DOE/ID-11426
Revision 0

# Action Memorandum for the EBR-II Final End State

April 2010

DOE/ID-11426
Revision 0
Project No. 23415

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April 2010

Prepared for the
U.S. Department of Energy
DOE Idaho Operations Office

Signature sheet for the Action Memorandum covering the EBR-II reactor and reactor building decommissioning activities at the U.S. Department of Energy's Idaho National Laboratory. This action is conducted by the U.S. Department of Energy with the concurrence of the U.S. Environmental Protection Agency and the Idaho Department of Environmental Quality.

Richard B. Provencher
Deputy Manager
U.S. Department of Energy Idaho Operations Office

Date 4/30/2010

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4/29/10
Date

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Daryl F. Koch

04-30-2010

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# ABSTRACT

This Action Memorandum documents the selected alternative for decommissioning of the Experimental Breeder Reactor II reactor building and reactor vessel at the Idaho National Laboratory Site under the Idaho Cleanup Project. Since the missions of the Experimental Breeder Reactor II have been completed, an engineering evaluation/cost analysis that evaluated alternatives to accomplish the decommissioning of the Experimental Breeder Reactor II reactor and reactor building was prepared and released for public comment. Comments received from the public have been considered and responses have been documented in this Action Memorandum.

The selected removal action alternative includes grouting the reactor vessel in place and removal of the reactor building. A concrete cover will be constructed over the Experimental Breeder Reactor II site and institutional controls will be maintained.

# EXECUTIVE SUMMARY

This Action Memorandum documents the selected alternative for the final end state of the Experimental Breeder Reactor II (EBR-II) reactor and reactor building. Preparation of this Action Memorandum has been performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.), as amended by the "Superfund Amendments and Reauthorization Act of 1986 (SARA)" (Public Law 99-499), and in accordance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300). This action is consistent with the joint U.S. Department of Energy and U.S. Environmental Protection Agency *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act* (DOE and EPA 1995), which establishes the CERCLA non-time-critical removal action process as an approach for decommissioning. This approach satisfies environmental review requirements and provides for stakeholder involvement, while also providing a framework for selecting the decommissioning alternative. An Administrative Record has been established to record information used to support the selected alternative as well as provide documentation of decisions and the progress of the removal action.

Actual or threatened release of hazardous substances from EBR-II, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health or welfare or the environment. As the EBR-II reactor and building continue to age, the threat of substantial release of radiological and hazardous substances increases with time, and containing these materials and preventing them from being released to the environment becomes more difficult.

This Action Memorandum documents the selected removal action alternative as the result of the *Engineering Evaluation/Cost Analysis for the EBR-II Final End State* (DOE-ID 2010). Four alternatives were evaluated in the Engineering Evaluation/Cost Analysis. Alternative 3, "Grouting the EBR-II Reactor Vessel in Place," was recommended and, ultimately, became the selected alternative subsequent to Agency reviews and public participation. Under Alternative 3, systems and structures above the reactor building floor will be demolished and most of the remaining systems and structures below floor level, including the EBR-II reactor vessel, will be grouted in place. The end state of EBR-II under Alternative 3 will be a concrete/grout monolith that extends approximately 8 ft above ground level.

The selected alternative is effective in that it is protective of human health by meeting the proposed removal action objectives regarding long-term risk and protective of worker safety while being compliant with applicable or relevant and appropriate requirements. Alternative 3 is also easily implemented and is cost-effective by reducing surveillance and maintenance costs on legacy Department of Energy buildings and structures.

# CONTENTS

ABSTRACT ..... ix
EXECUTIVE SUMMARY ..... xi
ACRONYMS ..... xv
1. PURPOSE ..... 1
2. SITE CONDITIONS AND BACKGROUND ..... 1
2.1 Idaho National Laboratory Site and Idaho Cleanup Project ..... 1
2.1.1 Materials and Fuels Complex History ..... 2
2.1.2 EBR-II Location ..... 2
2.1.3 EBR-II History ..... 4
2.1.4 EBR-II Systems and Component Descriptions ..... 5
2.1.5 Reactor Vessel and Neutron Shield Description ..... 7
2.2 Other Closure and Cleanup Activities at MFC ..... 12
2.2.1 CERCLA Activities at MFC ..... 12
2.2.2 Other Non-Time-Critical Removal Action Activities at MFC ..... 12
2.2.3 Other Regulatory Actions ..... 12
3. EBR-II RADIOLOGICAL AND NONRADIOLOGICAL INVENTORIES ..... 13
3.1 Radiological Inventory ..... 13
3.1.1 EBR-II Radiological Conditions ..... 14
3.2 EBR-II Nonradiological Inventory ..... 15
4. THREAT TO PUBLIC HEALTH, WELFARE, AND/OR THE ENVIRONMENT ..... 16
5. ENDANGERMENT DETERMINATION ..... 16
5.1 Removal Action Objectives ..... 17
5.2 Proposed Actions ..... 17
5.2.1 Contribution to Remedial Performance ..... 19
5.2.2 Basis for Selection of Proposed Alternative ..... 19
5.3 Compliance with Environmental Regulations, Including Those That Are Applicable or Relevant and Appropriate Requirements ..... 19
5.4 Cultural Resources ..... 23
5.5 Natural Resources ..... 24
5.6 Project Schedule ..... 24
6. PROJECT COST ..... 24
7. EXPECTED CHANGE SHOULD ACTION BE DELAYED OR NOT BE TAKEN ..... 25
8. STATUTORY AND REGULATORY AUTHORITY ..... 25

9. OUTSTANDING POLICY ISSUES ..... 25
10. ENFORCEMENT ..... 26
11. SELECTED ALTERNATIVE ..... 26
12. PUBLIC PARTICIPATION ..... 26
13. REFERENCES ..... 27
Appendix A—Comments Received During the Public Comment Period and Responses to Comments ..... A-1
Appendix B—Comment Resolution Matrix ..... B-1
Appendix C—Citizen's Advisory Board EBR-II Engineering Evaluation/Cost Analysis Recommendation ..... C-1
Appendix D—News Article Received During the Public Comment Period ..... D-1

## FIGURES

1. Location of the Materials and Fuels Complex on the Idaho National Laboratory Site ..... 3
2. Location of EBR-II reactor building (MFC-767) at the Materials and Fuels Complex ..... 3
3. Aerial view of the Material and Fuels Complex ..... 4
4. MFC-767 EBR-II reactor building ..... 5
5. EBR-II reactor building main floor ..... 6
6. EBR-II cross-section drawing ..... 8
7. Primary coolant tank with cover being lowered into biological shield ..... 9
8. Primary coolant tank support structure over the tank ..... 9
9. Schematic of EBR-II reactor vessel and neutron shields ..... 10
10. EBR-II reactor vessel and storage basket shown inside primary coolant tank ..... 11
11. EBR-II radiological inventory intervals for risk assessments ..... 14
12. Dose rates in EBR-II primary coolant tank taken November 2009 ..... 15
13. Conceptual drawing of EBR-II Alternative 3, Grouting Reactor Vessel in Place, final end state ..... 18
14. Conceptual end state of EBR-II under Alternative 3 ..... 27

## TABLES

1. Summary of applicable or relevant and appropriate requirements for the EBR-II non-time-critical removal action ..... 20

# ACRONYMS

| | |
|---|---|
| ALARA | as-low-as-reasonably-achievable |
| ARAR | applicable or relevant and appropriate requirement |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CY | calendar year |
| D&D | decommissioning and demolition |
| DOE | U.S. Department of Energy |
| DOE-ID | U.S. Department of Energy Idaho Operations Office |
| EBR | Experimental Breeder Reactor |
| EE/CA | engineering evaluation/cost analysis |
| HWMA | Hazardous Waste Management Act |
| ICDF | Idaho CERCLA Disposal Facility |
| ICP | Idaho Cleanup Project |
| INEEL | Idaho National Engineering and Environmental Laboratory (now INL) |
| INL | Idaho National Laboratory |
| MFC | Materials and Fuels Complex |
| NTCRA | non-time-critical removal action |
| OU | operable unit |
| PCB | polychlorinated biphenyl |
| RCRA | Resource Conservation and Recovery Act |
| ROD | record of decision |
| WAC | waste acceptance criteria |
| ZPPR | Zero Power Physics Reactor |

# Action Memorandum for the EBR-II Final End State

## 1. PURPOSE

The purpose of this Action Memorandum is to request and document approval of the proposed removal action described herein for the final end state of the Experimental Breeder Reactor II (EBR-II) reactor and building.

Preparation of this Action Memorandum has been performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.), as amended by the "Superfund Amendments and Reauthorization Act of 1986 (SARA)" (Public Law 99-499), and in accordance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300). This action is consistent with the joint U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act* (DOE and EPA 1995), which establishes the CERCLA non-time-critical removal action (NTCRA) process as an approach for decommissioning. This approach satisfies environmental review requirements and provides for stakeholder involvement, while also providing a framework for selecting the decommissioning alternative. An Administrative Record has been established to record information used to support the selected alternative as well as provide documentation of decisions and the progress of the removal action.

The U.S. Department of Energy Idaho Operations Office (DOE-ID) is the implementing agency for this NTCRA. Both the Idaho Department of Environmental Quality and the EPA concur that a NTCRA is warranted to protect human health and the environment. Through the NTCRA process, the risks presented in this document will be mitigated in a timely manner.

## 2. SITE CONDITIONS AND BACKGROUND

This section provides a summary of current EBR-II site conditions and historical background information. It identifies previous and ongoing closure and cleanup activities, including a description of the EBR-II reactor and reactor building addressed in this Action Memorandum and additional information relevant to the scope of this document. It also provides a discussion of the radiological and nonradiological characterization for EBR-II.

### 2.1 Idaho National Laboratory Site and Idaho Cleanup Project

The Idaho National Laboratory (INL) Site, managed by DOE, is located 51 km (32 mi) west of Idaho Falls, Idaho. It occupies 2,305 $km^2$ (890 $mi^2$) of the northeastern portion of the Eastern Snake River Plain. In 1949, the U.S. Atomic Energy Commission established the INL Site, then called the National Reactor Testing Station. Its purpose was to conduct nuclear energy research and related activities. It was renamed the Idaho National Engineering Laboratory in 1974 and then the Idaho National Engineering and Environmental Laboratory (INEEL) in 1997. In 2003, the INEEL was restructured into two separate business units: one for laboratory research and development missions (i.e., INEEL) and one for environmental cleanup activities (i.e., Idaho Completion Project). In February 2005, the two business units came under the management of two separate contractors, Battelle Energy Alliance, LLC, for the laboratory mission, and CH2M-WG Idaho, LLC, for environmental remediation. In addition, the laboratory was designated as the lead DOE laboratory for U.S. nuclear energy research and was renamed the INL in keeping with its mission realignment and multiple uses. The Idaho Completion Project was

renamed the Idaho Cleanup Project (ICP), and its mission continues to focus on environmental remediation and cleaning up historic contamination at the INL Site.

DOE-ID controls all land within the INL Site. Public access is restricted to public highways, sponsored tours, special-use permits, and the EBR-I National Historic Landmark. In addition, DOE-ID is cognizant of the Shoshone-Bannock tribal members' need for access to areas on the INL Site for cultural and religious purposes.

The INL Site is located primarily in Butte County; however, it also occupies portions of Bingham, Bonneville, Clark, and Jefferson counties. The 2000 census indicated the following populations for cities in the region: Idaho Falls–50,730; Pocatello–51,466; Blackfoot–10,419; Arco–1,026; and Atomic City–25.

Surface water flows on the INL Site consist mainly of three streams draining intermountain valleys to the north and northwest of the INL Site: (1) the Big Lost River, (2) the Little Lost River, and (3) Birch Creek. All of the channels terminate on the INL Site. Flows from Birch Creek and the Little Lost River seldom reach the INL Site because of irrigation withdrawals upstream. The Big Lost River and Birch Creek may flow onto the INL Site before the irrigation season or during high-water years, but the terminal reaches are usually dry. In those few wetter years when the Big Lost River carries water to the end of its channel, the water sinks into the ground.

The physical characteristics, climate, flora and fauna, demography, and cultural resources of the INL Site and the Materials and Fuels Complex (MFC) are further described in the Operable Unit (OU) 9-04 Record of Decision (ROD) (DOE-CH 1998).

### 2.1.1 Materials and Fuels Complex History

Originally under the name of Argonne National Laboratory–West, MFC was established in 1949 and was operated by the University of Chicago under the direction of DOE's Chicago Operations Office. For the next 50 years, the primary function of the facility was to design and develop the next steps in nuclear reactor power stations. Some of the facilities at MFC that played a role in reactor design include the Transient Reactor Test facility, the Zero Power Physics Reactor (ZPPR), and EBR-II. The Transient Reactor Test facility was used for testing the performance of materials in a nuclear reactor, especially during power excursions. The ZPPR facility was used to test reactor design features for different fuel materials and configurations. In 1969, the ZPPR was put into operation; in 1989, it was put in standby; and in 2009, the reactor was dismantled. EBR-II operated for 30 years, providing power and serving as a point of research for reactor development and testing.

In 2005, Argonne National Laboratory–West was renamed the Materials and Fuels Complex (MFC) and began operating under the direction of DOE-ID. Two principal activities are being conducted at the complex today. The electrometallurgical treatment of sodium-bonded spent nuclear fuel from EBR-II takes place in shielded hot cells at the MFC-765, Fuel Conditioning Facility, and converts unstable spent nuclear fuel to stable and disposable waste forms. The other main activity is destructive and nondestructive examination of nuclear materials for government and private customers. This activity is performed in the Hot Fuel Examination Facility. Figure 1 is an aerial view of MFC.

### 2.1.2 EBR-II Location

EBR-II is located at the MFC in the southeast portion of the INL Site (see Figure 1). The EBR-II reactor building (MFC-767) is located approximately in the west-central portion of MFC (see Figure 2). Figure 3 is an aerial view of the MFC facility and show the EBR-II building (containment dome).

Figure 1. Location of the Materials and Fuels Complex on the Idaho National Laboratory Site.

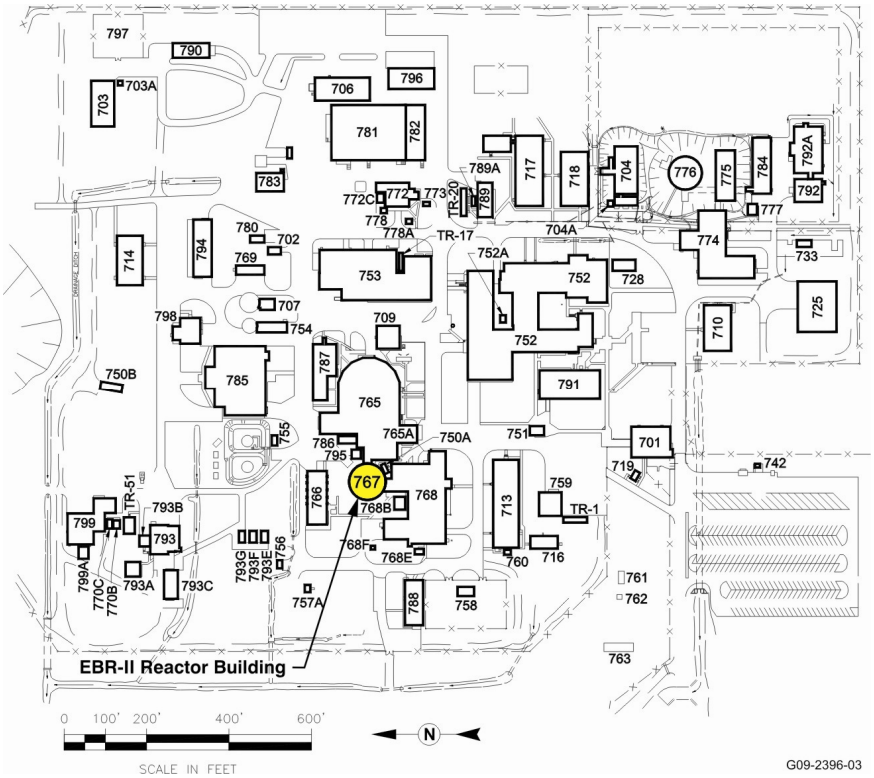


Figure 2. Location of EBR-II reactor building (MFC-767) at the Materials and Fuels Complex.

Figure 3. Aerial view of the Material and Fuels Complex.

### 2.1.3 EBR-II History

While it was in active operation, EBR-II was an unmoderated, sodium-cooled reactor and power plant with a power output of 62.5 MW of heat. The energy of the reactor was converted to 20 MW of electricity through a conventional steam cycle. The reactor was initially fueled with U-235; however, it was later used as an irradiation facility for testing mixed oxide fuel pins for liquid-metal-cooled reactors. During operation of the EBR-II reactor, an integral fuel processing facility was contained in MFC-765 where the irradiated fuel was processed, fabricated, and assembled for return to the reactor.

EBR-II achieved initial “dry” (i.e., without sodium) criticality on September 30, 1961, and “wet” criticality (i.e., with the core submerged in liquid sodium coolant) on November 11, 1963. EBR-II went to full power on August 13, 1964. EBR-II was shut down in 1994 amid concerns about plutonium production. In that year, Argonne National Laboratory established the EBR-II Plant Closure Project and included three phases.

Phase I involved defueling the reactor and was performed from October 1994 to December 1996. During the defueling, all reactor core fueled subassemblies, neutron source, inner blanket, reflector, outer blanket, and control and experiment subassemblies were removed and replaced with unirradiated stainless steel dummy assemblies. The only irradiated components remaining in the reactor core/blanket regions following this activity were 12 control rod thimbles, eight control rod drive mechanisms, and a welded-in-place stainless steel dummy subassembly. All removed components are stored at the MFC with the exception of the fuel subassemblies, which are currently being transferred to dry storage at the INL Site Idaho Nuclear Technology and Engineering Center. Additional work activities, which reduced the pre-demolition source term of the facility, included the removal of the primary cold traps and cesium traps.

Phase II involved removal of the bulk liquid sodium metal (the sodium was melted for removal) and some sodium-potassium alloy (NaK) from the primary and secondary systems and was completed in March 2001.

Phase III involved treating the EBR-II primary and secondary systems residual sodium volumes with $CO_2$ and water vapor in a process called carbonation. The purpose of carbonation was to cause the sodium to react with water to form a more stable material, such as sodium bicarbonate or sodium carbonate. Carbonation was stopped in March 2002, then restarted in May 2004 and continued through December 2005. Carbonation treatment was terminated in December 2005 because of diminishing reaction rates. Currently, the EBR-II reactor building has an estimated 850 gal of uncarbonated (elemental) sodium remaining on surfaces and in other ancillary equipment that will be treated or removed before the final end state of EBR-II is reached. There is also residual liquid NaK remaining inside pressure transducers in various systems throughout the reactor building.

### 2.1.4 EBR-II Systems and Component Descriptions

Descriptions of major EBR-II systems and components are provided in subsections below.

***2.1.4.1 Reactor Building.*** Construction on the EBR-II reactor building (MFC-767) began in 1957 (see Figure 4). The building is 80 ft in diameter and approximately 139 ft in height, 47 ft below and 92 ft above ground level. The main floor of the facility sits approximately 7 ft above ground level. The structure is a concrete-lined, gas-tight cylindrical steel shell, constructed of a 1-in.-thick carbon steel plate, and is designed to withstand a static internal pressure of approximately 25 psig. Heat was removed from the reactor by the primary sodium coolant system and transferred to the secondary sodium system. The secondary coolant system transferred the heat out of the EBR-II reactor building to the adjacent Sodium Boiler Building, MFC-766, in which superheated steam was produced that drove a conventional turbine-generator that generated electricity.

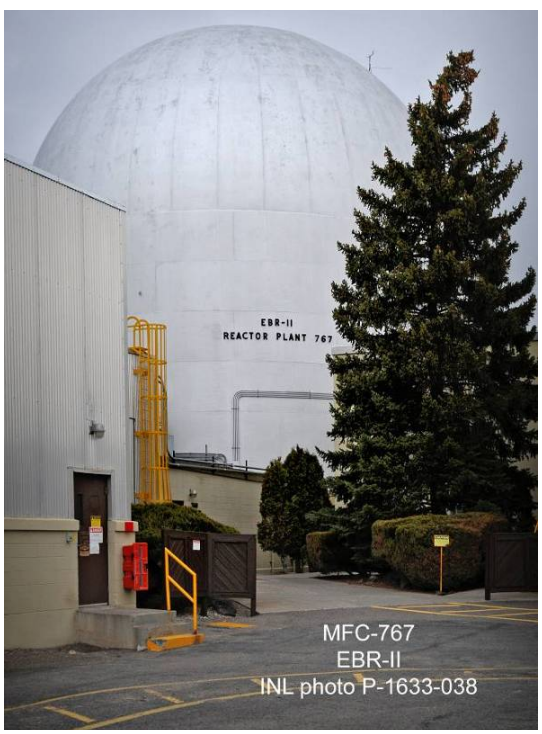


Figure 4. MFC-767 EBR-II reactor building.

The reactor building contains three main accessible working levels:

- The main floor contains the reactor subassembly movement components, cover gas cleanup system, and control rod drive tower, along with electrical distribution panels. A polar crane is situated near the top of the reactor building and was used for lifting equipment on the main floor and from lower levels of the building through hatches built in the main floor. The main floor is situated approximately 7 ft above ground level. Just below the main floor is a small space known as the depressed area. The depressed area floor is approximately at ground level and contains access to the emergency exit air lock and several support systems.

