conservative assumption that all groundwater contacting the compartment would exit saturated with nickel.

4.3.3.2.1.3 Extrapolation of Pacific Northwest Laboratory Nickel Study Results

The results from the Pacific Northwest Laboratory nickel migration study (PNL, 1994a) were extrapolated by the Navy to consider the cumulative effects of cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments with pre-LOS ANGELES Class submarine reactor compartments at the 218-E-12B burial ground. A total of 220 reactor compartments at the 218-E-12B burial ground were considered in the extrapolation for a conservative estimate of combined impact (pre-LOS ANGELES Class under the current disposal program plus the about 100 reactor compartments being considered under this final EIS). The detailed extrapolation study is documented in a Navy study (USN, 1995) and is summarized below.

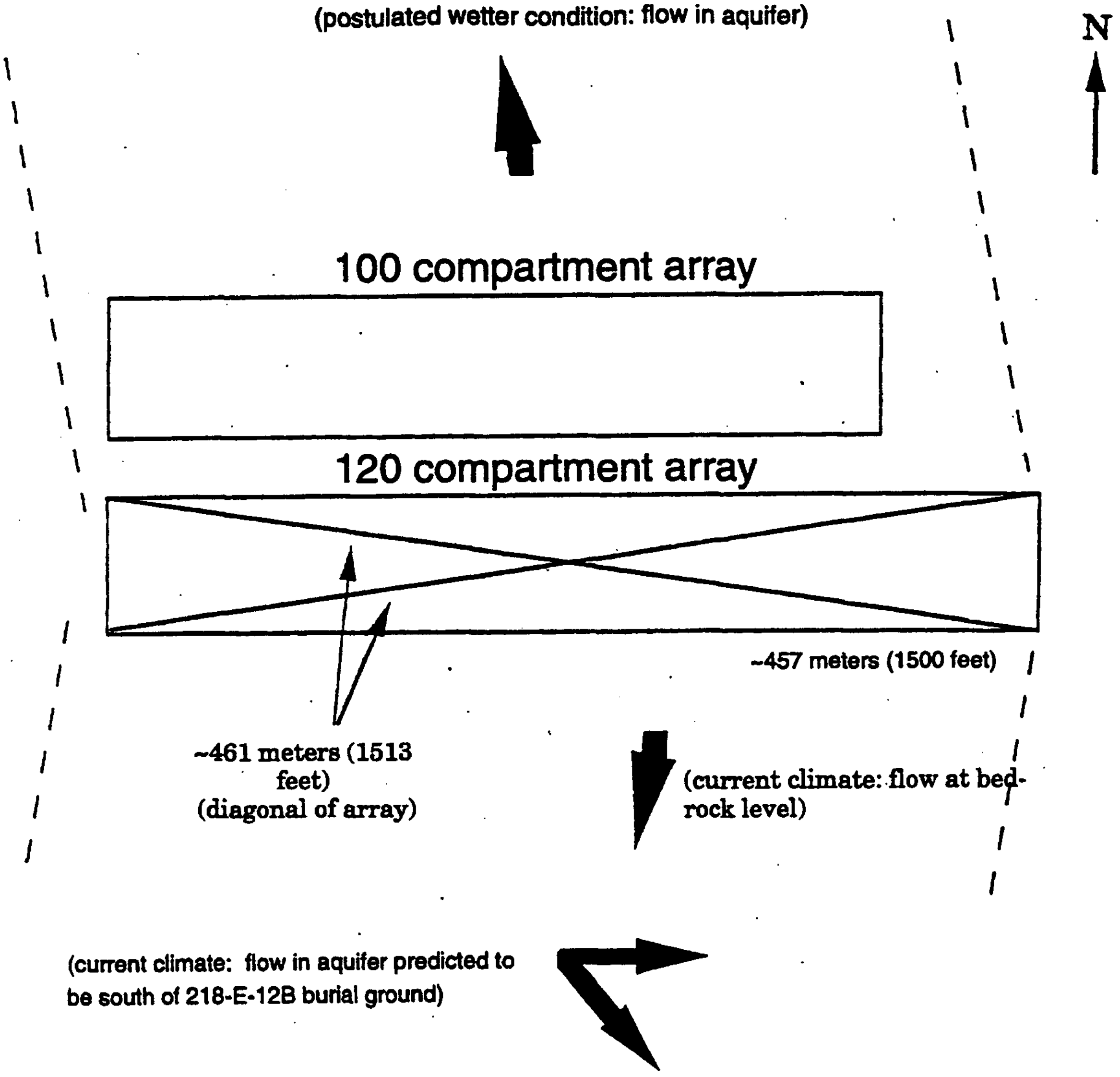
For the extrapolation, the 220 compartments were modeled in two parallel and adjacent arrays of 120 and 100 compartments each, Figure 4.3. Based on CFEST predictions from the lead and nickel migration studies (PNL, 1992, PNL, 1994a) this array configuration would introduce nickel from both arrays into essentially the same aquifer streamtube flowing under the burial ground and thus represents a worst case for the combined effect of the pre-LOS ANGELES and cruiser, LOS ANGELES, and OHIO class compartments.

The combined total of 220 compartments could be treated as a single large nickel source. Consequently, the compartments were modeled with average CRES 304, Inconel Alloy 600, and activated nickel quantities, consistent with the modeling conducted in the nickel migration study (PNL, 1994a). The average quantities for nickel alloy and activated nickel used by Pacific Northwest Laboratory reflected the average of pre-LOS ANGELES, LOS ANGELES, and OHIO classes of nuclear-powered submarines and all nuclear-powered cruisers. Thus, no change in these quantities was required for the extrapolation. Similarly, CRES 304 and Inconel Alloy 600 surface area estimates from the nickel migration study (PNL, 1994a) and corrosion rates from the Naval Facilities Engineering Service Center study (NFESC, 1993) remained applicable to the extrapolated condition.

Migration times as predicted in the nickel migration study (PNL, 1994a) were essentially unaffected by the extrapolation. The two arrays would not be considered by the modeling employed to release nickel into the same vertical soil column. However, within the aquifer, the two arrays would be considered to share the same streamtube, resulting in an increased concentration of nickel within the streamtube. With this condition, the use of an adsorption isotherm would result in a minor reduction in overall migration time compared to PNL, 1994a (a difference of less than 1% at the 100 meter well to less than 10% at the Columbia River).

As previously discussed, the U.S. Nuclear Regulatory Commission limit for nickel-59 in water effluent released to unrestricted areas is 0.0003 microcuries per milliliter (equivalent to 300,000 picocuries per liter) (10CFR20) and the Environmental Protection Agency limit for drinking water exposure dose is 4 mrem per year (40CFR141). For 220 reactor compartments in the assumed adjacent array configuration, under current climate conditions, peak nickel-59 concentration remained below 0.02 picocuries per liter (790,000 year migration time). For the postulated wetter climate condition (10 times higher recharge), peak concentration of nickel-59 was about 4 picocuries per liter, 0.0014% of the Nuclear Regulatory Commission limit (66,000 year migration time). Maximally exposed individual dose remained under 0.002 mrem per year under the wetter condition or less than 0.05% of the Environmental Protection Agency limit.

The Environmental Protection Agency (EPA) provides a Maximum Contaminant Level (MCL) of 0.1 milligrams per liter for nickel in community and non-community water systems serving 25 or more people (40CFR141). For exposure via drinking water, the Environmental Protection Agency also has advised that a higher 0.35 milligrams per liter concentration of nickel represents a level at which adverse effects would not be anticipated to occur for a lifetime of exposure of adults (ATSDR, 1988). For 220 reactor compartments in the assumed adjacent array configuration, under current climate conditions, peak total elemental nickel concentration in the aquifer at 100 meters downstream of the burial ground remained below 0.02 milligrams per liter (790,000 year migration time). For the postulated wetter climate condition (10 times higher recharge), peak total elemental nickel concentration in the aquifer at 100 meters downstream of the burial ground remained just below 0.1 milligrams per liter (66,000 year migration time). Only under the



Note: Upper arrow shows predicted direction of flow in the aquifer under Trench 94 for the postulated wetter condition. Lower arrows show predicted movement of water under current climate (at bedrock level under Trench 94 and with the aquifer predicted to be south of the 218-E-12B burial ground). Directions are from CFEST modeling based on orientation of Trench 94, 218-E-12B and orientation of adjacent 100 compartment array. Dashed lines define the streamtubes modeled.

Figure 4.3. Overhead View of Trench 94 and Second Trench to the North, Hanford Site 218-E-12B Burial Ground

postulated wetter condition was the lower of the two standards discussed above approached. However, the extrapolated total elemental nickel concentrations were based on a conservative assumption that all groundwater contacting the compartment would exit saturated with nickel.

Migration time to the aquifer for all forms of nickel and all migration scenarios considered was a minimum of 66,000 years. For comparison, the recorded history of human civilization is less than ten thousand years, and it is likely that human and geologic events occurring over the predicted time frame would result in impacts to the environment of a far greater nature. Figure 4.4 provides a timeline showing predicted migration times for nickel-59 and lead taken from 218-E-12B site specific studies (PNL, 1992, PNL, 1994a, USN, 1995).

The results of the extrapolation study (USN, 1995) can also be considered to bound the option of obtaining additional trench capacity by placing reactor compartments within Trench 94 closer together than currently done. The Pacific Northwest Laboratory nickel migration study (PNL, 1994a) employed a 150 square meter (1650 square foot) "storage area" per reactor compartment. Recharge passing through this area was assumed to contact the reactor compartment and exit saturated with nickel. The released nickel was then assumed to migrate vertically downward within a column of soil defined by this "storage area" and the depth to the vadose zone. The 150 square meter (1650 square foot) area is considerably smaller than the 230 square meter (2500 square foot) area of trench floor currently claimed per reactor compartment. Thus, placing reactor compartments closer together would not affect predicted nickel migration times as the nickel released from one reactor compartment would not enter a soil column modeled as receiving nickel from another compartment. In addition, predicted groundwater concentrations and resulting user doses would not be affected by the closer spacing of reactor compartments. The Pacific Northwest Laboratory modeling treated the entire array of reactor compartments as a single nickel source to the aquifer. The extrapolation study used a 457 meter (1500 foot) streamtube width for that portion of the aquifer receiving nickel from the reactor compartments above. Figure 4.2 would also represent the closer spacing of reactor compartments at Trench 94 except that the resulting array and stream tube width would actually be a little larger than shown. A larger streamtube width would result in lower predicted concentrations and doses.

4.3.3.2.1.4 Radioactive Corrosion Products Available for Migration

The predominant radionuclide present in Naval nuclear reactor compartments is cobalt-60, which emits highly penetrating energetic gamma radiation and decays by a factor of two every 5.3 years. From Table 1.1, over 10,000 curies of cobalt-60 could be present in a reactor compartment. This radionuclide also forms the bulk of the activated wear product distributed through the reactor plant. However, all of this radionuclide would decay to less than 1 microcurie in less than 200 years. During this time period, the compartment would remain intact, thus no migration could occur. At 50 years after disposal, Cobalt-60 decay would virtually eliminate external exposure to radiation even if someone were to enter the reactor compartment inadvertently (Appendix B).

Table 1.1 lists other radionuclides in quantities greater than 1% of total activity. Appendix D lists long lived radionuclides present in the reactor compartments which result from the neutron activation of structural materials. For most of the next millennium, the reactor compartment containment structure would effectively isolate this radioactivity from the environment. During this time the majority of the radioactivity would decay away. After 500 years, only about 1/50th to 1/200th of the activity of Table 1.1 would remain, all as nickel-63. Nickel-63 emits only beta particles. From Appendix D, at 2000 years, a few hundred curies, at most, of long lived activity would remain. Over 90%, of this activity would be nickel-59, which emits only weak X-rays and electrons. The remainder would essentially be carbon-14 and niobium-94. Carbon-14 emits only beta particles, and niobium emits a less energetic gamma than cobalt-60 and is also in small quantity.

The reactor vessel itself would continue to provide containment well beyond the point at which the compartment is breached (Appendix B). Remaining long lived radioactive atoms would be metallurgically bound into the matrix of irradiated metal structural components of the heavy walled reactor pressure vessel and its internal components. Release of these radionuclides to the environment would occur primarily by the very slow corrosion of the CRES 304 and Inconel Alloy 600 alloys in the vessel and internal components and the subsequent dissolving of the corrosion products into available water contacting the alloys.

Nickel-59 and Nickel-63

The results of the Pacific Northwest Laboratory nickel migration study have been extrapolated to account for the cumulative effect of 220 compartments comprising cruisers and the pre-LOS ANGELES, LOS ANGELES, and OHIO classes at the Hanford 218-E-12B burial ground (USN, 1995). The Navy's extrapolation determined that under the current site conditions, the maximally exposed individual who utilizes a well located 100 meters downstream of the 218-E-12B burial ground as the sole source of water would receive a radiological dose of less than $1x10^{-5}$ mrem per year of exposure from the 220 compartments. This dose would result from nickel-59, the nickel-63 having fully decayed prior to reaching the aquifer.

This dose is less than one millionth of the radiological dose an average individual normally receives from natural background radiation. Natural background radiation is what all people receive every day from the sun or from cosmic radiation, and from the natural radioactive materials that are present in our surroundings, including the rocks or soil we walk on. A typical person in the United States receives a 300 mrem/yr dose each year from natural background radiation (NCRP, 1987).

Niobium-94

The typical niobium-94 content in cruiser, LOS ANGELES, and OHIO reactor compartments is less than 1 curie. The total niobium-94 content of 220 reactor compartments is expected to be about 100-200 curies. Niobium-94 constitutes only a very small fraction of the existing radioactive waste at Hanford.

Niobium-94 is present in the reactor compartments as an integral activated part of the corrosion resisting materials contained within the pressure vessel (e.g., CRES 304 and Inconel Alloy 600). Release of niobium-94 from the reactor compartments would be controlled by the corrosion rate of these corrosion resisting alloys. This corrosion rate would be bounded by the rate provided by the Naval Facilities Engineering Service Center for buried CRES 304 alloy at the 218-E-12B burial ground of 0.02 milligrams alloy corroded per square decimeter alloy surface per year ($mg/dm^2/yr$) (NFESC, 1993). Consequently, the time required for the full corrosion of all niobium-94 bearing alloy in the reactor compartment is so long, at greater than 10,000,000 years, as to allow only less than 0.4% of the total quantity of niobium-94 in a reactor compartment to be released to the environment prior to complete decay (Appendix B).

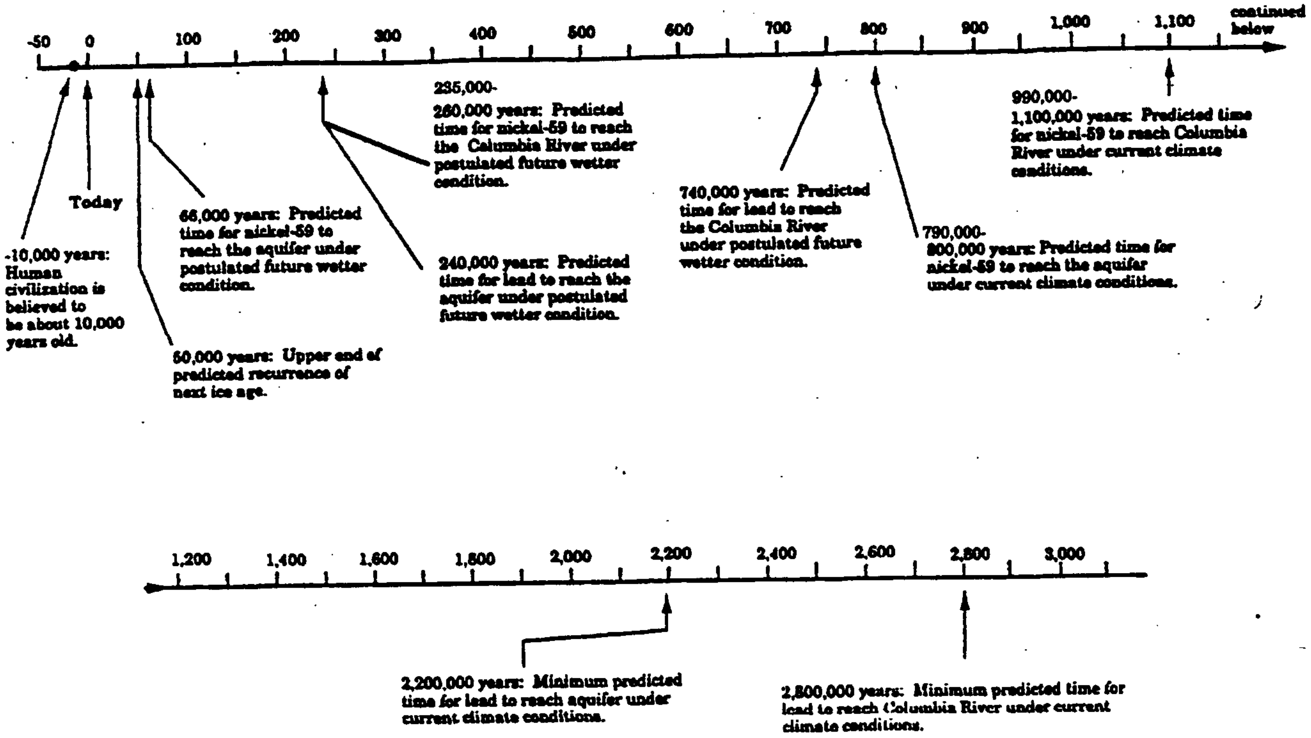


Figure 4.4. Timeline for Migration of Lead and Nickel-59 (time scale in thousands of years)

In Title 40 "Environment" of the Code of Federal Regulations, the Environmental Protection Agency limits radiological dose from drinking water at a 2 liter/day (0.52 gallon/day) consumption to 4 mrem per year (40CFR141). The Washington State Administrative Code (WAC), Part 173-200, establishes a 50 pCi/L limit for gross Beta activity in groundwaters. Given the long corrosion life of the materials containing Niobium-94, and adsorption of niobium-94 in subsurface soils, this radionuclide would enter the environment at such a minimal rate that its contribution to the radiological dose or groundwater concentration would be minor.

Carbon-14

Carbon-14 content in cruiser, LOS ANGELES, and OHIO reactor compartments ranges from less than 1 curie to over 10 curies. The total carbon-14 content of 220 reactor compartments is expected to be about 500-1,000 curies. Carbon-14 decays with a half-life of 5730 years; however, only low energy beta radiation is emitted as a result of this decay process. Carbon-14 in reactor compartments is locked in trace quantities within the molecular structure of metal alloys. Release of carbon-14 from the reactor compartments would be controlled by the corrosion rate of the corrosion resisting alloys containing the carbon-14. This corrosion rate would be bounded by the rate provided by the same CRES 304 corrosion rate discussed previously. Consequently, the time required for the full corrosion of all carbon-14 bearing alloy in the reactor compartment is so long, at greater than 10,000,000 years, as to allow only less than 0.2% of the carbon-14 in a reactor compartment to be released to the environment prior to complete decay (Appendix B). This release mechanism is much slower than the oxidation of pure carbon graphite evaluated in the Final Environmental Impact Statement on Decommissioning of Eight Surplus Production Reactors at the Hanford Site (DOE, 1992b).

Based on the expected carbon-14 inventory for 220 reactor compartments, less than 2 curies (less than 0.2% of the total) would be released to the environment over the corrosion life of the activated alloys containing the carbon-14. Since this corrosion life is very long, on the order of millions of years, the maximum release rate of carbon-14 would be less than 0.0001 curie/year. To put this small release rate into perspective, Title 10, Code of Federal Regulations, Part 20.2003 (10CFR20) allows NRC licensees to discharge up to one curie per year of carbon-14 containing compounds directly to sanitary sewers in concentrations below 0.3 microcuries per liter. Averaging the compartment release rate into the yearly volume of recharge water passing through the burial ground from the Pacific Northwest Laboratory migration modeling results in a Carbon-14 concentration in vadose zone groundwater at less than the 0.3 microcurie per liter standard.

The consequences of releasing carbon-14 in the quantities under consideration are small. For example, estimates of radiological dose resulting from the localized surface release to the atmosphere of one curie of carbon-14 over one year indicate that the maximally exposed individual 5,000 meters (16,400 feet) from the release would receive only 0.015 mrem when calculated using the EPA COMPLY Code, Version 1.4. However, for reactor compartments, this dose would be at least three orders of magnitude lower not only because of the much lower release rate but because releases of carbon-14 from buried naval reactor compartments will be by the groundwater pathway vice the surface pathway. This would be less than 5×10^{-9} of the dose to the same individual from natural background radiation in the same year.

4.3.3.2.1.5 Population Radiation Dose and Risk

The risk associated with disposal of long-lived radionuclides is the health effect upon future populations that may be exposed to this radioactivity through various environmental pathways. Models to estimate these health risks have been developed by both the Environmental Protection Agency and the United States Department of Energy. The Department of Energy estimates for Hanford releases are in a component of GENII (PNL, 1988), a computer program called "A Computer Program for Calculating Population Dose Integrated over Ten Thousand Years" (DITTY) (PNL, 1986b). DITTY results are in terms of a collective population dose (person-rem) over a 10,000 year period in a 3-million person stabilized population (ten times the current population in an 80 kilometer (50 miles) radius of the Hanford Site) per curie of a specific radionuclide released. Over a 10,000 year period, the 3 million person population would receive about 9 billion person-rem of collective dose due to naturally occurring radiation, resulting in about 4.5 million latent cancer fatalities. For the significant long-lived radionuclides in 220 reactor compartments the health effects have been predicted and are summarized as follows:

Nickel-59 - The maximum collective dose to the future population over 10,000 years has been estimated to be about 0.001 person-rem for 220 reactor compartments at the 218-E-12B burial ground (USN, 1995). This dose is substantially lower than the dose that would be expected to result in a single latent cancer fatality (2000 person-rem) over this 10,000 year period (PNL, 1994a).

Niobium-94 - DITTY (PNL, 1986b) estimated the total fatal cancers to the future population over 10,000 years from release of niobium-94 as 0.004 cancers per curie released. As discussed previously, less than 0.4% or approximately 0.6 curies is released to the environment with the remainder decaying while still locked within corroding alloy. Thus the number of latent cancer fatalities would be bounded by 0.003. However, this release is spread out over the very long corrosion life of the structure containing niobium 94 so that annual releases would be bounded at 10^{-5} curies/year. This slow release, combined with adsorption of niobium 94 in subsurface soil, would further reduce the potential for fatalities.

Carbon-14 - The Final Environmental Impact Statement on Decommissioning of Eight Surplus Production Reactors at the Hanford Site (DOE, 1992b) estimated the total latent cancer fatalities to the future population from the release of carbon-14 as $6x10^{-5}$ cancers per curie released. As discussed previously, less than 0.2% or about 2 curies of the total inventory of carbon-14 expected for 220 reactor compartments is released to the environment with the remainder decaying while still locked within alloy. This equates to less than $1.2x10^{-4}$ latent cancer fatalities.

Thus, the person-rem of total dose associated with the preferred alternative of land disposal has been estimated to result in much less than one latent cancer fatality to a future 3-million person population over a 10,000 year time period. This is insignificant compared to the expected 4.5 million latent cancer fatalities from natural background radiation occurring over the same 10,000 year period.

4.3.3.2.1.6 Waste Management Consequences

Approximately 4 hectares (10 acres) of land would be required for land disposal of the approximately 100 reactor compartment disposal packages from cruisers, LOS ANGELES, and OHIO Class submarines if additional capacity were obtained through expansion of Trench 94 or construction of a new trench. This would be a commitment of about 4 hectares (10 acres) of land from the 218–E–12B low level burial ground in the 200 East area of the Hanford Site. As is the case with other areas of the Hanford Site used for radioactive waste disposal, the land area used for disposal of the reactor compartment disposal packages and the surrounding buffer zone would constitute a commitment of that land area and the natural resources contained therein. Obtaining additional capacity by placing reactor compartments closer together in Trench 94 would not require this additional land commitment. The cruiser, LOS ANGELES, and OHIO Class reactor compartment disposal packages would be regulated for their radioactivity, lead, and PCB content. The volume of mixed waste generated by this alternative would be less than 120,000 cubic meters (4,240,000 cubic feet). Approximately 1,625 cubic meters (57,400 cubic feet) of other mixed waste from the reactor compartments would be generated and disposed of separately, primarily consisting of solidified radioactive potassium chromate solution. This mixed waste would be managed in accordance with the approved Shipyard Site Treatment Plan developed pursuant to the Federal Facilities Compliance Act.

4.3.3.3 Site Specific Migration Studies

4.3.3.3.1 Lead

Pacific Northwest Laboratory estimated the release and migration of lead through soils and groundwater at the Hanford Site 218-E-12B burial ground (PNL, 1992). This study considered the disposal of a group of 120 large metal components at the burial ground. A range of average lead quantity was used for the compartments that reflected the average of pre-LOS ANGELES, LOS ANGELES, and OHIO class submarines and all nuclear-powered cruisers. The lead quantities also conservatively represented the disposal of pre-LOS ANGELES class reactor compartments alone. Potential concentrations of lead resulting in the underlying aquifer from reactor compartment disposal were estimated as well as migration times for such concentrations to occur.

If the preferred alternative for disposal of cruiser, LOS ANGELES, and OHIO reactor compartments was selected, Trench 94 could receive cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments as well as or in lieu of pre-LOS ANGELES Class submarine reactor compartments which are currently being placed in the trench. This would fill the trench to its current capacity of 120 compartments. Additional capacity would be required for remaining compartments being disposed of (bounded 220 compartments combining the pre-LOS ANGELES Classes with the about 100 reactor compartments considered in this final EIS).

Figure 4.1 shows the basic migration model for the lead migration study. The TRANSS computer code, a one dimensional streamtube model (PNL, 1986a), was employed to predict migration through the soil underlying the compartments and in the aquifer itself. The Coupled Fluid, Energy, and Solute Transport (CFEST) computer code, a Hanford Site aquifer model (PNL, 1982), was employed to provide required data for TRANSS. Geologic, geochemistry, and geohydraulic data inputs for these codes were obtained from available literature and from laboratory testing using actual 218-E-12B burial ground soil samples.

The amount of precipitation falling on the site that would infiltrate through the soil to the buried compartments and downwards to the aquifer (recharge) was modeled at 0.5 centimeters per year (0.2 inches per year) for the current arid climate condition. A postulated wetter condition was also modeled with a recharge rate 10 times greater than that used for the current climate. The soil column from compartments to aquifer was modeled at 45 meters (150 feet) of thickness based on site measurements from the floor of the current excavation (Trench 94). This soil thickness represents the minimum distance from the compartments to the aquifer expected for disposal of reactor compartments at the 218-E-12B burial ground. The 120 compartments considered were modeled in a compact rectangular array, the planned configuration for Trench 94, Figure 4.2. The TRANSS model effectively treated this array as a single large lead source, Figure 4.1.

Release of lead from the reactor compartments would occur by corrosion of the solid elemental lead and subsequent solubilization of the corrosion products into recharge water contacting the lead. However, corrosion rates for elemental lead in the 218-E-12B environment were not estimated, rather, lead was very conservatively assumed to be immediately available for dissolution so that all groundwater contacting a 15.2 by 15.2 meter square (50 by 50 foot square) area encompassing a compartment would exit this area being fully saturated with dissolved lead (no credit was taken for the containment provided by the compartment or soil cover to be placed over the compartment). The capacity of the water to hold dissolved lead (solubility) was determined initially by a computer code and for estimating lead migration, by laboratory experiments with "upper envelope" solubility set at roughly double experimental results.

The lead released from each compartment was considered to migrate vertically downward. Batch and flow-through column laboratory experiments with 218-E-12B soils showed that solubilized lead would be strongly adsorbed in soil under the compartments, retarding the movement of this lead towards the aquifer. This testing determined the ratio of lead adsorbed in soil vice remaining in surrounding solution. The fixed ratio used in the model would underestimate lead adsorption in 218-E-12B soils (and underestimate migration times) vice a more accurate but more complex isotherm model such as that used in the nickel migration study (PNL, 1994a).

Iron and chromium (from steel alloys) would not be sufficiently soluble in a form that could compete with lead for soil adsorption sites. Laboratory tests were conducted to determine the competitive effect of nickel released from nickel alloys in the compartment on lead adsorption. These tests demonstrated that lead adsorption was not influenced by the presence of nickel at levels expected in the groundwater as a consequence of migration from the compartments. Colloidal transport mechanisms (i.e., lead or nickel piggy-backing on iron oxide colloids) were also evaluated by Pacific Northwest Laboratory in separate work (PNL, 1993). It was found that the colloids clumped together to form larger particles (coagulated) in the Hanford ground water chemistry, causing them to be filtered out by the soil, thus trapping adsorbed constituents and rendering the colloids ineffective as an accelerated transport medium.

The lead released from each compartment would be transported downward through the soil by groundwater. Adsorption in soil would delay the arrival of this lead at the aquifer. Upon arrival at the aquifer, lead would be carried away from the burial ground within the streamtube modeled by TRANSS. For the lead migration study, all lead released from the 120 compartment array was modeled as entering into a single hypothetical streamtube of width equal to the diagonal of the rectangular array, 461 meters (1513 feet), consistent with CFEST predictions of flow in the aquifer under the site in a general northerly direction for the future wetter condition, and the absence of an aquifer directly under the site under the current climate condition without artificial recharge from local site operations. Under the conditions, groundwater would contact bedrock under the site, and move southward through unsaturated sediment along the bedrock surface until entering the aquifer. Flow within the aquifer for the current climate is predicted to be generally east to southeastward toward the Columbia river (Figure 4.1 and 4.2). Resulting concentrations of lead (for the 461 meter wide streamtube) were estimated for the Columbia River and for hypothetical wells tapping the streamtube at 100 meters (330 feet) and 5000 meters (16,400 feet) from the burial ground (100 meter and 5000 meter wells, respectively).

A complex geologic pattern is present in the basalt bedrock under the 218-E-12B burial ground. Although flow is predicted to be southerly across the diagonal of the array for the current climate case, the CFEST computer code dows not model the exact contour or extent of "dry" bedrock under the burial ground, causing the predicted flow direction to be less certain than for the wetter condition modeled. Flow in alternate directions would reduce the width of the tube and the volume of water in the aquifer streamtube. As a result, predicted concentrations in the streamtube for the climate condition would increase. The range of possible streamtube widths varies from the current 461 meters (1513 feet) down to 61 meters (200 feet) for a west to east flow direction, which although unlikely, could potentially occur if the aquifer did not recede to south of the burial ground and was still present under the site.

Streamtube depths of 2.5 and 5 meters (8.2 to 16.4 feet) were used to model the current and wetter conditions respectively. The modeling did not allow mixing of water between the streamtube and adjacent water in the aquifer at locations downgradient (downstream) of the burial ground (i.e., no dissipation of the lead plume by spreading out).

Washington State, in their Dangerous Waste Regulations, Chapter 173-303, established a 50 parts per billion groundwater protection standard for lead under subsection 645, Releases from Regulated Units (treatment, storage, and disposal of dangerous wastes) (WAC, 1993).

Under current climate conditions, lead was not predicted to migrate to the 100 meter well for about 2.2 million years. Transit time through the soil column between compartments and aquifer accounted for almost all of this time (within 1000 years). Peak concentrations of lead in the aquifer at the 100 meter well occurred shortly after 2.2 million years and were estimated at 4 parts per billion.

Under the postulated wetter condition (10 times current recharge assumed), lead was not predicted to migrate to the 100 meter well for about 240,000 years. Transit time through the soil column between compartments and aquifer accounted for almost all of this time (within 1000 years). Peak concentrations of lead in the aquifer at the 100 meter well occurred shortly after 240,000 years and were estimated at 43 parts per billion.

Migration to the Columbia River was predicted to occur in about 2.8 million years under assumed current climate conditions and 740,000 years under the postulated wetter climate condition with river lead concentrations remaining below $1x10^{-7}$ parts per billion.

Refinements in hydrological modeling developed for the nickel migration study (PNL, 1994a) were applicable to the earlier lead migration study and would reduce predicted concentrations even further if incorporated. Nevertheless, lead was not predicted to reach the groundwater aquifer under the 218-E-12B burial ground for about 240,000 years even under the conservative modeling used. For comparison, the recorded history of human civilization is less than ten thousand years, and it is likely that human and geologic events occurring over the predicted time frame would result in impacts to the environment of a far greater nature.

4.3.3.3.2 Extrapolation of Pacific Northwest Laboratory Lead Migration Study

The results from the Pacific Northwest Laboratory lead migration study (PNL, 1992) were extrapolated by the Navy (USN, 1995) to consider the cumulative effects of all cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments at the 218-E-12B burial ground. A total of 220 reactor compartments at the 218-E-12B burial ground were considered in the extrapolation for a conservative estimate of combined impact (pre-LOS ANGELES Class under the current disposal program plus the 100 reactor compartments being considered under this final EIS). The extrapolation also incorporated a few refinements from the Pacific Northwest Laboratory nickel migration study (PNL, 1994a). A more accurate estimate for the area occupied by each compartment in the original 120 unit array (i.e the area contacted by recharge water) and a more accurate aquifer streamtube depth under the burial ground for the postulated wetter condition were incorporated. Consequently, extrapolated lead concentrations for the wetter condition were lower for 220 reactor compartments vice the 120 reactor compartments modeled in the lead migration study (PNL, 1992). Migration time did not change. The detailed extrapolation study is documented in a Navy study (USN, 1995) and is summarized below.

For the extrapolation (USN, 1995), the 220 compartments were modeled in two parallel and adjacent arrays of 120 and 100 compartments each, Figure 4.4. Based on CFEST predictions from the lead and nickel migration studies (PNL, 1992, PNL, 1994a) this array configuration would introduce lead from both arrays into essentially the same stream aquifer streamtube flowing under the burial ground and thus represents a worst case for the combined effect of the pre-LOS ANGELES and cruiser, LOS ANGELES, and OHIO class compartments. The combined total of 220 units could be treated as a single large lead source. Consequently, the compartments were modeled with average lead quantities, consistent with the modeling conducted in the lead migration study (PNL, 1992). The average lead quantities used by Pacific Northwest Laboratory provided a conservative estimate of the total quantity of lead that would be present at the 218-E-12B burial ground after the addition of cruiser, LOS ANGELES, and OHIO Class submarine reactor compartments. Thus the quantities used in the Pacific Northwest Laboratory work were conservatively applicable to the extrapolation as well.

Migration times as predicted in the lead migration study (PNL, 1992) were not affected by the extrapolation as the two arrays would not be considered by the modeling employed to release lead into the same vertical soil column.

During the course of the nickel migration study (PNL, 1994a) which used the same aquifer modeling as for the earlier lead migration study (PNL, 1992), it was realized that, for the wetter climate scenario, a stream tube depth of 5 meters (16.4 feet) should have been used vice the 2.5 meter (8.2 feet) depth originally used in the lead study. In addition, the lead migration study (PNL, 1992) assumed that all water contacting a 15.2 meters (50 foot) square area contacted a reactor compartment (which actually occupied about 60% of this area). The nickel migration study subsequently used a more accurate package size. These refinements are applicable to the original lead study (PNL, 1992) and have been incorporated into the extrapolation process.

For 220 reactor compartments in the adjacent array configuration, under current climate conditions, peak lead concentration in the groundwater would be below 3 parts per billion (2.2 million year migration time). Under the postulated wetter condition, using the upper envelope transport parameters, peak lead concentration would be 0.026 mg/L or 26 parts per billion (240,000 year migration time). Transport to the Columbia River was predicted to occur in about 2.8 million years under assumed current climate conditions and 740,000 years under the postulated wetter climate condition with river water lead concentration remaining below 1×10^{-8} milligrams per liter (much less than one part per trillion, a value far too low to even detect).

Part 141 of the Code of Federal Regulations, Title 40 "Environment" (40CFR141) provides an "action level" of 15 parts per billion requiring public water systems (25 or more people) to treat their water (e.g. filtration) to reduce lead levels when the action level is exceeded. The extrapolated 3 part per billion prediction for 220 compartments under current climate conditions was much below this action level. The action level was exceeded somewhat for the postulated wetter condition modeled, however, this condition involved a recharge rate 10 times that used to model the current climate condition at the burial ground. Recharge would have to increase some seven times over current climate assumptions to cause the 15 part per billion action level to be exceeded. In addition, the transport time for lead was a minimum of 240,000 years. For comparison, the recorded history of human civilization is less than ten thousand years, and it is likely that human and geologic events occurring over the predicted time frame would result in impacts to the environment of a far greater nature.

As discussed previously, Washington State, in their Dangerous Waste Regulations, Chapter 173-303, established a 50 part per billion groundwater protection standard for lead (WAC, 1993). This standard was not reached by predicted concentrations.

The results of the extrapolation study (USN, 1995) can also be considered to bound the option of obtaining additional trench capacity by placing reactor compartments within Trench 94 closer together than currently done. The extrapolation study employed a 150 square meter (1650 square foot) "storage area" per reactor compartment. Recharge passing through this area was assumed to contact the reactor compartment and exit saturated with lead. The released lead was then assumed to migrate vertically downward within a column of soil defined by this "storage area" and the depth to the vadose zone. The 150 square meter (1650 square foot) area of trench floor is considerably smaller than the 230 square meter (2500 square foot) area of trench floor currently claimed per reactor compartment. Thus, placing reactor compartments closer together would not affect predicted lead migration times as the lead released from one reactor compartment would not enter a soil column receiving lead from another compartment. The 150 square meter (1650 square foot) storage area is consistent with modeling refinements adopted by Pacific Northwest Laboratory in the more recent nickel migration study (PNL, 1994a). Also, predicted groundwater concentrations and resulting user doses would not be affected by the closer spacing of reactor compartments. The Pacific Northwest Laboratory modeling treated the entire array of reactor compartments as a single lead source to the aquifer. The extrapolation study used a 457 meter (1500 foot) streamtube width for that portion of the aquifer receiving lead from the reactor compartments above. Figure 4.2 would also represent the closer spacing of reactor compartments at Trench 94 except that the resulting array and streamtube width would actually be a little larger than shown. A larger streamtube width would result in lower predicted concentrations and doses.

4.3.3.3.3 Polychlorinated Biphenyls (PCB)

Pre-LOS ANGELES Class reactor compartment packages contain polychlorinated biphenyls (PCBs) in a solid form, tightly bound within the matrix of industrial materials (e.g., rubber, thermal insulation) but at levels greater than 50 parts per million, thus requiring regulation of the reactor compartment disposal under the Toxic Substances Control Act (TSCA). The maximum cumulative concentration of the PCB formulations found in reactor compartments that can be dissolved in water is 0.015 milligrams per liter. However, these PCBs are part of the formulation of solid materials within the reactor compartments and are tightly bound in the material's matrix. In this form the PCBs are not measurably soluble and cannot be removed by wipe sampling methods on a PCB bearing material surface even when using organic solvents (e.g., isooctane). Thus, the release of the PCBs would be over a long period of time as the parent materials break down.

Production of PCBs was banned in 1979 pursuant to the Toxic Substances Control Act, however, they have been found at greater than 50 parts per million in ship's materials dating to as late as 1983. LOS ANGELES and OHIO Class ships were constructed both before and after this time frame (cruisers - before) and thus some compartments may not contain solid PCBs while others may contain several pounds of solid PCBs (typically less than 10 pounds). Based on the common design characteristics of the reactor plants and their reactor compartments and a general comparison of ship's materials to earlier classes, when PCBs are present, they are expected to be in the same form and materials as for the pre-LOS ANGELES reactor compartments.

At the 218-E-12B burial ground, the PCB bearing materials would be sealed within the strong, all welded steel containment of the reactor compartments which would not be breached by corrosion for hundreds of years. Even when the PCBs could ultimately escape the compartments, the bound nature of the PCBs and low water solubilities would severely restrict the release of PCBs from entering the food chain or being consumed by humans.

Upon release from the compartments, the minimum migration time to the aquifer for the trace amounts of PCB that may be present would be the same as the time required for the groundwater to travel through the soil from the compartments to the aquifer. Pacific Northwest Laboratory predicted a 50 year groundwater travel time under a postulated wetter climate and about 500 years for the current climate (PNL, 1992, PNL, 1994a). Soil adsorption would occur to a degree, retarding the movement of PCBs through the soil to longer times than indicated above. Using the aquifer/transport modeling from the lead and nickel migration studies (PNL, 1992, PNL, 1994a), if 1/2 the recharge water contacting the compartment were very conservatively assumed to dissolve PCBs from industrial materials at the solubility limited PCB concentration (15 parts per billion total), downstream concentrations of PCBs in the aquifer would be less than 0.5 part per billion (total PCB) for the postulated wetter condition and less than 0.1 part per billion for the current climate.

The Environmental Protection Agency, under the National Primary Drinking Water Standards provides a Maximum Contaminant Level (MCL) of 0.5 parts per billion for PCBs in community and non-community water systems serving 25 or more people (40CFR141). The Environmental Protection Agency states that drinking water which meets this standard should be considered safe with respect to PCBs (40CFR141). It can be concluded then that PCBs in the reactor compartments would not pose an unreasonable risk to human health or the environment.

4.3.3.4 Migration of Other Constituents

Reactor compartments also contain significant quantities of iron and chromium in the structural steel and corrosion resisting alloys of the reactor compartment and surrounding structure. In many cases the same chromium based stainless steels present in compartments are used for high quality cooking utensils and other food preparation purposes. These metals do not affect the reactor compartment waste designation under the Washington State criteria of WAC 173-303 (WAC, 1993). However, these metals are regulated in Federal or state drinking water or groundwater standards. These metals will slowly corrode and be released to the environment where they would become available for migration to the underlying aquifer. This process may require millions of years to complete for the more corrosion resistant alloys. The corrosion performance of these metals is further discussed in section 4.3.3.2.1.1. The corrosion performance of the compartments is also discussed in Appendix B. The following paragraphs discuss the potential impact of these metals.

4.3.3.4.1 Chromium

Chromium is found in the environment in three major states - trivalent chromium (Cr^{3+}) compounds, hexavalent chromium (Cr^{6+}) compounds, and metallic chromium (Cr^0). The first of these is naturally occurring and the latter two produced primarily by industrial processes.

Hexavalent chromium has a health effect as an irritant, with short-term high-level exposure potentially resulting in ulcers of the skin, irritation of the nasal mucosa, perforation of the nasal septum, and irritation of the gastrointestinal tract. Hexavalent chromium may also cause adverse effects to the kidney and liver. On the other hand, trivalent chromium does not result in these effects. Trivalent chromium is considered to be an essential nutrient that helps to maintain normal metabolism of glucose, cholesterol, and fat in humans, with a daily ingestion of 50-200 micrograms estimated to be safe and adequate. Long term exposure to airborne chromium has been associated with lung cancer in workers, with hexavalent chromium substances regarded as the probable cause of these cancers based on animal studies. Long term studies in which animals were exposed to low levels of chromium compounds, particularly trivalent chromium compounds in food or water have not resulted in harmful health effects (ATSDR, 1989).

EPA regulates total chromium (trivalent chromium and hexavalent chromium) in drinking water based on the toxicity of hexavalent chromium, establishing a maximum concentration limit of 0.1 mg/l (Federal Register, Volume 56, 3536, January 30, 1991). The State of Washington has established a chromium ground water concentration limit of 0.05 mg/l, Table 1, WAC 173-200.

The long term corrosion of metallic chromium containing steels buried in Hanford soils would be expected to result in trivalent chromium compounds, most likely in the form of relatively insoluble hydroxides such as $CrOH_3$ and $FeOH_3$. Soluble trivalent chromium would be expected to adsorb onto soils with soil retention similar to that for nickel due to similar chemical properties. The production of toxic hexavalent chromium compounds would not be expected to occur in the Hanford soil and groundwater chemistry since, with the exception of the manganese oxides and dissolved oxygen, there are no other generally occurring inorganic oxidants that conceivably could oxidize trivalent chromium to hexavalent chromium in most waste materials and soils (EARY and RAI, 1987). Furthermore, ferrous ions rapidly reduce hexavalent chromium to trivalent chromium, tending to limit chromium solubility in water to less than 10^{-6} moles/liter (0.05 mg/L) at the chromium source for pH between 4 and 12 (Eary and RAI, 1989). The amount of MnO_2 in Hanford soils is small and the quantity of iron from the packages would be large. Thus, the presence of hexavalent chromium from metallic chromium corrosion would not be anticipated, and it can be concluded that the chromium content of the alloys in the reactor compartments would not be expected to pose any risk to future populations.

In addition to metallic chromium, a small amount of corrosion inhibitor, potassium chromate, would be dissolved in residual liquids present in reactor compartments. Potassium chromate contains hexavalent chromium. Under the WAC 173-303 (Dangerous Waste Regulations), the non-regulated limit for potassium chromate is 0.01% of the weight of the waste. For reactor compartments considered in this EIS, this limit would range from about 127-181 kilograms (280 to 400 pounds) per compartment, depending on the class. Actual quantities of potassium chromate remaining in cruiser, LOS ANGELES Class and OHIO Class submarine reactor compartments are not expected to exceed 1 kilogram (2 pounds) of chromate contained in residual potassium chromate solution that cannot be drained.

The potassium chromate would be contained in a tank within the thick hull and structure of the compartments which is conservatively predicted to provide containment for 600 years (DOE, 1992a). Absorbent would be added to the tank that contains the chromated water, in sufficient quantity to absorb twice the volume of water present, thus once exposed to soil, little potassium chromate may be released. If all of the chromated water at the 218-E-12B burial ground could be simultaneously released, this would represent less than 10% of one year's recharge through the area occupied by the reactor compartments under the current dry climate condition and less than 1% under a potential future wetter condition modeled by Pacific Northwest Laboratory in their lead and nickel migration studies (PNL, 1992, PNL, 1994a).

As discussed previously, ferrous ions, from the corrosion of iron, rapidly reduce hexavalent chromium to trivalent chromium and limit total chromium solubility at the source to a value less than the WAC standard of 0.05 mg/L for a pH range encompassing burial site conditions. The concentration in the underlying ground waters would be even lower. Corrosion of compartment hull steels would produce a ready supply of iron corrosion products (ferrous ion). Any hexavalent chromium that remained may also undergo a soil adsorption process, however, soil retention could be lower than for trivalent chromium due to the anionic nature of the chromate ion. Regardless, given the conditions discussed above, hexavalent chromium would not be found in sufficient quantity to pose a significant risk to future populations.

From this information it is considered that there is little reason to be concerned about an adverse effect of chromium from the reactor compartments on the Hanford environment, or upon the health of future populations.

4.3.3.4.2 Iron

Iron and its oxides are essentially non toxic and non carcinogenic. Iron is an essential human nutrient, being a constituent of hemoglobin, an important factor in cellular oxidation mechanisms. Because of aesthetic effects (noticeable bitter astringent taste and pronounced staining problems at 1.0 mg/l), EPA has listed iron as a secondary contaminant, with a limit of 0.3 mg/l in drinking water (Federal Register Volume 44, 42200, July 19, 1979). Based on the Federal guideline, the State of Washington lists iron as a secondary contaminant with a limit of 0.3 mg/l in groundwater.

From this information it is considered that there is little reason to be concerned about an adverse effect of iron from the reactor compartments on the Hanford environment, or upon the health of future populations.

4.3.3.5 Cumulative Impacts

There are no cumulative impacts specifically associated with the preferred alternative at the Shipyard. Because the radiation dose to the public is insignificant during transportation, there would be no cumulative transportation impacts.

The cumulative radiation dose to the shipyard workers to perform the preferred alternative of permanent land disposal at the 218-E-12B Low-Level Burial Ground at Hanford is estimated to be 8 to 20 rem (0.003 to 0.008 additional latent cancer fatalities) per reactor compartment package. The total radiation dose for the 100 reactor compartments under study in this EIS is estimated at 1018 rem (0.4 additional latent cancer fatalities).

The Hanford Site has procedures and controls to ensure the protection of individuals during site operations. The reactor compartment disposal packages typically would have exterior radiation levels of less than 1 mrem/hr on contact at the time of placement for burial. Areas with higher radiation levels would be typically found under the compartments and would have standard radiation markings. After 10 years, radiation levels would be reduced by a factor of 4. Within 50 years after placement for burial, typical exterior radiation levels at the compartment surface would be reduced to less than 0.002 mrem/hr with all contact levels less than 0.1 mrem/hr. The highest contact radiation levels would be found under the compartments where contact with the surface is improbable. Backfill placed over the compartments upon burial would effectively prevent direct contact and significantly reduce radiation levels. For comparison, radiation levels measured at Hanford in 1993 from fixed monitoring devices, were a maximum of 14,640 mrem/yr within the 100-N area and 1,100 mrem/yr at a tank farm in the 200 East area (PNL, 1994c). Contact readings at "hot spots" within these facilities would likely be higher. The present locations of the low-level radioactive waste burial grounds and other waste management facilities at the Hanford Site have already impacted the local environment. Given the conditions discussed above, additional impacts to Hanford workers and the environment from external radiation emitted by reactor compartment disposal packages are expected to be minimal.

The potential for cumulative impact would be from the addition of the cruiser, LOS ANGELES Class, and OHIO Class reactor compartments to the waste already at the Hanford burial grounds, or waste planned to be buried at Hanford. However, the cumulative impact from the addition of these reactor compartments to the Low Level Burial Ground at Hanford will be delayed for long periods of time, possibly long after the impacts from the other activities at Hanford have dissipated.

A comparison of the Hanford radioactive waste (DOE, 1991) and the reactor compartment waste shows differences. The Hanford radioactive wastes resulted primarily from the plutonium production process. The radioisotopes are predominantly strontium-90 and cesium-137 which will decay away relatively rapidly, leaving after 1000 years iodine-129, technetium-99, uranium-238, plutonium-239, 240, americium-241, and carbon-14 as the significant radionuclides of concern.

For the initial several hundreds of years following burial, Hanford generated strontium and cesium will be undergoing decay, while the reactor compartment radioactivity will be isolated from the environment by the heavy walled disposal package. The piping and equipment inside the reactor compartment would provide additional isolation for this radioactivity after the package is breached. Short lived radionuclides would thus decay prior to radioactivity being released to the environment and would not be additive to Hanford waste. Long lived radionuclides would be further isolated within the reactor vessel internal structure (discussion in Appendix B). Very low corrosion rates for this structure would restrict the release of this activity (e.g. less than 0.2% of the initial carbon-14 inventory would ever be released to the environment prior to decay). Soil adsorption effects would delay the migration of long lived activity allowing for further decay (e.g. 66,000 years for nickel-59 to reach the groundwater under wetter conditions). Only carbon-14, technetium-99, and trace amounts of iodine-129 are common to both Hanford waste and reactor compartments.

