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HDP-PR-FSS-701 Final Status Survey Plan Development		
Revision Number	**Effective Date**	**Summary of the Revision**
0	01/16/2012	Initial issuance of the procedure.
1	02/04/2013	Provided clarification on soil sampling by stratum as indicated in Decommissioning Plan Table 14-24.
2	02/12/2013	Provided additional instructions for creating FSS Plans for Reuse Soil.
3	11/26/2014	Significant revision for clarification and minor corrections.
4	01/07/2015	Subsequent to comments received by NRC Region III regarding content of this procedure a technical readiness review was performed and the procedure revised accordingly.
5	02/11/2015	Updated the scan MDCs for U, Th-232 and Ra-226.
6	03/25/2015	Clarification of guidance for background ranges including acceptable ranges for use of a 10,000 cpm background for calculations and direction when background values are outside that range or survey parameters differ from those in HDP-TBD-FSS-002.
7	06/15/2015	Added information regarding piping survey plans, updated Ra-226 in-growth background value, clarified mean of SO equation, added direction on adjusting grid spacing to account for potential Tc-99 hotspots.
8	08/21/2015	The revision is initiated upon an agreement between the NRC and Westinghouse HDP in regards to Tc-99 sidewall sampling. The agreement was reached during a NRC Public Teleconference Meetings held on August 12, 2015, and August 19, 2015
9	10/28/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.
10	11/19/2015	Resolution and clarification of 100% GWS based on discussions with NRC Headquarters.

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HDP-PR-FSS-703 Final Status Survey Quality Control		
Revision Number	**Effective Date**	**Summary of the Revision**
0	01/16/2012	Initial issuance of the procedure.
1	11/26/2014	Clarification for SSC Survey units.
2	10/28/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

HDP-PR-FSS-710 Final Status Surveys and Radiological Sampling of Re-use Soil		
Revision Number	**Effective Date**	**Summary of the Revision**
0	01/16/2012	Initial issuance of the procedure.
1	01/31/2012	Revised step 8.1.2 from collect a general area background "at approximately waist level in the area of the survey" to "near the surface of clean soil".
2	05/03/2012	Procedure revised to allow material disposition at the direction of the RSO, move direction on action levels to Form HDP-PO-HP-100-2, and to allow for random sampling of cohesive materials.
3	05/14/2012	Procedure revised to clarify that a pile did not have to be marked with the sample ID # when the RSO has authorized for combining piles prior to receiving sample results.
4	02/04/2013	Added steps which describe the 3 approaches for performing surveys and sampling of potential re-use soil.
5	05/19/2014	Incorporated the requirements of Memo HEM-13-MEMO-099, Radiological Requirements for the Handling of Re-Use Soils During Development of Stockpile 8
6	11/26/2014	Applicability review revision that includes clarification to the approaches implemented in revision 4, typographical and formatting revisions.
7	03/18/2015	Procedure revised to discuss an alternative for approach 3 to allow surveying and sampling a re-use pile in layers and then remove each layer rather than spread each layer out

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HDP-PR-FSS-710
Final Status Surveys and Radiological Sampling of Re-use Soil

Revision Number	Effective Date	Summary of the Revision
		individually. Clarified wording to better describe requirements for sampling and survey of high, low and medium areas.
8	10/28/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

HDP-PR-FSS-711
Final Status Surveys and Sampling of Soil and Sediment

Revision Number	Effective Date	Summary of the Revision
0	01/16/2012	Initial issuance of the procedure.
1	02/04/2013	Updated reference to HDP-PR-FSS-701.
2	02/13/2013	Typographical correction. The procedure still had "Draft A, Proposed 1" listed under the revision heading on the title page when it was placed onto SharePoint.
3	04/25/2013	Provided clarification when survey instructions cannot be followed as written.
4	11/26/2014	Added instructions for notifications when working in or near physical security structures and components.
5	02/09/2015	Added steps to provide further details on where to document background readings and how to apply the backgrounds during the survey.
6	04/15/2015	Added detail for the notification and direction in the event that isolation controls are breached in a survey unit.
7	10/28/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.
8	11/19/2015	Added clarification to Step 8.4.3 that a 100% GWS is required in Class 1 areas, and that professional judgment may be used to scan additional areas than the minimum requirements for Class 2 and Class 3 areas.

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HDP-PR-FSS-721 Final Status Survey Data Evaluation		
Revision Number	**Effective Date**	**Summary of the Revision**
0	01/16/2012	Initial issuance of the procedure.
1	02/06/2013	Administrative revision only, forms changed to appendices.
2	02/20/2013	Administrative revision only, references updated.
3	11/26/2014	Provided clarification SOF, Corrected typographical error in SOF equation and other steps.
4	01/06/2015	Minor revision to insert procedure number in front of procedure title in Section 5.0 References.
5	02/09/2015	Clarifications on the calculation of statistics in Section 8.3 and SOF in Section 8.4, Additional guidance on completion of the WRS test and correct terminology used for the Test Statistic, Clarifications between the requirements for soil and structural survey units, added notes to clarify using the DCGLs used to develop the FSS plan unless instructed otherwise by the RSO, added step to Appendix G-1 to verify Laboratory quality control parameters are within acceptable limits.
6	03/25/2015	Clarifications on the calculation of statistics to correct negative values to zero when listing basic statistical data and listing the background values. Replaced Appendix C with table 14-4 from Attachment 4 to HEM-11-96 as this table is more appropriate since inferred Tc-99 is prohibited for use to demonstrate compliance. Added a note to clarify that it is prohibited to use U-235 to infer Tc-99 to demonstrate compliance. Removed references to SEA in the procedure and in the acronym list. Various terminology corrections. Added the calculation to use for obtaining a U-234 value when not measured for the calculation. Changed scan action level for Class 1 to be consistent with change to HDP-PR-FSS-701. Added underground piping.
7	04/15/2015	Added detail in Step 7.5.4 as to notification and direction in the event that isolation controls are breached in a survey unit.
8	06/15/2015	Updated the Ra-226 soil background value. Added

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HDP-PR-FSS-721 Final Status Survey Data Evaluation		
Revision Number	**Effective Date**	**Summary of the Revision**
		instruction for use of other DCGL conceptual site models rather than only the uniform DCGL.
9	08/13/2015	This revision implements clarification on the determination of dose for survey units. The changes are based upon an agreement between the U.S. NRC and Westinghouse in regards to calculating dose. The technical changes were agreed upon during the NRC-Westinghouse teleconference held on August 12, 2015.
10	10/28/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

HDP-PR-HP-411 Radiological Instrumentation		
Revision Number	**Effective Date**	**Summary of the Revision**
0	12/01/2010	Initial issuance of the procedure. This procedure superseded HDP-PR-HP-028.
1	12/20/2010	This revision provides clarifications regarding MDA and requirements when instruments are used for FSS.
2	04/01/2011	Provided additional information for set up of instrumentation.
3	10/25/2011	Updated Appendix A to be consistent with the DP.
4	11/21/2011	Administrative changes.
5	11/30/2011	Administrative changes.
6	07/22/2013	Added instruction For NaI 2x2 survey instruments designated for FSS Surveys to ensure that the High Voltage (HV) is set to the calibrated “GROSS” setting, the threshold is set at 100 keV, and the window is in the “Out” position.
7	06/13/2014	Clarified the requirements for using NIST traceable sources.

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HDP-PR-HP-411 Radiological Instrumentation		
Revision Number	**Effective Date**	**Summary of the Revision**
8	11/19/2014	Updated the Operating Instruction sheet for the Ludlum 3030 to also include the Ludlum 2929.
9	11/19/2015	Changed procedure to Westinghouse Proprietary Class 2.

HDP-PR-HP-416 Operation of the Ludlum 2221 for Final Status Survey		
Revision Number	**Effective Date**	**Summary of the Revision**
0	01/16/2012	Initial issuance of the procedure.
1	02/09/2015	Clarified instruction that the probe be kept as close to the ground as possible, nominally 1 inch from the surface and not to exceed 3 inches. Clarified instruction to scan at 1 foot per second and that head phones should be used when it is noisy and interferes with hearing audible count rate. Revised wording consistent with current wording in FSS instructions. Added a step to stop and pause when elevated count rates are identified to determine if further investigation is needed. Added clarification that documentation using HDP-PR-FSS-701 is following directions as specified in the FSS instructions.
2	11/19/2015	Administrative changes. Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

HDP-PR-HP-601 Remedial Action Support Surveys		
Revision Number	**Effective Date**	**Summary of the Revision**
0	03/14/2012	Initial issuance of the procedure.
1	04/09/2012	Updated procedure to accommodate performing 6 inch excavation lifts instead of 12 inch excavation lifts, updated Table 1 Column B screening count rate to 46k cpm for saturated soil, which is more conservative than the 58k cpm

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HDP-PR-HP-601 Remedial Action Support Surveys		
Revision Number	**Effective Date**	**Summary of the Revision**
		and is associated with a lump of material, Updated flow chart in Appendix B to move evaluation of items after the initial survey, and to include pipe surveys, Section 8.1.6.2 updated to identify items for further evaluation and evaluate them after the initial survey to determine if they are NCS Exempt. Clarifications for the count rates are less than or equal to (≤) instead of "less than", consistent with wording in Section 8.7 of this procedure and the applicable NCSA, removed "general area" to clarify that the background count rate used will be obtained from the daily background check. Added reference to NSA-TR-HDP-11-06 for surveys of pipe and added section for surveying piping to determine if it is NCS Exempt. Specified that the screening level for reuse is on Form HDP-PR-HP-100-2.
2	06/11/2012	Administrative changes and clarifications.
3	06/26/2012	Updated procedure to use the general area background count rate when performing surveys or items and containers and Sections 8.4.3 and 8.7 to specify the external surfaces of containers need to be surveyed, not only the bottom of the containers.
4	07/05/2012	Updated Section 8.2 to clarify that the radiological surveys do not need to be formally documented prior to determining if an area meets NCS Exempt criteria and can be excavated. Additionally, 2 independent HP Technicians can verify all hotspots/items have been evaluated and handled required to ensure the surveyed area meets NCS Exempt Material criteria. Updated Section 8.4.3 to remove the requirement to have intact containers in a vertical position when surveying them because this is not required as all external surfaces of the container are surveyed. Updated Section 8.7 to clarify the criteria for Field Containers with net count rates between 300,000 and 1,400,000 cpm.
5	08/14/2012	The requirement to identify areas that are NCS Exempt for a 12 inch cut depth (i.e., areas that are 19k ≤ ncpm < 66k dry soil, marked as blue) was removed because the maximum permitted cut depth will be 6 inches. Blue will no longer be

