Department of Energy
Brookhaven Site Office
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DEC 2 8 2011

Mr. Chek Beng Ng
New York State Department of
Environmental Conservation
Division of Environmental Remediation
625 Broadway – 11th Floor
Albany, New York 12233

Ms. Jessica Mollin
Federal Facilities Section
U.S. EPA – Region II
290 Broadway – 20th Floor
New York, New York 10007-1866

Dear Mr. Ng and Ms. Mollin:

SUBJECT: BROOKHAVEN NATIONAL LABORATORY REMEDIAL DESIGN IMPLEMENTATION REPORT – DIFFERENCES IN THE SCOPE OF REMOVAL OF THE BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR) BIOLOGICAL SHIELD, DECEMBER 21, 2011

References: Letter from C. B. Ng, NYSDEC, to J. Sattler, EM-BHSO, Subject: Differences in the Scope of Removal of the BGRR Biological Shield, dated November 7, 2011.

Letter from J. Malleck, USEPA, to J. Sattler, EM-BHSO, Subject: Differences in the Scope of Removal of the BGRR Biological Shield, September 19, 2011, dated December 5, 2011.

Enclosed please find two copies of the subject report for each of your organizations; please note that the draft of this report was previously transmitted to you under the title of "Technical White Paper." Each report includes copies of the responses to the comments that were provided on the draft report by the U.S. Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC), as well as the supporting documents cited in the report and the responses to comments. If you have any questions, please contact John Rampe, of my staff, at (631) 344-3519, or via e-mail at jrampe@bnl.gov.

Sincerely,

John Sattler
Brookhaven Federal Project Director
Office of Environmental Management

Enclosures:
As Stated

cc: J. Malleck, USEPA, w/o encls.
O. Povetko, USEPA, w/encls.
J. Swartwout, NYSDEC, w/o encls.
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ENVIRONMENTAL RESTORATION PROJECTS

Remedial Design Implementation Report

Differences in the Scope of Removal of the Brookhaven Graphite Research Reactor (BGRR) Biological Shield

December 21, 2011

A. Executive Summary

Since the issuance of the Record of Decision (ROD) for the Brookhaven Graphite Research Reactor (BGRR) in 2005 (Ref. 1) and the Remedial Design/Remedial Action Work Plan (RD/RA Work Plan) for the Biological Shield Removal in 2008 (Ref. 2), work has progressed significantly on the demolition of the reactor pile and surrounding structures. As work progressed, different approaches were defined to accomplish the goals described in the ROD with more efficiency and less dose consequence to the workers than the approach described in the RD/RA Work Plan, and in one instance, from the end state described in the ROD. This paper documents those deviations from the original plans defined in the RD/RA Work Plan in detail, and discusses the effect of the deviation from the specific language of the ROD. The conclusion of the paper is that although changes have taken place in the project work plans, these are changes of approach which have no effect on meeting the end-state goals defined in the 2005 ROD.

B. Purpose

The purpose of this paper is to describe Significant, Nonsignificant and Minor Differences in the proposed End State of the BGRR after removal of the biological shield as compared to the End State anticipated in the ROD and the RD/RA Work Plan.

The Difference which significantly differs from the ROD is also documented through an Explanation of Significant Differences (ESD) as required by Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This ESD, titled *Area of Concern 9 Brookhaven Graphite Research Reactor, Explanation of Significant Differences for the Biological Shield Removal* (Ref. 4) is prepared for DOE by BSA.

C. Description of the BGRR Biological Shield

The BGRR biological shield and associated components are the structures that shielded personnel from radiation during reactor operation, and provided physical support and an airtight membrane around the BGRR graphite pile.

The BGRR Technical Manual (BSA, 1962, Ref. 3) describes the "Biological Shielding"; however, the term "biological shield" is most commonly used in describing the structure. The biological shield was constructed of steel and high density concrete and surrounded the graphite pile and air plenum chambers. The biological shield was 55'-0" long by 37'-6" wide by 33'-7" high as measured from elevation 106'-9". Referring to Figure 1, the biological shield walls are set 3'-3" lower than the building floor at elevation 110'-0".

The graphite pile and the plenum chambers were surrounded by the biological shield. The thickness of the biological shield walls varied by location from 4'-3" to 5'-6". The outer walls were 3" thick steel plate. The east and west inner walls were 6" thick (two 3" thick plates adjoined) in the area immediately adjacent to the graphite pile location and 3" thick elsewhere. In addition to the four walls, additional elements such as the two 3" thick steel neutron shields, and the thermal shielding and binding plates in the exhaust plenums comprised the biological shield.

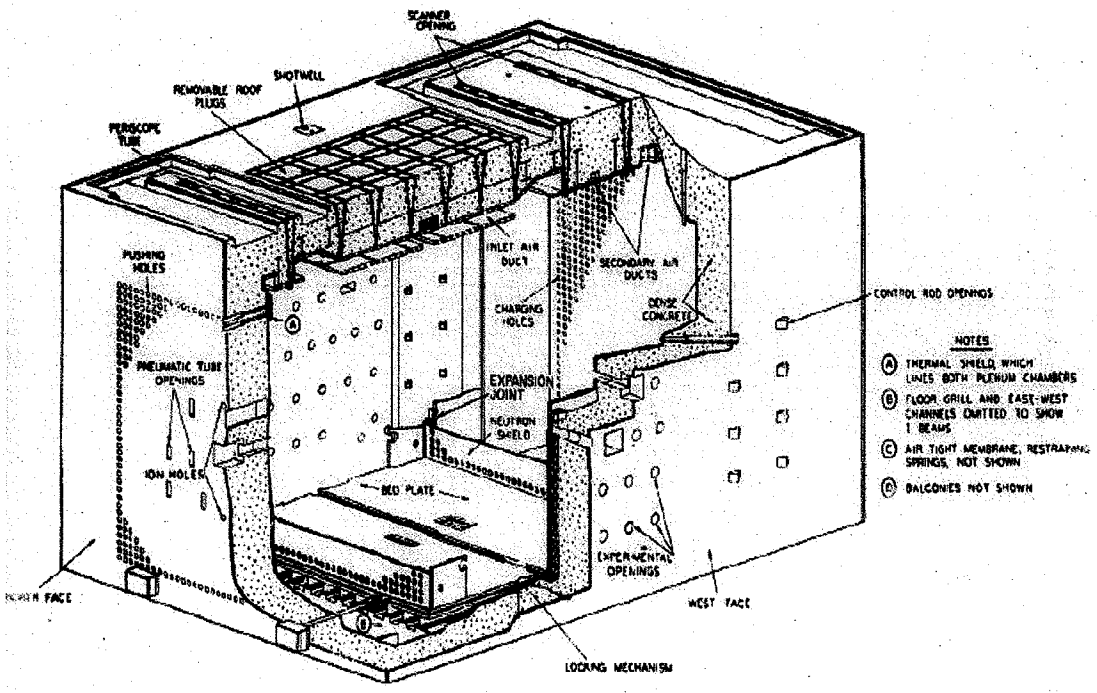

Figure 1

BGRR Biological Shield Isometric Cutaway View

(Figure 1-6 from RD/RA Work Plan)

D. Project Summary

In preparation for removal of the graphite pile, the east and west reactor cooling air intake plenums and the void space beneath the lower graphite pile bedplates were filled with a concrete grout to prevent the graphite blocks and debris from falling into these inaccessible areas. Placement of this grout was

topped at the bottom surface of the lower pile bedplates at elevation 108.2' (Figure 2). BSA completed the removal of the graphite pile in 2010, and immediately commenced preparations for the removal of the biological shield.

In preparation for the removal of the biological shield, 3-inch thick steel plates were placed over the upper pile bedplates to reduce the radiological dose to the workers who would be exposed during the setup and operation of the torch-cutting and concrete breaking equipment. These steel plates were secured in place with a concrete grout similar to that used in grouting the intake plenums. The elevation on the upper surface of these steel plates and the grout is elevation 109'-0" (Figure 2).