The potential impacts resulting from reactor compartment radioactivity are very small and in the far distant future. The major isotope of concern, nickel-59, would not migrate to groundwater for at least 66,000 years, and then only in a quantity so small that any resulting health effects would be insignificant compared to those resulting from other causes including normal background radiation. Also, reactor compartment contaminants would only enter the narrow aquifer streamtube passing under the reactor compartment burial trenches and would only be additive to other contaminants that could enter the same streamtube (which would exclude most Hanford radioactive waste). Columbia River impacts in the future could be additive, but the reactor compartment component would be vanishingly small.

The cumulative effect of the reactor compartment lead shielding with other hazardous metal constituent sources, including lead which may have been buried at the Hanford Site, would not shorten the very long times (over 240,000 years) calculated for lead in the reactor compartments to migrate to the aquifer. The disposal of additional lead at the Hanford Site, such as from the Hanford production reactors (DOE, 1992b) would not change this conclusion. Initially, migration is through the vadose zone at the Navy reactor compartment burial site. The direction is essentially downward (vertically), so that interference from another source elsewhere on the site is unlikely, even if within the 200 East area. Also, once through the vadose zone, Navy reactor compartment lead would only enter the aquifer streamtube passing under the reactor compartment burial site and would only be additive in terms of dissolved concentration to other contaminants that could enter the same streamtube. The streamtube under the Navy reactor compartment burial is shown by modeling to only be under a portion of the 200 East area. No significant lead quantities are expected to be disposed at the 200 East area. Also, the streamtube does not flow under 200 West area, which is a potential disposal location for the Hanford production reactors.

Columbia River impacts in the future could be additive, but the reactor compartment component would be vanishingly small. Similarly the small volume of PCBs released over very long time frames would have negligible impact in the large 200 East area burial grounds.

The cumulative impact of the preferred action was also evaluated against the performance criteria of DOE Order 5820.2A issued September 26, 1988 (DOE, 1988). This Order requires that DOE low-level waste disposed after the issuance of the Order shall be managed to "assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, ground water, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public." DOE requires that the 25 mrem dose shall not be exceeded for at least 1,000 years after disposal (DOE, 1990). The contribution to the dose from the reactor compartments would be essentially zero during this time, therefore there would be no cumulative impact as determined by the requirements of the DOE Order. Furthermore, if long-lived radionuclides from the reactor compartments ultimately migrates to the aquifer and the Columbia River, any resulting dose to the maximally exposed person would be below 25 mrem per year.

In view of the foregoing, there will be no significant cumulative impact on the Hanford site from disposal of the cruiser reactor compartments, LOS ANGELES Class submarine or OHIO Class submarine reactor compartments.

4.3.4 Potential Air and Water Quality Effects

Operations that would be conducted in connection with the Preferred Alternative would not be expected to have an impact on air resources. Work practices and precautions at the Shipyard would be in accordance with applicable Shipyard directives to minimize the discharge of air pollutants. Work associated with the preferred alternative would be performed such that the Shipyard air [discharge] permit and the regulations of the Puget Sound Air Pollution Control Authority would not be violated. At the Hanford Site, the Department of Energy would meet applicable regulations regarding the maintenance of air quality. Facility construction work, such as earth moving, could negatively impact air quality through the emission of fugitive dusts and pollutants from diesel and gasoline powered equipment. The increase in off–site ambient levels would be small because of the large distance to the nearest public access, and the use of control measures when necessary, such as water spray to contain dust. Pollutants from the transport of reactor compartments to the Hanford Site would be generated from moving sources, diluted across large areas, with the result being de–minimus (non–significant) with respect to regional air quality.

Operations that would be conducted in connection with the Preferred Alternative would not be expected to have an impact on water resources. Shipyard operations would be performed under a National Pollution Discharge Elimination System (NPDES) permit. Procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment. Shipyard spill prevention and spill contingency directives would be in effect. Secondary containment for containers of hazardous waste would be built into storage facilities for this waste. Procedures used for water and land transportation of the cruiser, LOS ANGELES, and OHIO Class reactor compartment disposal packages would be designed to minimize the potential for accidents and to mitigate the consequences of potential accidents. The reactor compartment disposal packages would provide a durable containment for hazardous and radioactive constituents, which would not be readily released even if exterior package containment were to be breached.

Groundwater monitoring would be conducted at the 218-E-12B burial ground as part of site operations through a system of Resource Conservation and Recovery Act compliant groundwater monitoring wells already in place along the burial ground boundary. In addition a Resource Conservation and Recovery Act compliant cover would be placed over the disposal packages after burial of all packages to reduce the infiltration of moisture from the surface. The Hanford Site is not located above a "sole source aquifer" as designated in the provisions of the Safe Drinking Water Act (40CFR149). Regardless, as discussed in previous sections, impacts on water resources from the Preferred Alternative would be minimal, occurring only after the long periods of time required for corrosion and groundwater migration processes to occur.

4.3.5 Socioeconomic Impacts of the Preferred Alternative

The preferred alternative involves no socioeconomic change in any of the involved regions since it merely continues the type and volume of work already on-going for pre-LOS ANGELES Class reactor compartment disposal work.

4.4 No Action - Indefinite Waterborne Storage at Puget Sound Naval Shipyard and Norfolk Naval Shipyard

A conceptual plan to provide the additional space needed for indefinite waterborne storage of the defueled cruisers, and later class submarines has been developed, taking into account the fact that since such storage would occur after the vessels have been defueled, the stringent and onerous requirements that would otherwise apply to ensure safe storage with spent fuel aboard can be avoided. Specifically, there is no need to have a large portion of each vessel's crew remain assigned to ensure vessel upkeep, and to ensure reactor plant conditions are maintained for spent fuel safety. Further, there is no need to operate ship systems for that purpose, which avoids the need to consume shore supplied services such as electricity and pure water.

Figure 4.5 shows a conceptual mooring layout for the defueled ships that could be placed in indefinite waterborne storage at Norfolk Naval Shipyard at the existing inactive nuclear ship mooring facility, Pier E. Pier E would have to be modified and upgraded to accommodate the proposed berthing arrangement. Some repairs to the existing structure may be required to strengthen the piers to accept the increased breasting loads from the nests of ships over a long period. A complete inspection above and below the pier decks and underwater would be required to determine the full scope and cost of the required work.

The most significant work required to accommodate the storage of the proposed ships is dredging. Current depths between the piers range from approximately 17 feet to 23 feet. These drafts are insufficient for the proposed ships with drafts ranging from 24 feet to 33 feet. The latter draft is

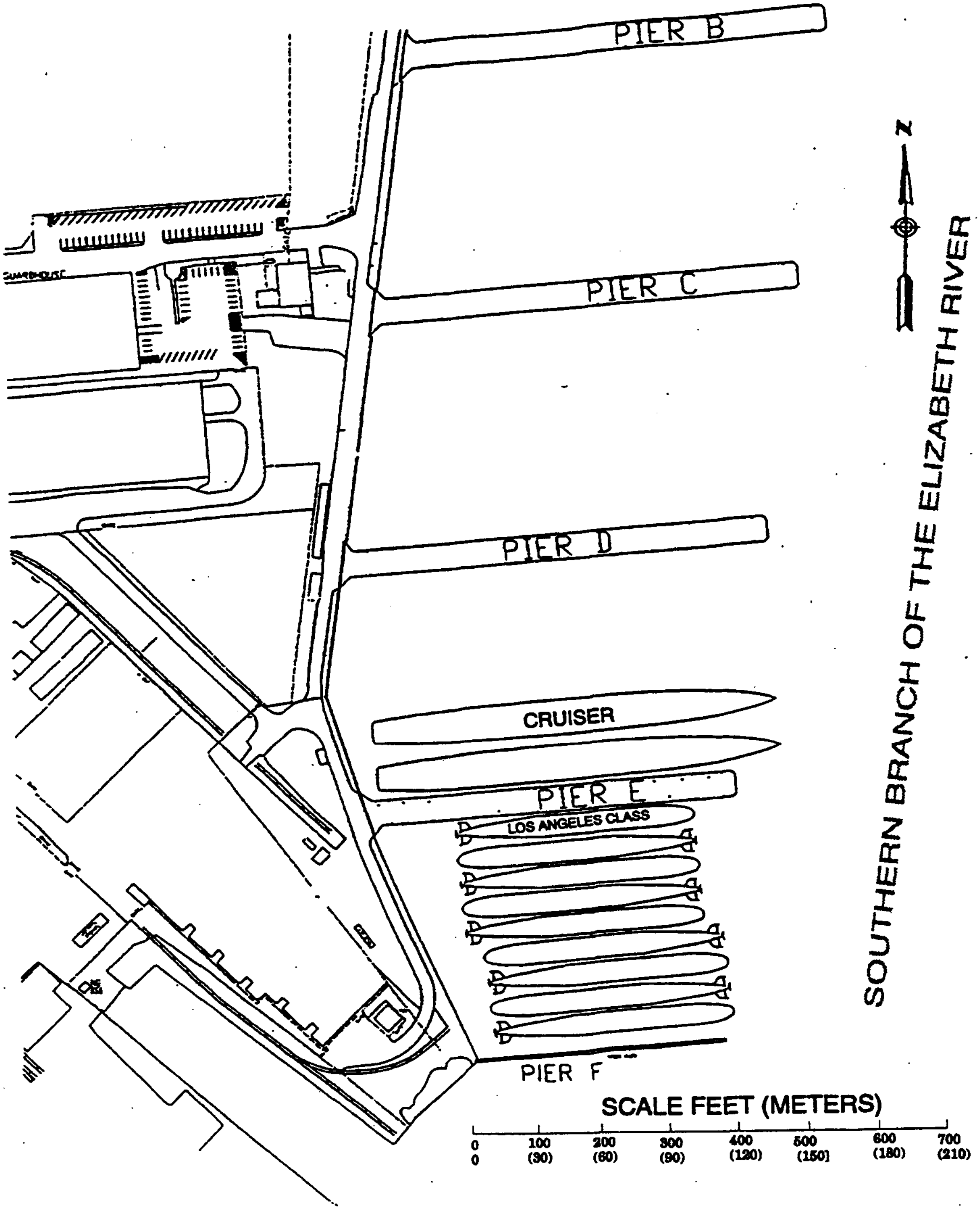


Figure 4.5. Norfolk Naval Shipyard Conceptual Mooring Arrangement at South Gate Annex

for OHIO Class submarines. To minimize the amount of dredging required, it might be possible to store all defueled OHIO Class submarines at Puget Sound Naval Shipyard where deeper draft storage is available without dredging.

Past soundings have indicated sedimentation at the rate of three inches per year in the Norfolk area. Ships in inactive status are dry docked approximately every 15 years for hull preservation. Dredge depth would be established to allow for 45 inches of sedimentation between dredgings to preclude having to move the ships between the planned hull preservation periods. One foot depth would be added to allow for variations due to trim and one foot added for absolute under-hull clearance. Dredging depths would have to be the maximum hull drafts plus six feet (measured at low tides). These depths would be 30 feet for cruisers, and 33 feet for LOS ANGELES Class submarines. An estimated cost for the initial dredging would be $1.1 million to remove approximately 165,000 cubic yards of material. Maintenance dredging at 15 year intervals would require removal of only about 50% as much material. This amount of dredging is based on having any defueled decommissioned OHIO Class submarines at Puget Sound Naval Shipyard and defueled decommissioned cruisers and LOS ANGELES Class submarines at both Puget Sound and Norfolk Naval Shipyards.

At Norfolk Naval Shipyard, no long term adverse environmental impacts due to the required dredging are anticipated. Dredging is routinely performed in this area with no known adverse effects. The Virginia Marine Resources Commission functions as the point of contact for all dredging permitting actions at Norfolk Naval Shipyard. They receive permitting applications and in turn notify and coordinate the involvement of all other regulatory and oversight agencies. These agencies are the U.S. Army Corps of Engineers, the Virginia Department of Environment, the Wetlands Board of the City of Portsmouth, and the State Environmental Protection Agency. Norfolk Naval Shipyard maintenance dredging permits specify Craney Island as the disposal site for dredge spoils. It is anticipated that a permit for deepening the berths at the Southgate Annex north and south of Pier E would similarly specify Craney Island as the disposal site because it is the only active disposal site in the area. The Craney Island spoils area is available to accept any dredge spoils removed from the Hampton Roads Basin (of which the Southgate Annex is a part). Craney Island currently receives approximately 3,500,000 cubic yards of dredge spoils from the Hampton Roads area annually. Approximately 1,000,000 cubic yards of dredge spoils are from dredging at naval facilities in the area. The dredge spoils from this project would make up less than 1/3% of the total dredge spoils received on an annual basis.

At Puget Sound Naval Shipyard no dredging is expected as a result of this alternative because the sediment rate in the area is less than one foot per 50 years.

At Norfolk Naval Shipyard, required modifications to accommodate the proposed ships would include the installation of high capacity fixtures for tying off mooring lines and replacement of the existing bumpers with a new bumper system. The total estimated cost of repairs and modifications is approximately $850,000. The existing utilities on Pier E should be adequate to accommodate the proposed inactive ships.

Figure 4.6 shows a conceptual mooring layout for indefinite water borne storage at Puget Sound Naval Shipyard. The current inactive nuclear-powered ship moorage facility could be used to berth approximately 32 defueled LOS ANGELES Class submarines with space for three larger defueled ships, either cruisers or OHIO Class submarines or a combination of both. Other mooring configurations and mix of ships would be possible but based on space requirements, roughly two defueled LOS ANGELES Class submarines can be berthed in place of one defueled cruiser or OHIO Class submarine.

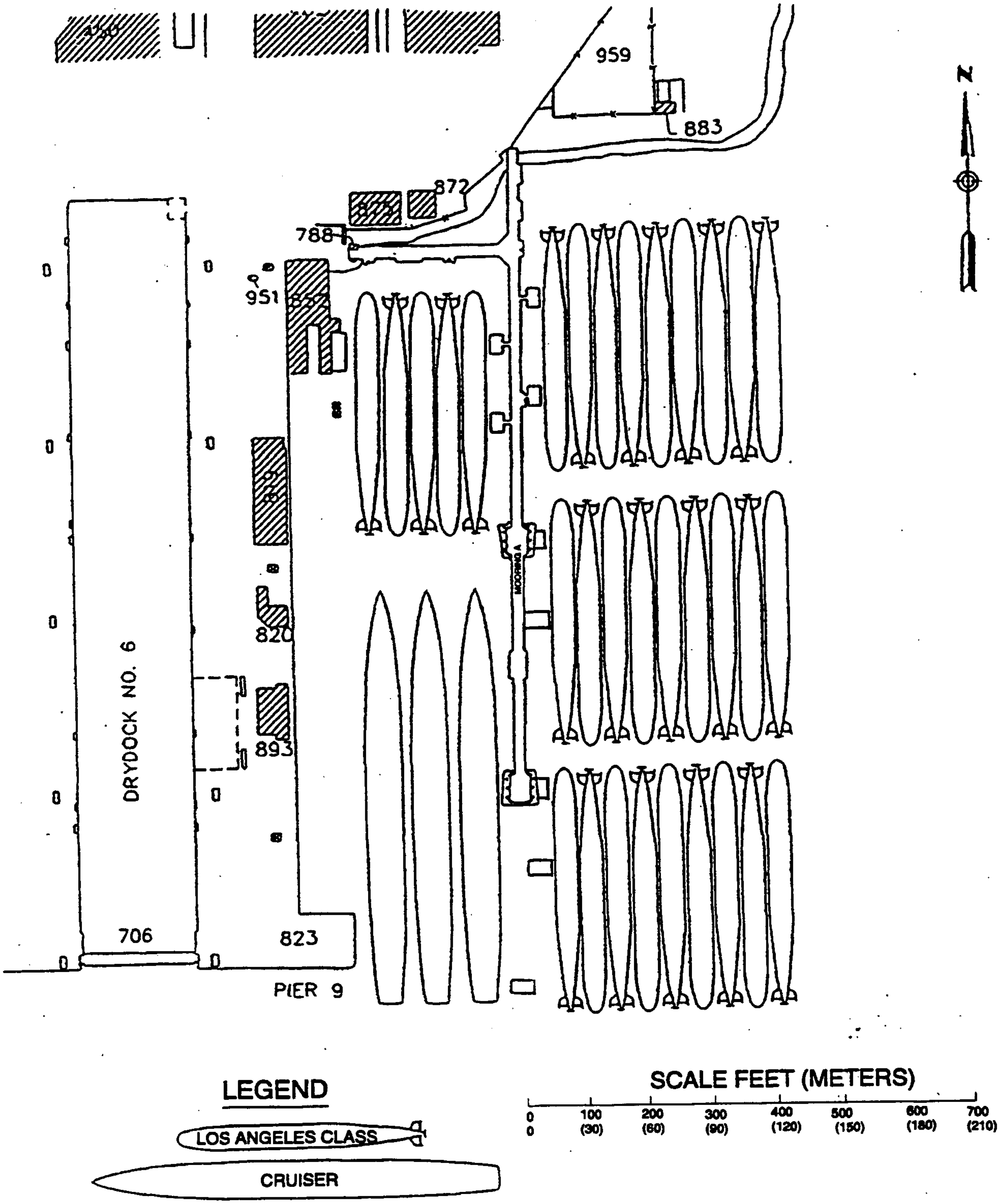


Figure 4.6. Puget Sound Naval Shipyard Conceptual Mooring Arrangement

The existing inactive nuclear-powered ship mooring facility at Norfolk Naval Shipyard and Puget Sound Naval Shipyard would accommodate nearly half of the ships considered by this EIS. This would be adequate to handle the cruisers and submarines inactivated until after the year 2000. At that time, some action would be needed to accommodate additional ships.

This evaluation does not include maintenance costs for the facilities at either shipyard since there is no change in the use of these areas for storage. Although maintenance would be required, it is primarily a result of weather and time and not directly connected to the use of the facilities. Any maintenance required would not be increased by using the facility as indefinite waterborne storage sites. Actual maintenance requirements may be less due to the low activity at the facilities.

Puget Sound Naval Shipyard lies within the usual and accustomed fishing area of the Suquamish Tribe. The activities at Puget Sound Naval Shipyard resulting from the no-action alternative would have no impact on the tribal fishing rights because the moorage would not be extended beyond the existing mooring areas of the shipyard.

Hull preservation would be accomplished at about 15 year intervals. The process would involve grit blasting and repainting the hulls with antifouling paint. This is a normal industrial operation and there are procedures in place at the Shipyards to dispose of used grit that are protective of the environment. This process of hull preservation will prevent any adverse impact on the water quality at either Puget Sound Naval Shipyard or Norfolk Naval Shipyard.

4.4.1 Socioeconomics Impact of the No Action Alternative

As part of the socioeconomic analysis it was assumed that no more than half of the Shipyard workforce would be dedicated to accomplish the work to prepare ships for indefinite waterborne storage. Personnel used to accomplish this work would be the same as those currently performing work in support of pre-LOS ANGELES Class reactor compartment disposal work. No new employees would be hired.

The cruisers and submarines can be placed in waterborne storage as soon as inactivation is complete. The limiting factor for this alternative is immediate availability of adequate storage facilities. The socioeconomic impacts in the Puget Sound Region result from Puget Sound Naval Shipyard workload decrease following completion of pre-Los Angeles Class reactor compartment disposal work.

This reduction in Shipyard workload would result in a loss of 5,253 jobs at Puget Sound Naval Shipyard. These jobs are postulated to result in a County/region population reduction of approximately 31,862 persons or 15%.

The loss of 5,253 jobs equates to 13,658 excess housing units. This is 18% of the housing units existing in 1990. The loss of jobs also equates to the loss of 7,880 school-age children from the schools in the region. School district studies indicate that a new school is required for every increase of 500 students. The postulated reduction in school-age population could require school closure with resultant loss of teacher, maintenance and administrator employment.

Since this alternative would not affect Norfolk Naval Shipyard's currently planned work, there would be no socioeconomic impact at Norfolk Naval Shipyard.

4.4.2 Extreme Natural Phenomena

The two Shipyards capable of protective waterborne storage are located in areas which experience relatively few extreme natural phenomena.

The credible flooding hazard for the Puget Sound Area would be from locally generated tsunamis and seiches. The system of straits and inlets surrounding Puget Sound provides a natural barrier for the Puget Sound Area, which effectively dampens the propagation of distantly generated tsunamis. The potential damage from tsunamis and seiches was found to be minimal by the Seismic Design Study for the Water Pit Facility at Puget Sound Naval Shipyard conducted by Shannon and Wilson, Inc. in December 1978 (STUDY, 1978). The principal hazard from a seiche is the same as that of a tsunami, which is flooding. Based on the historic record, the risk of a seismically induced seiche of magnitude to cause flooding at Puget Sound Naval Shipyard is highly unlikely. A more detailed description of the Puget Sound regional conditions is documented in the Seismic Design Study for the Water Pit Facility at Puget Sound Naval Shipyard (STUDY, 1978). These events would not significantly impact the waterborne storage of defueled, decommissioned cruisers, and LOS ANGELES Class and OHIO Class submarines because the methods to be used to moor the vessels would allow for these affects. Extreme weather conditions, such as thunderstorms, tornados, etc., rarely occur in the Puget Sound area.

There is no known fault line within 915 kilometers (3000 feet) of the Bremerton Naval Complex. There has been no known surface faulting in conjunction with earthquakes in the Shipyard vicinity. The potential hazards from volcanism for Puget Sound Naval Shipyard are minimal and limited to wind-borne volcanic ash. Both the distance from the Cascade vents and the configuration of the intervening topography exclude other volcanic products, such as lava flows and volcaniclastic units, from being hazardous to the site. Only ash from a "large" or "very large" eruption would potentially reach the site.

No major faults underlie the Tidewater region which includes Norfolk Naval Shipyard and the region is considered aseismic (SCIENCE, 1969). The 1980 eruption of Mount St. Helens, Washington, approximately 195 kilometers (120 miles) south of the Shipyard, resulted in a very slight coating of ash at the Shipyard. No volcanic hazards have been identified for Norfolk Naval Shipyard.

Hurricanes and other tropical storms are considered to be credible natural phenomena for Norfolk Naval Shipyard. However, the Shipyard is located south of the average path of storms originating in the higher latitudes and north of the usual tracks of hurricanes and other tropical storms. Norfolk Naval Shipyard is situated so that it is not susceptible to any significant wind generated waves from any direction. There are no long fetches of water that would result in significant wind generated waves. Norfolk Naval Shipyard is a recommended safe moorage location for small craft during gale force winds. The greatest threat at Norfolk Naval Shipyard from tropical cyclones is storm surge which can add several feet to the height of the usual tide. In the event of storm surge, the mooring lines of ships would be adjusted to preclude breaking.

North to northeast winds predominate during the winter months at Norfolk Naval Shipyard. Strong northeast winds and heavy rains could cause localized flooding of low-lying areas of the Tidewater region. Since the Chesapeake Bay is shallow, a strong northeast wind could move large amounts of water from the north end of the bay southward. When this elevated water level is combined with a high tide, flooding occurs. Added to this is the heavy rainfall and poor drainage due to the low elevation. High tide levels six to eight feet above normal could be experienced during major northeast winds. However, flooding at Norfolk Naval Shipyard is not considered to be a natural phenomena capable of impacting waterborne storage because the methods to be used to moor the vessels would allow for tidal affects.

Other natural phenomena are considered not possible or not capable of inflicting damage to these vessels should the decision be made to moor them at either Puget Sound or Norfolk Naval Shipyards.

4.4.3 Radiological Impacts

The radiation exposure rate at the surface of the hull of the cruisers, and defueled LOS ANGELES Class and OHIO Class submarines is generally below 1 mrem per hour; however, localized spots of elevated rates could exist. The designated storage areas would be within fenced and guarded areas at the two Shipyards; consequently, entry into the storage areas would be strictly controlled and Shipyard personnel would be monitored for radiation exposure, if entering radiation areas. Radiation levels above background levels would not be detected at the fence to the storage area, nor at the boundary of the shipyard.

The radioactivity contained in the defueled cruisers and LOS ANGELES Class and OHIO Class submarines is in the form of solid activated metal corrosion products and solid activated metal fully contained with the sealed reactor compartment. Initially the primary source of radiation is from solid activated metal corrosion products; but after an extended period of waterborne storage (over 20 years), the solid activated metal would become predominant. The solid activated metal corrosion products consist primarily of the relatively short lived, high energy emitting radionuclide cobalt-60 (5.3 year half-life, gamma emitter); while the solid activated metal is primarily long lived, low energy radionuclides such as nickel-59 and nickel-63 (nickel-59, 76,000 year half-life, X-rays; nickel-63, 100 year half-life, beta emitter). The radioactivity would not be readily releasable under the protective waterborne storage alternative because it is an integral part of the metal in the reactor compartment or is contained by the sealed reactor compartment; therefore, the general public could not be exposed to radioactivity under this alternative.

The radiation exposure dose to the general public is expected to be zero for this alternative. There is essentially no risk of radiation exposure to anyone in the general public as a result of protective waterborne storage of the defueled cruisers, and LOS ANGELES Class and OHIO Class submarines since the radiation dose rate outside the reactor compartments would be well below the federal transportation limits specified in Part 173 of Title 49, Code of Federal Regulations (49CFR173). Additionally, the storage areas would fenced and within the security confines of the Shipyard.

4.4.4 Hazardous Material Impacts

The inactivated, defueled, and decommissioned cruisers and LOS ANGELES Class and OHIO Class submarines are expected to contain regulated quantities of lead as shielding, asbestos, and solid PCBs which would be fully contained within the sealed reactor compartments. The OHIO Class submarines and most LOS ANGELES Class submarines are expected to contain much less asbestos and PCBs than earlier classes since they were built after these materials started to be removed from commerce. Sea connections would be blanked, ensuring the preservation of containment barriers such as the hull, and installing fire and flooding alarms. The designated waterborne storage areas would be within fenced and guarded areas of Puget Sound Naval Shipyard and Norfolk Naval Shipyard; consequently, entry into the storage areas would be strictly controlled. The general public is not expected to experience any exposure to hazardous materials from the waterborne storage alternative because the hazardous material would be contained by the ship's hull. Periodic preservation of the ship's hull would be performed to maintain the containment barriers.

4.4.5 Potential Air and Water Quality Effects

Operations that would be conducted in connection with the No Action Alternative would not be expected to have an impact on air resources. Work practices and precautions at the Shipyard would be in accordance with applicable Shipyard directives to minimize the discharge of air pollutants. Work associated with the preferred alternative would be performed such that the Shipyard air [discharge] permit and the regulations of the Puget Sound Air Pollution Control Authority would not be violated.

Operations that would be conducted in connection with the No-Action alternative would not be expected to have an impact on water resources. Shipyard operations would be performed under a National Pollution Discharge Elimination System (NPDES) permit. Procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment. Periodic preservation of the ship's hull and methods used for securing ships would maintain the containment barrier to keep contaminants out of the environment.

At Norfolk Naval Shipyard, no long term adverse environmental impacts due to the required dredging are anticipated. Dredging is routinely performed in this area with no known adverse effects. The Virginia Marine Resources Commission functions as the point of contact for all dredging permitting actions at Norfolk Naval Shipyard. They receive permitting applications and in turn notify and coordinate the involvement of all other regulatory and oversight agencies such as the U.S. Army Corps of Engineers, the Virginia Department of Environment, the Wetlands Board of the City of Portsmouth, and the State Environmental Protection Agency. Norfolk Naval Shipyard maintenance dredging permits specify Craney Island as the disposal site for dredge spoils. It is anticipated that a permit for deepening the berths at the Southgate Annex north and south of Pier E would similarly specify Craney Island as the disposal site because it is the only active disposal site in the area. The Craney Island spoils area is available to accept any dredge spoils removed from the Hampton Roads Basin (of which the Southgate Annex is a part).

At Puget Sound Naval Shipyard no dredging is expected as a result of this alternative because the sediment rate in the area is less than one foot per 50 years.

4.5 Disposal and Reuse of Subdivided Portions of the Reactor Plants.

4.5.1 Radiological Consequences

Radiological consequences include off-site exposure to the public and on-site exposure to workers. Off site exposure is discussed in Appendix E. On Site exposure is discussed in this subsection and Appendix C. For the subdivision alternative of this EIS, the exposures are considered to be bounded by actual exposures reported by DOE for decommissioning of the Shippingport reactor compartment and NRC estimates for commercial plants. The Shippingport pressurized water reactor was operated for the first time in December of 1957. During its lifetime it had three different cores that produced 68 MWe, 150 MWe, and 72 MWe respectively. The reactor plant operated for almost 25 years and produced over 84,000 effective full power hours of power. Operations were terminated in October of 1982. The reactor plant was subsequently dismantled and the site was certified for unrestricted use in December of 1989. Dismantling of the Shippingport reactor cost 155 rem of worker exposure (DOE, 1989c).

Estimated on site exposures to workers for the subdivision alternative are provided in Appendix C. The values are based on the 155 rem from dismantling of the Shippingport nuclear power plant, which began 3 years after operations ceased. NRC data tabulated in NUREG-0586 (NRC, 1988) for similar operations involving dismantling of a large, commercial pressurized water reactor are included for comparison. In order to be consistent with exposure estimates for the other alternatives, which do not include exposure received in the course of decommissioning operations, the estimates do not include exposures for decommissioning work.

These estimates involve a considerable amount of uncertainty. Based solely on the comparative sizes of the reactor compartments and relative amounts of radioactive waste to be processed, the subdivision alternative would require less radiation exposure per reactor compartment than Shippingport. The exposure estimate for subdividing the reactor compartments based on the Shippingport data is 22,500 person-rem (6,090 person-rem after 10 years). However the curie contents of the Naval plants are typically much higher than Shippingport. Also, the estimate based on NUREG-0586 is nearly five times the Shippingport based estimate. Per NUREG/CR-0130 (NRC, 1978) the estimated dose would be about the dose from three typical refueling and maintenance outages, which would be from 24,000 to 83,000 person-rem (6,440 to 22,300 person-rem after ten years). Therefore, worker exposure for the subdivision alternative is expected to be bounded by the Shippingport-based estimate on the low end and by the NUREG-0586 based estimate on the high end.

4.5.2 Waste Management Consequences

The subdivision alternative would generate toxic, hazardous, radioactive and mixed wastes. The most significant wastes would be asbestos bearing materials, PCB bearing materials and radioactive waste, including lead made radioactive by exposure of impurities in lead to neutrons during reactor operation. The subdivision alternative's adverse impacts are far greater than any of the other alternatives based on occupational radiation exposure at the shipyards without adding any of the potential impacts due to waste management at the disposal sites. Since detailed estimates of the waste management impacts of subdivided pieces would not affect the relative environmental ranking of the alternatives, a detailed analysis was not performed. For disposal of subdivided portions at Hanford, the long term radiological impacts should be similar to the whole reactor compartments since the amount of radioactivity and the physical characteristics of the disposal site would be the same. For a more humid site with a high water table, somewhat greater impacts would be expected, but still within the requirements of DOE Order 5820.2.

Decommissioning of the Shippingport pressurized water reactor compartment produced 6,060 cubic meters (214,000 cubic feet) of low-level radioactive waste that weighed 4,200 tons (DOE, 1989c). It was smaller than most commercial power plants and underwent dismantlement shortly after operations ceased. Consequently, results reported for the Shippingport Decommissioning Project are considered to be relevant to subdivision of Naval reactor compartments.

The volumes within the boundaries of reactor compartment packages from cruisers and LOS ANGELES class and OHIO class submarines would range from about 850 cubic meters (30,000 cubic feet) to about 2,150 cubic meters (76,000 cubic feet) and the weights of the packages would range from about 1,400 tons to 2,700 tons. Using these volumes and weights, an upper bound on the waste from subdivision can be determined. The volume of radioactive waste from subdivision of a single Naval reactor compartment should be about 13% to 36% of the Shippingport volume. The weight would be about 33% to 65% of the Shippingport weight. The volume and weight of radioactive waste from subdivision of a reactor compartment would be less than that of the corresponding intact package due to reductions achieved through reuse and consolidation.

The total quantity of waste that would be produced by the subdivision alternative can conservatively be bounded by the 120,000 cubic meter (4,240,000 cubic foot) combined volume of the various reactor compartments that are to be disposed of. The actual quantity would be less due to recycling and volume reduction. The 120,000 cubic meter (4,240,000 cubic foot) volume is 6% of the 2,005,000 cubic meters (70,800,000 cubic feet) of low-level waste that is projected to be buried at DOE sites in the 20-year period from 1996 to 2016 (DOE, 1994a, Table 4.2). It is estimated that from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet) of mixed and radioactive–PCB waste would be generated. This waste would consist of approximately 630 cubic meters (22,200 cubic feet) of activated shielding lead, from zero to 4,000 cubic meters (141,000 cubic feet) of insulating material and approximately 1,625 cubic meters (57,400 cubic feet) of other mixed waste, primarily solidified radioactive potassium chromate. This mixed waste would be managed in accordance with the approved Shipyard Site Treatment Plan developed pursuant to the Federal Facilities Compliance Act.

An intermediate estimate of radioactive waste volume for the subdivision alternative is based on the assumption that the entire reactor compartment structure and 75% of the shielding lead could be recycled. Large items, such as reactor pressure vessels, steam generators, pressurizers and coolant pumps would be disposed of in one piece, while smaller items would be disposed of in bulk containers. These assumptions result in an estimated radioactive waste volume of about 24,000 cubic meters (847,000 cubic feet).

The lower bound on the volume of radioactive waste for the subdivision alternative is about 10,000 cubic meters (353,000 cubic feet). This volume is based on the same assumptions as the intermediate estimate except it is assumed that the reactor pressure vessels, steam generators, pressurizers, coolant pumps and other metal components could be reduced to a solid mass by melting.

The NRC, in its Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities indicated that there could be a ten-fold reduction in the volume of radioactive waste if dismantlement of a commercial pressurized water reactor compartment was deferred 30 to 50 years (NRC, 1988, Table 4.4-1). Deferral of Naval reactor compartment subdivision by an equivalent amount of time would not result in any significant reduction in radioactive waste volume, however, largely due to Ni^{63}, which emits beta radiation, distributed throughout the interior of reactor plant systems. Ni^{63} has a half life of 100 years and will decay to only 81% and 71% of its initial levels after 30 and 50 years respectively. Therefore, items that are radioactive when plant operations cease will still be radioactive 30 to 50 years later.

Large quantities of recyclable lead and lead made radioactive by contact with radioactive material or by neutron activation would need to be processed. Disposition of this lead is discussed in Appendix A.

Foundry technology has recently been licensed which could be used to reduce the overall volume of waste metal from the subdivision alternative. The Navy has used the technology to process some Navy radioactive waste metals. In December of 1993, Norfolk Naval Shipyard awarded a contract for processing of radioactive waste, which included provisions for recycling of radioactively contaminated metals by foundry melting. The amount of metal involved was estimated to be 136,000 kilograms (300,000 lb). The contract precluded processing of mixed waste, transuranic waste, and Class B and Class C waste per 10CFR61. It has not been demonstrated that this technology is suitable for disposition of reactor vessels.

4.5.3 Transport

The subdivision alternative would involve the transport of an estimated 1571 packages from either Puget Sound Naval Shipyard or Norfolk Naval Shipyard to one or more appropriate disposal sites. Impacts along transportation routes that would be used are evaluated in Appendix E. Four origin-destination cases are evaluated (Puget Sound to Hanford, Puget Sound to Savannah River, Norfolk to Hanford and Norfolk to Savannah River). Since two of the cases are for origins and destinations on the same coast and two are for origins and destinations on opposite coasts, the evaluation is considered to bound shipments from either of the two origins (Puget Sound and Norfolk) to any disposal site within the 48 contiguous states.

4.5.3.1 Radiation Exposure from Normal Conditions of Transport

For normal conditions of transport (incident free), exposure to the general population is estimated to be 11 to 119 person-rem (0.00551 to 0.0597 latent cancer fatalities) and the maximum exposed individual in the general population is estimated to receive 1.28 to 1.73 person-rem (0.000638 to 0.000861 latent cancer fatalities. Exposure to the transportation crew is estimated to be 11.7 to 96.3 person-rem (0.00466 to 0.0386 latent cancer fatalities) and the maximum exposed transportation worker is estimated to receive 5.11 to 48.0 person-rem (0.00204 to 0.0192 latent cancer fatalities). Non-radiological fatalities are estimated to be from 0.00310 to 0.0334.

4.5.3.2 Accident Scenarios

For hypothetical accident conditions, when both the probability and severity of an accident are considered, exposure to the general population from radiological accidents is estimated to be from 0.0145 to 0.106 person-rem (0.00000724 to 0.0000532 latent cancer fatalities) and there are estimated to be from 0.0271 to 0.781 fatalities from non-radiological accidents. Assuming an accident actually does happen, the maximum consequences are estimated to be 0.287 rem (0.000143 latent cancer fatalities) to a maximum exposed individual and a collective dose to the exposed population of 3,643 person-rem (1.82 latent cancer fatalities).

4.5.4 Socioeconomics Impacts of the Land Disposal and Reuse of Subdivided Portions of the Reactor Plant

The following are the major assumptions made in performing the socioeconomic analysis of this alternative:

All ships have been previously inactivated and defueled.

No more than half the Shipyard Workforce would be dedicated to performing this work.

Overall Shipyard employment levels would not change.

Based on these assumptions, maximum throughput was determined to be a total of 3.11 per year (1.85 Puget/1.26 Norfolk). This throughput results in a minimum duration for the work of 32.2 years with the limiting factor being available workforce. This alternative involves no socioeconomic change in either of the shipyard regions since the work performed would neither increase nor decrease employment levels.

No socioeconomic impacts from the subdivision alternative associated with waste disposal sites were identified. Waste from the subdivision alternative would only be a small fraction of the volume of other waste that will require disposal during the same time period. Little or no change in employment levels or infrastructure would be anticipated.

4.5.5 Potential Water Quality Effects

Operations that would be conducted in connection with the subdivision alternative would not be expected to have an impact on water resources.

Shipyard operations would be performed under a National Pollution Discharge Elimination System (NPDES) permit. There would be the potential for a spill of hazardous waste or radioactive waste during transferring and loading operations. Shipyard spill prevention contingency directives would be in effect. The secondary containment for containers of liquid hazardous waste would be large enough to contain either 100 percent of the largest single container or 10 percent of the total volume of all stored containers of hazardous waste.

Neither of the representative disposal sites (Hanford Site and Savannah River Site), are above a "sole source aquifer" as designated by provisions of the Safe Drinking Water Act implementing regulations (40CFR149).

4.5.6 Potential Air Quality Effects

Air quality could potentially be affected by the removal, handling, and disposal of asbestos, polychlorinated biphenyls (PCBs), lead, and radioactive materials.

Work practices and precautions at the affected Shipyards would be in accordance with applicable Shipyard directives to minimize the discharge of air pollutants. For Puget Sound Naval Shipyard, work would be performed such that the Shipyard's air permits and the regulations of the Puget Sound Air Pollution Control Authority would not be violated. Likewise, for Norfolk Naval Shipyard, work would be performed such that the Shipyard's air permits and the regulations of Region 6 of the Department of Environmental Quality would not be violated. The Department of Energy would meet applicable regulations regarding the maintenance of air quality at their disposal sites. Facility construction work, such as earth moving, could negatively impact air quality through the emission of fugitive dusts and pollutants from diesel and gasoline powered equipment. The increase in offsite ambient levels would be small because of the large distance to the nearest public access, and the use of control measures when necessary, such as water spray to contain dust. Pollutants from the transport of subdivided components to burial sites would be generated from moving sources, diluted across large areas, with the result being de–minimus (non–significant) with respect to regional air quality.

4.6 Indefinite Storage Above Ground at Hanford

The cruiser, LOS ANGELES, and OHIO class reactor compartments would be packaged in the same manner and with the same resulting impacts as for the preferred alternative (i.e. minimal socioeconomic impact, radiation dose to workers packaging the compartments of between 13 and 25 mrem (or 0.005 to 0.01 latent cancer fatalities) per compartment). The transport method and route for these compartments would be the same as for the preferred alternative with the same resulting impacts.

Compartment packaging and transport costs for this alternative would be identical to those described in Appendix C for the preferred alternative. Costs associated with the maintenance of surface coatings (paint) on the compartments are discussed in Appendix C as well. The need or extent of foundation maintenance will be affected by the length of the storage period and the actual design of the foundations when built.

The Hanford Site, a Department of Energy managed facility, has adequate procedures and controls to ensure the protection of individuals during site operations. The reactor compartment disposal packages typically would have exterior radiation levels of less than 1 mrem/hr on contact at the time of storage. Areas with higher radiation levels would typically be found under the compartments and would be reduced by a factor of 4 after 10 years of storage. Within 50 years after placement in storage, typical exterior radiation levels at the compartment surface would be reduced to less than 0.002 mrem/hr with all contact levels less than 0.1 mrem/hr. Under these conditions, added radiation doses to Hanford site workers maintaining the compartments would be minimal compared to the 5,000 mrem/yr federal limit under 10CFR20.

The present locations of the low-level radioactive waste burial grounds and other waste management facilities at the Hanford Site have already impacted the local environment. Additional impacts to plants and wildlife from external radiation emitted by stored reactor compartment disposal packages are also expected to be minimal. The highest contact radiation levels are found under the packages where contact with the surface is improbable. For comparison, external near facility radiation levels measured at Hanford in 1993 from fixed monitoring devices, were a maximum of 14,640 mrem/yr within the 100-N area and 1,100 mrem/yr at a tank farm in the 200 East area (PNL, 1994c). Contact readings at "hot spots" within these facilities would likely be higher.

Air quality impacts would be bounded by those discussed for the preferred alternative. Groundwater monitoring would be conducted at the storage site as part of site operations through a system of Resource Conservation and Recovery Act compliant groundwater monitoring wells already in place along the burial ground boundaries. The Hanford Site is not located above "sole source aquifer" as designated in the provisions of the Safe Drinking Water Act (40CFR149). Regardless, in the arid climate of the Hanford Site, with periodic maintenance of compartment surface coatings (paint) and foundation structures as required, the reactor compartments in storage would retain their structural integrity indefinitely. Thus, no migration of lead, polychlorinated biphenyls, or radioactivity would occur, regardless of whether the compartments were outdoors or enclosed under a roof. Consequently, no impacts to the environment are foreseen.

4.6.1 Socioeconomic Impacts of Indefinite Storage Above Ground at Hanford

This alterative would have the same socioeconomic effects as the Preferred alternative.

4.7 Environmental Justice

In February 1994, Executive Order 12898 titled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* was released to Federal Agencies. This order directs Federal Agencies to incorporate environmental justice as part of their missions. As such, Federal Agencies are specifically directed to identify and address as appropriate disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations.

In accordance with Executive Order 19898, this action has been evaluated for potential disproportionately high and adverse impacts on minority or low-income populations. There is not a high and adverse impact on the general public from any of the alternatives. There would be an adverse impact on the shipyard workforce from the subdivide and reuse alternative; however, these workers are neither disproportionately minority nor low-income.

The DOE Programmatic Spent Nuclear Fuel Management and INEL Environmental Restoration and Waste Management Final Environmental Impact Statement (DOE, 1995) analyzed potential environmental justice concerns based on a qualitative assessment of the impacts identified. The methodology, data, maps, and conclusions for environmental justice analysis is contained in Appendix L of Volume I of this EIS. The appendix is titled "Environmental Justice" (pages L-1 to L-41). On page L-40, this analysis concluded the potential impacts present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population. Therefore, the impacts do not constitute a disproportionately high and adverse impact on any particular segment of the population, minorities or low-income communities included, and thus do not present an environmental justice concern.

The potential impacts to the general public from the alternatives evaluated for reactor compartment disposal are less than those evaluated in the Programmatic Spent Nuclear Fuel Management Environmental Impact Statement. In addition, the sites and transport routes analyzed in that EIS encompass those for reactor compartment disposal alternatives. Therefore, the conclusions from the Programmatic Spent Nuclear Fuel Management Environmental Impact Statement are also valid for this analysis.

Even if all the potential exposure to the general public from any of the reactor compartment disposal alternatives was received solely by minority or low-income populations, clearly a conservative and bounding assumption, no significant increase in latent cancer fatalities would occur. The impacts to the general public do not constitute a disproportionately high and adverse impact on any particular segment of the population, minorities or low-income communities included, and thus do not present an environmental justice concern.

4.8 Summary of Environmental Consequences

4.8.1 Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

4.8.1.1 Shipyard Operations

Radiation exposure to Shipyard workers associated with reactor compartment disposal packaging operations to accomplish the preferred alternative has been estimated to be 1508 rem (approximately 0.6 additional latent cancer fatalities).

In all of the alternatives, the Navy would generate radioactive waste, PCB waste, and hazardous waste for disposal. However, the Navy would minimize the amount generated and any waste generated would be disposed of in accordance with applicable state and federal regulations using licensed transportation contractors and disposal sites.

4.8.1.2 Transport Route

The impacts along the transportation route that would be used to move reactor compartments from Puget Sound Naval Shipyard to the Hanford Site for disposal are evaluated an Appendix E. It is estimated that the preferred alternative would involve 100 reactor compartment shipments and would result in exposure to the general population of 5.8 person-rem (0.003 latent cancer fatalities). For the transportation crew it is estimated that exposure would be 5.8 person-rem (0.002 latent cancer fatalities).

In order to use the existing land transport route, six overhead power lines may need to be modified to accommodate the larger reactor compartment disposal packages under consideration in this EIS. If necessary, these modifications would only affect the sections of the power line within the immediate vicinity of the land transport route.

4.8.1.3 Land Disposal Site

Approximately 4 hectares (10 acres) of land would be required for land disposal of the approximately 100 reactor compartment disposal packages from the cruisers, LOS ANGELES, and OHIO Class submarines. This would be a commitment of about 4 hectares (10 acres) of land from the 218-E-12B low level burial ground in the 200 East area of the Hanford Site. As is the case with other areas of the Hanford Site used for radioactive waste disposal, the land area used for disposal of the reactor compartment disposal packages and the surrounding buffer zone would constitute an irretrievable and irreversible commitment of that land area and the natural resources contained therein. The cruiser, LOS ANGELES, and OHIO Class reactor compartment disposal packages would be regulated for their radioactivity, lead, and PCB content. The release rates for these constituents are expected to be extremely small such that applicable environmental standards are not expected to be exceeded. The total volume of reactor compartments would be about 120,000 cubic meters (4,240,000 cubic feet). The migration of these constituents from the reactor compartments to the groundwater aquifer and to the Columbia River is also expected to be slow. For radioactivity, only the longer lived radionuclides are expected to be released. Approximately 1,625 cubic meters (57,400 cubic feet) of other mixed waste from the reactor compartments would be generated and disposed of separately, primarily consisting of solidified radioactive potassium chromate solution.

4.8.2 No-Action Alternative

4.8.2.1 Shipyard Operations

Radiation exposure to the Shipyard workers associated with preparing the ships for indefinite waterborne storage following inactivation and decommissioning to accomplish the No Action alternative is estimated to result in a dose of approximately 50 rem (0.02 latent cancer fatalities). This would include the first 15 years of waterborne storage maintenance operations and inspections. Because radiation exposure to the workers is primarily due to Cobalt-60 which has a half life of 5.3 years, during each 15 years storage period nearly three half lives of radioactive decay occur. As a result, exposure during the second 15 years waterborne storage period would result in a dose of only 5.3 rem (0.002 latent cancer fatalities).

At Norfolk Naval Shipyard, no long term adverse environmental impacts due to the required dredging are anticipated. Dredging is routinely performed in this area with no known adverse effects. The Virginia Marine Resources Commission functions as the point of contact for all dredging permitting actions at Norfolk Naval Shipyard. They receive permitting applications and in turn notify and coordinate the involvement of all other regulatory and oversight agencies. These agencies are the U.S. Army Corps of Engineers, the Virginia Department of Environment, the Wetlands Board of the City of Portsmouth, and the State Environmental Protection Agency. Norfolk Naval Shipyard maintenance dredging permits specify Craney Island as the disposal site for dredge spoils. It is anticipated that a permit for deepening the berths at the Southgate Annex north and south of Pier E would similarly specify Craney Island as the disposal site because it is the only active disposal site in the area. The Craney Island spoils area is available to accept any dredge spoils removed from the Hampton Roads Basin (of which the Southgate Annex is a part).

At Puget Sound Naval Shipyard no dredging is expected as a result of this alternative because the sediment rate in the area is less than one foot per 50 years.

4.8.3 Disposal and Reuse of Subdivided Portions of the Reactor Compartment

4.8.3.1 Shipyard Operations

Based on results from dismantling of the Shippingport nuclear power plant and NRC projections for decommissioning of a commercial nuclear power plant, this alternative would result in from 22,500 to 109,000 rem (9.1 to 43.7 additional latent cancer fatalities) of worker radiation dose if performed immediately after decommissioning of the ships. Worker radiation dose would be reduced by about one–half for every 5 years that operations are deferred such that after a ten year deferral, worker radiation dose would be reduced to between 6,090 and 33,100 rem. (2.4 to 13.2 additional latent cancer fatalities).

4.8.3.2 Transport Routes

The impacts along transportation routes that would be used to move subdivided portions of reactor compartments to disposal sites are evaluated in Appendix E. Four origin-destination cases are evaluated (Puget Sound to Hanford, Puget Sound to Savannah River, Norfolk to Hanford and Norfolk to Savannah River). Since two of the cases are for origins and destinations on the same coast and two are for origins and destinations on opposite coasts, the evaluation is considered to bound shipment of subdivided components from either of the two origins (Puget Sound and Norfolk) to any disposal site within the 48 contiguous states. It is estimated that the subdivision alternative would involve 1571 shipments and would result in exposure to the general population of 11 to 119 person-rem (0.006 to 0.060 latent cancer fatalities). For the transportation crew it is estimated that exposure would be from 12 to 96 person-rem (0.005 to 0.039 latent cancer fatalities).

4.8.3.3 Disposal Sites

The amount of waste estimated for the subdivision alternative ranged from a high of 120,000 cubic meters (4,240,000 cubic feet), assuming no volume reduction, to a low of 10,000 cubic meters (353,000 cubic feet) assuming extensive volume reduction. An assumption of moderate volume reduction resulted in an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). In all three cases the amount of mixed waste and radioactive-PCB waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

4.8.4 Indefinite Storage Above Ground at Hanford

As in the No Action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive and hazardous material contained by the reactor compartment. As discussed in section 4.6, the impacts of this alternative would be the same as those summarized in section 4.8.2.