- The next level down is the basement area and contains the primary coolant purification system, Radioactive Sodium Chemistry Loop, primary coolant sampling system, ventilation ducting, and inert gas systems. Also located in the basement are two separate mezzanines that contained primarily electrical equipment.

- The lowest level of the building is known as the sub-basement and houses primarily ventilation systems for the reactor shield coolant system and neutron detector thimble cooling.

Figure 5 is a photo of the main reactor building floor.

The primary coolant tank makes up the balance of the space in the EBR-II reactor building and is described in the section below.

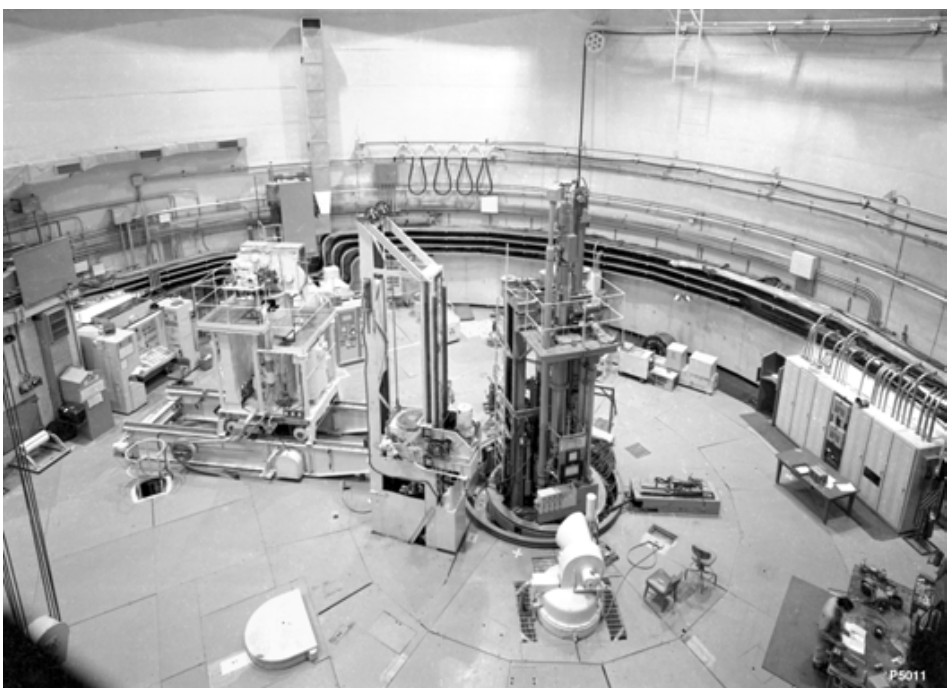


Figure 5. EBR-II reactor building main floor.

***2.1.4.2 EBR-II Primary Coolant Tank.*** The EBR-II reactor vessel and the primary coolant system, including the heat exchanger and sodium coolant pumps, are contained in a large tank that was operated completely submerged in the liquid sodium metal. The primary coolant tank is of double-wall construction to provide increased reliability of sodium containment. The tank is constructed of Type 304 stainless steel. The inner tank has a 26-ft internal diameter and the outer tank wall has a 26-ft, 11-in.

internal diameter. The inner side wall is constructed of 1/2-in.-thick plate. The outer side wall is constructed of 1/4-in.-thick plate. The bottoms of the tanks are 1-in.-thick plates and are stiffened with radial beams. The primary coolant tank support structure consists of a system of columns and beams that transmit the loads to the main internal building foundation. In combination with the biological shield, it forms a "pressure vessel" surrounding the primary tank. A ring of ordinary concrete measuring 6 ft thick forms the biological shield. The concrete is reinforced with continuous hoops of reinforcing rods to allow the concrete to resist an internal pressure of 75 psig. Figure 6 is a drawing depicting a cross section of EBR-II.

The primary coolant tank cover is welded to the top of the inner and outer tank walls and provides numerous nozzles (e.g., access ports) for equipment access to the primary coolant tank. A large and a small rotating plug were fitted inside a large center access hole. The small plug rotated inside the large plug and the large plug rotated inside the primary coolant tank cover center hole to allow very accurate orientation over the reactor vessel below. Figure 7 is a photo during construction of the empty EBR-II primary coolant tank with the installed cover being lowered into the biological shield.

Once the primary coolant tank was in place in the biological shield, a six-spoke support structure was assembled over the tank, and the tank was then suspended from this structure within the biological shield. By suspending the coolant tank from the support structure, thermal expansion of the metals composing the tank could be accommodated without warping or damaging systems. Figure 8 is a photo of the primary coolant tank support structure assembled over the primary coolant tank.

### 2.1.5 Reactor Vessel and Neutron Shield Description

The reactor vessel is located in the primary coolant tank and was constructed of an outer shell, an inner shell, and thermal baffles, all of 304 stainless steel. The reactor vessel is considered to extend from the low-pressure coolant plenum on the bottom to the reactor vessel cover on the top (see Figure 9).

During operation, the EBR-II reactor vessel contained a hexagonal central core, which, in turn, contained enriched uranium that was completely surrounded by radial and axial subassembly layers or "blankets." These blankets originally contained stainless steel or depleted uranium subassemblies that were intended to function both as a neutron reflector and as fertile material for the breeding of plutonium. In 1994, when the reactor was shut down, the radial blanket regions contained stainless steel reflector pieces and depleted uranium, or stainless steel and nickel blanket pieces. The core and blanket region materials consisted of 636 free-standing and one welded-in-place subassemblies, which were contained in and supported by the reactor vessel.

The radial neutron shield reduced neutron leakage from the reactor to minimize activation of the secondary sodium coolant and components exterior to the reactor. It also served as a neutron reflector, conserving a relatively small number of neutrons that would have otherwise leaked from the reactor. The entire radial shield consists of an inner shield, located between the inner and outer shells of the reactor vessel, and an outer shield located outside of the vessel. A total of 108 "cans" form the two layers of inner neutron shield and 948 cans form the five layers of outer neutron shield. Most cans are 4.3 in. square and 52.5 in. long. The cans contain either graphite or borated graphite or were empty and open at the top to allow liquid sodium to fill the can. The cans that contained sodium were allowed to drain when the sodium was drained from the primary coolant tank because of a small hole in the bottom of each can.

The reactor vessel assembly includes the double-walled reactor vessel, seven rows of neutron shielding cans, coolant plenums, grid plates, the reactor vessel cover, and the 637 stainless steel subassemblies. The reactor vessel assembly is approximately 12 ft in diameter and 13 ft high and weighs approximately 170 tons.

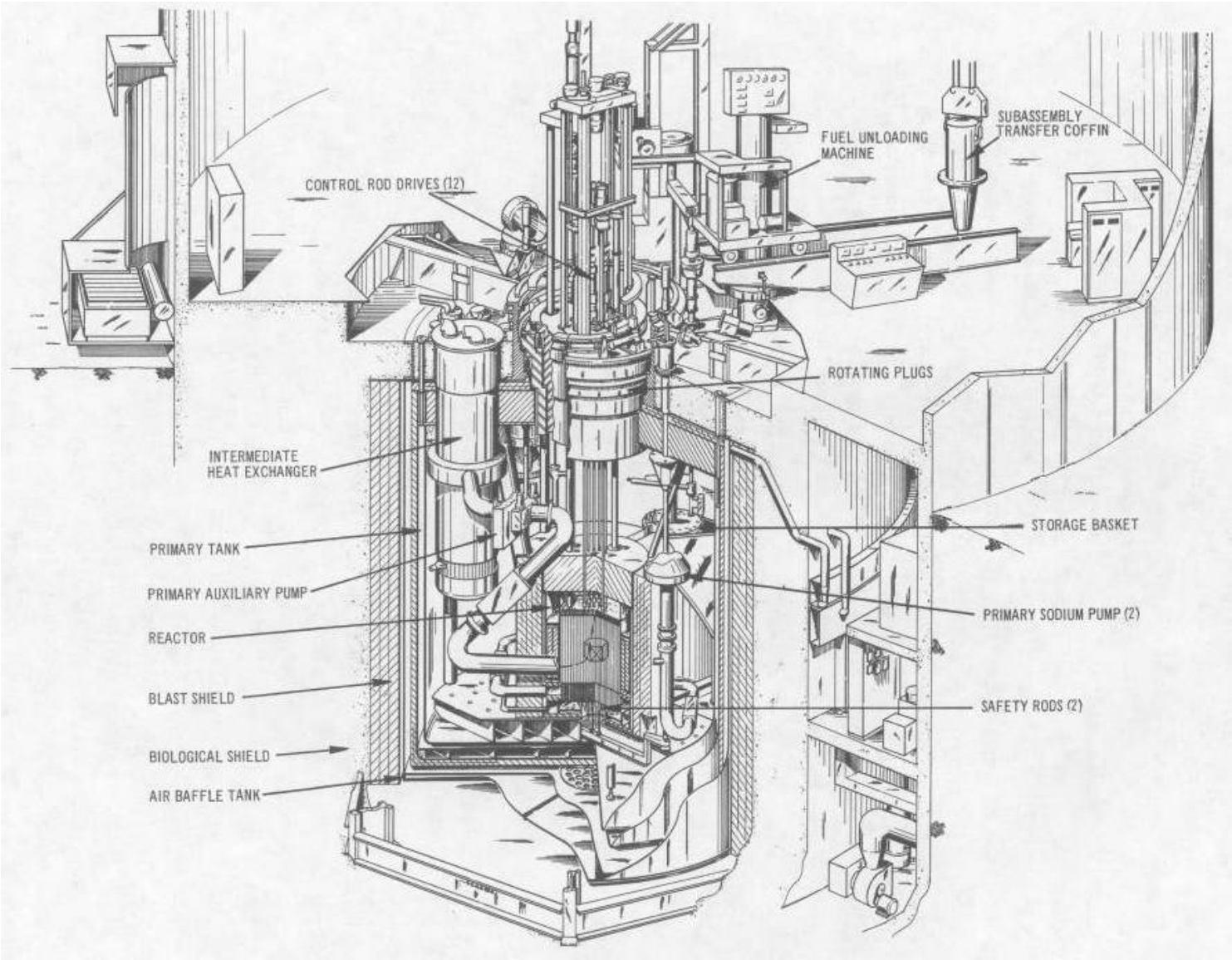


Figure 6. EBR-II cross-section drawing.

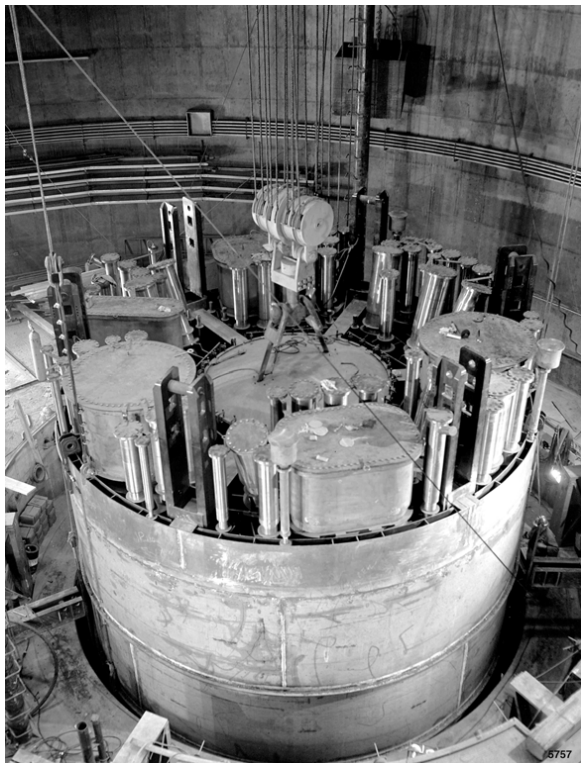

Figure 7. Primary coolant tank with cover being lowered into biological shield.

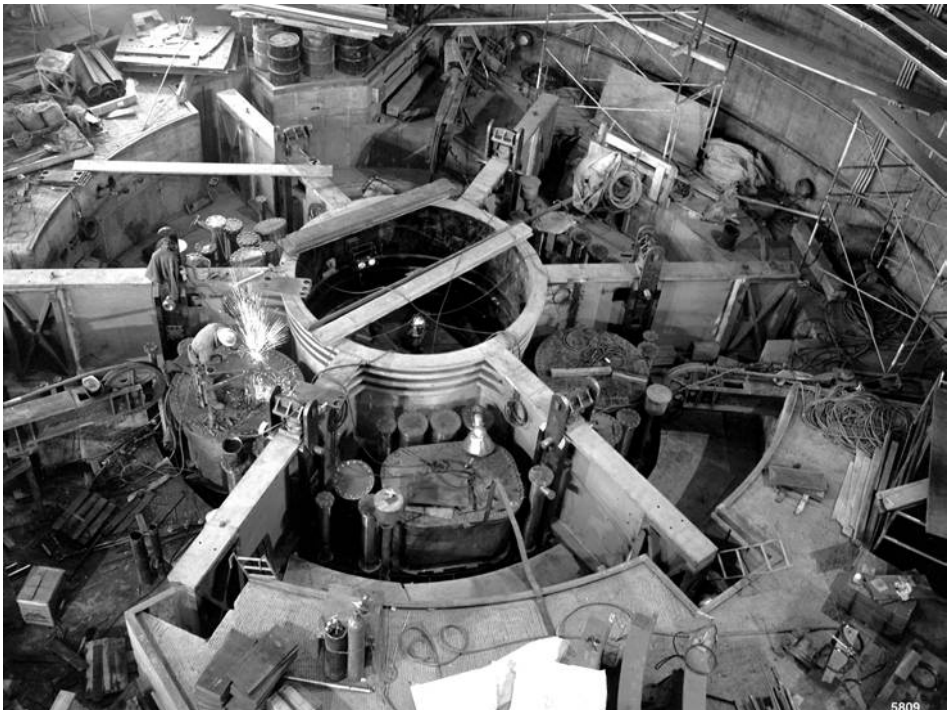

Figure 8. Primary coolant tank support structure over the tank.

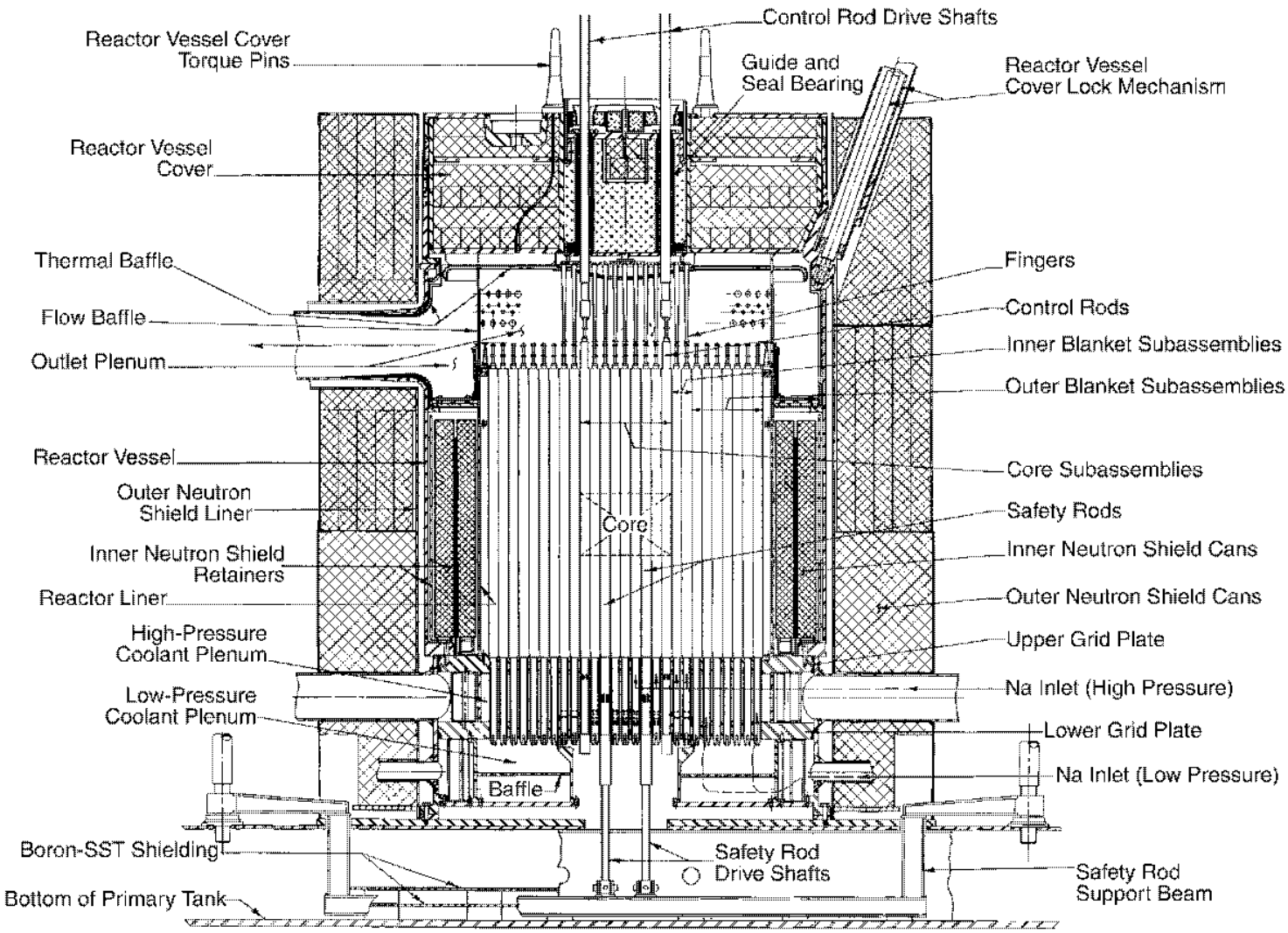


Figure 9. Schematic of EBR-II reactor vessel and neutron shields.

***2.1.5.1 Primary Coolant Tank Components.*** The primary coolant tank held approximately 86,000 gal of molten sodium metal during reactor operations. The operating temperature of the EBR-II reactor coolant system was between 700 and 883°F. During operations, sodium was continuously circulated through the reactor vessel to maintain the desired core temperature. Sodium was pumped by two primary coolant pumps that were suspended from the primary coolant tank cover into the sodium. Coolant piping ran from the pumps to the plenums below the reactor vessel and collected the thermally "hot" coolant at the top of the reactor vessel and transported it to the intermediate heat exchanger.

The melting point of sodium is 208°F. Six submersible heaters maintained the sodium in the reactor at approximately 700°F when it was not in operation. Two shutdown cooler columns in the primary coolant tank transported excess heat to heat exchangers on the outside of the reactor building from the primary coolant if the primary pumps failed.

The primary coolant tank also held the subassembly handling system and storage basket. Subassemblies were loaded and unloaded from the primary coolant tank and placed in the reactor vessel using the transfer arm. Subassemblies removed from the reactor core could be placed in the storage basket to allow short half-lived radionuclides to decay to a lower activity before being removed from the primary coolant tank. The foreground in Figure 10 shows the top of the reactor vessel with the control rods descending into the reactor vessel cover, and the storage basket is shown on the far side of the reactor vessel. This photo was taken during construction of components in the primary coolant tank.

The primary coolant tank also contained many thermocouples for measuring temperatures and pressure transducers. Numerous hollow tubes called "thimbles" extend from the primary coolant tank cover into the tank to allow instrumentation such as fission chambers for measuring neutron flux. Overall, the primary coolant tank is very crowded with systems, structures, and components.

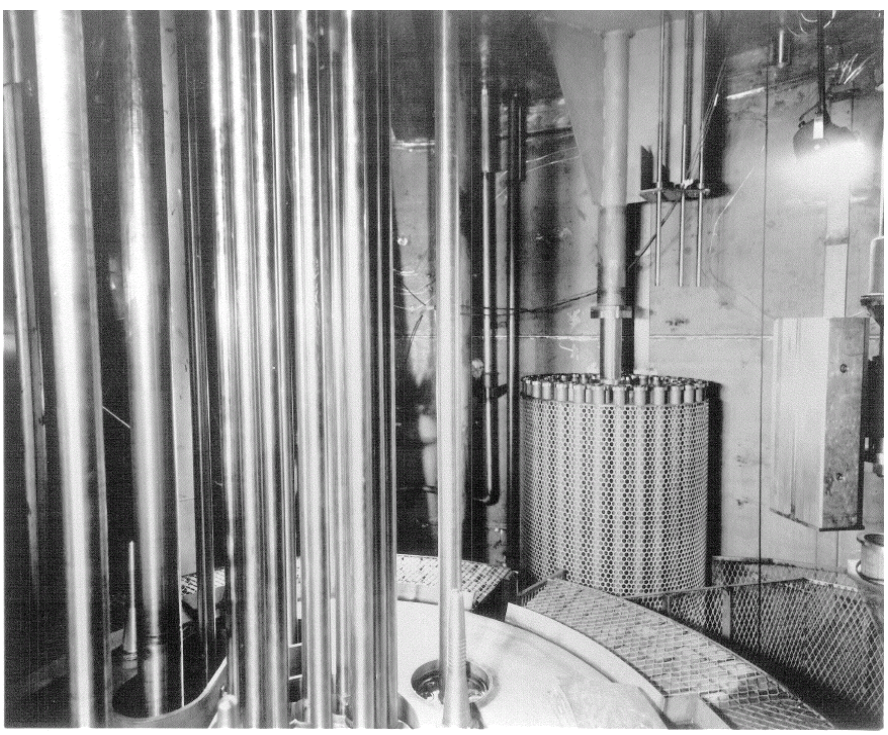

Figure 10. EBR-II reactor vessel and storage basket shown inside primary coolant tank.