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HDP-PR-HP-601 **Remedial Action Support Surveys**		
Revision Number	**Effective Date**	**Summary of the Revision**
		used to mark areas as it is no longer applicable since it is associated with the NCS Exempt criteria for a 12 inch cut depth. This change includes the removal of Column A in Table 1. Updated the count rates in Table 1 for Columns C & D, and in associated locations throughout the procedure. These count rates were previously based on a cut depth of 7 inches (an extra 1 inch greater than the cut depth for conservatism). The count rates were adjusted in this revision to the count rates associated with a cut depth of 6 inches. Based on operational experience and the current maximum permitted cut depth (i.e., 6 inches), an extra 1 inch of conservatism is not necessary. Updated the NCS Field Container Loading Limit from 1,400k ncpm to 1,500k ncpm. 1,400 ncpm was based on 102 g235U, assuming up to 3 field containers in a collared drum (total mass in a collared drum <350 g235U). Since only 2 field containers can fit into a collared drum, the count rate was increased to 1,500k based on 150 g 235U.
6	08/23/2012	Corrected misnumbered step references.
7	09/06/2012	Added note to include the segregation of material with substantially differing characteristics (i.e., radiological, media type) when loading a field container.
8	12/03/2012	NSA-TR-09-15 Revision 4 was issued. Changes to the CSCs in Revision 4 were incorporated throughout the procedure. Sections 7.12 and 8.9 were revised to include instructions on assigning a 235U gram quantity based on close proximity radiological survey results.
9	03/07/2013	This was a significant revision which incorporated nuclear criticality information and requirements based upon NSA-TR-09-08, NCS of Subsurface Structure Decommissioning at Hematite Site and NSA-TR-11-11, NCS Assessment of the USEI Site for Landfill disposal of Additional Decommissioning Waste from Hematite Site.
10	04/08/2013	Added to Step 8.1.7.2 "NOTE: Sections of subterranean pipe less than the NCS Exempt Piping Limit may be crushed and treated as soils, in accordance with HDP-PR-HP-607 (Reference 5.18); however, depending on the size, thickness and material type of the subterranean piping pieces (i.e.,

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HDP-PR-HP-601 Remedial Action Support Surveys		
Revision Number	**Effective Date**	**Summary of the Revision**
		Bulky pieces with linear dimensions exceeding the permitted cut depth, and thick metallic items) should be treated as Non-Conforming Items. (NSA-TR-09-08 CSC 11)".
11	05/01/2013	Instructions were added for evaluating hot spots using the LaBr3 probe.
12	05/22/2013	A clarification was made in regards to evaluating intact containers.
13	06/21/2013	Added instruction to ensure Pre and Post Assay QC checks are performed in accordance with HDP-PR-NC-008, Probe, when the LaBr3probe is used to determine if an area meets NCS Exempt requirements.
14	07/22/2013	Added instruction to allow for Ex-situ scanning of soil in less than 6 inch layers. Added instruction for surveying material underneath the Former Building 240 Slab to allow excavation of material up to 0.8 g235U/L as NCS Exempt.
15	07/25/2013	Instructions added for performing measurements using a NaI 2x2 detector with a "Closed Window" setting of 75 to 250 keV and added option to survey a greater than 5L container to less than or equal to 34k to determine if it meets NCS exempt criteria.
16	08/07/2013	Revised to incorporate the requirements of HEM-13-MEMO-067, Remediation of Soil Under the Concrete Slabs.
17	08/15/2013	Revised to allow the survey of piping from discovered Burial Pits to be performed in one foot increments.
18	09/11/2013	Redundant FSS design requirements were removed from as they are captured in FFS procedure. Introduced the terms "Large Volume Container" and "Small Volume Container" throughout procedure. Removed all instructions for Inspector 1000 with LaBr3 probe as it will no longer be used to evaluate "hot spots" as part of the initial radiological survey. Extensive changes were made to this procedure to remove directions on performing measurements using a NaI 2x2

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HDP-PR-HP-601 Remedial Action Support Surveys		
Revision Number	**Effective Date**	**Summary of the Revision**
		detector with a "Closed Window" setting of 75 to 250 keV. Steps were added to Section 8.5 to satisfy expanded NCS Controls to perform a visual inspection of Ex-situ excavated material in layers prior to consolidation at the WCA.
19	09/12/2013	Step 8.5.2 was revised to clarify the requirement of NSA-TR-09-15 CSC 25, to "Identify and demarcate an area, using paint, flags, or other appropriate means, adjacent to the excavation area that does not contain any Non-NCS Exempt Material (identified in accordance with Section 8.1)".
20	09/30/2013	The term Inspection Items was introduced. References to the use of GPS in section 8.1 were removed since GPS use is considered optional. References to DCGL were replaced with Reuse Material Screening Level (RML) and a count rate of 12k ncpm is now specified. Section 8.4 was revised to include detailed direction on how intact containers are to be emptied in the field. Section 8.9 title was changed to "Surveys of Non-Conforming Items or Items Potentially Containing Fissile Material"
21	10/01/2013	Minor typographical errors were corrected from the previous revision.
22	10/23/2013	Step added to "Identify the area to be excavated" prior to excavation of an area. Added that the adjacent working surface should be demarcated with pink paint or flags. Step was revised to specify that a GWS with Visual Inspection will be performed of the ex-situ soil layer regardless if visible Non- Conforming Items were identified.
23	11/22/2013	Added instruction for remediation of soils surrounding radium filter press plates in the Burial Pits.
24	01/10/2014	Revised the scope of Section 8.10 to apply to all pavement and building slabs covering soil under NCS controls. Added saturated soil numbers to Sections 8.11 and 8.12. Added step to address the use of ISOCS measurements performed in the field as part of evaluation of radium contaminated soil areas.
25	05/19/2014	Incorporated the requirements of Memo HEM-13-MEMO-099, Radiological Requirements for the Handling of Re-Use

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HDP-PR-HP-601 **Remedial Action Support Surveys**		
Revision Number	**Effective Date**	**Summary of the Revision**
		Soils During Development of Stockpile 8. Added the requirements of NSA-TR-09-08 CSC 17, and CSC 20 and NSATR- HDP-11-11 CSC 15 related to septic and sewage treatment tanks. Removed references to remediation contractor.
26	06/02/2014	Updated work package references throughout procedure, as work package numbers have changed.
27	07/10/2014	Added potential NCS Evaluation for Non-Conforming Items which are > 0.1 g U-235/L to Appendix C.
28	08/11/2014	Clarified the requirements for excavation cut depth outside of NCS controlled areas. Clarified how "areas where buried debris has been identified" is defined by NCS.
29	09/18/2014	Added instruction to allow the third visual inspection and processing of potentially NCS exempt material to take place on a working surface that will no longer be required to be located adjacent to the excavation area.
30	11/05/2014	A step was added to provide guidance when performing surveys and visual inspections under artificial lighting.
31	11/06/2014	Administrative changes.
32	12/05/2014	Added instruction to implement the enhanced work controls developed to ensure compliance with the USEI WAC when excavation in the Site Pond. Added Reference to HEM-14-MEMO-112, NCS Analysis of the HDP Site Pond Remediation Activities.
33	02/04/2015	Added instruction on the direct loading of waste for disposal at a NRC licensed burial facility up to a concentration of 0.8 g235U/L.
34	11/19/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

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HDP-PR-QA-006 Chain of Custody		
Revision Number	**Effective Date**	**Summary of the Revision**
0	04/29/2010	Initial issuance of the procedure.
1	02/07/2011	Added allowance to write sample information directly on the sample bottle for flexibility of completion of requirement. Added exception to assignment of unique sample number to each sample to provide for routine, location-specific samples. Removed documentation storage requirements as the storage of samples occurs at the laboratory and not locally, therefore documentation of storage cannot be maintained. Clarified process of where the original chain of custody is placed. Clarified how the laboratory/end user returns the chain of custody form(s) to HDP. Added specification that the procedure is applicable to samples that are intended for offsite analysis.
2	02/29/2012	Administrative change.
3	12/19/2012	Minor clarification changes.
4	11/18/2015	Changed procedure to Westinghouse Proprietary Class 2. No technical changes.

Volume 2 Chapter 1 – Appendix B

HDP-TBD-HP-406 Preliminary Evaluation and Test Plan for ISO 3 for Assaying and Segregating Soil at HDP that is Potentially Contaminated with Uranium

Westinghouse

Hematite Decommissioning Project

Technical Basis Document

NUMBER: **HDP-TBD-HP-406**

TITLE: **Preliminary Evaluation and Test Plan for ISO 3 for Assaying and Segregating Soil at HDP that is Potentially Contaminated with Uranium**

REVISION: **0**

Approvals:

Author: Chris Miles ______ Joseph Guido for Chris Miles

Owner: Joseph Guido ______

Revision Log	
Revision No. Effect. Date	**Change(s)**
11/01/13	This is a new technical basis document.

1 PURPOSE

This paper is intended to document a preliminary evaluation of the ISO-PACIFIC Nuclear Assay Systems Inc. S3 technology (S3) system and its application at the Hematite Decommissioning Project (HDP) to assay and segregate soil that exceeds preset set points for both distributed and discrete radioactivity. The concepts described in Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (Reference 8.1) for Scan Minimum Detectable Activities form the basis for this evaluation. The process for testing and validating this system is also described.

2 DISCUSSION

The S3 conveyor belt assay system has been identified for use for screening potential reuse material at the HDP site. This system utilizes a conveyer belt to pass a specified approximate thickness (3 inches) of soil, 5 feet wide, beneath a linear array of 11 3" X 3" NaI detectors. Each detector is shielded to minimize background.

The technical requirements (data quality objectives) for this system include the ability to detect uniformly contaminated soil at 50% of the excavation scenario DCGL (a concentration of 15.5 pCi/g of U-235 or 57.7 pCi/g of U-238 based on 4 weight percent U-235); 4 weight percent is based on the site average documented in the Hematite Decommissioning Plan). A secondary requirement for the system is that it must have the capability to detect a pellet fragment of uranium containing 0.1 gram (0.21 μCi) of U-235 at 4% enrichment. Such a fragment would also contain about 0.8 μCi of U-238. This document provides the technical basis for ensuring that the methodologies employed by the S3 have adequate detection sensitivity.

In order to evaluate the S3, the efficiencies of the NaI detectors must be determined for the contaminants of concern, in this case, uranium enriched to 4% by mass of U-235. Consideration must be given to all possible contaminant location within the soil layer as the soil passes beneath the detectors. The speed of the conveyor belt will affect the observation interval for the detectors and the potential locations of contaminants during that observation interval. In this evaluation, the focus is on the worst-case scenario, when the potential contaminant is a point source or small fragment of uranium passing precisely through the midpoint between two detectors. For this scenario, the detection efficiency is evaluated assuming that the contaminant is located at the very bottom of the soil layer. This represents the location of maximum source to detector distance and also the location of maximum soil attenuation. An evaluation of the scenario where the contaminant is located on top of the soil surface is also evaluated. In this case, the solid angle field of view to the detector is small and the intrinsic peak efficiency for photons reaching the detector at this angle is anticipated to be at a minimum. A best case scenario for the contaminant directly below the detector was also evaluated.