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GLOSSARY

absorbed dose	When ionizing radiation passes through a material, some of its energy is imparted to the material. The amount of energy retained per unit mass of the material is called the absorbed dose and is measured in rads. Rads are usually converted to dose units of rem when referring to the absorbed dose in humans. This conversion considers the different impacts that various forms of ionizing radiation produce in the human body. Consequently absorbed doses expressed in rad and equivalent rem may not be numerically equal.
activation	The process of making a material radioactive by exposing the material to neutrons, protons, or other nuclear particles. In this EIS, a large percentage of the radioactivity present in defueled nuclear reactor plants was formed by activating the metal structures in the reactor compartment with neutrons during normal reactor plant operations. Activation is also referred to as radioactivation.
adsorption	Taking up of molecules by physical or chemical forces by the surfaces of solids or liquids with which they are in contact.
beta particle	[Symbol β (beta)] A charged particle emitted by certain radioactive materials. It has a unit electrical charge and a mass which is equal to 1/1837 of a proton. A negatively charged beta particle is identical to an electron and is the more common form of beta activity. A positively charged beta particle is called a positron and is less common. Exposure to large levels of beta particles may cause skin burns, and materials that emit beta particles are harmful if they enter the body. Most beta particles are stopped by a few millimeters of lead or steel.
curie	[Abbreviation Ci] A unit of radioactivity. One curie of radioactivity in a material results in 37 billion (3.7×10^{10}) nuclear disintegrations per second. This unit does not give any indication of the radiological hazard associated with the disintegration.
decommissioning	Actions to remove a Naval vessel from active service.
dose	A general term which denotes the quantity of radiation or energy absorbed; usually expressed in rem for doses to man.
dose commitment	The total radiation dose accrued by an individual over a specified period of time due to the exposure of the individual to radiation during a given interval of time. This includes the total time the radioactive material would reside in the body, if ingested or inhaled. Dose commitments are usually expressed in rem.

GLOSSARY (Continued)

gamma ray	[Symbol γ (gamma)] High-energy, short wavelength electromagnetic radiation. Gamma radiation frequently accompanies beta particle emissions. Gamma rays are very penetrating and are stopped most effectively by dense materials such as lead or uranium. They are essentially similar to x-rays but are usually more energetic and originate from the nucleus. Cobalt-60 is an example of a radionuclide that emits gamma rays.
inactivation	The process by which a nuclear-powered ship is prepared for decommissioning and for eventual disposition of the ship. Thus term is often used interchangeable with deactivation.
half-life	The time required for half of the atoms of a radioactive material to decay to another nuclear form.
inner bremsstrahlung	Electromagnetic radiation produced by the sudden retardation of an electrical particle (electron or positron) in the intense electrical field of the atomic nucleus.
ionizing radiation	Any radiation which displaces electrons from atoms or molecules, thereby producing ions. Examples include alpha, beta, and gamma radiation. Exposure to ionizing radiation may produce skin or tissue damage.
latent cancer fatality	The increased number of fatal cancers is based on the calculated increase in exposure to radiation that would be seen by the general public. The average annual dose received by a member of the population of the United States from background radiation is approximately 300 millirem. When people are exposed to additional radiation, the number of radiation induced cancer and other health effects increase. In a typical group of 10,000 persons who do not work with radioactive material, a total of about 2,000 (20 percent) will normally die of cancer. If each of the 10,000 persons received an additional 1 rem of radiation exposure (10,000 person-rem) in their lifetime, then an estimated 5 additional cancer deaths (0.05 percent) might occur. Therefore, the likelihood of a person contracting fatal cancer during their lifetime could be increased nominally from 20 percent to 20.05 percent by receiving a dose of 1 additional rem of radiation. The factor used in this EIS to obtain fatal cancers is 0.0004 fatal cancers per person-rem for workers and 0.0005 fatal cancers per person-rem for the general public.
radioactivity	The process of spontaneous decay or disintegration of an unstable nucleus of an atom; usually accompanied by the emission of ionizing radiation.
rem	An acronym for roentgen equivalent man. A special unit for measuring dose equivalents. A rem gives the same biological effects as one roentgen of x-rays gamma or beta radiation.

GLOSSARY (Continued)

seiche	A wave caused by seismic or atmospheric disturbances which oscillates in enclosed bodies of water. Oscillations occur from a few minutes to a few hours.
x-rays	Penetrating electromagnetic radiation with wavelength shorter than visible light. They are usually produced (as in medical diagnostic x-ray machines) by irradiating a metallic target with large numbers of high-energy electrons. In nuclear reactions, it is customary to refer to photons originating outside the nucleus as x-rays and those originating in the nucleus as gamma rays.

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FEASIBILITY STUDY FOR LEAD REMOVAL FROM AND STRUCTURAL RESTORATION OF CRUISER, OHIO, AND LOS ANGELES CLASS REACTOR COMPARTMENT DISPOSAL PACKAGES

Appendix A

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EXECUTIVE SUMMARY

The Navy has performed feasibility studies for the removal of permanently installed shielding lead from cruiser, LOS ANGELES, and OHIO class reactor compartments that are being considered for disposal at the Department of Energy's (DOE) Hanford site.

LOS ANGELES and OHIO Class submarines have one reactor compartment. Nuclear cruisers have two reactor compartments. It is estimated that the cost to remove the several hundred tons of shielding lead from these packages would be between $16 and $108 million per reactor compartment in fiscal 1994 dollars. The personnel who would perform this work at Puget Sound Naval Shipyard would be exposed to an additional radiation exposure of approximately 585 rem to 1065 rem per reactor compartment. For comparison, all other reactor compartment packaging work would not be expected to exceed 20 rem of radiation exposure per package. The total radiation exposure to the Shipyard workforce performing the lead removal operations is estimated at approximately 90,000 rem for the approximate 100 reactor compartments.

For comparison, this estimated radiation exposure (90,000 rem) is almost double the radiation exposure the entire Naval Nuclear Propulsion program received in the ten years from 1982 to 1992. Additionally, if a total radiation exposure of 90,000 rem were received over the span of a lead removal program, there might be an additional 36 fatal cancers in the lifetime of a typical group of 10,000 persons. This additional radiation induced cancer risk to the workers outweighs any potential environmental benefit in reusing part of the removed lead.

An equally important aspect in addition to the radiation exposure is that approximately 25% of the lead removed would remain radiologically controlled due to neutron activation of the impurities within the lead. This lead would have to be encapsulated and packaged for land disposal as mixed waste. The estimated quantities of shielding lead, costs for removal, and radiation exposure for shielding lead removal from the ship classes considered are summarized in Table A.1. Thus, both the expense and additional radiation exposure for shielding lead removal would be substantial and prohibitive. The subdivision alternative, unlike the preferred alternative, would not require the structural integrity of the reactor compartment to be maintained to meet shipping requirements, so it would result in easier lead removal.

1. INTRODUCTION

The Navy's 1984 Environmental Impact Statement (EIS) discussed the disposal of decommissioned, defueled naval submarine reactor plants. Since the disposal of lead was not controlled by Federal or State regulations at that time, disposal of lead radiation shielding was acknowledged without special precautions in the Navy's 1984 EIS.

Currently, the shielding lead in the submarine packages is not regulated under the Federal Resource Conservation and Recovery Act since the shielding is still serving its intended purpose and thus is not waste. In 1989, the State of Washington Department of Ecology determined that this lead is a regulated waste under the state's Hazardous Waste Management Act (RCW 70.105.050). This Act requires:

> Prior to disposal, or as part of disposal, all reasonable methods of treatment, detoxification, neutralization, or other waste management methodologies designated to mitigate hazards associated with these wastes shall be employed, as required by applicable federal and state laws and regulations.

In 1990, a shielding lead removal feasibility study provided information to the State of Washington on the disposal of the several hundred tons of permanently installed lead shielding that is contained within the welded steel plates and structure of each reactor plant packaged under the submarine disposal program described in the 1984 EIS.

The cruiser, LOS ANGELES, and OHIO class reactor compartment packages would continue to consist of the section of the ship containing the reactor compartment. For cruisers, the reactor compartment would be cut from the ship and a thick steel outer package installed around and welded to the reactor compartment to produce a strong, tightly sealed containment. The current submarine packaging methodology of closing the ends of the submarine hull with welded steel bulkheads would be applied to the LOS ANGELES and OHIO classes. The configurations of cruiser and submarine reactor compartment packages are essentially various sizes of vertical or horizontal cylinders respectively, with the exception of the USS LONG BEACH (CGN-9), which would be a rectangular box. The packaging for these reactor compartments would be designed to meet all regulatory requirements for transport of radioactive materials.

This report contains the results of the shielding lead removal feasibility study for reactor compartment packages from the cruiser, LOS ANGELES, and OHIO classes. The quantity of shielding lead involved, cost for removal, personnel radiation exposure, and occupational risks to workers performing the shielding lead removal tasks are presented.

2. DESCRIPTION OF SHIELDING LEAD CONTAINED IN REACTOR COMPARTMENT PACKAGES

2.1 Permanent Shielding Lead

Shielding is installed to satisfy three functions:

1. To reduce gamma and neutron radiation from the reactor and reactor coolant system to safe levels outside the reactor compartment during operation.

2. To reduce radiation from core fission products and primary shield activation to safe levels for access to the reactor compartment and system tanks after plant shutdown.

3. To reduce neutron activation of materials in the reactor compartment.

There are four separate permanent shielding systems installed on nuclear cruisers and LOS ANGELES and OHIO class submarines to accomplish the above functions:

1. The primary shield which encompasses the reactor vessel itself .

2. The secondary shield which encompasses the primary plant components and the majority of the associated piping (Figure A.1).

3. Primary and secondary shielding above and beneath the reactor vessel.

4. Individual component shielding.

Shielding design is generally the same for each class of surface ship or submarine reactor plant. Steel plates cover the shielding lead to maintain its position and prevent abrasion or damage. For further strength, the majority of shielding lead is permanently bonded to the structure and components during construction.

2.2 Miscellaneous Lead

Cruiser, LOS ANGELES, and OHIO class reactor compartment packages would contain relatively small quantities of lead bound in the matrices of paint, glass, adhesives, brass and bronze alloys and numerous other industrial materials used in the construction of components and equipment. The average quantity of lead in these reactor compartment packages is estimated at less than 450 kilograms (1,000 pounds) per package. Since this quantity of lead is small with respect to the total quantity of shielding lead in a reactor compartment package, it is not considered further in this study.

2.3 Considerations

In the development of methods for shielding lead removal, several requirements were given primary consideration, specifically maintaining the structural integrity of the existing ship's structure in order to facilitate conversion to a reactor compartment package, compliance to the Code of Federal Regulations transportation requirements of 10CFR71, and the long term integrity of the reactor compartment package for containing the radioactive and hazardous material. The removal of permanent shielding lead as described in this report would require the removal of a significant quantity of structural interferences. All critical structure to be removed is considered to be reinstalled to full strength.

A significant effect of shielding lead removal is the resultant increase in package exterior radiation levels. Calculations indicate that after the removal of shielding materials, localized contact radiation levels on the exterior of the reactor compartment package would be above the Code of Federal Regulations transportation limits, section 10CFR71.47. These localized high contact radiation levels could be reduced by installing additional steel shielding plates. Other package contact radiation levels, although increased because of shielding removal, would comply with the Federal transportation limits.

2.4 Assumptions

While this study evaluates the methods, costs, and radiation exposure required for a large scale lead removal program, it does not consider in detail some of the practical issues that actual implementation of such a program would entail. For example, lead removal work would occupy shipyard drydocks for long periods of time, which would displace other ship maintenance work. Significant shipyard labor force disruptions would be caused by the large increase in the number of lead and radiation workers combined with the reduction in ship maintenance work displaced by the lead removal work. The costs involved with issues such as training and qualification of new personnel and procurement of required materials and equipment, were incorporated into the overall shielding lead removal cost estimate. Table A.1 summarizes the result of these estimates for the nuclear cruiser, LOS ANGELES, and OHIO classes.

3. SHIELDING LEAD REMOVAL PREPARATIONS

3.1 Training

Puget Sound Naval Shipyard has considerable experience in removing small quantities of permanently installed shielding lead and employs a sufficient number of radiologically qualified lead workers to accomplish the shielding lead removal work. During current overhaul, reactor compartment packaging, and hull recycling work, this Shipyard processes an average of 45 tons of shielding lead using radiological controls. This process involves controlling the lead as a potentially radioactive material until an evaluation of the lead can be made to determine whether the lead can be released from radiological controls. The evaluation involves a combination of surface radiation and activity measurement and in some cases, internal activity determination by analyzing gamma radiation emission (requires reducing removed lead into relatively small chunks of 9 kilograms (20 lbs) or less). Due to the large quantity of shielding lead described in this report, the existing group of radiologically trained lead workers would be insufficient to undertake a shielding lead removal project of this magnitude.

In addition to basic skill qualification training, special mock-up training would be required prior to commencement of critical work evolutions in high radiation and shielding lead removal areas. This training, which utilizes mockups of the actual components and structures, has proven effective in reducing worker exposure to radiation and hazardous materials. Job skills, qualification testing, tooling, and instructions are rehearsed and verified before accomplishment of the actual work. The costs associated with this mockup training for shielding lead removal have been factored into the cost estimates, Table A.2.

3.2 Interference Removal

Naval ship design inherently attempts to minimize the overall size of the spaces within the ship. Designers attempt to utilize the available space to its maximum extent. Access to areas not requiring routine maintenance, in most cases, was a secondary consideration and in some cases, no access was provided. Permanently installed shielding lead is often located beneath interfering components (e.g., cabling, piping, deck gratings, hangers and equipment foundations) and large reactor plant equipment (e.g., steam generators, pressurizers, and reactor coolant pumps). Additionally, significant quantities of asbestos from ships constructed during the 1950's and 1960's and radioactively contaminated interferences would require removal. These latter interferences pose a significant personnel health hazard which will be discussed elsewhere in more detail. Interference removal therefore would be a major expense and has been factored into the shielding lead removal cost estimates of Table A.2.

3.3 Shielding Lead Removal Techniques

The following discussion describes the most practical method for Puget Sound Naval Shipyard to remove the permanently installed shielding lead (up to 99% removal) while attempting to minimize personnel exposure (lead and radiation). The discussion is general in nature but provides sufficient detail to establish an understanding of the magnitude of the work involved. Work prerequisites, such as standard interference removals, radiation containment tent installations, etc., are routinely accomplished in the Shipyard. They are not included in these descriptions unless necessary to emphasize the complexity of a particular task.

3.4 Removal of Shielding Lead Bonded to Structure

Shielding lead is generally metallurgically bonded to the reactor compartment structures in varying thicknesses and sizes and is covered by steel plate. In order to minimize structural degradation of the reactor compartment package, the following method of shielding lead removal was selected. The welds on the steel plate covers would be cut by carbon arc gouging and the plates removed. After the lead is exposed, it would be melted from the structure using hand torches in a controlled environment or enclosure to reduce lead and radioactive contamination to the workers. All removed materials would be transported to a controlled storage building for radiological survey and segregation and, if possible, released from radiological controls.

In some locations polyethylene neutron shielding is collocated with the lead shielding. For fire prevention, some of the polyethylene shielding will require removal before hot lead removal work can be done in the immediate vicinity.

Normal reactor compartment packaging work already removes some of the items interfering with access to shielding lead, therefore additional interference removal for shielding lead work in these areas would be minimized. However, removal of some additional piping and components adjacent to the reactor compartment structure would be required. Some of these systems are radioactively contaminated and require special controls during their removal.

The removal of shielding lead that is metallurgically bonded to structures is complicated when this lead is installed in geometrically complex arrangements, behind surfaces covered by asbestos thermal insulation, and in areas with loose and fixed radioactive contamination. Lead removal under these conditions would require an elaborate lead burning and radioactive contamination containment tent. Some items would be disassembled and disposed of separately, such as the reactor compartment leaded glass viewing window assembly by removing the shielding leaded glass from the Lucite and plate glass. In horizontal areas, the shielding lead would be removed by melting with hand torches and allowing the molten lead to drain through holes that are either melted or drilled through ship's structure. Collection pans would be placed directly beneath the drain holes to catch the molten lead or temporary troughs would be placed to direct the molten lead laterally into collecting pans. An elaborate scaffolding system would be required inside the reactor compartment to support the lead collection equipment, to allow adequate personnel access, and support the containments necessary for lead vapor control. After completion of shielding lead removal, residual shielding lead would be removed using chipping or grinding within containment tents. In order to restore integrity in some structures, key structural stiffeners would be repaired. This would necessitate lead free cleanliness requirements in localized areas prior to rewelding.

Some shielding lead was installed prior to the installation of major plant equipment. Removal of this equipment is impractical while maintaining the reactor compartment structural integrity. An elaborate combination of partial foundation removal, installation of temporary supports, and lead removal techniques would be required.

In order to maximize the advantages of the existing shielding lead in reducing personnel radiation exposure, some shielding lead removal operations would be deferred until relatively late in the packaging sequence, tending to increase costs due to re-setup of equipment and containments.

3.5 Removal of Component Shielding

Several components of reactor plants are shielded with a combination of portable and permanently installed shielding lead. To remove the components from the reactor compartment package for separate disposal, the portable shielding, which is an interference to the component's removal, would be removed first. The component would then be removed from the package and the component's permanent shielding lead removed using melting and/or chipping. For some components, residual amounts of internal fluids would also have to be removed or adsorbed prior to disposal.

Finally, some component foundations incorporate shielding lead which would require removal, or replacement, of the foundation in the reactor compartment package. Once removed, the foundation shielding lead can be further segregated prior to disposal

4. DISPOSAL OF REMOVED MATERIALS

The generation of radioactive waste is an unavoidable byproduct of the disposal work on Naval Nuclear reactor plants. Radioactive waste materials, generated by work on contaminated ship's systems or by removal of activated and/or contaminated components, would be containerized and shipped to licensed radioactive waste burial sites. Burial sites for low level wastes have limited capacity; therefore, every effort is made to ensure the volume of disposed radioactive waste is kept as small as practicable.

Puget Sound Naval Shipyard has established a solid waste minimization program to reduce the volume of radioactive waste. At the center of this program is the concept of waste segregation. Waste is segregated at the worksite into one of three categories: non-contaminated, potentially contaminated, or known contaminated. Radiological surveying resolves the potentially contaminated category by reclassifying it as either known contaminated or non-contaminated. All known contaminated waste would be disposed of as radioactive waste while non-contaminated waste would be disposed of in accordance with State and Federal regulations.

Waste quantity is also reduced by recycling materials to the maximum extent practicable. Recycling consists of techniques such as reusing tools and laundering anti-contamination clothing.

It is anticipated that over 75 % of the shielding lead removed from each reactor compartment package would be released from radiological controls and recycled through the Defense Reutilization and Marketing Office. However, some shielding lead may have impurities which have become activated due to neutron activation. Decontamination of this lead by removal of radioactive impurities would not be practicable because lead used in reactor shielding already is high purity lead which was refined an extra step to minimize impurities. This lead would need to be stored in accordance with the Site Treatment Plan as a mixed waste for eventual disposal, since, lead cannot be released from radiological controls. Radioactive lead must be disposed of as mixed waste, since shielding lead is also regulated as a dangerous waste by Washington State regulations. These regulations require that disposal of mixed waste be at an approved disposal site. There are presently no disposal sites authorized to accept mixed waste.

The fact that much of the lead would require radioactive disposal after removal from the reactor compartment eliminates much of the potential benefit of removing the lead. The shielding lead is well encapsulated in the reactor compartment package. Little is accomplished in removing the lead at considerable risk to workers and expense if much of the lead must then be reencapsulated and buried somewhere else.

5. PERSONNEL HEALTH AND SAFETY HAZARDS

5.1 Personnel Exposure to Lead

Pure lead is a solid heavy metal at standard atmospheric conditions. It can combine with various substances to form numerous lead compounds. Lead in its various forms may enter the body by being swallowed, inhaled, or absorbed through the skin.

Lead may be swallowed by eating contaminated foods, smoking or chewing contaminated tobacco products, licking of lips, or placing fingers in the mouth. Lead absorption can be the result of neglecting to cleanse the hands and/or face thoroughly before eating, drinking, or smoking. However, these pathways would not be considered common place based on the occupational safety controls employed at the Shipyard.

Lead may be inhaled as lead fumes from heated lead or leaded materials; as mists from lead-pigmented paints; as dust from abrasive blasting, caulking, machining, grinding, sawing, sanding, scraping, or filing of lead or leaded materials; or as vapors from volatile lead compounds such as tetraethylene lead or lead paint dryers. Lead exposure by inhalation of particles or vapors from the melting, chipping, and scraping removal process described in this report would be the most common form of exposure.

Lead workers and supervisors must be trained in work involving lead hazards, enrolled in Puget Sound Naval Shipyard's medical surveillance program, and be respirator qualified.

The highest level of lead in the air to which a worker may be exposed over an eight hour workday is 50 micrograms per cubic meter of air (50 $\mu g/m^3$) and is called the Occupational Safety and Health Act (OSHA) permissive exposure limit (PEL). Lead melting operations described in this study have produced unfiltered air concentrations up to 5500 $\mu g/m^3$ in an eight hour (time weighted average) period at Puget Sound Naval Shipyard. The use of protective clothing, air supplied respirators, engineered controls, and containment tents, allows Shipyard personnel exposures to be kept below the OSHA requirements when exposed to these airborne lead levels.

5.2 Personnel Exposure to Asbestos

In order to conduct shielding lead removal from reactor compartment packages, asbestos containing items, such as lagging, must first be removed as interference. Several controls are used to prevent personnel exposure to airborne asbestos during asbestos removal. First, asbestos removal operations are accomplished by employees of Puget Sound Naval Shipyard who are both medically qualified and trained in the proper asbestos handling and removal control processes. Second, to control the release of asbestos fibers, processes would be used that include engineered High Efficiency Particulate Air (HEPA) filtered negative exhaust ventilation systems, asbestos wetting, HEPA filtered industrial vacuum cleaners, containment tents, and containment glovebags. Third, following asbestos removal, Puget Sound Naval Shipyard's Occupational Safety and Health Office would conduct post clean-up certifications, including air sampling and visual inspections, prior to releasing the space for unprotected personnel access.

5.3 Personnel Exposure to Ionizing Radiation

Control of radiation exposure in the Naval Nuclear Propulsion Program has always been based upon the assumption that any radiation exposure, no matter how slight, involves some risk. However, radiation exposure within the accepted exposure limits, as promulgated by federal regulations, represents a small risk compared with the normal hazards of life.

Current federal regulations allow personnel beyond 18 years of age to receive a whole body penetrating radiation dose of 5 rem for each year of a persons life over age 18. The Navy has established more restrictive limits for individuals receiving radiation exposure from the Naval Nuclear Program. Normal local exposure control level for Shipyard personnel is 0.5 rem per calendar year. In some rare cases, it is necessary for selected personnel, due to their trade skills, to exceed this local control level. In these cases, local control levels may be incrementally increased up to but not exceeding 2 rem per calendar year. The Navy has established these limits as a commitment to maintain radiation exposure to personnel as low as reasonably achievable.

During reactor compartment package preparation work, exposure to gamma radiation is generally limited to the vicinity of the reactor plant. The principle source of this gamma radiation is Cobalt-60 activity. Cobalt-60 has a half-life of 5.27 years, which means that the total quantity of Cobalt-60 activity decreases by a factor of two every 5.27 years. Other radionuclides present in the compartments either do not emit gamma radiation, such as nickel-63 which emits a short range beta particle, or if gamma radiation is produced, the radionuclides are present in much smaller activities than Cobalt-60 and have much shorter half-lives.

In determining how to remove permanently installed shielding lead, techniques were primarily considered which would minimize personnel radiation exposure. This included sequencing shielding removal to utilize the benefits of the primary shield as long as possible. Because of the proximity to the reactor vessel during significant amounts of lead removal work, personnel exposure to high radiation fields will require restrictive radiological controls to ensure adequate protection. The amount of time workers can spend in high radiation fields of the magnitude expected and not exceed Shipyard control levels for radiation exposure is unacceptably short. To further complicate lead removal work, physical constraints can preclude the use of temporary shielding.

Immediate removal of all permanently installed shielding lead from the reactor compartment package and installation of a permanently installed steel shield package, to reduce package external radiation levels, would result in an estimated radiation exposure of approximately 585 rem to 1065 rem per package. This rem estimate is based upon; (1) reducing radiation levels within the reactor compartment during work by installing temporary shielding; and (2) applying the estimated mandays during which workers are subjected to this reduced exposure.

6. RADIOLOGICAL AND ENVIRONMENTAL CONTROL REQUIREMENTS

Because most work would be accomplished in radiation or high radiation areas, and some work would involve loose surface and/or fixed radioactive contamination, radiological controls would be required for the various shielding lead removal operations.

A large containment structure would be required to enclose each reactor compartment package. This structure would serve several functions. Work inside this structure would be accomplished primarily using smaller temporary containment structures with HEPA filtered exhausts to control radioactive contamination to ensure adequate personnel and environmental protection from the shielding lead removal operations. In addition, for work in a controlled surface contamination area, portable air samples would be taken at the start of work and every four hours thereafter until work is complete. The reactor compartment containment structure may consist of several smaller units since the largest single containment necessary would exceed 13 meters (42 feet) in height and 17 meters (55 feet) in length.

In addition to radioactive and hazardous material containment structures, support facilities and services (e.g., air conditioning, lead vapor filtration, negative ventilation, personnel changing and shower facilities, temporary controlled material storage facilities, separate controlled work areas that would allow segregation and disassembly of components removed from the reactor compartment, personnel access and weight handling support structures, etc.) would be required for this work. The specifics of these requirements are not discussed in this study, but have been factored into the cost estimates of Table A.2.

7. FINDINGS

7.1 Costs

The estimated shielding lead removal costs for the nuclear cruiser, LOS ANGELES, and OHIO classes, based on mandays for Puget Sound Naval Shipyard's organization, are summarized in Table A.1 and listed by each type of reactor compartment in Table A.2. The costs vary from $16 million for OHIO class submarines to $108 million for the cruiser USS LONG BEACH (CGN-9).

7.2 Radiation Exposure

Of greater importance than cost is the additional personnel radiation exposure of approximately 585 rem to 1065 rem per reactor compartment package. For comparison, all other reactor compartment packaging work combined is not expected to exceed 20 rem of radiation exposure per package. This large personnel radiation exposure for shielding lead removal could not be accommodated by the relatively small lead/hazardous materials qualified workforce available at Puget Sound Naval Shipyard. Retraining a large part of the Shipyard workforce for qualification in removing lead/hazardous materials is expected to increase the total number of Shipyard radiation workers. The lead workers would not be available for other radiation work due to these personnel reaching annual radiation exposure control levels.

A brief description of the effects of exposure to radiation would help understand why this is important. The total radiation dose received by the Shipyard workforce is estimated at 90,000 rem to support lead/hazardous material removal. To place this radiation exposure into perspective, the dose received by all Navy and civilian personnel associated with Naval Nuclear Propulsion in the ten years from 1982 to 1992 was approximately 50,000 rem. The combined total of Navy and civilian personnel monitored for radiation exposure for those ten years was slightly less than one million people. To comply with the maximum individual radiation exposure control level of 2.0 rem per year established by the Navy, Puget Sound Naval Shipyard would need a dedicated workforce of at least 4500 employees to support the lead/hazardous material removal effort for a 10 year program. This would be a significant portion of the entire shipyard production workforce presently employed at Puget Sound Naval Shipyard.

The risk associated with exposing these shipyard employees to radiation dose can be evaluated by utilizing risk assessment guidelines established by the International Commission on Radiation Protection. The Commission established a method to assess the risk by comparing exposure to only natural background radiation to exposure to additional industrial radiation. The average annual dose received by a member of the population in the United States from natural background radiation is approximately 0.3 rem, with a average annual collective dose of 69 million person-rem to the entire population.

In a typical group of 10,000 persons who are exposed only to natural background radiation, about 2000 (20 percent) will normally die of cancer. If each of the 10,000 persons received an additional 1 rem of industrial radiation exposure in their lifetime, an estimated 5 additional cancer deaths might occur (2005 total cancer fatalities).

To be consistent with the Commissions analysis, assume that this 90,000 rem is evenly distributed to a workforce of 10,000 employees (90,000 person-rem). The risk factor published by the Commission for fatal cancers to workers is 0.0004 per person-rem. Therefore, there might be an additional 36 fatal cancers in the lifetime of a typical group of 10,000 persons associated with a total radiation exposure of 90,000 rem.

The analysis of this feasibility study has focused on the costs and effects from lead removal activities performed shortly after the ship has been decommissioned, typically less than 5 years after decommissioning. The effects from delaying this work for an extended period of time after decommission, such as 5 years, 10 years, and 15 years, are briefly discussed here.

Worker radiation exposure for lead removal would result in increased worker dose for the preferred alternative but is already factored into the dose estimates for the subdivision alternative. The radiation levels within the reactor compartments should decrease by a factor of 2 every 5.27 years, based on the half-life of Cobalt-60. Worker radiation dose would be reduced by delaying operations. This effect is shown in Table A.1.

The cost of lead removal activities is also provided in Table A.1. Lead removal would be an added cost for the preferred alternative of land burial at Hanford but is already factored into the cost for the subdivision alternate. Delaying the work would not significantly affect the estimated man-hours utilized to determine the total cost in Table A.2 because the work would still require radiological controls and lead controls. However, the overall cost is expected to increase. The amount of increase is difficult to estimate but should be bounded on the lower end by the rate of inflation for the delay period.

The cost to remove lead in conjunction with the preferred alternative would be comparable to the cost to remove lead as an integral part of the subdivision alternative. The subdivision alternative, unlike the preferred alternative, would not require the structural integrity of the reactor compartment to be maintained to meet shipping requirements, so it would result in easier lead removal. However, the quantity of lead, its general configuration and the basic removal techniques would be the same in each case plus radiological controls and lead controls would still be required. These factors would result in similar costs. Radiation exposure to workers would also be comparable for the preferred alternative and the subdivision alternative for the same reasons.

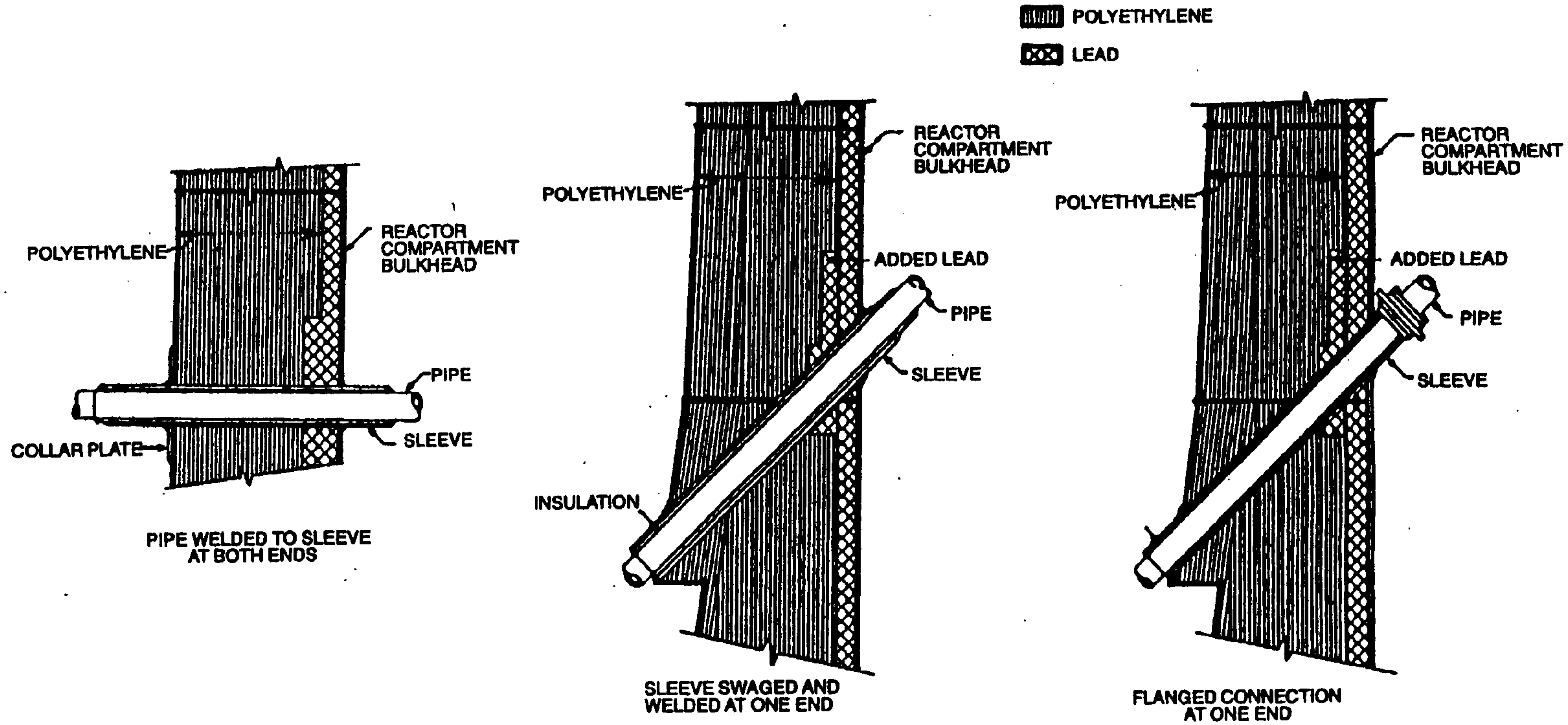
8. CONCLUSION

The removal of several hundred tons of shielding lead from cruiser, LOS ANGELES, and OHIO class reactor compartment packages is estimated to cost in fiscal 1994 dollars between $16 million and $108 million per reactor compartment package.

The total radiation dose receiving by Shipyard personnel performing the lead/hazardous material removal operations is estimated to be up to 90,000 rem. This is almost double the radiation exposure received by all Navy and Shipyard personnel for the ten years from 1982 to 1992. It has been estimated that 90,000 person-rem might result in 36 additional fatal cancers in the lifetime of 10,000 people.

About 25% of the lead removed from the reactor compartment disposal packages would not be released from radiological controls, resulting in large quantities of mixed waste to be encapsulated and packaged for land disposal.

The costs, radiation exposure, and also environmental risks to personnel associated with the removal of shielding lead from cruiser, LOS ANGELES, and OHIO class reactor compartment packages are substantial and prohibitive. A similar conclusion was reached in 1990 for the pre-LOS ANGELES class reactor compartment packages prepared under the current submarine disposal program.



PIPE WELDED TO SLEEVE AT BOTH ENDS

SLEEVE SWAGED AND WELDED AT ONE END

FLANGED CONNECTION AT ONE END

Figure A.1 Typical Small Piping Penetration

	LOS ANGELES CLASS SUBMARINES	OHIO CLASS SUBMARINES	D2G CRUISER[1]	LONG BEACH CRUISER
QUANTITY	>100 tons	>100 tons	>100 tons	>100 tons
COST	$18M	$16M	$29M	$108M
RADIATION DOSE (REM)				
No Delay	1065	585	680	750
5 year Delay	552	303	352	389
10 year Delay	286	157	183	201
15 year Delay	148	81	95	104

NOTE: The above estimates are based on an engineering evaluation of the required removal efforts. Cost and radiation dose estimates were developed from summaries of the required removal efforts. Radiation dose estimates were developed utilizing radiation fields expected to be typical of the reactor plant being evaluated. Costs are based on using Puget Sound Naval Shipyard's current (FY94) rates.

[1] BAINBRIDGE, TRUXTUN, CALIFORNIA Class, and VIRGINIA Class

Table A.1 Lead Removal Estimate Summary (per reactor compartment)

D2G CRUISERS

Engineering Services	8,840
Radiological Control Services	6,234
Production Services	31,794
TOTAL Man-days	46,868
TOTAL COST (including material)	$28,840,300

1: BAINBRIDGE, TRUXTUN, CALIFORNIA Class, and VIRGINIA Class

LOS ANGELES CLASS SUBMARINES

Engineering Services	6,008
Radiological Control Services	4,005
Production Services	26,863
TOTAL Man-days	36,876
TOTAL COST (including material)	$18,300,000

OHIO CLASS SUBMARINES

Engineering Services	5,143
Radiological Control Services	3,396
Production Services	22,726
TOTAL Man-days	31,265
TOTAL COST (including material)	$15,600,000

LONG BEACH CRUISER

Engineering Services	27,418
Radiological Control Services	18,107
Production Services	89,904
TOTAL Man-days	135,429
TOTAL COST (including material)	$108,196,150*

* Magnitude of estimate due to extensive shielding of package

Table A.2 Lead Removal Cost Estimates (per reactor compartment)

EVALUATION OF SHALLOW LAND BURIAL OF DEFUELED NAVAL REACTOR COMPARTMENT PACKAGES AT HANFORD

(protection of the inadvertent intruder and the environment from radioactivity contained in irradiated structure)

Appendix B

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List of Illustrations

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1. PURPOSE

The purpose of Appendix B is to demonstrate that the disposal of Naval Reactor Compartments at the 218-E-12B Low Level Waste Burial Ground at Hanford, WA, meets the performance objectives for intruder and environmental protection under 10CFR61 for shallow land burial.

2. BACKGROUND

2.1 Location and Nature of Reactor Compartment Radioactivity

Naval Reactor Compartment Disposal Packages encompass the Reactor Compartment, that portion of a ship which supports and contains the ship's nuclear reactor plant. The reactor plant consists of the reactor vessel and associated piping and components that transfer heat from the reactor vessel and generate steam to propel the ship. Figure B-1 provides a simplified layout of a naval reactor compartment. Figure B-2 provides a simplified cross section of the reactor vessel itself. When the reactor plant is operational, reactor fuel is held within the reactor vessel internal structure shown. Neutrons escaping the fuel and adjacent areas activate the reactor vessel internal structure and to a smaller extent the interior the reactor vessel and surrounding areas. Certain longer lived radionuclides are of primary significance in naval reactor plants due to a combination of half-life, type and energy of decay radiation produced, and quantity within the reactor vessel. Table B-1 provides relevant properties of these principle radionuclides. Reactor vessel internal structure and operational life varies from ship to ship with a resulting variance in activity. Once the reactor has been defueled and inactivated, activity ranges are typical of that presented in Table B-1. Additional analysis of longer lived radioactivity within the reactor vessel can be found in Appendix D.

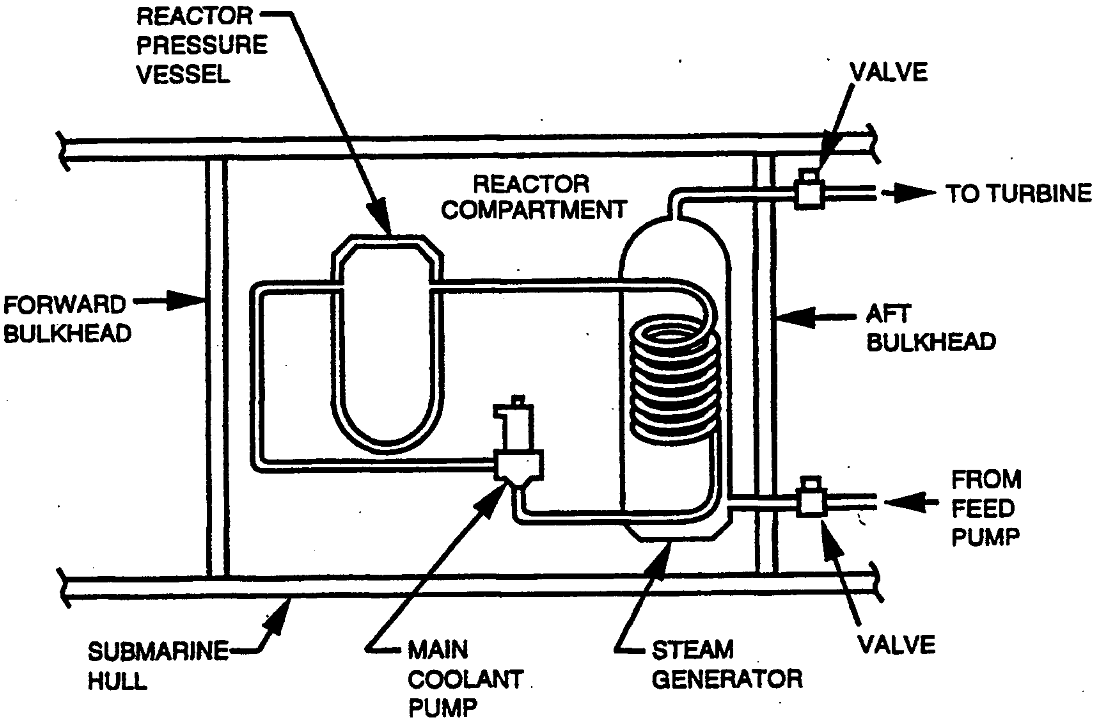

Figure B-1 Reactor Compartment Layout (conceptual)

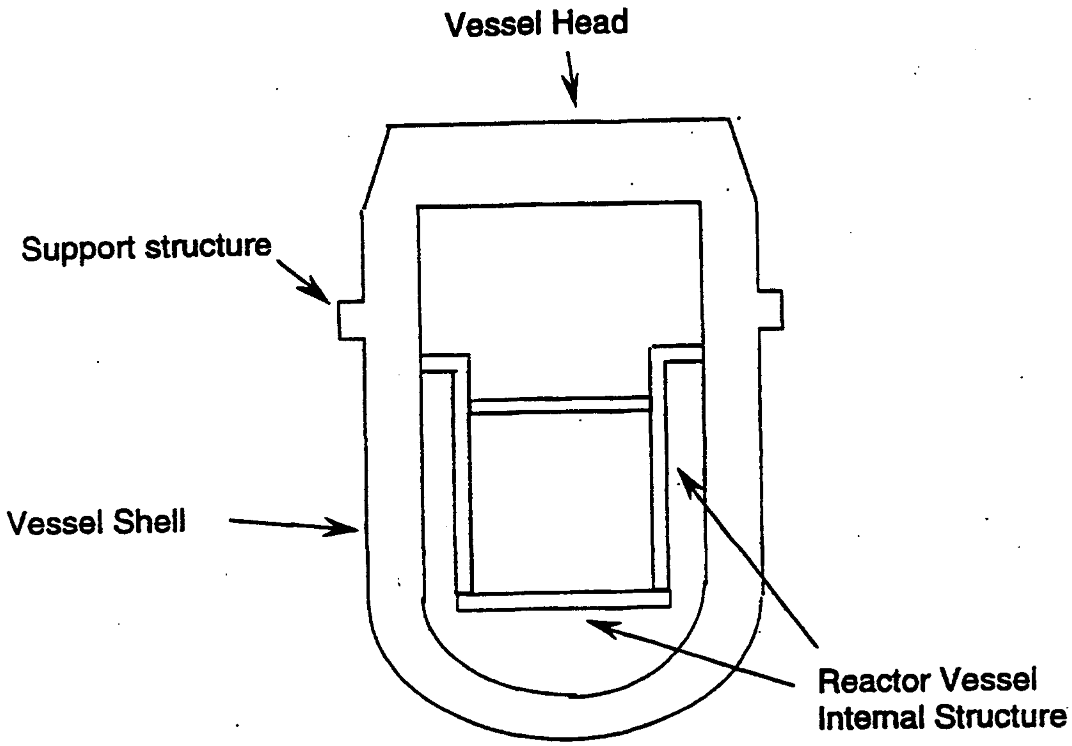

Figure B-2 Reactor Vessel (typical)

Radionuclide	Radiation	Gamma Ray Energy per Disintegration	Half-life (years)	Typical Quantity in Reactor Compartments (curies)
carbon-14	beta particle	no gamma	5730	0.5 - 15
nickel-59	X-ray	no gamma. X-ray energy typically less than 0.01 MeV.	75,000	100 - 300
nickel-63	beta particle	no gamma	100	10,000 - 30,000
niobium-94	beta particle and gamma ray	two in-series gammas: 0.87 MeV (100%) 0.70 MeV (100%)	20,300	0.5 - 1
technetium-99	beta particle	no gamma	213,000	0.01 - 0.03

Table B-1 Significant Longer Lived Reactor Compartment Radionuclides

3. EVALUATION OF REACTOR COMPARTMENTS

3.1 Structure and shielding

Reactor compartments are by nature massive, robust, integrated structures composed of interconnected structural containment walls, foundations, components, piping, and shielding, including the reactor vessel and its internals. These compartments, along with portions of adjacent spaces and tanks are sealed to form the disposal package by utilization of existing external ships structure such as submarine pressure hull and placement of external bulkheads and covers. Figure B-3 shows the external appearance of a typical submarine reactor compartment disposal package. The proposed LOS ANGELES and OHIO class packages would be somewhat larger than the current pre-LOS ANGELES reactor compartment packages but the basic configuration would remain the same. Submarine hulls are typically very high tensile strength (HY-80) alloy about two inches thick. External bulkheads would be installed for disposal and would be 3/4 inch steel plate.

T-stiffeners may project out from the plate as shown. Inside the end bulkheads, additional ship's bulkheads of at least 1/2 inch thickness steel enclose the reactor compartment. Entry to the reactor compartment would be blocked by the external bulkheads and one or more secured accesses. Ship's hull penetrations would be covered by welded plates. Hull penetrations leading directly into the reactor compartment fall within two groups (1) holes 6 inches or less in diameter that would be covered by a minimum of 1/2 inch thick welded blanks which overlap the hull surface and (2) larger access cuts through the hull that would be restored with much thicker material, typically the same section of hull originally removed to create the access. High strength (HS/HT) carbon steel is typically found in ship's bulkheads and structure installed for disposal.

Figure B-4 shows the external appearance of the conceptual cruiser reactor compartment disposal package. Cruiser reactor compartments are located deep inside the ship. Existing ship's inner bottom structure would be incorporated into the foundation of the disposal package with high strength carbon steel containment structure installed up the side and over the top to form the package. This containment structure would be a minimum of 1.25 inches thick at the top of the package, and thicker at the bottom for added support. Inside this containment structure, an existing ship's 0.625 inch thick high strength carbon steel bulkhead would enclose the reactor compartment which has the same shape as the package. Support fixtures would be added to aid in transporting the package. The resulting disposal package would be as robust as the disposal packages for submarines.

Reactor plant design is similar between cruisers and submarines. The reactor vessel internal structure is nested inside the vessel and is composed typically of Inconel Alloy 600. An enclosed shield water tank structure of several inches of combined metal thickness surrounds most of the reactor vessel. The reactor vessel is constructed of alloy steels and varies in thickness from a minimum of approximately 3 inches to over 6 inches. The combined thickness of the reactor vessel and surrounding tank structure result in a minimum of about one half foot of steel preventing access to the reactor vessel internal structure.

Existing lead shielding in and around the reactor compartment provides gamma attenuation. The ship's bulkheads which enclose the reactor compartment are lined with solid lead shielding, bonded or cast in place and covered by 0.25 inch minimum metal canning plate. Additional canned lead is placed in various locations on reactor plant components and at various locations around the inside of the ship's hull where this structure forms part of the reactor compartment. Existing polyethylene shielding, for neutron attenuation, is also attached on the ship's bulkheads and on the reactor vessel itself.

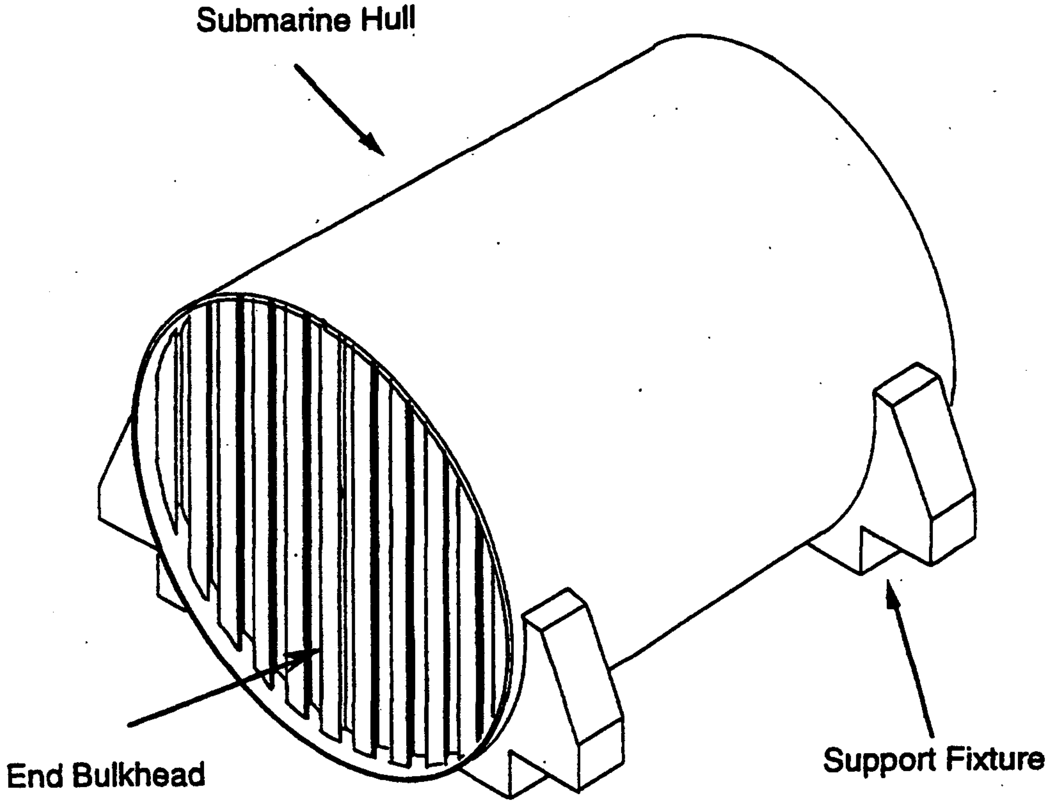

Figure B-3 Typical Submarine Reactor Compartment

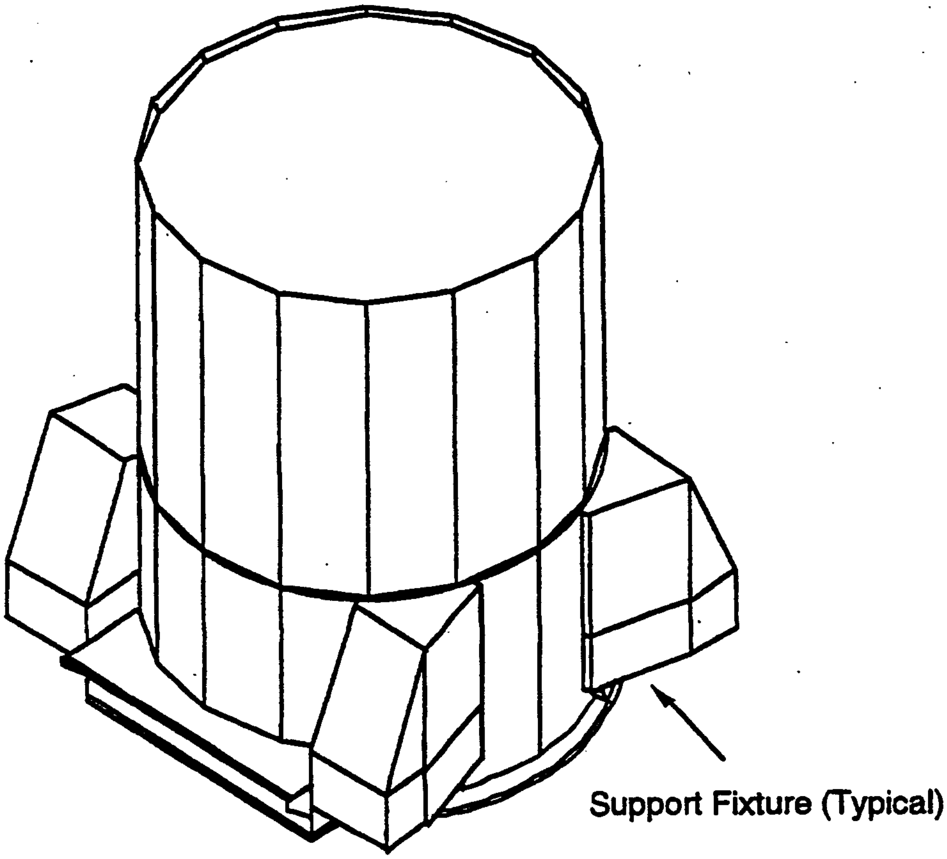

Figure B-4 Conceptual Cruiser Reactor Compartment

3.2 Disposal Site

The Hanford Site is a 560 square mile (1450 square kilometer), mostly undisturbed area of relatively flat shrub-steppe desert lying within the Pasco Basin of the Columbia Plateau, a semi-arid region in the rain shadow of the Cascade Mountain Range.