## 2.2 Other Closure and Cleanup Activities at MFC

Closure and cleanup activities have taken place and will continue at MFC under several programs and regulatory authorities. The following sections briefly describe those activities.

### 2.2.1 CERCLA Activities at MFC

The MFC Federal Facility Agreement and Consent Order (FFA/CO) (DOE-ID 1991) remedial action objectives for Waste Area Group 9 are documented in the OU 9-04 ROD (DOE-CH 1998), the *Final Explanation of Significant Differences to the Record of Decision for Argonne National Laboratory-West Operable Unit 9-04, Idaho National Engineering and Environmental Laboratory* (DOE-CH 2000), and the *Explanation of Significant Difference Argonne National Laboratory-West, Operable Unit 9-04* (DOE-CH 2004). Past release sites requiring further actions are documented in the OU 9-04 ROD. Remedial actions are complete for seven of the release sites identified, and continued institutional controls to prevent inadvertent access to three of the release sites are in place.

The OU 9-04 ROD states that groundwater monitoring will continue until 2018. The MFC groundwater monitoring program consists of one upgradient well and three downgradient wells. In addition, one production well is sampled from within the MFC security area. All wells are sampled twice annually—typically in April and October.

### 2.2.2 Other Non-Time-Critical Removal Action Activities at MFC

Decommissioning and demolition (D&D) of the ZPPR has been completed. D&D of the reactor portion of the ZPPR facility was conducted in accordance with a CERCLA NTCRA as allowed by the *Action Memorandum for General Decommissioning Activities under the Idaho Cleanup Project* (DOE-ID 2009a).

Other facilities at MFC are undergoing D&D or are scheduled for D&D under the Action Memorandum for General Decommissioning. These facilities include MFC-766, Sodium Boiler Building; MFC-750A, EBR-II Experimental Building; MFC-793A, Alcohol Recovery Facilities Storage Pad; MFC-793B, Alcohol Recovery Facility; and MFC-795, EBR-II Cover Gas Cleanup System. D&D has been completed on MFC-793E and F, Sodium Storage Buildings, and the MFC-757A, EBR-II Cooling Tower System Building.

### 2.2.3 Other Regulatory Actions

Residual sodium and sodium-potassium (NaK) alloy remaining in the EBR-II facilities are being managed outside of the NTCRA and in accordance with the *HWMA/RCRA Storage and Treatment Permit for the Experimental Breeder Reactor-II and Buildings MFC-793E and MFC-793F located at the Materials and Fuels Complex on the Idaho National Laboratory* (DEQ 2009). This Resource Conservation and Recovery Act (RCRA) (42 USC 6901 et seq.) permit and the associated closure plan will guide the handling, storage, and treatment of sodium and NaK until the closure performance standards provided in the closure plan are satisfied. Sodium and NaK treatment is expected to take place before the initiation of activities under this NTCRA, but some closure activities may indeed occur concurrently with this NTCRA. There currently is estimated to be 500 gal of elemental sodium in the primary coolant tank and 350 gal in the ancillary systems (e.g., Radioactive Sodium Chemistry Loop). Much of the sodium in the primary tank is coated with a sodium bicarbonate layer that is a result of previous treatment (carbonation). Moist carbon dioxide was vented into the primary coolant tank and some of the ancillary equipment to slowly react the sodium. This treatment resulted in the sodium

bicarbonate layer and will likely have to be dissolved in future treatment regimes to allow treatment of the underlying untreated sodium metal.

Actions are currently ongoing in MFC-767 to remove shielding lead and lead-containing components, mercury switches, silver solder, circuit boards, and florescent lamps to ensure compliance with Hazardous Waste Management Act (HWMA) (IC 1983)/RCRA regulations. While the intent of this NTCRA is to remove accessible lead and lead shielding, it must be recognized that not all lead will be removed under this NTCRA. Some lead wall anchors will remain in place under all the alternatives. Additional lead that will not be removed is found in the painted surfaces of the buildings that have had lead-containing paint applied at various times over the lifetime of this facility.

Asbestos will be removed throughout the facility in accordance with National Emission Standards for Hazardous Air Pollutants regulations (40 CFR 61).

# 3. EBR-II RADIOLOGICAL AND NONRADIOLOGICAL INVENTORIES

This section discusses the inventories (source terms) of radiological and nonradiological materials currently within the EBR-II reactor building. More information concerning these inventories and the proposed removal action alternatives can be found in the EBR-II Engineering Evaluation/Cost Analysis (EE/CA) (DOE-ID 2010).

## 3.1 Radiological Inventory

The total estimated radiological inventory in the EBR-II building is 1.50E+04 Ci. Of the 1.50E+04 Ci remaining, 1.44E+04 Ci (95.8%) are contained within the primary coolant tank. Of this primary coolant tank activity, a total of 1.437E+04 Ci (99.92%) is from activated materials remaining in the core/blanket regions and activated materials forming the reactor vessel structure. The remainder of the primary coolant tank activity is from the following sources: primary system surface contamination—1.12E+01 Ci, residual primary sodium metal and NaK—7.04E-02 Ci, residual secondary sodium metal remaining in the intermediate heat exchanger—6.14E-04 Ci, and U-235 activity remaining in the neutron detectors—2.96E-05 Ci.

Of the 6.24E+02 Ci in the remainder of the EBR-II reactor building, the vast majority of this activity is from activated material stored in the storage pits within the facility and accounts for 99.9% of the inventory outside the primary coolant tank. Other significant contributors to the inventory outside of the primary tank comprise the following: primary sodium remaining in ancillary equipment—2.08E-02 Ci and surface contamination in the shielded pentagon area—2.14E-03 Ci. For determining radiological inventories, the sodium inventories are conservatively assumed to remain in the primary and secondary reactor systems after RCRA closure is complete either as sodium bicarbonate or some other nonreactive form of sodium. The activated material in the storage pits is stored below the 10-ft below-ground-level interval and, therefore, does not contribute to the radiological inventory in the interval that is used in the calculation of Alternative 3 risks (10 ft below to 7 ft above ground level). The radiological inventory below ground level, including the primary coolant tank and reactor vessel, was used to determine the long-term groundwater risk.

As a fast breeder reactor, large neutron flux fields were generated in the core of the reactor that had the potential to transmutate the impurities in EBR-II materials of construction into long half-lived transuranic isotopes. The transuranic activity of various components in the reactor vessel was calculated, and the inner shield wall of the reactor vessel had the highest transuranic activity of 0.77 nCi/g.

The assumed final end state of the facility under Alternative 3 will include approximately 7 ft of the existing above-ground-level structures and components; therefore, the ground-level to 7 ft above-ground-level inventory was considered. Figure 11 depicts a cutaway drawing of the EBR-II building and the radiological curies of each interval that was used in the risk assessments presented in the EBR-II EE/CA (DOE-ID 2010).

### 3.1.1 EBR-II Radiological Conditions

In this section, radiological conditions are discussed in terms of radiation fields that a worker would be exposed to if working in proximity to the inventories listed above. Radiation means ionizing radiation, or capable of producing ions, which, at EBR-II, is primarily gamma rays. Gamma ray exposure is expressed as roentgen (R) and the rate of exposure as R/hr or mR/hr (an mR is a one-thousandth of an R).

Dose rates in the primary tank down the O2 thimble (a tube that extends through the primary tank cover just outside of the neutron shield that surrounds the reactor vessel) showed measured exposure rates of approximately 14 R/hr near the core vertical centerline to as high as 233 R/hr near the open reactor top. The dose rates, measured in 1-ft intervals in the primary tank, are presented in Figure 12. The modeled exposure rate inside the reactor vessel above the core/blanket region is approximately 3,500 R/hr, and the modeled maximum exposure rate on the outside of the primary coolant tank is 2 R/hr. The general area dose rates in the accessible areas throughout the facility are generally low (less than 0.5 mR/hr), though higher dose rates exist in areas containing residual sodium, such as the Radioactive Sodium Chemistry Loop cubicles and the shielded pentagon area.

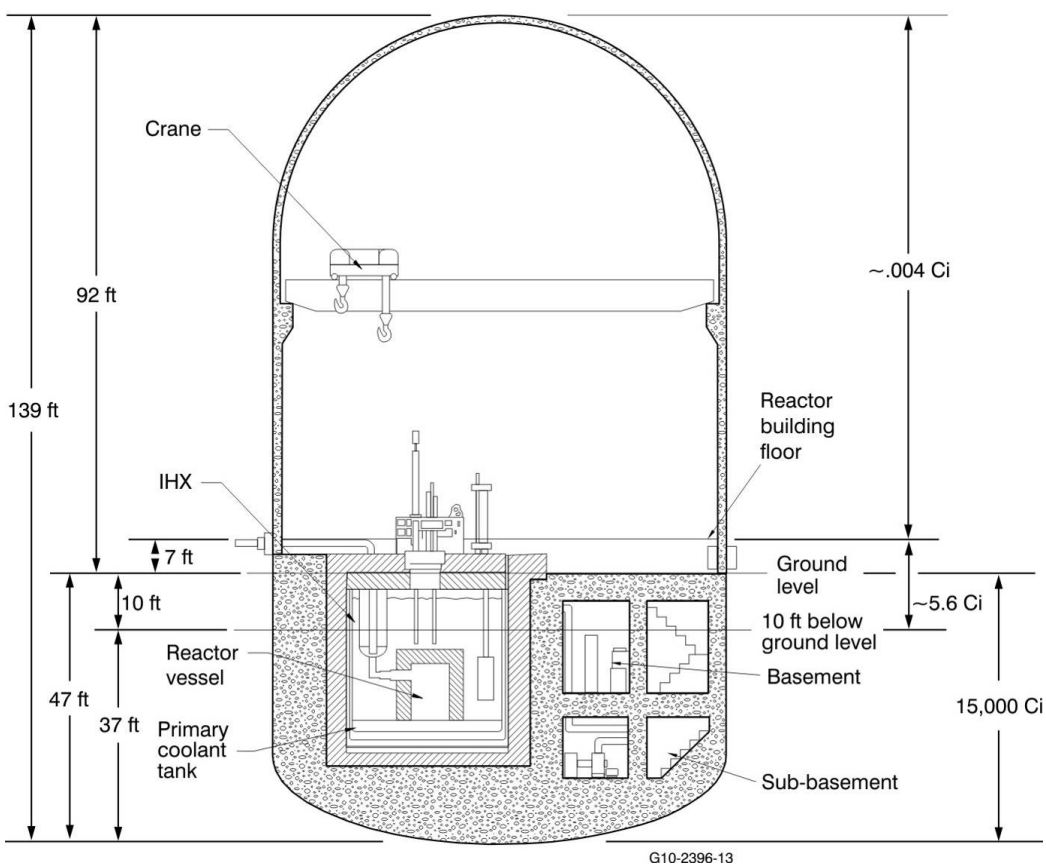


Figure 11. EBR-II radiological inventory intervals for risk assessments.

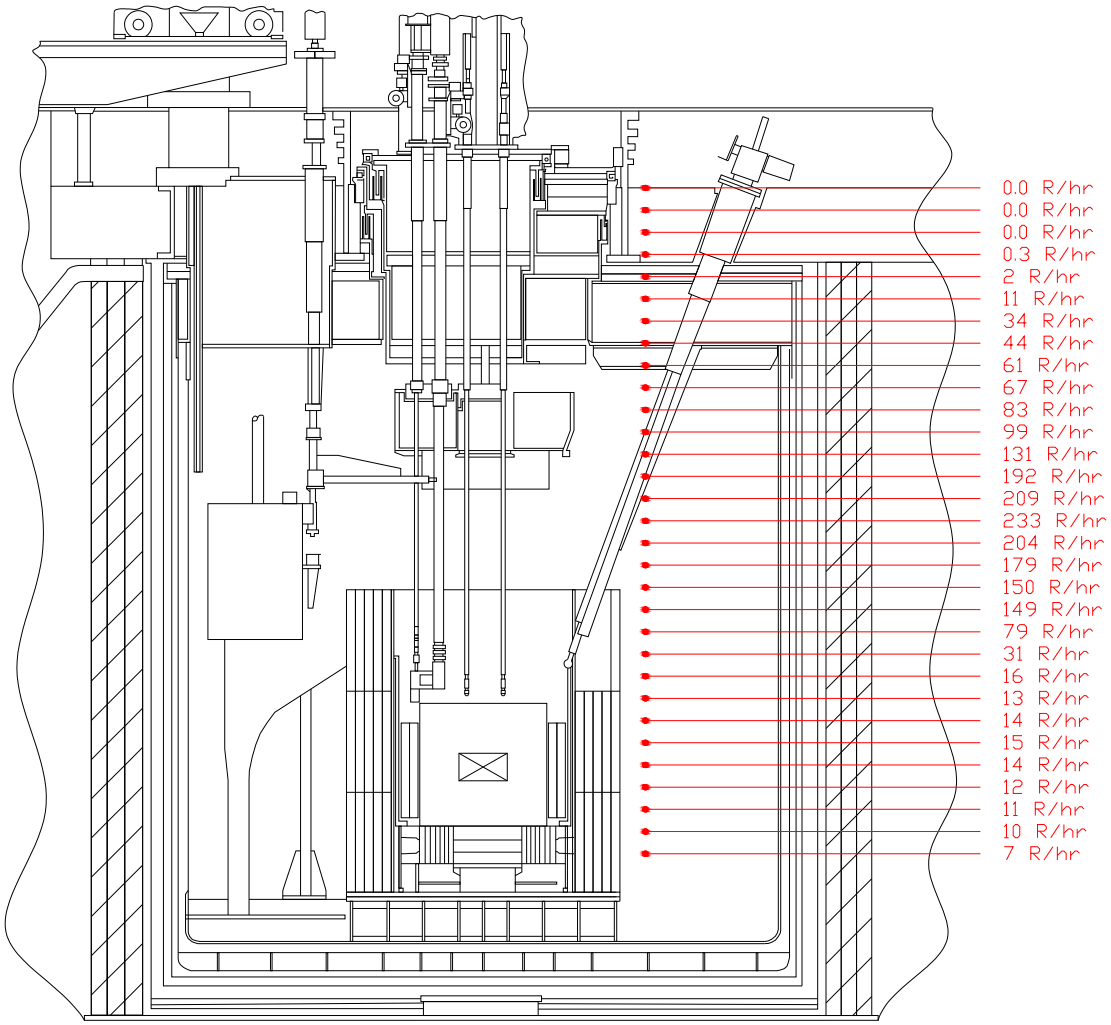


Figure 12. Dose rates in EBR-II primary coolant tank taken November 2009.

## 3.2 EBR-II Nonradiological Inventory

The EBR-II nonradiological inventory was determined by the inspection of drawings, system description documents, and measurements and order of magnitude estimates taken of the EBR-II reactor building. Building materials included aluminum in ducting; antimony and lead in wall anchors; chromium, manganese, and nickel contained in the stainless steel; and iron contained in the carbon steel. EBR-II also included approximately 265 lb of depleted uranium that was used as shielding for fuel-handling components and in the air purification system.

# 4. THREAT TO PUBLIC HEALTH, WELFARE, AND/OR THE ENVIRONMENT

Conditions at this site meet the criteria for a NTCRA as stated in the National Contingency Plan (40 CFR 300.415) as follows:

**Actual or potential exposure to hazardous substances or pollutants or contaminants by nearby populations or the food chain (40 CFR 300.415(b)(2)(i)).** While access to the INL Site is restricted, there is the potential that, over time, the EBR-II reactor will decay and the radionuclides could be released into the environment. This will create the potential for exposure to concentrations of radionuclides via inhalation of windblown dust from the debris, direct ingestion of contaminated soils by nearby human populations and INL Site workers, and ingestion of contaminated plants or animals by nearby human populations. The location of EBR-II is approximately 3 miles from U.S. Highway 20 and 5.5 miles from the nearest cattle ranch.

Ecological receptors could be exposed to Site contaminants through direct or indirect contact with radionuclides and with materials contaminated by radionuclides and through ingestion of food (e.g., soil-dwelling insects, vegetation) that is contaminated with nonradiological contamination such as heavy metals. The ecologically based screening levels are established to evaluate whether an internal exposure increase could occur to plants and animals that would result in the lack of maintenance or recovery of healthy local populations of ecological receptors that are, or should be, at or near the Site.

**High levels of hazardous substances or pollutants in soils largely at or near the surface that may migrate (40 CFR 300.415(b)(2)(iv)).** The total activity from radionuclides at this site is identified in Section 3.1. If no action is taken, the potential exists for this radiological contamination to be ingested or transported via the wind to receptors.

# 5. ENDANGERMENT DETERMINATION

Actual or threatened release of hazardous substances from EBR-II, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health or welfare or the environment. As EBR-II continues to age, the threat of substantial release of radiological and hazardous substances increases with time, and containing these materials and preventing them from being released to the environment becomes more difficult. The surveillance and maintenance activities required to confine the hazardous substances may increase the risk of potential exposure to personnel.

The potential exposure to workers and ecological receptors, the potential threat of future releases, and the substantial risks associated with the radiological and hazardous substances at the facilities addressed by this Action Memorandum due to degradation of the EBR-II building to the point where radiological or hazardous materials are released to the soils and/or become airborne justify use of CERCLA removal action authority in accordance with 40 CFR 300.415(b)(2)(i) and (iv) of 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan." Actual and/or threatened releases of hazardous substances from these facilities have the potential to present a threat to public health and/or the environment.

## 5.1 Removal Action Objectives

The removal action objectives for this NTCRA are to achieve a final end state of EBR-II consistent with, or more conservative than, the remedial action objectives listed in the OU 9-04 ROD (DOE-CH 1998). The removal action objectives for this NTCRA should achieve the following:

- Inhibit direct exposure to radionuclide contaminants of concern that would result in a total excess cancer risk greater than 1 in 10,000 (1E-04) to 1 in 1,000,000 (1E-06) for current and future workers and future residents
- Inhibit ingestion of radionuclide and nonradiological contaminants of concern by all affected exposure routes (including groundwater, soil, and homegrown produce ingestion) that would result in a total excess cancer risk greater than 1 in 10,000 (1E-04) to 1 in 1,000,000 (1E-06) or a hazard index of 1 or greater for current and future workers and future residents
- Prevent unacceptable internal exposure of biota that would result in the lack of maintenance or recovery of healthy local populations/communities of ecological receptors that are or should be present at or near the site.

The acceptable risk level at the INL Site established for CERCLA removal action objectives is 1E-04, based on (a) use of 1E-04 in previous risk management decisions across the INL Site, (b) remote location of the INL Site, and (c) conservative approaches in risk assessment that tend to over estimate the risk. In addition to the CERCLA removal action objectives, DOE has goals for the selected alternative, including reducing the "risk footprint" to as practicable extent as possible in consideration of (a) as-low-as-achievable (ALARA) principles governing radiological exposure to decommissioning personnel, (b) safe engineering standards, (c) waste acceptance criteria (WAC) for the Idaho CERCLA Disposal Facility (ICDF), and (d) desired CERCLA site end states.

## 5.2 Proposed Actions

The EBR-II EE/CA (DOE-ID 2010) evaluated four NTCRA alternatives, listed below, for the final end state of the reactor building and reactor vessel. All alternatives would take place after the residual sodium metal and sodium-potassium alloy (NaK) remaining in the EBR-II systems are treated or removed, in compliance with the approved HWMA/RCRA closure plan. The four alternatives evaluated are as follows:

> **Alternative 1, No Action—**Under the "no action" alternative, no decommissioning and demolition would be conducted at EBR-II and no further surveillance and maintenance would be performed at the facility. For risk analysis, the No Action alternative is a hypothetical, conservative, baseline assumption in that the sum of all identified radiological or chemical contamination, if not properly contained or controlled, may be released to the environment, causing an unacceptable risk to potential receptors. These assumptions are for comparative purposes only and do not reflect the DOE requirement to comply with federal and state laws that require DOE to monitor, maintain, and mitigate potential or actual hazardous or radiological constituent releases to the public or the environment from any facility or site. Currently, administrative and physical controls are in place to prevent unacceptable exposures of ionizing radiation and other chemical hazards from the contaminated materials contained in EBR-II; however, implementation of the No Action alternative would remove these controls. Therefore, Alternative 1 is not considered a viable alternative and is presented only for comparative purposes.

**Alternative 2, No Action: Continued Surveillance and Maintenance—**Under Alternative 2, no action would be performed except surveillance and maintenance. This alternative offers no reduction in toxicity or volume of contaminants, but it does provide more protection from mobilization of the contaminants to the environment than Alternative 1.