During initial phases of the biological shield removal project, a remote-operated, rail-mounted excavator with a hydraulic breaker hammer was utilized to break the concrete on the roof and sidewalls. Once the roof had been removed, and removal of the sidewalls was in progress, it became evident that this excavator/hammer unit lacked sufficient force to break the high-density concrete effectively enough to support the project schedule. The decision was made to deploy a larger excavator/hammer unit which would be capable of breaking the concrete in the walls at a higher rate. Once the new unit was selected, it was determined the building floor as well as the floor area within the footprint of the biological shield required reinforcement to support the machine, which weighed over 35 tons. To accomplish this, the void areas beneath the Building 701 high bay area outside of the biological shield footprint were filled with cementious grout, and steel plates were placed atop this floor surface to evenly spread the load of the new excavator/hammer unit. To strengthen the floor area within the biological shield footprint, the north and south outlet air plenums were filled with reinforced concrete to elevation 109'-0". This configuration not only provided a solid, void-free surface on which to operate the new excavator, it provided additional shielding which allowed workers (including the excavator operator) to enter the interior of the biological shield for the first time in the project to perform tasks that had previously been inefficiently accomplished by remote means.

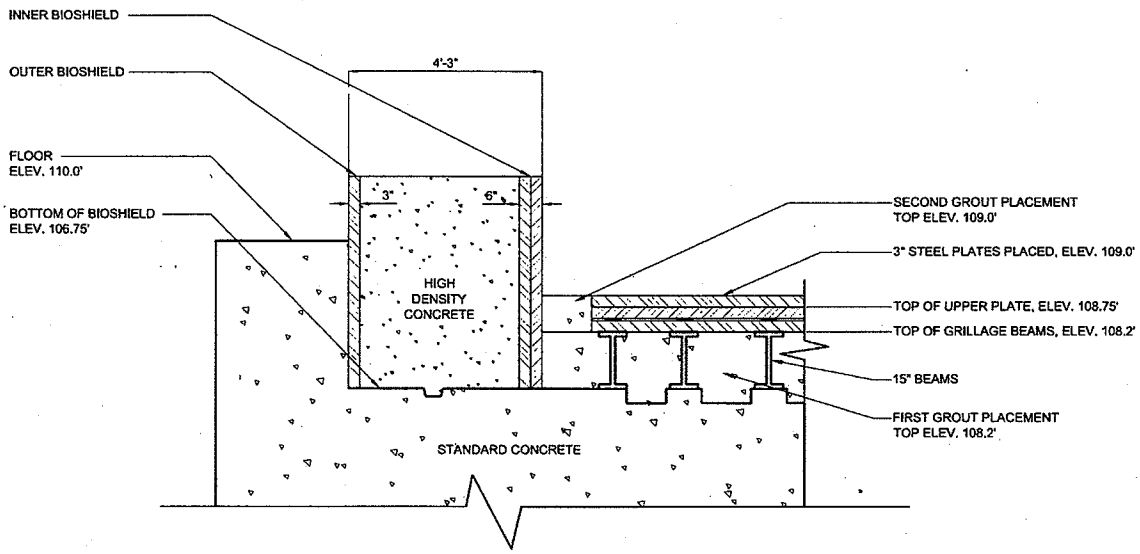

Figure 2

Section View of Biological Shield during Removal Activities

E. Description of Differences

1. Significant Difference

The BGRR ROD Selected Remedy, Alternative C, states "Removal of the biological shield will include the removal of the neutron shields and the steel-encased concrete walls. Loose debris will be removed and a fixative will be applied to the exposed surfaces." As stated in 2.0 above, the steel-encased concrete walls have a height of 33'-7" and their foundations are seated at elevation 106'-9", 3'-3" below the building floor. The RD/RA Work Plan further details the selected remedy, describing the removal of the biological shield down to elevation 106'-9". BSA proposes a completed End State which is different than that described in the Selected Remedy. The difference is:

a. **Biological Shield Foundation below Floor Elevation (Figure 3):** Removal of the biological shield inner steel wall and concrete structure will take place to the Building 701 floor level (elevation 110'-0"). The outer steel walls which are free of radiological activation will also be removed to elevation 110'-0". The remaining portion of the bioshield foundation below the building floor will be protected beneath a reinforced concrete cover. The steel plates that were placed over the pile bedplates and cementious grout installed during the removal activities will also remain in place beneath the reinforced concrete cover. This will provide for a structurally stable long-term configuration,

with no void spaces, no pathway to groundwater for radioactive contaminants, and radiological dose rates not exceeding 0.1 milliRem per hour (mR/hr). The remaining portion of the bioshield wall will also be documented in an Explanation of Significant Differences document. This ESD, titled Area of Concern 9 Brookhaven Graphite Research Reactor, Explanation of Significant Differences for the Biological Shield Removal (Ref. 4) is prepared for DOE by BSA.

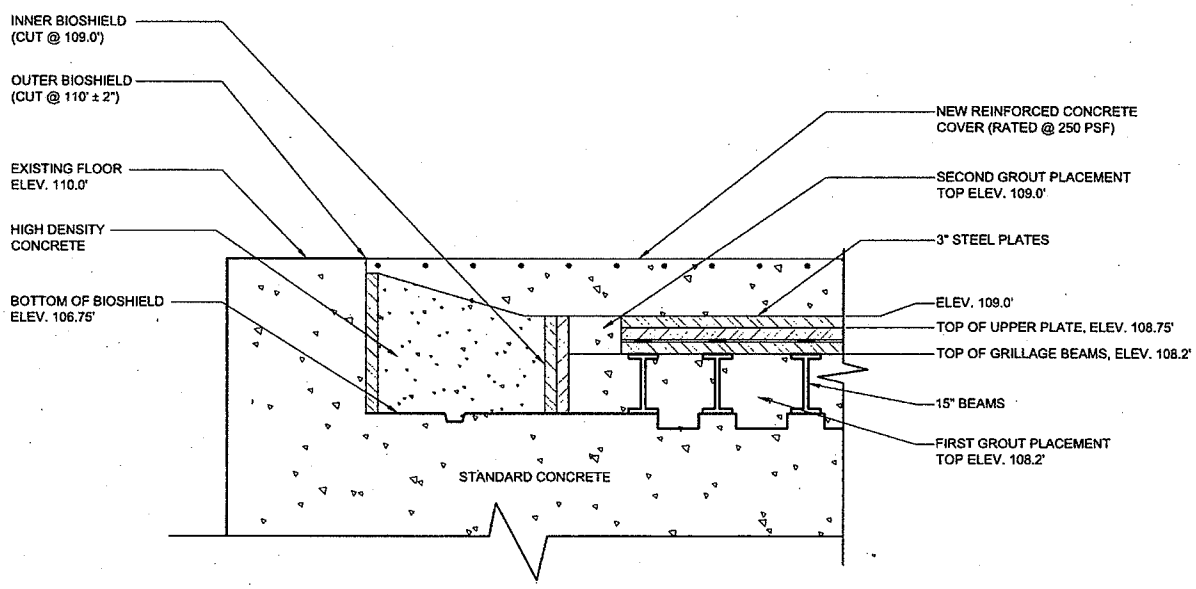

Figure 3

Section View of Proposed End State

(Typical for North, West & South Walls)

2. Nonsignificant and Minor Differences

The following are nonsignificant and minor differences in the End State of the BGRR biological shield as anticipated in the RD/RA Work Plan.