Pre-LOS ANGELES class reactor compartments are currently being disposed of at the 218-E-12B burial ground of the Hanford Site. This location is also the preferred alternative for disposal of cruisers and LOS ANGELES class and OHIO class submarines. Soil at the 218-E-12B burial ground is a typical mix of sandy-gravel, sand, and gravelly sand found in the Hanford Formation which underlies the burial ground. The soil is dry with a moisture content of less than 6% by weight, well drained, slightly alkaline with a pH of 8.2, and low in chlorides at 0.08 milligram equivalents per 100 grams soil or about 30 parts per million (NFESC 1993). Soil resistivity at the 218-E-12B burial ground is high, measured as greater than 30,000 ohm-cm. (NFESC, 1993). These conditions, coupled with the average rainfall of 6.3 inches per year are considered beneficial for minimizing corrosion.

The geology and hydrology under the 218-E-12B burial ground are described in detail in Estimation of the Release and Migration of Lead through Soils and Groundwater at the Hanford Site 218-E-12B Burial Ground (PNL, 1992). In general, groundwater occurs under the burial ground in both unconfined and confined aquifers, with the confined (deeper) aquifers bounded above by basalt layers and the unconfined (uppermost) aquifer lying at the interface between the Hanford Formation and the underlying bedrock Miocene basalts. The depth to the uppermost aquifer under the burial ground is approximately 200 feet from site surface and approximately 150 feet from the floor of the current excavation for reactor compartment disposal.

The unconfined aquifer receives little, if any, recharge directly from precipitation that falls on vegetated areas of the Hanford site because of a high rate of evapotranspiration from native soil and vegetation. Surface precipitation may contribute recharge where soils are coarse textured and bare of vegetation (PNL, 1994b). Recharge rates of 0.5 cm/yr and 5 cm/yr have been used at the Hanford Site to model recharge to the unconfined aquifer from the current arid climate and potentially wetter conditions, respectively, assuming no artificial surface barriers (DOE, 1987, DOE, 1989). These recharge rates have been applied specifically to the 218-E-12B burial ground for modeling the leaching of constituents from wastes (PNL, 1992, PNL, 1994a). Actual recharge at 218-E-12B, after closure, may be even lower for a substantial period of time due to the placement of an engineered cover which will result in over 5 meters of soil between the buried reactor compartments and the site surface.

Groundwater modeling conducted by Pacific Northwest Laboratory for the 218-E-12B burial ground (PNL, 1992, PNL, 1994a) suggests that under current climate conditions, in a natural state, the unconfined aquifer will recede southward and not be present under the burial ground. As artificial groundwater discharges in the area surrounding the 218-E-12B burial ground have diminished, aquifer wells adjacent to Trench 94 have been frequently dry.

Hanford formation sediments underlying the 218-E-12B burial ground exhibited a strong tendency to adsorb (immobilize) nickel and nickel radionuclides from groundwater in site specific testing (PNL, 1994a). Nickel solubility was also experimentally determined. Predicted migration times for nickel and nickel-59 from the burial ground to the aquifer varied from 800,000 years for the current climate down to 66,000 years for a postulated wetter condition modeled in which 10 times more water (recharge) is assumed to pass through the burial site than under the current climate condition.

3.3 Corrosion

High strength (HS/HT) carbon steel and very high tensile strength nickel alloyed (HY-80) steel typically form the exterior of reactor compartment disposal packages. Inconel Alloy 600 (a nickel-iron-chromium alloy) is present inside the reactor vessel as the reactor vessel internal structure. Stainless steels such as CRES 304 can also be found inside the disposal package. Site specific studies have been accomplished to determine the performance of reactor compartment disposal packages at the 218-E-12B burial ground. These studies showed that corrosion rates for carbon steels in the soil would be low, with an expected average general corrosion rate of 0.0002 inch per year and a corresponding maximum general corrosion rate of 0.0006 inch per year (DOE, 1992).

The actual general corrosion rates for compartment structure are expected to be less than these predictions. The studies were based on test data for open hearth carbon steel which is somewhat less corrosion resistant than the HY-80 and high strength carbon steel that forms the exterior of reactor compartments and much less corrosion resistant than the Inconel A600 alloy (or CRES 304).

The general corrosion rates for carbon steel at the 218-E-12B burial ground were based on a comparison to actual test data from underground storage tanks exhumed at the Hanford Site as well as available data from National Institute of Standards (NIST) test sites with soil conditions approximating those at Hanford. Pitting rates developed in this manner were converted to general corrosion rates by the use of a conservative conversion factor (DOE, 1992).

Upper limit corrosion rates expressed in milligrams of metal alloy weight loss per square decimeter of surface per year for CRES 304 and A600 Inconel alloys present in reactor compartments, were also estimated for the 218-E-12B burial ground (NFESC, 1993). These corrosion rates are as follows: for CRES 304 - 0.02 milligrams per square decimeter per year, and for Inconel Alloy 600 alloy - 0.01 milligrams per square decimeter per year.

3.4 Performance of Reactor Compartments

Based on the above corrosion rates, Table B-2 outlines the expected performance of a reactor compartment when buried at the 218-E-12B burial ground with respect to personnel access. Structural information and corrosion rates are summarized from previous discussions and used to estimate the time required for access to be gained inside structures as a result of corrosion. Soil pressure exerted on the disposal package exterior is also considered. From Table B-2 it can be seen that access inside the reactor compartment and to the more highly activated structure will require very long periods of time.

> Note: The term "access" is used in this evaluation to denote the physical entering of a space or area by a person's entire body (not just extremities). Access times provided in this section describe the time required for corrosion to allow access as defined above. These times do not imply that structure being accessed or structure through which access is gained is unrecognizable from surrounding soil or dispersible in surrounding soil. Access times also do not imply that a radiation dose exceeding the basis levels for the waste classification method of Title 10 "Energy" of the Code of Federal Regulations, Part 61 (10CFR61) will result from a person entering a space or area at the time provided (i.e. 500 mrem/yr for an intruder and 25 mrem/yr for the environment (NRC, 1982)). Radiation exposure rates associated

with accessing selected reactor compartment structures are discussed in section 3.5. Intruder and migration scenarios resulting in potential radiation dose are discussed in section 3.6.

	Personnel Access to Reactor Compartment	Personnel Access (entire body) to Reactor Vessel Internal Structure	Reactor Vessel Internal Structure
Limiting Barrier	Submarine End Bulkheads	Combination of Reactor Vessel and surrounding tank structure	NA
Thickness	0.75 inch	~ 1/2 foot	NA
Expected Corrosion Rate	0.0002 inch/year	0.0002 inch/year	NA
Expected Time to Access:	~2,000 years	~ 30,000 years	NA
Maximum Corrosion Rate	0.0006 inch/year	0.0006 inch/year	0.02 milligrams metal loss per square decimeter per year
Minimum Time to Access	~600 years	~ 10,000 years	>10,000,000 years (for complete corrosion)

Table B-2 Reactor Compartment Disposal Package Performance

For access to the reactor vessel internal structure, the limiting case considers both access from the inside of the reactor compartment once the endplates have been breached and access directly through the ship's hull under the reactor vessel. Breach of the endplates does not immediately provide access to the interior of the reactor compartment since a secured hatch would have to forcibly opened. However, no credit is taken in Table B-2 for the delaying effect of this hatch on access to the reactor compartment. Inside the reactor compartment, the reactor vessel internal structure is enclosed by a combination of the reactor vessel and a surrounding tank structure providing a series of nested metal structures. For access to the inside of the reactor vessel, corrosion is modeled as occurring in series through these nested structures from the outside to the inside of the reactor vessel.

For the corrosion life of the reactor vessel internal structure, this structure is modeled as a 0.5 inch thick plate with a 2 cubic meter volume. This produces a conservative surface area to volume ratio as the actual thickness and overall volume of this structure varies but is typically greater. The corrosion rate for the reactor vessel internal structure presented in Table B-2 reflects the occasional use of CRES 304 alloy vice the typical Inconel Alloy 600 which corrodes at a lower rate. The greater than 10,000,000 year period for complete corrosion of the reactor vessel internal structure is conservatively based on the CRES 304 corrosion rate multiplied by a factor of 10.

From Table B-2, greater than 10,000,000 years would be required to fully corrode the reactor vessel internal structure. Nearly all of the long-lived radioactivity in the reactor vessel internal structure will have decayed within the metal matrix before it is made available for migration by the extremely slow process of corrosion. Table B-3 provides an illustration of how little of the original inventory of long lived radionuclides could be released during the first 10,000 years of corrosion and over the entire period of corrosion.

3.5 Radiation Exposure

External radiation levels for reactor compartment disposal packages are essentially the result of Cobalt-60 activity contained within the reactor plant. This activity will decay by a factor of 2 every 5.3 years, thus in about 50 years, external radiation levels would be negligible at less than 0.1 mrem/hr on contact. Correspondingly, internal compartment radiation levels would be negligible at less than 0.1 mrem/hr and would remain low until the reactor vessel corrodes substantially exposing the reactor vessel internal structure and thus allowing exposure to gamma radiation from structural material containing niobium-94 inside the vessel.

Close proximity, and one meter distant radiation levels, have been estimated for a reactor vessel internal structure in a bare (exposed) condition and under fully corroded conditions representing the long term consequence of disposal by burial. These radiation levels were based on a 500 year decay period from the time of disposal. For exposed reactor vessel internal structure at 500 years, the radiation level would be a maximum of 11 mrem/hr at 1 meter. For a reactor vessel internal structure assumed to be completely reduced into a pile of corrosion products at 500 years, the radiation levels would be a maximum of 36 mrem/hr at 1 meter from this pile of corrosion products.

Radionuclide	Percentage of initial radionuclide inventory released during the first 10,000 years of corrosion	Percentage of initial radionuclide inventory ever released by corrosion
nickel-63	< 0.003%	<0.003%
carbon-14	<0.1%	<0.2%
niobium-94	<0.2%	<0.4%
nickel-59	<0.2%	<2%
technetium-99	<0.2%	<6%
Combined long lived radionuclides	<0.005%	<0.02%

Table B-3 Activity Released from Reactor Vessel Internal Structure via Corrosion

Table Note:

The 10,000 year period is provided for perspective. Corrosion will not likely initiate until the reactor vessel internal structure is exposed at ~ 10,000-30,000 years.

Different types of reactor vessel internal structures and varying operating times on these structures can be found among the reactor compartment classes considered. Maximum radiation levels presented are based on the combination of structure and operating time that results in bounding radiation levels for all of these classes.

95% of the radiation emitted from the reactor vessel internal structure at 500 years is from niobium-94 which produces gamma radiation with an activity half-life of 20,300 years. The remainder is mainly from nickel-59, which produces lower energy gamma/X-ray radiation with an activity half-life of 75,000 years. At 10,000 years, the minimum time predicted for corrosion processes to allow for whole body access to the reactor vessel internal structure, about 90% of this radiation would still be from niobium-94.

A 500 year decay period is overly conservative when considering the length of time required for corrosion processes at the Hanford Site to bring the reactor vessel internal structure into the exposed and corroded state. From Table B-2, a minimum decay period of greater than 10,000 years and an expected decay period of greater than 30,000 years would occur before the reactor vessel internal structure would potentially be exposed. Consequently, based on the minimum decay period of greater than 10,000 years, the resulting radiation levels at 1 meter would be reduced from the 500 year based 11 mrem/hr to about 8 mrem/hr as a maximum. Based on the expected decay period of over 30,000 years, the resulting radiation levels at 1 meter would be reduced from the 500 year based 11 mrem/hr to about 4 mrem/hr as an expected value.

By the time metallic debris surrounding the reactor vessel internal structure is transported away from the disposal site by corrosion and dissolution into groundwater, substantial activity decay would occur in the reactor vessel internal structure. The slow corrosion rate of the reactor vessel internal structure itself severely limits the amount of activity in this structure that could be released to the environment (e.g. less than 0.02% of total activity, less than 0.4% of niobium-94 activity, and less than 2% of nickel-59 activity, per Table B-3). Even these small percentages of the original reactor vessel internal structure's activity would not be found at any one time in the soil due to decay occurring both in the soil and in the structure as the slow corrosion process releases radionuclides.

The metal alloys of the reactor vessel internal structure are hard, difficult to machine or drill, and not prone to mechanical separation into the soil. The slow corrosion rate of the reactor vessel internal structure severely limits the amount of activity that could be released through corrosion. However, it is unrealistic to assume that a pile of corrosion products could remain exposed and undiluted in soil during and after the greater than 10 million year corrosion period predicted for the reactor vessel internal structure at the Hanford Site 218-E-12B burial ground. In any case, most internal activity in the structure would have decayed before a fraction of the structure could corrode. A very conservative very long term exposure scenario would be to assume that (1) over the greater than 10 million year corrosion life of the reactor vessel internal structure, 1% of niobium-94 and 5% of the nickel-59 activity in the reactor vessel internal structure has been released to the surrounding soil as corrosion products indistinguishable from soil and (2) that this released activity has mixed within a small volume of soil (a 10 by 10 by 10 foot box) and not decayed. The soil volume chosen is roughly 4-5 times the envelope volume of typical reactor vessel internal structure. The resulting radiation levels at 1 meter from the soil would be less than 0.5 mrem/hr. This does not account for the effect of residual metallic elements in the soil, which would add extra shielding benefits.

Table B-4 presents a summary of reactor compartment performance and resulting radiation levels associated with accessing the reactor vessel internal structure.

Minimum corrosion time for access to the reactor vessel internal structure (Table B-2)	Minimum predicted time for complete corrosion of the reactor vessel internal structure (Table B-2)	Percentage of initial radionuclide inventory released during the first 10,000 years of reactor vessel internal structure corrosion (Table B-3)	Percentage of initial radionuclide inventory released by the complete corrosion of the reactor vessel internal structure (Table B-3)	External Dose rate for reactor vessel internal structure when accessible (section 2.5)	External Dose rate for fully corroded reactor vessel internal structure in soil (section 2.5)
~ 10,000 yrs	>1.0 E +7 yrs	<0.005%	<0.02%	~ 8 mrem/hr at 1 meter (maximum) ~ 4 mrem/hr at 1 meter (expected)	< 0.5 mrem/hr at 1 meter

Table B-4 Reactor Compartment Evaluation Summary

3.6 Comparison of Reactor Compartment Disposal to Criteria/Assumptions Used in NRC Exposure Evaluations

3.6.1 Deliberate Intrusion

In the Final Environmental Impact Statement on 10CFR61, Volume 1 (NRC, 1982), the NRC stated that deliberate intrusion into a disposal facility cannot reasonably be protected against and is thus not considered further by the NRC in the development of 10CFR61. Nevertheless, upon closure of the 218-E-12B Low Level Waste Burial Ground at Hanford, WA, the reactor compartments would be buried more than 5 meters deep with an engineered cover placed over the buried compartments. The robust nature of the compartments and their durability in combination with the manner of their burial would discourage deliberate intrusion.

3.6.2 Inadvertent Intrusion

The NRC has based the waste classification method of 10CFR61 on assumptions of agricultural and construction related intruder scenarios where the activity from Class C wastes is, after 500 years, indistinguishably mixed with soil so that an intruder would not know that a waste site was being intruded upon. Limits for activity concentration in the waste were determined based on a 500 mrem/yr maximum exposure from these scenarios (NRC, 1982).

In 10CFR61 Part 56(b), waste stability is cited as a factor in limiting exposure to an inadvertent intruder, since the stability provides a recognizable and non-dispersible waste. The robust nature of the compartments and their durability in combination with the manner and depth of their burial at Hanford would prevent inadvertent intrusion involving the type of agricultural and construction scenarios evaluated by the NRC. Significant activity from the compartments would not be brought inadvertently upwards into the food chain at the land surface. From Table B-2, the reactor compartment, reactor vessel, reactor plant components and the reactor vessel internal structure itself will provide for physical remnants very distinguishable from surrounding soils for the foreseeable future. The reactor vessel internal structure disperses very slowly due to its long corrosion life. From Table B-3, the reactor vessel internal structure would release less than 0.02% of its activity to the soil and the structure itself would also remain essentially intact and distinguishable from soil for the foreseeable future.

Consequently, the only realistic intruder scenario that should be considered for disposal of reactor compartments is the intruder well penetrating through the 218-E-12B burial ground with a less probable hypothetical scenario wherein a person inadvertently manages to exhume a reactor compartment and enters it or inadvertently exhumes remnants of this reactor compartment at a very long time in the future.

3.6.2.1 Intruder Well

In the 10CFR61 Environmental Impact Statement (NRC, 1982), an intruder well scenario was evaluated for the current "no action" case of pre-10CFR61 disposal practices with a resulting maximum dose of about 11 mrem/yr to the thyroid from iodine-129 and a dose of less than 0.1 mrem/yr to the whole body. Iodine-129 Class-C limit based activity concentration fractions for reactor compartment reactor vessel internal structures are less than 0.000001 and thus thyroid dose would not be of concern. The remaining whole body dose as evaluated by the NRC is already well below the 500 mrem/yr basis for intruder scenarios or even the 25 mrem/yr basis for protection of the environment via migration pathways.

For buried reactor compartments, the long lived radionuclide inventory of niobium-94, nickel-63, and nickel-59 that control the waste classification are locked within the metal matrix of activated materials that will take greater than 10,000,000 years to fully corrode. A well drilled through the burial site would contact and be obstructed by high strength steels from the disposal package for thousands of years and from the reactor vessel for tens of thousand of years. This same well would be obstructed by non-activated CRES 304 and Inconel Alloy 600 from the reactor plant for as long as the life of the reactor vessel internal structure. In addition, Inconel Alloy 600 tends to work harden and is difficult to machine.

If the intruder well stops at the depth of the obstruction (the buried waste), the well should be dry. If the well continues to the bedrock below, the well should be dry under the current climate conditions at Hanford and if not, niobium-94 and nickel-59 should take a very long time to migrate to this depth.

Pacific Northwest Laboratory estimated the migration of nickel through soils and groundwater at the 218-E-12B burial ground from a group of 120 large metal components representing reactor compartments. A current climate condition was modeled and a postulated wetter condition with a recharge rate set at 10 times the rate used to model the present climate. Groundwater modeling conducted as part of this work suggests that under current climate conditions, in a natural state, the aquifer under the 218-E-12B burial ground will recede southward and not be present under the burial ground. Even under a postulated wetter condition modeled with a site recharge rate set at 10 times the rate used to model the present climate, the water table under the burial ground is still predicted to be about 40 meters (130 feet) below the bottom of the burial excavation.

Pacific Northwest Laboratory predicted very long times of over 66,000 years under the postulated wetter condition modeled and 800,000 years under the current climate condition for nickel-59 released from buried disposal packages to reach a well drilled 100 meters (330 feet) downstream of the site (PNL, 1994a). Transport time from the disposal packages to the bedrock directly under the disposal site occupied over 99% of these predicted times due to adsorption of nickel into the unsaturated soil. Nickel-63 decayed en-route and never reached an aquifer. Thus, nickel-63 from reactor compartment disposal packages would likely never enter an intruder well and nickel-59 would take 66,000 years, a very long time, to enter such a well.

An estimate of the time required for niobium-94 to migrate to the aquifer under the burial site can be made by use of retardation factors provided by the 10CFR61 EIS (NRC, 1982). Retardation factors account for the effects of adsorption in soil which delays the migration of radionuclides through the soil. The retardation factors provided in the NRC EIS essentially represent the relative time required for radionuclides to travel a given distance through soil compared to the time required for groundwater to travel the same distance. The higher the retardation factor, the slower the radionuclide moves. Niobium-94 retardation factors provided by the NRC are at least twice as large as for nickel-59, therefore, niobium-94 should take twice as long to transit a given depth of soil as for nickel-59. This is conservative in that niobium-94 concentration in reactor vessel internal structures is 2 orders of magnitude below nickel-59 concentration and is contained within the same corrosion resistant metal alloys as nickel-59. This would tend to increase transport times for niobium even further. The release rate of niobium-94 in curies per year per compartment would be 2 orders of magnitude lower than for nickel-59 initially, decreasing even further relative to nickel-59 as niobium-94 decays 3 times faster. Even though ingestion of niobium-94 at a given concentration would likely produce a higher exposure dose than ingestion of an equivalent concentration of nickel-59, this effect should be overcome by the lower release rate and longer migration time.

Pacific Northwest Laboratory (PNL, 1994a) predicted doses that would result under a maximally exposed individual scenario involving a person who uses water from an aquifer well 100 meters (330 feet) downstream of the burial site for all personal food production and consumption needs. This work, which used the GENII dose model (PNL, 1988), produced a dose from nickel-59 ingestion of less than 0.001 mrem/yr after a 66,000 year minimum migration time. A group of 120 large metal components representing reactor compartments was assumed to be buried at the site. Considering the placement of 220 reactor compartments at the burial site, niobium-94, and the location of the intruder well, this dose would not increase to the 500 mrem/yr intruder limit or even to the 25 mrem/yr release to the environment performance standard of Subpart C of 10CFR61.

3.6.2.2 Exhumation

External radiation levels on reactor compartment disposal packages are essentially the result of Cobalt-60 activity contained within the reactor compartments which will decay by a factor of 2 every 5.27 years. Thus, in about 50 years, external radiation levels would be negligible at less than 0.1 mrem/hr even on contact. Correspondingly, radiation levels inside the reactor compartment would be negligible at less than 0.1 mrem/hr and intruder exposure would remain very low until about 10,000 to 30,000 years have elapsed (Table B-2) at which point the reactor vessel has corroded sufficiently to allow intruder access (whole body) through the reactor vessel to the reactor vessel internal structure.

Based on a minimum 10,000 year access time for the reactor vessel internal structure, the maximum radiation level at 1 meter from an exposed reactor vessel internal structure would be 8 mrem/hr. At this radiation level, the intruder would have to spend 2.5 days at 1 meter from this structure to reach a 500 mrem/yr exposure.

Based on an expected 30,000 year access time for the reactor vessel internal structure, the expected radiation level at 1 meter from an exposed reactor vessel internal structure would be 4 mrem/hr. At this radiation level, the intruder would have to spend 5 days at 1 meter from this structure to reach a 500 mrem/yr exposure. However, direct or very close proximity contact with reactor vessel internal structure over a period of time necessary to reach the 500 mrem/yr basis is not considered plausible because the reactor vessel internal structure would likely never be actually exposed and unshielded to an inadvertent intruder.

Over the 10,000 to 30,000 year period required for corrosion to allow entire body access to the reactor vessel internal structure, the reactor compartment hull, being thinner than the reactor vessel, subject to external soil pressure, and supporting the compartment internals, would likely have collapsed downward bringing the compartment contents down on top of the reactor vessel. Lead shielding plates, corrosion resistant steels such as CRES 304 and Inconel Alloy 600 that comprise the reactor plant inside the compartment, remnant heavy steel framing from the hull, corrosion products, and polyethylene shielding from the reactor vessel and the remainder of the compartment would cover the reactor vessel remnant and the reactor vessel internal structure inside hindering access and providing shielding not considered in this analysis.

Greater than 100 tons of lead shielding is present in reactor compartment disposal packages with some of this lead being in a position to fall over the pressure vessel upon compartment collapse. Due to the very low solubility of lead predicted for the 218-E-12B burial ground environment (PNL, 1992) some shielding lead in reactor compartment disposal packages will continue to be present for perhaps as long as remnants of the reactor vessel internal structure remain. On average, over 90 metric tons (100 tons) of CRES 304 and/or Inconel Alloy 600 typically form the reactor plant which occupies the reactor compartment along with the reactor vessel. This material shares the same low corrosion rate discussed in section 2.3 as for the reactor vessel internal structure and remnants will last as long.

The volume of lead and corrosion resistant materials in the compartment is much greater than that of the reactor vessel internal structure. The volume of metal directly above the reactor vessel internal structure up to the top of the reactor compartment disposal package is typically much greater than that of the reactor vessel internal structure. Collapse of the compartment over the reactor vessel internal structure and the filling of void spaces remaining within the remnant compartment with soil should completely cover the reactor vessel internal structure producing a difficult to penetrate mound of debris that would provide some shielding benefit.

Eventually corrosion processes will remove the less corrosion resistant materials from the debris mound. Over the greater than 10 million years required to fully corrode the reactor vessel internal structure, less than 0.02% of total activity will be released to the soil due to decay. Correspondingly, less than 0.4% of niobium-94 activity and less than 2% of nickel-59 activity will be released to the soil. If this activity is very conservatively assumed to be released all at once into a cubic volume of soil 3 meters (10 feet) to a side or 27 cubic meters (1000 cubic feet) total, resulting radiation levels at 1 meter from this volume of soil would be less than 0.5 mrem/hr not accounting for self shielding effects in the soil resulting from residual metallic elements adsorbed onto soil particles. However, this exposure will not actually ever occur because the activity that is released into the soil is released so slowly that only a fraction of the 0.02% total released would be present at any one time in the soil. Ingestion of soil by the intruder sufficient to result in a significant intruder dose is not considered plausible due to the dilution provided by clean soil and the mass of corrosion products resulting from corrosion of the reactor compartment and the slow release of a small amount of activity over a long time.

Intruder doses under the scenario discussed above would not likely reach the 500 mrem/yr limit used by the NRC to develop the 10CFR61 waste classification method. Intruder dose for the intruder well scenario would also not reach the 500 mrem/yr limit. It should be noted that the long times required for radionuclides to be released into the soil from the reactor vessel internal structure are beyond the accepted time scale of human civilization on earth.

3.6.2.3 Groundwater

The only plausible exposure scenario to the general public from buried reactor compartments would involve the groundwater pathway tapped by a well. The depth and manner of burial of the compartments coupled with the free-draining arid nature of the Hanford Soils and the slow release of activity from the compartments inhibit the migration of activity upward from the compartments to the land surface.

As discussed previously in the intruder well evaluation, Pacific Northwest Laboratory (PNL, 1994a) predicted very long times of over 800,000 years under the current climate condition and over 66,000 years under the postulated wetter condition modeled for nickel-59 released from buried reactor compartment disposal packages to reach a well drilled 100 meters (330 feet) downstream of the burial site. Nickel-63 decayed en-route and never reached the site aquifer or a downstream well. As a result, "maximally exposed" individual doses calculated for a person using the 100 meter (330 feet) downstream well were less than 0.001 mrem/yr based on nickel-59 ingestion alone.

Other radionuclides are not present in sufficient quantity in the reactor compartments to add any significant dose under the groundwater migration pathway. Thus, maximally exposed individual doses for the groundwater pathway would not reach the 25 mrem/yr "release to the environment" performance standard of Subpart C of 10CFR61.

3.7 Compliance with 10CFR61 Subpart C Performance Objectives

3.7.1 Part 61.41 Protection of the Public from Releases of Radioactivity

Releases to the general environment shall not to exceed 25 mrem/yr to the whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other organ equivalent dose to the public (10CFR61.41)

As discussed in section 3.6.2, the only plausible exposure scenario to the general public from buried reactor compartments would involve the groundwater pathway tapped by a well. This type of pathway would not result in exposure doses exceeding 25 mrem/yr.

3.7.2 Part 61.42 Protection of Individuals from Inadvertent Intrusion

The 10CFR61 EIS (NRC 1982) indicates that the NRC in developing the waste classification method of 10CFR61 set a maximum 500 mrem/yr equivalent intruder dose as the basis for determining appropriate limits for activity.

As discussed in section 3.6 and section parts 3.6.1. and 3.6.2., the only plausible intruder scenarios for disposal of reactor compartments at the Hanford Site 218-E-12B burial ground involve an intruder well and a less probable exhumation of the compartment. Exposure doses from the intruder well would not reach 500 mrem/yr. Exposure dose from the exhumation scenario would not likely reach 500 mrem/yr. The depth and manner of burial of the reactor compartments, and the robust, long lived nature of the compartments, inhibits intrusion and limits exposure.

3.7.3 Part 61.43 Protection of Individuals During Disposal Site Operations

The Hanford Site, a Department of Energy managed facility, has adequate procedures and controls to accomplish this purpose. The reactor compartment disposal packages typically would have exterior radiation levels of less than 1 mrem/hr on contact at the time of disposal. Areas with higher radiation levels would be found under the compartment and would have standard radiation markings. Within 50 years of disposal, all exterior radiation levels would decay to negligible levels less than 0.1 mrem/hr.

3.7.4 Part 61.44 Stability of the Disposal Site After Closure

The Hanford Site has adequate procedures and controls to accomplish this purpose. The reactor compartments are strong and durable and would not cause any significant subsidence at the burial site surface upon burial and for at least 600 years afterwards. An engineered cover would be placed over the disposal site upon closure to add stability and limit moisture influx.

4. CONCLUSIONS

Disposal of Naval Reactor Compartments at the 218-E-12B Low Level Waste Burial Ground at Hanford, WA meets the performance objectives for intruder and environmental protection from 10CFR61. The requirements of Department of Energy Order 5820.2A "Radioactive Waste Management" (DOE, 1988) provide a similar level of protection equivalent to the NRC regulations of 10CFR61 and in many cases mirror the NRC regulations. Consequently, disposal of reactor compartments at the 218-E-12B burial ground, Hanford, WA is also consistent with the DOE order.

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

Appendix C

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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:

$$\begin{aligned}\text{Cost} \quad &= 75 + 0.0088P \text{ (in millions of January 1986 dollars)}\\ &= \$85.56 \text{ million per reactor plant}\end{aligned}$$

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.

LONG LIVED RADIONUCLIDES IN IRRADIATED STRUCTURE WITHIN CRUISER, LOS ANGELES, AND OHIO CLASS REACTOR PLANTS

Appendix D

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1. INTRODUCTION

Because of the various materials used in a reactor plant that can become activated during its operation, cruiser, LOS ANGELES, and OHIO class reactor plants contain a variety of radionuclides. The radionuclides include small quantities of long lived radionuclides. These radionuclides, with half-lives ranging from several thousand to several million years, are primarily in structure located within the reactor vessel that has been irradiated and subsequently activated. Less than 0.1% of the long lived activity is freed from this structure and transported out of the reactor vessel as wear product, a negligible amount. This appendix discusses the type, distribution, and amount of long lived radioactivity found within the irradiated structure of cruiser, LOS ANGELES, and OHIO Class reactor plants, and the methods used to calculate long lived activity within these structures. Specifically, the long lived radionuclides carbon-14, iodine-129, nickel-59, niobium-94, selenium-79, and technetium-99 are considered. Nickel-63, with a half-life of 100 years, is also considered in this appendix due to the presence of many thousands of curies of this radionuclide in activated structure within the reactor vessel.

2. BACKGROUND

2.1 Nature of Reactor Compartment Radioactivity

Naval Reactor Compartment Disposal Packages encompass the Reactor Compartment, that portion of a ship which supports and contains the ship's nuclear reactor plant. The reactor plant consists of the reactor vessel and associated piping and components that transfer heat from the reactor vessel and generate steam to propel the ship. Figure D-1 provides a simplified conceptual layout of a naval reactor compartment. Figure D-2 provides a simplified conceptual cross section of the reactor vessel showing the conceptual arrangement of the internal structure within the vessel. Neutrons escaping the fuel activate the reactor vessel internal structure and, to a smaller extent, the interior of the reactor vessel and associated structure. Table D-1 provides relevant properties of long lived radionuclides produced by this irradiation. From Figure D-2, the reactor vessel internal structure is essentially cylindrical and primarily composed of Inconel Alloy 600. Five types of this structure would exist for the cruiser, LOS ANGELES, and OHIO class reactor plant designs. Table D-2 provides the volumes occupied by these reactor vessel internal structures (i.e. volume based on the exterior dimensions of the cylindrical structure). Structure #1 is the most commonly found and would represent about 60% of the reactor plants being evaluated. Structures #2, #3, #4, and #5 would represent about 20%, 14%, 4%, and 2% of these plants, respectively.

3. LONG LIVED ACTIVITY

3.1 Long Lived Curie Content of Reactor Vessel Internal Structure

Since the exact design and operational life of reactor vessel internal structure varies between ship classes, activity will also vary. Estimates of long lived radionuclide activity in reactor vessel internal structure are presented in Table D-3. These estimates are based on a decay period of 1 year after final reactor shutdown of the cruiser, LOS ANGELES, and OHIO class reactor

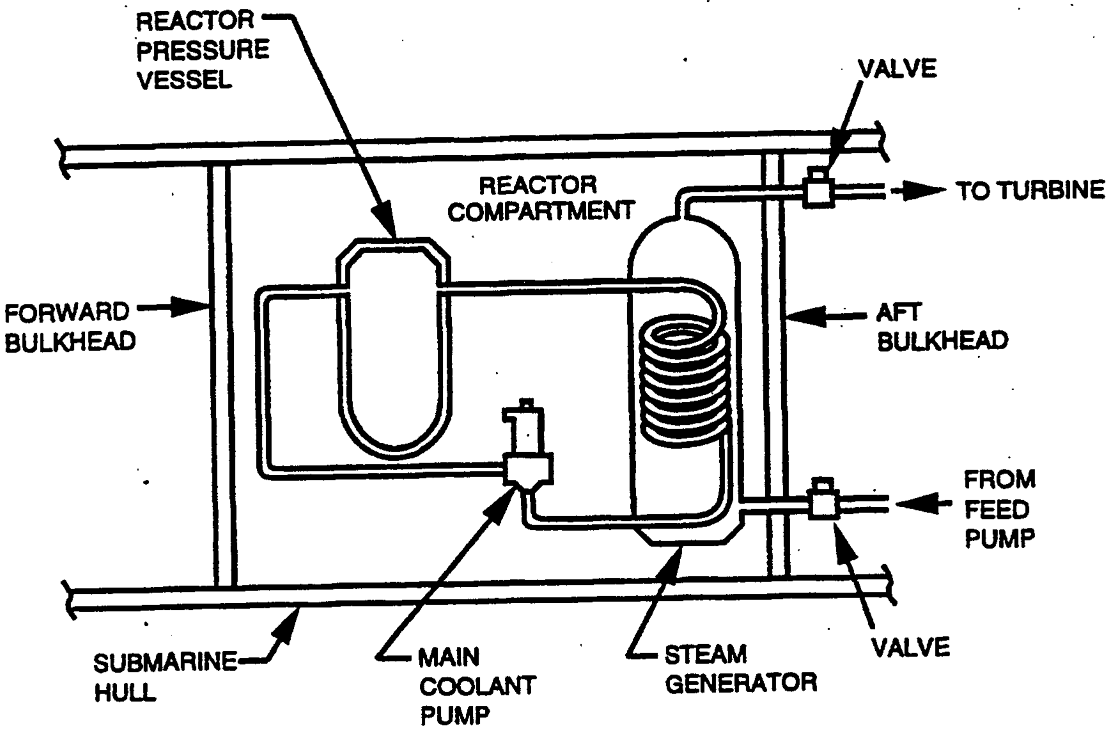

Figure D-1. Reactor Compartment Layout (conceptual)

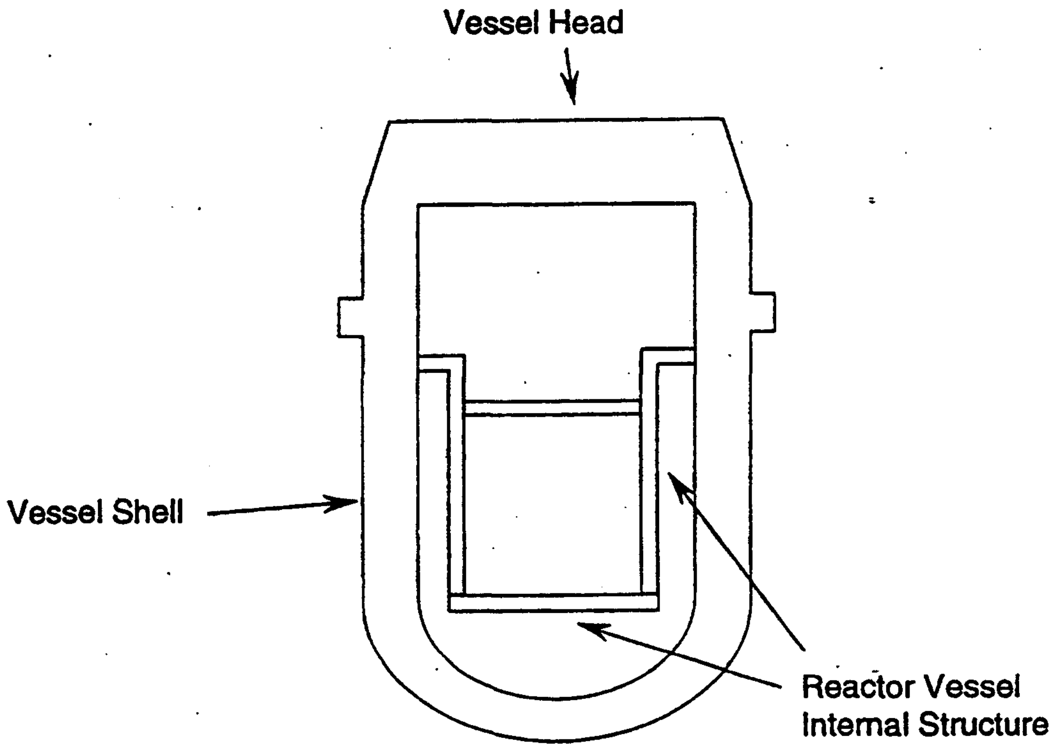

Figure D-2. Reactor Vessel with Internal Structure (conceptual)

Radionuclide	Radiation Emitted[1]	Energy per Disintegration[1]	Half-life (years)[1]
nickel-63	beta particles	maximum beta 0.066 MeV	100
carbon-14	beta particles	maximum beta 0.156 MeV	5,730
niobium-94	gamma rays beta particles	two in-series gammas: 0.87 MeV (100%) 0.70 MeV (100%) maximum beta 0.47 MeV	20,300
selenium-79	beta particles	maximum beta 0.15 MeV	65,000
nickel-59	X-rays e^-	less than 0.01 MeV less than 0.01 MeV	75,000
technetium-99	beta particles	maximum beta 0.29 MeV	213,000
iodine-129	X-rays beta particles e^-	less than 0.04 MeV maximum beta 0.15 MeV less than 0.04 MeV	15,700,000

1: KOCHER, 1981.

Table D-1, Long Lived Radionuclides in Activated Structure

Structure Type:	#1	#2	#3	#4	#5
Volume (m^3):	11.0	19.2	11.0	11.0	24.0

Table D-2, Reactor Vessel Internal Structure Volume

Radionuclide	Decay period (yr)[a]	Structure Type #1 (curies)	Structure Type #2 (curies)	Structure Type #3 (curies)	Structure Type #4 (curies)	Structure Type #5 (curies)
nickel-63	1	24,000	12,600	18,000	35,900	7,420
	500	751	394	563	1,120	232
	2000	0.023	0.012	0.017	0.034	0.007
carbon-14	1	1.20	0.621	13.5	26.9	0.396
	500	1.13	0.585	12.7	25.3	0.373
	2000	0.942	0.488	10.6	21.1	0.311
niobium-94	1	0.770	0.522	0.645	1.29	0.142
	500	0.757	0.513	0.634	1.27	0.140
	2000	0.719	0.488	0.602	1.20	0.133
selenium-79	1	2.22×10^{-5}	1.14×10^{-5}	6.15×10^{-5}	1.23×10^{-4}	3.34×10^{-6}
	500	2.21×10^{-5}	1.13×10^{-5}	6.12×10^{-5}	1.22×10^{-4}	3.32×10^{-6}
	2000	2.17×10^{-5}	1.12×10^{-5}	6.02×10^{-5}	1.20×10^{-4}	3.27×10^{-6}
nickel-59	1	219	116	156	311	63.5
	500	218	115	155	310	63.2
	2000	215	114	153	305	62.3
technetium-99	1	0.0287	0.0115	0.0143	0.0286	0.00348
	500	0.0287	0.0115	0.0143	0.0286	0.00347
	2000	0.0285	0.0114	0.0142	0.0284	0.00346
iodine-129	1	2.01×10^{-10}	3.04×10^{-9}	8.45×10^{-8}	1.69×10^{-7}	4.36×10^{-8}
	500	2.01×10^{-10}	3.04×10^{-9}	8.45×10^{-8}	1.69×10^{-7}	4.36×10^{-8}
	2000	2.01×10^{-10}	3.04×10^{-9}	8.45×10^{-8}	1.69×10^{-7}	4.36×10^{-8}

a: 1 year after final shutdown, 500 years and 2,000 years later;
Decay constant = 0.693/(half-life of radionuclide in year).

Table D-3, Reactor Vessel Internal Structure Curie Content

plants. Five hundred and 2000 year decay estimates are provided for comparison. Further discussion of the calculation method and statistical uncertainty in the quantities presented is provided in section 5 of this appendix.

3.2 Long Lived Curie Distribution in Reactor Vessel Internal Structure

Long lived activity is primarily found in the reactor vessel internal structure. Carbon-14 and iodine-129 are concentrated towards the inside of the structure while the other Table D-3 radionuclides are more generally distributed through the structure. Niobium-94 can be predominately found in weld materials used within the reactor vessel internal structure. This material is fused with surrounding base metal and is thus an intrinsic part of the overall structure.

3.3 Long Lived Curie Content in the Reactor Vessel

Neutrons that penetrate through the internal structure can activate atoms in the reactor vessel. This results in the long lived radionuclides of Table D-1, but to a much lesser extent than for the internal structure. For estimating long lived activity contained in the reactor vessel, the curie contents provided in Table D-3 for reactor vessel internal structure can be increased by a scaling factor to include long lived curies found in the reactor vessel materials. Scaling factors for this purpose range from 1.05 to 1.20, depending on the reactor vessel internal structure type. Scaling factors were developed by estimating the nickel-59, nickel-63, and niobium-94 quantities expected in the most highly activated regions of the reactor vessel. Of these three radionuclides, the greatest amount of activation in the reactor vessel, on a percentage basis compared to the internal structure, was for niobium-94. The niobium-94 reactor vessel activities were rounded upwards to produce conservative scaling factors and the resulting niobium-94 based scaling factors were used. Differences in scaling factors between internal structure types result from a number of factors including expected operating life of the reactor plant and design of the internal structure.

4. SUITABILITY OF REACTOR VESSEL INTERNAL STRUCTURE FOR SHALLOW LAND BURIAL AT HANFORD SITE

4.1 Hanford Site Activity Concentration Limits

The Department of Energy Hanford Site Solid Waste Acceptance Criteria Document (WHC, 1993) provides activity concentration limits for the Hanford Site. Hanford Category 3 limits are intended to be functionally equivalent to 10CFR61 Class C limits, developed by the Nuclear Regulatory Commission (NRC), in defining a waste suitable for land burial. Both the Hanford and NRC limits are based on a maximum radiological dose to an intruder of 500 mrem/yr. The NRC limits allow for surface oriented agricultural and construction related intruder scenarios (NRC, 1982). The Hanford limits consider site specific characteristics, which eliminates all plausible intruder scenarios except well-drilling (WHC, 1993). Table D-4 presents Hanford activity concentration limits for the radionuclides considered in this appendix, in curies per cubic meter. For comparison to these limits, Table D-4 also presents activity concentration fractions. The curie contents provided in Table D-3 for a 1 year decay period are divided by the structure volumes of Table D-2 to produce activity concentrations in curies per cubic meter. These concentrations are then divided by the Hanford Category 3 limits provided in Table D-4 to produce the decimal fractions shown. Activity concentrations for the entire reactor compartment could be similarly calculated based on reactor vessel volume and the radionuclide content of the vessel. These activity concentrations would be lower than those for the internal structure in Table D-4 due to the much larger exterior volume of the reactor vessel compared to the internal structure.

		Activity Concentration Limit Fractions for Internal Structure				
Radionuclides	Hanford Category 3 limit (Ci/m³) [a]	Type # 1	Type # 2	Type # 3	Type # 4	Type # 5
nickel-63	170,000	0.0128	0.0039	0.0096	0.0192	0.0018
carbon-14	91	0.0012	0.0004	0.0135	0.0269	0.0002
niobium-94	0.56	0.125	0.0485	0.105	0.209	0.0106
selenium-79	83	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
nickel-59	8,300	0.0024	0.0007	0.0017	0.0034	0.0003
technetium-99	1.2	0.0022	0.0005	0.0011	0.0022	0.0001
iodine-129	0.59	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

a: Limit for radionuclide in activated metal.

Table D-4, Activity Concentration Fractions for Long Lived Activity Based on Hanford Category 3 Limits (WHC, 1993)

4.2 10CFR61 Activity Concentration Limits

In 10CFR61, the Nuclear Regulatory Commission (NRC) established activity concentration limits for radioactive materials being disposed of at NRC licensed sites. These limits are not directly applicable to Department of Energy sites (Hanford) but are presented in Table D-5 for the radionuclides considered in this appendix for comparison. Table D-5 presents activity concentration limits for activated metals for Class C waste, in curies per cubic meter. No limit for selenium-79 is found in 10CFR61. Table D-5 also presents activity concentration fractions. The curie contents provided in Table D-3 for a 1 year decay period are divided by the structure volumes of Table D-2 to produce activity concentrations in curies per cubic meter. These concentrations are then divided by the 10CFR61 Class C limits provided in Table D-5 to produce the decimal fractions shown.

From Table D-5, activity concentrations are well below 10CFR61 Class C limits for the radionuclides listed. As stated previously, activity concentrations would be reduced further if the reactor vessel internal structure and the less activated reactor vessel were considered together as a whole.

The disposal of cruiser, LOS ANGELES, and OHIO class reactor compartments at the Hanford 218-E-12B burial ground would also meet the intruder and environmental protection standards of 10CFR61 (for radiological dose). Appendix B provides a more detailed discussion of this condition.

		Activity Concentration Limit Fractions for Internal Structure				
Radionuclides	Class C limit (Ci/m³) [a]	Type # 1	Type # 2	Type # 3	Type # 4	Type # 5
nickel-63	7000	0.312	0.0938	0.234	0.466	0.0442
carbon-14	80	0.0014	0.0004	0.0153	0.0306	0.0002
niobium-94	0.2	0.350	0.136	0.293	0.586	0.0296
nickel-59	220	0.0905	0.0275	0.0645	0.129	0.0120
technetium-99	3	0.0009	0.0002	0.0004	0.0009	<0.0001
iodine-129	0.08	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

a: Limit for radionuclide in activated metal.

Table D-5, Activity Concentration Fractions for Long Lived Activity based on 10CFR61 Class C Limits

4.3 Uncertainty in Activity Concentration Fractions

Section 5 discusses the calculation of activity in reactor vessel internal structure and conservatisms or uncertainty in the calculation method. In summary, the curie contents presented in Table D-3 are considered reasonably accurate. This accuracy results from assumptions employed in the calculation process. Validation has confirmed the accuracy of the calculation method with measured activities predicted to within plus and minus 30% (e.g., see SHURE, 1967). Reactor vessel internal structure volumes are also based on accurate construction drawings. The resulting degree of uncertainty in activity concentration fractions would not be sufficient to alter the conditions discussed in the previous sections.

5. CALCULATION OF ACTIVATION PRODUCT CURIES

Neutrons interact with nonradioactive atoms (target isotopes) that are found within reactor materials, causing these atoms to become activated to radionuclides. This process is modeled by an equation which relates the flux of neutrons generated by the fuel to properties of the material being irradiated and reactor operation/shutdown times. Neutrons are produced with a range of energies which also must be considered in the model. The basic model equation is thus repeated for different neutron energy groups to sum the contributions of all neutrons to the activation process.

5.1 Equation

The following equation is used to calculate curie contents resulting from the activation of material.

$$A(t_o, t_s) = [\, P\, V\, f\, N\, \sigma\, \phi\, f_c\, (1 - e^{-(\lambda t_o)})\, e^{-(\lambda t_s)}\,] / 3.7 \times 10^{10}$$

t_o = the operating time for the reactor.

t_s = the shutdown time; the time between the end of the operating period t_o and the time at which the activity is determined (e.g., if the reactor is shut down in year X and the curie content is evaluated for year X+Y, then t_s [shutdown time] is Y years.

$A(t_o, t_s)$ = the number of curies of activity contained in a volume of material due to a specific radionuclide for a particular operating time (t_o), and shutdown time (t_s).

P = the fraction of full power of reactor operation during the period t_o.

V = the volume of material activated (cm^3).

f = the target isotope's abundance in the activated material relative to the abundance of the target isotope's element (the number of atoms of the target isotope per atom of the element).

N = the atom density (atoms/barn-cm) of the target isotope's element in the material activated (e.g., if niobium-93) is the target isotope then niobium is the target isotope's element so the atom density of niobium in the activated material is used).