**Alternative 3, Grouting the EBR-II Reactor Vessel in Place—**Under Alternative 3, systems and structures above the reactor building floor will be demolished and most of the remaining systems and structures below floor level, including the EBR-II reactor vessel, will be grouted in place. The end state of EBR-II under Alternative 3 is a concrete/grout monolith that extends approximately 8 ft above ground level.

**Alternative 4, Removal of the EBR-II Reactor Vessel—**Alternative 4 includes demolition of the EBR-II reactor building and removal and disposal of the EBR-II reactor vessel. The containment building would be demolished to ground level or below. Radioactive waste, including the reactor vessel and primary sodium tank components, would be removed from the site and disposed of at the ICDF in accordance with WAC. The end state for Alternative 4 is a below ground-level concrete/grout monolith.

Alternative 3, grouting the reactor vessel in place, was the recommended alternative presented in the EBR-II EE/CA (DOE-ID 2010).

Under Alternative 3, systems and structures above the reactor building floor will be demolished, and most of the remaining systems and structures below floor level, including the EBR-II reactor vessel, will be grouted in place. The final end state of EBR-II under Alternative 3 is a concrete/grout monolith that contains the EBR-II primary coolant tank with internal components, including the reactor vessel. Void spaces remaining will be grouted as practicable, including the basement, sub-basement, and interior of the primary coolant tank, resulting in encapsulation of the reactor vessel. The concrete/grout monolith will extend approximately 8 ft above ground level and will be finished with a concrete cover to facilitate drainage away from the EBR-II site. Residual radioactive materials at EBR-II remaining after D&D activities are completed will stay in place and be managed under the Long-term Management and Control Program. Alternative 3 will take place after the residual sodium metal and sodium-potassium alloy (NaK) remaining in the EBR-II systems are treated or removed in compliance with the approved HWMA/RCRA closure plan. Figure 13 is a conceptual drawing of the Alternative 3 final end state.

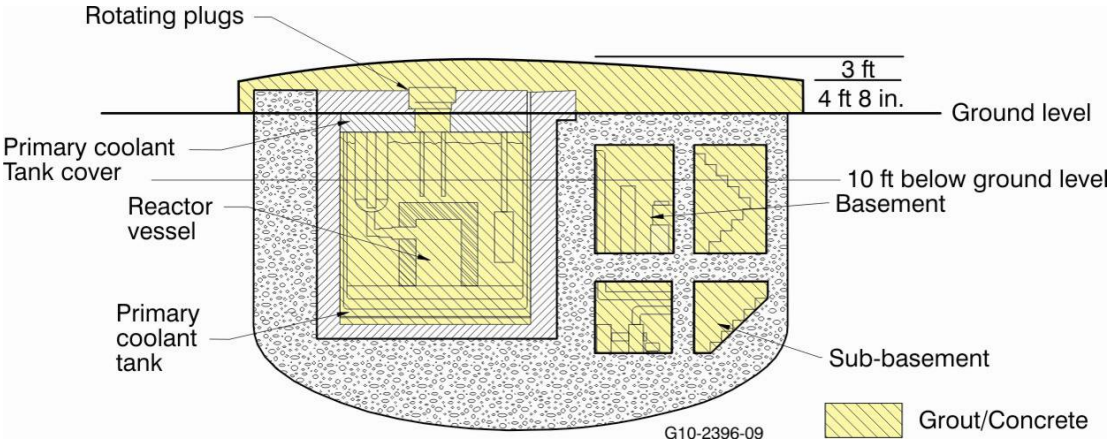


Figure 13. Conceptual drawing of EBR-II Alternative 3, Grouting Reactor Vessel in Place, final end state.

### 5.2.1 Contribution to Remedial Performance

The selected alternative will contribute to the overall cleanup of the INL Site by preventing future releases to the environment of radiological and/or hazardous constituents. No future remedial actions are anticipated to be needed once the concrete monolith is in place.

### 5.2.2 Basis for Selection of Proposed Alternative

In accordance with the *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA* (EPA 1993), the EE/CA's four NTCRA alternatives were evaluated with respect to three criteria: (1) effectiveness, (2) implementability, and (3) cost. The detailed analysis can be found in Section 7 of the EBR-II EE/CA (DOE-ID 2010). Below is a summary of that evaluation.

No action alternatives, such as Alternative 1 and Alternative 2, are hypothetical, conservative, baseline assumptions that offer no reduction in toxicity, mobility, or volume of contaminants in that the sum of all identified chemical and/or radiological contamination, if not properly contained or controlled, may be released to the environment, causing an unacceptable risk to potential receptors. These baseline assumptions are for comparative purposes only and do not reflect DOE's mandate to monitor, maintain, and mitigate potential or actual hazardous or radiological constituent releases to the public or the environment from any facility or site. Therefore, Alternative 1 and Alternative 2 were not carried forward for detailed evaluation.

Alternative 3 grouts the EBR-II reactor vessel in place, is protective of human health and the environment, and is more protective than Alternative 4 for workers, providing fewer and potentially less-consequential industrial hazards and radiological exposures. Alternative 3 costs are about one-third of the cost of Alternative 4.

Alternative 4 completely removes the EBR-II reactor vessel and leaves very little contamination at the EBR-II site, so that it is more protective for human health and the environment than Alternative 3. Alternative 4, with its complexities of dealing with multiple heavy-component lifts and the potential of high-radiological exposure, is less protective of workers than Alternative 3 and costs more.

Both Alternative 3 and Alternative 4 are shown to be within the acceptable risk of less than 1 excess cancer risk in 10,000 people (less than 1E-04); therefore, worker risk is a discriminating factor in choosing the selected end-state alternative. Therefore, Alternative 3 is the selected remedy.

## 5.3 Compliance with Environmental Regulations, Including Those That Are Applicable or Relevant and Appropriate Requirements

Section 121 of CERCLA (42 USC § 9621) requires the responsible CERCLA implementing agency to ensure that the substantive standards of HWMA/RCRA and other applicable laws, as applicable, will be incorporated into the federal agency's design and operation of its long-term remedial actions and into its more immediate removal actions.

Table 1 lists the applicable or relevant and appropriate requirement (ARARs) that have been identified for this removal action. The ARARs list is based on several key assumptions:

- RCRA closure of the sodium-containing systems in the MFC-767 reactor building will be completed in compliance with the *HWMA/RCRA Storage and Treatment Permit for the Experimental Breeder Reactor-II and Buildings MFC-793E and MFC-793F located at the Materials and Fuels Complex on the Idaho National Laboratory* (DEQ 2009).

Table 1. Summary of applicable or relevant and appropriate requirements for the EBR-II non-time-critical removal action.

| Requirement (Citation) | ARAR Type | Comments |
|---|---|---|
| **Clean Air Act and Idaho Air Regulations** | | |
| "Toxic Substances," IDAPA 58.01.01.161<br>"Toxic Air Pollutants, Non-Carcinogenic Increments," IDAPA 58.01.01.585<br>"Toxic Air Pollutants, Carcinogenic Increments," IDAPA 58.01.01.586<br>"Environmental Remediation Source," IDAPA 58.01.01.210.16(a) | Applicable requirement | Applies to any toxic substances emitting during implementation of the removal action. |
| <10 mrem/yr, "Standard," 40 CFR 61.92 | Applicable requirement | Applies to the waste-handling activities. |
| "Emission Monitoring and Test Procedures," 40 CFR 61.93 | Applicable requirement | Applies to the waste-handling activities. |
| "Compliance and Reporting," 40 CFR 61.94(a) | Applicable requirement | Applies to the waste-handling activities. |
| "Standard for Demolition and Renovation," 40 CFR 61.145 | Applicable requirement | Applies to any asbestos-containing materials removed during the decommissioning. |
| "Rules for Control of Fugitive Dust" and "General Rules," IDAPA 58.01.01.650 and IDAPA 58.01.01.651 | Applicable requirement | Applies to the waste-handling activities. |
| **Idaho Solid Waste Facilities Act** | | |
| "Applicable Requirements for Tier II Facilities," IDAPA 58.01.06.012 | Applicable requirement | Applies to disposal of solid wastes. |
| **RCRA and Idaho Hazardous Waste Management Act** | | |
| *Generator Standards:* | | |
| "Standards Applicable to Generators of Hazardous Waste," IDAPA 58.01.05.006, and the following, as cited in it: | | |
| "Hazardous Waste Determination," 40 CFR 262.11 | Applicable requirement | Applies to waste that would be generated during the removal action. |

Table 1. (continued).

| Requirement (Citation) | ARAR Type | Comments |
|---|---|---|
| *General Facility Standards:* | | |
| "Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," IDAPA 58.01.05.008, and the following, as cited in it: | | |
| "Temporary Units (TU)," 40 CFR 264.553 | Applicable requirement | Waste may be treated or temporarily stored in a temporary unit prior to disposal. |
| "Staging Piles," 40 CFR 264.554 | Applicable requirement | Waste may be temporarily staged prior to disposal. |
| "General Inspection Requirements," 40 CFR 264.15 | Applicable requirement | Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility. |
| "Preparedness and Prevention," 40 CFR 264, Subpart C | Applicable requirement | Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility. |
| "Contingency Plan and Emergency Procedures," 40 CFR 264, Subpart D | Applicable requirement | Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility. |
| "Disposal or Decontamination of Equipment, Structures, and Soils," 40 CFR 264.114 | Applicable requirement | Applies to contaminated equipment used to remove, treat, or transport hazardous waste. |
| "Use and Management of Containers," 40 CFR 264.171-178 | Applicable requirement | Applies to containers used during the removal and treatment of hazardous waste. |
| *Land Disposal Restrictions:* | | |
| "Land Disposal Restrictions," IDAPA 58.01.05.011, and the following, as cited in it: | | |
| "Applicability of Treatment Standards," 40 CFR 268.40(a)(b)(e) | Applicable requirement | Applies to hazardous waste and secondary waste, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement. |
| "Treatment Standards for Hazardous Debris," 40 CFR 268.45 | Applicable requirement | Applies to hazardous debris, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement. |
| "Universal Treatment Standards," 40 CFR 268.48(a) | Applicable requirement | Applies to nondebris hazardous waste and secondary waste, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement. |
| "Standards for Universal Waste Management," IDAPA 58.01.05.016 | | |
| "Standards for Large Quantity Handlers of Universal Waste," 40 CFR 273, Subpart C | Applicable requirement | Applies to management of universal wastes. |

Table 1. (continued).

| Requirement (Citation) | ARAR Type | Comments |
|---|---|---|
| **Idaho Groundwater Quality Rules** | | |
| "Ground Water Quality Rule," IDAPA 58.01.11 | Applicable requirement | The waste-handling activities must prevent migration of contaminants from the EBR-II reactor building that would cause the SRPA groundwater to exceed applicable State of Idaho groundwater quality standards in 2095 and beyond. |
| **TSCA** | | |
| "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761 | Applicable requirement | Applicable to removal, decontamination, storage, and disposal of items (including equipment) with PCB contamination. |
| **Migratory Bird Treaty Act of 1918** | | |
| "Protection of Migratory Game and Insectivorous Birds," 16 USC 7 | Applicable requirement | Applies to disturbances of nesting migratory birds. |
| **To-Be-Considered Requirements** | | |
| "Radiation Protection of the Public and the Environment," DOE O 5400.5 Chg 2, Chapter II(1)(a,b) | TBC | Applies to the EBR-II reactor building before, during, and after the removal action. Substantive design and construction requirements would be met to keep public exposures as-low-as-reasonably-achievable. |
| "Radioactive Waste Management," DOE O 435.1 Chg 1 | TBC | Applies to the EBR-II reactor building before, during, and after the removal action. Substantive design and construction requirements would be met to protect workers. |
| *Region 10 Final Policy on the Use of Institutional Controls at Federal Facilities* (EPA 2006) | TBC | Applies to residual waste following completion of the removal action. |

| | | | | | |
|---|---|---|---|---|---|
| ARAR | applicable or relevant and appropriate requirement | ICDF | Idaho CERCLA Disposal Facility | TBC | to be considered |
| CFR | Code of Federal Regulations | IDAPA | Idaho Administrative Procedures Act | TSCA | Toxic Substances Control Act |
| DOE | U.S. Department of Energy | PCB | polychlorinated biphenyl | USC | United States Code |
| EBR-II | Experimental Breeder Reactor II | RCRA | Resource Conservation and Recovery Act | WAC | waste acceptance criteria |
| EPA | U.S. Environmental Protection Agency | SRPA | Snake River Plain Aquifer | | |

- Lead shielding will be removed from the MFC-767 reactor building prior to initiation or during this removal action through other regulatory activities intended to place the facility in an environmentally safe condition. Some lead, such as impractical-to-remove lead incidental to demolition (for example wall anchors), may remain in place or may be managed under the scope of the NTCRA as CERCLA waste and will be disposed of in the ICDF in accordance with WAC. Removed lead that cannot be recycled or reclaimed shall be declared a hazardous waste or mixed low-level waste, will be managed in accordance with the substantive requirements of the HWMA/RCRA, and will be disposed of at an off-Site disposal facility in accordance with the disposal facility WAC.

- Disposal of CERCLA waste generated during the removal action at ICDF will be subject to meeting the ICDF WAC (DOE-ID 2009b).

- If decontamination liquids are generated, they will be disposed of at the ICDF evaporation ponds in accordance with the approved WAC. Small amounts of decontamination liquid may be solidified with absorbent and be disposed of in the disposal cells at the ICDF.

- Debris generated during this removal action may be covered with paint that contains polychlorinated biphenyls (PCBs). If encountered, such waste may trigger substantive requirements of the Toxic Substances Control Act (15 USC § 2601 et seq.). Lead-contaminated paint also may be present on demolition debris and would be subject to the substantive requirements of RCRA hazardous waste regulations. Nonhazardous low-level waste will be disposed of at the ICDF. Waste that can be demonstrated to be nonhazardous and to contain no added radiological constituents will be eligible for disposal as solid waste at an approved on-Site solid waste disposal facility. Any PCB-containing electrical equipment, such as PCB-containing light ballasts or capacitors, will be removed and disposed of off-Site at an approved disposal facility.

- Asbestos-containing material, both friable and nonfriable, may be encountered incidental to performance of this NTCRA. Friable or regulated asbestos-containing material will be subject to substantive asbestos regulations and will be acceptable for disposal at the ICDF and/or, if not radiologically contaminated, at an approved on-Site solid waste disposal. Nonradiologically contaminated asbestos that is nonfriable may be disposed of at the MFC CERCLA Demolition Waste Landfill or another appropriate solid waste disposal facility. Regulated asbestos will be removed and disposed of as required by 40 CFR 61.150, "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations." Undisturbed asbestos or asbestos found in high-radiation, high-contamination, and/or inaccessible locations may be left in place.

- Mercury located in mercury fluorescent lamps is planned for removal prior to this removal action under other regulatory activities intended to place the facility in an environmentally safe condition, as are the mercury-containing electrical switches and lights. No mercury at concentrations of regulatory concern is expected to be present in the building substructure at the start of the removal action.

## 5.4 Cultural Resources

Section 106 of the National Historic Preservation Act of 1966 (16 USC § 470 et seq.), as amended, requires agencies to consider the impact of undertakings on properties listed or eligible for listing in the National Register of Historic Places and to consult with the Idaho State Historic Preservation Officer and other interested parties when impacts are likely. It also requires federal agencies to invite the Advisory

Council on Historic Preservation to participate in consultation when impacts may be adverse. The National Historic Preservation Act, Section 106, process has been tailored to meet the unique needs of the INL Site. Section 110 of the National Historic Preservation Act directs federal agencies to establish programs to find, evaluate, and nominate eligible properties to the National Register of Historic Places, including previously unidentified historic properties that may be discovered during the implementation of a project (36 CFR 800). In addition, the "Archaeological Resources Protection Act of 1979" (16 USC § 470aa–470mm), as amended, provides for the protection and management of archaeological resources on federal lands.

Procedures and strategies to tailor these requirements to the unique needs of the INL Site are described in the *Idaho National Laboratory Cultural Resource Management Plan* (DOE-ID 2007). The INL Cultural Resource Management Plan is implemented through a programmatic agreement between DOE-ID, the Idaho State Historic Preservation Officer, and the Advisory Council on Historic Preservation (DOE-ID 2007).

The MFC-767 EBR-II reactor building is a Category 1 historic property, eligible for nomination to the National Register of Historic Places. DOE-ID has made the decision to proceed with demolition of the facility. To mitigate the adverse impacts caused by such action, DOE-ID, through measures outlined in the INL Cultural Resource Management Plan and by the 2005 *Memorandum of Agreement Between the United States Department of Energy, Idaho Operations Office, and the Idaho State Historic Preservation Office* (DOE-ID 2005) and the 2004 Programmatic Agreement (contained in DOE-ID 2007), has committed to the preservation of the MFC-767 building and reactor history through the completion of a Historic American Engineering Record for the facility and large-format photographs of the facility. A letter advising the State Historic Preservation Office of DOE-ID's preferred alternative for demolition of the EBR-II reactor building and vessel disposition was transmitted on October 22, 2009, and outlines the planned mitigation actions for the preferred alternative (Gallegos 2009).

## 5.5 Natural Resources

DOE-ID was required to review as guidance the most current U.S. Fish and Wildlife Service list for threatened and endangered plant and animal species. DOE-ID determined that none of the alternatives would impact any threatened and endangered species and also determined that formal consultation with the U.S. Fish and Wildlife Service was not required for this action.

## 5.6 Project Schedule

Completion of the selected alternative for this removal action is planned to occur on or before December 2011. However, meeting this schedule is contingent on successful treatment of sodium and NaK alloy contained in the EBR-II primary systems and certification of closure of this HWMA/RCRA unit.

# 6. PROJECT COST

Detailed cost estimates were prepared for the EE/CA Alternatives 2, 3, and 4. No costs are associated with Alternative 1, No Action, because the EBR-II reactor building would be simply left to degrade.

The estimates were prepared in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). Costs are calculated for both D&D costs and future surveillance and maintenance expenses. In accordance with EPA guidance, the cost for the alternatives over time is calculated as present net worth costs, which are the costs in 2009 dollars.

Alternative 2 assumed maintenance of the EBR-II reactor building over an 85-year period ending in 2095. Alternative 2 would require ongoing surveillance, including routine radiological inspections and instrument checks. Maintenance includes facility repairs, maintaining the ventilation systems and heat, and periodic repainting of the EBR-II reactor building. Surveillance and maintenance costs for Alternative 2 would likely go beyond the institutional control period for an indeterminable period of time; therefore, CY 2095 was used for comparative purposes. For Alternative 3 there will be some surveillance and maintenance costs on the concrete monolith; these costs are estimated to be approximately $60,000 over the 85-year planning window.

Changes in the cost elements are likely to occur as a result of new information and data collected during the performance of the removal action. Major changes will be documented in the form of a memorandum placed into the Administrative Record file. The cost estimates were an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30% of actual project cost. The present-worth cost estimate for Alternative 3, the selected alternative, is $15,460,000, which was $15,000,000 less than the estimated cost to complete Alternative 4.

# 7. EXPECTED CHANGE SHOULD ACTION BE DELAYED OR NOT BE TAKEN

The expected change to the EBR-II reactor and reactor building, should action be delayed or not be taken, would be that the facilities would remain under administrative and institutional control. However, as the facilities continue to age, the threat of substantial release of radiological and hazardous substances increases with time, and containing these materials and preventing them from being released to the environment becomes more difficult. The surveillance and maintenance activities required to confine the hazardous substances may increase the risk of potential exposure to personnel. If the action were delayed, continued expenditures for surveillance and maintenance costs would accrue during the time interval elapsed until final decommissioning activities are performed.

# 8. STATUTORY AND REGULATORY AUTHORITY

The proposed removal action is being undertaken in accordance with 40 CFR 300.415, by DOE-ID, as the lead agency, pursuant to CERCLA, Section 104(a) (42 USC 9604), and Executive Order 12580, as recognized by Section 5.3 of the Federal Facility Agreement and Consent Order (DOE-ID 1991). In accordance with 40 CFR 300.415(j) and DOE guidance, on-Site removal actions conducted under CERCLA are required to meet ARARs to the extent practicable considering the exigencies of the situation. DOE-ID will comply with the ARARs and the “to-be-considered” guidance as set forth in Section 5.3.

# 9. OUTSTANDING POLICY ISSUES

There are no outstanding policy issues.

# 10. ENFORCEMENT

DOE-ID is conducting this removal action as the lead agency under the authority of 40 CFR 300.5, "Definitions," and 40 CFR 300.415, "Removal Action."

# 11. SELECTED ALTERNATIVE

The selected removal action alternative is Alternative 3. Under Alternative 3, systems and structures above the reactor building floor will be demolished and most of the remaining systems and structures below floor level, including the EBR-II reactor vessel, will be grouted in place. The final end state of EBR-II under Alternative 3 is a concrete/grout monolith that contains the EBR-II primary coolant tank with internal components, including the reactor vessel. Void spaces remaining will be grouted as practicable, including the basement, sub-basement, and the interior of the primary coolant tank, resulting in encapsulation of the reactor vessel. The concrete/grout monolith will extend approximately 8 ft above ground level and will be finished with a concrete cover to facilitate drainage away from the site. Residual radioactive materials at EBR-II remaining after D&D activities are completed will stay in place and be managed under the Site-Wide Long-Term Management and Control Program.