Efficiency estimates, given these geometrical considerations, have been made using MicroShield®[1] software (Reference 8.2) as described in the Hematite Decommissioning Plan, Section 14.4.4.2.9 (Reference 8.3). The concepts described in MARSSIM for determining Scan MDCs for walkover surveys are applicable in this situation where, in this case, soil is scanned by passing soil beneath a stationary detector, rather than passing a detector over soil that is stationary.

Prior to processing soil at HDP through the S3, alarm set points and soil segregation decision points will be predetermined based upon system counting efficiencies that are computed from measurements of actual enriched uranium pellets and prepared uranium contaminated soil samples under onsite conditions (e.g., using actual measured background count rates). General descriptions of the components that will be included in this evaluation are described in this document. HDP will pass actual uranium pellets and/or pellet fragments through the system at various locations within the soil to determine system efficiencies for detecting fragments of uranium. HDP will prepare a containerized sample(s) for the purpose of evaluating the systems efficiency for uniform soil contamination and its ability to detect contaminated soil at the DCGLs.

3 GEOMETRICAL CONSIDERATIONS

The ISO-PACIFIC S3 includes a conveyor belt system that creates a 3-inch layer of processed soil (approximately 1 g/cm^3) that is 5 feet wide. A straight line row of 11 each 3X3 NaI detectors are positioned approximately 1 inch above the soil which is passed beneath them. The detectors are spaced 6 inches apart (center to center). The outermost detectors are centered over the outside edges of the 5-foot wide layer of soil being assayed on the belt. Attachment A is a drawing of the detector layout.

It can be seen from the drawing that, given a 6 inches per second belt speed, a particle in the worst-case location (i.e., farthest away from any given detector) will reside at a horizontal distance of less than 10.8 cm (square root of $7.62^2 + 7.62^2$) from the detector centerline for the duration of a 1 second observation interval.

For the purposes of this evaluation, which is intended to estimate the worse-case efficiency for this system, a hypothetical contaminant particle is assumed to pass precisely through the midpoint between two detectors, either at the top of the soil layer or at the bottom. The observation interval used in the Scan MDC calculations is 1 second.

4 PRELIMINARY EFFICIENCY AND ASSOCIATED SCAN MDC DETERMINATION USING MICROSHIELD SOFTWARE

A methodology for determining scan MDCs utilizing the MicroShield software (computer code in conjunction with NUREG-1507 (Reference 8.4) is described in the Hematite Decommissioning Plan (DP), Section 14.4.4.2.9 *Open Land Area Gamma Scan*

[1] MicroShield® is a trademark of Grove Software, Inc., registered in the U.S. and other countries.

MDCs. This same methodology has been used for this application and is described below.

Minimum Detectable Count Rate (MDCR)

The MDCR for the detector was calculated using Equation 14-31 of the DP, then dividing by the square root of the surveyor efficiency, using the following inputs:

- Background count rate of 2,000 cpm;
- Observation interval of 1 second;
- Index of sensitivity (d′) of 1.38;
- Surveyor efficiency is assumed to be 1.0 for the ideal (non-human) observer.

The MDCR was calculated to be 478 cpm and is illustrated below:

$$MDCR = \frac{1.38\sqrt{2{,}000 \times \frac{1}{60}} \times \left(\frac{60}{1}\right)}{\sqrt{1.0}} = 478\ cpm$$

MicroShield® Modeling Results

Models of uranium pellets containing 0.1 gram of U-235 (4% enriched) and soil uniformly contaminated with U-234, U-235, and U-238 (each at 1 pCi/g) were created in MicroShield® software (v6.21). The pellets were modeled as being enriched uranium, 4% by mass, and therefore also contained U-234 and U-238. The models were setup to compute the anticipated uranium detection efficiency for six different detector/source geometries:

Scenario A	pellet on soil surface directly beneath center of detector
Scenario B	pellet on conveyor belt under soil layer and directly beneath center of detector
Scenario C	pellet on soil surface at midpoint between detectors
Scenario D	pellet on conveyor belt under soil and at midpoint between detectors
Scenario E	pellet on soil surface at the maximum offset during the observation interval (4.25 inches)
Scenario F	pellet on conveyor belt under soil and at the maximum offset during the observation interval (4.25 inches)
Scenario G	Soil uniformly contaminated with U-234 at 1 pCi/g
Scenario H	Soil uniformly contaminated with U-235 (and the associated Th-231 progeny) at 1 pCi/g.
Scenario I	Soil uniformly contaminated with U-238 (and the associated Pa-234, Pa-234m, and Th-234 progeny) at 1 pCi/g

The results are as follows:

Scan MDA for Uranium Pellet Fragment

Geometry Scenario	Description	MDA (µCi of U-235)	MDA (grams of U-235)
A	Pellet on soil surface directly beneath detector	0.002	0.001
B	Pellet under soil layer directly beneath detector	0.1	0.05
C	Pellet on soil surface at midpoint between detectors	0.02	0.009
D	Pellet under soil layer at midpoint between detectors	0.2	0.08
E	Pellet on soil surface at maximum offset (4.25 inches from detector centerline)	0.04	0.02
F	Pellet under soil layer at maximum offset (4.25 inches from detector centerline)	0.2	0.1

The MDAs presented in the above table were computed under the assumption of static conditions, i.e., conveyor belt not moving during the 1 second observation interval. Scenario F represents the worst-case scenario under static conditions. A more realistic worst-case scenario under dynamic conditions (belt moving) would be the average of the results of Scenarios D and F.

In addition to the discreet source (pellet) geometries described above, the Scan MDA for uniformly contaminated soil was also calculated using the same background and Index of Sensitivity assumptions as above. Scan MDAs for the distributed contamination case (i.e. uniform soil contamination) are tabulated below and are listed as a fraction of either the uniform DCGL or the excavation DCGL assuming 4 weight percent U-235.

Scan MDA for Distributed Uranium Contamination

Geometry Scenario	Description	MDA
G, H, I	3 inch thick region of soil with 3 inch radius.	11% of the Excavation DCGL SOF 46% of the Uniform DCGL SOF (both at 4 weight percent U-235)

A level of conservatism built into the above MicroShield software calculations is that bremsstrahlung radiation generated by the U-238 progeny beta emitters is not considered. This source of photons would be expected to be a significant contributor to the signal in the region of interest for low-enriched uranium.

5 ON-SITE EFFICIENCY AND SCAN MDC DETERMINATION USING AVAILABLE URANIUM STANDARDS

In the previous section, preliminary calculations of detector efficiencies were presented. These calculations were made under various assumptions for the purpose of determining the likelihood that the S3 system will have sufficient sensitivity to meet the pre-determined data quality objectives at HDP. Specifically, the intended purpose of the calculations was to determine whether or not the system would be capable of detecting 0.1 gram of U-235 in a 4% enriched uranium pellet, regardless of its location within the soil stream. The conclusion of that preliminary evaluation is yes, the system should have adequate detection sensitivity to meet that objective. A secondary, but equally important objective was that the system will also have the capability to detect uniformly contaminated soil at (50% of the excavation scenario DCGL (15.5 pCi/g of U-235 or 57.7 pCi/g of U-238). Based upon the preliminary calculations, that objective is achievable using the S3 system.

Since it is recognized that many assumptions were required for the preliminary efficiency calculations, when the system arrives at HDP, the above-described evaluations will be repeated using actual samples of uranium pellet(s), soil samples of known concentrations of uranium contamination, and under onsite background conditions.

Once deployed, the first task will be to conduct energy calibrations and optimize the settings for the system such that the signal to background noise ratio is at a maximum. This will be achieved using representative uncontaminated local soil to determine the background count rates. The signal of interest will be provided by a well-characterized uranium pellet with an enrichment of approximately 4% U-235 by mass.

The detection efficiency of the system for detecting a pellet of uranium or pellet fragment will then be determined empirically by passing a pellet(s) through the S3 detector array at various geometrical locations. The least efficient location is anticipated to be when the pellet is located beneath a layer of soil at a point that passes precisely between two NaI detectors. Measurements will also be made with the pellet passing directly under a detector and at surface locations in order to capture the range geometry-dependent efficiencies.

Similarly, soil samples of known uranium concentration will be placed under the detector for the purpose of determining system counting efficiency for uniformly contaminated soil.

The resulting data from the onsite measurements, i.e., background count rate and efficiencies, will be used to determine the scan MDA's of the system for the various scenarios. Those data will be reviewed to verify that the system has adequate detection sensitivity to meet the data quality objectives and will be used as the basis for setting detector alarm points and making decisions regarding soil segregation.

After the completion of system setup, the draft test plan shown in Attachment B will be executed.

6 CONCLUSIONS

It has been determined via calculation, using what is believed to be conservative assumptions, that the S3 system will have adequate detection capabilities to meet the data quality objectives at HDP for soil assay and segregation. Since well-characterized uranium standards are available for use at HDP, those standards will ultimately be used, along with onsite background measurements, to empirically determine measurement efficiencies and Scan MDAs for the S3. Alarm set-points and segregation decision points will be based accordingly.