Appendix 1 provides a cross-referenced summary of these differences compared to the descriptions originally included in the 2005 ROD and the 2008 RD/RA Work Plan. The following descriptions summarize the various differences:

a. Experimental Balcony Removal:

Section 2.1.1.4.a of the RD/RA Work Plan states that the two uppermost balconies (located at elevation 136'-0") shall be removed in

their entirety, and the remaining five balconies shall be removed "...to a point no greater than five feet (5'-0") from the biological shield attachment points." The intended purpose of partially removing these five large experimental balconies was to provide worker and equipment access during the removal of the outer biological shield steel walls. During preparation for demolition of the biological shield, it became apparent that the north and west balconies had to be removed in their entirety due to work space restrictions. In addition, BSA estimated that approximately $40,000.00 in savings was realized by separating the steel from the concrete in the north and west balconies and disposing of it in an alternative disposal facility instead of a commercial low-level waste disposal facility.

b. Pile Bedplates Removal:

Although they are not part of the BGRR biological shield, the RD/RA Work Plan anticipates removal of the upper bedplate and skids which supported the graphite pile. Removal of the pile bedplates is not discussed in the Record of Decision. As explained above, the placement of concrete and steel shielding to limit worker exposure was required for the removal of the graphite pile and the biological shield. BSA proposes to allow the upper pile bedplates to remain in place due to worker exposure that would result from removal activities and cost and schedule considerations of removing the previously-placed concrete and steel. This will provide a structurally stable long-term configuration, with radiological dose rates not exceeding 0.1 mR/hr after installation of the permanent concrete cover over the building floor at elevation 110'-0".

c. Chemo-Nuclear System Lead Wall Removal:

The RD/RA Work Plan states that the Chemo-Nuclear System lead walls will be removed. The Chemo-Nuclear system within Bldg. 701 high bay has been removed in its entirety, including the lead walls, to provide additional working space for equipment and work execution.

d. Verification of As-Left Radiological Survey/Contamination Levels:

The RD/RA Work Plan anticipates that a final radiological survey will be performed on the upper surface of the lower bedplates, and that DOE will independently verify this survey. With the current configuration of leaving the upper bedplates in place beneath the existing 3" of steel shield plating and concrete, BSA will perform a radiological survey of the surface after the biological shield has been demolished, loose debris has been removed, and a preliminary pour of concrete has been applied as a fixative. After the survey is performed, a reinforced concrete floor will be finalized over the footprint of the removed biological shield to an elevation of 110'. A final as-left radiological survey will be performed on this final floor surface to verify

dose rates are less than 0.1mR/hr. DOE will independently verify this survey.

F. Differences in Radiological End Point

The total radioactivity remaining in the pile base plates is calculated to be ~11.2 Curies (Ci) with the majority of the activity being Ni-63 (78%). Ni-63 will not contribute to the end state radiation levels because Ni-63 is a beta-emitting radionuclide that will be completely shielded by the proposed concrete floor. Of the 11.2 Ci of radioactivity remaining in the pile base plates there will be ~2 Ci of Co-60, which is the main contributor to the end state radiation levels at the 110' elevation pile floor area. The 3 inches of steel and 12 – 14 inches of concrete placed over the pile base plates will provide sufficient shielding to reduce the end state radiation dose rate to a value of <0.1 mR/hr at the center of the pile 110' floor area.

The ROD states that Alternative C (the selected alternative) will result in the removal of 8,093 Ci from the BGRR complex, with the graphite pile and biological shield accounting for 8,044 Ci. With the upper base plate and the below floor-level bioshield concrete remaining, the total Ci remaining will be on the order of 15 Ci, which includes residual soil contamination below the building. Leaving the upper and lower bed plates, as well as the below grade bioshield, results in 99.8 percent of the initial inventory being removed, vs 99.9 percent if only the lower bed plate remains. Both these figures are consistent with the statement in Section 11.1 of the ROD which describes the remedy as removing over 99 percent of the radioactive material inventory at the BGRR complex, and the change is not considered to create a variance with the end-state defined in the ROD.

G. Conclusion

It is BSA's conclusion that the differences in the removal scope for the BGRR biological shield from those delineated in the RD/RA Work Plan are consistent with described processes and end points in the ROD, and reduced worker exposure during the removal of the BGRR biological shield. The proposed end state configuration is consistent with the ROD, is stable, and will not affect the long-term management of Building 701. BSA believes that this end state achieves the intent of Alternative C in the Record of Decision, and will meet the radiological end points in the RD/RA Work Plan.

The differences in actions taken have been driven by operational efficiency and ALARA considerations. The ROD specifies in section 7.0 that one Remedial Action Objective is to "use the As Low As Reasonably Achievable (ALARA) principle, while implementing the remedial action..." The removal of the entire west and north balconies and the removal of the entire Chemo-Nuclear Loop were driven by operational efficiency. Leaving the upper pile base plate and the portion of the biological shield below floor-level is driven

by ALARA principles, and does not affect the end state configuration in any significant way. The adjustment of the final status survey to reflect the remaining upper pile bed plate achieves the same radiological end-state goal relative to dose on the surface of the final floor and contamination levels in the accessible areas of the building as were specified in the ROD and the RD/RA Work Plan.

Alternative C, as defined in the ROD, describes the end state of the BGRR as follows: "...Building 701 will remain intact with a covering over the open floor space and residual radioactivity within the reactor pile foundation, support structure, and deep pit stabilized in place and sealed from Building 701... These contaminants are bound within concrete, embedded within steel or located within areas that are currently inaccessible and are not considered a groundwater contamination source term." The changes described in this white paper do not affect this described end state. The contamination that will remain in the upper bed plate is embedded within steel and bound within the concrete of the final cap. The contamination remaining in the bioshield below floor level is bound within the hardened concrete, embedded in the outer steel plating, and bound within the concrete of the final cap. This remaining contamination has no mechanism for infiltrating into groundwater.

Additionally, the ROD states in Section 11.1 that the chosen remedy removes over 99 percent of the radioactive material in the BGRR complex. As discussed above, the remaining upper pile bed plate and below floor-level portion of the biological shield do not affect this commitment. The calculated removal of inventory is approximately 99.8% based on estimated inventory in the upper baseplate and the remaining below-grade portion of the bioshield.

The changes discussed in this paper do not affect any aspect of the Land Use Institutional Controls discussed in the ROD. The last paragraph of the section in the ROD which discusses Land Use Institutional Controls states that "Following completion of the BGRR remediation, residual radioactivity will remain within inaccessible pockets of contaminated soils and contaminated below grade structures. These contaminants are bound within the concrete and steel structures and are located within the BGRR complex." The changes described in this white paper do not affect this description. The contamination that will remain in the upper bed plate is embedded within steel and bound within the concrete of the final cap. The contamination remaining in the biological shield below floor level is bound within the hardened concrete, embedded in the outer steel plating, and bound within the concrete of the final floor. The roof of the BGRR protects this floor from the elements. This remaining contamination has no mechanism for infiltrating into groundwater.

The changes described in this paper do not affect compliance with any ARARs defined in the ROD.

H. Reference Documents

1. Final Record of Decision for Area of Concern 9, Brookhaven Graphite Research Reactor (BGRR) dated January 31, 2005.
2. Remedial Design/Remedial Action Work Plan for the Biological Shield Removal dated March 28, 2008.
3. Technical Manual, Brookhaven Graphite Research Reactor, prepared by Burns and Roe for submission to the US Atomic Energy Commission, October 1962.
4. Area of Concern 9, Brookhaven Graphite Research Reactor, Explanation of Significant Differences for the Biological Shield Removal (date pending).