Nonhazardous, low-level radioactive waste generated as part of this removal action will be disposed of at the ICDF in compliance with facility WAC. Demolition debris that is not hazardous waste and is nonradiologically contaminated and that meets the requirements of the Idaho Solid Waste Management Rules for Tier II landfills (IDAPA 58.01.06.012) will be disposed of at the MFC CERCLA Demolition Waste Landfill or another appropriate solid waste disposal facility.

The selected alternative meets the proposed removal action objectives for human health and environmental protectiveness and is cost-effective. It also is consistent with the remedial action objectives of the OU 9-04 ROD (DOE-CH 1998); is compliant with ARARs; and satisfies the DOE goal of reducing the "risk footprint" to as practicable an extent as possible in consideration of (a) ALARA principles governing radiological exposure to decommissioning personnel, (b) safe engineering standards, (c) ICDF WAC (DOE-ID 2009b), and (d) desired CERCLA site end states. Figure 14 is a conceptual final end state for Alternative 3 showing the EBR-II end state concrete monolith.

# 12. PUBLIC PARTICIPATION

Appendix A describes the public participation process and provides a summary of the comments received along with the responses to the comments. Appendix B is a list of the individual comments received and a reference to the response in Appendix A. Appendix C is the letter received from the INL Site Environmental Management Citizens Advisory Board documenting the recommendation of selecting Alternative 3. Appendix D is the news article received during the public comment period.

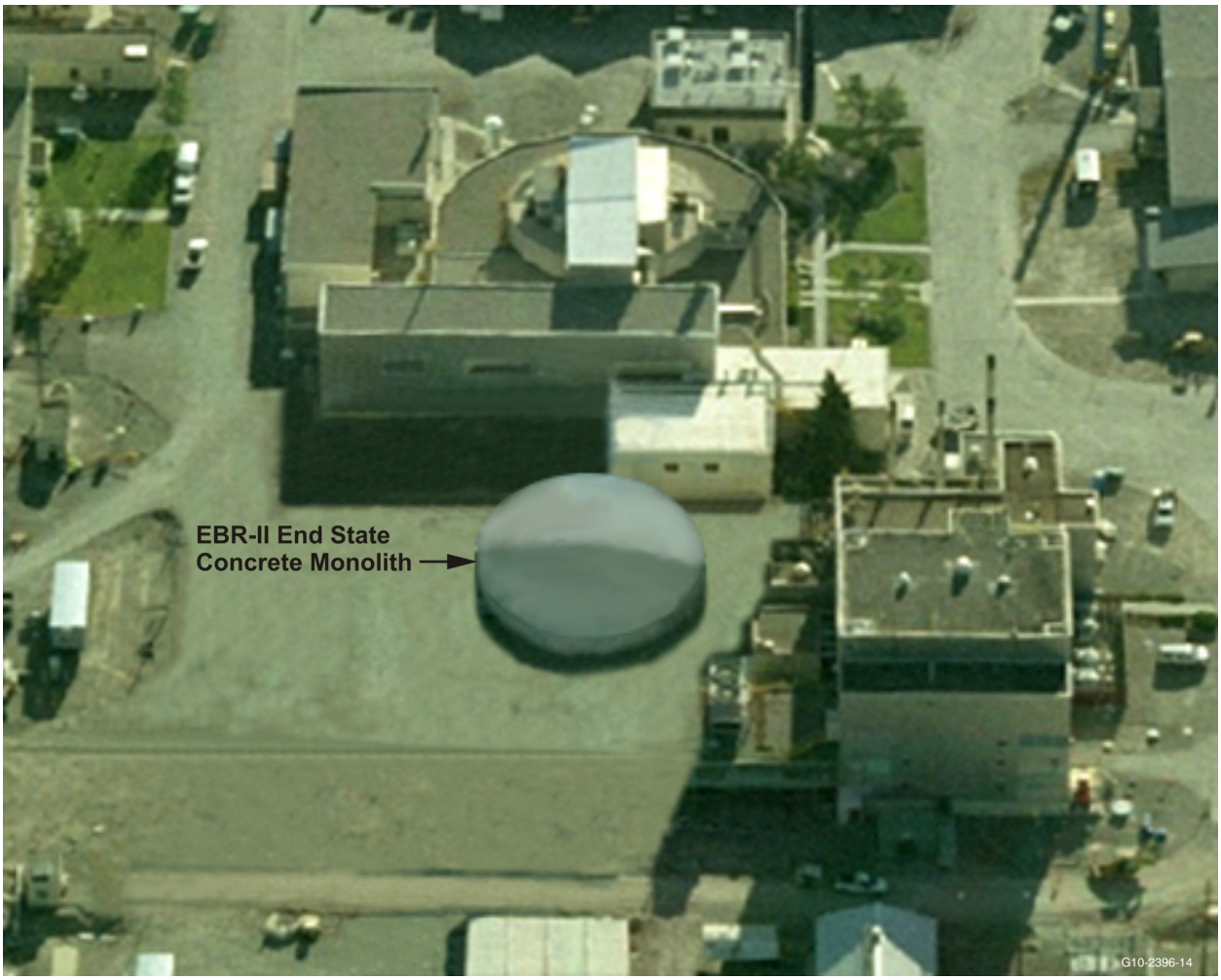


Figure 14. Conceptual end state of EBR-II under Alternative 3.

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# Appendix A

# Comments Received During the Public Comment Period and Responses to Comments

# Appendix A

# Comments Received During the Public Comment Period and Responses to Comments

The public participation period for the *Engineering Evaluation/Cost Analysis (EE/CA) for the EBR-II Final End State* (DOE-ID 2010) was from January 21, 2010, through February 22, 2010. A public notice was sent to nine different Idaho and Wyoming newspapers that began the public participation period. The notice was posted in the U.S. Department of Energy (DOE) Administrative Record electronically, and hard copies of the document were sent to the DOE Public Reading rooms in Idaho Falls and Boise. A presentation was provided to the Idaho National Laboratory (INL) Citizens Advisory Board on January 21, 2010, which was also open to participation from the general public. A separate presentation was also made to the Shoshone-Bannock Fort Hall Business Council February 18, 2010. Written comments on the EE/CA have been received from:

Shoshone-Bannock Tribes, Fort Hall, Idaho

The INL Citizens Advisory Board

Mr. John Tanner, President of Coalition 21, Idaho Falls

Mr. Evan Belnap, Idaho National Laboratory

Mr. Mark L. Stoneberg, Idaho National Laboratory

Ms. Zee Hill, Olympia, Washington

Ms. Dawn Cowan, U.S. Forest Service

Dr. Steve Sherman, Aiken, South Carolina

Mr. Ben Cowan, Idaho National Laboratory

Mr. David Russell Corrigan, Idaho National Laboratory

Mr. John Silva, Twin Falls, Idaho

Mr. Allen Schubert, Ammon, Idaho

Mr. Bevin A. Brush, Idaho Falls, Idaho

Dr. Barney Hadden, Idaho National Laboratory

Mr. Franklin Just, Idaho Falls

Mr. Alan Christensen

Mr. Joseph Piccoli

Mr. Marty Huebner, Sun Valley, Idaho.

Comments received were compiled and comments that are similar in meaning are summarized and consolidated below. A complete list of public and Shoshone-Bannock Tribes comments is presented in Appendix B along with the resolution references to the comment responses. DOE appreciates all of the comments received.

*Comment #1: Some commenters stated that they preferred EE/CA Alternative 2, No Action: Continued Surveillance and Maintenance, so the EBR-II reactor and reactor containment dome (building) can be preserved as a symbol of pride and for the history that the facility represents.*

**Response:** The Cultural Resource Management Plan negotiated with the State Historical Preservation Office (SHPO) for the INL Site includes the agreement for how historic properties on the INL Site will be dispositioned and the requirements for maintaining historical records. The EBR-II reactor is a Category 1 historic facility. As such, the agreement requires that a Historic American Engineering Record (HAER) report be completed prior to significantly altering the structure.

The HAER report is being prepared and will be completed by the end of May 2010. With submittal of this document to the SHPO, DOE-ID will have completed its agreed-upon responsibilities with regard to historical preservation. The EBR-II HAER report is being written by Susan Stacy (author of *Proving the Principle*) and includes information such as the original construction drawings and many historic photos. The report will capture the unique and creative use of this facility and its place in nuclear history in the United States.

While DOE-ID is equally interested in preserving the history of important facilities on the INL Site, preserving EBR-II as an historical landmark for potential public access is an unworkable end state for several reasons. Ongoing and future missions within the MFC involving nuclear fuel development and associated research preclude public access due to security reasons, with a number of facilities also having significant and unique safety requirements. Although public tours of certain areas on the INL Site are conducted, MFC, because of its nuclear-related mission, is not one of them. Specifically, the EBR-II reactor is a radiological facility requiring dosimetry and security badging or escorted access.

DOE-ID must also demonstrate that it can complete the facility life-cycle for reactors and other major facilities, which is accomplished through the decommissioning and demolition process, as has been completed for the Engineering Test Reactor (ETR), Power Burst Facility reactor, Loss-of-Fluid Test reactor, and the CPP-601/640 Fuel Processing Facility. These actions demonstrate that nuclear power is a manageable part of the national infrastructure and that DOE can close and dispose of facilities and safely handle and disposition nuclear waste materials once their useful life has been expended. In addition, there is a long-term liability associated with maintaining aging facilities on the INL Site. Addressing this liability by reducing the footprint of facilities requiring ongoing surveillance and maintenance is part of safely and efficiently managing INL Site facilities. This cradle-to-grave approach to facilities management will remove a barrier for new nuclear projects on the INL Site as well as potentially removing that barrier for nuclear infrastructure in the United States.

In order to preserve and make available to the public as much of the construction and operational history of the EBR-II reactor as possible, DOE-ID will prepare an EBR-II display at the EBR-I reactor National Historical Landmark. DOE-ID will form a public focus group to assist in determining the content and layout of the exhibit. The landmark is open for general public access from Memorial Day to Labor Day to allow visitors to see and read about the achievements that have occurred at the INL Site since its inception in the late 1940s. This facility is staffed with knowledgeable interpreters who help the public understand the advancements in nuclear energy research and development that have taken place at the INL Site.

*Comment #2: Several comments noted that Alternative 2, No Action; Continued Surveillance and Maintenance, was less expensive than Alternative 3, Grouting the Reactor in Place, which includes the removal of the reactor building.*

**Response:** The EE/CA only presented costs for Alternative 2 through the year 2095. Alternative 2 will be less costly in the short term but more costly to maintain the dome and radiological controls in preventing

migration of radiological constituents to the environment and human receptors, in the long term. As the facility ages, maintenance costs will increase dramatically. Currently, the EBR-II carbon steel containment dome is showing signs of rust and one of the ventilation systems that provides for air movement has failed and requires repair or replacement. Therefore, given the reasons in response to Comment #1, the facility would still be proposed for decommissioning sometime in the future, thereby requiring additional funding for this level of effort. Alternative 2 is about deferred costs rather than cost savings.

> *Comment #3: Several comments were in favor of Alternative 3, Grouting the Reactor in Place, which includes the removal of the reactor building. Additionally, one commenter stated that it would be a waste of money to maintain EBR-II because it is "totally obsolete and will never be used again."*

**Response:** The Department of Energy agrees with the comment and believes that the advancement of nuclear energy research and development is better demonstrated by bringing legacy buildings to a safe and stable end state.

> *Comment #4: One comment stated that "it appears that the RCRA permit was not considered in selecting the best option for EBR-II" and also stated that grouting was not the preferred option for achieving the goals of the RCRA permit.*

**Response:** Residual sodium and sodium-potassium (NaK) alloy remaining in the EBR-II facilities are being managed outside of this removal action and in accordance with the *HWMA/RCRA Storage and Treatment Permit for the Experimental Breeder Reactor - located at the Materials and Fuels Complex on the Idaho National Laboratory.* This Resource Conservation and Recovery Act (RCRA) (42 USC 6901 et seq.) permit and the associated closure plan will guide the handling, storage, and treatment of sodium and NaK until the closure performance standards provided in the closure plan are satisfied. Sodium and NaK treatment are expected to take place before the initiation of activities under this removal action, but some closure activities may indeed occur concurrently with this activity. There currently is estimated to be 500 gal of elemental sodium in the primary coolant tank and 350 gal in the ancillary systems (e.g., Radioactive Sodium Chemistry Loop). Much of the sodium in the primary tank is coated with a sodium bicarbonate layer that is a result of previous treatment (carbonation). Moist carbon dioxide was vented into the primary coolant tank and some of the ancillary equipment to slowly react the sodium. This treatment resulted in the sodium bicarbonate layer and will have to be dissolved in future treatment regimes to allow treatment of the underlying untreated sodium metal. Grouting the primary coolant tank or any lines that previously contained sodium or NaK will occur subsequent to certification that these RCRA hazardous materials have been treated to the performance standards established in the RCRA permit/closure plan.

> *Comment #5: Several comments stated that Alternative 2 leaves the environment cleaner than Alternatives 3 and 4 because there would be no disruption of hazardous materials.*

**Response:** Alternative 2 is essentially an interim measure that only delays a needed future action. The EBR-II EE/CA describes the assessment of risk for the environment and concludes that both Alternatives 3 and 4 are protective of the environment over the long term while Alternative 2 was not.

> *Comment #6: One comment stated that they are very surprised that the Department of Environmental Quality has not objected to all but Alternative 2.*

**Response:** The DRAFT EBR-II EE/CA was reviewed by the State of Idaho Department of Environmental Quality (DEQ) as well as the EPA in accordance with the CERCLA non-time-critical-removal-action (NTCRA) process. The Agencies also reviewed additional support documents before providing comments to DOE, which resulted in the Agencies' selection of Alternative 3 as the preferred

alternative. The Agencies' support was predicated on Alternative 3 being protective of human health and the environment, including protecting the workers performing the removal action as well as the co-located workers at MFC and the general public.

DEQ is also mindful of preserving historical sites at the INL Site. However, the agency's role in the NTCRA process is as a reviewer of the EE/CA and as a signatory to the Action Memorandum with DOE and EPA, which authorizes DOE to proceed with D&D of EBR-II. An EPA/DOE policy and the tri-agency *Federal Facilities Agreement/Consent Order* (FFA/CO 1991) agreement guide DEQ in its review of INL Site NTCRA EE/CAs and selection of a preferred alternative. The 1995 *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response) Compensation) and Liability Act* (CERCLA) gives DOE the authority to use the streamlined NTCRA approach for decommissioning surplus facilities at its sites. DOE determines the schedule for the NTCRA process by submission of the draft EE/CA to DEQ and EPA, resolves comments from the Agencies, and, in concurrence with DEQ and EPA, selects a preferred alternative. DEQ and EPA independently evaluated the EBR-II EE/CA and supporting information and came to the conclusion that Alternative 3 best satisfies the criteria for effectiveness, implementability, and cost; with further analysis as to protectiveness of the public, D&D workers, and the environment; technical feasibility; availability of equipment, personnel, services, and disposal facilities; and other regulatory requirements, such as the regulations under the State of Idaho Hazardous Waste Management Act.

As explained in the EE/CA and elsewhere in this Response to Public Comments, previous D&D of reactor facilities at the INL Site has typically resulted in complete removal and disposal of the reactor in the Idaho CERCLA Disposal Facility (ICDF), in keeping with DOE's policy of "footprint reduction." However, given the complexity of the EBR-II primary coolant tank and reactor construction, worker access to perform specific tasks to separate and remove these assemblies was deemed an unacceptable worker radiation exposure, not in keeping with as-low-as-reasonably-achievable (ALARA) guidance. This determination, coupled with the extremely heavy weight of the tank and reactor, limited space in which to lift and move the reactor and tank, lack of available transport trailers, and over-the-limit width and weight issues for highway transport, all lead to the decision that D&D of EBR-II would best be met by removing the above-ground less-contaminated containment dome and other components and by filling the below-ground reactor and tank area with grout. Allowing the radiation (mainly cobalt-60) to decay to a safe level many decades from now to possibly provide for safe access for workers to separate and remove the reactor and coolant tank would still not address the weight, limited space, or transportation issues. Furthermore, reactor disposal at the ICDF will no longer be available for use at this point in time, precluding efficient and cost-effective disposal.

Following the issuance of this Action Memorandum and D&D of the EBR-II facility, DEQ and EPA will oversee DOE as it meets its obligation to perform long-term maintenance and control of the EBR-II end-state monolith and surrounding area. This oversight role will be accomplished under the INL CERCLA Site-Wide Institutional Controls and Operations and Maintenance program, which is already in use and functional at the INL Site.

*Comment #7: One comment stated: "Shut down the reactor and destroy it".*

**Response:** The EBR-II reactor has been shut down since 1994 and the fuel has been removed. The reactor is no longer able to operate nor is it able to be restarted in the future.

*Comment #8: Several comments were received concerning the "life expectancy" of the grout that would be used in the EBR-II end state monolith and what effects high radiation would have on the grout.*

**Response:** The final end state of the EBR-II facility will have the below-floor areas spaces, including the reactor, filled with grout. This grouted area will then be encased in a robust reinforced concrete cover both on top and on the sides of the grouted areas. Since both grout and concrete are very stable construction components, it is believed that the monolith will be intact for many centuries. The oldest known concrete structure is the Pantheon in Rome, Italy. The concrete dome of the Pantheon was completed about 125 AD, nearly 19 centuries ago, and is currently still intact and functioning as the builders intended.

The ETR and the Materials Test Reactor (MTR) have received many thousands of times the radioactive flux as the grout that will be placed inside the EBR-II reactor. The concrete material surrounding these two reactors (ETR and MTR) have been inspected and there has been no degeneration seen. The grout immediately inside the EBR-II reactor vessel may degrade slightly due to thermal heat from the heat of radioactive decay; however, the reactor vessel is surrounded by approximately 8 additional feet of grout, two stainless steel tanks, another carbon steel tank, and 6 or more feet of concrete that are not affected by this thermal heat. Therefore, the grout and the concrete that forms the vast majority of the monolith will remain structurally sound and functioning, as intended, to prevent migration of contaminants or intrusion by an ecological receptor. The EBR-II concrete monolith will be inspected regularly as part of the Site-Wide Institutional Controls and Maintenance Program. Any maintenance required on the concrete cover, such as cracks or chips, will be repaired to ensure the integrity of the cover is maintained.

*Comment #9: One commenter asked if the cumulative effects to workers were ever calculated.*

**Response:** For a number of reasons, including the variations of individuals in a population, it is extremely difficult to "calculate" the cumulative effects of radiation exposure on workers. Ultimately, all of the numerical standards for radiation protection are tied back to radiobiology data. In the earliest standards, these data were chiefly from animal experiments. As experience has grown, more and more human data have been obtained through the use of radiation in a variety of medical treatments and through data from occupational workers and radiation accidents. Unfortunately, much of the data has been obtained at doses and dose rates well in excess of those typically encountered in the workplace. For example, the average dose rate received by workers (who actually received a recorded dose above background radiation levels) in 1991 at U.S. commercial nuclear power stations was 0.00029 rem per hour. The typical dose rates for medical uses might be 100,000 or 1 million times higher. DOE is mandated to keep exposures ALARA. The federal limit for exposures is 5 rem per year total whole body dose. DOE sets an administrative limit of 0.700 rem per year for workers to ensure the federal limits are not encroached upon. Average exposure to D&D personnel is significantly less than the 0.700-rem per year.

*Comment #10: One commenter wanted to know what the ecological target species was.*

**Response:** There was no one specific target species that was evaluated; rather, the ecological risk assessment performed for the EBR-II EE/CA evaluated various plant and invertebrate species as well as 13 animal species. These included Great Basin Spadefoot toads, ferruginous hawks, pygmy rabbits, and deer mice. The assessments conducted for radiological contaminants for all alternatives demonstrated no unacceptable risk to ecological receptors at the population level. For the nonradiological assessment, and specifically for the selected Alternative 3, three metals (chromium, manganese, and nickel) did not screen out. However, these metals were subsequently eliminated from further assessment by the Agencies due to the very conservative risk assessment assumption that all piping, wiring, and stainless steel would uniformly degrade (corrode) and these metals would be evenly distributed in the soil and available for bio-uptake. This decision is further supported by the understanding that the wiring, piping, and stainless steel would be additionally isolated from the surrounding soil by encapsulation in grout inside the structure.

*Comment #11: One commenter wanted to know if a human risk assessment was done for sensitive populations and why was cobalt used as the driving risk factor for the assessment.*

**Response:** Yes, a human health risk assessment was performed for all alternatives using a hypothetical, very conservative scenario where a family builds a house with a basement (10 ft below ground level) on the EBR-II site after it has degraded to rubble over the next 85 years. The family would live in the house for 30 years, including 6 years of childhood, and be exposed to radiation from direct exposure, ingestion of crops grown in contaminated soil, ingestion of animals consuming contaminated soil, plants grown in contaminated soil, inhalation of fugitive dust, and consumption of contaminated groundwater. Radioactive cobalt-60 makes up about half of the current (2009) radiological inventory; however, for purposes of the risk assessment the EBR-II site would not be available for building the home until 2095 (CERCLA program assumption when institutional controls could hypothetically be relaxed). In 2095, most of the cobalt-60 would have decayed away with strontium-90 becoming the dominant risk driver for soil ingestion/inhalation at 1.69E-04 for Alt 1 with no removal or grouting, and 8.45E-05 for Alt 3 with partial removal and grouting of the reactor in-place. For groundwater risk after 2095, carbon-14 is the dominant risk driver with a maximum risk of 6.48E-05, in the year 2224 for Alt 1, and 5.14E-08 in 2610 for Alt 3, due to delayed mobility of C-14 in the cement grout. All of the Alt 3 risks are below 1E-04, which is the acceptable risk level established for CERCLA removal actions at the INL Site.