7 ATTACHMENTS

Attachment A - Source / Detector Geometry

Attachment B - Initial Testing Plan

8 REFERENCES

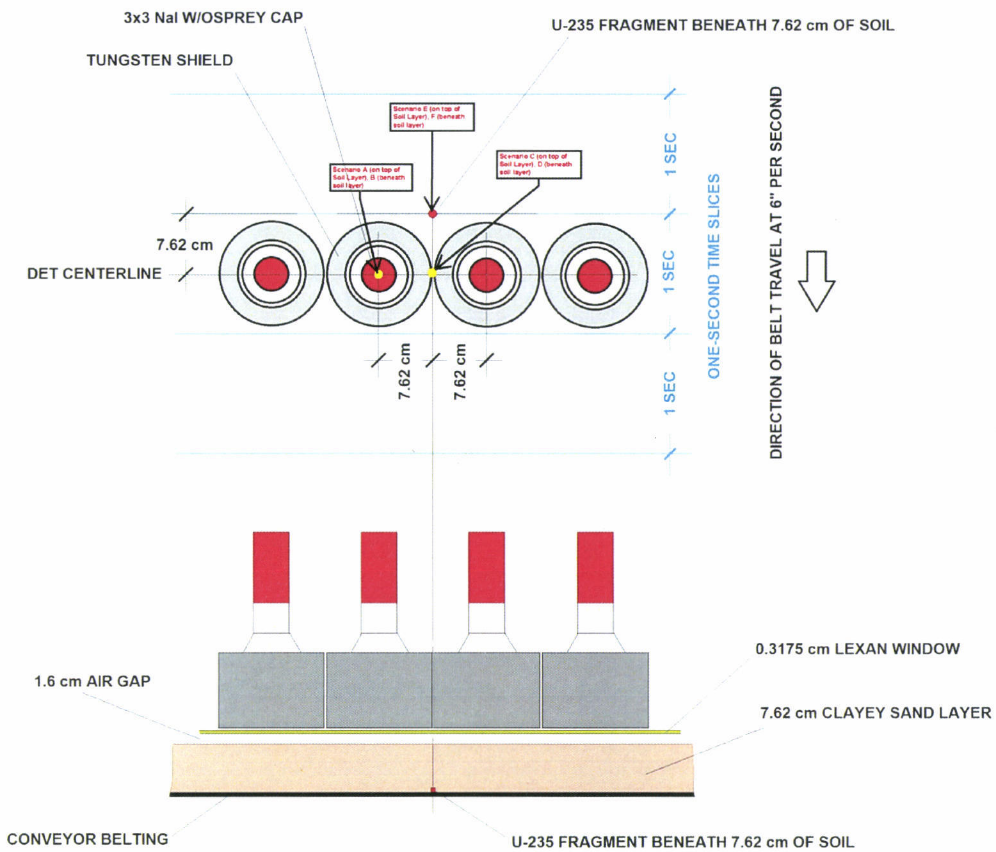
8.1 NUREG-1575 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)

8.2 MicroShield Software, version 7.02, Licensed to Westinghouse Electric Company (08-MSD-7.02-1424), Grove Software, Inc., 2006

8.3 HDP Decommissioning Plan, DO-08-004

8.4 NUREG 1507 Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions

Attachment A
Source / Detector Geometry



DETECTORS ARE MOVABLE UP AND DOWN INSIDE THE SHIELD, AND THE ENTIRE ARRAY MAY ALSO BE RAISED AND LOWERED. DETECTOR HEIGHT INSIDE SHIELD AND OVERALL DETECTOR HEIGHT MAY BE OPTIMIZED BY THE CANBERRA MODELING EFFORT.

Attachment B
Initial Testing Plan

Distributed Source Geometry – Static Count

Scenario	Purpose
Background with Clean (offsite fill) soil on belt	Establish system background

Distributed Source Geometry – Belt Running (operating speed)

Scenario	Purpose
Background with empty belt	Establish background response for belt, baseline for system contamination
3 inch layer of contaminated soil (closed container) of various concentrations (~10% - 200% Excavation DCGL) under each detector	Establish alarm response for distributed soil contamination

Discrete Source Geometry – Static Count

Scenario	Purpose
NIST Traceable Co-60/Cs-137 point source. - Source positioned on the surface of the belt, directly under each detector.	Verify calibration against NIST traceable source
Cs-137 button sources - Source positioned on surface of the belt, directly under each detector	Compare system response to Cs-137 button sources with response to NIST standard (also containing Cs-137). Setup control charts for system operation

Discrete Source Geometry – Belt Running (operating speed)

Scenario	Purpose
~0.1 gram U-235 in pellet fragment – positioned under 3 inch of soil (or equivalent shielding) and midway between detectors.	Establish alarm response for discrete particle contamination
~0.1 gram U-235 in pellet fragment – positioned on top of 3 inch of soil (or equivalent shielding) and midway between detectors.	Establish alarm response for discrete particle contamination

Volume 2 Chapter 1 – Appendix C

HDP-TBD-FSS-002 Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)

Westinghouse Non-Proprietary Class 3

Hematite Decommissioning Project

NUMBER:	**HDP-TBD-FSS-002**
TITLE:	**Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)**
REVISION:	**3**
EFFECTIVE DATE:	AUG 19 2015

Author:	Scott G. Zoller	Date: 08/14/15
Independent Reviewer:	Brian A. Miller	Date: 8/14/15
Owner / Manager:	W. Clark Evers	Date: 8/17/15

REVISION LOG	
Revision No. Effect. Date	**Change(s)**
0 02/06/2015	See Revision 0 of this document for information on its changes.
1 03/13/2015	See Revision 1 of this document for information on its changes.
2 04/07/2015	See Revision 2 of this document for information on its changes.
3 See Cover Page	Revised to incorporate a surveyor efficiency of 0.75 rather than 1.0. The revision to the surveyor efficiency value is implemented based upon discussions and agreement between the U.S. Nuclear Regulatory Commission and Westinghouse HDP in regards to the value used for the surveyor efficiency. The agreement was reached during an NRC Public Teleconference Meeting held on August 12, 2015, and will be recorded in the NRC Meeting Summary document.

TABLE OF CONTENTS

ACRONYMS

AF	Area Factor
cpm	Counts Per Minute
DCGL	Derived Concentration Guideline
FSS	Final Status Survey
HDP	Hematite Decommissioning Project
MDC	Minimum Detectable Concentrations
Ra	Radium
Tc	Technetium
Th	Thorium
U	Uranium

1.0 PURPOSE

The purpose of this Technical Basis Document is to evaluate and document the scanning minimum detectable concentrations (MDC) for final status surveys (FSS) at the Hematite Decommissioning Project (HDP). The process for calculating the scan MDC is detailed in Section 14.4.4 of the Hematite Decommissioning Plan. The evaluation was performed for the radioisotopes of concern: Radium (Ra)-226, Thorium (Th)-232, and Uranium (U)-234, 235, and 238. The evaluation also includes parameters specific to the performance of FSS at HDP such as scan speed and the height of the detector in relation to the ground surface.

1.1 Open Land Area Gamma Scan MDCs

The calculation for scan MDCs follows the methodology in Section 6.8.2 of NUREG-1507 (Reference 1) of postulating an elevated area, modeling the exposure rate using MicroShield®[1], and then determining a scan MDC using manufacturer reported conversion factors for exposure rates to count rates. A scan MDC is calculated for each Uranium isotope and then the radioactivity fractions (provided in Table 14-5 of the Hematite Decommissioning Plan) are used to calculate a total Uranium scan MDC for a particular U-235 enrichment using Equation 9.15 of *Decommissioning Health Physics: A Handbook for MARSSIM Users* (Abelquist, E.W., 2001) (Reference 2). Calculations are discussed below for a two inch by two inch Sodium Iodide scintillation detector.

1.1.1 *Calculation of $MDCR_{surveyor}$*

The $MDCR_{surveyor}$ was calculated using the following inputs:

- Background count rate of 10,000 counts per minute (cpm);
- Observation interval of 1.64 seconds. This is derived by the ratio of 0.5 meter per second scan speed provided in NUREG-1507 for an observation interval of 1 second and the 1 foot (0.3048 m)per second scan speed used at HDP for FSS;
- Index of sensitivity (d′) of 1.38; and,
- Surveyor efficiency of 0.75 for data obtained using GPS and subsequently post-processed using GIS software.

The $MDCR_{surveyor}$ was calculated to be 964 cpm and is illustrated below:

$$MDCR_{Surveyor} = \frac{1.38\sqrt{10{,}000 \times \frac{1.64}{60}} \times \left(\frac{60}{1.64}\right)}{\sqrt{0.75}} = 964cpm$$

[1] Grove Software, 4925 Boonsboro #257 Rd, Lynchburg, VA 24502.

1.1.2 *MicroShield® Modeling*

A model of a postulated small elevated area was created in MicroShield® v7.02. The model was setup with the following inputs and options consistent with the information provided on Page 6-21 of NUREG-1507:

- Cylinder Volume – End Shields;
- Height of 15 centimeters (cm) and radius of 28 cm;
- Dose Point #1 at x=0 cm and z=0. The y dose point was set at one, two and three inches (17.551, 20.091, and 22.631 cm) based on the performance of FSS at HDP. The instructions given to FSS technicians are to survey as close as possible to the ground surface, (nominally one inch, but not to exceed three inches distance from the surface);
- Source material of concrete with a density of 1.6 grams per cubic centimeter (g/cm3);
- Air gap with density of 0.00122 g/cm3;
- All source activities equal to 8E-6 microCuries per cubic centimeter (µCi/cm3) per Equation 6-19 of NUREG-1507, which is equivalent to 5 pCi/g; and,
- Source input grouping method of standard indices.

Models were created for the individual radionuclides of Th-2332, Ra-226, U-234, U-235, and U-238 and associated short-lived progeny, as shown below:

- Th-232, Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, (64% yield, 5.12E-6 µCi/cm^3), and Tl-208 (36% yield, 2.88E-6 µCi/cm^3);
- Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, and Po-210;
- U-234 only;
- U-235 and Th-231; and,
- U-238, Th-234 and Protactinium-234m (Pa-234m)

Ignoring gamma energies less than or equal to 15 keV, the total exposure rate in microRoentgens per hour (µR/hr) at the dose point is presented in the following table:

MicroShield® Exposure Rate at Dose Point (µR/hr)					
Air Gap	Ra-226	Th-232	U-234	U-235	U-238
3”	4.10	5.75	1.08E-4	3.59E-1	3.91E-2
2”	4.86	6.83	1.23E-4	4.17E-1	4.59E-2
1”	5.85	8.23	1.40E-4	4.88E-1	5.44E-2

Additionally, MicroShield® provided the exposure rate for a number of gamma energies associated with each input source term. The MicroShield® outputs are presented in Appendix A.

1.1.3 *Calculation of the MDER*

The MicroShield® results were independently tabulated by grouped gamma energies and exposure rates for each Uranium isotope. Table 6.3 of NUREG-1507 provides normalized detector count rate versus exposure rate calculations based on the manufacturer's detector response to Cs-137. The exposure rate for each gamma energy group was then multiplied by the count rate versus exposure rate to determine the weighted count rate versus exposure rate for each energy and the results were summed. The minimum detectable exposure rate (MDER) was then calculated by dividing the $MDCR_{surveyor}$ by the total weighted count rate versus exposure rate per Equation 6-21 of NUREG-1507. The results are presented in the following Table.

Minimum Detectable Exposure Rate (μR/hr)					
Air Gap	Ra-226	Th-232	U-234	U-235	U-238
3"	1.16	1.17	9.02E-2	1.93E-1	2.75E-1
2"	1.17	1.18	9.02E-2	1.94E-1	2.81E-1
1"	1.18	1.20	9.03E-2	1.94E-1	2.90E-1

The weighted count rate and MDER calculations are presented in Appendix B.

1.1.4 *Calculation Individual Scan MDCs*

The scan MDC for each isotope is calculated using Equation 6-22 of NUREG-1507 using the results provided above. The results are shown below. Note that the value of 5 pCi/g equates to the modeled source concentration.

