ALTERNATIVES FOR DECOMMISSIONING THE SURPLUS PRODUCTION REACTORS AT HANFORD

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ABSTRACT

Alternatives for decommissioning eight surplus plutonium production reactors owned by the U.S. Department of Energy (DOE) at the DOE's Hanford Site were analyzed in a draft environmental impact statement published by DOE in March 1989. The alternatives include no action, immediate one-piece removal, safe storage followed by deferred one-piece removal, safe storage followed by deferred dismantlement, and in situ decommissioning. The environmental impacts of decommissioning by any alternative are not great, the most significant impact being worker exposure to radioactivity. This impact (for all eight reactors) is approximately equal to the annual worker dose at a large commercial nuclear power plant. Uncertainty as to the applicability to decommissioning of the Resource Conservation and Recovery Act and/or the Comprehensive Environmental Response, Liability, and Compensation Act may become an issue in the implementation of decommissioning.

INTRODUCTION

Eight water-cooled, graphite-moderated plutonium production reactors were constructed and operated by the U.S. government along the Columbia River at the Hanford Site near Richland, Washington between 1943 and 1971. These reactors are now retired from service and are available for decommissioning. A ninth reactor, the N Reactor, was constructed and operated between 1959 and 1988, but is not now available for decommissioning. In March 1989, the U.S. Department of Energy (DOE) published a draft environmental impact statement (EIS) on the decommissioning of the retired reactors.(1) Information from the draft EIS is presented in this paper.

All eight retired reactors are similar in design, construction, and radiological condition, except that the two newer reactors differ from the others in the number, size, and types of process tubes; the size of the moderator (graphite) stack; and the type of reactor block shielding. The differences are not significant for decommissioning purposes. A typical reactor block consists of a graphite moderator stack encased in a thermal shield, surrounded by a biological shield. The entire block rests on a massive concrete base and foundation. Each older reactor block assembly (graphite stack, thermal shield, biological shield, and base) weighs approximately 8,100 tonnes, and has overall dimensions of 14 meters wide, 12 meters deep, and 14 meters high. The two newer reactor block assemblies are larger than the older reactor block assemblies and weigh approximately 11,000 tonnes each. Inventories have been estimated for the surplus production reactors. Radionuclides of primary interest (described in terms of their half-lives and total curie amounts in all eight reactors as of March 1985) are tritium (12.3 years; 98,100 curies), carbon-14 (5,730 years; 37,400 curies), chlorine-36 (300,000 years; 270 curies), cobalt-60 (5.3 years; 74,400 curies), cesium-137 (30.2 years; 267 curies), and uranium-238 (4.5 billion years; 0.013 curies). Cobalt-60 and cesium-137 are of importance because they contribute to the dose received by decommissioning workers. Carbon-14, chlorine-36, and uranium-238 are of importance because of their contribution to long-term individual and population doses. Tritium is not of particular importance either with respect to worker doses or to public doses, but is mentioned here because it is present in large amounts. In addition to radionuclides, irradiated lead (Pb) is present in the thermal shields (653 tonnes in all eight reactors). Lead, as a waste, is considered to be a hazardous waste under provisions of the Resource Conservation and Recovery Act.

DECOMMISSIONING ALTERNATIVES

The decommissioning alternatives evaluated in the draft EIS are no action, immediate one-piece removal, safe storage followed by deferred one-piece removal, safe storage followed by deferred dismantlement, and in situ decommissioning. Except for the no action alternative, a protective barrier will be included as part of the disposal technology. The protective barrier is an engineered barrier constructed for the purpose of limiting the transport of water through the barrier to the waste form. The barrier consists of a fine-grained soil at its surface which acts as a capillary medium. Beneath the fine-grained soil is a layer of clay or rocks, either of which forms a capillary barrier. The purpose of the capillary medium is to hold water from rain or snow until the water can be evaporated or taken up by plant roots and transpired to the atmosphere. Annual rainfall at Hanford is approximately 16 centimeters per year. Engineering studies indicate that the barrier will limit transport of water through the barrier to 0.1 centimeter per year. The long-term impacts from lead and radionuclides discussed in the next section are based on an infiltration rate of 0.1 centimeter per year, except for the no action impacts

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which are based on an infiltration rate of 16 centimeters per year. The alternatives are summarized below.

No Action

Evaluation of the impacts of no action is required by the regulations of the Council on Environmental Quality relating to the preparation of an EIS. For the purpose of this EIS, no action means to leave each reactor in its present location in the Hanford 100 Area and to continue the routine surveillance, monitoring, and maintenance activities that now take place. These activities are the same as those required during the safe-storage period of deferred decommissioning.

Immediate One-Piece Removal

Immediate one-piece removal means to transport each reactor block intact on a tractor-transporter from its present location in the Hanford 100 Area to the Hanford 200-West Area (about 8 kilometers from the Columbia River) for disposal under a protective barrier. Engineering studies have determined that the reactor blocks could be safely removed and transported in this fashion. Other contaminated portions of the facility would be removed by conventional means and transported to the 200-West Area for disposal beneath a protective barrier.

Safe Storage Followed by Deferred One-Piece Removal

Safe storage followed by deferred one-piece removal means a multidecade safe storage period during which surveillance, monitoring, and maintenance are continued as at present, followed by the transport of each reactor block intact on a tractor-transporter from its present location in the 100 Area to the 200-West Area for disposal under a protective barrier. As in immediate one-piece removal, other contaminated portions of the facility would be removed by conventional means for disposal in the 200-West Area along with the reactor blocks.