*Comment #12: One commenter stated that she would like to see more removal actions done before the facility is filled with grout.*

**Response:** There is significant removal of hazardous materials, such as lead and mercury, currently ongoing at EBR-II. Asbestos and depleted uranium are also being removed. Radioactive sodium will be treated and the sodium-bearing systems will be flushed. Removal of the hazardous materials and flushing of the sodium systems will remove much of the radiological contamination in the EBR-II building, leaving only the activated materials in the primary coolant tank associated with the reactor vessel. As discussed in the EE/CA, removal of the reactor vessel is unlike previous reactor removals at the INL Site in that worker access to remove the primary coolant tank and the reactor from the structure would require radioactive exposure to workers not in accordance with ALARA. Additionally, although heavy lifting and rigging is a relatively routine aspect of D&D reactor removal at the INL Site, the challenges for EBR-II are unique due to the weight involved and limited space available for crane and equipment placement and movement, further contributing to D&D worker risk.

*Comment #13: One commenter stated that the safety of the workers and others when they attempt this monumental task should be considered. Good planning and lessons learned should be addressed prior to and during the completion of these tasks.*

**Response:** DOE agrees with the comment. Safety of workers and other people that can be affected by the D&D activities are of greatest importance while planning and executing the work. Identification of the hazards before the work is begun and mitigation of those hazards is required of every task, no matter how seemingly inconsequential they may be. Incorporation of lessons learned from similar activities is also key in performing the work safely. Work is done in accordance with approved procedures that include those hazard mitigations and lessons learned.

*Comment #14: One comment stated that for some DOE activities, including the EBR-II removal action, where "'footprint reduction" is claimed to occur there is no actual reduction in the footprint. This commenter goes on to state areas that are determined to be cleaned up are not being cleaned but removed to other locations on the INL on site or left in place and grouted.*

**Response:** In the last 5 years, DOE has made significant reductions in the actual physical area (footprint) occupied by building or structures on the INL Site. In this time period, over 160 buildings or structures have been decommissioned and demolished, most of them completely demolished to below ground

surface. This accounts for nearly 1.7 million $ft^2$ of footprint reduction. As stated in the EBR-II EE/CA, footprint reduction will be accomplished as long as worker safety is not compromised. Specifically, the EBR-II EE/CA states, in reference to Alterative 3, grouting the reactor in place:

> .....satisfies the U.S. Department of Energy goal of reducing the "risk footprint" to as practicable extent as possible in consideration of (a) ALARA principles governing radiological exposure to decommissioning personnel, (b) safe engineering standards, (c) waste acceptance criteria for the ICDF, and (d) desired CERCLA site end states.

RCRA-designated hazardous wastes, such as lead, mercury, and silver contained in shielding, switches, and solder from circuit boards, are removed and shipped out of Idaho to another disposal facility. It is simply not practical nor responsible to ship all waste material and debris from D&D at the INL Site out-of-state. Nonradioactive and nonhazardous wastes are consolidated into designated industrial landfills on the INL Site. Low-level radioactive waste is consolidated in a state-of-the-art lined landfill at the Idaho CERCLA Disposal Facility where radioactive wastes are allowed to decay while being confined.

*Comment #15: One comment stated a concern about the foundation of the reactor building and its ability to withstand the additional weight if the building is grouted.*

**Response:** Prior to construction of the EBR-II building (containment dome), the site was excavated to basalt; some of the basalt was removed so that the lower portions of the dome were actually sitting on and surrounded by the basalt. The foundation was designed to hold many times the weight of the reactor building and all of the contents, including the 86,000 gal of sodium that is now removed. This foundation will easily support the weight of the grout and concrete that will form the resultant EBR-II monolith. One other related note: before EBR-II was sited at its current location in the late 1950s, a site evaluation was conducted that included evaluating whether there were any void spaces below the building site such as lava tubes or caves. This evaluation determined that the basalt did not have any significant voids that would collapse once the weight of the building and all the internals were in place.

*Comment #16: One commenter noted that the term "relative routine" was included in the EBR-II EE/CA for the work activities that would need to be done to complete Alternative 3. The comment went on to note that when working with high radiation fields there is always a potential for human error and contaminant exposure.*

**Response:** DOE agrees that working around high-radiation fields is inherently hazardous and is one of the major reasons why Alternative 3 was recommended as the preferred alternative. Alternative 3 provides far less opportunity for a worker to be exposed to high radiation as opposed to Alternative 4, removing the reactor vessel. The activities to complete Alternative 3 are routine for the D&D workers performing the activities because the hazards have been encountered before by these D&D crews, and the methods to mitigate the hazards are well understood.

*Comment #17: One commenter stated a concern for exposure to workers as they removed the building (containment dome) down to the floor level.*

**Response:** Radiological surveys of the above-floor areas of EBR-II have indicated there is minimal contamination on the containment dome. As long as the primary coolant tank containing the reactor vessel is left intact, the potential for exposure to the workers while removing the dome is minimal. Furthermore, the primary coolant tank will be grouted to protect any potential penetration into the primary coolant tank and resultant release of contamination and radiation during containment dome removal.

*Comment #18: One commenter stated a concern for worker safety as sodium is being removed from the EBR-II systems.*

**Response:** We understand the concern the commenter has and are taking extraordinary precautions in dealing with the sodium and sodium treatment. DOE is overseeing the contractor (CWI) for the performance of this work. CWI has visited the FERMI-I sodium-cooled reactor in Michigan to learn how sodium treatment is being accomplished there, and CWI brought back to Idaho many of the lessons learned that they will apply to the sodium treatment activities at the INL Site. CWI has also subcontracted with a specialized sodium treatment company with significant experience in successfully treating alkali metals (including sodium).

*Comment #19: The Shoshone-Bannock Tribes asked if the MFC facility monitoring wells can be added to the list of wells currently monitored by the Tribes.*

**Response:** Yes, these wells will be added to the list of wells monitored by the Tribes as negotiated in the Agreement of Principle and the Monitoring Agreement, which covers their monitoring activities. Funding is provided under a cooperative agreement with the Tribes for these monitoring activities.

# Appendix B

# Comment Resolution Matrix

# Appendix B

# Comment Resolution Matrix

| # | Commenter | Comment | Appendix A Response Reference |
|---|---|---|---|
| 1 | Evan A Belnap<br>Idaho National Laboratory | I am definitely not in favor of tearing down EBR-II. This reactor is an icon and represents great accomplishments for the United States in the nuclear world. I believe it should stand as a reminder of what we had and what we could have had better if the Democrats hadn't shut it down. We lost billions of dollars of research and future research that this great reactor could have still been providing. | Please see the response to Comment #1. |
| 2 | Mark L Stoneberg<br>Idaho National Laboratory | To whom it may concern,<br>I have worked at Argonne/MFC for 35 years and EBR-II has always been a great pride for me while working for the labratory. I cannot believe that we as a lab can opt to demolish this symbol of pride and the history that this facility represents. I vote that we leave EBR-II intact and complete for all of us and for those generations to come. | Please see the response to Comment #1. |
| 3 | Zee Hill<br>Olympia Washington | What are they thinking?!?!?! Taking down EBR-II…..that is unthinkable! My husband worked at the site from 1961 until he died in 2002 and he started out at EBR-II and during the 1980's was the manager of the Satsop Nuclear Power Plant in Washington. He is probably turning over in his grave right now. I worked at Central for 8 years myself and I am in shock at the thought of doing that because I work for Washington State's Historic Preservation Office. Needless to say I think it should be put on the National Register of Historic Places where it belongs. Stop this lunacy before it's too late! You will be tearing down history that can't be replaced……it is our past and once it is gone it's GONE. Please contact your State Historic Preservation Office (SHPO) in Boise and let them walk you through the process.<br>The MFC-767 EBR-II reactor building is a Category 1 historic property, eligible for nomination to the National Register of Historic Places. DOE-ID has made the decision to proceed with demolition of the facility.<br>I believe it to be in the best interest of the environment, public health and safety, and the taxpayers, nation wide, to allow the EBR-II reactor building to remain a Category 1 historic property. This option (Alternative 2) will cost less money and will not adversely affect the environment like Alternatives 3 and 4.<br>Please accept my choice of Alternative 2 as a written choice into the public opinion statements. | Please see the responses to Comments #1 and #2. |

| # | Commenter | Comment | Appendix A Response Reference |
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| 4 | Dawn Etta Cowan<br>U.S. Forest Service | The MFC-767 EBR-II reactor building is a Category 1 historic property, eligible for nomination to the National Register of Historic Places. DOE-ID has made the decision to proceed with demolition of the facility.<br><br>I believe it to be in the best interest of the environment, public health and safety, and the taxpayers, nation wide, to allow the EBR-II reactor building to remain a Category 1 historic property. This option (Alternative 2) will cost less money and will not adversely affect the environment like Alternatives 3 and 4.<br><br>Please accept my choice of Alternative 2 as a written choice into the public opinion statements. | Please see the response to Comment #1. |
| 5 | Steven R. Sherman<br>Aiken, South Carolina | My name is Steven R. Sherman, and I worked as the lead technical engineer in charge of carbonating EBR-II from 2001 through 2005. I wish to make a few comments about the engineering/cost evaluation for the EBR-II treatment options.<br><br>At least until September 2007, EBR-II was covered under a RCRA permit that required the residual sodium coolant (and its reaction products, i.e. sodium bicarbonate) to be treated and removed from the EBR-II system. This RCRA permit, which became active in 2002, is effective for 10 years, with the option to renew it for another 10 years if sufficient progress had been made towards reducing the residual sodium inventory. According to the EBR-II RCRA permit, the end state of the EBR-II facility must be "RCRA-Closed." This RCRA permit had nothing to do with radiological concerns, but was instead focused on the chemical hazard associated with the residual sodium. As far as the State of Idaho is concerned, EBR-II is a large storage tank, and the sodium inside the tank became categorized as RCRA-regulated waste once the reactor vessel was no longer in use. The current RCRA permit is not a risk-based permit, and RCRA-closure can only be achieved by de-activating and cleaning all residual sodium metal from the system, as verified by an outside professional engineer.<br><br>In looking at the document supporting the four options, it appears that the RCRA permit was not considered in selecting the best option for EBR-II. If the RCRA permit were not a factor, then all of the options may be considered. With the RCRA permit in place, only the 4th option -- complete dismantlement and removal of the EBR-II vessel and its components -- fulfills the RCRA permit. The preferred option, filling the reactor with grout, may be a viable option, but only if the RCRA permit is re-worked to allow for a risk-based closure, as defined by the needs of the State of Idaho.<br><br>The options were re-visited in January 2008 when a panel of experts was convened at the INL to discuss the preferred options for EBR-II clean-up. I was part of that expert panel. The results of this workshop reinforced the need to de-activate the residual sodium in-place prior to taking further action. For more information about this workshop, please see the following link: | Please see the response to Comment #4. |

| # | Commenter | Comment | Appendix A Response Reference |
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| | | http://www.em.doe.gov/EM20Pages/PDFs/DDTechFactSheet_EBR-II-FINAL.pdf<br>Grouting was considered, but was not the preferred option at that time due to concerns about achieving the goals of the RCRA permit.<br>If you have any questions or comments, please let me know. | |
| 6 | Ben F Cowan<br>Idaho National Laboratory | As an engaged and concerned research employee and a supportive citizen, my selection would be Alternative 2.<br>In my opinion, to proclaim a world class status, we would want to keep EBR-II and maintain the Historical structure that helped begin the nuclear energy renaissance. To tour citizens and other world countries would be more suiting and impressive than to show them a bunch of pictures.<br>I have reviewed the literature supplied by DOE and came to the following simplified conclusions.<br>Alternative 1: Not an alternative … no action and not even feasible… the EBR-II containment building is a dome of steel… 85 years would not cause the dome to collapse even if it were not painted. This is not a selection option.<br>Alternative 2: Alternative 2 is my preferred selection option… this option leaves EBR-II intact and maintained… approx. 62.5K per year to maintain it, or a total of $5,300,000.00 after 85 years and it would remain as an Historical Site… It would seem that a world class laboratory would desire to have such an example to display.<br>Alternative 2 also leaves a cleaner environment then the Alternatives 3 & 4 because there would be no disruption of hazardous materials.<br>Since we are a research lab… there is the possibility to stabilize the unstable atoms in the future and neutralize any chemical hazardous waste. Hazards contained and left in place, could be taken care of correctly… disrupted now and grouted or buried would mean exponential hazards and costs to our future generations.<br>Alternative 3: Alternative 3 Grouting the EBR-II Reactor Vessel in Place would actually cause an increase to the hazardous waste issues to the environment (land fills, … leaching into the ground water… and they would increase exposures to construction workers removing the material. (cost: $15,460,000.00)<br>Alternative 4: Alternative 4 Removal of the EBR-II Reactor Vessel would actually cause an increase to the hazardous waste issues to the environment (land fills, … and they would increase exposures to construction workers removing the material. (cost: $45,400,000.00)<br>I do not wish to see EBR-II demolished... I am very surprised that the Department of Environmental Quality has not objected to all but alternative 2. | Please see the responses to Comments #1, #5, and #6. |

| # | Commenter | Comment | Appendix A Response Reference |
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| 7 | David Russell Corrigan<br>Idaho National Laboratory | Why spend the money to maintain something that is totally obsolete and will never be used again. Remove the vessel and remove the foundation down far enough that the area where the facility is setting can be utilized for future growth of MFC. Keeping antiquated structures purely for posterity is in most cases a burden to the future mission of the laboratory. | Please see the response to Comment #3. |
| 8 | John A. Silva<br>Twin Falls, Idaho | Hello,<br>I worked at EBRII for 35 years, retiring in Jan. 2005.<br>In my opinion if all the sodium, nak, reactor subassemblys plus a few other things such as the sodium cleanup and chemistry components and other parts that contained radioactive substance were removed, the containment bldg., reactor vessel, and Sodium Boiler bldg. could remain intact as a historical entity. The radiation left in the steel structural components would be minimal and not pose much of an environmental hazard.<br>I would hate to see that facility completely destroyed. It represents a very large and important chapter in this country's nuclear power development. This is not recognized by most people now but will be in the future. | Please see the response to Comment #1. |
| 9 | Allen Schubert<br>Ammon, Idaho | Regarding the EE/CA for the EBR-II reactor, I support Alternative 3, grouting the vessel in place. This alternative is protective of the environment and reduces worker exposures. | Please see the responses to Comment #3. |
| 10 | Bevin A Brush<br>Idaho Falls, Idaho | Continued surveillance and maintenance. EBR-II should be designated as a National Historic Monument similar to EBR-I. Efforts are in the works to stabilize the remaining sodium in the primary and secondary loops. If that is accomplished, then I believe DOE can look at the as a rare achievement in US reactor history and leave it as it is. | Please see the responses to Comment #1. |
| 11 | Barney C Hadden<br>Idaho National Laboratory | I understand that this is a period of public comment on the proposed end state of the EBR-II reactor at the INL. I came to work for the INL's contractor roughly three years ago, and my first assignment was within sight of the EBR-II containment structure. When I arrived, I had no idea of the significance of the reactor. At that time, I really had no reason to advocate for the preservation of the building.<br>After only a few years working with some of the former operators of the facility, examining the processes of the adjoining Fuel Conditioning Facility, and learning of the important proofs of principle that went on there, I am a strong advocate of leaving this structure as intact as can be managed. Six months ago it was my privilege to tour the facility, top to bottom, with several members of its erstwhile crews, and I found the opportunity to be one that I will always remember. I wish the public could learn about the history of the work there as I did, by being allowed to walk through the containment building while hearing about what was done there by knowledgeable guides. | Please see the response to Comment #1. |

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| | | For this reason, I'd like to see the reactor grouted in place, not removed, and the containment building left intact. Once this resource is demolished, it will be forever gone, but its preservation in its current state may allow its future identification and preservation as a historic site, much as has been done with the first Experimental Breeder Reactor.<br>These are my private views, and they in no way reflect the opinions of my employers (or if they do, I don't know about it), but they are the views of someone who knows the importance of the Integral Fast Reactor project in the history of fuel processing. They are also the feelings of someone who is impressed with the gee-whiz quality of science done well.<br>Thanks for this opportunity to contribute my thoughts. | |
| 12 | Alan Christiansen<br>No address provided | After reviewing the alternatives presented, I would recommend alternative 3, Grouting the EBR-II vessel in place. This is the most logical and least cost. | Please see the response to Comment #3. |
| 13 | Joseph Piccoli<br>No address provided | Shut down the reactor and destroy it, Mary Louise Breitenbach | Please see the response to Comment #7. |
| 14 | John Tanner, President<br>Coalition 21 | Our members regret the lack of foresight that has resulted in the permanent disablement of EBR-II. Given that this reactor can no longer be restored to operating condition, we generally agree that Alternative 3 would be the most appropriate disposition method for it. This would avoid the continued maintenance costs of Alternatives 1 and 2, and also avoid the large cost of removal and transport of Alternative 4.<br>We expect one of our members to submit an alternative proposal. | Please see the response to Comment #3. |
| 15 | Franklin H. Just<br>Idaho Falls, Idaho | The EBR-II Reactor building and reactor should not be destroyed but should be left intact – the first of four alternatives should be followed:<br>No Action. The no action alternative assumes no decommissioning or demolition would be conducted on the reactor structure and support structures and there would be no further surveillances or maintenances. The no action alternative offers no reduction in toxicity, viability or volume of contaminants and is only used as a baseline for comparison.<br>Further this facility should become a National Historic Landmark because of its numerous contributions to reactor safety, clean energy production and maintaining a positive environmental effect.<br>To name a few:<br>The Integral Fast Reactor (formerly EBR-II) closed the fission process cycle such that all of the fissionable fuel is consumed. Hence, there is no so called nuclear waste and the fission by-products are either used in other processes or readily stored on site.<br>ZERO IMPACT ON THE ENVIRONMENT | Please see the response to Comment #1. |