Scan MDC (pCi/g)					
Air Gap	Ra-226	Th-232	U-234	U-235	U-238
3"	1.42	1.02	4166	2.70	35.2
2"	1.21	0.87	3659	2.32	30.6
1"	1.01	0.73	3221	1.99	26.6

The scan MDC for Ra-226 and Th-232 is 1.21and 0.87 pCi/g, respectively using a two inch air gap. A two inch air gap is utilized as a conservative measure considering NUREG-1507 states the position relates to the average height of the detector. The FSS technicians are instructed to survey as close as possible to the ground surface, (nominally 1", but not to exceed 3" distance from the surface). As such, the use of a two inch air gap is conservative.

Appendix C presents scan MDCs for the radionuclides of concern for various background count rates since background levels may vary across the site. The values may be utilized if driven to do so by procedure or as directed by the RSO.

1.1.5 *Calculation of Total Uranium Scan MDC*

After establishing the individual scan MDCs, the total Uranium scan MDC can be calculated using the relative fractions of the individual Uranium isotopes using Equation 9.15 of *Decommissioning Health Physics: A Handbook for MARSSIM Users* (Abelquist, E.W., 2001). Using the radioactivity fractions (provided in Table 14-5 of the Hematite Decommissioning Plan) for 4 percent U-235 enrichment, the total Uranium scan MDC is calculated below.

$$Scan\ MDC_{Total\ Uranium} = \frac{1}{\frac{0.7928}{3659} + \frac{0.0438}{2.32} + \frac{0.1634}{30.6}} = 40.9 pCi/g$$

2.0 CONCLUSION

The calculations above demonstrate compliance with the $DCGL_w$'s for the gamma emitting radionuclides of concern. However considerations also need to be given to Technetium (Tc)-99 since it is a hard to detect nuclide. For this reason three Surrogate Evaluation Areas (SEA) are established in the Chapter 14 of the Hematite Decommissioning Plan, the Burial Pit SEA, Plant Soil SEA, and the Tc-99 SEA. In each area a relationship was established between U-235 activity and Tc-99 activity. The Decommissioning Plan provides an adjusted $DCGL_w$ for U-235 that has been reduced to account for the potential presence of Tc-99. Using the adjusted U-235 $DCGL_w$, an adjusted Total Uranium $DCGL_w$ is calculated. The application of the modified U-235 $DCGL_w$ (and associated total uranium $DCGL_w$) is restricted to Final Status Survey design (for the evaluation of scan sensitivity only). The adjusted Total Uranium $DCGL_w$'s (based on 4% enrichment) are 79.6 pCi/g for the Burial Pit SEA, 44.1 pCi/g for the Plant Soil SEA, and 24.0 pCi/g for the Tc-99 SEA.

Applying the parameters that are utilized as part of performance of FSS at HDP, the scan MDC is less than all the derived concentration guidelines (DCGLs) other than the total Uranium value for inferred Tc-99 within the Tc-99 SEA. The Tc-99 SEA is designated as a Class I area for FSS. Scan MDCs over the $DCGL_w$ are compared to the $DCGL_w$ multiplied by the Area Factor (AF) for the area represented by each sample of the statistical population. This area is typically between 100 to 250 square meters depending on the size of the survey unit. The AF for 4 % enriched uranium is 2.02 using a 300 square meter AF from HDP-PR-FSS-701 Appendix H for the Uniform conceptual site model. Multiplying the DCGL of 24 pCi/g by 2.02 indicates a scan MDC below 48.48 pCi/g is sufficient to identify small areas of elevated activity. Therefore, there is no requirement for increasing the number of statistical samples. Each survey unit is subject to this calculation during FSS sampling plan development using the actual enrichment obtained from remedial action support survey and/or characterization samples. HDP will incorporate the parameters used in this document into the FSS program.

3.0 REFERENCES

1. NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions
2. Decommissioning Health Physics: A Handbook for MARSSIM Users (Abelquist, E.W., 2001)

4.0 Appendices

Appendix A: MicroShield Output

Appendix B: MDER Calculations

Appendix C: Scan MDCs at Various Background Levels

Appendix A
MicroShield Output

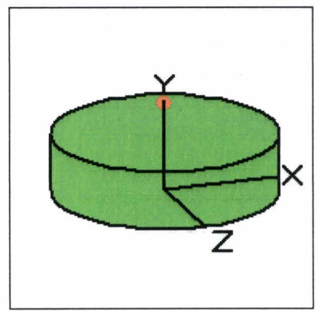
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Ra226 Hot Spot 3 Inch Gap.ms7	January 30, 2015	2:21:53 PM	00:00:00

Project Info	
Case Title	Ra-226 Hot Spot - 3"
Description	Ra-226 Hot Spot - 3 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	22.631 cm (8.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Bi-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-218	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-226	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-222	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Appendix A
MicroShield Output

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.638e+02	4.701e-04	7.707e-04	1.252e-06	2.053e-06
0.08	2.521e+03	5.987e-03	1.448e-02	9.474e-06	2.291e-05
0.1	1.484e+01	5.118e-05	1.355e-04	7.831e-08	2.074e-07
0.2	1.178e+03	1.069e-02	2.774e-02	1.886e-05	4.895e-05
0.3	2.257e+03	3.487e-02	8.117e-02	6.614e-05	1.540e-04
0.4	4.185e+03	9.427e-02	2.004e-01	1.837e-04	3.904e-04
0.5	1.954e+02	5.899e-03	1.169e-02	1.158e-05	2.295e-05
0.6	5.273e+03	2.023e-01	3.775e-01	3.948e-04	7.368e-04
0.8	1.033e+03	5.781e-02	9.884e-02	1.100e-04	1.880e-04
1.0	3.424e+03	2.565e-01	4.123e-01	4.727e-04	7.599e-04
1.5	2.082e+03	2.637e-01	3.823e-01	4.437e-04	6.431e-04
2.0	2.927e+03	5.339e-01	7.305e-01	8.257e-04	1.130e-03
Totals	**2.565e+04**	**1.466e+00**	**2.338e+00**	**2.538e-03**	**4.099e-03**

Appendix A
MicroShield Output

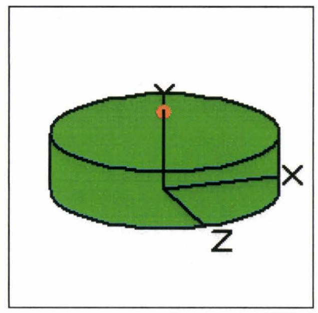
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Ra226 Hot Spot 2 Inch Gap.ms7	January 31, 2015	7:53:35 AM	00:00:00

Project Info	
Case Title	Ra-226 Hot Spot - 2"
Description	Ra-226 Hot Spot - 2 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	20.091 cm (7.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Bi-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-218	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-226	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-222	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Appendix A
MicroShield Output

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.638e+02	5.288e-04	8.688e-04	1.409e-06	2.314e-06
0.08	2.521e+03	6.775e-03	1.652e-02	1.072e-05	2.614e-05
0.1	1.484e+01	5.807e-05	1.557e-04	8.884e-08	2.383e-07
0.2	1.178e+03	1.220e-02	3.238e-02	2.154e-05	5.714e-05
0.3	2.257e+03	3.996e-02	9.530e-02	7.580e-05	1.808e-04
0.4	4.185e+03	1.084e-01	2.360e-01	2.112e-04	4.598e-04
0.5	1.954e+02	6.798e-03	1.380e-02	1.334e-05	2.708e-05
0.6	5.273e+03	2.336e-01	4.461e-01	4.560e-04	8.708e-04
0.8	1.033e+03	6.702e-02	1.171e-01	1.275e-04	2.227e-04
1.0	3.424e+03	2.982e-01	4.891e-01	5.497e-04	9.016e-04
1.5	2.082e+03	3.085e-01	4.549e-01	5.190e-04	7.654e-04
2.0	2.927e+03	6.269e-01	8.710e-01	9.695e-04	1.347e-03
Totals	**2.565e+04**	**1.709e+00**	**2.773e+00**	**2.956e-03**	**4.861e-03**

Appendix A
MicroShield Output

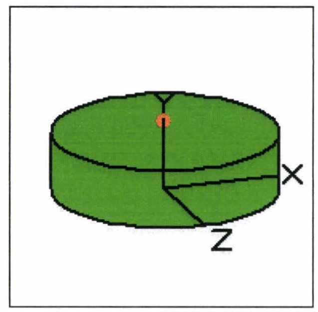
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Ra226 Hot Spot 2 Inch Gap.ms7	January 31, 2015	12:58:58 PM	00:00:00

Project Info	
Case Title	Ra-226 Hot Spot - 1"
Description	Ra-226 Hot Spot - 1 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	17.551 cm (6.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Bi-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-210	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-214	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-218	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-226	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-222	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Appendix A
MicroShield Output

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.638e+02	5.914e-04	9.747e-04	1.575e-06	2.597e-06
0.08	2.521e+03	7.638e-03	1.881e-02	1.209e-05	2.976e-05
0.1	1.484e+01	6.567e-05	1.789e-04	1.005e-07	2.736e-07
0.2	1.178e+03	1.391e-02	3.798e-02	2.455e-05	6.703e-05
0.3	2.257e+03	4.577e-02	1.127e-01	8.683e-05	2.138e-04
0.4	4.185e+03	1.246e-01	2.806e-01	2.428e-04	5.467e-04
0.5	1.954e+02	7.846e-03	1.646e-02	1.540e-05	3.230e-05
0.6	5.273e+03	2.704e-01	5.334e-01	5.278e-04	1.041e-03
0.8	1.033e+03	7.799e-02	1.405e-01	1.484e-04	2.673e-04
1.0	3.424e+03	3.486e-01	5.887e-01	6.425e-04	1.085e-03
1.5	2.082e+03	3.636e-01	5.502e-01	6.117e-04	9.257e-04
2.0	2.927e+03	7.434e-01	1.057e+00	1.150e-03	1.634e-03
Totals	**2.565e+04**	**2.004e+00**	**3.337e+00**	**3.463e-03**	**5.846e-03**

Appendix A
MicroShield Output

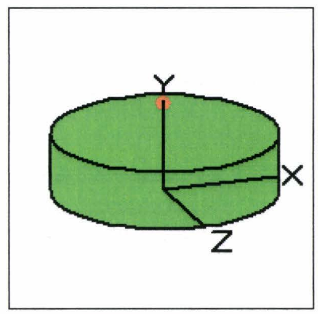
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Th-232 Hot Spot 3 Inch Gap.ms7	January 30, 2015	2:22:39 PM	00:00:00

Project Info	
Case Title	Th-232 Hot Spot - 3"
Description	Th-232 Hot Spot - 3 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	22.631 cm (8.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Ac-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-212	1.8937e-007	7.0065e+003	5.1256e-006	1.8965e-001
Po-216	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-224	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-220	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-232	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Tl-208	1.0620e-007	3.9292e+003	2.8744e-006	1.0635e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Appendix A
MicroShield Output