Appendix 1
Removal Scope Comparison with ROD and RD/RA Work Plan

Removal Item	Reference	Delineated Removal Scope	Actual/Proposed Difference in Removal Scope
Biological Shield Removal	Record of Decision Section 10, Selected Remedy, Removal of the Biological Shield (p.34)	"Removal of the biological shield will include removal of the neutron shield and the steel-encased concrete walls. Loose debris will be removed and a fixative applied to the exposed surfaces."	The outer steel walls will be removed down to elevation 110'-0". The inner steel walls and the concrete between the inner and outer walls will be removed down to elevation 109'-0". The north and south neutron shields will be removed. Loose debris will be removed and a first pour of concrete will be applied as a fixative to the exposed surfaces.
	RD/RA Work Plan, Section 2.1.1.4.c, Statement of Work (p.12)	"The biological shield walls shall be removed from the top at elevation 140'-4" down to elevation 106'- 9"."	
Experimental Balcony Removal	RD/RA Work Plan, Section 2.1.1.4.a, Statement of Work (second paragraph, p.12)	"There are seven (7) balconies attached to the outer biological shield walls. Two balconies, each located on the north and west walls at elevation 136 ft shall be removed in their entirety. The remaining five (5) balconies shall be removed to a point no greater than five feet (5'-0") from the biological shield attachment points. The asbestos containing material (ACM) floor tiles on the balcony areas shall be removed prior to demolition of the structures."	The two west balconies and the single north balcony have been removed in their entirety in order to provide adequate working space for cutting operations and installation of the contamination control enclosure.
Pile Bedplates Removal	RD/RA Work Plan, Section 2.1.1.4.c.vi., Statement of Work (p.12)	"Removal of the pile upper bedplates and sliding rails. The steel beams and fixed lower bedplates shall remain."	Both the upper and lower bedplates will remain. The upper sliding rails have been removed and a 3-inch thick steel plate has been installed on top of the upper bedplate and grouted in place to reduce radiological dose after placement of the final reinforced concrete cover over the footprint of the removed biological shield.

Appendix 1
Removal Scope Comparison with ROD and RD/RA Work Plan

Removal Item	Reference	Delineated Removal Scope	Actual/Proposed Difference in Removal Scope
As-Left Radiological Survey/Contamination Levels	RD/RA Work Plan, Section 2.1.3 (p.17)	"The final step for the biological shield removal is the installation of a permanent reinforced concrete over the footprint of the removed biological shield (Figure 2-4). Prior to the cover installation, verification that all loose and visible debris within the biological shield footprint has been removed will be conducted. BSA shall perform a final radiological survey of the top of the lower bedplates and accessible concrete surfaces around the bedplates to verify that residual contamination levels are less than 100,000 dpm beta gamma. The DOE will independently verify the as-left condition. Once the inspection is completed, a fixative will be applied to the internal surfaces of the biological shield footprint and the permanent reinforced concrete cover will be installed."	Prior to the placement of the final reinforced concrete cap over the footprint of the removed biological shield on the elevation 109'-0", all loose and visible debris will be removed. In lieu of the surface contamination survey of the lower bedplate described in the RD/RA Work Plan, BSA will perform a radiological survey to document the as-left status of the upper surface of the 3" steel plates and concrete placed during the removal of the biological shield. This survey will verify that residual contamination levels are less than 100,000 dpm beta/gamma and 10 mR/hr at a foot. In addition, following placement of the reinforced concrete cover to the 110' level, BSA will perform a final as-left survey that DOE will independently verify. This survey will demonstrate that the as-left dose rate on the floor surface is less than 0.1 mR/hr, and that all remaining contamination has been fixed in place. The final concrete placement on the bioshield floor will assure than all remaining contamination is bound in steel and concrete within the BGRR structure.
Chemo-Nuclear System Removal	RD/RA Work Plan, Section 2.1.1.4.a. (Para. 4, last sentence) (p.12)	"The lead walls associated with the Chemo-Nuclear loop will be completely removed. "	The Chemo-Nuclear System within Bldg. 701 high bay, including the lead walls, has been removed in its entirety.

COMMENT RESOLUTION FORM
REMEDIAL DESIGN IMPLEMENTATION REPORT (TECHNICAL WHITE PAPER)
December 2011

Reviewer and Organization:		
Number	**Comment**	**Response**
NYSDEC - 01	Please comment on DOE's approach for the public outreach and information regarding the change in removal scope for the BGRR. The State suggests that this outreach should be done preceding the actual work change.	Based on comments received from the DEC, ERP now intends to develop two documents, an Explanation of Significant Difference (ESD) addressing the portions of the Bioshield walls that are intended to be left behind, and a revised Remedial Design Implementation Report (RDIR) addressing both the Bioshield foundation and the other topics that the draft White Paper (now reformatted as the RDIR) covered. Refer to document EPA 540-R-98-031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Documents* *http://www.epa.gov/superfund/policy/remedy/rods/pdfs/guide_decision_documents_071999.pdf* With respect to the ESD, required public notification via published summary of the ESD in a major newspaper will be performed. With respect to the RDIR, the described changes to the scope of the BGRR Biological Shield removal as delineated in the ROD and RD/RA plan are believed by DOE/BSA to constitute a "Nonsignificant or Minor" change as outlined in section 7.0 of the above referenced document, and therefore no public outreach is required. However, DOE will inform the BNL Community Advisory Council (CAC) of the contents of the RDIR and ESD at a regularly scheduled meeting and will also brief the Brookhaven Executive Roundtable (BER). Unfortunately, the tight schedule at the BGRR does not allow the project to be stopped pending notifications. As there are no regulatory requirements to notify the public prior to continuing work, the project will carry on to perform the work as described in the ESD and RDIR.
NYSDEC - 02	What was the dose rate on the upper bedplate before it was covered?	Surveys of the upper bed plates were conducted following the removal of the graphite pile. The dose rate ranged from 20 to 120 mr/hr with the highest activity in the center and lower readings around the outer edges and corners.

COMMENT RESOLUTION FORM
REMEDIAL DESIGN IMPLEMENTATION REPORT (TECHNICAL WHITE PAPER)
December 2011

Reviewer and Organization:

Number	Comment	Response
NYSDEC - 03	What is the worker dose savings realized by leaving the upper bedplate, etc. in place instead of removing it?	An ALARA evaluation was conducted which determined that 1,000 mrem was saved by installing 3" of shielding over the upper bedplate while the bioshield roof and walls were removed. The dose estimate to remove the upper bedplate is 1,045 mrem. The total savings for leaving the upper bedplate is 2,045 mrem. The ALARA evaluation is attached, "Bioshield Base Plate Shielding ALARA Evaluation". In summary, it supports the following estimate of Dose to workers: | | **Dose (mrem)** | | Part 1- Use of shielding | 1,000 | | Part 2 – Removal of base plate | 1,045 | | **Total** | **2,045** |
NYSDEC - 04	Can DOE provide a more detailed description on the basis for the assessment of remaining radioactive materials (i.e. 2 Ci of Co-60, 78% Ni-63) and compare it to the assessment in the ROD (1.41 Ci remaining)?	The statement in the white paper is confusing and will be revised. The ROD does not quote the value of 1.41 Ci remaining; in fact it does not address the bedplates at all. The 1.41 Ci figure is DOE/BSA's estimate of the Curie content of the lower bed plate. The RD/RA Work Plan states without quantification of Curie content that the lower bed plate will remain. In the attachment to this document titled "Evaluation of Total Remaining Curie Content of the BGRR Complex vs. ROD Commitments," the calculation of remaining radioactive materials at the BGRR and a comparison to the requirements in the ROD is presented in detail.
NYSDEC - 05	What are the future plans for the section of property that was the BGRR?	Upon completion of the D&D of the biological shield, the facility will be placed into a long-term surveillance and maintenance condition (S&M). There are no plans to occupy the building. S&M will include monitoring the integrity of the building structure as well as the integrity of the engineered cap, and inspecting for water intrusion into the below ground ducts and the building itself.