σ = the target isotope's microscopic activation cross section (barns).

ϕ = the full power value of the activating neutron flux assigned to the volume (V) of the material [neutrons/(cm^2-sec)].

f_c = a neutron spectrum correction factor that is consistent with flux and cross section used.

λ = the activated radionuclide's decay constant (0.693 divided by the half-life of the radionuclide).

3.7×10^{10} = 37,000,000,000; the number of disintegrations per second for one curie of activity.

Note: In the equation, the exponential term using t_s can be approximated by 1 for long lived radionuclides. The exponential term using t_o is subtracted from 1 and thus this combination approaches zero for very long lived radionuclides but can vary by orders of magnitude depending on λ. For long lived radionuclides, curies increase essentially linearly with increasing t_o.

5.2 Quantifying Variables

When using the equation to estimate a radionuclides activity, the following considerations govern values assigned to variables in the equation.

5.2.1 Target Isotope Abundance (f)

Table D-6 provides the target isotopes for the long lived radionuclides of Table D-1 and values for the target isotope's abundance, the variable (f), used in the basic equation. Isotopic abundance is given in % of atoms of the element that are the target isotope. For example, nickel-62 is the target isotope for nickel-63 production and 3.59 percent of the nickel atoms present are assumed to be nickel-62.

Table D-1 Radionuclide	Target Isotope	Isotopic Abundance of Target Isotope (%)	Concentration of Target Isotope's Element in Inconel Alloy 600 (weight %)[a]
carbon-14	carbon-13 nitrogen-14 oxygen-17	1.10 99.63 0.04	0.10 [b] 0.013 [c] 0.04 [c]
nickel-63	nickel-62	3.59	80 [b]
niobium-94	niobium-93	100	0.070 [c]
selenium-79	selenium-78	23.6	7.0×10^{-5} [c]
nickel-59	nickel-58	68.27	80 [b]
technetium-99	molybdenum-98	24.13	0.30 [c]
iodine-129	tellurium-128	31.7	9×10^{-7} [c,d]

a. Basis for atomic density (N).

b. Upper end of material specification range.

c. From material testing.

d. A significantly higher tellurium concentration of 0.005 wt% is found in Inconel Alloy X-750 which is also present in the internal structure but in much smaller quantity than Alloy 600.

Table D-6 Target Isotopes, Isotopic Abundances, and Target Isotope Element Concentrations Used for Activity Calculation

5.2.2 Atom Density (N)

Atom density is based on the concentration of the element in the material being irradiated. Table D-6 presents element concentrations for Inconel Alloy 600, the primary alloy found in reactor vessel internal structure. Based on results from detailed chemical composition measurements, concentrations for important trace elements have been compiled primarily for use in curie calculations. This work represents an increased level of effort and provides a higher degree of accuracy compared to more common methods for determining element concentrations. In the cases where the material specification required a concentration range for an element, the upper end of the specification range is used. For example, nickel-62 is the target isotope for nickel-63. Nickel would thus be the target isotope's element. For Inconel Alloy 600 in reactor plants, the material specification is 72-80% nickel, thus 80% is selected as the element concentration and the atom density corresponding to this higher content is used. This results in a maximum (N) value being used vice an average value.

5.2.3 Cross Section (σ)

Neutron energies are divided into three groups: thermal (energy less than 0.625 electron-volts), epithermal (energy greater than 0.625 electron-volts), and fast (energy over 1 million electron-volts). The equation (section 5.1) is used to calculate the activity generated by each of these groups. Resulting curie contents are then summed to obtain a total activity. The appropriate cross section (σ) used in the equation varies for the different neutron energy groups. Thermal, resonance integral, and fission spectrum values for (σ) are used for thermal, epithermal, and fast neutrons, respectively. Standard published cross section values are used such as those from Chart of the Nuclides and Isotopes (CHART, 1989).

5.2.4 Neutron Flux (ϕ) and Flux Spectrum Correction Factor (f_c)

Neutron fluxes are determined for the three energy groups and coupled to appropriate values for the other variables of the equation to assess the effect of the different neutron energy groups on the production of activated radionuclide. Conservative assumptions on the design and performance of the fuel result in estimated neutron fluxes which are considered conservative. The effects of variations in fuel on neutron fluxes outside the fuel assembly over the fuel assembly life are considered. Flux spectrum correction factors are provided in the ORIGEN (Oak Ridge National Laboratory Isotope Generation) computer program which is used to assist in curie calculations. This program is discussed further in section 5.3.

5.2.5 Refined Method for Neutron Reaction Rate

The equation of section 5.1 is repeated for each of the three neutron energy groups in order to account for activation produced by each group. For each energy group, average values for variables are used. The combined terms ($N\ f_c\ \sigma\ \phi$) essentially represent a neutron activation reaction rate. This rate for the thermal neutron energy group normally controls the total amount of activity produced (the curie contribution from higher energy neutrons is not significant). However, for some radionuclides, reactions with epithermal and fast neutrons produce significant amounts of activity relative to thermal neutrons. For these radionuclides, when using the equation of section 5.1, the use of average values for the ($N\ f_c\ \sigma\ \phi$) variables can generally lead to over predicting activity. To remedy this situation, the epithermal and fast neutron energy groups are divided up into numerous sub groups according to energy level and the effects summed together. This more refined treatment generally results in more realistic calculated activities. Niobium-94 activity is calculated in this manner. For Table D-1 radionuclides, the refined method could potentially be of benefit for selenium-79, technetium-99, and iodine-129 activity. However, this method was not used for Table D-3 because the predicted concentration of these radionuclides was relatively small in comparison to the standards discussed and use of average reaction rate terms generally over predicts activity.

5.3 Computer Assistance for Calculations

The ORIGEN (Oak Ridge National Laboratory Isotope Generation) computer program applies the equation to the different energy groups of neutrons produced by the reactor. The effects of each group are summed and the additional activation that occurs from secondary reactions and decay processes is included. Complex reactor power histories are accounted for. Other programs are available for use in this application, such as SPAN5 and CINDER, however, results are relatively insensitive (± 10 percent) to the calculation method when the atom density of the target isotope's element (N), the activation cross section (σ), and the neutron flux (ϕ) are known. The considerations discussed previously for quantifying these variables ensure that conservatively accurate values of the variables are used.

5.4 Uncertainty/Conservatism in Curie Calculations

No explicit conservatism factors are applied to predicted activities. These activities are considered to be reasonably accurate because of the selection of values for variables and the conservative analysis models used for predicting neutron flux. Several comparisons of activity calculations to actual measurements have been made to qualify the method described in this section. These comparisons have shown that measured activities can be predicted to within plus or minus 30%, with a majority of predictions being much closer to measured values (e.g., see SHURE, 1967).

6. CONCLUSION

Long lived activity in cruiser, LOS ANGELES, and OHIO class reactor plants is concentrated in the reactor vessel internal structure. This activity is not in a quantity or form that would cause the reactor compartments to be unsuitable for shallow land burial either under Hanford Site of NRC criteria. The methods used to estimate this activity are reasonably accurate and any uncertainty would not be large enough to affect the aforementioned conclusion.

REFERENCES

CHART, 1989	Chart of the Nuclides and Isotopes, General Electric Company, Nuclear Operations, San Jose California, 14th edition (1989).
KOCHER, 1981	Radioactive Decay Data Tables - A Handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessments, David C. Kocher, Health and Safety Research Division Oak Ridge national Laboratory, 1981, U.S. Dept. of Energy, available as DOE/TIC-11026 from National Technical Information Center, US Dept of Commerce.
NRC, 1982	Final Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste", Volume 1. Summary and Main Report, NUREG-0945-V1, United States. Nuclear Regulatory Commission, Washington, D.C., November 1982.
SHURE, 1967	"Neutron Exposure of the PM-2A Reactor Vessel", K. Shure and Carl T. Oberg, Nuclear Science and Engineering, Vol. 27 (1967), p. 348-359.
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10CFR61	Code of Federal Regulations Title 10 "Energy", Part 61.

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EVALUATION OF THE HEALTH RISK TO THE PUBLIC AND WORKERS ASSOCIATED WITH THE SHIPMENT OF DEFUELED REACTOR COMPARTMENTS FROM CRUISERS AND LOS ANGELES CLASS AND OHIO CLASS SUBMARINES

Appendix E

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1. INTRODUCTION

This appendix presents an evaluation of the health risks to the public and occupational workers associated with the transportation of defueled reactor compartments fro decommissioned U.S. Navy nuclear-powered cruisers and submarines. It is applicable to the cruisers USS LONG BEACH (CGN 9), USS BAINBRIDGE (CGN 25), USS TRUXTUN (CGN 35), the two cruisers of the USS CALIFORNIA Class (CGN 36 and CGN 37), the four cruisers of the USS VIRGINIA Class (CGN 38, CGN 39, CGN 40, CGN 41), USS LOS ANGELES Class submarines, and USS OHIO Class submarines. BAINBRIDGE, TRUXTUN, and CALIFORNIA Class cruisers were not analyzed individually and are considered to be equivalent to VIRGINIA class cruisers for purposes of this evaluation due to similarity of reactor plant design. Shipments from either Puget Sound Naval Shipyard (PSNS) or Norfolk Naval Shipyard (NNSY) to either the Hanford disposal site or Savannah River disposal site are covered. For the shipment of reactor compartments from PSNS to Hanford, the reactor compartments are assumed to be shipped whole or subdivided into smaller packages. For all other cases, the reactor compartments are assumed to be subdivided into smaller packages. Whole reactor compartment shipments from NNS or to the Savannah River disposal site are not possible due to physical limitations such as the depth of the river and overhead obstructions due to bridges.

2. SHIPMENTS EVALUATED

The package origin/destination options and the modes of transportation considered for various package types are summarized in Table E-1.

3. TECHNICAL APPROACH - GENERAL

The general approach taken to evaluate the radiological health risks (i.e., increase in potential of cancer fatalities) associated with the transport of the subject reactor compartment packages is described as follows. First, the radiological risks to the general population, to the transport crew, and to hypothetical maximum exposed individuals are evaluated for gamma radiation emanating directly from the package for normal transport (i.e., incident-free) conditions. Next, the radiological risks to the general population for accident scenarios resulting in corrosion product release to the atmosphere are evaluated based on a conditional probability for occurrence of accidents with various severity. To upper bound the significance of an accident, the radiological consequences assuming a severe accident has occurred are also evaluated for hypothetical maximum exposed individuals and the general population. In conjunction with these incident-free and accident radiological evaluations, non-radiological risks to the population are presented from causes associated with vehicular exhaust emissions and transportation accidents.

3.1 Computer Codes

Several computer codes were used in the analyses. Specifically, the RADTRAN 4 computer code, developed by Sandia National Laboratories, was used to calculate the radiological risk for both the incident-free and accident risk scenarios (SNL, 1992 and SNL, 1993). For this evaluation, RADTRAN was determined not to be appropriate for the consequence analyses or assessment of maximum exposed individuals (MEI).

The RISKIND computer code, developed by Argonne National Laboratory, was used to calculate the maximum radiological consequences to the general population and to individuals for postulated accident condition (ANL, 1993). For this evaluation, RISKIND was determined not to be appropriate for the risk analyses aspect or incident-free evaluation.

Table E-1 Package Origin/Destination and Transport Mode

ITEM		MODE			ORIGIN		DESTINATION	
	Package Type	Truck	Rail	Barge/ Transporter	PSNS	NNS	Hanford	Savannah River
A	Whole Reactor Compartment			●	●		●	
B	Miscellaneous Components	●			●	●	●	●
C	Reactor Pressure Vessel			●	●	●	●	●
D	Steam Generator	(a)	(b)		●	●	●	●
E	Pressurizer		●		●	●	●	●

(a) Steam generators from cruisers assumed to be shipped by truck.
(b) Steam generators from submarines assumed to be shipped by rail.

Several other codes were used to provide input for the RADTRAN 4 and RISKIND computer codes. These codes include INTERLINE, HIGHWAY, and SPAN 4.

The INTERLINE computer code, developed by Oak Ridge National (ORNL) Laboratory, was used to evaluate rail routes for particular shipments and provides mileage and population densities in the rural, suburban and urban segments of the route (ORNL, 1993a). INTERLINE is an interactive computer program designed to simulate routing using the U.S. rail system. The INTERLINE code used is the latest available from ORNL and contains the 1990 census data.

The INTERLINE database consists of networks representing various competing rail companies in the U.S. The routes used in this evaluation use the standard assumptions in the INTERLINE model which simulates the selection process that railroads would use to direct shipments of the items under consideration. The code is updated periodically to reflect current track conditions and has been benchmarked against reported mileage and observations. INTERLINE also provides the weighted population densities for rural, suburban, and urban populations averaged over all states along the shipment route and the percentage of mileage traveled in each population density. The distance traveled, weighted population density, and percentage of distance in each population density are input variables in the RADTRAN 4 code.

The HIGHWAY computer code also developed by ORNL, was use to evaluate the truck routes excluding the partial routes by truck (transporter) for the whole reactor compartment and reactor pressure vessel (ORNL, 1993b). HIGHWAY is an interactive computer code designed to simulate routing using the U.S. highway system.

The HIGHWAY code used in this evaluation is the latest available from ORNL. The code is updated periodically as new roads are added. The routes used for this study use the standard assumptions in the highway model. HIGHWAY provides the distance between the origin and destination, the weighted population densities along the routes and the percentage of distance traveled in each population density, which are all input variables for the RADTRAN 4 computer code.

The SPAN 4 computer code (Bettis, 1972) was used to perform gamma exposure rate calculations for the various shipping containers to assess the effect of increased distance from the source on exposure. SPAN 4 is a point kernel code where appropriate exponential kernels are integrated over a source distribution. SPAN 4 was developed by the Bettis Atomic Power Laboratory specifically for naval spent nuclear fuel and associated reactor components.

3.2 Conversion to Fatality Rates

The radiological impacts are first expressed as the calculated total effective exposure (person-rem) for the exposed population, transportation crew, and the maximum exposed individuals. The calculated total exposures are then used to estimate the hypothetical health effects, expressed in terms of estimated cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection (ICRP, 1991) which specifies 0.0005 latent cancer fatalities per rem for members of the public and 0.0004 latent cancer fatalities per rem for workers. These conversion factors assume no radiological threshold occurs. Therefore, upon interpreting the results, the risks associated with population exposure (person-rem) and maximum exposed individual (rem) are equivalent for equal exposure levels. For example, the risk associated with 0.1 rem exposure to a population of 10 persons (1.0 person-rem) is equivalent to the risk from exposure of 1 rem to 1 individual (1 person-rem).

Non-radiological risks related to the transportation of naval reactor compartments are also estimated. The non-radiological risks are those resulting from vehicle exhaust emission for incident-free transportation and fatalities resulting from transportation accidents for accident risk assessment. The non-radiological risks associated with shipments required to return empty containers to the origin are also included. Risk factors for exhaust emissions and state level fatality rates (Saricks, 1994, SNL, 1982 and SNL, 1986) are summarized in Table E-2.

Table E-2 Fatality Rates for Non-Radiological Risks

	RAIL	TRUCK	WATERWAY
Fatalities/km due to Pollutants	1.3×10^{-7}	1.0×10^{-7}	0.0
Fatalities/km due to Accidents in Washington State	*2.82×10^{-8}	1.47×10^{-8}	NA
Fatalities/km due to Accidents as a National Average	2.82×10^{-8}	5.82×10^{-8}	NA
Fatalities/km due to Accidents for the Pacific Coast	NA	NA	3.2×10^{-9}
Fatalities/km due to Accidents for the Atlantic Coast	NA	NA	3.2×10^{-9}
Fatalities/km due to Accidents for the Inland Waterways	NA	NA	7.3×10^{-9}

* Not readily available so national average was used.

4. TECHNICAL APPROACH FOR THE ASSESSMENT OF INCIDENT-FREE TRANSPORTATION

4.1 General Population Exposure and Transportation Crew Exposure

To assess the health risk associated with incident-free transportation of naval reactor compartments, the RADTRAN 4 computer code was used to calculate the external radiological exposure to the general population and the transportation crew. Exposures received during incident-free transport are attributed to gamma radiation emanating mainly from activated structures (Cobalt-60) within the reactor compartment package.

Included in the RADTRAN 4 computer code incident-free risk calculations for transport are models predicting:

(1) Exposure to persons within about one-half mile of each side of the transport route (off-link exposures).

(2) Exposures to persons (e.g., passengers on passing trains or vehicles) sharing the transport route (on-link exposures).

(3) Exposures to persons at stops (e.g., residents or rail and truck crew not directly involved with the shipment).

(4) Exposures to transportation crew members.

The exposures calculated for the three groups, (off-link, on-link and crew) were added together to obtain the general population exposure estimates. On-link was not included in the transporter shipment of whole reactor compartments and pressure vessels because it is assumed that access controls to the highway would be imposed.

The exposure calculated for the crew was assigned to occupational exposure.

The transportation crew exposure is associated with exposure directly from the package during transit and/or inspection periods. For truck/transporter shipments, RADTRAN assumes crew exposure is entirely from exposure during the transit period and no inspections occur. For both waterway and rail shipments, RADTRAN assumes crew exposure is from exposure during periods of package inspections and negligible during the transit time due to relatively long separation distances and massive shielding of intervening structures. This RADTRAN model was concluded to be reasonable for both truck and rail shipments but not for the treatment of the waterway shipments of interest.

For reactor compartment waterway shipment RADTRAN crew exposure predictions were concluded not to be applicable since no package inspections are performed (the package is welded to the barge) and intervening distances during transit is not always sufficient to entirely preclude crew exposure. Therefore, reasonable conservative hand calculations were performed to account for waterway crew exposures during transit using equivalent point source formulas (similar to the first formula presented in Section 5.2.) together with the data presented in Table E-7.

4.2 Maximum Exposed Individuals

To estimate the maximum radiological exposure to occupational and non-occupational individuals during routine transport of reactor compartments, various scenarios were hypothesized.

For exposure to the general population during rail shipments, three scenarios were assumed:

(1) A rail yard worker who was assumed to be working at a distance of ten meters from the package for two hours.

(2) A resident who was assumed to live 30 meters from the rail line while the package was being transported.

(3) A resident who was assumed to be living 200 meters from a rail stop where the reactor compartment package was sitting for 20 hours.

The maximum occupational exposure during rail shipments was assumed to be that occurring from inspections of the package as calculated by RADTRAN.

For truck shipments, the maximum exposed individual (general population) was hypothesized to be:

(1) A person who is caught in traffic and located 1.0 meters away from the reactor compartment package for one half hour.

(2) A resident assumed to be living 30 meters from the highway while the package was being transported.

(3) A service station worker who was assumed to be working at a distance of 20 meters from the package for 2 hours.

The maximum exposed occupational worker was assumed to be the driver of the truck as calculated in RADTRAN.

For the waterway shipments, the scenarios for the maximum exposed individual were:

(1) A bridge workman located 10 meters above the centerline of the package for 2 hours while stopped, and

(2) a motorist is disabled on a bridge above the water route during the total time the package is being transported and is positioned a distance above the water route equivalent to the package radius plus 10 meters.

The maximum exposed occupational worker was assumed to be a ship crew member during transit.

For predicting radiological exposure to persons at a fixed distance (the maximum exposed individual) from the package during a stop, the following formula was used.

Exposures to a person at a fixed distance from the container:

$$E = T \times K \times TI/D^2 \qquad \text{Formula (1).}$$

where:

E = exposure
T = total exposure time
K = shipment external dose rate to exposure conversion factor based on package size
TI = shipment external dose rate at one meter from the package surface
D = average distance from centerline of container to exposed person

The maximum exposed individual is assumed to be the same individual for all shipments of the same type.

Exposure to individuals at a fixed distance from the transport route was calculated using the following formula for a moving radiation source traveling with a fixed velocity, V. All other terms are the same as described for Formula (1).

$$E = (\pi \times K \times TI)/(V \times D) \qquad \text{Formula (2)}$$

5. TECHNICAL APPROACH FOR POSTULATED ACCIDENTS

5.1 General Population and Risk

The RADTRAN 4 computer code was used to calculate the radiological risk to the general population under accident conditions. The RADTRAN 4 computer code evaluates six pathways for radiation exposures resulting from an accident. The six evaluated pathways are:

(1) Direct radiation exposure from the damaged package.

(2) Inhalation exposure from the plume of radioactive material released from the damaged package.

(3) Direct radiation exposure from immersion (cloudshine) in the plume of radioactive material released from the damaged package.

(4) Direct radiation exposure from ground deposition of the radioactive material released from the damaged package.

(5) Inhalation exposure from resuspension of the radioactive material deposited on the ground.

(6) Ingestion exposure from food products grown on the soil contaminated by ground deposition of radioactive material released from the damaged package.

For each pathway, a specific formula is used to determine an estimate of the radiological exposure from that particular pathway with the total radiation exposure equal to the sum of the exposure for each pathway. The internal pathways (inhalation and ingestion) exposures are based on a committed effective dose to the body over a 50-year period. The total accident radiation exposure accounts for the probability f an accident occurring and the probability of a accident of a particular severity. The general equation for the population risk from all pathways is:

$$DR = \Sigma_{c,r} L_c P_r \times \Sigma_{i,j,k} (P_j \times RF_j \times D_{i,j,k})$$

where:

DR = population exposure risk from the accident
L_c = shipment distance (Table E-3)
P_t = probability of traffic accidents per unit distance (Accident Probabilities, Table E-8)
P_r = probability of accident severity category (Severity Fractions, Table E-9)
RF_j = fraction of curies released from shipping container by severity category j (Corrosion Product Release Fractions, Table E-10)
$D_{i,j,k}$ = radiation exposure commitment resulting from accident severity category j through pathway i in population density zone k.

Because it is impossible to predict the specific location of a transportation accident, neutral weather conditions (Pasquill Stability Class D) were assumed (Pasquill, 1974). Since neutral meteorological conditions are the most frequently occurring atmospheric conditions in the United States, these conditions are most likely to be present in the event of a transportation accident.

5.2 Maximum Consequence to Individual and Population

In addition to the estimation of the accident risk described above, the accident consequence was evaluated assuming an accident of the highest severity occurs. The consequence, expressed as radiological exposure, is calculated for the maximum exposed individual (MEI) and the general population. Exposures to the general population are calculated for each of the three population density regions (rural, suburban, and urban) over a 50-mile radius.

A fraction of the total corrosion product inventory in the package can be released to the atmosphere assuming a severe accident occurs. This release fraction was conservatively estimated to be 32% to 40% for whole reactor compartment shipments and varying amounts for subdivided shipments and was used in the consequence and risk analysis.

The RISKIND computer code, modified to accept the inventory associated with naval reactor compartment corrosion products was used to calculate the exposure. The pathways evaluated by RISKIND for the general population are identical to those used in the RADTRAN 4 computer code for the risk evaluation.

The MEI exposure includes the contributions from inhalation, groundshine and cloudshine. No food ingestion pathway to an individual is considered because it was assumed that radioactive contamination from plausible accidents would be cleaned up promptly and, therefore would not enter the food chain. Direct radiation exposure from the damaged package to the MEI and maximum exposed population would be less that 0.1% of the exposure from inhalation, groundshine, and cloudshine which would occur at 160m to 400m from the package. It was assumed that the MEI would be exposed unshielded during the passage of the plume of radioactive material released from the accident under worst (stable) atmosphere conditions.

Remedial actions following an accident would significantly reduce the consequences of an accident; however, no credit was taken in the risk or maximum consequence evaluations.

5.2.1 Probability Cutoff Criterion. Consistent with the U.S. Department of Energy's, Office of Environmental Management and Idaho National Engineering Laboratory, Environmental Waste Management Programs Environmental Impact Statement (DOE, 1995), a conservative severe accident probability cutoff criterion of one in ten-million (1×10^{-7}) was selected for excluding improbable accidents from the maximum consequence evaluation.

To determine the overall severe accident probability, the probability of an accident times the severity fraction times the fraction of travel in each population area times the probability of the meteorological conditions was calculated.

The probability of the accident per year was calculated by multiplying the accident probability rates times the distance traveled in each state times the maximum number of shipments per year. The number of shipments per year was conservatively assumed to be 8 complete reactor compartment shipments (except 2 for the LONG BEACH) for purposes of determining this cutoff probability. This was done for each combination of origin and destination and ship class.

To calculate the probability of the meteorological conditions, the established criteria for assigning atmospheric stability classes (Pasquill, 1974) was used. Pasquill Class D was considered to be equivalent to 50% meteorology; that is 50% of the time conditions are expected to be more severe, and 50% of the time conditions are expected to be less severe. Pasquill Class F was considered to be equivalent to 95% meteorology; that is 5% of the time it is more severe and 95% of the time it is less severe. Analyses performed by the National Oceanic and Atmospheric Administration (NOAA, 1976) confirm that this assumption is reasonable.

Upon comparing the resultant probabilities to the 1×10^{-7} per year criterion, the most severe atmospheric (Pasquill Class F) results were presented if warranted by the cut-off. If the probability was less than the 1×10^{-7} cutoff, the consequences resulting from release of 1% of the corrosion products (Pasquill Class D) would be presented at the minimum. This later case never occurred. This method of determining the atmospheric condition and corresponding release fraction is consistent with the U.S. Department of Energy's, Office of Environmental Management and Idaho National Engineering Laboratory, Environmental Waste Management Programs Environmental Impact Statement (DOE, 1995).

Careful attention was paid to ensure that the probabilities were not calculated for such small categories that the resulting probabilities were less than the criterion and results would inadvertently present less severe consequences.

6. ROUTING ANALYSIS

In order to assess the radiological risk associated with transportation, it was necessary to determine route characteristics based on the origin and destination of each shipment as well as the method of shipment.

For naval reactor compartment shipments, the origin is the shipyard location where the reactor compartment has been removed form the ship. In this analysis, the two possible points of origin are Puget Sound Naval Shipyard (PSNS) and Norfolk Naval Shipyard (NNSY). The destination is one of two burial sites, the Savannah River Site or the Hanford Site.

The method of shipment for each package type is shown in Table E-1. For the large packages (whole reactor compartments and reactor pressure vessels), the package is transported via barge over an ocean leg and a river leg, and then via transporter for land transport. The estimated mileage for each part of the shipment of the large packages is given in Table E-3

For the rail and truck shipment of the subdivided reactor compartment, INTERLINE and HIGHWAY were used to generate routing data.

7. INPUT PARAMETERS AND ASSUMPTIONS

The major input parameters and assumptions used to evaluate the radiological risks associated with the shipments identified in Table E-1 are provided in this section. A number of the input parameters were developed for these particular shipments while others are standard RADTRAN 4 computer code values. The standard RADTRAN 4 default values are provided in Table E-4. Exceptions to the default values are identified in Table E-4 and further discussed below. These are representative values for purposes of evaluation and may vary in actual practice.

Table E-3 Distance (km) for the Transportation of Large Packages

	OCEAN BARGE		RIVER BARGE	TRANSPORTER
PSNS to Hanford	Sound & Strait	241	Vancouver to Port of Benton	Port of Benton to Site
	Ocean	261		
	River	166		
	TOTAL	668	386	42
PSNS to Savannah River	Sound & Strait	241	Savannah to Barge Wharf	Barge Wharf to Site
	Ocean	12,260		
	Panama Canal	82		
	Savannah River	0		
	TOTAL	12,583	253	16
NNS to Hanford	Elizabeth River	48	Vancouver to Port of Benton	Port of Benton to Site
	Ocean	12,884		
	Panama Canal	82		
	Columbia River	166		
	TOTAL	13,180	386	42
NNS to Savannah River	Elizabeth River	48	Savannah to Barge Wharf	Barge Wharf to Site
	Ocean	885		
	Savannah River	0		
	TOTAL	933	253	16

7.1 Incident-Free Transportation

This section provides the input parameters and assumptions used to determine the radiological impacts associated with routine, incident-free (i.e., no accident) transportation of all of the package types under consideration.

7.1.1 Planned Shipments. Table E-5A provides a list of whole reactor compartment shipments (estimated size and estimated number of packages) that are possible from PSNS to the Hanford Site. Table E-5B provides a summary of shipments for the subdivided alternative from either of the two origins and to either of the two proposed destinations (estimated size and estimated number of packages).

Table E-4 Default Values for RADTRAN 4 Input Parameters

	RADTRAN 4 Input Parameter	Truck	Rail	Barge
1	Fraction of Travel in Rural Zone	0.90	0.90	0.90
2	Fraction of Travel in Suburban Zone	0.05	0.05	0.09
3	Fraction of Travel in Urban Zone	0.05	0.05	0.01
4	Velocity in Rural Zone (km/hr)	88.49	64.37	16.09*
5	Velocity in Suburban Zone (km/hr)	40.25	40.25	8.06*
6	Velocity in Urban Zone (km/hr)	24.16	24.16	3.2*
7	Number of Crew on Shipment	2.00	5.00	2.00*
8	Average Distance from Radiation Source to Crew During Shipment (meters)	3.10	152.40	45.70*
9	Number of handlings per shipment	0.0	2.00*	2.00*
10	Stop Time for Shipment (hr/km)	0.011	0.033	0.01*
11	Minimum stop time per trip (hr)	0.0	10.00	10.00*
12	Distance Independent Stop Time per Trip (hr)	0.0	60.0	0.0
13	Minimum number of Rail Inspections or Classifications	0.0	2.00	0.0
14	Number of Persons Exposed During Stop	50.0	100.0	50.0
15	Average Exposure Distance When Stopped (meters)	20.0	20.0	50.0
16	Storage Time per Shipment (hr)	0.0*	4.00*	24.00*
17	Number of Persons exposed During Storage	100.0*	100.0*	100.0*
18	Average Exposure Distance During Storage (Meters)	100.0*	100.00*	100.00*
19	Number of Persons per Vehicle Sharing the Transport Link	2.0	3.00	0.0
20	Fraction of Urban Travel During Rush Hour	0.08	0.0	0.0
21	Fraction of Urban Travel on City Streets	0.05	1.0	0.0
22	Fraction of Rural and Urban Travel on Freeways	0.85	0.0	0.0
23	One-Way Traffic Count in Rural Zones	470.00	1.00	0.0
24	One-Way Traffic Count in Suburban Zones	780.00	5.00	0.0
25	One-Way Traffic Count in Urban Zones	2,800	5.00	0.0

* Default values not used.

Table E-5A Package Data for Whole Reactor Compartments

Package Type	LA Class	OHIO Class	VIRGINIA Class	LONG BEACH Class
Whole Reactor Compartment via ocean barge, river barge, and transporter	42' long x 33' diam 62 pkgs	55' long x 42' diam 18 pkgs	37' high x 31' diam 16 pkgs	37' x 38' x 42' 2 pkgs

7.1.2 Package Size. The package sizes used in RADTRAN 4 are shown in Table E-6. The reasonability of the package sizes selected for this evaluation were confirmed using an independent computer code (SPAN4) having the explicit package dimensions modeled to calculate radiation levels. The SPAN4 calculated dose falloff was compared to that produced using RADTRAN 4 to confirm the reasonability on the package size input to RADTRAN 4.

7.1.3 Shipment External Dose Rate. The maximum gamma radiation level measured at one meter from the surface of the package is directly proportional to the incident-free predicted exposure. For the subdivided alternative, the shipment external dose rate was assumed to be 2.0 mrem/hr which is consistent with conservatisms achieved in design practice. For shipment of whole reactor compartments, the shipment external dose rate was assumed to be 2.8 mrem/hr based on historical data.

Table E-5B Packages Data for Subdivided Reactor Compartments

Package Type	LA Class	OHIO Class	VIRGINIA Class	LONG BEACH Class
Misc Components via Truck	8'x10'x40'	8'x10'x40'	8'x10'x40'	8'x10'x40'
Reactor Pressure Vessels via Barge	21' long x 11' diam	20' long x 15' diam	26' long x 12' diam	27' long x 15' diam
Steam Generators via Rail	14'x7'x19'	16'x8'x21'	NA	NA
Steam Generators via Truck	NA	NA	23' long x 5' diam	27' long x 6' diam
Pressurizers via Rail	23' long x 7' diam	28' long x 7' diam	25' long x 5' diam	28' long x 7' diam
Total Number of Packages	854	444	196	43

7.1.4 Transportation Distance and Population Densities. Section 7 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. In the analysis done for the U.S. Department of Energy's, Office of Environmental Management and Idaho National Engineering Laboratory, Environmental Waste Management Programs Environmental impact Statement (DOE, 1995), historical data were obtained on the distance traveled for shipments from the shipyards and prototype sites to the Expended Core Facility at the Idaho National Engineering laboratory. These data were averaged by origin and compared to the value calculated by INTERLINE. The actual data were approximately 11% higher than the distance predicted by INTERLINE on average. Therefore, consistent with the Environmental Waste Management Programs Environmental Impact Statement (DOE, 1995), INTERLINE distances in each populations density were increased by 11%.

Table E-6 Effective Diameter/Package Size for RADTRAN 4

Package Type	LA Class	OHIO Class	VIRGINIA Class	LONG BEACH Class
Whole Reactor Compartment	10.0 m	12.8 m	9.4 m	11.3 m
Miscellaneous Components	3.0 m	3.0 m	3.0 m	3.0 m
Reactor Pressure Vessel	3.4 m	4.6 m	3.7 m	4.6 m
Steam Generator	2.1 m	2.4 m	1.5 m	1.8 m
Pressurizer	2.1 m	2.1 m	1.5 m	2.1 m

Similarly, historical data for Navy shipments indicates that the distance traveled for highway shipment is typically 3% greater than that predicted by HIGHWAY. Therefore, the percentage of distance traveled in each population density calculated in HIGHWAY were increased by 3%.

7.1.5 Radiation Exposure Decreased Due to Distance. The RADTRAN 4 computer code calculates the gamma and neutron radiation exposure decrease based on distance from the package and package size. (Neutron calculations do not apply for defueled reactor compartment shipments because there is no neutron source.) For gamma radiation, the RADTRAN 4 computer code distance falloff calculations was consistent with the falloff predicted by SPAN 4 in free space.

7.1.6 Shipment Storage Time. Shipments of naval radioactive material would not be stored while in the process of being shipped; therefore there was no shipment storage time associated with any of the shipments.

7.2 Train Shipments

7.2.1 Train Velocity. The RADTRAN 4 computer code provides standard values for train speeds that are dependent on the population density. These default values were applied to the shipment of the smaller packages.

7.2.2 Train Stop Time. The RADTRAN 4 computer code provides standard values for train stop times that were used in this evaluation.

7.2.3 Number of Train Crew Members. The RADTRAN 4 computer code value for the number of train crew members is five. Although the items would be radioactive, they would not contain spent fuel and would not be considered to be a special shipment; therefore, the default value for the train crew is considered to be adequate. In the RADTRAN 4 computer code, exposure to the crew is not calculated.

7.2.4 Train Stop Shield Factors. For train stops, the standard RADTRAN 4 computer code gamma shield factor is 0.1. This value assumes the presence of substantial rail yard structures equivalent to approximately four inches of steel. Four inches of steel reduces gamma radiation exposure by more than a factor of ten. Therefore, a shield factor of 0.1 is considered to be reasonable.

7.2.5 Distance from the Source to the Crew. The RADTRAN 4 default of 152.4 meters was used for train shipments.

7.3 Truck and Transporter Shipments

7.3.1 Truck Velocity. For truck shipments, the RADTRAN 4 defaults were used in all three population density zones. For the transporter segment of large package shipment, the velocities are summarized in Table E-7.

7.3.2 Truck Transportation Crew. The RADTRAN 4 computer code default values for the truck crew were used for the truck shipments for the smaller packages. For the larger packages (whole reactor compartment or reactor vessel pressure vessel), the number of persons to be included in the transporter transportation crew is summarized in Table E-7.

7.3.3 Number of Truck Inspection Inspections. The shipments are inspected prior to leaving the shipyard. Otherwise, it is assumed that there are no inspections during transport.

7.3.4 Truck Stop Time. The RADTRAN 4 default values for the truck stop times were used for the evaluation of the smaller packages. For the shipment of the whole reactor compartments and reactor pressure vessels, the transporter stop time is summarized in Table E-7.

7.3.5 Distance from the Source to the Crew. The crew is assumed to be located 3.1 meters from the outside of the packages for the truck and the transporter.

7.4 Waterway Shipments

The standard RADTRAN values for waterway (i.e., barge) shipments were replaced by the values in Table E-7 as discussed below.

Table E-7 RADTRAN 4 Parameters for Waterway Shipments

Input Parameter	Ocean Barge	River Barge	Transporter
Velocity for rural areas	12.8 km/hr	13.1 km/hr	8 km/hr
Velocity for suburban areas	12.8 km/hr	13.1 km/hr	8 km/hr
Velocity for urban areas	12.8 km/hr	13.1 km/hr	8 km/hr
Stop and storage time	2.3 hours	29.0 hours	2.0 hours
Distance from the outside of the package to the crew	a) through the sound, the strait and the ocean, 221 meters b) through the mouth of the Columbia River, 51 meters	21 meters	3.1 meters*
Number of crew members	6	12	4

*RADTRAN 4 default

7.4.1 Barge Transportation Crew. The barge transportation crew numbers (ocean and river) are summarized in Table E-7. These crew members are actually not for the barge but occupy the tugboat.

7.4.2 Barge Stop Time. Barge stop times are summarized in Table E-7. The stop time for the river barge includes the time required to pass through the locks on the Columbia River for transport to the Hanford Site and the time to transfer the package from the barge to the transporter.

7.4.3 Barge Velocity. The barge velocity for rural, suburban and urban population zones are summarized in Table E-7.

7.4.4 Barge Distance from the Shore. RADTRAN 4 assumes a distance of 200 meters from the barge to the shore. For river transport, this is considered to be adequate. However, the ocean barge would be from 5 to 15 nautical miles offshore during the ocean leg of the transport of the large packages, resulting in off-link incident-free population exposure of zero for that link. An independent analysis that included an evaluation of population exposure at long distances confirms this conclusion. Therefore, for the portion of the route where the barge is in the ocean (versus the sound, the strait or the river) off-link exposure is considered to be zero.

7.4.5 Distance from the Source to the Crew. For the transport of the barge with an ocean tugboat through the sound, the strait, and the ocean, the distance is 221 meters; for the transport of the barge with an ocean tugboat through the mouth of the river, 51 meters, and for the transport of the barge up the river using a river tugboat, 21 meters, This summarized in Table E-7. These distances were used in estimating exposure to crew members during shipment.

7.4.6 Shield Factor. A shield factor of 0.5 was applied to account for structural bulkheads between the crew and the package during transport.

7.5 Other Standard RADTRAN 4 Computer Code Values Used

The following standard RADTRAN 4 computer code values were reviewed and were determined to reflect the best estimate of current practices:

(1) Number of people per vehicle sharing the transport route (on-link).

(2) Traffic count passing a specific point - rural, suburban and urban zones.

(3) Average exposure distance when stopped.

(4) Persons exposed when stopped.

(5) Fraction of travel during rush hour, on city streets, and on freeways.

7.6 Exposure to Handlers

Handlers are defined to include all workers involved in the transfer of packages from one mode or location to another. Exposure to handlers is not included in this evaluation.

7.7 Accident Model for Transportation of Naval Reactor Compartments

This section provides the input parameters and assumptions used to determine the radiological impact for postulated accidents during transportation of the reactor compartments. The planned shipments, transportation distances, population densities, and the percentages of travel in each population density described in Section 7.1 were used in the accident analysis. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

7.7.1 Accident Probability. The probability of an accident by transportation mode was obtained from a report submitted to the U.S. Department of Energy's Reactor Technology and Transportation Division (Saricks, 1994). For the shipments from PSNS to Hanford, accident rates for the States of Washington were used. Otherwise, the U.S. averages were employed. The employed accident probabilities are presented in Table E-8 and are the same for rural, suburban, and urban areas except as noted.

The truck accident rates for shipments from PSNS to Hanford are best estimate rates based on the State of Washington Federal-Aided Interstate Urban and Rural accident rates (FAI-U and FAI-R) provided in the report (Saricks, 1994). Use of this state-specific FAI data is considered consistent with the HIGHWAY routing analysis which showed interstate to be the primary highway traveled from Bremerton to Hanford. For all other destination/origin combinations, the truck accident rates are based on the national average Federal-Aided Primary (FAP) highway accident rates provided in the report (Saricks, 1994). This simplified treatment of combining statewise accident rates and ensured a conservative model (FAP national rates are about 10% to 60% greater than corresponding FAI-R and FAI-U national rates).

Table E-8 Accident Probabilities

Transport Mode	National Average Probability (Accidents/km)	Washington State Probability (Accidents/km)
Truck	3.94×10^{-7}	2.50×10^{-7} (Rural) 1.61×10^{-7} (Urban) 1.61×10^{-7} (Suburban)
Rail	5.57×10^{-8}	3.49×10^{-8}
Pacific Ocean	1.7×10^{-6}	Same as national average
Atlantic Ocean	5.46×10^{-6}	NA
Inland Waterways	3.82×10^{-6}	Same as national average

7.7.2 Severity Fractions. Accidents in which a shipment is subjected to various degrees of forces are assigned to an accident severity fraction category. In order to calculate the probability of a severe accident, the accident probability is multiplied by the severity fraction.

For purposes of determining the accident severity probability for reactor compartment shipments, a two category scheme was used. Category I applies to the probability of accidents which do not exceed the 10CFR71 limits and Category II applies to those which have a probability of severe accidents exceeding the limits with subsequent corrosion product release.

For the rail and truck shipments, the employed accident severity probabilities are same as those used for the "Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement" (DOE, 1995) for corrosion products release. That study conservatively identifies that for truck and rail accidents, a 99.4% probability exists for accident conditions that do not exceed the 10CFR71 criteria (i.e., category I). The remaining 0.7% and 0.6% are the Category II severe accident probabilities which result in release of corrosion products. DOE, 1995 also identifies a third category where there is a corrosion product release and fission product release. For these reactor compartments there is no fission product source or release and therefore a two-category release scheme for corrosion products is appropriate.

For the barge shipments a 99.65% probability of an accident not exceeding 10CFR71 was assumed for this evaluation. This is based on the values presented in Table 5-7 of the "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes" (NRC, 1977) for the sum of minor and moderate accident severity fractions. The source document (NRC, 1977) identifies 99.65% of all waterway accidents are minor or moderate type with release levels depending on container strength. However, evidence obtained after publication of the source document (NRC, 1977) and presented in a U.S. Department of Energy Environmental Assessment (DOE, 1994a) showed that no release can occur for Type B packages for these types of accidents. This 99.65% probability is also consistent with the U.S. Department of Energy's Environmental Assessment (DOE, 1994a) which employs 99.7% to be the Category I non-release probability for maritime shipments.

The overall resulting severity fractions that were use in the analyses are summarized in Table E-9.

Table E-9 Accident Severity Fractions

Category	Truck/Transporter Shipments	Rail Shipments	Barge Shipments
I	0.9940	0.9940	0.9965
II	0.0060	0.0060	0.0035

As stated above, the product of the accident probability and the severity fraction gives the severe accident probability. For barge shipments along the Pacific Coast and Atlantic Coast the severe accident probability per distance traveled is 5.95×10^{-9}/km (i.e., 1.704×10^{-6} accidents/km x 0.35×10^{-2} severity fraction) and 1.9×10^{-8}/km, respectively. These values are reasonably conservative when compared the severe accident in domestic waterborne barge probabilities presented in an Atomic Energy Commission survey of radioactive material transportation (AEC, 1972)(i.e., 1.9×10^{-9}/km).

7.7.3 Package Release Fractions. The release fraction represents the fraction of the corrosion product inventory in the package that would be released into the atmosphere for a severe accident. The corrosion product release model accounts for all activated corrosion products which adhered to all wetted surfaces inside the reactor vessel and coolant system over plant life. Additionally, the corrosion products in the purification system components were assumed to be part of the reactor compartment shipment. Most of the corrosion product is strongly adherent and only a small fraction would realistically be released if a severe accident were to occur. In developing a model of the activity released for a severe accident, it was conservatively assumed that 50% of the loose activity in the steam generators, and 10% of the loose activity in all other components (except purification filters and ion exchangers) are released from the package. The amount of loose activity is assumed to be 33% of the total corrosion product activity for all components based on an upper limit estimate from oxide film analysis of surveillance coupons from the S3G prototype reactor coolant system. The corrosion products released from the purification components were conservatively assumed to be 100% of the total available in the resin bed during shipment. This overall approach was derived from the model presented in "Final EIS on the Disposal of Defueled Naval Submarine Reactor Plants, Vol. 1, 1984" (USN, 1984). Application of this model results in about 32% to 40% release of the corrosion products from a whole reactor compartment for use in a severe accident scenario.

The severe accident release fractions employed in this evaluation by component are summarized in Table E-10. The corresponding whole reactor release fractions resulting from applying the Table E-10 values are 0.38. 0.32, 0.36 and 0.40 for the LOS ANGELES, VIRGINIA, OHIO, and LONG BEACH class ships, respectively.

7.7.4 Corrosion Product Activity. The corrosion product activities employed in the accident analyses were derived based on formulas that predict corrosion product deposition levels from reactor plant pipewall dose rate measurements with Cobalt-60 being the dominant radioisotope (Cobalt-60 contributes over 95% to the accident total exposure levels). The corrosion product activity estimates were calculated for the earliest time after reactor compartment shutdown for which disposal shipment could occur. The activities used in the risk analyses are projected end-of-life plant values based on the average over all ships of the same class with the first reactor core installed except for the USS LONG BEACH which is based on the last core. In the consequences analyses, the highest projected activity (peak) of all ships in the same class was used.

Table E-10 Corrosion Product Release Fractions

Category	Truck	Rail	Barge
I	0.0	0.0	0.0
Misc II	0.033	NA	0.033
Resin II	1.0	NA	1.0
Reactor Pressure Vessel II	0.033	NA	0.033
Steam Generator II	0.167	0.167	0.167
Pressurizer II	NA	0.033	0.033

7.7.5 Plume Release Height. For the accident risk assessment, a ground level release was used in the RADTRAN 4 model. For the maximum consequence assessment, a plume release height of ten meters was used in the RISKIND model.

7.7.6 Direct Exposure from a Damaged Package. The radiation level following an accident was assumed to be at the 10CFR71 regulatory limit of one rem at one meter from the component surface.

7.7.7 Food Transfer Factors. The food transfer factors for the RADTRAN 4 assessment were developed using the same method as the "Environmental impact Statement on Environmental Restoration and Waste Management Activities at the Idaho National Engineering Laboratory" (DOE, 1995). For shipments from PSNS to Hanford, the Washington State food transfer factors were used. For all other shipments, the food transfer factors were those that represented the U.S. average.

7.7.8 Distance from the Accident Scene to the Maximum Exposed Individual. An assumption was made that the maximum exposed individual would be unshielded for the time that the plume passes by. The location of maximum exposure was also assumed to be at the location for which maximum exposure would occur (160 m to 400 m from the accident site). This location was determined using RISKIND based on the assumed atmospheric stability and plume release height.

7.7.9 RISKIND Population Density. The standard national average for each population density from the RADTRAN 4 computer code was used for the RISKIND maximum consequence assessment. The assessment considers the population within 80 km (50 miles) of the site under both neutral and stable weather conditions. The population ranged from 1.5 million (urban) to 2,600 (rural).

8. SUMMARY OF RESULTS

The results of the evaluation for shipment of 100 reactor compartments are summarized in Table E-11. Under incident-free conditions the whole reactor compartment shipment from PSNS is expected to have a lower risk of cancer fatalities than the subdivided alternative for any other origin/destination combination. Furthermore, the predicted health risk for incident-free shipments is greater than the predicted health risk due to an accident during shipment. This is because there is a low probability of a severe accident for the various transportation modes of interest. The health risk in the event that an accident does occur is evaluated as the maximum consequence to an individual and to the general public in rural, suburban, and urban population zones and is discussed separately.

The maximum consequences of an accident assuming a severe accident occurs have been evaluated for whole reactor compartment shipment and the subdivision alternative. The results are tabulated in Table E-12. Accident results are presented for both the maximally exposed individual and the general population. The transportation crew is considered to be part of the general population under accident conditions, so a member of the transportation crew could be the maximally exposed individual.