Results					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.118e+02	4.835e-05	6.692e-05	2.139e-07	2.960e-07
0.06	7.561e+01	9.964e-05	1.977e-04	1.979e-07	3.926e-07
0.08	4.719e+03	1.121e-02	2.710e-02	1.773e-05	4.289e-05
0.1	7.760e+02	2.676e-03	7.087e-03	4.094e-06	1.084e-05
0.15	4.596e+02	2.839e-03	7.712e-03	4.675e-06	1.270e-05
0.2	5.940e+03	5.389e-02	1.399e-01	9.512e-05	2.469e-04
0.3	2.851e+03	4.405e-02	1.026e-01	8.356e-05	1.945e-04
0.4	2.587e+02	5.829e-03	1.239e-02	1.136e-05	2.414e-05
0.5	1.517e+03	4.580e-02	9.079e-02	8.991e-05	1.782e-04
0.6	3.477e+03	1.334e-01	2.489e-01	2.603e-04	4.859e-04
0.8	3.484e+03	1.949e-01	3.333e-01	3.707e-04	6.339e-04
1.0	6.368e+03	4.770e-01	7.667e-01	8.792e-04	1.413e-03
1.5	1.467e+03	1.858e-01	2.693e-01	3.126e-04	4.531e-04
2.0	3.319e+01	6.055e-03	8.283e-03	9.363e-06	1.281e-05
3.0	3.921e+03	1.178e+00	1.502e+00	1.599e-03	2.038e-03
Totals	**3.546e+04**	**2.342e+00**	**3.517e+00**	**3.738e-03**	**5.748e-03**

Appendix A
MicroShield Output

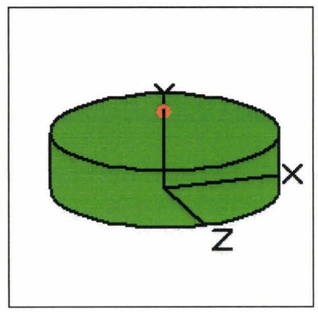
MicroShield 7.02 Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Th-232 Hot Spot 2 Inch Gap.ms7	January 31, 2015	7:54:32 AM	00:00:00

Project Info	
Case Title	Th-232 Hot Spot - 2"
Description	Th-232 Hot Spot - 2 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	20.091 cm (7.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Ac-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-212	1.8937e-007	7.0065e+003	5.1256e-006	1.8965e-001
Po-216	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-224	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-220	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-232	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Tl-208	1.0620e-007	3.9292e+003	2.8744e-006	1.0635e-001

Buildup: The material reference is Source Integration Parameters	
Radial	20
Circumferential	10
Y Direction (axial)	10

Appendix A
MicroShield Output

Results					
Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.118e+02	5.423e-05	7.514e-05	2.399e-07	3.323e-07
0.06	7.561e+01	1.123e-04	2.237e-04	2.231e-07	4.443e-07
0.08	4.719e+03	1.268e-02	3.092e-02	2.007e-05	4.893e-05
0.1	7.760e+02	3.036e-03	8.143e-03	4.645e-06	1.246e-05
0.15	4.596e+02	3.233e-03	8.956e-03	5.325e-06	1.475e-05
0.2	5.940e+03	6.154e-02	1.633e-01	1.086e-04	2.882e-04
0.3	2.851e+03	5.049e-02	1.204e-01	9.577e-05	2.284e-04
0.4	2.587e+02	6.701e-03	1.459e-02	1.306e-05	2.843e-05
0.5	1.517e+03	5.279e-02	1.071e-01	1.036e-04	2.103e-04
0.6	3.477e+03	1.541e-01	2.942e-01	3.007e-04	5.742e-04
0.8	3.484e+03	2.260e-01	3.948e-01	4.298e-04	7.509e-04
1.0	6.368e+03	5.546e-01	9.097e-01	1.022e-03	1.677e-03
1.5	1.467e+03	2.173e-01	3.205e-01	3.656e-04	5.393e-04
2.0	3.319e+01	7.110e-03	9.877e-03	1.099e-05	1.527e-05
3.0	3.921e+03	1.390e+00	1.796e+00	1.886e-03	2.436e-03
Totals	**3.546e+04**	**2.740e+00**	**4.179e+00**	**4.368e-03**	**6.825e-03**

Appendix A
MicroShield Output

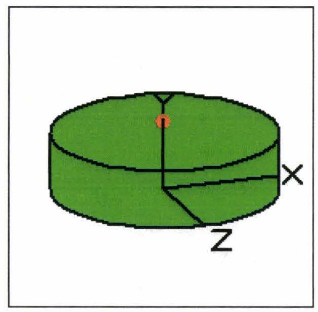
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
Th-232 Hot Spot 1 Inch Gap.ms7	January 31, 2015	1:00:47 PM	00:00:00

Project Info	
Case Title	Th-232 Hot Spot - 1"
Description	Th-232 Hot Spot - 1 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	17.551 cm (6.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Ac-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Bi-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Pb-212	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Po-212	1.8937e-007	7.0065e+003	5.1256e-006	1.8965e-001
Po-216	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-224	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Ra-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Rn-220	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-228	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-232	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Tl-208	1.0620e-007	3.9292e+003	2.8744e-006	1.0635e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Appendix A
MicroShield Output

Results						
Energy (MeV)	**Activity (Photons/sec)**	**Fluence Rate MeV/cm²/sec No Buildup**	**Fluence Rate MeV/cm²/sec With Buildup**	**Exposure Rate mR/hr No Buildup**	**Exposure Rate mR/hr With Buildup**
0.04	1.118e+02	6.038e-05	8.379e-05	2.670e-07	3.706e-07
0.06	7.561e+01	1.261e-04	2.524e-04	2.504e-07	5.013e-07
0.08	4.719e+03	1.430e-02	3.521e-02	2.262e-05	5.572e-05
0.1	7.760e+02	3.433e-03	9.351e-03	5.253e-06	1.431e-05
0.15	4.596e+02	3.674e-03	1.042e-02	6.050e-06	1.717e-05
0.2	5.940e+03	7.014e-02	1.915e-01	1.238e-04	3.380e-04
0.3	2.851e+03	5.783e-02	1.424e-01	1.097e-04	2.702e-04
0.4	2.587e+02	7.706e-03	1.735e-02	1.501e-05	3.380e-05
0.5	1.517e+03	6.092e-02	1.278e-01	1.196e-04	2.508e-04
0.6	3.477e+03	1.783e-01	3.518e-01	3.481e-04	6.866e-04
0.8	3.484e+03	2.630e-01	4.738e-01	5.002e-04	9.012e-04
1.0	6.368e+03	6.483e-01	1.095e+00	1.195e-03	2.018e-03
1.5	1.467e+03	2.562e-01	3.876e-01	4.310e-04	6.522e-04
2.0	3.319e+01	8.430e-03	1.198e-02	1.304e-05	1.853e-05
3.0	3.921e+03	1.662e+00	2.187e+00	2.254e-03	2.967e-03
Totals	**3.546e+04**	**3.234e+00**	**5.042e+00**	**5.144e-03**	**8.225e-03**

Appendix A
MicroShield Output

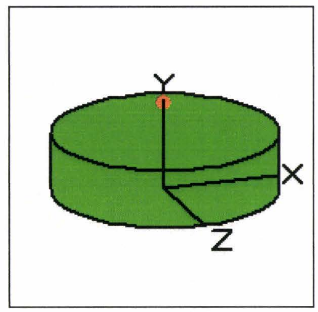
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-234 Hot Spot 3 Inch Gap.ms7	February 2, 2015	10:50:46 AM	00:00:00

Project Info	
Case Title	U-234 Hot Spot - 3"
Description	Uranium-234 Hot Spot - 3 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	22.631 cm (8.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
U-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.290e+01	1.076e-05	1.764e-05	2.867e-08	4.699e-08
0.1	4.380e+00	1.511e-05	4.000e-05	2.311e-08	6.120e-08
Totals	**1.728e+01**	**2.587e-05**	**5.764e-05**	**5.178e-08**	**1.082e-07**

Appendix A
MicroShield Output

Case Summary of U-234 Hot Spot - 2" Page 1 of 1

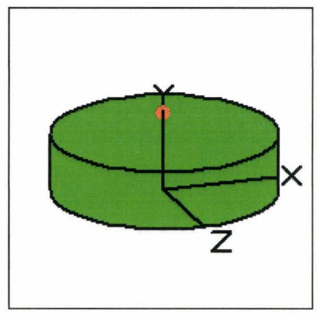
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-234 Hot Spot 2 Inch Gap.ms7	February 2, 2015	10:51:56 AM	00:00:00

Project Info	
Case Title	U-234 Hot Spot - 2"
Description	Uranium-234 Hot Spot - 2 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	20.091 cm (7.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
U-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.290e+01	1.210e-05	1.988e-05	3.224e-08	5.297e-08
0.1	4.380e+00	1.714e-05	4.597e-05	2.622e-08	7.032e-08
Totals	**1.728e+01**	**2.924e-05**	**6.585e-05**	**5.846e-08**	**1.233e-07**

Appendix A
MicroShield Output

Case Summary of U-234 Hot Spot - 1" Page 1 of 1

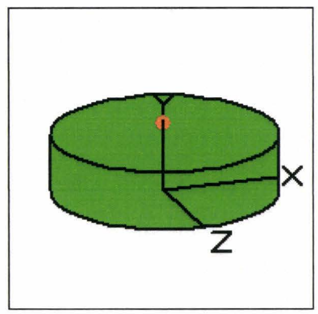
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-234 Hot Spot 1 Inch Gap.ms7	February 2, 2015	10:53:01 AM	00:00:00

Project Info	
Case Title	U-234 Hot Spot - 1"
Description	Uranium-234 Hot Spot - 1 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	17.551 cm (6.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
U-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.290e+01	1.354e-05	2.231e-05	3.606e-08	5.943e-08
0.1	4.380e+00	1.938e-05	5.279e-05	2.965e-08	8.076e-08
Totals	**1.728e+01**	**3.292e-05**	**7.510e-05**	**6.571e-08**	**1.402e-07**

Appendix A
MicroShield Output

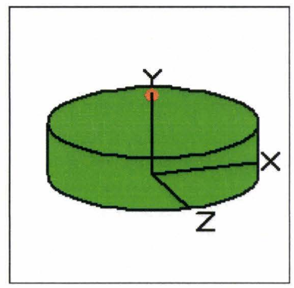
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-235 Hot Spot 3 Inch Gap.ms7	February 2, 2015	10:44:45 AM	00:00:00