COMMENT RESOLUTION FORM
REMEDIAL DESIGN IMPLEMENTATION REPORT (TECHNICAL WHITE PAPER)
December 2011

Reviewer and Organization:		
Number	**Comment**	**Response**
NYSDEC - 06	What are the assumptions for occupancy of the area by members of the public (non-radiation workers) after completion? Depending on the assumptions made, a dose rate of 0.1mR/hr could result in exceeding the dose rate limits to a member of the public (100mrem/year).	The assumption is that no one will occupy the office or high bay (former reactor location). The dose rate inside both of these areas, which are accessible to authorized personnel, including non-radiation workers, will be less than 0.1mR/hr. Routine surveillances may result in a few person-hours per year of exposure to workers.
NYSDEC - 07	Does DOE plan to perform sampling and analysis of the remaining bioshield to support the assumptions outlined in the White Paper?	BSA will perform a radiological survey of the floor above the upper bedplate upon completion of the biological shield wall removal below the 110' elevation and cleanup of debris and dust. The survey results will be evaluated to ensure the proposed thickness of the concrete floor will provide sufficient shielding to achieve the targeted dose rate value of less than 0.1 mR/hr. After the concrete floor has been placed, an as-left survey will be performed by BSA and verified by DOE ORISE to ensure the <0.1 mR/hr value has been achieved. In addition, surveys were conducted of the north and west bioshield walls at the 108' elevation to assist in calculation of the amount of activity remaining. Using the dose rates observed and the known distribution of radioisotopes in the activated steel and concrete, a calculation was performed which concluded that 1.11 Curies of activity remains within the steel and concrete of the biological shield walls below the 110' elevation. This calculation is attached, "Calculation of Total Curie Content in the Biological Shield below the 110' Elevation". Samples were taken of the remaining bioshield steel and concrete below the 110'-0" floor level which will be analyzed to validate the calculation.

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December 2011

Reviewer and Organization:		
Number	**Comment**	**Response**
NYSDEC - 08	DOE should provide detailed analysis to support the use of ALARA to justify the idea of not removing the entire bioshield.	The ALARA evaluation for leaving the upper bedplate is attached and is titled - Bioshield Base Plate Shielding ALARA Evaluation. This evaluation concludes that a dose consequence for workers removing the upper bedplate would be on the order of 1,000 mrem. Since the upper bedplate is not mentioned in the ROD, this justification is considered strong enough to offset the residual radioactivity in the bedplates, which will be well within the parameters documented as acceptable in the ROD. (See attached paper, "Evaluation of Total Remaining Curie Content of the BGRR Complex vs. ROD Commitments.") The justification for leaving the foundation of the bioshield below elevation 110'-0" is a financial as well as an ALARA one. The dose estimate to remove the portion of the bioshield walls below the 110'-0" elevation would be approximately 240 man-mRem. This is based on the schedule assumption that it would take a month to remove this portion of the walls, with two shifts working 10 hrs/day, 5 days a week. Two workers plus one RadCon tech would be involved, and the effective dose rate in the area of the bioshield walls ranges from 0.1 to 2mr/hr. An assumption was made that half of the full duration the workers would be exposed to 0.4 mr/hr. This results in the 240 man-mRem figure. The amount of residual radioactivity is very small (less than 1.11 Curies) and well within the ROD parameters for residual radioactivity as demonstrated in the attached paper titled "Evaluation of Total Remaining Curie Content of the BGRR Complex vs. ROD Commitments." In each case the remaining radioactive material will be encased in concrete below a reinforced concrete cap within the BGRR building, and will therefore pose no danger of migration to groundwater. The interior of the BGRR and the cap will be inspected routinely to assure any degradation is identified and corrected in a timely manner.

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Reviewer and Organization:		
Number	**Comment**	**Response**
EPA-01	Provide volume and mass estimates of material proposed to leave in place as is as compared to ROD Alternative C.	Alternative C anticipates removal of the bioshield in its entirety down to elevation 106'9" and the north and south neutron shields. Total volume/weight is: - Inner/outer wall steel: 4,170 ft^3/2,022,000 lbs - High density concrete: 26,500 ft^3/7,400,000 lbs The volume/weight of the bioshield which is proposed to be left in place below the floor (elev. 106'-9" – 110'-0"): - Inner/outer wall steel: 223 ft^3/108,000 lbs - High density concrete: 1900 ft^3/531,000 lbs Note: Concrete density is assumed at 279 lb/ ft^3 – steel density assumed at 485 lb/ ft^3
EPA-02	*" To reduce worker exposure during the removal of the Biological Shield, steel plates and concrete were placed up to elevation 109'0". BSA proposes not to remove this previously placed steel and concrete due to worker exposure and cost and schedule considerations, and because the biological shield below floor level was not exposed to significant flux during the operation of the reactor and is therefore almost entirely free of radiological activation."* Provide technical basis for this statement. Include 3-D map of flux levels in bioshield and plates during full power operations. Basis: ROD(2005) states that "Characterization results indicate that almost all of the radiological inventory is confined to the inner one-third of the biological shield." That portion of bioshield is proposed not to remove as compared to the ROD Alternative C.	A 3-D map of the flux levels in the bioshield and plates during full power operations were not available during the time period the BGRR was in operation (1950 – 1968). What is available is a graph of the flux symmetry from the document Graphite Research Reactor Facilities and Services Guide Figure 7a, which is attached. Additionally the "BGRR Radiological and Hazardous Material Assessment of the BGRR Bioshield and Associated Components" Appendix D "BGRR Flux Symmetry Estimates" states "Based on the drop off to about 4% at 12 feet from the center (near the edge of the pile), the area outside the pile would have been exposed to substantially less neutron fluence. A conservative assumed that metal and concrete outside the pile area (beyond 12.5 feet from center) would comprise less than 10% of the total radioactivity in the pile region." The referenced assessment is also attached. In the attached "Calculation of Total Curie Content in the Biological Shield below the 110' Elevation," it is determined that 1.11 Curies of activity remains within the steel and concrete of the biological shield walls below the 110' elevation, based on conservative assumptions and measured dose rates.

Reviewer and Organization:

<table>
<tr><th>Number</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td></td><td>Radiation surveys were performed of the North and South walls at elevation 108' and compared to surveys of the walls above 110', documenting the low levels of activity in the below-floor portion of the bioshield as documented in the chart below.

<table>
<tr><td></td><td>North wall above 110'</td><td>North wall at 108'</td><td>West wall above 110'</td><td>West wall at 108'</td></tr>
<tr><td>~1 foot from wall (mR/hr)</td><td>–Max 350</td><td>5</td><td>Max 1,100</td><td>10</td></tr>
</table>

Sampling of the remaining bioshield steel and concrete below the floor level was completed and will be analyzed to validate the calculations of residual activity.</td></tr>
<tr><td>EPA-03</td><td>" BSA proposes to allow the upper pile bedplates to remain in place due to worker exposure that would result from removal activities and cost and schedule considerations of removing this previously-placed concrete and steel. This will provide for a structurally stable long-term configuration."

Explain how the temporarily added components that were not intended to provide long-term structural strength would provide "a structurally stable long-term configuration". Provide technical basis demonstrating that temporarily added components would not reduce the long-term structural stability of the remaining configuration.</td><td>The added components consist of high-strength reinforced concrete (4,000 psi and greater), cementious grout, and 3-inch thick shield plates laid horizontally on top of the upper pile bedplates. The RD/RA Work Plan (Section 2.1.5) described "Installation of a permanent reinforced concrete cover over the footprint of the removed biological shield." This installation, which will cover the grouted bedplates with a reinforced concrete cap 12" thick, will establish a configuration with no void spaces within the footprint of the biological shield, and will result in a stable condition. The entire installation design was approved by a NYS-registered Professional Engineer.</td></tr>
</table>

