



**DEPARTMENT OF THE AIR FORCE**  
AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFMC)  
BROOKS CITY-BASE TEXAS

19 June 2007

MEMORANDUM FOR 30 MDOS/SGOA  
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FROM: AFIOH/SDR  
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SUBJECT: Consultative Letter, IOH-SD-BR-CL-2007-0077, Radiological Dose Assessment of  
Two BOMARC CIM-10 Debris Sites, Vandenberg AFB CA

1. The Air Force Institute for Operational Health (AFIOH), on behalf of 30 MDOS/SGOA, performed an environmental dose assessment of two sites on Vandenberg Air Force Base, Lompoc, CA, on 12-14 Feb 07. An external radiation survey of the general area was also conducted by 30 MDOS/SGOA personnel (SSgt Yaskulski). Based on the results of the assessment, AFIOH staff concluded that the on-site burial locations are unlikely to present a potential dose to the public in excess of the levels that would be considered as low as reasonably achievable under conditions of release for unrestricted use, consistent with the provisions of AFI 40-201 and 10 CFR 20 Subpart E, "Radiological Criteria for License Termination." AFIOH further determined that some additional guidance on regulatory requirements will be needed to determine whether the site may be released for unrestricted use pursuant to the current regulations in 10 CFR 20.1402, Subpart E, and AFI 40-201.

2. Background:

a. During testing of CIM-10 missiles at Vandenberg AFB, two of the missiles tested failed during the launch process and were destroyed, on 24 Aug 1966 and on 21 Feb 1969. One was deliberately destroyed while airborne and fell to the ground, and the other crashed, both within the confines of Vandenberg AFB. Each missile potentially contained up to 108.9 kilograms of magnesium-thorium (Mg-Th) alloy with up to 4% natural thorium by weight. Within a few days or weeks of the associated occurrence, the debris from each mishap was collected and placed within a pit dug for that purpose at or near the place where the debris had been scattered. The debris was then covered with an overburden of up to 4 meters, with a minimum of about 1.8 meters. The locations were noted on range records and marked as containing radioactive materials. In the mid-1990s, the areas were fenced to prevent access and to more definitively identify the burial location. Routine annual surveys were conducted to check for radiological hazards and integrity of the site(s).

b. During a routine annual radiation survey on 12 Dec 2006, base bioenvironmental engineering (30 MDOS/SGOA) personnel discovered one or more artifacts that appeared to be Mg-Th alloy on the surface outside the fence. At the request of 30 MDOS/SGOA, AFIOH/SDRH staff visited the site and performed an assessment of the occupational and environmental hazards and risk associated with the two sites. This assessment concentrated on the potential dose consistent with unrestricted public access.

### 3. Assessment Parameters:

a. Various Vandenberg AFB maps, plats, topographical references, crash response reports, and range records were used in conjunction with the CIM-10 manufacturer's literature, to determine the maximum potential inventory of radioactive materials associated with each crash/burial site. References used are listed at Atch 1, and dose modeling parameters and results are listed at Atch 2.

b. The two sites were visually examined for material condition of the fences and overburden. A few small artifacts that appeared to be weathered aircraft debris (small pieces of metal alloy and/or plastic, paint chips, etc.) were observed on and around the sites, and base personnel conducted radiation surveys of the metal alloy artifacts to determine if they exhibited radioactive properties. In a few cases the artifacts exhibited very low contact radiation rates of about 1000-3000 counts per minute (cpm) on an ADM-300 beta-gamma survey instrument. Minor variations in general area radiation rates of less than 1000 cpm gamma were observed. These levels appeared consistent with the potential concentration of thorium alloy contained in CIM-10 missile components. No areas exhibited measurements significantly above background. The calibration certificate for the instrument is shown at Atch 3.

c. Dose assessment and modeling was performed using RESRAD 6.3 (ANL, 2005). The default parameters were modified to address site-specific conditions and potential scenarios of use, both for current conditions and for projected future uses under unrestricted release conditions. The following considerations were used in determining input parameters for the assessments. The specific values are tabulated at Atch 2:

(1) Maximum quantity available from a CIM-10 BOMARC missile as reported by the manufacturer was 240 lbs (109 kg) of magnesium alloy (MgTh) containing natural thorium (100%  $^{232}\text{Th}$ ). This information was re-stated in several of the memoranda regarding the launch and recovery activities at the time of the occurrences. Area of concern (AOC)-167<sup>1</sup> was reported to have 100 lbs (45.4 kg) of thorium alloy, and AOC-168 was reported to have essentially the entire missile (109 kg). Additional review of site-specific information and of the specific alloy indicated the thorium content was 3% by weight from alloy HK31<sup>2</sup>. This corresponds to a maximum source term at the sites, based on the reported quantities of metal interred, of 3.27 kg  $^{232}\text{Th}$  at AOC-168, and 1.36 kg of  $^{232}\text{Th}$  at AOC-167. Since AOC-167 was reported to contain considerably less material than AOC-168, dose calculations were focused on the greater potential inventory in AOC-168.