Table E-11 Shipment of 100 Reactor Compartments

	No. of Pkgs.	General Population (RADTRAN 4)				Transporatation Crew (RADTRAN 4)		MEI General Population (Formulas (1) and (2) Paragraph 4.2 scenarios)		MEI Occupational (Paragraph 4.2 scenarios)		Non-Radiological	
		Incident Free		Hypothetical Accident		Incident Free		Incident Free		Incident Free		Incident Free	Hypothetical Accident
		Exposure (Person-Rem)	Cancer Fatalities	Exposure (Person-Rem)	Cancer Fatalities	Exposure (Person-Rem)	Cancer Fatalities	Exposure (Person-Rem)	Cancer Fatalities	Exposure (Person-Rem)	Cancer Fatalities	Fatalities	Fatalities
Whole:													
PSNS to Hanf.	100	$5.81 \times 10^{+0}$	2.91×10^{-3}	8.38×10^{-1}	4.19×10^{-4}	$5.79 \times 10^{+0}$	2.32×10^{-3}	1.22×10^{-1}	6.11×10^{-5}	6.36×10^{-1}	2.54×10^{-4}	4.16×10^{-5}	9.47×10^{-4}
Subdivided:													
PSNS to Hanf.	1571	$1.10 \times 10^{+1}$	5.51×10^{-3}	3.98×10^{-2}	1.99×10^{-5}	$1.17 \times 10^{+1}$	4.66×10^{-3}	$1.28 \times 10^{+0}$	6.41×10^{-4}	5.11×10^{-0}	2.04×10^{-3}	3.10×10^{-3}	2.71×10^{-2}
PSNS to SRS	1571	$1.08 \times 10^{+2}$	5.42×10^{-2}	6.20×10^{-1}	3.10×10^{-4}	$9.35 \times 10^{+1}$	3.74×10^{-2}	$1.28 \times 10^{+0}$	6.38×10^{-4}	$4.72 \times 10^{+1}$	1.88×10^{-2}	2.56×10^{-2}	7.56×10^{-1}
NNS to Hanf.	1571	$1.19 \times 10^{+2}$	5.97×10^{-2}	7.52×10^{-1}	3.76×10^{-4}	$9.63 \times 10^{+1}$	3.86×10^{-2}	$1.28 \times 10^{+0}$	6.38×10^{-4}	$4.80 \times 10^{+1}$	1.92×10^{-2}	3.34×10^{-2}	7.81×10^{-1}
NNS to SRS	1571	$1.75 \times 10^{+1}$	8.72×10^{-3}	1.14×10^{-1}	5.72×10^{-5}	$1.78 \times 10^{+1}$	7.09×10^{-3}	$1.73 \times 10^{+0}$	8.61×10^{-4}	8.53×10^{-0}	3.41×10^{-3}	4.39×10^{-3}	1.18×10^{-1}
Comparison:													
Whole: PSNS to Hanf. versus Subdivided:													
PSNS to Hanf.	6.4%		52.6%		1260%		49.8%		9.5%		12.5%	1.3%	3.5%
PSNS to SRS	6.4%		5.4%		194%		6.2%		9.6%		1.4%	0.2%	0.1%
NNS to Hanf.	6.4%		4.9%		175%		6.0%		9.6%		1.3%	0.1%	0.1%
NNS to SRS	6.4%		33.4%		845%		32.7%		7.1%		7.4%	1.0%	0.8%

"PSNS" = "Puget Sound Naval Shipyard", "NNS" = "Norfolk Naval Shipyard, "Hanf." = "Hanford Site", "SRS" = "Savannah River Site"

Table E-12 Summary of Maximum Consequences Assuming an Accident Occurs

	Maximum Exposed Individual (Riskind)		Rural (Riskind)		Suburban (Riskind)		Urban (Riskind)	
	Exposure (rem)	Cancer Fatalities	Collective Dose (person-rem)	Cancer Fatalities	Collective Dose (person-rem)	Cancer Fatalities	Collective Dose (person-rem)	Cancer Fatalities
Whole Reactor Compartment	2.57	1.29×10^{-3}	4.41×10^{2}	2.20×10^{-1}	5.06×10^{3}	2.53	8.16×10^{3}	4.08
Subdivided Reactor Compartment	9.73×10^{-1}	4.86×10^{-4}	1.67×10^{2}	8.34×10^{-2}	1.91×10^{3}	9.57×10^{-1}	1.03×10^{4}	5.14

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DISTRIBUTION

Appendix F

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1. BACKGROUND

During the scoping process for this EIS, the Navy actively solicited comments from a wide group of interested parties. The Navy published a Notice of Intent (NOI) to prepare an Environmental Impact Statement for Disposal of Decommissioned Defueled Cruiser, Ohio and Los Angeles Class Naval Reactor Plants as required by the National Environmental Policy Act. The NOI included a schedule for conduct of five public scoping meetings as well as an address for submittal of written comments. The NOI was published in the Federal Register (59 F.R. No.37; Feb. 24, 1994; p. 8915) and in newspapers serving the affected regions (Bremerton, WA; Seattle, WA; Richland, WA; Portland, OR; and Norfolk, VA). In addition, the NOI was mailed directly to agencies, organizations and individuals likely to have an interest in the EIS. Written comments, as well as oral comments from 5 public scoping meetings, were provided to the Navy in response to the announcement. Provision was made at the scoping meetings for individuals to request copies of the draft EIS.

As a result of the scoping process the Navy developed a list of potentially interested parties for the initial distribution of the EIS. The list includes individuals who requested copies of the draft EIS at the scoping meetings or in writing and those parties to whom the draft EIS is to be made available for review and comment. The list will be updated based on responses to the Notice of Availability for the draft EIS. A copy of the most current version of the distribution list can be obtained from the following Navy point-of-contact for the EIS:

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Commander Davis, Marine Safety Center, United States Coast Guard

Captain H. H. Dudley, 13th District, United States Coast Guard

Rear Admiral J. W. Lockwood, 13th District, United States Coast Guard

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Indian Tribes

Hanford Project Coordinator, Confederated Tribes of the Umatilla Indian Reservation

Hanford Project Manager, Nez Perce Tribe

Mr. Tony Forsman, Acting Tribal Administrator, Suquamish Tribe

Mr. Phill Meyers, Suquamish Tribe

Mr. John Brodeur, Yakama Indian Nation

Ms. Augustine Howard, Yakama Indian Nation

Mr. Russell Jim, Manager, Environmental Restoration Waste Management Program, Yakama Indian Nation

Elected Officials

Oregon

The Honorable John Kitzhaber, Governor, State of Oregon

The Honorable Mark O. Hatfield, Member, United States Senate

The Honorable Robert W. Packwood, Member, United States Senate

The Honorable Elizabeth Furse, Member, United States House of Representatives

The Honorable Wes Cooley, Member, United States House of Representatives

The Honorable Ron Wyden, Member, United States House of Representatives

The Honorable Peter A. DeFazio, Member, United States House of Representatives

The Honorable Jim Bunn, Member, United States House of Representatives

Virginia

The Honorable George F. Allen, Governor, Commonwealth of Virginia

The Honorable John W. Warner, Member, United States Senate

The Honorable Charles S. Robb, Member, United States Senate

The Honorable Herbert H. Bateman, Member, United States House of Representatives

The Honorable Owen Pickett, Member, United States House of Representatives

The Honorable Robert C. Scott, Member, United States House of Representatives

The Honorable Norman Sisisky, Member, United States House of Representatives

The Honorable L. F. Payne, Jr., Member, United States House of Representatives

The Honorable Bob Goodlatte, Member, United States House of Representatives

The Honorable Thomas J. Bliley, Jr., Member, United States House of Representatives

The Honorable James P. Moran, Member, United States House of Representatives

The Honorable Rick Boucher, Member, United States House of Representatives

The Honorable Frank R. Wolf, Member, United States House of Representatives

The Honorable Thomas M. Davis, Member, United States House of Representatives

The Honorable William E. Ward, Mayor, City of Chesapeake

The Honorable James L. Eason, Mayor, City of Hampton

The Honorable Barry E. Duval, Mayor, City of Newport News

The Honorable Mason Andrews, Mayor, City of Norfolk

Mr. C. W. McCoy, City of Portsmouth

The Honorable Gloria O. Webb, Mayor, City of Portsmouth

The Honorable S. Chris Jones, Mayor, City of Suffolk

The Honorable Meyera E. Oberndorf, Mayor, City of Virginia Beach

Washington

The Honorable Mike Lowry, Governor, State of Washington

The Honorable Slade Gorton, Member, United States Senate

The Honorable Patty Murray, Member, United States Senate

The Honorable Rick White, Member, United States House of Representatives

The Honorable Jack Metcalf, Member, United States House of Representatives

The Honorable Linda Smith, Member, United States House of Representatives

The Honorable Richard 'Doc' Hastings, Member, United States House of Representatives

The Honorable George R. Nethercutt, Jr., Member, United States House of Representatives

The Honorable Norman D. Dicks, Member, United States House of Representatives

The Honorable Jim McDermott, Member, United States House of Representatives

The Honorable Jennifer Dunn, Member, United States House of Representatives

The Honorable Randy Tate, Member, United States House of Representatives

The Honorable Lynn Horton, Mayor, City of Bremerton

State/Local Agencies

Oregon

Ms. Mary Shaver, Co-Chair, Transport Committee, Oregon Hanford Waste Board

Ms. Norma Jean Germond, Oregon Hanford Waste Board, Public Involvement Committee, Chair

Administrator, Facility Regulation Division, Oregon State Department of Energy

Mr. David A. Stewart-Smith, Oregon State Department of Energy

Virginia

Mr. Edgar E. Maroney, City Manager, City of Newport News

Ms. Marilee Hawkins, Director of Housing and Emergency Services, City of Portsmouth

Mr. Keith J. Buttleman, Department of Environmental Quality, Commonwealth of Virginia

Director, Division of Intergovernmental Coordination, Virginia Department of Environmental Quality

Washington

Mr. B. Bennett, Port of Benton

Mr. James L. Nolan, Puget Sound Air Pollution Control Agency

Mr. Bob Atwood, Washington State Association of Health Office

Ms. Joy Kinmark, Washington State Department of Ecology

Ms. Barbara J. Ritchie, Environmental Review Section, Washington State Department of Ecology

Mr. Rundlett, Washington State Department of Ecology

Mr. Roger Stanley, TPA Implementation Director, Washington State Department of Ecology

Mr. Terry R. Strong, Director, Division of Radiation Protection, Washington State Department of Ecology

Mr. Mike Wilson, Washington State Department of Ecology

Mr. Joseph Witczak, Manager, Nuclear Waste Program, Regulatory and Technical Support Unit, Washington State Department of Ecology

Mr. Randy S. Acselrod, Washington State Department of Health

Mr. John Blacklaw, Washington State Department of Health

Mr. Ray Lasmanis, Washington State Department of Natural Resources

Mr. John A. Hall, Washington State Department of Wildlife

Staff Director, Energy and Utilities Committee, Washington State House of Representatives

Staff Director, Energy and Utilities Committee, Washington State Senate

Public

Illinois

Mr. Wayne Bloomster

Nevada

Ms. A. A. Francis, CEM, Emergency Management Services

Oregon

Mr. Ross Tewksbury

Mr. Tom Cropper, Eastside Democratic Club

Ms. Paige Knight, Hanford Watch

Ms. Paige Knight, Nuclear Free Port Coalition

Tennessee

Mr. Harry A. Bryson, Senior Project Engineer, CHMM

Utah

Mr. Donald E. Evett

Virginia

Mr. James D. Bailey

Mr. David Baker

Ms. Margy Baker

Ms. Joanne Bentley

Mr. Stephen P. Bergfield

Mr. Tom Cadorette

Ms. Sylvia Clute

Ms. Roberta Hodgen

Ms. Nancy M. Poarch

Ms. Priscilla C. Wash

Minister Rafiq Zaidi, President, Black Concerned Citizens

Ms. A. T. Boush, Secretary, Chesapeake Association of Family, Community and Education

Mr. James Hartley, IFPTE Local No.1

Mr. Drew Terry, IFPTE Local No. 1

Mr. Alan E. Gollihue, Olde Towne Civic League

Mr. Robert Deegan, Sierra Club, Virginia Chapter, Nuclear Waste Issues Chair.

Mr. Edward R. Baird, Jr., Willcox & Baird, Attorneys at Law

Washington

Mr. Jim Adrian

Mr. Walter D. Blair

Mr. Michael W. Briggs

Mr. and Mrs. Britton

Ms. Kathryn A. Crandall

Mr. George Evans

Mr. J. W. Feigel

Ms. Anne Kinnaman

Mr. Ken Koemmpel

Mr. Tom McLaughlin

Mr. George Prater

Mr. Rick Pressley

Ms. Jewel Quisenberry

Mr. Karl Schutt

Ms. Bettie J. Stone

Ms. Maron Wang

Mr. Kip Wilson

Mr. S. A. Martinelli, P. E., Ecology and Environment, Inc.

Mr. Gerald Pollet, Heart of America Northwest

Ms. Cynthia Sarthou, Heart of America Northwest

Ms. Pat Herbert, Herbert and Associates

Ms. Beverly Kincaid, Kitsap County Central Labor Council

Mr. Norm Buske, SEARCH

Mr. Harry Wilson, Sierra Club

Mr. Dave Davison, Union River Basin Protection Association

Ms. Elaine Manheimer, Union River Basin Protection Association

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COMMENTS AND RESPONSES

Appendix G

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Table of Contents

Chapter **Title** **Page**

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1. Introduction

This Appendix did not appear in the Draft Environmental Impact Statement (DEIS). It has been added to the Final Environmental Impact Statement (FEIS) to present comments received following distribution of the DEIS together with the Navy's responses to those comments. In cases where the text of the FEIS has been changed from the DEIS, a sidebar has been placed in the margin of the FEIS adjacent to the revised text.

On August 9, 1995 the Navy began distribution of the DEIS. The period for comment began with publication of the Notice of Availability in the Federal Register (60 FR 43147-01) on August 18, 1995 and remained open for 53 days, ending on October 10, 1995. The Notice of Availability announced that during the comment period public hearings would be held at Bremerton, Washington; Portland, Oregon; Seattle, Washington and Richland, Washington. In addition to the Federal Register Notice, 12 public notices were printed among the newspapers Bremerton Sun, Tri-City Herald, Oregonian and Seattle Post-Intelligencer, which have a collective distribution of over 650,000. Also, the Tri-Party Agreement Publications, which have a distribution over 1,000, identified the time and place of the public hearings. Over 160 notices and DEISs were distributed by the Navy to individuals and organizations that have expressed an interest in the disposal of defueled Navy reactor compartments.

A total of fifteen written statements and five oral statements were received as follows:

	Written	Oral
Federal Agencies	2	0
State Agencies	3	1
Local Groups	6	2
Individuals	4	2

2. Comment Letters and Records of Public Hearings

This chapter incorporates comment letters and records of public hearings. Unique identification numbers have been assigned to each letter and statement. The identification numbers correspond to the sequence in which the material was received by the Navy and, therefore, approximate a chronological correlation. An exception to this chronological order occurs where a respondent provided more than one exhibit. In these cases the identification number for the first submittal was assigned in order and suffix letters have been used with the initial identification number to differentiate submittals.

Exhibits have been sidebarred to identify issues which have been numbered according to the order in which they are presented in the Navy's responses to issues from public review. The analyses and responses to issues can be located in chapter 3.

An Exhibit Index is provided at the end of this chapter. The index is comprised of listings of three associated identifiers: (1) name of commenter or organization, (2) identification number assigned to the associated letter or statement, and (3) the page number where the letter or statement begins. The Exhibit Index lists each letter or statement by numerical sequence of identification number. The Exhibit Index provides a cross reference for readers to readily locate exhibits of a known commenter and to relate exhibits of specific interest to respective commenters.

#1

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, WA 98314-5001

August 18, 1995

Dear Mr. Gordon:

This serves as my comment upon the DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER, OHIO CLASS, AND LOS ANGELES CLASS NAVAL REACTOR PLANTS.

1.7 I guess I'm real disappointed about our having to decommission another set of nuclear-powered ships. With the last environmental impact statement on submarines in which ten reactors were supposed to be decommissioned, we've found that there has been many more reactor cores buried at Hanford. So, I'm worried on one level that Washington state may be in for more than what this draft statement is telling us.

And then again we will be considering the radiation, lead, and PCB's which will be
buried with them and be dumped into the soil and then into the aquifers and underground
rivers into the Columbia River. I find it strange that the government is currently intently
involved with spending millions to clean up the underground rivers and soils in the 100
areas eventually where the pollutants from these very cores along with others will also
end before going into the Columbia River. Somehow knowing whether the cores are
buried aboveground or underground doesn't really solve the enormous problems we will 2.5
be faced with in these ensuing burials. And, we will have permits given out by the
Department of Ecology on wastes which if they were anywhere else in this state but
Hanford would not be permitted.

And yet, I do feel Hanford is probably the best place to bury these cores. They can be removed at the shipyard where the workers have plenty of experience, where the equipment is sufficient, where the safety precautions are well known, and where it is relatively close to the burial site which is also experienced with reactor cores.

1.9 I guess what really bothers me is the enormous amounts of money being spent in such wasteful ways when so many people are unemployed and job development for all of us has deteriorated. At a time when this country should be developing decent well-paying jobs for everyone, we see the majority of money being spent for defense and defense-related projects of which this is one.

What can we do together to insure we dispose of these cores in an environmentally-conscious manner and still realize that a peaceful society spends its' money on projects which give the optimum peace to all? It seems to me we should be most concerned with the way we spend billions to build a force of nuclear ships and submarines which is too large for the threat we are allegedly seeing in the world. 1.9 We have seen such waste in the past and are still seeing waste in projects which are basically unreal. We build too many nuclear vessels, we spend too much on burials and cleanup, we lie to the public after hearing their concerns. When is this going to end? Certainly not in my generation. What are we giving our children but bills and problems with undereducated peers many of whom today are barely able to survive. Doesn't this bother you? We've spent all of this month informing people of the tortures and injustices of World War II while we are currently doing the same thing to just as many people in our own country.

Well, thank you for allowing me to comment.

Sincerely,
Pat Herbert

Pat Herbert
P.O. Box 95966
Seattle, WA 98145

#2

Donald Eugene Evett
3106 South 975 East
Bountiful, Utah 84010

September 18,1995

Mr. John Gordon
Public Affairs Officer
Puget Sound Naval Shipyard
1400 Farragut Avenue
Bremerton, WA 98314-5001

RE: **DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER, OHIO CLASS, AND LOS ANGELES CLASS NAVAL REACTOR PLANTS**

Dear Mr. Gordon:

I have carefully reviewed the August 1995 impact study and I concur with the Navy's report on th impact of burial of the applicable reactors at the Hanford Site. The impact study is very thorough i that it covers all of the major aspects of concerns to the public. Hanford appears to be the best suite site for burial of the reactors and the report indicated that Hanford will be an indefinite burial sit lasting for many years.

I wish to thank you for having the opportunity to review the study and to submit my comments. It a very comprehensive study and in my opinion all safety factors have been carefully studied an explained in the report and the entire process of dismantling, transport and burial will be safe to th general public for now and in the distant future.

Sincerely,

Donald E. Evett

COPY

PROCEEDINGS

PUBLIC HEARING
DRAFT ENVIRONMENTAL IMPACT STATEMENT
ON DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER,
OHIO CLASS AND LOS ANGELES CLASS
NAVAL REACTOR PLANTS

Performing Arts Center
Bremerton High School
Bremerton, Washington 98310

BAYSIDE REPORTERS
4041 Ruston Way
Suite 1-D
Tacoma, Washington 98402

REPORTED BY PAMELA J. FRANZ
September 18, 1995

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ATTENDANCE

MR. DICK SHIPLEY - Director of Environment, Safety, and Health, Puget Sound Naval Shipyard, presiding officer.

MR. JIM WRZESKI - Navy's reactor compartment disposal manager.

MR. MARK FRENCH - Department of Energy

The Assembly of the Public Hearing regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants convened on the 18th of September, 1995, at the Performing Arts Center, 1500 13th Street, Bremerton, Washington, beginning at the hour of 7:00 p.m., Mr. Shipley presiding.

* * * * * * *

MR. SHIPLEY: Good evening, ladies and gentlemen. Thank you for coming. My name is Dick Shipley, and I'm the director of Environment, Safety, and Health at Puget Sound Naval Shipyard. Tonight, I'm serving as the presiding officer for this public meeting.

With me this evening is Mr. Jim Wrzeski, the Navy's reactor compartment disposal manager. Also with us tonight from the Department of Energy is Mr. Mark French. The Department of Energy is a cooperating agency in the development of the Environmental Impact Statement.

On August 15th, 1995, the Navy announced in the Federal Register the availability of the Draft Environmental Impact Statement, what we call the Draft EIS, on the disposal of decommissioned, defueled reactor plants from cruisers and the OHIO Class and LOS ANGELES

Class submarines. The Navy, in cooperation with the Department of Energy, has prepared this Draft EIS to focus on the potential for significant environmental impacts and to consider reasonable alternatives.

The management of spent fuel is not the subject of this EIS. The disposition of spent fuel was addressed in the Department of Energy EIS, identified on this slide, with the Navy as the cooperating agency.

The Navy's Federal Register announcement scheduled public meetings at various locations in order to provide organizations and individuals with an interest in this matter with an opportunity to present their views. We are here this evening to conduct one of these scheduled public meetings.

Tonight's meeting is being held as part of the decision-making process required by the National Environmental Policy Act called NEPA. NEPA is our basic national charter for protection of the environment. NEPA procedures ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken.

The Draft EIS was developed based on public input received during the scoping phase of the NEPA process.

Tonight we are here to listen to what you have to say. We will not be directly responding to questions tonight. The purpose of tonight's meeting is to receive your input so that it can be addressed in the development of the Final EIS. The purpose is not to engage in debate.

It is my responsibility to receive statements so that they can be considered in preparing the final EIS. For that reason, this meeting is being recorded.

Copies of the agenda for tonight's meeting are available on the table at the back. It explains the order of our meeting this evening and will consist of a presentation by Mr. Wrzeski on the alternatives evaluated in the Draft EIS.

This presentation will last approximately 20 minutes and will be followed by the formal comment period. The comment period is the time we listen to you. Responses to each individual comment or question will be in the Final EIS.

After all comments have been given, we will conclude the meeting with closing remarks. I will afford an opportunity to those individuals and organizations who wish to speak. I would appreciate it if anyone wishing to speak would fill out a registration form over by the door.

To get everyone's comment, I will ask that long statements be summarized to five minutes with the

written statement submitted for the record.

Whether or not you speak this evening, you may also provide written comments to me or leave them with the staff at the registration table. Oral and written input will be considered equally in the development of the Final EIS.

If you desire to provide written comments at a later time, they should be sent to: Mr. John Gordon, Puget Sound Naval Shipyard, 1400 Farragut Avenue, Code 1160, Bremerton, Washington 98314-5001.

Written comments postmarked by October 10th, 1995 will be considered in preparation of the Final EIS. Comments postmarked after that date will be considered to the extent practical.

Before we begin receiving public input, I would like to introduce Mr. Wrzeski, who will provide a general overview of the alternatives which have been evaluated in the DEIS.

Mr. Wrzeski.

* * * * * * * * *

PRESENTATION

MR. WRZESKI: Thank you, Mr. Shipley. Good evening, ladies and gentlemen.

By the 1980s, many of the Navy's submarines were reaching the end of their useful life. At that time, the Navy prepared an Environmental Impact Statement to evaluate various disposal methods for the radioactive components associated with the nuclear power plants on these submarines.

In the 1984 Record of Decision, the Navy selected land burial of the reactor compartment as the disposal method for these components. Since then, the Navy has completed 50 successful shipments under the 1984 program.

Now, in the 1990s, recent changes in the national defense structure have resulted in downsizing of the fleet, including nuclear-powered combatants. Because of this downsizing, the Navy will soon need to address disposal of the reactor compartments associated with cruisers, OHIO Class submarines and LOS ANGELES Class submarines.

This EIS has been prepared because the approximately 100 reactor compartments from these classes of ships were not covered under the 1984 EIS.

This figure shows the location of the reactor compartments on the typical Navy cruiser and submarine.

The functional design of the ship's reactor compartment makes it an ideal disposal package. The compartment is completely enclosed by structural walls known as bulkheads and, in the case of a submarine, part

of the enclosure is the ship's pressure hull.

The bulkheads contain lead shielding to protect the crew during reactor operation. The bulkheads are designed to meet the shocks and stresses of a military ship under combat conditions.

These features make the reactor compartment a superior transportation and disposal package that is far stronger than typical industry containers used to dispose of low-level radioactive waste.

The remainder of the ship is recycled to reuse the metals.

Tonight I will first discuss the alternatives the Navy considered for disposal of the reactor plant. Later in my presentation, I will cover the potential environmental consequences. In all of the alternatives considered, the spent fuel would be removed before initiating disposal.

The Navy evaluated several alternatives in this EIS. Land burial of the entire reactor compartment at Hanford, Washington is our preferred alternative. We also looked at waterborne storage of the ship, which is the no-action alternative. We evaluated subdivision of the reactor compartment. This alternative disassembles the reactor plant and disposes of the components separately. Finally, we looked at above-ground storage of the reactor compartments at Hanford.

Now I would like to describe our preferred alternative. In the interest of time tonight, my presentation will focus mainly on the preferred alternative, even though the Draft EIS analyzes the others in considerable detail.

As discussed earlier, the reactor compartment makes an ideal disposal package. For this and other reasons that I'll discuss, the Navy has determined that burial of the entire reactor compartment at Hanford is the preferred alternative.

This is the same basic method as our current disposal program, which has been demonstrated to be safe, effective, and is accomplished with no significant impact to workers, the public, or the environment.

As I discuss the preferred alternative, I will be using slides taken from the Navy's current disposal program to illustrate the proposed method.

The reactor compartment would be separated from the rest of the ship and placed on a barge for waterborne transport. The sealed package would meet all Department of Transportation and Nuclear Regulatory Commission requirements. The barges used would all meet the United States Coast Guard and Navy requirements.

The inset shows the transportation route proposed

for all of the alternatives that take an entire reactor compartment to Hanford. The shipments would leave from Puget Sound Naval Shipyard, proceed along the Washington coast, up the Columbia River to the Port of Benton near the Hanford site. This is the same route taken under the current disposal program.

I would like to go into some detail on the safety features we would use for waterborne transport of the reactor compartment.

We designed the waterborne transport system conservatively. This means the transport system is capable of safely handling conditions much worse than we actually expect.

As you can see in this picture, the barges are designed with multiple tanks and watertight bulkheads between them. The barge will remain stable under storm conditions even if two of these tanks are damaged and completely flooded. Even more damage and flooding could be sustained and still the barge would remain floating.

Safety is further assured by not shipping in bad weather. We use only experienced towing contractors and always use a back-up tug that follows the shipment.

In addition, the Navy designs the reactor compartment package with a number of engineered features that would facilitate location and salvage.

At the Port of Benton, the reactor compartment would be offloaded from the barge, hauled over land, and placed in a burial trench similar to what is shown in this picture.

The proposed burial site for the reactor compartments is the low-level burial grounds located near the center of the Hanford site. These burial grounds are well suited to the permanent disposal of reactor compartments. The arid climate, plus existing soil characteristics, are beneficial for waste disposal. In addition, the site is accessible by barge with a short overland haul.

Now I'd like to briefly describe the other alternatives.

The no-action alternative we evaluated is protective waterborne storage of the ship for an indefinite period. The locations considered for waterborne storage are the Puget Sound Naval Shipyard in Bremerton, Washington and the Norfolk Naval Shipyard in Portsmouth, Virginia.

While the impacts are very small during storage, the no-action alternative does not provide for a permanent solution. The effort for final disposition would have to be undertaken sometime in the future.

In contrast to our preferred alternative, in the

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subdivision alternative, rather than remain whole, the reactor compartment would be disassembled.

Because of the reactor compartment's rugged nature, the disassembly effort requires extensive structural work. This work would involve rigorous environmental protection techniques to remove the radioactive components.

Packaging of the large components would require that special shipping containers be designed and built for their disposal. Many would be large enough that shipment by truck or rail would not be feasible. These components would be disposed of at Department of Energy sites such as Hanford or Savannah River.

The amount of smaller components to be processed and transported would be significantly greater under this alternative. This alternative requires 15 times more shipments than the preferred alternative.

The Navy also evaluated storing the reactor compartments above ground for an indefinite period. The location considered for storage is the Department of Energy site at Hanford.

Similar to the no-action alternative, the impacts are very small during storage. However, this alternative also does not provide for a permanent solution and some future action would be required.

Now I am going to talk about the environmental consequences of the alternatives we considered.

Our evaluation was broken down into three segments that reflect where potential impacts would take place: at shipyards, along the transportation route, and at the disposal site.

For each of these segments, I will discuss the results of the environmental studies that were performed. Several of the studies were performed by independent, technical organizations outside the Navy, such as Pacific Northwest Laboratory.

The environmental areas we studied for shipyards are summarized on this slide. We looked at the possible effects from industrial work such as welding, sandblasting, and hazardous material removal.

We determined that the principle effect is that shipyard workers would receive some exposure to radiation. Personnel radiation exposures are maintained as low as reasonably achievable and would be kept within the guidelines set by the Nuclear Regulatory Commission. Total exposure is expected to be much higher in the subdivision alternative than if the reactor compartment were left whole.

The industrial procedures used to prepare reactor compartments for disposal would be the same as these

currently used at the shipyard. These procedures are in compliance with Navy Occupational Safety and Health requirements. These requirements are designed to protect workers from industrial hazards associated with their work.

The measures used by the Navy to protect its own workers from potential hazards during disposal work would protect the surrounding public and the environment as well.

The environmental areas we studied for transportation are summarized on this slide. The potential health effects to the general population and the transport crew were evaluated for normal conditions of transport and accident scenarios. The potential impacts from transport were found to be very low for all scenarios considered.

In the extremely unlikely event that a barge did sink and water entered the reactor compartment, no significant environmental impact would occur. Now, this is because 99.9 percent of the radioactivity in the reactor compartment is part of the reactor plants' metal components and can only be released through corrosion. The remaining radioactivity is contained within the sealed reactor plant systems.

There would be no environmental consequences from other hazardous substances. This is because most are solids and would, therefore, not be released to surrounding waters.

The environmental areas we studied at the burial site are summarized on this slide. The focus of our analysis was the movement of radioactive and hazardous substances from the burial site. We call this process migration.

It is important to point out a couple of areas where the studies assumed unfavorable conditions. Making these assumptions mean the study results are worse than we actually expect.

Hanford has an arid climate with only about 6 inches of rainfall per year. The study assumed that there is ten times more moisture in contact with the buried compartments than is expected under current conditions.

The migration study also assumed that the hazardous materials were exposed and immediately available for movement through the ground. When, in fact, the corrosion study determined that the reactor compartments are so robust that they will contain these materials for at least 600 years.

This slide summarizes the results of the migration study.

The study determined that it would take over 700,000 years for lead to reach the Columbia River. Most of the radioactive material would decay away before being released. Radioactive nickel would make up the bulk of what is released and this nickel would take over 200,000 years to reach the river.

For all substances considered in this evaluation, concentrations would not exceed current groundwater protection standards.

Because these results are based on the unfavorable assumptions, we expect the actual movement of radioactive and other hazardous materials to take much longer and result in even lower concentrations.

Now I would like to discuss the potential impact of radiation exposure to workers and the public.

The health concern of low-level exposure to radiation is the potential to induce cancer over time, referred to as latent cancer. Many studies have been done to determine the effect radiation would have on the chance of a person developing cancer.

Our studies determined the potential radiation exposures for all the alternatives evaluated. We then used conversion factors approved by the International Council on Radiological Protection to determine the number of potential latent cancer fatalities.

First, let's look at the analysis of impacts to shipyard workers.

To dispose of the entire reactor compartment, no more than .6 additional latent cancer fatalities are projected among shipyard workers. This is for disposal of all 100 reactor compartments.

The subdivision alternative involves significantly more work. Because of this, shipyard workers would receive more radiation exposure than if the reactor compartment were left whole. Depending on whether subdivision occurred at the time of ship decommissioning or was delayed ten years, 13 to 44 additional latent cancer fatalities are projected among shipyard workers.

The impact on shipyard workers is a key discriminator between land burial of the entire reactor compartment and the subdivision alternative.

For the general public, we looked at the effects of transporting the reactor compartment to the burial site. The general public population in the vicinity of the transport route is about 200,000 people. As you can see in this table, there would be virtually no effect to dispose of all 100 reactor compartments regardless of the alternative selected.

There are projected to be no more than .003 total additional cancer fatalities as a result of the land

burial alternative. Now, what this number really means is that the effect of land burial of all 100 reactor compartments at Hanford is insignificant when compared to the chance of being struck by lightning.

We concluded that all of the alternatives evaluated would have minimal impact on the general public and the environment.

For workers, however, land burial of the entire reactor compartment at Hanford would result in a much lower potential for latent cancer fatalities as compared to the subdivision alternative.

And finally, land burial of the entire reactor compartment at Hanford also has the advantage of being a permanent solution.

I thank you all very much for your courtesy and attention.

Mr. Shipley.

MR. SHIPLEY: Ladies and gentlemen, it's important that all of those who wish to speak are provided with an opportunity to do so.

Do we have any cards that were filled out for registration?

Out of courtesy, I intend to recognize representatives of government organizations and then individual citizens.

I request your cooperation and courtesy tonight while people are speaking. It's important to provide comments within the time limit so that we may be certain that all who wish to speak have an opportunity to do so.

To allow time for everyone's comments, statements should be summarized to five minutes with written statements submitted for the record.

This lighting system will be used to monitor time available to speakers. The green light will initially be illuminated, the yellow light will indicate when 60 seconds remain, and the red light will indicate when your time has expired.

The procedure for public comment will be as follows: I will announce each registered speaker; when called, please proceed to and use one of the two microphones provided; please state your name for the record; if you are representing an organization, please also give the name of the organization as well; and all of your comments should be directed to me.

* * * * * * * * * *

PUBLIC COMMENT PERIOD

MR. SHIPLEY: We are pleased to have as our first speaker — Is it Mr. Henrik —

MR. LANGHJEM: Yes.

MR. SHIPLEY: — Langhjem?

MR. LANGHJEM: That's right.

MR. SHIPLEY: Thank you.

#3

MR. LANGHJEM: Yes, Mr. Shipley. What I'd like to say first is I'm pretty disappointed at the turnout, considering, you know, what all of this does for the community.

4.7

The next thing I'd like to ask is when you're talking about storage, of waterborne storage, we're kind of doing that now and have been doing it for many years. Do we not need to look the public in the eye and tell them what we're doing with that and how we're maintaining the integrity of these older vessels?

We've got numerous of them parked out on the waterfront. It's very much a concern. And how long are we going to continue maintaining these on the waterfront? I know we're talking about a different class of submarines, but it's still a valid point.

Another thing I'm concerned with is when it comes to you're talking workers, I agree with you. The burial is the best method. And I've been involved directly, in some cases, in some of the design applications for the 25-35 sub for incapsulation of the reactor compartments at the shipyard.

4.8

What I'm concerned about is the work for the recycling end of things. We are hurting workers when

4.8 we're doing this type of work. We are not giving the workers the right to know. We are producing emissions that the public are unaware of.

There's a report that I asked for a copy of, and I have it over at the seat there. It's called a Toxic Release Information Summary Report. I believe it's publication No. 95-417 and it's put out by the State Department of Ecology.

There is not one single entry for this entire county in that report but yet we are doing airborne and waterborne emissions. We're trying to do our best, obviously, to limit them, but there are certain emissions that I'm concerned with. Evolutions where we're doing arc weld processes over lead canning and ballast tanks, using torches to cut through copper,
4.9 antifouling paint. We're bringing in boats to work on right now that we do not have the material safety data sheets available for.

Case in point, the 597, the worker on that particular project asked his supervisor, you know, what am I working with. And under federal law we have what we call the right to know, okay? Right to know means not right to ask but right to know. These people are supposed to be told up front what they're working with.

These particular material and safety data sheets

4.9 that I have possession of right now took a week to get. I had to go to Washington to get them and find out who the manufacturer of the material was, who the applicator was, what particular facility applied it. And we're dealing with some pretty nasty materials.

Some of these sheets reflect, how should you say it, concerns over pregnancy, birth defects and whatnot. We've got a couple of pregnant women down on the dry dock working on these things. I'm very concerned about it.

I think that in view of the estimates that we've provided to NAVSEA and what it would cost to cut up these boats and what we're actually cutting them up for and the profits that we've made in this last year — As you know, we've just received an American citation medal for the shipyard based on our comearound against our AOR. I believe what it was is $180 million deficit. We've now gone into the black. But what I don't see is improvements in the work processes against this recycling effort.

2.4 People have to understand and the public should know that to recycle these boats, there is a lot more than just how we deal with the reactor part and whether we bury them or not. We're stripping the rest of the boat down.

4.10

We have boats lined up, you know, funded for years to come that we're going to be working on. I would like to know what kind of process improvements are going to be made, you know, as far as the environment, workers safety, that type of thing. Are we going to roll back some of those funds that we've been, you know, putting against our AOR into improved processes for the workers?

Thank you.

4.11

MR. SHIPLEY: Thank you very much.

MR. LANGHJEM: Oh, one last thing. We say that we're 99.9 percent defueled. I'm speaking now because I understand we don't have a great drove of people.

MR. SHIPLEY: Go right ahead.

MR. LANGHJEM: The materials inside these reactor compartments are, in a sense, exposed to neutron flux. They're activated in themselves. Themselves being a source of energy of sorts. We're talking of all of the materials within the reactor compartment are subject to that and we check for it.

Is the public aware that -- I don't know if that 99.9 percent is really an accurate figure. Maybe you can come back at me on that one. Thank you.

MR. SHIPLEY: Thank you very much, sir.

MR. WRZESKI: Just to clarify the 99.9 percent figure, that's --

4.11

MR. LANGHJEM: I'm sorry?

MR. WRZESKI: Just to clarify the 99.9 percent figure, to clarify that referring out of my presentation, that was how much radioac-- Of the radioactivity in the reactor compartment when we ship it, that's how much of it is contained in the solvent medal pieces that we ship. All of the fuel has been removed from the reactor compartment when we ship.

MR. LANGHJEM: Okay. Looking at it the other way is just a little bit misleading because people don't understand, when you're talking about the public in general. You're saying that all of the fuel is out with the exception of one-tenth of one percent, but we're not making that statement for the medal itself because the medal itself is inherent with energy.

It emits energy because it's been exposed to neutron flux, correct?

MR. WRZESKI: Yes. That's correct.

MR. LANGHJEM: Thank you.

#4

MR. SHIPLEY: Mr. Roy Hocker. Is that pronounced correctly?

MR. HOCKER: Hocker. Close enough.

MR. SHIPLEY: Thank you.

MR. HOCKER: I think you've done a good job of covering the different things.

Kind of going on with what the previous speaker had to say, I'm only concerned about one thing, and I'm not going to speak to individual issues or any of that. I work in the shipyard and I see an increasing effort and I think it's a good faith effort to contract out things that we can get done more cheaply other ways, but my concern is the process controls are not in place the same way they are for the shipyard workers for contractors.

1.8

I have personal knowledge, I've got background in training in QA, and now I work on the waterfront, and I see that the contractors are not constrained by the same process controls that we are.

It's really nice to say that this is what the environmental impact is going to be for us disposing of the reactor compartments, but in the worst-case scenario, from my standpoint, I'm a civil servant, should contractors come in, someone from another shipyard or another entity of some type, and commence to disposing of nuclear vessels?

I have absolutely zero confidence that any of this would mean anything. I have seen the lack of process controls and I have addressed them directly myself through the system in the shipyard and the bottom line comes down to they play off of a different sheet of

music. They have controls that they're constrained by, yes, but they're not anything that's even vaguely similar to what we have to deal with as shipyard workers in civil service, as far as NAVSEA is concerned.

1.8

And so the one question I have - I know it's not a question-and-answer period tonight - but my concern, as a citizen living in the city, is if someone other than us, shipyard workers working for the civil service, if someone other than us does this job, is this EIS still valid?

MR. SHIPLEY: Thank you very much, sir.

Ladies and gentlemen, I have no further registrations. Has anyone registered to speak that I have not given the opportunity to?

I want to thank all of you on behalf of the United States Navy for taking the time to participate in the hearing tonight. We appreciated the opportunity to hear your comments, and we will work to make sure that they're addressed in the Final EIS.

This meeting is adjourned.

HEARING CONCLUDED: 7:30 p.m.

C-E-R-T-I-F-I-C-A-T-E

STATE OF WASHINGTON)
) ss.
COUNTY OF PIERCE)

I, PAMELA J. FRANZ, a duly authorized Notary Public in and for the State of Washington, do hereby certify that this is a true transcript of the Public Hearing regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants; that the minutes of said meeting were recorded in shorthand and later reduced to typewriting; and that the above and foregoing is a true and correct transcript of said meeting.

I do further certify that I am not a relative of, employee of, or counsel for either of said parties or otherwise interested in the event of said proceedings.

I HAVE HEREUNTO set my hand and affixed by official seal this 22nd day of September, 1995.

Pamela J. Franz
Pamela J. Franz, Notary Public in and for the State of Washington, residing at Tacoma.
CSR #: FRANZ*PJ085P8

PAMELA J. FRANZ
STATE OF WASHINGTON
NOTARY --•-- PUBLIC
My Commission Expires 8-11-96

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#4a

DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE DISPOSAL OF DECOMMISSIONED, DEFUELED, CRUISER, OHIO CLASS AND LOS ANGELES CLASS NAVAL REACTOR PLANTS

COMMENT FORM

Name: Roy Hocker
Organization/Agency: PSNS - Representing Myself
Please check type of organization:
Federal Agency X State Agency ____ Local Group ____ Individual X
Mailing Address:
Street: 3311 Rodgers
City: Bremerton **State:** Wa **Zip:** 98312 **Telephone:** 377-5917

You may turn your comment in at the close of the hearing in the comment box located in the lobby or send it to the address at the bottom of this sheet. Written comments may also be submitted in letter or other format.

I'm confident the professionals at PSNS working as civil servants can and will comply with the requirements of the EPA.

However, the increasing "contracting out" of our functions is skeptical. Contractors are not required to meet our standards. I have no confidence the standards we maintain will be applicable, much less upheld. 1.8

Mail to: Mr. John Gordon
Puget Sound Naval Shipyard
1400 Farragut Ave., Code 1100
Bremerton, Washington 98314-5001

COPY

PROCEEDINGS

PUBLIC HEARING
DRAFT ENVIRONMENTAL IMPACT STATEMENT ON DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER, OHIO CLASS AND LOS ANGELES CLASS NAVAL REACTOR PLANTS

Red Lion Hotel-Jantzen Beach
Glisan Room
909 North Hayden Island Drive
Portland, Oregon 97217

BAYSIDE REPORTERS
4041 Ruston Way
Suite 1-D
Tacoma, Washington 98402

REPORTED BY PAULA SOMERS
September 19, 1995

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APPEARANCES

MR. DICK SHIPLEY - Director of Environment, Safety, and Health, Puget Sound Naval Shipyard

MR. JIM WRZESKI - Reactor Compartment Disposal Manager, U.S. Navy

MR. MARK FRENCH - Department of Energy

The Assembly of the Public Hearing, regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants, convened on the 19th of September, 1995, at the Red Lion Hotel-Jantzen Beach, Glisan Room, 909 North Hayden Island Drive, Portland, Oregon 97217, beginning at the hour of 7:06 p.m., Mr. Shipley, presiding.

* * * * * * *

MR. SHIPLEY: Good evening. Thank you for coming. My name is Dick Shipley. I'm the Director of Environment, Safety, and Health at Puget Sound Naval Shipyard. Tonight I'm serving as a presiding officer for this public meeting.

With me this evening is Mr. Jim Wrzeski, the Navy's reactor compartment disposal manager. Also with us tonight from the Department of Energy is Mr. Mark French. The Department of Energy is a cooperating agency in the development of the Environmental Impact Statement.

On August 15th, 1995, the Navy announced in the Federal Register the availability of the Draft Environmental Impact Statement, which we call the Draft EIS, on the disposal of decommissioned, defueled, reactor plants from cruisers, OHIO Class and LOS ANGELES

Class submarines. The Navy, in cooperation with the Department of Energy, has prepared this Draft EIS to focus on the potential for significant environmental impacts and to consider reasonable alternatives.

Spent fuel is not the subject of this EIS. The disposition of spent fuel was a draft in the Department of Energy Environmental Impact Statement identified on this slide with the Navy as a cooperating agency.

The Navy's Federal Register announcement scheduled public meetings at various locations in order to provide organizations and individuals with an interest in this matter with an opportunity to present their views. We are here this evening to conduct one of these scheduled public meetings.

Tonight's meeting is being held as part of the decision-making process required by the National Environmental Policy Act called NEPA. NEPA is our basic national charter for the protection of the environment. NEPA procedures ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken.

The Draft EIS was developed based on public input received during the scoping phase of the NEPA process.

Tonight we are here to listen to what you have to say. We will not directly be responding to questions.

The purpose of tonight's meeting is to receive your input so it can be addressed in the development of the final EIS. The purpose is not to engage in debate.

I'm going to wait just a minute until our latest person is seated, so we'll proceed then.

It's my responsibility to receive statements so they can be considered in preparing a Final EIS. For that reason, this meeting is being recorded.

Copies of the agenda for tonight's meeting are available on the table in the back. It explains that the order of our meeting this evening will consist of a presentation by Mr. Wrzeski on the alternatives evaluated in the Draft EIS.

This presentation will last approximately 20 minutes and will be followed by the formal comment period. This comment period is the time we listen to you. Responses to each individual comment or question will be in the Final EIS.

After all comments have been given, we will conclude the meeting with closing remarks. I will afford an opportunity to those individuals and organizations who wish to speak. I would appreciate it if anyone wishing to speak would fill out a registration form at the door.

To get everyone's comments, I will ask that long

statements be summarized to five minutes with the written statement submitted for the record.

Whether or not you speak this evening, you may also provide written comments to me or leave them with the staff at the registration table. Oral and written input will be considered equally in the development of the EIS.

If you desire to provide written comments at a later time, they should be sent to: Mr. John Gordon, Puget Sound Naval Shipyard, 1400 Farragut Avenue, Code 1160, Bremerton, Washington 98314-5001.

Written comments postmarked by October 10th, 1995, will be considered in preparation of the Final EIS. Comments postmarked after that date will be considered to the extent practical.

Before we begin receiving public input, I would like to introduce Mr. Wrzeski, who will provide a general overview of the alternatives which have been evaluated in the Draft EIS.

Mr. Wrzeski.

* * * * * * *

PRESENTATION

MR. WRZESKI: Thank you, Mr. Shipley. Good evening, ladies and gentlemen.

By the 1980s many of the Navy's submarines were reaching the end of their useful life. At that time, the Navy prepared an Environmental Impact Statement to evaluate disposal methods for the radioactive components associated with the nuclear power plants on these submarines.

In the 1984 Record of Decision, the Navy selected land burial of the reactor compartment as the disposal method for these components. Since then, the Navy has completed 50 successful shipments under the 1984 program.

Now, in the 1990s, recent changes in the national defense structure have resulted in downsizing the fleet, including nuclear-powered combatants. Because of this downsizing, the Navy will soon need to address disposal of reactor compartments associated with cruisers, OHIO Class submarines, and LOS ANGELES Class submarines.

This EIS has been prepared because the approximately 100 reactor compartments from these classes of ships were not covered under the 1984 EIS.

This figure shows the location of reactor compartments on a typical Navy cruiser and submarine.

The functional design of the ship's reactor compartment makes it an ideal disposal package. The compartment is completely enclosed by structural walls known as bulkheads and, in the case of a submarine, part

of the enclosure is the ship's pressure hull.

The bulkheads contain lead shielding to protect the crew during reactor operation, and the bulkheads are designed to meet the shocks and stresses of the military ship under combat conditions.

These features make the reactor compartment a superior transportation and disposal package that is far stronger than typical industry containers used to dispose of low-level radioactive waste.

The remainder of the ship is recycled to reuse the metals.

Tonight I will first discuss the alternatives the Navy considered for disposal of the reactor plant. Later in my presentation, I will cover the potential environmental consequences. In all of the alternatives considered, the spent fuel will be removed before initiating disposal.

The Navy evaluated several alternatives in this EIS. Land burial of the entire reactor compartment at Hanford, Washington, is our preferred alternative. We also looked at waterborne storage of the ship, which is the no-action alternative. We evaluated subdivision of the reactor compartment. This alternative disassembles the reactor plant and disposes of the components separately. Finally, we looked at above-ground storage of the reactor compartment at Hanford.

Now I'd like to describe our preferred alternative. My presentation tonight will focus mainly on the preferred alternative, even though the Draft EIS analyzes others in considerable detail.

As discussed earlier, the reactor compartment makes an ideal disposal package. For this and other reasons that I'll discuss, the Navy has determined that land burial of the entire reactor compartment at Hanford is the preferred alternative.

This is the same basic method as our current disposal program, which has been demonstrated to be safe, effective, and is accomplished with no significant impact to workers, the public, or environment.

As I discuss the preferred alternative, I will be using slides taken from the Navy's current disposal program to illustrate the proposed method.

The reactor compartment would be separated from the rest of the ship and placed on a barge for waterborne transport. The sealed package would meet all Department of Transportation and Nuclear Regulatory Commission requirements. The barges used would meet all the United States Coast Guard and Navy requirements.

The inset shows the transportation route proposed for all alternatives that take an entire reactor

compartment to Hanford. The shipments would leave from Puget Sound Naval Shipyard, proceed along the Washington coast, up the Columbia River to the Port of Benton near the Hanford Site. This is the same route taken under the current disposal program.

I'd like to go into some detail on the safety features we would use for waterborne transport of the reactor compartment.

We designed the waterborne transport system conservatively. This means the transport system is capable of safely handling conditions that are much worse than we actually expect.

As you can see in this picture, the barges are designed with multiple tanks and watertight bulkheads between them. The barge will remain stable under storm conditions even if two of these tanks are damaged and completely flooded. Even more damage and flooding could be sustained and still the barge would remain floating.

Safety is further assured by not shipping in bad weather. We use only experienced towing contractors and always use a back-up tug that follows the shipment.

In addition, the Navy designs the reactor compartment package with a number of engineered features that would facilitate location and salvage.

At the Port of Benton, the reactor compartment would be off-loaded from the barge, hauled over land, and placed in a burial trench similar to what's shown in this picture.

The proposed burial site for reactor compartments is the low-level burial grounds located near the center of the Hanford Site. These burial grounds are well suited to the permanent disposal of reactor compartments. The arid climate, plus existing soil characteristics, are beneficial for waste disposal. In addition, the site is accessible by barge with a short overland haul.

Now I'd like to briefly describe the other alternatives.

The no-action alternative we evaluated is protective waterborne storage of the ship for an indefinite period. The locations considered for waterborne storage of the ship are Puget Sound Naval Shipyard in Bremerton, Washington, and Norfolk Naval Shipyard in Portsmouth, Virginia.

While the impacts are very small during storage, the no-action alternative does not provide for a permanent solution, and the effort for final disposition would have to be undertaken sometime in the future.

In contrast to our preferred alternative, in the subdivision alternative, rather than remain whole, the reactor compartment would be disassembled.

Because of the reactor compartment's rugged nature, the disassembly effort requires extensive structural work. This work would involve rigorous environmental protection techniques to remove the radioactive components.

Packaging of the large components would require that special shipping containers be designed and built for their disposal. Many would be large enough that shipment by truck or rail would not be feasible. These components would be disposed of at Department of Energy sites such as Hanford or Savannah River.

The amount of smaller components to be processed and transported would be significantly greater under this alternative. This alternative requires 15 times more shipments than the preferred alternative.

The Navy also evaluated storing the reactor compartments above ground for an indefinite period. The location considered for storage is the Department of Energy Site at Hanford.

Similar to the no-action alternative, the impacts are very small during storage. However, this alternative also does not provide for a permanent solution, and some future action would be required.

Now I'm going to talk about the environmental consequences of the alternatives we considered.

Our evaluation was broken down into three segments that reflect where the potential impacts would take place: at shipyards, along the transportation route, and at the burial site.

For each of these segments, I will discuss the results of the environmental studies that were performed. Several of the studies were performed by independent, technical organizations outside the Navy, such as Pacific Northwest Laboratory.

The environmental areas we studied for shipyards are summarized on this slide. We looked at the possible effects from industrial work such as welding, sandblasting, and hazardous material removal.

We determined that the principal effect is that shipyard workers would receive some exposure to radiation. Personnel radiation exposures are maintained as low as reasonably achievable and would be kept within the guidelines set by the Nuclear Regulatory Commission. Total exposure is expected to be much higher in the subdivision alternative than if the reactor compartment were left whole.

The industrial procedures used to prepare reactor compartments for disposal would be the same as those currently used at shipyards. These procedures are in

compliance with Navy Occupational Safety and Health requirements. These requirements are designed to protect workers from industrial hazards associated with their work.