COMMENT RESOLUTION FORM
REMEDIAL DESIGN IMPLEMENTATION REPORT (TECHNICAL WHITE PAPER)
December 2011

Reviewer and Organization:		
Number	**Comment**	**Response**
EPA-04	*"The ROD states that Alternative C (the selected alternative) will result in the removal of 8,093 Ci from the BGRR complex, leaving approximately 1.41 Ci in the lower bed plate. With the upper base plate and the below floor-level bioshield concrete remaining, the total Ci remaining will be on the order of 15 Ci,"* Provide technical basis for this estimate. Include separately for both, plate and bioshield: (1) Radionuclide inventory proposed to leave as is as compared to ROD Alternative C, (2) activities of specific radionuclides. Basis: ROD(2005) states that "Characterization results indicate that almost all of the radiological inventory is confined to the inner one-third of the biological shield." That portion of bioshield is proposed not to remove as compared to the ROD Alternative C.	The statement in the white paper is confusing and will be revised. The ROD does not quote the value of 1.41 Ci remaining; in fact it does not address the bedplates at all. The RD/RA Work Plan states without quantification of Curie content that the lower bed plate will remain. The figure of 1.41 Ci is ERP's current estimate of the Curie content of the lower bed plate. In terms of quoted Curie content in the ROD, Alternative C stated that 99% of the 8,093 Ci of radioactive material would be removed by the selected remedy. The attached paper, "Evaluation of Total Remaining Curie Content of the BGRR Complex vs. ROD Commitments," provides a detailed evaluation of all remaining radioactivity in the BGRR complex post-remediation and compares that to the ROD commitments.
EPA-05	*"These contaminants are bound within concrete, embedded within steel or located within areas that are currently inaccessible and are not considered a groundwater contamination source term." The changes described in this white paper do not affect this described end state."* Provide technical basis for this statement. Include characterization results of the materials proposed to leave in place as is in addition to those outlined in ROD Alternative C. Include estimates of degradation degree of concrete, steel and other activated and contaminated materials. Basis: ROD states that "Historical leaks and spills at the BGRR complex have resulted in contaminated groundwater."	The attached paper, "Evaluation of Total Remaining Curie Content of the BGRR Complex vs. ROD Commitments," provides a detailed evaluation of all remaining radioactivity in the BGRR complex post-remediation and compares that to the ROD commitments. The remaining activity in the bed plates and the bioshield foundation is bound within the activated steel and concrete that is inaccessible beneath the 12" of reinforced concrete floor, and is therefore not considered a groundwater contamination source term. The contamination left in place will be fixed by ~12" of concrete, and protected by the physical structure of the building and the surrounding engineered cap. The condition of the material that is proposed to be left is very robust. The concrete is estimated to have a strength of approximately 7,000 pounds per square inch and has been very resistant to demolition. The steel is 3" thick, and although it may have superficial rust in places, the structural integrity of the steel is not diminished.

COMMENT RESOLUTION FORM
REMEDIAL DESIGN IMPLEMENTATION REPORT (TECHNICAL WHITE PAPER)
December 2011

Reviewer and Organization:		
Number	**Comment**	**Response**
		The 12" of reinforced concrete and the engineered cap are new as of 2011; therefore degradation is not an immediate issue. The building itself is currently inhabited, and is not experiencing any water intrusion. After the completion of the project the building, engineered cap and poured concrete floor will be subject to routine inspections as part of the long term S&M plan for the BGRR.

Evaluation of Total Remaining Curie Content of the Brookhaven Graphite Research Reactor (BGRR) Complex vs. Record of Decision (ROD) Commitments

Prepared: Diane Rocco, ERP Director 12/20/11

Executive Summary

This evaluation is intended to explain the determination that the end state conditions described in the December 2011 Evaluation of Significant Differences and Remedial Design Implementation Report describe a configuration that satisfies the commitment in the ROD to remove 99% of the original BGRR Curie Content as stated in the ROD (8093 Ci).

Table 1 presents the Curie contents of the various components of the BGRR complex as they were described in the 2005 ROD, which sum to the total of 8093 Curies quoted in the Alternative C discussion in the ROD. The Table also presents a conservative estimate of remaining Curie content as of December 2011. Details supporting this table are presented in subsequent sections, numbered per features in Table 1 below. The conclusion of this evaluation is that the proposed end state of the BGRR reflects removal of 99.82% of the original 8093 Curies, which is supportive of the commitment in the ROD.

Feature	ROD (Ci)	Dec 2011(Ci)
1) Pile	3239	0
2) Bioshield	4805	12.3
3) Deep Pit	0.1685	0.1685
4) Fuel Canal	0.0222	0.0222
5) BGD Ext.	0.8252	0.8252
6) BGD Int.	0.423	0.423
7) Soils	1.81	0.38
8) Sec. 4.1, 4.2	45.75	0.4575
Total	8093	14.58
	% removed	99.82%

Table 1 – Curie Content of BGRR in 2005 ROD

1. Graphite Pile

As of December 2011, the graphite pile has been removed in its entirety. Its current Curie content is now 0 Curies.

2. Bioshield

2.1 Curie Content Remaining in the Bioshield Foundation below the 110' Elevation

The calculation is performed sequentially on the three components of the Bioshield and then summed at the end. The three components are:

- Interior steel
- Concrete
- Exterior steel

2.1.1 Bioshield Interior Steel

Input Data:

- Dose rate at 1 ft on East/West walls: 10 milliRem (mR)/hr
- Dose rate at 1 ft on North/South walls: 5 mR/hr
- Ratio of dose rate on second layer of 3" steel to interior layer of 3" steel: 10:1

Microshield runs have been performed and documented in the Technical Basis Document for Bioshield Intermodal Containers (October 2011) which addresses activated steel plate from the Bioshield. The steel left under the floor will be 3'-3" tall, and will run right around the interior of the bioshield cavity. For ease of calculation, the Microshield run for the plate that is 3'-6" x 10'-0" x 0'-3" will be used as a basis of estimating Curie content in the inner steel plate left behind. Per the Microshield run, a plate 3'-6" x 10'-0" x 0'-3" which contained 0.001 Ci of Co-60 would exhibit a dose rate of 0.887 mR/hr at a foot. This dose rate would scale linearly with Ci content. Therefore, a plate of that size exhibiting 10 mR/hr would contain 0.01127 Ci of Co-60, and a plate of that size exhibiting 5 mR/hr would contain half as much, or 0.00564 Ci of Co-60. The interior dimensions of the Bioshield are 46.5 ft x 28.5 ft. Therefore, the interior steel plate of each of the East/West walls will contain (46.5/10) * 0.01127 = 0.05242 Ci of Co-60, and the interior steel plate of each of the North/South walls will contain (28.5/10)*0.00564 = 0.01607 Ci of Co-60. To account for the second layer of steel between the inner steel and the concrete, the total of the inner steel is multiplied by a factor of 1.10 to account for the lesser activation of the second layer of steel. The total calculated Co-60 for the steel remaining in the below-grade bioshield is

$$1.1 * 2\,(0.005242 + 0.01607) = 0.151 \text{ Ci of Co-60.}$$

Using the scaling factors documented in the Technical Basis Document for Bioshield Intermodal Containers (October 2011), which are based on sampling and analysis of activated Bioshield steel, Table 2 presents the total isotopic content of the activated steel:

Nuclide	Percent in Steel - Jan 2011	Nuclides Scaled from Co-60 (Ci)
C-14	0.15%	7.03E-04
Fe-55	0.72%	3.37E-03
Ni-59	0.80%	3.74E-03
Co-60	32.4%	1.51E-01
Ni-63	66.0%	3.08E-01
Total	100%	**4.67E-01**

Table 2 – Total Activation in Bioshield Foundation Steel

2.1.2 Bioshield Concrete

The total volume of concrete left behind is calculated from the interior dimensions (46.5 ft x 28.5 ft) and the thickness of the concrete (4.25 ft). By applying the density of the concrete (279 lbs/cu ft) to the total volume, one arrives at a total weight of concrete in the areas below floor level of approximately 650,000 lbs. The Technical Basis Document for Bioshield Intermodal Containers (October 2011) offers a method of using pounds of concrete to calculate total isotopic content of the concrete, based on sampling and analysis data of concrete from upper areas of the Bioshield. Assays of the concrete at floor level demonstrate that the concrete in the Bioshield at these lower elevations is substantially less activated than the concrete which was closer to the center of the pile. A maximum ratio of 1:4 is observed between isotopes assayed from the floor level and the isotopic concentrations used in the Technical Basis Document. Therefore, the concentrations of isotopes presented in the Technical Basis Document may conservatively be reduced to a third of their tabulated value in the calculation of the isotopic content of the below-floor level Bioshield Concrete. Table 3 presents the results of this calculation:

Weight of Concrete (lb):		650,000
Nuclide	**Ci/lb**	**Activity in Concrete (Ci)**
H-3	6.77E-07	4.40E-01
C-14	1.39E-09	9.01E-04
Fe-55	1.62E-10	1.05E-04
Ni-59	2.50E-10	1.63E-04
Co-60	1.42E-08	9.22E-03
Ni-63	2.84E-08	1.85E-02
Sr-90	8.98E-09	5.84E-03
Y-90	8.98E-09	5.84E-03
Cs-137	1.01E-07	6.54E-02
Ba-137m	1.01E-07	6.54E-02
Eu-152	4.63E-08	3.01E-02
Th-234	3.84E-10	2.50E-04
Pa-234m	3.84E-10	2.50E-04
U-234	3.84E-10	2.50E-04
U-238	3.84E-10	2.50E-04
Pu-239	5.72E-10	3.71E-04
Pu-240	2.45E-10	1.59E-04
Am-241	8.54E-10	5.55E-04
Total	9.90E-07	6.43E-01

Table 3 – Curie Content in Bioshield Foundation Concrete

2.1.3 Bioshield Exterior Steel

The exterior steel is not activated, as has been demonstrated in the Bioshield Characterization Report and confirmed through project experience. The net contribution of the exterior steel to Curie content of the below-grade Bioshield is zero.