Project Info	
Case Title	U-235 Hot Spot - 3"
Description	Uranium-235 Hot Spot - 3 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	22.631 cm (8.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Th-231	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-235	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.057e+01	2.302e-07	2.367e-07	1.974e-08	2.030e-08
0.03	1.602e+03	2.605e-04	3.067e-04	2.581e-06	3.040e-06
0.06	5.197e+01	6.849e-05	1.359e-04	1.360e-07	2.699e-07
0.08	1.283e+03	3.046e-03	7.366e-03	4.820e-06	1.166e-05
0.1	1.143e+03	3.942e-03	1.044e-02	6.031e-06	1.597e-05
0.15	1.703e+03	1.052e-02	2.858e-02	1.732e-05	4.706e-05
0.2	6.748e+03	6.123e-02	1.589e-01	1.081e-04	2.805e-04
Totals	**1.255e+04**	**7.906e-02**	**2.057e-01**	**1.390e-04**	**3.585e-04**

Appendix A
MicroShield Output

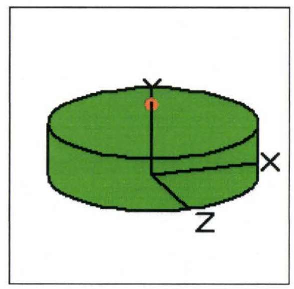
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-235 Hot Spot 2 Inch Gap.ms7	February 2, 2015	10:47:58 AM	00:00:00

Project Info	
Case Title	U-235 Hot Spot - 2"
Description	Uranium-235 Hot Spot - 2 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	20.091 cm (7.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Th-231	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-235	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.057e+01	2.569e-07	2.643e-07	2.203e-08	2.267e-08
0.03	1.602e+03	2.910e-04	3.426e-04	2.884e-06	3.395e-06
0.06	5.197e+01	7.721e-05	1.537e-04	1.534e-07	3.054e-07
0.08	1.283e+03	3.447e-03	8.405e-03	5.455e-06	1.330e-05
0.1	1.143e+03	4.472e-03	1.199e-02	6.842e-06	1.835e-05
0.15	1.703e+03	1.198e-02	3.318e-02	1.973e-05	5.464e-05
0.2	6.748e+03	6.991e-02	1.855e-01	1.234e-04	3.274e-04
Totals	**1.255e+04**	**9.018e-02**	**2.396e-01**	**1.585e-04**	**4.174e-04**

Appendix A
MicroShield Output

Case Summary of U-235 Hot Spot - 1" Page 1 of 1

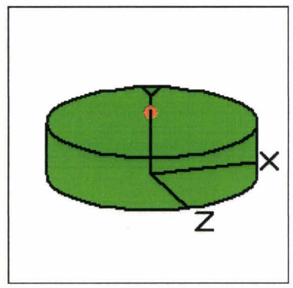
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-235 Hot Spot 1 Inch Gap.ms7	February 2, 2015	10:49:04 AM	00:00:00

Project Info	
Case Title	U-235 Hot Spot - 1"
Description	Uranium-235 Hot Spot - 1 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	17.551 cm (6.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Th-231	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-235	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.057e+01	2.840e-07	2.924e-07	2.436e-08	2.508e-08
0.03	1.602e+03	3.229e-04	3.800e-04	3.200e-06	3.766e-06
0.06	5.197e+01	8.664e-05	1.735e-04	1.721e-07	3.446e-07
0.08	1.283e+03	3.886e-03	9.570e-03	6.149e-06	1.514e-05
0.1	1.143e+03	5.057e-03	1.377e-02	7.737e-06	2.107e-05
0.15	1.703e+03	1.361e-02	3.862e-02	2.242e-05	6.360e-05
0.2	6.748e+03	7.968e-02	2.176e-01	1.406e-04	3.840e-04
Totals	**1.255e+04**	**1.026e-01**	**2.801e-01**	**1.803e-04**	**4.880e-04**

Appendix A
MicroShield Output

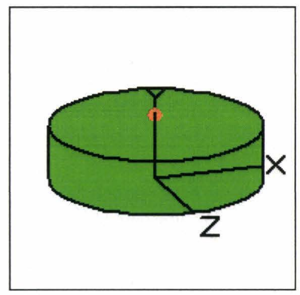
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-238 Hot Spot 1 Inch Gap.ms7	February 2, 2015	10:39:02 AM	00:00:00

Project Info	
Case Title	U-238 Hot Spot - 1"
Description	Uranium-238 Hot Spot - 1 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	17.551 cm (6.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Pa-234m	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-238	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.06	4.274e+02	7.126e-04	1.427e-03	1.415e-06	2.834e-06
0.08	1.552e+01	4.703e-05	1.158e-04	7.442e-08	1.833e-07
0.1	6.611e+02	2.925e-03	7.967e-03	4.475e-06	1.219e-05
0.8	2.260e+01	1.706e-03	3.073e-03	3.244e-06	5.845e-06
1.0	1.053e+02	1.072e-02	1.811e-02	1.976e-05	3.338e-05
Totals	**1.232e+03**	**1.611e-02**	**3.069e-02**	**2.897e-05**	**5.443e-05**

Appendix A
MicroShield Output

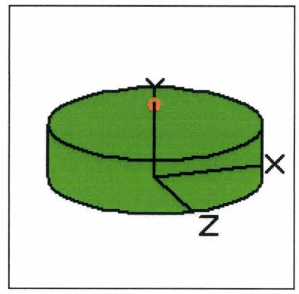
MicroShield 7.02 Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-238 Hot Spot 2 Inch Gap.ms7	February 2, 2015	10:37:45 AM	00:00:00

Project Info	
Case Title	U-238 Hot Spot - 2"
Description	Uranium-238 Hot Spot - 2 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	20.091 cm (7.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	2254.53 in³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Pa-234m	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-238	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.06	4.274e+02	6.351e-04	1.265e-03	1.261e-06	2.512e-06
0.08	1.552e+01	4.172e-05	1.017e-04	6.602e-08	1.610e-07
0.1	6.611e+02	2.587e-03	6.938e-03	3.957e-06	1.061e-05
0.8	2.260e+01	1.466e-03	2.561e-03	2.788e-06	4.871e-06
1.0	1.053e+02	9.172e-03	1.504e-02	1.691e-05	2.773e-05
Totals	**1.232e+03**	**1.390e-02**	**2.591e-02**	**2.498e-05**	**4.589e-05**

Appendix A
MicroShield Output

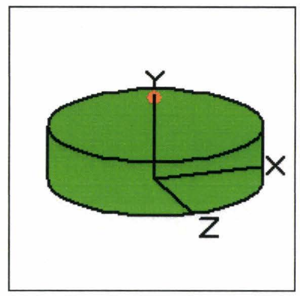
MicroShield 7.02
Westinghouse Electric Co. (08-msd-7.02-1424)

Date	By	Checked

Filename	Run Date	Run Time	Duration
U-238 Hot Spot 3 Inch Gap.ms7	February 2, 2015	10:36:10 AM	00:00:00

Project Info	
Case Title	U-238 Hot Spot - 3"
Description	Uranium-238 Hot Spot - 3 Inch Air Gap
Geometry	8 - Cylinder Volume - End Shields

Source Dimensions	
Height	15.0 cm (5.9 in)
Radius	28.0 cm (11.0 in)



Dose Points			
A	X	Y	Z
#1	0.0 cm (0.0 in)	22.631 cm (8.9 in)	0.0 cm (0.0 in)

Shields			
Shield N	Dimension	Material	Density
Source	3.69e+04 cm³	Concrete	1.6
Air Gap		Air	0.00122

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Pa-234m	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
Th-234	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001
U-238	2.9556e-007	1.0936e+004	8.0000e-006	2.9600e-001

Buildup: The material reference is Source
Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.06	4.274e+02	5.633e-04	1.117e-03	1.119e-06	2.220e-06
0.08	1.552e+01	3.686e-05	8.915e-05	5.834e-08	1.411e-07
0.1	6.611e+02	2.280e-03	6.038e-03	3.488e-06	9.237e-06
0.8	2.260e+01	1.264e-03	2.162e-03	2.405e-06	4.111e-06
1.0	1.053e+02	7.888e-03	1.268e-02	1.454e-05	2.337e-05
Totals	**1.232e+03**	**1.203e-02**	**2.209e-02**	**2.161e-05**	**3.908e-05**

Appendix B
MDER Calculations

MDER - U-238 - 3"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.06	60	2.22E-06	2.22E-03	13000	7.38E+02
0.08	80	1.41E-07	1.41E-04	12000	4.33E+01
0.1	100	9.24E-06	9.24E-03	9840	2.33E+03
0.8	800	4.11E-06	4.11E-03	710	7.47E+01
1	1000	2.34E-05	2.34E-02	540	3.23E+02
Totals		**3.91E-05**	**3.91E-02**		**3.51E+03**
				MDER (µR/hr)	**2.75E-01**

MDER - U-238 - 2"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.06	60	2.51E-06	2.51E-03	13000	7.12E+02
0.08	80	1.61E-07	1.61E-04	12000	4.21E+01
0.1	100	1.06E-05	1.06E-02	9840	2.28E+03
0.8	800	4.87E-06	4.87E-03	710	7.54E+01
1	1000	2.77E-05	2.77E-02	540	3.26E+02
Totals		**4.59E-05**	**4.59E-02**		**3.43E+03**
				MDER (µR/hr)	**2.81E-01**

MDER - U-238 - 1"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.06	60	2.83E-06	2.83E-03	13000	6.77E+02
0.08	80	1.83E-07	1.83E-04	12000	4.04E+01
0.1	100	1.22E-05	1.22E-02	9840	2.20E+03
0.8	800	5.85E-06	5.85E-03	710	7.62E+01
1	1000	3.34E-05	3.34E-02	540	3.31E+02
Totals		**5.44E-05**	**5.44E-02**		**3.33E+03**
				MDER (µR/hr)	**2.90E-01**

Appendix B
MDER Calculations

MDER - U-235 - 3"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.015	15	2.03E-08	2.03E-05	1187	6.72E-02
0.03	30	3.04E-06	3.04E-03	5160	4.38E+01
0.06	60	2.70E-07	2.70E-04	13000	9.79E+00
0.08	80	1.17E-05	1.17E-02	12000	3.90E+02
0.1	100	1.60E-05	1.60E-02	9840	4.38E+02
0.15	150	4.71E-05	4.71E-02	6040	7.93E+02
0.2	200	2.81E-04	2.81E-01	4230	3.31E+03
Totals		**3.59E-04**	**3.59E-01**		**4.98E+03**
				MDER (µR/hr)	**1.93E-01**