The measures used by the Navy to protect its own workers from potential hazards during disposal work would protect the surrounding public environment as well.

The environmental areas we studied for transportation are summarized on this slide. The potential health effects to the general population and the transport crew were evaluated for normal conditions of transport and accident scenarios. The potential impacts from transport are found to be very low for all scenarios considered.

In the extremely unlikely event that a barge did sink and water entered the reactor compartment, no significant environmental impact would occur. This is because 99.9 percent of the radioactivity in the reactor compartment is part of the reactor plant's metal components and can only be released through corrosion. The remaining radioactivity is contained within the sealed reactor plant systems.

There would be no environmental consequences from other hazardous substances. This is because most are solids and would, therefore, not be released to surrounding waters.

The environmental areas we studied at the burial site are summarized on this slide. The focus of our analysis was the movement of radioactive and other hazardous substances from the burial site. We call this process migration.

It is important to point out a couple of areas where the studies assumed unfavorable conditions. Making these assumptions mean the study results are worse than we actually expect.

Hanford has an arid climate with only about 6 inches of rainfall per year. The study assumed there is ten times more moisture in contact with the buried compartments than is expected under current conditions.

The migration study also assumed that the hazardous materials were exposed and immediately available for movement through the ground. When, in fact, the corrosion study determined that the reactor compartments are so robust that they will contain these materials for at least 600 years.

This slide summarizes the results of the migration study.

The study determined that it would take over 700,000 years for lead to reach the Columbia River.

Most of the radioactive material would decay away before being released from the reactor compartments. Radioactive nickel would make up the bulk of what is released and this nickel would take over 200,000 years to reach the river.

For all the substances considered in this evaluation, concentrations would not exceed current groundwater protection standards.

Because these results are based on the unfavorable assumptions, we expect the actual movement of radioactive and other hazardous materials to take much longer and result in even lower concentrations.

Now I'd like to discuss the potential impact of radiation exposure to workers and the public.

The health concern of low-level exposure to radiation is the potential to induce cancer over time, referred to as latent cancer. Many studies have been done to determine the effect radiation would have on the chance of a person developing cancer.

Our studies determined the potential exposures for all the alternatives evaluated. We then used conversion factors approved by the International Council on Radiological Protection to determine the number of potential latent cancer fatalities.

First, let's look at our analysis of the impacts to shipyard workers.

To dispose of the entire reactor compartment, no more than .6 additional latent cancer fatalities are projected among shipyard workers. This is for disposal of all 100 reactor compartments.

The subdivision alternative involves significantly more work. Because of this, shipyard workers would receive more radiation exposure than if the reactor compartment were left whole. Depending on whether subdivision occurred at the time of decommissioning or was delayed ten years, 13 to 44 additional latent cancer fatalities are projected among shipyard workers.

This impact on shipyard workers is a key discriminator between land burial of the entire reactor compartment and the subdivision alternative.

For the general public, we looked at the effects of transporting the reactor compartments to the burial site. The general public population in the vicinity of the transport route is about 200,000 people. As you can see in this table, there would be virtually no effect to dispose of all 100 reactor compartments regardless of the alternative selected.

There are projected to be no more than .003 total additional cancer fatalities as a result of the land

---

burial alternative. What this number really means is that the effect of land burial of all 100 reactor compartments at Hanford is insignificant when compared to the chance of being struck by lightning.

We concluded all the alternatives evaluated would have minimal impact on the general public and the environment.

For workers, however, land burial of the entire reactor compartment at Hanford would result in a much lower potential for latent cancer fatalities as compared to the subdivision alternative.

And finally, land burial of the entire reactor compartment at Hanford also has the advantage of being a permanent solution.

I thank you for your courtesy and attention.

Mr. Shipley.

* * * * * * *

MR. SHIPLEY: Thank you.

Ladies and gentlemen, it's important that all who wish to speak are provided with an opportunity to do so.

I request your cooperation and courtesy tonight while people are speaking. It is important to provide comments within the time limits.

To allow time for comments, statements should be summarized to five minutes with written statements submitted for the record.

This lighting system will be used to monitor time available to speakers. The green light will initially be illuminated. The yellow light will indicate when 60 seconds remain. The red light will indicate when your time has expired.

The procedure for public comment will be as follows: I will announce each registered speaker; when called, please proceed to and use one of the microphones provided; please state your name for the record; if you are representing an organization, please give the name of the organization as well; and all comments are to be directed to me.

We are pleased to have as our first speaker, Mr. Doug Stewart-Smith.

Mr. Smith.

* * * * * * *

PUBLIC COMMENT PERIOD

#5

MR. STEWART-SMITH: Good evening. For the record, my name is David A. Stewart-Smith. I'm the administrator of the Facility Regulation Division for the Oregon Department of Energy, 625 Marion Street, Northeast, Salem, Oregon.

We will provide written comments prior to the October 10th deadline.

The first point I'd have is that we appreciate the Navy conducting this series of hearings and, in particular, holding a hearing in Oregon on the issue. But we would suggest that in the future, that as the state agency responsible for issues involving nuclear disposal and transportation, that you work with us on setting up this kind of a public meeting.

We have a number of contacts. We'd like to help you get public notice out, and we think we could help you have perhaps a more meaningful discussion with members of the public if we were involved a little bit earlier.

Specifically, with respect to your proposal, our recent experience with the submarine reactor compartment shipments has been uniformly positive. The Oregon Health Division, the state's radiation control agency, has inspected several of the shipments of the 50 that you mentioned for the existing campaign, and it's found them to be well in compliance with all applicable regulations.

The Oregon-Hanford Waste Board's nuclear transportation committee - the Oregon-Hanford Waste Board is a citizen advisory commission set up to advise both the governor and the legislature assembly of issues related to Hanford - was given a thorough briefing on the existing reactor compartment disposal shipment campaign at the Puget Sound Naval Shipyard and found the operation to be well run.

Our agency has been given sufficient notice prior to each shipment, and we continue to appreciate that. So I guess my point is as long as the Navy continues a second disposal program, as you are proposing, in the same manner as our experience has indicated with the current one, we believe these shipments can be conducted safely.

Thank you.

Any questions of me?

MR. WRZESKI: Thank you very much.

* * * * * * *

MR. SHIPLEY: Thank you very much.

Ladies and gentlemen, I have no further registrations. Has anyone registered to speak that I've not given the opportunity to?

I want to thank you all on behalf of the United States Navy for taking the time to participate in the hearing tonight. We appreciated the opportunity to hear your comments and will work to make sure they are addressed in the Final EIS.

This meeting is adjourned. Thank you very much.

HEARING CONCLUDED: 7:27 p.m.

C-E-R-T-I-F-I-C-A-T-E

STATE OF WASHINGTON)
) ss.
COUNTY OF KING)

I, PAULA SOMERS, a duly authorized Notary Public in and for the State of Washington, do hereby certify that this is a true transcript of the Public Hearing regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants; that the minutes of said meeting were recorded in shorthand and later reduced to typewriting; and that the above and foregoing is a true and correct transcript of said meeting.

I do further certify that I am not a relative of, employee of, or counsel for either of said parties or otherwise interested in the event of said proceedings.

I HAVE HEREUNTO set my hand and affixed my official seal this 27th day of September, 1995.

Paula Somers, Notary Public
in and for the State of
Washington, residing at Renton.
CSR #: 299-06

#5a

Oregon

DEPARTMENT OF
ENERGY

October 3, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, Washington 98314-5001

Dear Mr. Gordon:

Thank you for the opportunity to comment on the Draft Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class and Los Angeles Class Naval Reactor Plants. The following comments are submitted on behalf of the Oregon Department of Energy. The Oregon Department of Energy has lead responsibility for the safe transport of radioactive waste through Oregon.

Our recent experience with the Navy's submarine reactor compartment shipments has been positive. The Oregon Health Division has inspected some shipments and found them well in compliance with all applicable regulations. The Oregon Hanford Waste Board's Transport Committee (an advisory group to our agency) was given a thorough briefing on the shipments at Puget Sound Naval Shipyard and found the operation to be very well run. Our agency is also given sufficient notice prior to each shipment.

So long as the Navy continues the disposal program in the same manner as it has in the past, we believe the shipments can be conducted safely. Should the Navy plan any major changes from that program, such as using only one tug instead of two, or not allowing state inspections, then we would have to re-assess the program.

While we are pleased that the Navy conducted a public meeting in Oregon on this issue, in the future, we ask that you work with our agency on schedule, location, and meeting publicity so that we can help you have a meaningful discussion with interested Oregonians. We believe the fact that no members of the public turned out for your Portland meeting is more an indication of your lack of sufficient publicity, rather than a lack of public interest.

Sincerely,

David A Stewart-Smith

David A. Stewart-Smith, Administrator
Facility Regulation Division

John A. Kitzhaber
Governor

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Salem, OR 97310
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Toll-Free 1-800-221-8035

COPY

P R O C E E D I N G S

PUBLIC HEARING
DRAFT ENVIRONMENTAL IMPACT STATEMENT
ON DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER,
OHIO CLASS AND LOS ANGELES CLASS
NAVAL REACTOR PLANTS

Jackson Federal Building
915 Second Avenue
Seattle, Washington 98104

BAYSIDE REPORTERS
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Tacoma, Washington 98402

REPORTED BY KAREN M. RUSK, CSR
September 20, 1995

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ATTENDANCE

MR. DICK SHIPLEY - Director of Environment, Safety, and Health, Puget Sound Naval Shipyard

MR. JIM WRZESKI - Reactor Compartment Disposal Manager, U.S. Navy

MR. MARK FRENCH - Department of Energy

The Assembly of the Public Meeting regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants convened on the 20th of September, 1995, at the Jackson Federal Building, 915 Second Avenue Seattle, Washington, beginning at the hour of 7:00 p.m., Mr. Shipley presiding.

* * * * * * *

MR. SHIPLEY: Good evening, ladies and gentlemen. Thank you for coming tonight. My name is Dick Shipley, and I am the Director of Environment, Safety, and Health at Puget Sound Naval Shipyard. Tonight, I am serving as the presiding officer for this public meeting.

With me this evening is Mr. Jim Wrzeski, the Navy's reactor compartment disposal manager. Also with us tonight from the Department of Energy is Mr. Mark French. The Department of Energy is a cooperating agency in the development of the Environmental Impact Statement.

On August 15th, 1995, the Navy announced in the Federal Register the availability of the Draft Environmental Impact Statement, which we call the Draft EIS, on the disposal of decommissioned, defueled reactor plants from cruisers and OHIO and LOS ANGELES Class

submarines. The Navy, in cooperation with the Department of Energy, has prepared this Draft EIS to focus on the potential for significant environmental impacts and to consider reasonable alternatives.

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It is my responsibility to receive statements so that they can be considered in preparing the Final EIS. For that reason, the meeting is being recorded.

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Before we begin receiving public input, I would like to introduce Mr. Wrzeski, who will provide a general overview of the alternatives which have been evaluated in the Draft EIS.

Mr. Wrzeski.

* * * * * * *

PRESENTATION

MR. WRZESKI: Thank you, Mr. Shipley. Good evening, ladies and gentlemen.

By the 1980's, many of the Navy's submarines were reaching the end of their useful life. At that time, the Navy prepared an Environmental Impact Statement to evaluate various disposal methods for the radioactive components associated with the nuclear power plants on these submarines.

In the 1984 Record of Decision, the Navy selected land burial of the reactor compartment as the disposal method for these components. Since then, the Navy has completed 50 successful shipments under the 1984 program.

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This EIS has been prepared because the approximately 100 reactor compartments from these classes of ships were not covered under the 1984 EIS.

This figure shows the location of the reactor compartments on a typical Navy cruiser and submarine.

The functional design of the ship's reactor compartment makes it an ideal disposal package. The compartment is completely enclosed by structural walls known as bulkheads and, in the case of a submarine, part of the enclosure is the ship's pressure hull.

The bulkheads contain lead shielding to protect the crew during the reactor operation. The bulkheads are designed to meet the shocks and stresses of a military ship under combat conditions.

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The Navy evaluated several alternatives in this EIS. Land burial of the entire reactor compartment at Hanford, Washington, is our preferred alternative. We also looked at waterborne storage of the ship, which is the no-action alternative. We evaluated subdivision of the reactor compartment. This alternative disassembles the reactor plant and disposes of the components separately. Finally, we looked at above-ground storage of the reactor compartments at Hanford.

Now I would like to describe our preferred alternative. My presentation will focus mainly on the preferred alternative, even though the Draft EIS analyzes the others in considerable detail.

As discussed earlier, the reactor compartment makes an ideal disposal package. For this and other reasons that I'll discuss, the Navy has determined that burial of the entire reactor compartment at Hanford is the preferred alternative.

This is the same basic method as our current disposal program, which has been demonstrated to be safe, effective and is accomplished with no significant impact to workers, the public, or environment.

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The reactor compartment would be separated from the rest of the ship and placed on a barge for waterborne transport. The sealed package would meet all Department of Transportation and Nuclear Regulatory Commission requirements. The barges used would meet all United States Coast Guard and Navy requirements.

The inset shows the transportation route proposed for all the alternatives that take an entire reactor compartment to Hanford. The shipments would leave from Puget Sound Naval Shipyard, proceed along the Washington coast, up the Columbia River to the Port of Benton near

the Hanford site. This is the same route taken under the current disposal program.

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As you can see in this picture, the barges are designed with multiple tanks and watertight bulkheads between them. The barge will remain stable under storm conditions even if two of these tanks are damaged and completely flooded. Even more damage and flooding could be sustained and still the barge would remain floating.

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In addition, the Navy designs the reactor compartment package with a number of engineered features that would facilitate location and salvage.

At the Port of Benton, the reactor compartment would be off-loaded from the barge, hauled over land and placed in a burial trench similar to what is shown in this picture.

The proposed burial site for the reactor compartments is the low-level burial grounds located near the center of the Hanford site. These burial grounds are well suited to the permanent disposal of reactor compartments. The arid climate, plus existing soil characteristics are beneficial for waste disposal. In addition, the site is accessible by barge with a short overland haul.

Now I'd like to briefly describe the other alternatives.

The no-action alternative we evaluated is protective waterborne storage of the ship for an indefinite period. The locations considered for waterborne storage of the ship are Puget Sound Naval Shipyard in Bremerton, Washington and at Norfolk Naval Shipyard in Portsmouth, Virginia.

While the impacts are very small during storage, the no-action alternative does not provide for a permanent solution. The effort for final disposition would have to be undertaken sometime in the future.

In contrast to land burial of the reactor compartment package, in the subdivision alternative, rather than remain whole, the reactor compartment would be disassembled.

Because of the reactor compartment's rugged nature,

the disassembly effort requires extensive structural work. This work would involve rigorous environmental protection techniques to remove the radioactive components.

Packaging of the large components would require that special shipping containers be designed and built for their disposal. Many would be large enough that shipment by truck or rail would not be feasible. These components would be disposed of at the Department of Energy sites such as Hanford or Savannah River.

The amount of smaller components to be processed and transported would be significantly greater under this alternative. This alternative requires 15 times the number of shipments as the preferred alternative.

The Navy also evaluated storing the reactor compartments above ground for an indefinite period. The location considered for storage is the Department of Energy site at Hanford.

Similar to the no-action alternative, the impacts are very small during storage. However, this alternative also does not provide for a permanent solution and some future action would be required.

Now I am going to talk about the environmental consequences of the alternatives we considered.

Our evaluation was broken down into three segments that reflect where potential impacts would take place: at shipyards, along the transportation route, and at the disposal site.

For each of these segments, I will discuss the results of the environmental studies that were performed. Several of the studies were performed by independent, technical organizations outside the Navy, such as Pacific Northwest Laboratory.

The environmental areas we studied for shipyards are summarized on this slide. We looked at the possible effects from industrial work such as welding, sandblasting, and hazardous material removal.

We determined that the principal effect is that shipyard workers would receive some exposure to radiation. Personnel radiation exposures are maintained as low as reasonably achievable and kept within guidelines set by the Nuclear Regulatory Commission. Total exposure is expected to be much higher in the subdivision alternative than if the reactor compartment were left whole.

The industrial procedures used to prepare reactor compartments for disposal would be the same as those currently used at shipyards. These procedures are in compliance with Navy Occupational Safety and Health requirements. These requirements are designed to

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protect workers from industrial hazards associated with their work.

The measures used by the Navy to protect its own workers from potential hazards during disposal work would protect the surrounding public and the environment as well.

The environmental areas we studied for transportation are summarized on this slide. The potential health effects to the general population and the transport crew were evaluated for normal conditions of transport and accident scenarios. The potential impacts from the transport were found to be very low for all scenarios considered.

In the extremely unlikely event that a barge did sink and the water entered the reactor compartment, no significant environmental impact should occur. This is because 99.9 percent of the radioactivity in the reactor compartment is part of the reactor plants' metal components and can only be released through corrosion. The remaining radioactivity is contained within the sealed reactor plant systems.

There would be no environmental consequences from other hazardous substances. This is because nearly all are solids and would, therefore, not be released to the surrounding waters.

The environmental areas we studied at the burial site are summarized on this slide. The focus of our analysis was the movement of radioactive and other hazardous materials from the disposal site. We call this process migration.

It is important to point out a couple of areas where studies assumed unfavorable conditions. Making these assumptions mean the study results are worse than we actually expect.

Hanford has an arid climate with only 6 inches of rainfall per year. The study assumed that there is ten times more moisture in contact with the buried compartments than is expected under current conditions.

The migration study also assumed that the hazardous materials were exposed and immediately available for movement through the ground. When in fact, the corrosion study determined that the reactor compartments are so robust that they will contain these materials for at least 600 years.

This slide summarizes the results of the migration study.

The study determined that it would take over 700,000 years for lead to reach the Columbia River. Most of the radioactive material would decay away before being released from the reactor compartments.

Radioactive nickel would make up the bulk of what is released and this nickel would take over 200,000 years to reach the river.

For all of the substances considered in this evaluation, concentrations would not exceed current groundwater protection standards.

Because these results are based on the unfavorable assumptions, we expect the actual movement of radioactive and other hazardous materials to take much longer and result in even lower concentrations.

Now I would like to discuss the potential impact of radiation exposure to workers and the public.

The health concern of low-level exposure to radiation is the potential to induce cancer over time, referred to as latent cancer. Many studies have been done to determine the effect radiation would have on the chance of a person developing cancer.

Our studies determined the potential radiation exposures for all of the alternatives evaluated. We then used conversion factors approved by the International Council on Radiological Protection to determine the number of potential latent cancer fatalities.

First, let's look at our analysis of impacts to the shipyard workers.

To dispose of the entire reactor compartment, no more than .6 additional latent cancer fatalities are projected among shipyard workers. This is for disposal of all 100 reactor compartments.

The subdivision alternative involves significantly more work. Because of this, the shipyard workers would receive more radiation exposure than if the reactor compartment were left whole. Depending on whether subdivision occurred at the time of decommissioning or was delayed ten years, 13 to 44 additional latent cancer fatalities are projected among shipyard workers.

This impact on shipyard workers is a key discriminator between land burial of the entire reactor compartment and the subdivision alternative.

For the general public, we looked at the effects of transporting the reactor compartment to the burial site. The population in the vicinity of the transport route is about 200,000 people. As you can see in this table, there would be virtually no affect to dispose of all 100 compartments regardless of the alternative selected.

There are projected to be no more than .003 total additional cancer fatalities as a result of the land burial alternative. What this number really means is that the effect of land burial of all 100 reactor compartments at Hanford is insignificant when compared

to the chance of being struck by lightning.

We concluded that all of the alternatives evaluated would have minimal impact on the general public and the environment.

For workers, however, land burial of the entire reactor compartment at Hanford would result in a much lower potential for latent cancer fatalities as compared to the subdivision alternative.

And finally, land burial of the entire reactor compartment at Hanford also has the advantage of being a permanent solution.

I thank you for your courtesy and attention.

Mr. Shipley.

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MR. SHIPLEY: Ladies and gentlemen, it is important that all of those who wish to speak are provided with an opportunity to do so.

Out of courtesy, I intend to recognize representatives of government organizations and then individual citizens.

I request your cooperation tonight while people are speaking.

The procedure for public comment will be as follows: I will announce each registered speaker; when called, please proceed to and use one of the microphones provided; please state your name for the record; if you are representing an organization, please give the name of the organization as well; please direct all of your comments to me.

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PUBLIC COMMENT PERIOD

MR. SHIPLEY: We are pleased to have as our first speaker tonight Cynthia Sarthou. Cynthia?

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MS. SARTHOU: My name is Cynthia Sarthou.

I'm the staff attorney for Heart of America Northwest, 1305 Fourth Avenue, Suite 208, Seattle, Washington 98102. We are an organization of 15,000 members located in the City of Seattle. Our members are throughout the state of Washington and Oregon, and we are interested in this issue.

I brought some comments that I would like to read, and then I have, I guess, one or two little things to add to the presentation.

4.12

1) The Draft Environmental Impact Statement professes to reveal and discuss all possible environmental impacts attendant to decommissioning and transportation of the specified nuclear naval reactor plants. The Navy has been reluctant, however, to allow the public to verify the validity of the information provided within the EIS.

4.12

In fact, recently, the Navy has requested that Restricted Area 2 in Sinclair Inlet be deemed entirely off-limits to public access. In so doing, the Navy is suggesting to the public that it is unwilling to disclose or hold up to objective scrutiny the environmental impacts of decommissioning and transportation operations in Puget Sound.

4.13

2) The reactor compartments contain lead- and PCB-laden materials. Although deemed a low-level burial ground, the area slated for disposal is, in effect, a system of large trenches with minimal protections against leaching of contaminants. It is imperative that the EIS address the potential environmental impacts of these materials in the absence of institutional controls.

Equally importantly, these materials, if disposed of at the Hanford low-level burial grounds, must be subject to regulation under the Washington State Dangerous Waste Regulations to minimize the effect of disposal of these materials.

4.14

3) The Navy has recently instructed the Department of Energy to bar public and press viewing of burial grounds containing naval reactor compartments during USDOE tours of the Hanford Nuclear Reservation. By this action, the Navy is implicitly stating that it is

4.14 unwilling to open its disposal practices to public scrutiny. This is objectionable. There is no national security justification for denying the public scrutiny of burial practices, and therefore they should not be barred from seeing these practices.

4) The EIS predicts the need for four hectares, or ten acres, for disposal of the compartments addressed by this EIS. Approximately four hectares, or ten acres, has already been used for the Pre-LOS ANGELES Class compartments, and additional lands will be required for reactor compartments of subsequent classes of vessels slated for decommissioning.

4.15 The Navy should minimize its use of Hanford lands for disposal of these materials. The public does not consider Hanford a sacrifice zone and objects to the continual use of large areas of Hanford for Navy and DOE waste disposal. Moreover, the cost of Hanford lands should be included in any analysis of the fiscal cost of this alternative.

3.1 5) The EIS also refers to the production of 1,625 cubic meters of mixed waste. The EIS does not appear to address disposal of these materials. It is evident that Hanford's low-level burial ground is not appropriate for disposal of these low-level mixed wastes. Accordingly, the EIS must address a site for disposal of these

3.1 materials and the environmental impacts attendant thereto.

4.16 The production of mixed waste should also be minimized and materials recycled where possible. The EIS should consider inclusion of recyclable materials within the proposed United States Department of Energy Recycle program or policy, known as Recycle 2000. This would minimize the amount of land needed for disposal of this material.

4.17 The other comment I have from this basic presentation was that I was somewhat disturbed by the calculations of transportation time of contaminants from the burial ground. I would just like the EIS to possibly consider that more fully.

I am not sure, but I'm pretty sure that those are based upon USDOE calculations. And in the past ten years, we have been shown that the USDOE's calculations are erroneous and overestimate the travel time by a significant amount, especially if you look at tritium quantities that were estimated not to be reaching the Columbia River for hundreds of years which are now reaching the Columbia River. So we would suggest that you maybe more carefully scrutinize that.

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MR. SHIPLEY: Thank you very much, Ms. Sarthou.

Ladies and gentlemen, I have no further registrations. Is anyone registered to speak to whom I have not given the opportunity?

I'd like to thank you all on behalf of the United States Navy for taking the time to participate in the hearing tonight. We appreciated the opportunity to hear your comments, and we'll work to make sure they are addressed in the Final EIS.

This meeting is adjourned.

HEARING CONCLUDED: 7:25 p.m.

C-E-R-T-I-F-I-C-A-T-E

STATE OF WASHINGTON)
) ss.
COUNTY OF PIERCE)

I, KAREN M. RUSK, a duly authorized Notary Public in and for the State of Washington, do hereby certify that this is a true transcript of the Public Hearing regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants; that the minutes of said meeting were recorded in shorthand and later reduced to typewriting; and that the above and foregoing is a true and correct transcript of said meeting.

I do further certify that I am not a relative of, employee of, or counsel for either of said parties or otherwise interested in the event of said proceedings.

I HAVE HEREUNTO set my hand and affixed my official seal this 27th day of September, 1995.

3-13-98

Karen M. Rusk
Karen M. Rusk, Notary Public in
and for the State of Washington,
residing at Tacoma.
CSR #: RUSK*KM416SR

#6a

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Executive Director
Gerald M. Pollet

HeartOfAmericaNorthwest
"Advancing our region's quality of life."

COMMENTS OF HEART OF AMERICA NORTHWEST ON THE NAVY'S DRAFT ENVIRONMENTAL IMPACT STATEMENT ON DISPOSAL OF DECOMMISSIONED, DEFUELED, CRUISER, OHIO CLASS AND LOS ANGELES CLASS SUBMARINE NAVAL REACTOR PLANTS

1. Although the Navy in its Draft Environmental Impact Statement professes to reveal and discuss all possible environmental impacts attendant to decommissioning and transportation of the specified Naval Reactor Plants, the Navy has been reluctant to allow the public to verify the validity of the information provided within the EIS. In fact, recently, the navy has requested that Restricted Area 2 in Sinclair Inlet be deemed entirely off-limits to public access. In so doing, the navy is suggesting to the public that it is unwilling to disclose or hold up to objective scrutiny the environmental impacts of decommissioning and transportation operations in Puget Sound. **4.12**

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The production of mixed waste should be minimized and materials recycled where possible. The EIS should consider inclusion of recyclable materials within the proposed United States Department of Energy Recycle Policy/Program (Recycle 2000). This would minimize the amount of land needed for disposal of this material. **3.1**

COPY

PROCEEDINGS

PUBLIC HEARING
DRAFT ENVIRONMENTAL IMPACT STATEMENT ON DISPOSAL OFF DECOMMISSIONED, DEFUELED CRUISER, OHIO CLASS AND LOS ANGELES CLASS NAVAL REACTOR PLANTS

Shilo Inn-Rivershore
International 1 Room
50 Comstock Street
Richland, Washington 99352

BAYSIDE REPORTERS
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Suite 1-D
Tacoma, Washington 98402

REPORTED BY PAULA SOMERS
September 21, 1995

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APPEARANCES

MR. DICK SHIPLEY - Director of Environment, Safety, and Health; Puget Sound Naval Shipyard

MR. JIM WRZESKI - Reactor Compartment Disposal Manager, U.S. Navy

MR. MARK FRENCH - Department of Energy

The Assembly of the Public Hearing, regarding the Draft Environmental Impact Statement on the disposal of decommissioned, defueled cruiser, OHIO Class and LOS ANGELES Class naval reactor plants, convened on the 21st of September, 1995, at the Shilo Inn-Rivershore, International 1 Room, 50 Comstock Street, Richland, Washington 99352, beginning at the hour of 6:59 p.m., Mr. Shipley presiding.

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The proposed burial site for reactor compartments is the low-level burial grounds located near the center of the Hanford Site. These burial grounds are well suited to the permanent disposal of reactor compartments. The arid climate, plus existing soil characteristics, are beneficial for waste disposal. In addition, the site is accessible by barge with a short overland haul.

Now I'd like to briefly describe the other alternatives.

The no-action alternative we evaluated is protective waterborne storage of the ship. The locations considered for waterborne storage of the ship are Puget Sound Naval Shipyard in Bremerton, Washington, and Norfolk Naval Shipyard in Portsmouth, Virginia.

While the impacts are very small during storage, the no-action alternative does not provide for a permanent solution, and the effort for final disposition would have to be undertaken sometime in the future.

In contrast to land burial of the reactor compartment package in the subdivision alternative, rather than remain whole, the reactor compartment would be disassembled.

Because of the reactor compartment's rugged nature, this disassembly effort requires extensive structural work. This work would involve rigorous environmental protection techniques to remove the radioactive components.

Packaging of the large components would require that special shipping containers be designed and built for their disposal. Many would be large enough that shipment by truck or rail would not be feasible. These components would be disposed of at Department of Energy sites such as Savannah River or Hanford.

The amount of smaller components to be processed and transported would be significantly greater under this alternative. This alternative requires 15 times the number of shipments as the preferred alternative.

The Navy also evaluated storing the reactor compartments above ground for an indefinite period.

The location considered for storage is the Department of Energy site at Hanford.

Similar to the no-action alternative, the impacts are very small during the storage. However, this alternative also does not provide for a permanent solution, and some future action would be required.

Now I'm going to talk about the environmental consequences of the alternatives we considered.

Our evaluation was broken down into three segments that reflect where potential impacts would take place: at shipyards, along the transportation route, and at the disposal site.

For each of these segments I will discuss the results of the environmental studies that were performed. Several of these studies were performed by independent technical organizations outside the Navy, such as Pacific Northwest Laboratory.

The environmental areas we studied for shipyards are summarized on this slide. We looked at the possible effects from industrial work such as welding, sandblasting, and hazardous material removal.

We determined that the principal effect is that shipyard workers would receive some exposure to radiation. Personnel radiation exposures are maintained as low as reasonably achievable and would be kept within the guidelines set by the Nuclear Regulatory Commission. Total exposure is expected to be much higher in the subdivision alternative than if the reactor compartment were left whole.

The industrial procedures used to prepare reactor compartments for disposal would be the same as those currently used at shipyards. These procedures are in compliance with Navy Occupational Safety and Health requirements. These requirements are designed to protect workers from industrial hazards associated with their work.

The measures used by the Navy to protect its own workers from potential hazards during disposal work would protect the surrounding public environment as well.

The environmental areas we studied for transportation are summarized on this slide. Potential health effects to the general population and the transport crew were evaluated for normal conditions of transport and accident scenarios. The potential impacts from transport were found to be very low for all the scenarios considered.

In the extremely unlikely event that a barge did sink and water entered the reactor compartment, no significant environmental impact would occur. This is because 99.9 percent of the radioactivity in the reactor compartment is part of the reactor plant's metal components and can only be released through corrosion. The remaining radioactivity is contained within the sealed reactor plant systems.

There would be no environmental consequences from other hazardous substances. This is because nearly all are solids and would, therefore, not be released to surrounding waters.

The environmental areas we studied at the burial site are summarized on this slide. The focus of our analysis was the movement of radioactive and other hazardous materials from the burial site. We call this process migration.

It's important to point out a couple areas where the studies assumed unfavorable conditions. Making these assumptions mean the study results are worse than we actually expect.

Hanford has an arid climate with only about 6 inches of rainfall per year. The study assumed that there is ten times more moisture in contact with the burial compartments than is expected under current conditions.

The migration study also assumed that the hazardous materials were exposed and immediately available for movement through the ground, when, in fact, corrosion studies determined that the reactor compartments are so robust that they will contain these materials for at least 600 years.

This slide summarizes the results of the migration study.

The study determined that it would take over 700,000 years for lead to reach the Columbia River.

Most of the radioactive material would decay away before being released from the reactor compartments. Radioactive nickel would make up the bulk of what is released, and this nickel would take over 200,000 years to reach the river.

For all substances considered in this evaluation, concentrations would not exceed current groundwater protection standards.

Because these results are based on the unfavorable assumptions, we expect the actual movement of radioactive and other hazardous materials to take much longer and result in even lower concentrations.

Now I'd like to discuss the potential impact of radiation exposure to workers and the public.

The health concern of low-level exposure to radiation is the potential to induce cancer over time, referred to as latent cancer. Many studies have been done to determine the effect radiation would have on the chance of a person developing cancer.

Our studies determined the potential radiation exposures for all the alternatives evaluated. We then used conversion factors approved by the International Council on Radiological Protection to determine the number of potential latent cancer fatalities.

First, let's look at our analysis of impacts to shipyard workers.

To dispose of the entire reactor compartment, no more than .6 additional latent cancer fatalities are projected among shipyard workers. This is for disposal of all 100 reactor compartments.

The subdivision alternative involves significantly more work. Because of this, shipyard workers would receive more radiation exposure than if the reactor compartment were left whole. Depending on whether subdivision occurred at the time of decommissioning or was delayed ten years, 13 to 44 additional latent cancer fatalities are projected among shipyard workers.

This impact on shipyard workers is a key discriminator between land burial of the entire reactor compartment and the subdivision alternative.

For the general public, we looked at the effects of transporting the reactor compartments to the burial site. The population in the vicinity of the transport route is about 200,000 people. As you can see in this table, there would be virtually no effect to dispose of all 100 reactor compartments regardless of the alternative selected.

There are projected to be no more than .003 total additional cancer fatalities as a result of the land burial alternative. Now, what this number really means

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is that the effect of land burial of all 100 reactor compartments at Hanford is insignificant when compared to the chance of being struck by lightning.

We concluded all of the alternatives evaluated would have minimal impact on the general public and the environment.

For workers, however, land burial of the entire reactor compartment at Hanford would result in a much lower potential for latent cancer fatalities as compared to the subdivision alternative.

And, finally, land burial of the entire reactor compartment at Hanford also has the advantage of being a permanent solution.

I thank you for your courtesy and attention.

Mr. Shipley.

* * * * * * *

MR. SHIPLEY: Ladies and gentlemen, it is important that all who wish to speak tonight are provided with an opportunity to do so.

Out of courtesy, I intend to recognize representatives of government organizations and then individual citizens.

I request your cooperation and courtesy tonight while people are speaking.

The procedure for public comment will be as follows: I will announce each registered speaker; when called, please proceed to and use one of the microphones provided; please state your name for the record; if you are representing an organization, please give the name of the organization as well; all comments should be directed to me.

We are pleased to have as our first speaker tonight, Mr. Dave Dillman of TRIDEC.

Mr. Dillman.

* * * * * * *

PUBLIC COMMENT PERIOD

#7

MR. DILLMAN: Good evening. Thank you. My name is Dave Dillman. I'm Senior Vice President, Economic Transition, for TRIDEC, 901 North Colorado, Kennewick, Washington 99336.

What I'd like to do is - I've already submitted written comments - I'd just like to paraphrase those, if I could.

TRIDEC is the Tri-Cities' community not-for-profit Tri-Cities Industrial Development Council, representing approximately 600 businesses and agencies throughout the mid-Columbia region.

The purpose of our organization for the past 30 years has tried to look at the potential industrial recruitment for the Tri-Cities community as it relates

to bringing all the economic development bodies together. Representing the port, the cities, all those respective chambers of each of the communities, and trying to create a community one-voice agenda relative to the economic transition for the Tri-Cities, specifically tonight, relating to the Hanford Site.

Because of the uniqueness of Hanford - particularly in the last eight months, with the Congressional budget reductions, the work force reduction of approximately 4700 workers in 1995 - the role and mission of Hanford and how the Tri-Cities relates to that transition has changed significantly. And, in that, the past has been somewhat not much of a concern for the Tri-Cities community relating to what was being done or shipped to the Hanford Site.

That role and mission has been changed significantly in that as we proceed forward to try to do industrial recruitment both on the business side, the tourism side, relating to the development of agribusiness in our community, we feel there is definitely economic adverse effects. That is not really part of the Draft EIS at this point. What we're formally requesting is that the record of decision in this matter that the U.S. Navy address the issue of an advice on how to propose to work with the community in

4.18

4.18

mitigating the adverse impacts of the reactor burial.

TRIDEC does not express objections for a preferred alternative. We believe that further examination of the alternative is required from the standpoint of an economic and social impact upon the community. With that, to clarify what's the reasoning behind TRIDEC's agenda on this issue - as we have done over the last couple years - we are finding that as we are trying to diversify our economic base, it is very difficult for us to recruit businesses when we have the issue of both Hanford attached to any potential recruitment.

As part of that, there's been enough publicity throughout the region that any time you have Hanford relating to a particular issue, whether it's transportation, bringing waste into the Hanford Site, or Hanford hits the paper in any reason, we have a great difficulty in trying to work with the business constituency of saying: "Come to the Tri-Cities. Hanford is not in issue." And yet the perception is that this continues to be moving forward as: "Hanford: The nuclear waste site capital of the world."

So we would like to have an opportunity to have the Navy look into the Draft EIS, of saying, how can we help mitigate — How can we help the Tri-Cities community in working through some type of economic and social impact

4.18

process that would be supportive of the Tri-Cities community and help us in this diversity project that we have going on.

I appreciate the confidence, and hopefully the Tri-Cities community can work with the United States Navy and the Department of Energy.

Thank you.

* * * * * * *

MR. SHIPLEY: Thank you very much, Mr. Dillman.

Ladies and gentlemen, I have no further registrations. Has anyone registered to speak to whom I have not given the opportunity?

I want to thank you all on behalf of the United States Navy for taking the time to participate in the hearing tonight. We appreciated the opportunity to hear your comments and will work to make sure they are addressed in the Final EIS. Thank you.

This meeting is adjourned.

HEARING CONCLUDED: 7:27 p.m.

C-E-R-T-I-F-I-C-A-T-E

STATE OF WASHINGTON)
) ss.
COUNTY OF KING)

I, PAULA SOMERS, a duly authorized Notary Public in and for the State of Washington, do hereby certify that this is a true transcript of the Public Hearing regarding the Draft Environmental Impact Statement on Disposal of Decommissioned, Defueled Cruiser, OHIO Class and LOS ANGELES Class Naval Reactor Plants; that the minutes of said meeting were recorded in shorthand and later reduced to typewriting; and that the above and foregoing is a true and correct transcript of said meeting.

I do further certify that I am not a relative of, employee of, or counsel for either of said parties or otherwise interested in the events of said proceedings.

I HAVE HEREUNTO set my hand and affixed my official seal this 27th day of September, 1995.

Paula Somers

Paula Somers, Notary Public
in and for the State of
Washington, residing at Renton.
CSR #: 299-06

#7a

TRIDEC
TRI-CITY INDUSTRIAL DEVELOPMENT COUNCIL
901 N. Colorado • Kennewick, WA 99336-7885 U.S.A. • (509) 735-1000 • FAX (509) 735-6609 • 1-800-TRI-CITY

COMMENTS OF THE TRI-CITY INDUSTRIAL DEVELOPMENT COUNCIL IN RESPONSE TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE DISPOSAL OF DECOMMISSIONED DEFUELED CRUISER OHIO CLASS AND LOS ANGELES CLASS NAVAL REACTOR PLANTS

SEPTEMBER 21, 1995 - RICHLAND, WASHINGTON

Thank you for the opportunity to provide these comments on behalf of the Tri-City Industrial Development Council. TRIDEC is a not for profit, private-sector organization representing nearly 600 business organizations throughout the Mid-Columbia Region. Our mission is to achieve economic stability and balanced development of the Mid-Columbia Region for the benefit of its citizens and businesses.

We respectfully request that in the Record of Decision in this matter, the U.S. Navy address the issue and advise how it proposes to work with the community in mitigating the adverse impacts of the reactor burial. 4.18

As the draft environmental impact statement notes, the Department of Energy Hanford Site adjacent to the Tri-Cities has in recent years been the recipient of pre-Los Angeles class submarine reactor compartments which have been shipped by barge from the Puget Sound Naval Shipyard in Bremerton, up the Columbia River for disposal at Hanford.

As we understand it, the present proposal would result in the burial of approximately 100 reactor compartments from cruisers, Los Angeles and Ohio class submarines, plus a volume of mixed waste estimated to be in the range of 57,400 cubic feet. The total estimated cost of the preferred alternative-meaning burial at the low-level waste site at Hanford is estimated to be $1.5 billion dollars.

While we do not express objection to the preferred alternative, we believe that further examination of the alternative is required from the standpoint of economic and social impacts upon the community. 4.18

As you are aware, the Department of Energy's Hanford site is presently in the midst of a downsizing which over time will result in the elimination of 14,000 jobs as the environmental remediation effort is concluded at the Hanford site.

Because of the projected job loss, this region is actively involved in a significant economic transition project which has its foundation in a variety of economic development strategies two of which are industrial recruitment and tourism. 4.18

Our industrial recruitment strategy seeks to leverage the remarkable assemblage of assets at the Hanford site along with the attributes of the Pacific Northwest Laboratory, Washington State University, and many other features to provide an attraction for the establishment or relocation of a broad array of industrial clients. Indeed our community is presently involved in a significant Strengths, Weakness, Opportunities and Threats Analysis to determine the particular industrial targets which should be pursued as a result of our effort. On the basis of information previously developed (or provided to us) there is a well established perception in the minds of many potential clients that this area represents a "nuclear waste dump" and is therefore an undesirable potential site.

For many there is a similar perception with respect to the development of the Mid-Columbia region and the Tri-Cities to the premier agricultural production region and as a tourism destination. Frequently adverse press coverage regarding the transporting of submarine reactor compartments is seen in Seattle, Portland and other major metropolitan areas from which tourists could be expected to travel to the Tri-Cities.

For these reasons we in the community believe that there is an adverse impact resulting from the transportation and storage of those reactor compartments at the Hanford site and that an appropriate means of mitigation is necessary to assist our communities in demonstrating to our industrial recruitment clients, tourists and agricultural customers that despite possible perceptions, there are no demonstrable human health and safety effects as a result of the reactor disposal.

We look forward to working with the U.S. Navy in assessing the negative impacts of the burial program and developing an appropriate means of resolving this issue.

We will provide a copy of these comments for the record along with other supportive materials and thank you for the opportunity to appear before you.

#8

September 27, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, Washington 98314-5001

SUBJECT: COMMENTS ON: DRAFT EIS ON THE DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER, OHIO CLASS, AND LOS ANGELES CLASS NAVAL REACTOR PLANTS

A permanent solution not another temporary storage location is needed. It is recommended the preferred alternative - land burial of the entire reactor compartment at the Department of Energy (DOE) low level waste burial grounds at the Hanford site in Washington State - be the selected option. This option is contingent on the following all activities leading up to and the preparation for shipment from Puget Sound Naval Shipyard oversight be provided by the following organizations: 2.3

Department of Energy, Richland Office, Environment, Safety, and Health Division.

Washington Department of Ecology, Kennewick, Washington Office.

Hanford Site Contractor responsible for low-level burial grounds.

Walter D. Blair, Member
Hanford Advisory Board
Health Safety Waste Management Committee

Mailing Address: Walter D. Blair, B1-12
Hanford Advisory Board
P.O. Box 1970
Richland, WA 99352

cc: P. W. Kruger A5-54
W. A. Hamilton T3-01

#9

Robert F. Deegan
Sierra Club Virginia Chapter
348 Ramapo Road
Virginia Beach, VA 23462

VIRGINIA CHAPTER
SIERRA CLUB

> "When we try to pick out anything by itself,
> we find it hitched to everything else in the universe."
> *John Muir*

October 9, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, Washington 98314-5001

Re: Draft Environmental Impact Statement (EIS) on the Disposal of Naval Nuclear Reactor Plants

Dear Mr. Gordon:

Thank you for this opportunity to comment on the Navy's August 1995 Draft EIS on the Disposal of Decommissioned, Defueled Naval Reactor Plants. These comments supplement my letter to you of August 17, 1995 to which you replied on Sept. 18, 1995. These comments are on behalf of the 10,000 members of our environmental group throughout Virginia.

1.4 The Draft EIS is manifestly inadequate because it does not address the full scope of environmental impacts of disposal of defueled naval reactor plants. Rather, the Draft EIS improperly seeks to "segment" this environmental problem by only considering the future disposal of certain classes of ships. The Draft EIS must include the reactor compartments of all nuclear ships in existence or planned by the U.S. government. The courts have rejected similar government attempts to "segment" the scope of EIS's. As we urged at the scoping hearing for this EIS, the scope of the EIS must include the reactor plants of all nuclear aircraft carriers, as well as the reactor plants of Seawolf Class and "New Attack" Class submarines. The EIS must also cover the reactor plant of Nuclear Ship Savannah, controlled by the U.S. Maritime Administration.

1.5 The Draft EIS is also inadequate in treating the "Protective Waterborne Storage" alternative as a "no action" alternative. The sites chosen for the protracted waterborne storage of the reactor plants would clearly have environmental impacts from this. The custodians of the ships, and nearby residents and workers, would clearly incur a risk of exposure to radiation. Moreover, the mere presence of the added ships would have environmental impacts.

Robert F. Deegan
Robert F. Deegan
Nuclear Waste Issues Chairman

Robert F. Deegan
Sierra Club Virginia Chapter
348 Ramapo Road
Virginia Beach, VA 23462

#10

Nuclear
Military Monitoring

"...the truth is leaking out."

1995.OCT.10

Mr. John Gordon
PSNS Public Affairs
1400 Farragut Ave., Code 1160
Bremerton, WA 98314-5001

Re: Comments: DEIS on Disposal of Decommissioned, Defueled ... Naval Reactor Plants

John,

This letter provides comments on the DEIS you sent me for comment.

(1) NMM supports the decommissioning and permanent disposal of **all** naval nuclear reactors, and the Preferred Alternative approach is endorsed.

(2) Despite this endorsement of the Navy's overall objective and approach, the DEIS is so seriously flawed, technically as to suggest PSNS likely will not be able to complete the anticipated decommissioning of about 100 naval nuclear reactors without one or more serious nuclear accidents occurring. 1.1

This fundamental criticism notes the history of probabilistic risk assessment regarding nuclear reactors, from the groundbreaking Rasmussen report (WASH-1400, NUREG 75/014) to the 1992 report of the New Zealand Special Committee on Nuclear Propulsion, "The Safety of Nuclear Powered Ships" (ISBN 0-477-001628-6). That era opened with great hope that quantification of nuclear risks would allow reduction of those risks and ended with an emerging realization that quantification reveals a sad curiosity of nuclear reactors: that the overall hazard of nuclear reactor operations (a) is attributable to extremely rare, catastrophic accidents and (b) is unacceptably large. With this realization, reactor operators such as PSNS have retreated to reliance on their generally favorable track records.

From the standpoint of probabilistic risk assessment, this means that PSNS has acquired an *it's-safe-because-there's-been-no-accident* mindset that *invites* a major nuclear accident at the shipyard. The development of this mindset as revealed by the DEIS is surely technically negligent, and it appears to be grossly negligent in the legal sense as well. 1.2

The concern for accidents is obviously one of the greatest concerns for both safety and environmental consequences of the proposed decommissioning and disposal activities. Yet in the DEIS, the only assessment of Hypothetical Accident Conditions (Sec.2.1.5.3) addresses one type of transportation accident. In particular, the decommissioning activities at PSNS are taken as risk free. 2.2

This outlook to risk issues seems to pervade the modern nuclear Navy and PSNS in particular. But history has shown that in an atmosphere of disregard for risks, accident frequencies mushroom. With nuclear reactor and/or weapons activities, this institutionalized disregard for risks leads inexorably to TMI and Chernobyl sorts of occurrences. 1.2

Finally, I notice that after two years of NMM studies proximate to PSNS, the shipyard still does not address criticism of its nuclear attitude and radiological data.

(3) The DEIS is essentially *reactor shield paint* -- what used to be called boiler plate. It is unclear whether the DEIS superficiality serves to deflect public suspicions or is a consequence of ongoing loss of Navy perspective. For example, the second paragraph of the Background (Sec.1) mentions some of the power plant components which are of concern for decommissioning and disposal with special flagging of neutron activation of impurities in the 100+ tons of lead shielding around a reactor. But this flag is disappointing. The description of hazards of elemental lead in Sec.4.2.3 is unrelated, and the curie contents of the reactor vessel internal structures tabulated in Appendix D are not broken out by components. This leaves the reviewer in doubt whether the information is being withheld from the public for some reason or whether the Navy is unaware of the requisite radiological details. If the former is correct, one worries about the Navy's motives for disinformation. If the latter is correct, one worries that the shipyard workers will be exposed to toxic materials, radiation, and hazardous situations because PSNS is technically undiscriminating in technical issues related to safety. 1.3

Such examples abound in the DEIS.

(4) The thrust of Comments (2) and (3) is that the DEIS does not provide an adequate technical basis for the proposed disposal of the decommissioned naval reactor plants. Yet that disposal is endorsed despite the Navy's lack of technical foundation, because the hazards presently posed by naval nuclear reactors and operational naval nuclear weapons are so very much greater.

Any questions or comments are welcome. Please note the change of NMM address.

Sincerely,

N Buske

Norm Buske

#11

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
P.O. Box 47600 • Olympia, Washington 98504-7600 • (206) 407-6000 • TDD Only (Hearing Impaired) (206) 407-6006

October 10, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
1400 Farragut Ave Code 1160
Bremerton WA 98314-5001

Dear Mr. Gordon:

Thank you for the opportunity to comment on the draft environmental impact statement (DEIS) for the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants. The Washington Department of Ecology's Nuclear Waste Program has reviewed the DEIS and offers the following comments. We appreciate the Navy's presentation of the analyses in a compact form.

Ecology recognizes that the preferred alternative is based on nearly ten years experience with pre-Los Angeles class submarine reactor compartments. The Navy has worked with Ecology to comply with hazardous and radioactive waste disposal requirements, and has demonstrated that the disposal can be done without measurable contamination of the environment.

The Navy has also worked with appropriate agencies in both Washington and Oregon to assure safe and uneventful transport of the reactor compartments from Bremerton to Hanford. So long as present procedures for notification, inspection and escort continue, we believe that the transportation risks are acceptable.

The State of Washington believes in shared responsibility among the states. Disposal of naval reactor compartments ought to be considered in the context of disposal of other radioactive and hazardous wastes left over from the Cold War era. Washington citizens will be willing to consider the preferred alternative for reactor compartment disposal on the merits so long as other states accept other nuclear waste disposal burdens. **1.6**

We would recommend that the final EIS provide data that would help the public evaluate a modified waterborne storage ("no action") alternative. Section 4.4 of the Draft EIS does not indicate the decrease in worker and transport exposure that would result from deferring the preferred method of disposal for **4.6**

fifteen years. It may be that this alternative would that significantly reduce worker exposures, exposures in transport, and, therefore, the costs associated with disposal. **4.6**

If you have any questions, please call Mr. Max Power with our Nuclear Waste Program at 360-407-7118.