2.1.4 Total Curie Content of Bioshield Foundation

The Sum of the calculated Curie content of the concrete and steel of the Bioshield below elevation 110' is 6.43E-01 Ci from concrete, and 4.67E-01 Ci from steel, for a total of 1.11 Curies left in the below-grade Bioshield. Forty percent of that total is from Tritium (H-3) which has a relatively short half-life of 12 years. The other two significant contributors are the longer lived isotopes Co-60 and Ni-63.

2.2 Curie Content Remaining in the Bioshield BedPlates

The assessment of the isotopic composition of the upper and lower bedplate is based on sampling and analysis performed of activated steel plates earlier in the project.

The activity contained in the bed plates was calculated following the graphite pile removal when the upper bed plate was accessible to survey.

Table 4 provides the activities calculated for the bed plates.

Nuclide	Activity (Ci) remaining in lower 3" bed plate	Total activity (Ci) remaining in 6" both bed plates
Co-60	0.26	2.07
Fe-55	0.02	0.16
Ni-59	0.03	0.24
Ni-63	1.10	8.74
Total	**1.41**	**11.2**

Table 4 – Total Curie Content in Bioshield Bed Plate Steel

2.3 Total Curie Content Remaining in Bioshield

Based on the above calculations, the total Curie Content remaining in the Bioshield Post-Remediation will be 1.11 + 11.2 = 12.3 Curies.

3, 4, 5, 6 Deep Pit, Fuel Canal, BGD Exterior to and Below the BGRR

Although the remediation of these areas has reduced the overall Curie content, the contribution to a calculation of Curie content remaining post-remediation is trivial. For the purposes of this paper, it will be conservatively assumed that the full Curie content is still present in these features.

7. Soils

Approximately 1.81 Curies were originally stated in the 2005 ROD to be present in the contaminated soil around the BGRR (See Table 5). Removals required by the Alternative C plan are the soils adjacent to the below-ground duct expansion joint #4, the fuel canal concrete structure and associated soils, and the soils adjacent to the blow-ground duct secondary cooling-air bustle. All these removals have taken place, as well as the soil below the sample room in the trench area, and those removals account for 1.44 Curies. Therefore, the remaining Curie content in the soils is conservatively stated as 0.38 Curies.

Area	CuYd	cc/cy	cubic cm	soil g/cc	Ave pCi/g	pCi	Ci/pCi	Ci	
Bustle	35.3	764555	2.70E+07	1.52	32655	1.34E+12	1.00E-12	1.34E+00	removed
Canal OW	18.5	764555	1.41E+07	1.52	956	2.06E+10	1.00E-12	2.06E-02	removed
Canal CJ	11	764555	8.41E+06	1.52	1411.4	1.80E+10	1.00E-12	1.80E-02	removed
Exp Jt 4	107	764555	8.18E+07	1.52	425	5.28E+10	1.00E-12	5.28E-02	removed
Drains OS	3	764555	2.29E+06	1.52	149	5.19E+08	1.00E-12	5.19E-04	
Drains IS	5	764555	3.82E+06	1.52	2180	1.27E+10	1.00E-12	1.27E-02	
RB Trench	2	764555	1.53E+06	1.52	1831.98	4.26E+09	1.00E-12	4.26E-03	removed
BGD	69	764555	5.28E+07	1.52	4515.6	3.62E+11	1.00E-12	3.62E-01	
Deep Pit	20	764555	1.53E+07	1.52	155.75	3.62E+09	1.00E-12	3.62E-03	

Table 5 – Calculation of Original Curie Content in Soils per 2005 ROD

8. ROD Section 4.1 and 4.2 Actions

In arriving at the original total Curie content of the BGRR, the ROD discussed actions which were already complete in Section 4.1 and actions which were underway as of the date of publication in Section 4.2. All these actions have been completed; therefore the Curie contents associated with those elements is 0.

APPENDIX D – BGRR Flux Symmetry Estimates

BGRR Flux Symmetry Estimates

The consideration of established flux symmetry in the core of the Pile during selection of graphite sampling points was based on historical information provided in the BGRR Technical Manual and Graphite Research Reactor Facilities and Services Guide [Ref 8]. Figure 7a of Reference 8 is reproduced as Figure 10 in the text of this report. The following method was used to estimate that the average flux across a face of the pile was 62% of that at the center. Since the North-South and East-West flux percentages were close to each other, an average of both was taken as the estimate of symmetry. This is considered to be within the uncertainties of the calculations.

The average value of 62% was used when developing values for dose rates and total activity when limited survey or sample data was available.

Table A- 1. Estimate of BGRR Pile Flux Symmetry

ft from NS	% flux	ft from EW	% flux	Dist from center	Avg NS and EW
0	95	0	100	0	97.5
1	95	1	100	1	97.5
2	95	2	95	2	95
3	100	3	90	3	95
4	100	4	85	4	92.5
5	90	5	75	5	82.5
6	85	6	65	6	75
7	75	7	50	7	62.5
8	55	8	35	8	45
9	45	9	25	9	35
10	25	10	12	10	18.5
11	12	11	8	11	10
12	4	12	4	12	4
	67%		57%		62%

Note that the percent flux values above were estimated from the curves in Figure 10 of this report (Figure 7a of Reference 8). Based on the drop off to about 4% at 12 feet from the center (near the edge of the pile), the area outside the pile would have been exposed to substantially less neutron fluence. A conservative estimate was made and it was assumed that the metal and concrete outside the pile area (beyond 12.5 feet from center) would comprise less than 10% of the total radioactivity in the pile region.