MDER - U-235 - 2"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.015	15	2.27E-08	2.27E-05	1187	6.45E-02
0.03	30	3.40E-06	3.40E-03	5160	4.20E+01
0.05	50	3.05E-07	3.05E-04	13000	9.51E+00
0.06	60	1.33E-05	1.33E-02	12000	3.82E+02
0.08	80	1.84E-05	1.84E-02	9840	4.33E+02
0.1	100	5.46E-05	5.46E-02	6040	7.91E+02
0.15	150	3.27E-04	3.27E-01	4230	3.32E+03
Totals		**4.17E-04**	**4.17E-01**		**4.98E+03**
				MDER (µR/hr)	**1.94E-01**

Appendix B
MDER Calculations

MDER - U-235 - 1"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.015	15	2.51E-08	2.51E-05	1187	6.10E-02
0.03	30	3.77E-06	3.77E-03	5160	3.98E+01
0.05	50	3.45E-07	3.45E-04	13000	9.18E+00
0.06	60	1.51E-05	1.51E-02	12000	3.72E+02
0.08	80	2.11E-05	2.11E-02	9840	4.25E+02
0.1	100	6.36E-05	6.36E-02	6040	7.87E+02
0.15	150	3.84E-04	3.84E-01	4230	3.33E+03
Totals		**4.88E-04**	**4.88E-01**		**4.96E+03**
				MDER (µR/hr)	**1.94E-01**

MDER - U-234 - 3"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.05	50	4.70E-08	4.70E-05	11800	5.12E+03
0.1	100	6.12E-08	6.12E-05	9840	5.57E+03
Totals		**1.08E-07**	**1.08E-04**		**1.07E+04**
				MDER (µR/hr)	**9.02E-02**

MDER - U-234 - 2"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.015	15	5.30E-08	5.30E-05	11800	5.07E+03
0.03	30	7.03E-08	7.03E-05	9840	5.61E+03
Totals		**1.23E-07**	**1.23E-04**		**1.07E+04**
				MDER (µR/hr)	**9.02E-02**

Appendix B
MDER Calculations

MDER - U-234 - 1"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (μR/hr)	cpm per μR/hr	cpm per μR/hr (weighted)
0.015	15	5.94E-08	5.94E-05	11800	5.00E+03
0.03	30	8.08E-08	8.08E-05	9840	5.67E+03
Totals		**1.40E-07**	**1.40E-04**		**1.07E+04**
				MDER (μR/hr)	**9.03E-02**

MDER - Ra-226 - 3"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (μR/hr)	cpm per μR/hr	cpm per μR/hr (weighted)
0.05	50	2.05E-06	2.05E-03	11800	5.91E+00
0.08	80	2.29E-05	2.29E-02	12000	6.71E+01
0.1	100	2.07E-07	2.07E-04	9840	4.98E-01
0.2	200	4.90E-05	4.90E-02	4230	5.05E+01
0.3	300	1.54E-04	1.54E-01	2520	9.47E+01
0.4	400	3.90E-04	3.90E-01	1700	1.62E+02
0.5	500	2.30E-05	2.30E-02	1270	7.11E+00
0.6	600	7.37E-04	7.37E-01	1010	1.82E+02
0.8	800	1.88E-04	1.88E-01	710	3.26E+01
1	1000	7.60E-04	7.60E-01	540	1.00E+02
1.5	1500	6.43E-04	6.43E-01	350	5.49E+01
2	2000	1.13E-03	1.13E+00	260	7.17E+01
Totals		**4.10E-03**	**4.10E+00**		**8.29E+02**
				MDER (μR/hr)	**1.16E+00**

Appendix B
MDER Calculations

MDER - Ra-226 - 2"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.05	50	2.31E-06	2.31E-03	11800	5.62E+00
0.08	80	2.61E-05	2.61E-02	12000	6.45E+01
0.1	100	2.38E-07	2.38E-04	9840	4.82E-01
0.2	200	5.71E-05	5.71E-02	4230	4.97E+01
0.3	300	1.81E-04	1.81E-01	2520	9.37E+01
0.4	400	4.60E-04	4.60E-01	1700	1.61E+02
0.5	500	2.71E-05	2.71E-02	1270	7.08E+00
0.6	600	8.71E-04	8.71E-01	1010	1.81E+02
0.8	800	2.23E-04	2.23E-01	710	3.25E+01
1	1000	9.02E-04	9.02E-01	540	1.00E+02
1.5	1500	7.65E-04	7.65E-01	350	5.51E+01
2	2000	1.35E-03	1.35E+00	260	7.20E+01
Totals		**4.86E-03**	**4.86E+00**		**8.23E+02**
				MDER (µR/hr)	**1.17E+00**

Appendix B
MDER Calculations

MDER - Ra-226 - 1"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.05	50	2.60E-06	2.60E-03	11800	5.24E+00
0.08	80	2.98E-05	2.98E-02	12000	6.11E+01
0.1	100	2.74E-07	2.74E-04	9840	4.61E-01
0.2	200	6.70E-05	6.70E-02	4230	4.85E+01
0.3	300	2.14E-04	2.14E-01	2520	9.22E+01
0.4	400	5.47E-04	5.47E-01	1700	1.59E+02
0.5	500	3.23E-05	3.23E-02	1270	7.02E+00
0.6	600	1.04E-03	1.04E+00	1010	1.80E+02
0.8	800	2.67E-04	2.67E-01	710	3.25E+01
1	1000	1.09E-03	1.09E+00	540	1.00E+02
1.5	1500	9.26E-04	9.26E-01	350	5.54E+01
2	2000	1.63E-03	1.63E+00	260	7.27E+01
Totals		**5.85E-03**	**5.85E+00**		**8.14E+02**
				MDER (µR/hr)	**1.18E+00**

Appendix B
MDER Calculations

MDER - Th-232 - 3"					
Energy (MeV)	**Energy (keV)**	**Exposure Rate (mR/hr)**	**Exposure Rate (µR/hr)**	**cpm per µR/hr**	**cpm per µR/hr (weighted)**
0.04	40	2.96E-07	2.96E-04	8880	4.57E-01
0.06	60	3.93E-07	3.93E-04	13000	8.88E-01
0.08	80	4.29E-05	4.29E-02	12000	8.95E+01
0.1	100	1.08E-05	1.08E-02	9840	1.86E+01
0.15	150	1.27E-05	1.27E-02	6040	1.33E+01
0.2	200	2.47E-04	2.47E-01	4230	1.82E+02
0.3	300	1.95E-04	1.95E-01	2520	8.53E+01
0.4	400	2.41E-05	2.41E-02	1700	7.14E+00
0.5	500	1.78E-04	1.78E-01	1270	3.94E+01
0.6	600	4.86E-04	4.86E-01	1010	8.54E+01
0.8	800	6.34E-04	6.34E-01	710	7.83E+01
1	1000	1.41E-03	1.41E+00	540	1.33E+02
1.5	1500	4.53E-04	4.53E-01	350	2.76E+01
2	2000	1.28E-05	1.28E-02	260	5.79E-01
3	3000	2.04E-03	2.04E+00	180	6.38E+01
Totals		**5.75E-03**	**5.75E+00**		**8.25E+02**
				MDER (µR/hr)	**1.17E+00**

Appendix B
MDER Calculations

MDER - Th-232 - 2"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.04	40	3.32E-07	3.32E-04	8880	4.32E-01
0.06	60	4.44E-07	4.44E-04	13000	8.46E-01
0.08	80	4.89E-05	4.89E-02	12000	8.60E+01
0.1	100	1.25E-05	1.25E-02	9840	1.80E+01
0.15	150	1.48E-05	1.48E-02	6040	1.31E+01
0.2	200	2.88E-04	2.88E-01	4230	1.79E+02
0.3	300	2.28E-04	2.28E-01	2520	8.43E+01
0.4	400	2.84E-05	2.84E-02	1700	7.08E+00
0.5	500	2.10E-04	2.10E-01	1270	3.91E+01
0.6	600	5.74E-04	5.74E-01	1010	8.50E+01
0.8	800	7.51E-04	7.51E-01	710	7.81E+01
1	1000	1.68E-03	1.68E+00	540	1.33E+02
1.5	1500	5.39E-04	5.39E-01	350	2.77E+01
2	2000	1.53E-05	1.53E-02	260	5.82E-01
3	3000	2.44E-03	2.44E+00	180	6.42E+01
Totals		**6.83E-03**	**6.83E+00**		**8.16E+02**
				MDER (µR/hr)	**1.18E+00**

Appendix B
MDER Calculations

MDER - Th-232 - 1"					
Energy (MeV)	Energy (keV)	Exposure Rate (mR/hr)	Exposure Rate (µR/hr)	cpm per µR/hr	cpm per µR/hr (weighted)
0.04	40	3.71E-07	3.71E-04	8880	4.00E-01
0.06	60	5.01E-07	5.01E-04	13000	7.92E-01
0.08	80	5.57E-05	5.57E-02	12000	8.13E+01
0.1	100	1.43E-05	1.43E-02	9840	1.71E+01
0.15	150	1.72E-05	1.72E-02	6040	1.26E+01
0.2	200	3.38E-04	3.38E-01	4230	1.74E+02
0.3	300	2.70E-04	2.70E-01	2520	8.28E+01
0.4	400	3.38E-05	3.38E-02	1700	6.99E+00
0.5	500	2.51E-04	2.51E-01	1270	3.87E+01
0.6	600	6.87E-04	6.87E-01	1010	8.43E+01
0.8	800	9.01E-04	9.01E-01	710	7.78E+01
1	1000	2.02E-03	2.02E+00	540	1.32E+02
1.5	1500	6.52E-04	6.52E-01	350	2.78E+01
2	2000	1.85E-05	1.85E-02	260	5.86E-01
3	3000	2.97E-03	2.97E+00	180	6.49E+01
Totals		**8.23E-03**	**8.23E+00**		**8.02E+02**
				MDER (µR/hr)	**1.20E+00**

Appendix C
Scan MDCs at Various Background Levels

Scan MDCs for Radionuclides of Concern at Various Background Levels (pCi/g)						
Background cpm	Ra-226	Th-232	U-234	U-235	U-238	Total Uranium (4% EU)
4000	0.76	0.55	2314	1.47	19.4	25.9
5000	0.85	0.61	2587	1.64	21.6	29.0
6000	0.93	0.67	2834	1.80	23.7	31.7
7000	1.01	0.72	3062	1.94	25.6	34.3
8000	1.08	0.77	3273	2.08	27.4	36.6
9000	1.14	0.82	3471	2.20	29.0	38.8
10000	1.21	0.87	3659	2.32	30.6	40.9
11000	1.26	0.91	3838	2.43	32.1	42.9
12000	1.32	0.95	4008	2.54	33.5	44.9
13000	1.37	0.99	4172	2.65	34.9	46.7
14000	1.43	1.02	4330	2.75	36.2	48.5
15000	1.48	1.06	4482	2.84	37.5	50.2