Sincerely,

Rebecca J. Inman

Rebecca J. Inman
Environmental Review Section

RI:
95-6203

cc: Max Power, Nuc Waste
Geoff Tallent, Nuc Waste

#12

Dakota Creek Industries Inc.
820 Fourth Street P.O. Box 218 Anacortes, Washington 98221
Telephone (360) 293-9575 FAX (360) 293-6432

October 10, 1995

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. John Gordon
Puget Sound Naval Shipyard
1400 Farragut Avenue, Code 1160
Bremerton, WA 98314-5001

Subject: Comments on the Navy's "Draft Environmental Impact Statement (DEIS) on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class and Los Angeles Class Naval Reactor Components" dated August 1995

Dear Mr. Gordon,

We have taken the opportunity to review the subject DEIS and we would like to submit the following comments as a part of the public review process.

Item 1 - Consideration of Private Shipyard Facilities - The preferred alternative expressed in the Navy's Draft Environmental Impact Statement is for removal 100 nuclear submarine and cruiser reactor compartments using facilities at the Government owned and operated Puget Sound Naval Shipyard (PSNS) at Bremerton, WA, with subsequent barge transportation of reactor compartments to the Port of Benton for land burial facilities at the Hanford Nuclear Reservation (HNR). The DEIS, page 2-42, states that the land burial facilities at the Savannah River Site (SRS) are not adequate to support the proposed work and that "the Hanford site is the only site available for land disposal of the entire reactor compartment." It would therefore be inferred that the controlling factor for the reactor compartment disposal program is the access and availability of HNR to support land burial and that PSNS becomes the logical currently nuclear certified facility with drydocking capability to support the disposal work because of its close proximity to HNR. The DEIS does not address alternatives to allow the use of private shipyards in the Puget Sound area or along the Columbia - Willamette Rivers which could be certified to accomplish reactor compartment disposal work. It is requested that the DEIS be revised to establish the criteria which a privately owned shipyard would have to meet in order to become certified for performance of reactor compartment disposal work. 4.1

There are existing shipyard facilities located both on Puget Sound and along the Columbia-Willamette River systems which have the physical capability to support work operations as described in the DEIS. It should be noted that ship repair facilities located along the Columbia and Willamette Rivers have a significant advantage for shipment of reactor compartments because: 4.2

(1) The shipping distance becomes about 250 miles, all within protected waters. This approach eliminates the open ocean transport of the barge shipment which occurs in the shipping lanes of Puget Sound and along the Washington coast. As noted in the DEIS, the potential for a barge shipping accident is directly proportional to the distance shipped. Although the potential for a barge shipping accident is low, shipping from PSNS (a distance of 800 miles from HNR) would have 3.2 time the accident potential as a shipping from a site along the Columbia River with a shipping distance of 250 miles. In actuality, the highest accident potential exists during the open ocean transportation portion of the barge shipment and consequently, the accident potential would be reduced even further than the direct proportioning by distance. 4.2

(2) The DEIS notes that the Navy does not make barge shipments to HNR during the winter months due to the inclement weather off the Washington coast. A site on the Columbia-Willamette river system could be operated year around due to the elimination of the open ocean shipping portion of the travel.

(3) The potential severity of a barge accident is reduced when shipments are made from the Columbia - Willamette river system as compared to shipments from PSNS. As noted in the DEIS, the reactor compartment shipping packages will have a crush depth if about 300 feet; this being the point when the closure bulkheads would fail. During shipments from PSNS, over 70% of the ocean transit is in waters exceeding 300 feet and a barge collision resulting in a sinking would very likely breach the package boundaries, with potential release of radioactivity to the environment and would result in substantial cost to recover the reactor compartment, For shipment from the Columbia-Willamette river systems, the channel depth is maintained at 40 feet to the Portland area and at 14 feet from Portland to the off-loading site at the Port of Benton, consequently, a barge sinking accident on the Columbia River would not result in a breach of the reactor compartment and recovery actions would be considerably less expensive.

Dakota Creek Industries is a complete ship building and ship repair facility located at Anacortes, Washington, approximately 50 miles north of Seattle. Over the past few years, we have made substantial capital investment in our facilities which we believe makes our shipyard a well qualified facility to assist in the Navy's reactor compartment disposal program. Our major facilities include a 306-ft by 75-ft Syncrolift shiplift with a 5,000 ton lifting capacity and a 9,000 ton drydock with a length of 314-ft, with a clear width of 90-ft between wing walls. Our shiplift is certified for use by US Navy ships in accordance Mil Std 1625B, and our drydock is suitable for certification under Mil Std 1625B. The shiplift was constructed in 1987 and did not exist in 1984 when the Navy prepared the FEIS for the reactor compartment removal on the pre-Los Angeles class submarines. We are currently seeking additional drydocking capacity through acquisition of a longer drydock with a capacity of at least 15,000 tons. Additionally, we have pier side and industrial shop facilities which could be effectively used to support the Navy's reactor compartment disposal and ship recycling programs. Our existing and planned facilities in Anacortes have the capacity to perform the following operations for the Navy:

(1) Perform hull recycling work on defueled, decommissioned nuclear submarines which have had their reactor compartments removed; several ships in this status are currently in waterborne storage at Puget Sound Naval Shipyard. These boats could be used to refine hull dismantlement and recycling procedures prior to assignment of a defueled, decommissioned boat for reactor compartment removal. 2.1

4.1 (2) Perform reactor compartment removal on Los Angeles and pre-Los Angeles nuclear submarines, using our shiplift or drydock facilities. Figure 1 shows the general layout of the Dakota Creek facilities. The shiplift can also be used as a waterborne berth for Los Angeles Class submarines for preparatory work such as asbestos removal, making the hull cuts for equipment removal and removal of interferences in way of reactor compartment circumferential hull cuts. At least two pre-Los Angeles or Los angeles Class defueled submarines could be transferred land side for reactor compartment removal and submarine hull recycling. Each reactor compartment would be transferred to a disposal barge and the loaded barge would then be placed into the water using the shiplift. We believe that a level of four reactor compartment removal operations per year could be easily achieved at Dakota Creek Industries, Inc.

(3) With acquisition of increased drydocking capability, Dakota Creek Industries will have the capability to drydock defueled, decommissioned nuclear cruisers and Ohio Class submarines.

Recommendation - There currently exists substantial shipyard capacity in the Puget Sound area and along the Columbia - Willamette River systems to perform work operations on defueled, decommissioned naval nuclear powered ships. The Navy's preferred alternative should be modified to include the technical and administrative requirements which need to be met by private industrial facilities to obtain radiological work certification for performance of reactor compartment removal work on defueled, decommissioned naval ships.

C.1 **Item 2 - Cost Data** - Table C-1, Appendix C, Page C-3, provides a cost projection for accomplishing the reactor compartment disposal operations on cruiser, Ohio and Los Angeles class submarines. The Table footnotes indicate that the "costs are based on actual costs to prepare a pre-Los Angeles class submarine reactor compartment adjusted for the level of effort required for the larger packages." Paragraph 3, Page C-2, indicates that the monetary values are based on 1994 fiscal dollars, but the data does not indicate an average man day rate for the work.

Recommendation: In order to make a comparison more understandable, it is requested that Table C-1 be revised to show the actual cost data for a pre-Los Angeles class submarine and that the table also be revised to show the number of man days of shipyard effort required to accomplish the various phases of work (engineering, management, labor and support services, water removal and packaging) for pre-Los Angeles submarines, cruisers, Ohio and Los Angeles class submarines.

The Navy's reactor compartment disposal program has been a highly successful program and Dakota Creek Industries is very excited about the opportunity to present our capabilities to support this important effort. We are committed to providing high quality, cost effective services in support of the reactor compartment disposal program. At your convenience, we would be happy to arrange a tour of our facilities to provide additional information. Thank you for the opportunity to participate in the public comment portion of the environmental review process.

Sincerely,
Dakota Creek Industries, Inc.

Richard N. Nelson
President

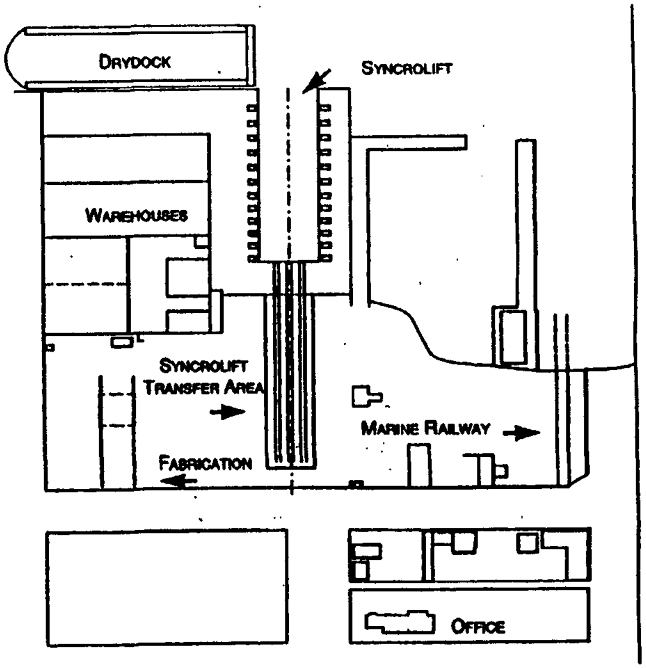

Figure 1 - Shipyard Layout for Dakota Creek Industries, Inc

#13

COMMONWEALTH of VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Peter W. Schmidt
Director

P.O. Box 10009
Richmond, Virginia 23240-0009
(804) 762-4000

October 10, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, Washington 98314-5001

Dear Mr. Gordon:

This is in response to your request for comments on the Draft Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants. The Department of Environmental Quality is responsible for coordinating Virginia's review of federal environmental documents and responding to appropriate federal officials on behalf of the Commonwealth. The Hampton Roads Planning District Commission, the Department of Health's Bureau of Radiological Health and the Department of Environmental Quality's Tidewater Regional Office took part in this review.

The preferred alternative is to continue disposal of these reactor plants at the Department of Energy's Hanford, Washington site. The Commonwealth is in agreement with this option.

The no action alternative involves protective storage of these ships and reactor plants at other facilities, including Norfolk Naval Shipyard in Portsmouth, Virginia. Protective storage at the Norfolk Naval Shipyard appears to be a viable short-term option from an environmental standpoint. However, there is relatively limited areas available for storage of a significant number of decommissioned and defueled ships and reactors.

The Department of Environmental Quality will coordinate the Commonwealth's review and response on the final environmental impact statement for this proposal. Correspondence should be addressed to: Director, Office of Environmental Impact Review,

629 East Main Street, Richmond, Virginia 23219 - Fax (804) 762-4500 - TDD (804) 762-4021

Department of Environmental Quality, P. O. Box 10009, 629 East Main Street, Richmond, Virginia 23240-0009.

Thank you for this opportunity to comment on the draft document. If you need further information, please contact Tom Felvey, (804) 762-4315, of my staff.

Sincerely,

Michael P. Murphy

Michael P. Murphy
Director, Grants Management
and Intergovernmental Affairs

cc: V. Wayne Orton, City of Portsmouth
John M. Carlock, Hampton Roads PDC
Tony R. Watkinson, VMRC
Leslie P. Foldesi, VDH

#14

City of Portsmouth, Virginia
Office of the Mayor
P. O. Box 820
Portsmouth, Virginia 23705-0820
Established 1752
(804)-393 8740

October 9, 1995

Mr. John Gordon
Puget Sound Naval Shipyard
Code 1160
Bremerton, Washington 98314-5001

Dear Mr. Gordon:

Thank you for the opportunity to comment on the Draft Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class and Los Angeles Class Naval Reactor Plants. I simply wish to comment on some presumptions contained in the No Action Alternative. This alternative would involve long term storage of defueled cruisers and later class submarines at the Norfolk Naval Shipyard in Portsmouth.

Initial dredging of 165,000 cubic yards of material would be required, according to the E.I.S. Additionally, maintenance dredging every 15 years would be necessary. This draft document states that this material will be dumped at Craney Island. This City has serious objections to dumping this material at Craney Island. Craney Island is reaching capacity, and the City strongly opposes any proposed expansion. Efforts to force this expansion could be bolstered by this added dredging requirement. 4.3

Further, the storage of these ships, with the associated danger 4.4
of contamination, albeit small, and the associated dredging inure no
economic benefit to the City of Portsmouth. Finally, the draft
E.I.S. notes that our geographic location "does not lie in the 4.5
principal storm tracks" for hurricanes. We have in fact been in the
middle of the expected landfall area several times in recent years.
I request that you clarify our potential for experiencing a hurricane
in the final form of this document.

Thank you again for the opportunity for comment.

Sincerely,

Gloria O. Webb

Gloria O. Webb
Mayor

cc: Members of Council

#15

United States Department of the Interior
OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
500 NE Multnomah Street, Suite 600
Portland, Oregon 97232-2036
IN REPLY REFER TO:

October 16, 1995

ER 95/641

John Gordon
Public Affairs Officer
Puget Sound Naval Shipyard
1400 Farragut Ave., Code 1160
Bremerton, Washington 98314

Dear Mr. Gordon,

The Department of the Interior (Department) has reviewed the Draft Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class and Los Angeles Class Naval Reactor Plants. The Department does not have any comments to offer.

We appreciate the opportunity to comment.

Sincerely,

For Charles S. Polityka
Regional Environmental Officer

#16

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

Reply To
Attn Of: WD-126

December 1, 1995

John Gordon
Public Affairs Officer
Puget Sound Naval Shipyard
1400 Farragut Avenue, Code 1160
Bremerton, WA 98314

Dear Mr. Gordon:

Re: DEIS on Disposal of Decommissioned Naval Reactor Plants

The Environmental Protection Agency has reviewed the draft Environmental Impact Statement (DEIS) on proposed alternatives for disposing of nuclear fuel plants on Ohio Class and Los Angeles Class vessels. Our review was conducted in accordance with the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. Our comments are offered to assist in the preparation of the final EIS.

We have given the DEIS an LO-1 rating (Lack of objections; sufficient information). The major issues of long-term nuclear waste storage are being addressed in Department of Energy documents under NEPA, which we are currently reviewing. We believe that you have adequately and thoroughly addressed the remaining major issues of personnel safety, public safety and transportation in this DEIS. Our potential concerns specific to your document and their resolution are enumerated below.

We support your preferred alternative of permanent storage of entire, defueled and processed, nuclear reactor compartments at the Hanford site. The other alternatives of indefinite storage or subdivision and reuse of components do not seem to be comparable. The latter alternative can be ruled out on estimated costs alone.

The DEIS addressed shielding lead issues (not regulated by EPA under RCRA) according to the Hazardous Waste Management Act, administered by the Washington State Department of Ecology. Appropriate training procedures for personned have been identified. Removal of all materials, including radioactive, will be conducted under the PSNS solid waste minimization program. Worker exposure to lead, asbestos and radioactive materials has been adequately addressed in accordance with OSHA and other federal regulations (Appendix A).

Waterborn transport out of the Sound and straits, on the ocean and on the Columbia River is thoroughly discussed (4-7 through 4-9, and E-9). Appropriate precautions and mitigation measures have been observed. A risk analysis of radiation exposure associated with transportation was conducted.

C.2

The cost analysis of alternatives does not indicate that future values have been discounted to present value, although there is reference to 1994 FY dollars. Since completion of this program will be spread out over 15 to 20 years, time values are an important consideration. The President's Office of Management and Budget (OMB) currently recommends an 8.1% nominal rate for 30 year projects (Circular A-94). Even though the cost estimates are "orders of magnitude" (C-2), it would be helpful to have some further explanation of the treatment of cost over time.

We hope these comments will be useful as you prepare the final EIS. Thank you for working with us during reorganization and other delays to our preparing a timely response. If you have any questions about our comments, please contact Doug Woodfill at (206) 553-4012.

Sincerely,

Richard B. Parkin

Richard B. Parkin, Manager
Geographic Implementation Unit

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EXHIBIT INDEX

3. Responses to Issues from Public Review

This chapter presents responses to 35 issues identified during the public review period for the Draft Environmental Impact Statement (DEIS). These issues were received in letters and in statements made at the public hearings as recorded in Chapter 2. The issues are identified where they appear in Chapter 2 by a sidebar and are given a serial number consisting of a subsection letter and number, such as 1.5 or 4.3, which relates the issue to the subsection of this chapter where the response is provided.

SECTION 1

This Section contains issues related to the Environmental
Impact Statement as a whole, to the Summary and to Chapter 1.

1.1 Summary of Issue

The Draft Environmental Impact Statement is flawed because it does not include a probabilistic assessment for reactor operations, such as the Rasmussen report or the New Zealand report on "The Safety of Nuclear Powered Ships." Such reports have shown that most of the risk from nuclear reactor operations comes from severe accidents, and this risk is unacceptably large.

Those Identifying Issue	Identification Number
Nuclear Military Monitoring - Norm Buske	10

Response

The subject of this Environmental Impact Statement is disposal of defueled reactor plants, that is, reactor plants from which the nuclear fuel has been removed. Therefore, probabilistic risk assessments of operating reactors with nuclear fuel are beyond the scope of this Environmental Impact Statement. It should be noted that the New Zealand report cited by the commenter concluded that "The presence in New Zealand ports of nuclear powered vessels of the navies of the United States and the United Kingdom would be safe. The likelihood of damaging emission or discharge of radioactive material from nuclear powered vessels is so remote that it cannot give rise to any rational apprehension."

1.2 Summary of Issue

The Draft Environmental Impact Statement reveals a mindset at Puget Sound Naval Shipyard that things are safe because there has been no accident. The development of this mindset as revealed by the Draft Environmental Impact Statement is surely technically negligent and it appears to be grossly negligent in the legal sense as well.

Those Identifying Issue	Identification Number
Nuclear Military Monitoring - Norm Buske	10

Response

The commenter offers no specific examples in the Draft Environmental Impact Statement to support his claim of a flawed and negligent mindset. To the contrary, the outstanding radiological safety record at Puget Sound Naval Shipyard, as well as throughout the Naval Nuclear Propulsion Program, derives in a great part from the careful attention to detail and the prevention of problems at their source.

1.3 Summary of Issue

The Draft Environmental Impact Statement is inadequate in its description of the radionuclide content of the lead shielding and the individual components of the reactor vessel internal structure.

Those Identifying Issue	**Identification Number**
Nuclear Military Monitoring - Norm Buske	10

Response

The Draft Environmental Impact Statement included specific radionuclide information in several sections. Section 1.2 described how 99.9% of the radioactivity is an integral part of activated metals, while the remaining 0.1% is radioactive corrosion and wear products deposited on the internal surfaces of piping systems. Table 1.1 provided the radionuclide breakdown for various classes of reactor plants. Appendix D provided a detailed discussion of how the radioactivity content was calculated for the activated structural material. Table D-3 provided a breakdown of the long-lived radionuclide content.

Appendix B discusses the long term performance of the reactor compartment packages in the burial environment, and how even the long-lived radionuclides are greatly limited in their release by the slow process of corrosion. Section 4.3.3.2.1.4 discusses analysis of the radiological significance of long term radionuclide release in the burial ground. Since all of the reactor vessel internal structure is conservatively assumed to be corroding slowly at the same time, the overall radionuclide content of this structure and its corrosion rate determines the release of radioactivity. A more detailed breakdown of components would not provide any additional information on potential environmental impacts.

The neutron activation of trace metals in the lead shielding makes an insignificant contribution to the overall radioactivity content of the reactor compartment package. The fact that such neutron activation occurs was discussed in the Draft Environmental Impact Statement to make clear the point that even if one went to the considerable expense and occupational radiation exposure to remove all of the lead shielding, much of this lead would have to be disposed of as radioactive waste anyway.

1.4 Summary of Issue

The Draft Environmental Impact Statement is inadequate because it "segments" the environmental problem by only considering the disposal of certain classes of ships. The Environmental Impact Statement should include analysis of all nuclear powered aircraft carriers, SEAWOLF Class submarines, the new attack class, and the nuclear ship Savannah.

Those Identifying Issue	**Identification Number**
Sierra Club, Virginia Chapter - Robert F. Deegan	9

Response

As discussed on page S-1, the Draft Environmental Impact Statement included all types of nuclear powered ships which are expected to be decommissioned in the next 20 years. Since the Navy is not faced with a decision on other classes of nuclear powered ships within this time period, there is no need to evaluate them at this time. Neither the Navy nor the Department of Energy is responsible for the nuclear ship Savannah, which is defueled and in floating storage as a museum at Charleston, South Carolina.

1.5 Summary of Issue

The Draft Environmental Impact Statement is inadequate in treating the floating storage alternative as a "no action" alternative. This alternative would clearly have risks and impacts for workers and nearby residents.

Those Identifying Issue	Identification Number
Sierra Club, Virginia Chapter - Robert F. Deegan	9

Response

The Council on Environmental Quality regulations for implementing the National Environmental Policy Act require the evaluation of the environmental impacts of a "no action" alternative. The "no action" alternative does not always result in "no impacts", because failure to take action can result in impacts. The environmental impacts associated with the "no action" waterborne storage alternative were fully discussed in Section 4.4 of the Draft Environmental Impact Statement.

1.6 Summary of Issue

Disposal of reactor compartments ought to be considered in the context of other radioactive and hazardous wastes left over from the Cold War era. Washington citizens will be willing to consider the preferred alternative for reactor compartment disposal on the merits so long as other states accept other nuclear waste disposal burdens.

Those Identifying Issue	Identification Number
Washington Department of Ecology - Rebecca J. Inman	11

Response

The disposal of other nuclear wastes derived from defense activities of the Cold War era is beyond the scope of this Environmental Impact Statement. The Navy notes that this Washington State policy has been stated in the course of negotiations between the States and the Federal Government as part of the Federal Facilities Compliance Act process. Issues of equity among the States have been a key part of the waste treatment and disposal agreements reached as part of this process.

1.7 Summary of Issue

The commenter expressed disappointment about having to "decommission another set of nuclear powered ships" and commented that "With the last environmental impact statement on submarines in which ten reactors were supposed to be decommissioned, we've found that there has been many more reactor cores buried at Hanford." The commenter also expressed concern that "Washington State may be in for more than what this draft statement is telling us."

Those Identifying Issue	**Identification Number**
Pat Herbert	1

Response

The Navy's Final Environmental Impact Statement on the Disposal of Defueled Naval Submarine Reactor Plants issued in May of 1984 stated "The most immediate concern and the action to which this statement is directed is the disposal of the reactor plants from the approximately 100 nuclear submarines that may be decommissioned during the remainder of this century." (USN, 1984a, Chapter 1, para I.A). In addition, Figure 1-1 of that EIS showed that the potential number of decommissioned submarines would be 50 to 85 by 1995.

It must be noted that the proposed action does not involve disposal of reactor cores. The core is the fuel-bearing part of the reactor and would be removed prior to disposal of the reactor compartment.

1.8 Summary of Issue

Contractors are not constrained by the same process controls as Naval Shipyard workers. Will the Environmental Impact Statement still be valid in the event that someone other than Naval Shipyard workers does the work?

Those Identifying Issue	**Identification Number**
Roy Hocker	4, 4a

Response

The Environmental Impact Statement would be valid regardless of whether public employees or private employees performed the work because the same technical requirements would be enforced for all work on Naval nuclear propulsion plants. For a more detailed discussion of these technical requirements, see the response to Issue 4.1.

1.9 Summary of Issue

A large amount of money to build a force of nuclear warships which is too large for the threat and too much money is spent on burials and cleanup.

Those Identifying Issue	**Identification Number**
Pat Herbert	1

Response

The Congress, by law, establishes the national defense structure and the level of spending for defense. This subject is outside the scope of this Environmental Impact Statement. Even though nuclear powered warships represent about forty percent of the Navy's major combatants, the handling and disposal of the resultant radioactive waste, including reactor compartment disposal, is only about 0.1% of the Navy budget (U.S. General Accounting Office report GAO/NSIAD-92-256, "Nuclear-Powered Ships Accounting for Shipyard Costs and Nuclear Waste Disposal Plans").

SECTION 2

This Section contains issues related to the Summary and
Chapter 2 of the Environmental Impact Statement

2.1 Summary of Issue

Private Shipyards in the Puget Sound area could perform recycling of ships from which the reactor compartments already have been removed.

Those Identifying Issue	Identification Number
Dakota Creek Industries Inc. - Richard N. Nelson	12

Response

The Navy has an existing recycling program for the nonradioactive sections of nuclear powered ships for which an Environmental Assessment and Finding of No Significant Impact have been issued. Recycling of nonradioactive ship sections is beyond the scope of this Environmental Impact Statement.

2.2 Summary of Issue

In the Draft Environmental Impact Statement, the only assessment of hypothetical accident conditions is in Section 2.1.5.3 and addresses one type of transportation accident. In particular, the decommissioning activities at PSNS are taken as risk free.

Those Identifying Issue	Identification Number
Nuclear Military Monitoring - Norm Buske	10

Response

The discussion in Section 2.1.5.3 of the Draft Environmental Impact Statement involves the hypothetical accident conditions for which shipping containers of radioactive materials must be designed. These hypothetical accident conditions are quite severe, including a 30 foot drop onto an unyielding surface, a drop onto a steel bar, immersion in a hot fire, and submergence in water. Packages designed to these standards are extremely robust packages.

In addition to discussion of how the reactor compartment packages meet these stringent safety requirements, the Draft Environmental Impact Statement included a discussion of several other potential accident scenarios. Section 7.7 of Appendix E discussed the analysis of potential accidents scenarios for both the barge shipment of reactor compartments as well as truck and rail shipments of subdivided components. This analysis included consideration of accident scenarios even more severe than the package design requirements. Even the extreme case of sinking in deep water where the package would be breached by sea pressure was evaluated in Section 4.3.2.3. Extreme natural phenomena such as catastrophic breach of the Grand Coulee dam were discussed in Section 4.3.3.1.

The severe transportation accidents analyzed represent the worst case condition that this radioactive material might experience. The shipyard preparation work would present less risk of a severe accident since the radioactive material would be handled under controlled conditions, by trained personnel, with onsite emergency response capability, without the element of fast moving vehicles or ships, and at a greater distance from the public than during transportation.

With regard to decommissioning activities at PSNS, this Environmental Impact Statement evaluates the alternatives for the disposal of defueled, decommissioned reactor compartments. That is, the reactor fuel was removed and the ship decommissioned prior to activities covered by this EIS. Defueling nuclear powered ships at PSNS or at any other Navy shipyard licensed to perform nuclear work has been safely conducted for many years. Defuelings have been done to support refuelings as well as decommissionings. All work is done to detailed work procedures and stringent safety practices. Conducting nuclear work in a manner that protects the environment, workers and the general public is among the Navy's highest priorities.

2.3 Summary of Issue

The commenter supports the preferred alternative contingent on oversight by the Department of Energy Richland Office, and the Washington State Department of Ecology.

Those Identifying Issue	Identification Number
Hanford Advisory Board - Walter D. Blair	8

Response

As discussed in Section 2.1.5.4, disposal of the reactor compartment packages is regulated by the Washington State Department of Ecology due to the quantity of permanent lead shielding present. The Department of Energy is a cooperating agency for this Environmental Impact Statement. The Department of Energy Richland Operations Office and the Hanford Site burial grounds contractor would fully participate in the reactor compartment disposal process if the preferred alternative were selected.

2.4 Summary of Issue

Disposition of the non-reactor compartment portions of ships is a significant part of the work that the public should know about.

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

The Navy's, June 1993 Environmental Assessment of the Submarine Recycling Program at Puget Sound Naval Shipyard provides the public with information on the disposition of nonreactor compartment portions of ships. Sections 2.1 and 2.3.2 of the Environmental Impact Statement explain that non-reactor compartment portions of the ships could be dispositioned by recycling.

2.5 Summary of Issue

Permits will be given out by the Department of Ecology on wastes, which if they were anywhere else in the state except Hanford, would not be permitted.

Those Identifying Issue	Identification Number
Pat Herbert	1

Response

The Washington Administrative Code, WAC-173-303 does require that certain types of wastes be disposed of only at Hanford. However, the technical standards for issuance of permits at Hanford are as stringent as for elsewhere in the State.

SECTION 3

This Section contains issues related to the Summary
and Chapter 3 of the Environmental Impact Statement

3.1 Summary of Issue

The Environmental Impact Statement refers to the production of 1,625 cubic meters of mixed waste. The Environmental Impact Statement does not appear to address disposal of these materials. It is evident that Hanford's Low-Level Burial Ground is not appropriate for disposal of these materials. Accordingly, the Environmental Impact Statement must address a site for disposal of these materials and the environmental impacts attendant thereto.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

Most of the 1,625 cubic meters of mixed waste is potassium chromate waste as discussed in sections 2.1, 4.3.3.2.1.6 and 4.5.2. As discussed in section 2.1.1.1, the potassium chromate mixed waste can be readily treated to render it nondangerous, after which it can be disposed of as nondangerous radioactive waste. The Final Environmental Impact Statement has been revised to state that mixed wastes will be managed in accordance with the approved Site Treatment Plan pursuant to the Federal Facilities Compliance Act of 1992.

SECTION 4

This Section contains issues related to the Summary
and Chapter 4 of the Environmental Impact Statement

4.1 Summary of Issue

Private shipyards in the Puget Sound area or along the Columbia River could perform the reactor compartment disposal work envisioned in the preferred alternative. The Draft Environmental Impact Statement should be revised to establish the criteria which a privately owned shipyard would have to meet in order to become certified for performance of reactor compartment disposal work.

Those Identifying Issue	Identification Number
Dakota Creek Industries Inc. - Richard N. Nelson	12

Response

Specific analysis of private shipyard performance of the preferred alternative was not identified by any commenters during the scoping process as a topic to be evaluated in the Environmental Impact Statement.

Any shipyard performing work on Naval nuclear propulsion plants is required to be authorized to perform such work by the Naval Nuclear Propulsion Program, pursuant to the Atomic Energy Act of 1954 as amended. Currently, there are four Naval Shipyards authorized to perform such work and two private shipyards, Newport News Shipbuilding of Newport News, Virginia and the Electric Boat Division in Groton Connecticut. Authorization to perform such work is a long and complex process involving extensive qualification in the areas of nuclear quality control, radiological control, welding, lifting and handling, and the specific features of the nuclear propulsion plants which are serviced in the shipyard. The last time any shipyard undertook the steps to achieve such authorization was in 1967. With the end of the Cold War, the Navy was faced with excess capacity in nuclear capable shipyards. Two nuclear capable Naval Shipyards have been closed in the 1990's through the Base Realignment and Closure Act process, and the workload at the two private shipyards has been reduced significantly. The Navy currently is not pursuing additional nuclear capable shipyard capacity.

If a private shipyard in the Puget Sound area were authorized and available to perform such work, the standards and radiological controls applied to the work would be the same as those employed at Puget Sound Naval Shipyard. The environmental impacts associated with the work, which are quite small as described in the Draft Environmental Impact Statement, would remain essentially unchanged. Therefore, the environmental impacts of this minor proposed variation of the preferred alternative were covered in the Draft Environmental Impact Statement.

4.2 Summary of Issue

A shipyard located on the Columbia River would have a significant advantage over Puget Sound Naval Shipyard. The shipping distance would be closer with less chance of accident. Shipments could be made all winter since winter storms in the ocean would not preclude shipments. The Columbia River channel is maintained at 40 feet deep to Portland and 14 feet deep upriver, so the entire shipment could be made without risk of package rupture in the event of a sinking.

Those Identifying Issue	Identification Number
Dakota Creek Industries Inc. - Richard N. Nelson	12

Response

While the shipping distance from a Columbia River shipyard would be shorter, this does not confer a significant advantage. Risks associated with shipping would be correspondingly smaller for a Columbia River shipyard, but these risks are already extremely small as discussed in Section 4.3.2 of the Draft Environmental Impact Statement. For example, the radiological risk to the public from all 100 shipments was calculated to be 0.000061 latent cancer fatalities for normal conditions and 0.0000929 for accidents. Section 4.3.2.3 discussed how even in the case of the sinking of two nuclear powered submarines in the deep ocean, environmental monitoring of the wreckage sites confirmed negligible impact. The winter shipping restriction has not limited the reactor compartment disposal output of the Puget Sound Naval Shipyard since reactor compartment packages completed in the winter can be stored easily for shipment during the following year.

4.3 Summary of Issue

The City of Portsmouth has serious objections to disposal of dredge spoils at Craney Island. Craney Island is reaching capacity, and the City strongly opposes any proposed expansion.

Those Identifying Issue	Identification Number
City of Portsmouth Virginia - Gloria O. Webb, Mayor	14

Response

Section 4.4. of the Draft Environmental Impact Statement stated that current permits for dredging at Norfolk Naval Shipyard specify Craney Island as the disposal site. The Environmental Impact Statement has been revised to explain that Craney Island receives about 3,500,000 cubic yards of dredge spoils per year from the Hampton Roads area. Based on this annual volume of dredge spoils, it is estimated that the site will not exceed its current capacity until the year 2030. It is also estimated that 165,000 cubic yards of dredge spoils would be produced over a 15 year period in support of the no action alternative. This would constitute less than 1/3 of 1% of the 52,500,000 cubic yards (3,500,000 cubic yards per year multiplied by 15 years) of dredge spoils that are expected to come from the Hampton Roads area during the same time period.

With regard to the indefinite storage option, the major point of this discussion in Section 4.4 is that the amount of dredging related to storage is small compared to overall dredging activity at Norfolk Naval Shipyard, and this small amount of dredge spoil could be disposed of in the same manner as the other shipyard dredge spoil.

4.4 Summary of Issue

Storage of ships would bring no economic benefit to the City of Portsmouth.

Those Identifying Issue	Identification Number
City of Portsmouth Virginia - Gloria O. Webb, Mayor	14

Response

This comment is consistent with Section 4.4.1 of the Draft Environmental Impact Statement, which stated that the storage alternative would result in no socioeconomic impact at Norfolk Naval Shipyard.

4.5 Summary of Issue

The Draft Environmental Impact Statement states that Norfolk Naval Shipyard "does not lie in the principal storm tracks' for hurricanes." In fact, Portsmouth has been in the middle of the expected landfall area several times in recent years.

Those Identifying Issue	Identification Number
City of Portsmouth Virginia - Gloria O. Webb, Mayor	14

Response

The quoted statement appeared in Section 4.4.2 of the Draft Environmental Impact Statement, which discusses the consequences of extreme weather for the waterborne storage alternative. A more complete description of the hurricane risk appeared in Section 3.2.2. The latter section noted that hurricanes can and do strike in the Portsmouth area, but they often veer away to sea. It also noted that the Shipyard's location protects it from buildup of large waves, and that the key threat posed by hurricanes at Norfolk Naval Shipyard is high water due to storm surge. The final Environmental Impact Statement has been revised to include more of this discussion in Section 4.4.2 and to exclude the statement concerning principal storm tracks.

4.6 Summary of Issue

The Final Environmental Impact Statement should provide data on an alternative where the preferred alternative of reactor compartment disposal is deferred for 15 years. It may be that this alternative would significantly reduce worker exposures, exposures in transit, and therefore the costs associated with disposal.

Those Identifying Issue	Identification Number
Washington Department of Ecology - Rebecca J. Inman	11

Response

From Table C-3, Appendix C, the total estimated exposure for the preferred alternative is 1,508 Rem. The majority of that exposure is a result of water removal which is accomplished during the inactivation phase. Water removal would also be done in preparation of the defueled, decommissioned submarines or cruisers for waterborne storage. Delaying reactor compartment disposal operations would reduce exposure by about 25% compared to immediate disposal operations.

From Table C-2, Appendix C, the cost to keep the ships covered by this EIS in protected waterborne storage for 15 years is about $143 million. This cost would subtract from any savings realized from the reduced exposure due to a 15 year delay in disposal operations. An important factor in reducing Shipyard operational expenses is through the efficient use of Shipyard resources, facilities and labor forces. This can best be accomplished (or achieved) by allowing as much flexibility in work scheduling as possible. The 15 year waterborne storage would (or could) be counter productive to the most efficient uses of Shipyard assets which would result in additional expenses to the disposal operations.

4.7 Summary of Issue

The numerous inactivated ships moored on the waterfront of Puget Sound Naval Shipyard are a concern. How is the integrity of these older vessels being maintained? How are they going to continue to be maintained there?

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

Section 2.2 on page 2-29 provides a description of the basic measures necessary to keep decommissioned defueled nuclear powered vessels in waterborne storage. This section discusses the conclusion given in the 1984 Final Environmental Impact Statement that protective waterborne storage could safely be done. The defueled submarines currently in waterborne storage at Puget Sound Naval are safely stored as described in both EIS documents.

4.8 Summary of Issue

The recycling part of the work is hurting workers. Emissions from arc welding processes over lead canning and ballast tanks and using torches to cut through copper anti-fouling paint are concerns. A toxic Release Information Summary Report, by the State Department of Ecology, does not contain one single entry for the entire county, but airborne and waterborne emissions are being created.

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

The Navy currently maintains and will continue to maintain comprehensive environmental and occupational, safety and health programs. Under those programs Puget Sound Naval Shipyard has conducted industrial hygiene sampling for work on cutting through hull sections coated with paint that contains a high percentage of copper. Air samples taken in the worker's breathing zone show levels of copper to be well below the permissible limit established by the Occupational Safety and Health Administration. Workers at any distance from the actual burning operation would receive an even lower exposure. In addition, welders wear respiratory protection during the cutting operation, which effectively reduces their exposure.

4.9 Summary of Issue

Material safety data sheets are not readily available for boats being worked on. Some Material Safety Data Sheets address how exposure to the material may increase the risk of birth defects. This information is of particular concern to pregnant workers.

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

This issue concerns the integrity of day-to-day operation of Puget Sound Naval Shipyard's occupational safety and health program. The program is comprehensive and covers thousands of workers involved in most every conceivable industrial task. It is to be expected that periodically a worker with legitimate concerns about exposure to hazardous substances will question an aspect of the program, therefore processes exist within the program for resolving issues such as the one raised by the commenter. Should any pregnant employee have any questions about her working environment, whether Material Safety Data Sheet related or not, she is trained and encouraged to raise those questions with her chain of command, or directly with the Shipyard's Environmental, Safety and Health Office.

Material Safety Data Sheets are not required for articles, which are manufactured items and may be fabricated from one or more different materials. Material Safety Data sheets fall under the hazard communication regulation set forth in 29 CFR 1910.1200. The purpose of the regulation is to ensure that hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. Under the regulation, articles are exempted from the requirements of the hazardous communication program and do not require Material Safety Data Sheets. For example, because a submarine or ship hull arrives in the shipyard in its final form, it is considered an article per 29 CFR 1910.1200. Hull surface coatings are considered intrinsic to the hull design and therefore also fall under the definition of an article and do not require a Material Safety Data Sheet.

Employees need to be protected from hazards associated with the work that they do, such as flame-cutting of painted metal articles, even though Material Safety Data Sheets are not required for the articles being cut. The keys to protecting them in such situations are training, material sampling, work area monitoring and personnel protective equipment. These are thoroughly addressed by the Shipyard's occupational safety and health program.

4.10 Summary of Issue

Some of the profits from recycling of nonradioactive sections of ships should be invested in process improvements for the shipyard workers and environment.

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

Although the Shipyard sells the nonradioactive materials from the ship recycling program, this program operates at a net loss for the Navy. The funds received from the sale of recycled materials are not sufficient to pay the costs of the Shipyard recycling effort. The Federal Government supports this program in order to ensure that the ships are recycled safely and responsibly. As discussed in the responses to Issues 4.8 and 4.9, this work is being conducted safely.

4.11 Summary of Issue

The Environmental Impact Statement should clarify statements about how much radioactivity is removed by defueling and how much remains in the defueled reactor compartment.

Those Identifying Issue	Identification Number
Henrik Langhjelm	3

Response

All (100%) of the fuel would be removed prior to disposal of the reactor compartment as explained in Section 1.1. Section 1.2 of the statement explains that 99.9 percent of the radioactive material that remains is an integral part of the solid metal structural alloys forming the plant components and that the other 0.1 percent remaining is radioactive corrosion and wear products deposited on piping system internals.

4.12 Summary of Issue

The fact that the Shipyard denies public access in the Restricted Area along the Shipyard waterfront suggests that the Navy is unwilling to allow objective scrutiny of the environmental impacts of decommissioning and transportation operations in Puget Sound.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

Since Puget Sound Naval Shipyard is a defense installation, public access to the Shipyard and the waters along the Shipyard waterfront is restricted. Nevertheless, the Navy consistently has invited independent environmental sampling by State and Federal officials, such as in the case of the 1994 and 1995 joint sampling with the Washington Department of Health and the

U.S. Environmental Protection Agency. The results of such monitoring have been published. In addition, the U.S. Environmental Protection Agency's "Radiological Surveys of Naval Facilities on Puget Sound" (EPA 520/5-88-016) reports the results of independent sampling performed in 1987. Representatives of Washington and Oregon routinely survey reactor compartment packages prior to shipment.

4.13 Summary of Issue

The reactor compartments contain lead and PCB-laden materials. Although deemed a low-level burial ground, the area slated for disposal is, in effect, a system of large trenches with minimal protections against leaching and contaminants. It is imperative that the EIS address the potential environmental impacts of these materials in the absence of institutional controls. These materials must be subject to regulation under the Washington State Dangerous Waste Regulations to minimize the effect of disposal of these materials.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

It is inaccurate to describe the reactor compartment disposal site as a trench with minimal protections against leaching contaminants. As discussed in section 4.3.3.2.1.1 of the Draft Environmental Impact Statement, the Hanford Low-Level Burial Grounds will have a protective cover installed to minimize water intrusion. As discussed in section 4.3.3.2.1.1 and Appendix B, the corrosion resistance provided by the thick steel reactor compartment package will prevent any leaching of contaminants for many hundreds of years, far longer than the regulatory requirements (30 years) for hazardous waste disposal trench liners and covers.

Nevertheless, the evaluation of migration of both radioactive and nonradioactive contaminants in the sections 4.3.3.2 and 4.3.3.3 takes no credit for the protective cover. Furthermore, the long term analysis in Appendix B assumes the absence of institutional controls.

As stated in section 1.2, reactor compartment disposal would be regulated by the Washington Department of Ecology under the Washington State dangerous waste regulations because of the lead shielding and by the U.S. Environmental Protection Agency for the small quantity of polychlorinated biphenyls (PCBs).

4.14 Summary of Issue

The Navy has recently instructed the Department of Energy to bar public and press viewing of burial grounds containing naval reactor compartments during U.S. Department of Energy tours of the Hanford Nuclear Reservation. By this action, the Navy is implicitly stating that it is unwilling to open its disposal practices to public scrutiny. This is objectionable. The public should not be barred from seeing these practices.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

Beginning with the first defueled reactor compartment disposal at Hanford in 1986, security of the low level waste burial grounds area established and enforced by the DOE did not allow public access to the trench. After DOE began to relax security requirements at the low level waste burial grounds and allow escorted public tours, the Navy requested that the Department of Energy limit access to the reactor compartment trench area to persons with regulatory responsibilities, such as personnel from the Washington State Department of Ecology or the U.S. Environmental Protection Agency. This provided consistency with Navy security practices that remained in effect at facilities involved in submarine activities. This practice did not prevent the public from receiving technical information regarding reactor compartment disposal.

The comment that the Navy is unwilling to subject its disposal practices to public scrutiny is incorrect. Examples of the extensive technical information which has been made available to the public regarding this project include: the 1984 Environmental Impact statement on the disposal of reactor plants from pre-LOS ANGELES class submarines; permitting documents for the disposal trench; and various studies. This information was placed in public libraries in Bremerton, Richland, Seattle, and Portland. In addition, the U.S. Navy publication, "US Naval Nuclear Powered Submarine Inactivation, Disposal, and Recycling" provides more detailed information about the reactor compartment disposal program. Further, this Environmental Impact Statement fully describes the reactor compartment disposal process, including a site map (Figure 2.8), a photograph of the reactor compartment disposal trench (Figure 2.11), conceptual diagrams of expanded trench capacity (Figures 2.10 and 2.12), and an extensive technical evaluation of the potential environmental impact (Chapter 4).

In summary, the information readily available to the public, fully describes the reactor compartment burial process.

4.15 Summary of Issue

The Navy should minimize its use of Hanford lands for disposal of Naval reactor plants. The public does not consider Hanford a sacrifice zone and objects to the continual use of large areas of Hanford for Navy and Department of Energy waste disposal. Moreover, the cost of Hanford lands should be included in any analysis of the fiscal cost.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

The Final Environmental Impact Statement has been revised to include discussion of a trench arrangement where the reactor compartments are placed closer together than the current arrangement. Such an arrangement appears to be feasible, and would eliminate the need to expand the trench or dig an adjacent trench.

The Federal Government has owned the land at the Hanford Site for over 50 years. Therefore, it is difficult to put an accurate monetary price on the value of the land. The highest prices for privately owned land in the Richland area are approximately $75,000 per acre for prime riverfront property that has been developed for residential use. Even with this high land value, the land cost would be less than 0.05 percent of the total project cost for the preferred alternative.

4.16 Summary of Issue

The production of mixed waste should be minimized and materials recycled where possible. The Environmental Impact Statement should consider inclusion of recyclable materials within the proposed United States Department of Energy Program policy, known as Recycle 2000.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6, 6a

Response

The Draft Environmental Impact Statement discusses recycling of radioactive materials. Section 2.1.1.1 discusses reuse of radioactive potassium chromate solutions. Such solutions are recycled in the construction of new submarines. This reduces the generation of mixed wastes. Section 2.3.2 explains that much of the radioactive metal that would be generated with the subdivision alternative would be recycled using already existing private industry foundry technology. This section also notes that the Navy already recycles radioactive metals by this method. The Department of Energy Recycle 2000 initiative envisions recycling of radioactive metals into radioactive waste containers. If implemented by DOE, this program would provide another metal recycling option for the Navy in addition to the existing private industry foundry prosess.

4.17 Summary of Issue

The calculated times for transport of contaminants from the burial ground are disturbing. The Environmental Impact Statement should consider them more fully. The calculations might be based on United States Department of Energy calculations which have been shown to be erroneous, especially for tritium.

Those Identifying Issue	Identification Number
Heart of America Northwest - Cynthia Sarthou	6

Response

The corrosion and transport evaluation in the Draft Environmental Impact Statement is the result of work of several organizations, including not only the Department of Energy, but the Battelle Pacific Northwest National Laboratory, the Naval Civil Engineering Laboratory, the Naval Facilities Engineering Laboratory, the National Institute of Standards and Technology, and Puget Sound Naval Shipyard. The contribution of each organization is identified in the Draft Environmental Impact Statement.

The migration analysis for elements such as lead and nickel differs greatly from the tritium migration example cited by the commenter. Tritium is in the chemical form of water, and it migrates readily wherever water migrates in the environment. Migration of metallic oxides is greatly retarded by soil and arid conditions. This results in the extremely long migration times discussed in the Draft Environmental Impact Statement.

4.18 Summary of Issue

The reactor compartment disposal at Hanford contributes to the perception of Hanford as the nuclear waste site capitol of the world. This makes it difficult to recruit new businesses and diversify the local economy. The Navy should help the Tri-Cities mitigate this perception and help demonstrate to industrial recruitment clients, potential tourists, and agricultural customers that there are no demonstrable human health and safety effects as a result of the reactor compartment disposal.

Those Identifying Issue	Identification Number
Tri-City Industrial Development Council - Dave Dillman	7, 7a

As discussed in sections 4.3 and 4.8.1 of the Draft Environmental Impact Statement, the socioeconomic and environmental impacts on the region from shipment of reactor compartments to the Hanford Site would be insignificant and therefore would not warrant mitigation. As part of the Environmental Impact Statement process, the Navy is going to considerable expense and effort to produce a credible and understandable analysis of the very small environmental impacts associated with reactor compartment disposal at Hanford. The Navy has made this analysis available to the public by widely distributing the Environmental Impact Statement to private citizens and groups, advertising its availability in newspapers, holding four public meetings throughout the state, and notifying elected public officials.

SECTION C

This Section contains issues related to the Summary
and Appendix C of the Environmental Impact Statement

C.1 Summary of Issue

In order to make a comparison more understandable, Table C-1 should be revised to show the actual cost data for a pre-LOS ANGELES Class submarine and to show the number of mandays of shipyard effort needed to accomplish the various phases of work.

Those Identifying Issue	Identification Number
Dakota Creek Industries Inc. - Richard N. Nelson.	12

Response

Appendix C summarizes the monetary costs as well as the radiological exposure costs of the alternatives in a format suitable for comparison. Dollars, as opposed to man-days, were used throughout Appendix C because dollars are considered most meaningful to most people for comparing monetary costs. The complexities of the Naval Shipyard financial and accounting systems would have to be explained in detail in order to make manday information meaningful to the public. The cost to dispose of a LOS ANGELES Class reactor compartment was considered to be the same as the actual cost of the most common pre-LOS ANGELES Class reactor compartments due to similarity in size and plant configuration. The footnote to Table C-1 has been revised to clarify this point.

C.2 Summary of Issue

The cost analysis of alternatives does not indicate that future values have been discounted to present value, although there is reference to 1994 FY dollars. Since completion of this program will be spread out over 15 to 20 years, time values are an important consideration. The President's Office of Management and Budget (OMB) currently recommends an 8.1% nominal rate for 30 year projects (Circular A-94). Even though the cost estimates are "orders of magnitude" (C-2), it would be helpful to have some further explanation of the treatment of cost over time.

Those Identifying Issue	Identification Number
United States Environmental Protection Agency - Richard B. Parkin.	16

Response

The purpose of including cost information in the Environmental Impact Statement is to provide the opportunity to compare various options on the same cost-type basis. Although not clearly stated in the Draft Environmental Impact Statement, all costs were expressed in constant (FY 1994) dollars. The Environmental Impact Statement has been revised to state clearly that all costs are provided in constant dollars.

The constant dollar costs were calculated by determining the cost of accomplishment in 1994. In the past, the cost of working with radioactive waste has increased much faster than the OMB established nominal rates. Due to the uncertainty of these primary cost drivers, the Navy did not forecast future values and then discount the costs to constant dollars, but took a more direct approach by applying FY 1994 estimates for all anticipated work. This method provides the constant dollar cost estimates required in capital budgeting and is considered by the Navy to be a more accurate and valid cost comparison procedure in this instance.

However, for comparison purposes, the Navy has modified the Environmental Impact Statement to include footnotes that provide total program costs discounted to present value using the Office of Management and Budget 30-year real discount rate of 4.9% per year. The "real" discount rate of 4.9% was used rather than the "nominal" rate of 8.1% since the future costs were already expressed in FY 1994 dollars rather than in future nominal dollars.