Safe Storage Followed by Deferred Dismantlement

Safe storage followed by deferred dismantlement means a multidecade safe-storage period during which surveillance, monitoring, and maintenance are continued as at present, followed by piece-by-piece dismantlement of each reactor and transport of radioactive waste to the 200-West Area for disposal under a protective barrier.

In Situ Decommissioning

In situ decommissioning means to remove each reactor building leaving the reactor block in pace and to cover the reactor block with a grout, gravel, and dirt mound and with a protective barrier.

Preferred Alternative

The DOE did not select a preferred alternative in the draft EIS, but will do so in the final EIS.

DECOMMISSIONING COSTS AND ENVIRONMENTAL IMPACTS

Estimated decommissioning costs and environmental impacts are presented in Table I. The costs were estimated in 1986 dollars for an assumed institutional control period of 100 years. The safe storage period was assumed to be 75

TABLE I
COMPARISON OF ALTERNATIVES(a)

Alternative	Total Cost (millions of 1986 $)	Occupational Radiation Dose (person-rem)	Population Dose over 10,000 yr(b) (person-rem)
No Action	41	24	50,000
Immediate one-piece removal	191	159	1,900
Safe storage followed by deferred one-piece removal	198	51	1,900
Safe storage followed by deferred dismantlement	217	532	1,900
In situ decommissioning	181	33	4,700

(a) Quantities are for all eight reactors. Costs are for 100 years.
(b) The same population would receive 9 billion person-rem over 10,000 years from natural radiation.

years. Occupational doses were estimated for the time period during actual decommissioning operations (including safe storage), and population doses were estimated for 10,000 years. Occupational doses arise from direct exposure to radiation. Population doses arise from long-term migration of the waste form into ground water and the Columbia River and subsequent transport to humans.

The decommissioning costs, except for no action, include the costs of well monitoring systems to meet the requirements of RCRA with respect to lead. Without well monitoring, in situ decommissioning would cost $85.7 million and would still be the least expensive alternative. The larger cost of safe storage followed by deferred dismantlement is caused mainly by the necessity to dismantle the reactors piece by piece.

The estimated occupational radiation doses (for all eight reactors) are similar to the annual dose to operation and maintenance workers at a large commercial nuclear power plant in the United States today. The largest estimated occupational dose is 532 person-rem (less than one health effect) for safe storage followed by deferred dismantlement. There are no health impacts to the workers from lead in any alternative.

The estimated population doses are small in comparison with doses from background radiation to the same population over the same time period. The estimated population doses depend on the rate of release of radionuclides from the waste form, on the rate of transport of the radionuclides vertically downward through the vadose zone, on the rate of transport of the radionuclides horizontally in the ground water to the Columbia River, and then on the rate of transfer through the biosphere to humans. The estimated population dose over 10,000 years from no action is 50,000 person-rem (less than 50 health effects); from in situ disposal in the 100 Area is 4,700 person-rem (less than 5 health effects); and from disposal by each of the other alternatives in the 200 Area is 1,900 person-rem (less than 2 health effects). The population doses result mainly from carbon-14 and chlorine-36 leached from the graphite. The doses differ because the travel time from the 200 Area to the Columbia River is longer than from the 100 Area (greater decay time), and because a larger amount of water reaches the waste form in the no action alternative. The estimated dose to the same population from natural radiation over 10,000 years is 9 billion person-rem (as many as 9 million health effects). The concentration of lead in the Columbia River from any alternative is estimated to be below the U.S. Environmental Protection Agency's (EPA) drinking water standard.

REGULATORY ISSUES

Final decommissioning of the surplus production reactors at Hanford may be subject to overlapping regulations and to overlapping regulatory authority. For example, the presence of radionuclides may invoke application of the EPA's low-level radioactive waste disposal regulations in 40 CFR 193. EPA has published an advance notice of proposed rulemaking for these regulations, but has not yet published a draft copy of the regulations for public review. Also, the presence of radionuclides may invoke application of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Hanford Site was placed on the CERCLA National Priorities List (NPL) on November 3, 1989. Further, the presence of lead may invoke the application of CERCLA and/or the Resource Conservation and Recovery Act (RCRA). EPA administers CERCLA, but has delegated much of its RCRA regulatory authority to the Washington State Department of Ecology (WDOE). DOE is responsible under these regulations as the owner of the Site.

While it is clear that the possibility exists for overlapping regulation of final decommissioning of the surplus production reactors, it is also a fact that a mechanism exists for the resolution of regulatory issues. The mechanism is the Hanford Federal Facility Agreement and Consent Order (the Tri-Party Agreement) which was signed on May 15, 1989, by the DOE, the EPA, and the WDOE in anticipation of the Hanford Site being placed on the NPL. The Tri-Party Agreement provides the necessary legal agreement, action plan, and milestones for the characterization and remediation of active and inactive waste sites at Hanford under either CERCLA or RCRA, and provides for the permitting of active waste sites under RCRA. And although decommissioning itself may not become part of the Tri-Party Agreement, the treatment, storage, and disposal of hazardous wastes generated from decommissioning activities are subject to the agreement. Thus, the interested federal and state regulatory agencies are brought together under the Tri-Party Agreement. These agencies have both the decision-making information in hand from the EIS and the cooperative framework in place to resolve the issues and to ensure that decommissioning is accomplished in a sound and efficient manner.

REFERENCES

1. Draft Environmental Impact Statement, Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, U.S. Department of Energy, DOE/EIS-0119D, March 1989.