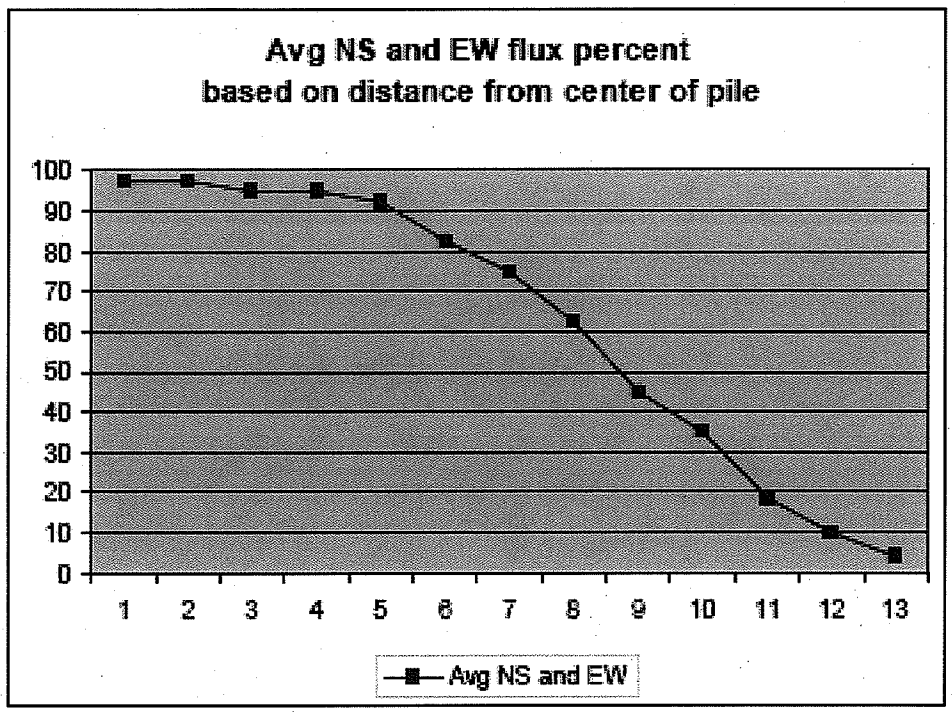
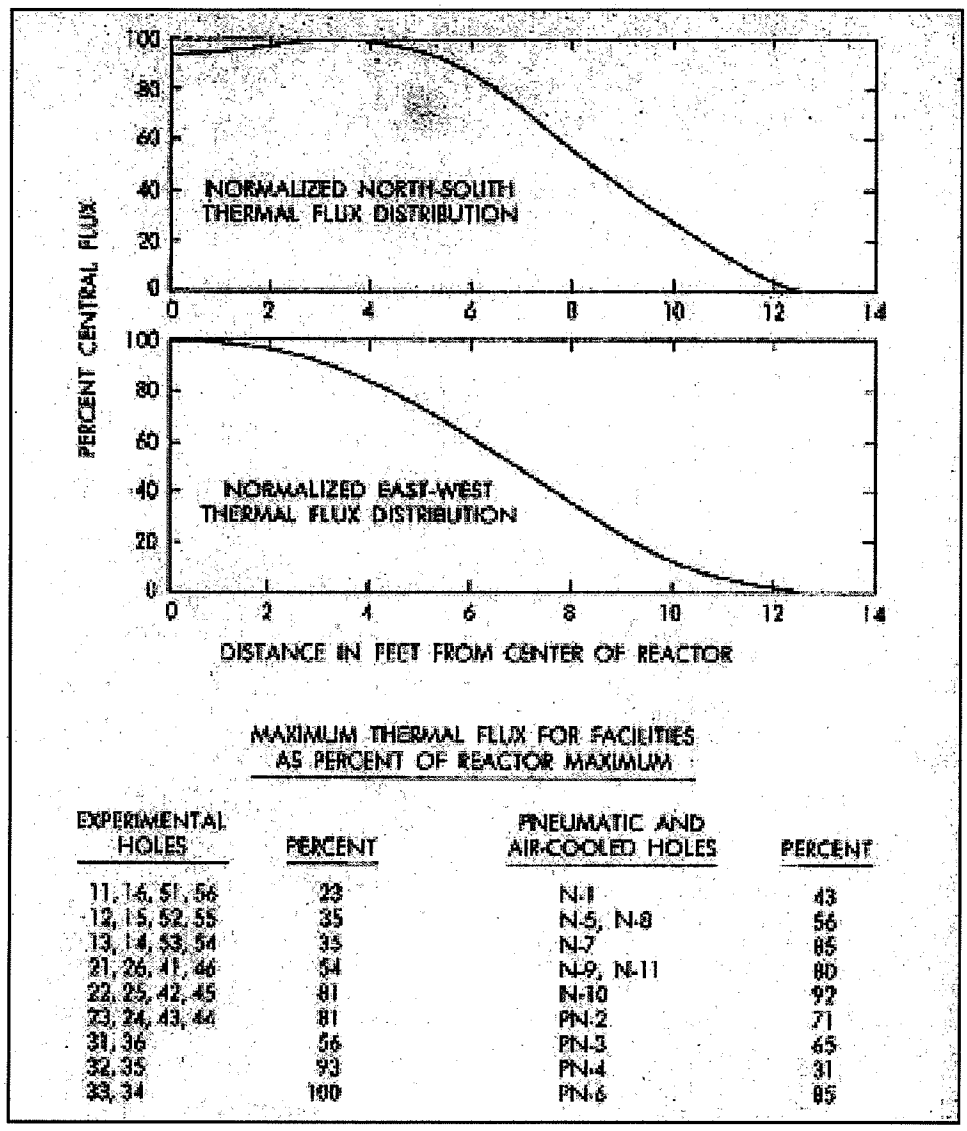


Figure D- 1. Curve of Average BGRR Flux Percent based on Distance from Center of Pile



MAXIMUM THERMAL FLUX FOR FACILITIES AS PERCENT OF REACTOR MAXIMUM

EXPERIMENTAL HOLES	PERCENT	PNEUMATIC AND AIR-COOLED HOLES	PERCENT
11, 16, 51, 56	23	N-1	43
12, 15, 52, 55	35	N-5, N-8	56
13, 14, 53, 54	35	N-7	85
21, 26, 41, 46	54	N-9, N-11	80
22, 25, 42, 45	81	N-10	92
23, 24, 43, 44	81	PN-2	71
31, 36	56	PN-3	65
32, 35	93	PN-4	31
33, 34	100	PN-6	85

Figure 10. Representative Flux Data

Sample locations and material were selected considering this symmetry to ensure a representative assessment of the entire bioshield.

Bioshield Base Plate Shielding ALARA Evaluation

Bioshield Survey

Bioshield base plate survey evaluation consisted of twenty survey points performed with a directional shielded probe of the pre and post base plate shielding condition.

	Dose Rate Range (mR/hr)	Average Dose Rate (mR/hr)
Exposed base plates	20 -120	32
Shielded base plates	10 - 25	14
Shielding factor		2.3

Radiation Dose Savings

The estimate of the dose saved by shielding the base plates consisted of two parts.

1. The dose saved during the bioshield demolition with the shielding installed on the base plates.
2. The dose that we be incurred to cut up, remove and package the top 3" of base plate.

Part 1

To estimate the amount of dose savings due to the addition of the base plate shielding, three RWPs involving entry into and on top of the bioshield were reviewed:

RWP	Actual Dose (mrem)	Dose Estimate (mrem)
2010-ERP-043 Bioshield D&D	3,701	4,194
2011-ERP-043 Bioshield D&D	3,695	5,064
2011-ERP-046 Bioshield Entry	448	1,200
Total	**7,844**	**10,458**

The dose contribution from the base plate is assumed to be about 1/5 of the total dose rate from the bioshield walls (4 side walls and base plate), because the base plate constitutes about 1/5 of the surface area. One could assume that the base plate, without any shielding, would contribute about 20% of the total dose for the above RWPs, or about 2,090 mrem based on the estimated dose. However, since the base plate was shielded, and the shielded dose rates were nominally a

factor of 2 lower, then the estimated 2,090 mrem from the base plate could be reduced by the shielding factor of 2 to about 1,000 mrem, or about 10% of the total estimated dose.

The 10% reduction to the overall dose received is ~800 mrem to date and up to ~1,000 mrem at project completion.

Part 2

The dose to remove the upper base plate would require the removal of the existing 3" of steel shielding, the cutting and packaging of the top 3" inches of the base plate. As stated the dose contribution from the base plate is assumed to be about 1/5 of the total dose rate from the bioshield walls (4 side walls and base plate), because the base plate constitutes about 1/5 of the surface area. Assuming that the base plate without any shielding would contribute about 20% of the total dose for the above RWPs, or about 2,090 mrem based on the estimated dose. Considering the fact that the base plate is being removed following the removal of the 4 side walls the dose would be reduced, but a portion of those savings would be offset because the cutting, removal and packaging would be primarily done manually.

The 2,090 mrem dose value would be reduced by 50% for a value of 1,045 mrem to cut, remove and package the upper 3" of base plate.

Dose Savings Total

	Dose (mrem)
Part 1- Use of shielding	1,000
Part 2 – Remove of base plate	1,045
Total	**2,045**