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| | | The Integral Fast Reactor is an inherently safe system, which means the reactor automatically shuts down from any mechanical failure or from human error. In other words, the reactor core cannot over heat and cause a "runaway".<br>The Integral Fast Reactor can use the tones of unburnt nuclear fuel left from the "once thru fuel process" which present day power reactors. POSITIVE EFFECT ON TH ENVIRONMENT<br>The Integral Fast Reactor can use consume any excess nuclear fuel from defense weapons programs. This is necessary because of the long half lives of Plutium-239 and Uranium-135. POSITIVE EFFECT ON TH ENVIRONMET<br>The Integral Fast Reactor can utilize the uranium left from enriching Uranium-285. This material is commonly called depleted uranium and is stored in various places the world over. POSITIVE EFFECT ON TH ENVIRONMET<br>The Integral Fast Reactor output energy can be used to break $CO_2$, (carbon dioxide) which is a by-product of hydrocarbon combustion into carbon and oxygen atoms. POSITIVE EFFECT ON TH ENVIRONMET<br>The estimated energy production from the consumption of "once thru fuel" and from the "depleted uranium" would supply the Nations energy needs for hundreds of years.<br>The estimated energy production from natural uranium (U-238), the normal fuel, for the Integral Fast Reactor is estimated to be in the millions of years. | |
| 16 | Martin F. Huebner<br>Idaho Falls, Idaho | Subject: Recommendation of Alternative # 2 for Disposition of EBR-II facilities at the INL<br>References:<br>(1) "Public comment sought on final end state of Experimental Breeder Reactor-II," dated January 20, 2010<br>(2) "Engineering Evaluation/Cost Analysis for the EBR-II Final End State" (DOE 11398) dated January 2010.<br>Dear sir,<br>Reference (1) called for public comment on four proposed dispositions of facilities associated with the EBR-II reactor and power plant. These dispositions were formulated to reach an "end state" compatible with federal and state remediation goals for such facilities.<br>Reference (2) provided a more complete and detailed discussion and analysis of pertinent technical aspects of such dispositions; all such were aimed towards minimizing the man made/artificial "footprint" on the otherwise pristine sagebrush steppes of the INL. | Please see the response to Comment #1. Also the *Nuclear News* article, "Vision and reality: The EBR-II Story," was included in Appendix D of this document. |

| # | Commenter | Comment | Appendix A Response Reference |
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| | | As a life long citizen-environmentalist, as well as a licensed nuclear professional, I wholly support such goals.<br><br>However, both of the references recommended a disposition "Alternative # 3 - Grouting the EBR-II Reactor Vessel in Place." Applying this too narrowly focused alternative (only remediation) is inappropriate at this time for the following reasons:<br><br>The EBR-II containment dome is an easily seen and easily recognized landmark by the thousands of motorists that pass by the INL every year on US Route 20. It is the only feature seen by the public that looks like a nuclear power plant. As such (I believe) the dome is a constant and reassuring symbol of nuclear power to the public.<br><br>With the public's increasing interest in and support of nuclear power, from a public relations standpoint, the EBR-II dome should be keep visible for the next 50 years or so, or until nuclear power plants (with their own containment structure) are built elsewhere in Idaho.<br><br>Besides Alternative # 2 being less expensive than the "preferred" alternative, as mentioned many times in Reference (2), the disposition of EBR-II and facilities are "non-time-critical removal actions"(NTCRA). Although planning for implementing any of the Alternatives would require a significant preparation period, it also provides for reconsidering why Alternative # 2 "No Action" - except for continued surveillance and maintenance should be the preferred alternative.<br><br>EBR-II, also, should be designated as a National Landmark (some day), and an information station with appropriate signage erected adjacent to Route 20. The hot cells adjacent to the EBR-II should also be kept intact to prove that nuclear proliferation can be eliminated by proper facility design and operation.<br><br>The EBR-II and facilities were in operation for so many years (~30) and were the site of so many technological achievements that it is easy to forget some of them. I have attached a copy of the "EBR-II Story" as a reminder.<br><br>I have always wondered what twisted logic on what ever level of government caused the EBR-II to cease operations. It was still a useful research facility. It was meeting all of the safety and operational objectives Vice President Al Gore had called for about nuclear power in his best selling book "Earth In The Balance." Go figure?! | |
| 17 | Christina Cutler Shoshone-Bannock Tribes | What is the life expectancy of the grouting? | Please see the response to Comment #8. |
| 18 | Christina Cutler Shoshone-Bannock Tribes | Was the cumulative affects to workers ever calculated? | Please see the response to Comment #9. |

| # | Commenter | Comment | Appendix A Response Reference |
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| 19 | Christina Cutler Shoshone-Bannock Tribes | What actions will be taken to ensure that the grouting maintains its structural integrity? | Please see the response to Comment #8. |
| 20 | Christina Cutler Shoshone-Bannock Tribes | If the grout is found to not be maintaining its structural integrity is there a plan in place to address how to fix it? | Please see the response to Comment #8. |
| 21 | Christina Cutler Shoshone-Bannock Tribes | What was the ecological target species? | Please see the response to Comment #10. |
| 22 | Christina Cutler Shoshone-Bannock Tribes | Was there a human risk assessment done for sensitive populations? | Please see the response to Comment #11. |
| 23 | Christina Cutler Shoshone-Bannock Tribes | Why was cobalt used as the driving risk factor for the action assessment? | Please see the response to Comment #11. |
| 24 | Christina Cutler Shoshone-Bannock Tribes | I would like to see more removal actions done before the facility is filled with grout. A middle ground between the Alt. 4 removal and Alt 3 grouting would be a better solution in my opinion. | Please see the response to Comment #12. |
| 25 | Willie Preacher, Shoshone-Bannock Tribes | The Shoshone-Bannock Tribes would like to thank DOE-ID and the Department of Energy for allowing us to comment on the Engineering Evaluation and Cost Analysis for the Decommissioning of the EBR II Reactor at the MFC Facilities. The following comments will also include the Tribal DOE Environmental Program.<br>Again we want to reiterate that in regards to "cleanup" at the INL it has always been the sentiment of Tribes that we strongly feel to fully ensure the safety of the environment and the aquifer that all of the legacy waste and contamination be removed.<br>One of the main issues we have is the term "Footprint Reduction" for in some cases there is no foot print reduction even though DOE states that there is. We feel that there is no footprint reduction if the EBR II is grouted and left in place in this case. Further as for "cleanup" the Tribes feel that areas determined to be cleaned up are not being cleaned up but removed to other locations on site or left in place and grouted. It seems that this has been determined to be the method of "cleanup" for the INL. | Please see the response to Comment #14. |
| 26 | Willie Preacher, Shoshone-Bannock Tribes | As for grouting the Tribes question the integrity of the grout as it is exposed to high levels of radiation over a long period of time. We would like to see information and statistics on where this has been applied and the results of long term grouting. | Please see the response to Comment #8. |

| # | Commenter | Comment | Appendix A Response Reference |
|---|---|---|---|
| 27 | Willie Preacher, Shoshone-Bannock Tribes | We also take in consideration the safety of the workers and others when they attempt this monumental task. Good planning and lessons learned should be addressed prior to and during the completion these tasks. | Please see the response to Comment #13. |
| 28 | Willie Preacher, Shoshone-Bannock Tribes | In review of the document we have some questions, comments, and recommendations with the alternative 3 that DOE has currently decided upon. On the proposed alternative that DOE has selected we share some concerns with the alternative 3 proposal. There will be exposure to workers as they remove the shell or dome of the EBR-II reactor vessel. One concern is when the reactor is grouted will the base floor be able to hold the weight of the grout and not tend to settle or possible crack the grout which may later allow contamination to seep into the aquifer. | Please see the response to Comment #15 and #17. |
| 29 | Willie Preacher, Shoshone-Bannock Tribes | The term that is used when performing D&D work is relative routine should be better defined. When working with high radiations fields there is always a potential for human error and contamination exposure. | Please see the responses to Comments #16. |
| 30 | Willie Preacher, Shoshone-Bannock Tribes | Removal of the Sodium is another concern for worker safety as it being removed and disposed of in a proper disposal site. | Please see the response to Comment #18. |
| 31 | Willie Preacher, Shoshone-Bannock Tribes | It is also the recommendation of the Tribes that a complete and thorough inspection and review be performed of the reactor area where workers may be entering to ensure workers will not be exposed to high radiation fields. This inspection will identify working conditions such as limited mobility as they try to remove sections of the vessels. It will also be recommendation that the workers who are identified to perform the tasks have knowledge of the area and they understand the physical and mental limits that they will go through to complete the tasks assigned. | Please see the responses to Comments #13. |
| 32 | Willie Preacher, Shoshone-Bannock Tribes | As for monitoring of the MFC facility, the Tribe would request to DOE to add this site to our list of wells that we currently monitor along with the INTEC and RWMC monitoring wells. | Please see the response to Comment #19. |

# Appendix C

# Citizen's Advisory Board EBR-II Engineering Evaluation/Cost Analysis Recommendation

# Appendix C

# Citizen's Advisory Board EBR-II Engineering Evaluation/Cost Analysis Recommendation

INL Site Environmental Management
CITIZENS ADVISORY BOARD

10-CAB-003

March 16, 2010

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**Vice Chair**
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Idaho Falls, ID 83415-1220

**Subject:** Recommendation #145, Engineering Evaluation/Cost Analysis for Experiment Breeder Reactor (EBR)-II D&D; Recommendation #146, Budget for Fiscal Years 2011 and 2012 (attached)

Mr. Provencher:

Please find attached the Board's recommendations regarding the Engineering Evaluation/Cost Analysis for the Experiment Breeder Reactor (EBR)-II D&D and the Budget for Fiscal Years 2011 and 2012. These recommendations were approved by consensus.

Thank you for informing the CAB and allowing us to provide a recommendation regarding these subjects.

Regards,

R.D. Maynard
Chairman

cc: Bob Pence, DOE-ID
Jeff Perry, DOE-ID
Mark Searle, DOE-ID

# Engineering Evaluation/Cost Analysis for Experiment Breeder Reactor (EBR) II D&D

## Alternative 3 Selection

The Idaho National Laboratory Environmental Management Citizens Advisory Board (CAB) received a presentation and engaged in lengthy discussion with various Department of Energy (DOE), Environmental Protection Agency, and Idaho Cleanup Project personnel regarding the EBR-II engineering evaluation/cost analysis (EE/CA). After reviewing the EE/CA and receiving presentations at both the January and March 2010 meetings, as well as a CAB full board conference call in February, the CAB voted unanimously to support Alternative 3 for many of the reasons outlined in the report.

As always, worker safety and ongoing monitoring are key concerns for the CAB. The CAB is pleased to hear that monitoring will be ongoing. If anomalies appear during long-term monitoring, the CAB would like to be informed.

The CAB would additionally like to be kept informed as the engineering plans for the removal of the dome are developed. The CAB has concerns over the safe removal of this structure, but are confident in the skill and ability of the work force performing the work.

# Appendix D

# News Article Received During the Public Comment Period

# Appendix D

## News Article Received During the Public Comment Period

Enrico Fermi and Walter Zinn (front row, left to right), along with the rest of the group that convened on the steps of Eckhart Hall at the University of Chicago, on December 2, 1946, for the fourth anniversary reunion of the first self-sustaining nuclear chain reaction at CP-1 (Chicago Pile-1). The CP-1 scientists are: back row (left to right): Norman Hilberry, Samuel Allison, Thomas Brill, Robert Nobles, Warren Nyer, and Marvin Wilkening. Middle row: Harold Agnew, William Sturm, Harold Lichtenberger, Leona W. Marshall, and Leo Szilard. Front row: Fermi, Zinn, Albert Wattenberg, and Herbert Anderson. (ANL)

# Vision and reality: The EBR-II story

BY CATHERINE WESTFALL

*Instead of becoming a stepping stone to EBR-III, EBR-II followed an unexpected path in the 30 years after construction.*

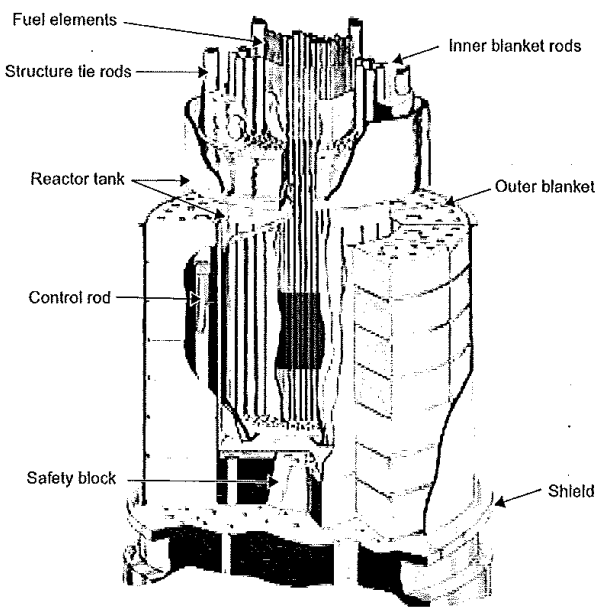
THE EBR-II STORY began in spring 1944. Work at Los Alamos, Oak Ridge, and Hanford to design, build, and provide fissionable material for the first atomic bombs was shifting into high gear. In stark contrast, initial bomb project studies on the nuclear chain reaction and plutonium were winding down at the Chicago Metallurgical Laboratory, Argonne National Laboratory's wartime predecessor.

Even as others zeroed in on the remaining wartime technical challenges, Chicago scientists turned their attention to the postwar possibilities for peaceful uses of nuclear energy. As part of this transition, on the morning of April 26, 1944, Enrico Fermi, Leo Szilard, Eugene Wigner, Alvin Weinberg and others gathered to discuss the possibilities for using nuclear fission to heat and light cities.

The scarcity of fissile material was on everyone's mind—it was agonizingly unclear at that time whether there was sufficient fissile material for usable wartime bombs. Fermi and the others therefore cast around for ways to produce maximum civilian power with minimal resources. They hit upon a novel scheme: designing a civilian power reactor that produced more fissile material than it consumed. Their plan was to place uranium-238 (or some other fertile material) near the reactor's core to capture the excess neutrons and thereby to breed new fissile fuel. They decided that such a device, which was later called a breeder reactor, would have to use fast neutrons—that is, neutrons would not be moderated as in most of the weapons materials reactors then in existence.

According to their calculations, with fast fission, enough neutrons would be created in the course of power production to hit the

*Catherine Westfall is Laboratory Historian at Argonne National Laboratory. ANL is managed by the University of Chicago for the U.S. Department of Energy under Contract No. W-31-109-ENG-38.*




The core of EBR-I. The dark-shaded region shows the location of the fissile material. The EBR-I core was very small, about the size of a standard football. (ANL)

fertile material and create extra fissionable material. Cities could be lit and heated, while in the process, the reactor could create some fraction of its future fuel.

To minimize these needs for replacement fissile fuel, the power-per-unit fissile fuel, loading in the reactor needed to be maximized. The scientists discussed the possibility of using sodium coolant because such a reactor would have a high power density, which would require effective heat removal. Sodium coolant was an attractive choice because it is an excellent heat removal fluid having minimal interaction with neutrons.

Nearly 20 years later, in August 1964, a reactor much like the one described by the Chicago scientists began operation at Argonne's Idaho reactor test site. The liquid-metal fast breeder racked up many accomplishments. Before it was shut down in 1994, EBR-II:

1. Successfully demonstrated that a pilot-scale breeder reactor could be built.
2. Operated for 30 years, the longest for any liquid metal–cooled reactor.
3. Achieved a capacity factor of 80 percent during its last decade even while operating as a test reactor, showing that fast-neutron sodium-cooled reactors can compete with thermal reactors.
4. Ushered in the development of electrochemical pyroprocessing, which takes the higher actinides out of waste so that they can be recycled into the fuel.
5. Produced proliferation-resistant fuel, since fissionable plutonium and higher actinides naturally stay together in electrochemical pyroprocessing, making fuel prohibitively radioactive.
6. Demonstrated inherent safety—that is, that the reactor regulated its own temperature and power with loss of coolant flow and no reactor scram.

But what happened in the 20 years separating wartime conception and operation of EBR-II? And what happened during the 30-year lifetime of the reactor—did the vision of Fermi and the others become a reality?

## First, EBR-I

Consideration of the new type of reactor did not end with the April 1944 meeting. Walter Zinn, one of the nation's few reactor experts and a close colleague of Fermi, was soon recruited to the cause. Zinn was full of enthusiasm for the project. By summer he had begun a more detailed investigation of breeder reactor designs. When the war ended, he did not wait for the postwar framework for administering nuclear energy research to form, instead obtaining permission from the Army to make initial tests. By the end of 1945, he had abandoned the idea of breeding U-233 in thorium and confirmed the original plan of breeding plutonium-239 with U-238 using fast fission.

By 1947, Zinn might well have lost interest in spearheading the breeder project. In fall 1946, the newly formed Atomic Energy Commission took control of the nation's nuclear research facilities and tapped Zinn to head the Chicago laboratory, which by then had been reorganized and renamed Argonne National Laboratory. The next year, AEC Commissioners unexpectedly decided to consolidate the entire AEC reactor program at Argonne. This decision drew Zinn into time-consuming wrangling about the national program at just the time when he was struggling to organize Argonne's postwar research program and move reactor work from the laboratory's wartime sites to a new location in DuPage County, southwest of Chicago.

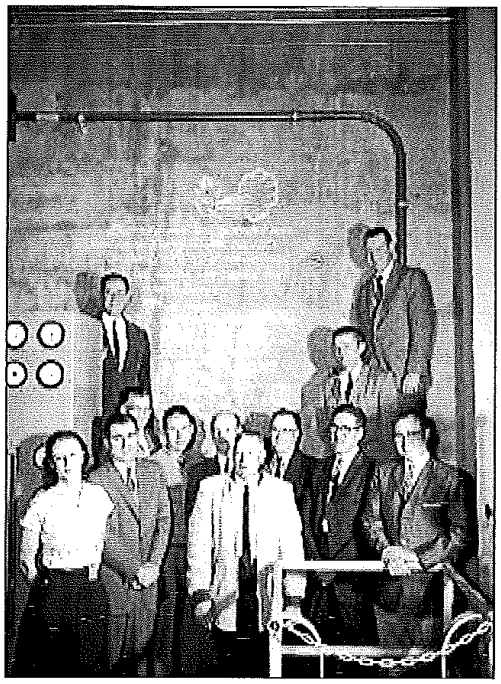
Despite his many other responsibilities, Zinn remained zealous about the breeder project. He successfully convinced the AEC to give it a top priority and insisted on directing the small team himself. And he was not the only one with an unshakable interest in the breeder. As the breeder effort began to grow, Fermi promoted it by giving lectures extolling the wonders of extracting almost 100 percent of energy from natural uranium. He also continued to contribute to the project, at least in the opinion of Leonard Koch, an early member of the breeder team. According to Koch, Zinn would sometimes preface directions by making "a comment such as, 'Enrico thinks. . . .'"

From this interest, a long-term plan emerged. Initial work would culminate in the construction of EBR-I, a small reactor that would test the principle of breeding. Next, Argonne engineers would build EBR-II, a pilot plant to check the feasibility of the breeder. Finally, the full-scale power plant, EBR-III, would be built by industry.

In fall 1947, Zinn presented a preliminary plan for EBR-I to the AEC. In the next few years, the EBR-I team members refined their ideas, and by late 1949 they had developed a feasibility report for the reactor. The EBR-I team had conceived a reactor with a core of U-235 surrounded by a "blanket" of U-238.

After carefully considering a number of possibilities, the EBR-I team decided to cool the reactor vessel with a sodium-potassium (NaK) alloy, which had excellent heat transfer properties. Since they knew little about the effect of this liquid-metal coolant on materials and worried that the control rods might stick or corrode, they decided to cool the rest of the reactor with air, which introduced the complexity of designing two completely separate cooling systems. Designing the reactor was also harder because the chemical reactivity of the sodium-potassium coolant (it reacts with water and burns quickly in air) meant that there could be no fluid leakage.

The breeder project brought other difficulties as well. From the beginning, questions had been raised about whether it was safe to build the reactor in the Chicago area. By summer 1948, Zinn was convinced the project needed to be built at a remote site and asked the AEC to find one.



Some of those who worked on EBR-I posed in front of the sign chalked on the wall when EBR-I produced electricity. In the elevated row, left to right: Bernard Cerutti, Lester Loftin, and Earl Barrow. Front row, left to right: Wilma Mangum, Charles Gibson, Orin Marcum (wearing glasses), Kirby Whitham, Mike Novick, Milton Wilkey (in white coat), Frank McGinnis, Len Koch, and Weslie Molen. (ANL)

Since this plan met with the enthusiastic approval of their safety experts, Commissioners were happy to comply and chose a site near Arco, Idaho, that had been a navy ordnance proving ground. The site came to be known as the National Reactor Testing Station and soon housed other Argonne reactor projects, as well as other government reactors.

Constructing EBR-I in Idaho complicated life for Zinn, since the AEC, to his chagrin, transferred contractual control from the experienced operations office in Chicago to a newly formed Idaho Operations Office. For their part, EBR-I team members found the move from Chicago to the as yet undeveloped test area "not a joy or an improvement." Commuting to work was particularly inconvenient—before a new road was built, they were forced to use a 70-mile stretch of poor highway that connected the site with Idaho Falls, where they lived with their families.

After preliminary work in Illinois, including experiments with liquid-metal coolants, EBR-I construction at the new Idaho site began in 1949. In January 1951, the last reactor components were shipped to the site. Construction proceeded quickly. EBR-I was a simple affair housed in a single brick building with three elevations. The basement level had cells and equipment rooms, while the middle floor housed the reactor in the middle of a thick concrete structure to provide radiation shielding. The reactor's top was at the partial second-floor level, which also contained the turbine-generator, the control room, and some office space.

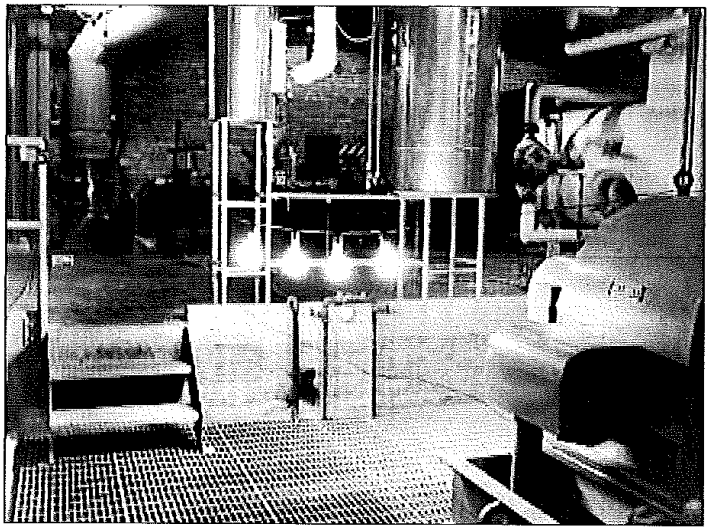
On December 20, 1951, EBR-I, driving a Rankine steam cycle, produced the first nuclear-powered electricity, lighting four light bulbs, a feat that drew a great deal of attention. The November 1952 briefing for President-elect Dwight D. Eisenhower on the nation's atomic energy program featured a picture of the event.

Although the world was impressed, EBR-I team members wasted little time in celebration, instead pressing forward to reach their main goal: proof of breeding. After tests and adjustments, the reactor operated long enough in February 1952 to permit breeding gain determinations. In June, the first samples—uranium slugs from the inside of the reactor—were sent to the Chemical Engineering Division at the Chicago site. By February, the numbers indicated that EBR-I was a breeding reactor. A few months later, it became official. On June 4, AEC Chairman Gordon Dean announced that in the process of operation, EBR-I changed nonfissionable uranium into fissile Pu-239 at a rate that at least equaled the rate it consumed U-235. As Koch later explained, EBR-I had not just proved breeding. It also showed "that heat could be produced in a controlled manner in an unmoderated reactor and this heat could be removed by a liquid-metal coolant (NaK) and used to generate electricity."

## Creating EBR-II

In fall 1952—well before the news of breeding had been officially announced—plans were also being developed for the next step, a pilot plant. This plant would test both the engineering and economic feasibility not only of the breeder reactor itself but also of the related recycle technology to show whether the vision of fully using uranium could be realized. By this time, Zinn had transferred Koch back to Chicago and made him a coordinator for the loosely organized project, which came to be called EBR-II.

Koch remembers that specialists from various parts of Argonne were engaged by the challenges posed by creating EBR-II and its associated fuel cycle. The reactor engineers were thinking about "larger sodium components, pumps and heat exchangers, the metallurgists were thinking about how to build fuel elements for a power reactor,"



On December 20, 1951, these four light bulbs were energized by EBR-I, in the world's first production of nuclear energy. (ANL)

Some of those associated with EBR-II. Left to right: Len Koch, Mick Novick, Steve Lawroski, Harry Monson, and Fred Thalgott. (ANL)

and the chemical engineers were thinking about "processing fuel, because from day one it was recognized that a fast reactor power program would require recycling of fuel." The plan to recycle fuel meant that it would be desirable to design a fuel cycle facility as part of the EBR-II complex, devise processing methods, and develop a system for removing and returning fuel elements to the reactor.

The group submitted a "Preliminary Proposal and Feasibility Report" for EBR-II to the AEC in December 1953. It would take about a year and a half for the request to wind its way through the funding approval process: On July 11, 1955, EBR-II would receive funding authorization for $14.85 million, a large sum for the time. While waiting for approval, the group labored to refine the design for the state-of-the-art reactor. As Koch later summarized: "It was an informal effort spread among three different divisions," and yet it was fueled by "a growing, common interest" in the development of the promising new technology. As a result, "the general outlines of the project were beginning to gel."

Zinn would resign the Argonne directorship in 1956 to be replaced by Norman Hilberry. But before he departed, he left one more legacy: He convened a review of the project. Although this review was held after the project had received its first funding authorization, its purpose, in the words of a January 1956 memo, was to answer the question: "Is the feasibility of the EBR-II reactor now sufficiently well established to justify the expenditure of sizeable sums of money on an architect-engineer?"

Milton Levenson, who was brought into the review as a representative of the Chemical Engineering Division, recalled that "this very unusual review" came about because as Zinn prepared to leave Argonne, he worried that EBR-II "would never come out right," that the goal of building a pilot breeder "would never be achieved." After all, even though EBR-I had proved that breeding was possible, building the first pilot breeder reactor and associated fuel cycle was still a considerable technical challenge. The enthusiastic but informal effort that had bound the Metallurgy, Chemical Engineering, and Reactor Engineering Divisions had brought them part of the way to their goal, but by early 1956, Zinn wanted the design to be carefully checked and he wanted far more detail.

Zinn consequently gathered experts from parts of the laboratory, and, in the words of Levenson, "the entire plant was gone over, not quite bolt by bolt, but almost." In Levenson's view, the resulting review laid the foundation of EBR-II's eventual success, both by creating a firm basis for detailed planning of the design and by "setting the precedent that we had to think of the science and first principles, even though it was an engineering project." At the same time, EBR-II was an engineering project and could emerge only if the priorities of both science and engineering were attended to.

Upon completion of the review, the EBR-II project was organized. Koch was named project manager, with Levenson project manager of the fuel cycle, Harry Monson project manager of the power system, and Frank Verber project engineer of the electrical power and distribution systems. Ninety-two people participated directly in the project or in technical support roles during design and construction.

Although EBR-II became a project, the working environment was less structured and more university-like than that found in industry at the time. Team members stayed within their original scientific divisions; Koch gave assignments, but did not evaluate personnel or make salary or promotion decisions. The rank and file regularly made technical decisions, and although progress was discussed and reviewed in regular management meetings, for the most part workers were not second-guessed. Howard Kittel, who worked on the metallurgy of fuels, noted that there was a "minimum of bureaucracy" in other ways as well. For example, supplies could be obtained "without forms or approvals—you just mentioned what you needed and the stockroom would get it for you." In Levenson's opinion, one of the beauties of this way of working was that "responsibility was delegated to a very low level." In the words of Jim Burelbach, a design engineer for the reactor, "People knew they had to take personal responsibility rather than wait for somebody else to catch their mistakes."

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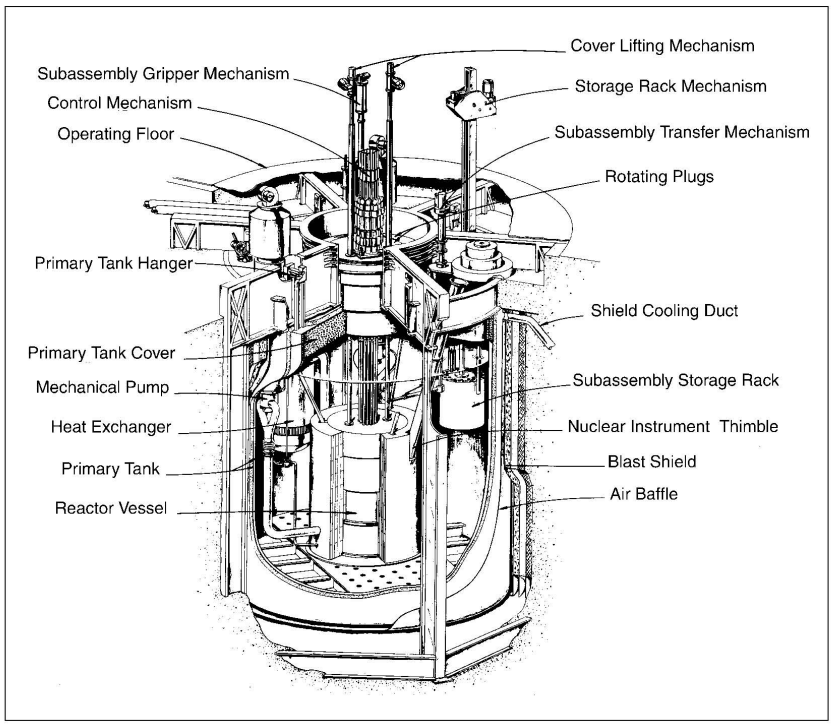



The primary system of EBR-II. (ANL)

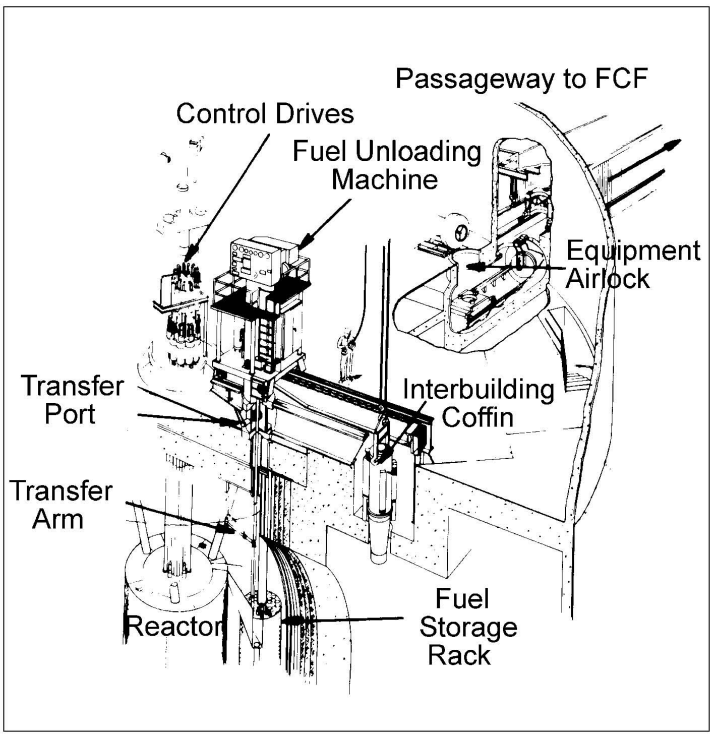
Koch later explained that the original estimate "was far too low, as we found out when we developed the more detailed plan and increased scope." The Commission was supportive of the revisions, and the AEC "agreed without too much fuss to provide the extra money." The authorization bill was signed into law in August 1957.

Creating the final design and constructing EBR-II was far from easy. After all, in Levenson's words, "Nobody had ever built anything like what we were building," and as a result, they "were forced to come up with some pretty far-out concepts." To gain better understanding and confidence, EBR-II designers used typical strategies, such as prototyping and testing. In the process, however, they drew on Argonne's special technical resources. For example, they tested criticality using Argonne procedures that were by then standard, and were able to use

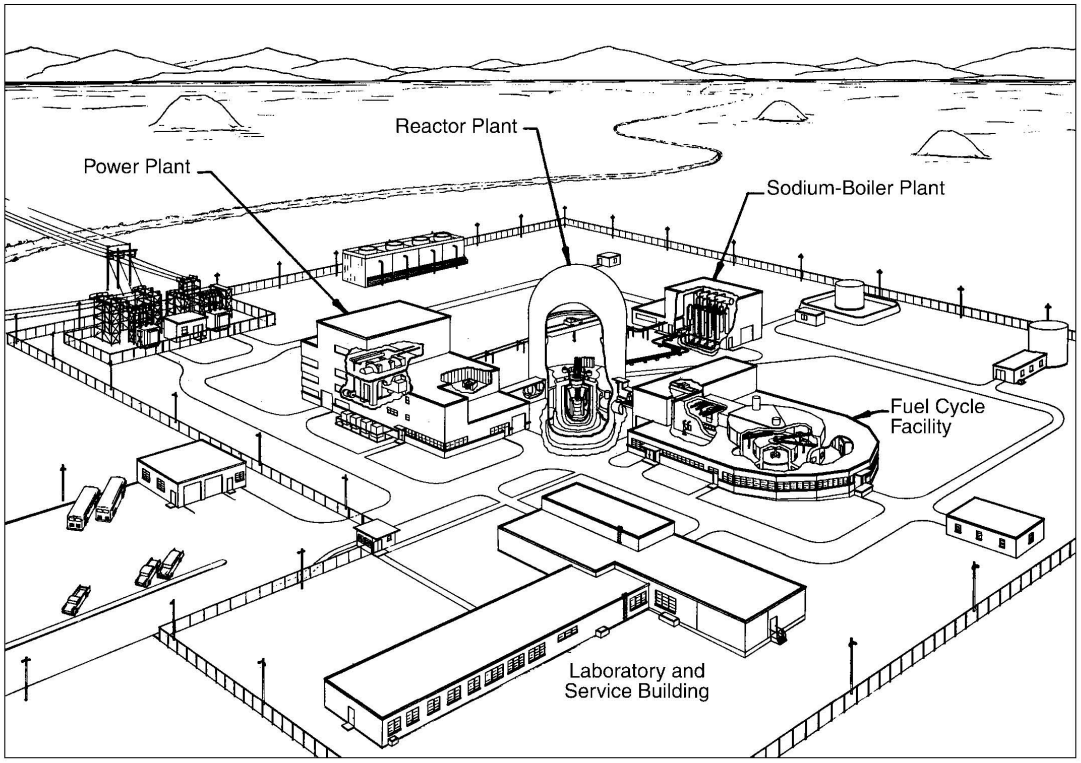
Although the EBR-II project benefited in many ways from a flexible management style, the project also drew on the strength of a solid structure: EBR-II operated, after all, within the permanent organizational framework of Argonne. The laboratory also offered considerable resources, including multidisciplinary expertise. John Poloncsik, who worked as a draftsman, noted: "There were a lot of people who gave you direction." As Burelbach added: "If somebody wasn't sure, they would find somebody who could make them feel sure."

Most EBR-II workers were men in their 20s who enjoyed the freedom, the camaraderie, and the resources Argonne provided. But the main incentive was the work itself. As Kittel noted: "We all felt we were on the cutting edge, doing things nobody had done before." People worked long hours because they "just hated to leave what they were doing."

Fueled by hard-working enthusiastic workers, the EBR-II project plowed forward. By fall 1956, the initial design was complete enough to bring in an architect engineering firm. After accepting bids from various companies, on November 15, 1956, H. K. Ferguson Company was chosen for the job, and in January the company was authorized to proceed with the project. The next month, a request was submitted to the AEC to raise EBR-II funding from $14.85 million to $29.1 million.




The fuel unloading and loading system for EBR-II. (ANL)




Layout of the EBR-II facility. (ANL)

the laboratory's Zero Power Reactor III (ZPR-III) to test alternatives for the reactor core.

One particularly crucial strategy—and one distinctive to the EBR-II efforts—was "what-iffing." As Koch later explained: "We would conjure up every circumstance we could think of, asking ourselves—what if such and such happens? What will the result be? How will we accommodate it?" The exercise was quite rigorous. "We had categories of how serious—or how acceptable—the consequences might be." In line with Zinn's long-term insistence on safety, "at the top of the list of what was unacceptable was that which would result in a hazard to the public, either the public on site, or the general public off site." If they determined that such a hazard existed, "that particular approach was discarded."

The emphasis on being careful was leavened by practical considerations. In the words of EBR-II engineer Ralph Seidensticker, Koch "never let us dawdle, never let us get so seduced by R&D that we forgot the task at hand." At the same time, he said, "we weren't doing this to save money or time. We also weren't doing this to spend all the money and take all the time in the world." In short, said Seidensticker, management "never lost sight of what was really important," but instead "totally focused on the end result." Constantly workers were told: "It has to work," and in the process, "conservatism was never compromised."

## Resulting design innovations

*Sodium coolant*—As Fermi and the others at the April 1944 meeting had anticipated, a key issue for a fast reactor is cooling. Although sodium reacts violently with water, EBR-II engineers chose it because it has a number of attractive features. In addition to having minimal interaction with neutrons (as the 1944 group noted), it has a high thermal conductivity, is noncorrosive with steel construction material, and has a high boiling point, which avoids safety issues that come with using a pressurized vessel.

*Pool-type configuration of primary system*—One of the distinctive features of EBR-II was that the primary system (the reactor vessel and core, pumps for pumping sodium, and an intermediate heat exchanger) was put into a single tank (later called the primary tank) instead of using the customary loop system with a series of connected pipes. This arrangement did pose the complication that components were not out in the open to maintain. However, it offered many advantages. Because sodium becomes radioactive due to neutron absorption when pumped through the reactor to the heat exchanger, by using the pool design, EBR-II designers avoided the problem of radioactive sodium leaks that would have plagued a loop system. EBR-II could also have a simple piping system instead of the elaborate measures that are necessary in an open system. The enclosed system also made it easy to keep sodium in the molten state needed for circulation—EBR-II designers simply made provisions for heating the entire submerged system.

*Closed fuel cycle*—A hallmark feature of EBR-II was that it had a closed fuel cycle. That is, as anticipated from the beginning of the project, the fuel would be recycled using a separate fuel cycle facility. Plans were thus made to take fuel out of the reactor (both the blanket and the fuel elements), reprocess it (in the process removing fission products), then refabricate fuel elements. Since fuel would be continuously reprocessed, EBR-II had the potential not only to make extra fuel, but also could exploit the full potential of the uranium. An additional advantage of this approach was that the fuel remained highly radioactive and therefore would be harder to steal; that is, it was proliferation-resistant.

*Continued*

*Fuel handling innovations*—Fuel handling was complicated by a number of factors. For one thing, EBR-II engineers needed to recycle fuel quickly to keep the total fuel cycle working inventory low so that the reactor could be operated economically. Also, fuel components consisted of subassemblies that were totally submerged in sodium in the primary tank and therefore were not visible during refueling operations. In addition, designers wanted to store fuel for fission-product decay-heat removal while the reactor was in operation. Extracting the fuel, transferring it first out of the reactor to a fuel storage rack and then out of the primary tank and then to the fuel cycle facility, then reprocessing and refabricating the fuel elements and transferring them back into place, was accomplished with a series of cleverly designed, meticulously engineered remote handling devices—grippers, a hold-down mechanism, and a transfer arm, as well as specialized devices for fabrication and for transferring the highly radioactive elements safely in and out of the sodium environment.

## Construction, initial operation

By the end of 1957, design work was winding down in Chicago and the effort began to relocate to Idaho, where EBR-II would be built. Those building EBR-II enjoyed advantages unknown to their EBR-I colleagues. For example, the EBR-II site was closer to Idaho Falls, the Idaho National Reactor Testing Station (NRTS) was up and running, a good road connected Idaho Falls and the site, and a rail line ran to the central facilities of NRTS.

Thus, EBR-II workers had a shorter commute, getting construction started was easier, and delivery of equipment was much more convenient. Workers coming from Chicago still had a transition to make, however, because in Burelbach's words, Idaho was "a different world." As Seidensticker noted: "The snow was deeper and temperatures colder. Sometimes in winter we had temperatures down to 25 below!" The site was also a particular haven for rattlesnakes.

Construction began in earnest amidst the rugged, beautiful Idaho landscape in 1958 and proceeded with few problems. Over the next three years, roads were cleared and buildings erected. Components were gathered and assembled from contractors all over the country and from the Chicago site and installed in the plant, including fuel subassemblies. While this work progressed, a hazards summary report and a step-by-step plan for safely achieving critical mass were prepared and successfully submitted for approval to both the AEC and the Advisory Committee on Reactor Safeguards. By fall 1961, the reactor plant and the power plant were completed. As the sodium boiler plant—the last piece of the power complex—was being finished, the EBR-II team was ready to perform dry critical tests—that is, criticality tests prior to filling the primary sodium system. On September 30, 1960, EBR-II achieved dry criticality, and in the next month tests were made of the reactor in this configuration.

After completion of the sodium plant in late 1962, it was time to make preparations so that the reactor could achieve wet criticality. After sodium was added, the EBR-II team carefully and methodically followed predetermined check-out procedures for the startup of the reactor, and then began the stepwise approach to wet criticality. The reactor achieved this milestone in November.

After some wet critical experiments, the group began what they called the "approach to power" starting on July 16, 1964, in which the power level of the reactor was slowly increased with levels of up to 30 MWt achieved by August. Much later, the reactor would be loaded with different types of fuel and other reactor experiments would be performed, including measurements of plutonium in the uranium blanket surrounding the core, which established the reactor's success as a breeder. In May 1965, the reactor used recycled fuel for the first time. By this time, the reactor was operating at 45 MWt, a power level that would continue for another three years; in September 1969, the power was increased to the design value of 62.5 MWt.

## Next, EBR-III

Instead of becoming a stepping stone to EBR-III, EBR-II followed an unexpected path in the 30 years after construction. By the time EBR-II was operating at design power in the late 1960s, the AEC's reactor division had developed a new and different vision of the nation's reactor program. Their idea was to choose one promising technology that could be achieved in the short term and put all possible resources into developing and commercially implementing it as quickly as possible. This approach left no room for Argonne's tradition of developing forward-looking concepts.

EBR-II played an important role as a fuels and materials testing reactor during the 1970s—supporting the national program in oxidized fuel fast reactor development. The recycle facilities were shut down, however, and Argonne managers were stripped of the authority to plan and manage the laboratory's breeder project.

EBR-II gained prominence again in the mid-1980s with the advent of the Integral Fast Reactor (IFR), a concept spearheaded by Charles Till. As Koch later explained, the IFR "was an attempt to restore the plant to its original intent . . . to go back and do what we started to do"—that is, "run it as a power plant on recycled fuel." The metal-fueled EBR-II was again joined to the fuel cycle facility, which had been altered so that it could reprocess the more advanced plutonium-based spent fuels using a new technology that offered many advantages—electrochemical pyroprocessing—as well as continue already developed fabrication processes.

As the concept of IFR was being defined, a crucial EBR-II experiment was under way. Gerry Golden, John Sackett, and Pete Planchon—along with other Argonne engineers—considered ways to show that EBR-II was inherently safe. That is, it would shut down safely even if safety systems failed to operate. This test was successfully completed in April 1986. Following a temperature rise, EBR-II regulated its own temperature and power without the use of emergency safety operations or operator intervention. Inherent safety became an important pillar of the IFR concept.

Despite EBR-II successes, in August 1994, Congress terminated the IFR, while providing $84 million for efforts to wind down the IFR program. On September 27, 1994, EBR-II ran for the last time. As of this date, no plans for EBR-III had materialized and none have subsequently been launched.

## Reality and the vision

A number of factors have conspired to divert plans for EBR-III. The prospects for rapid development of civilian reactors declined in the 1970s and 1980s as the technology appeared less economically feasible than previously thought and the accidents at Three Mile Island and Chernobyl raised safety concerns about nuclear power. In addition, the rationale for the fast breeder became less compelling when uranium prospecting produced more fissionable material than expected in the mid-1940s and early 1950s and when additional oil reserves were discovered. Breeders also got a black eye with a well-publicized accident at the sodium-cooled Fermi-1 reactor near Detroit, which was not built based on the EBR-II experience. As Leon Walters, who worked on IFR, points out, in this environment water-moderated reactors have dominated attention, "since they are relatively simple, the technology is well developed due to their use in submarines, and since industry is comfortable handling water."

Those who built and operated EBR-II have not given up the vision of EBR-III. As Walters notes, the design "is proven, it is proliferation-resistant, it decreases waste disposal problems, it's inherently safe, and perhaps most important of all, Fermi's original idea—conserving fissionable material—is still sound." Koch insists that EBR-III will eventually become a reality. "Maybe it won't be in my lifetime. But I think that someday there will be an EBR-III, just like Zinn and Fermi thought." NN