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<sup>1</sup> Vandenberg AFB. 1969. "Burial of Magnesium-Thorium Alloy (Radioactive BOMARC Missile Wreckage)" Memorandum to File, CPT Gerald E. Harbour, BSC Chief, 16 May 1969. Vandenberg AFB, Lompoc, California

<sup>2</sup> MWH. 2005. "Summary Sheet AOC-167." Memorandum to file, 23 March 2005. Vandenberg AFB, Lompoc, California

(2) Specific activity of pure natural  $^{232}\text{Th}$  was calculated to be approximately 4070 becquerels per gram ( $\text{Bq}\cdot\text{g}^{-1}$ ). As the alloy content of HK31 is 3% thorium by weight (i.e., gram molecular weight equivalence), the alloy would exhibit a specific activity of approximately  $122 \text{ Bq}\cdot\text{g}^{-1}$ .

(3) Mg-Th alloy is not a readily dispersible form as delineated in 10 CFR 40, and is effectively not available to impart dose except as external radiation. Multiple dose calculations assuming various configurations of the material demonstrated that the contribution to total effective dose equivalent (TEDE) was negligible, so it was not modified from the default of all pathways available. However, the model was modified from the default to account for the likely non-distributed nature of the debris. Incident reports for both sites indicated the crashes resulted in fire. Therefore, a portion (10%) was presumed to be in dispersed form, distributed over the entire burial site. Based on reports of the total volume of the burial site(s) and the nature of the debris, it was assumed for purposes of the assessment that the remaining 90% remained in discrete sheet metal fragments of 2 mm thickness. The density of the alloy<sup>3</sup> would be  $1.77 \text{ g}/\text{cm}^3$ . The corresponding surface area for the 98.1 kg of alloy fragments was calculated to be  $27.7 \text{ m}^2$ , similar to the MgTh alloy surface area of the CIM-10 missile. AOC-168 was reported to have contained all the relatively easily recoverable debris from the approximately 7000 kg missile, not just the 109 kg of components that were MgTh alloy. The non-dispersible 90% remainder was assumed to be distributed across an inhomogeneous volume with a  $100 \text{ m}^2$  area and 0.002 m depth, for a volume equal to  $0.2 \text{ m}^3$ , conservative by a factor of about 500 relative to the recommendation in NUREG 1757. This would reduce the calculated concentration by a corresponding factor to about  $40 \text{ Bq}\cdot\text{g}^{-1}$ . This assumption is not realistic, but was used for conservatism in the dose assessment, as the RESRAD model does not account for self-absorption of external radiation within the media. Comparison of the direct radiation results using Microshield Version 6.02<sup>4</sup> were consistent with the RESRAD results.

(4) The burial site estimate used above for the dispersed concentration calculation was an area of 10 meters by 10 meters, with a zone thickness of 3 meters, and an overburden of 6 feet (1.8 meters). These values were approximated from the reports of depth and breadth of the burial sites in range records.

(5) To account for the apparent high rate of erosion of the sandy soils as observed on site, the default erosion rate of 0.001 m/y was assumed to be 0.01 m/y. No credit was taken for re-application of overburden from shifting sands re-entering the site. Density of the missile components was assumed to be similar to the default soil, as sensitivity analyses indicated the mathematical contribution to self-shielding was negligible.

(6) The burial site estimate used above for the non-dispersed alloy dose calculation was a volume of 10 meters on a side, with a zone thickness of 0.002 m (2 mm sheet metal), and the same overburden of 1.8 meters eroding at 0.01 m/y. These values were approximated from the inhomogeneous contaminated zone recommendations in the RESRAD 6 user documentation.

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<sup>3</sup> Handbook of Chemistry and Physics, Mg-Th alloy 3%

<sup>4</sup> See Atch 1 for bibliographic information.

Using this area and zone thickness allowed most of the material to be available to impart external dose at about the same time, as a conservative assumption.

(7) The total dose from the 10% dispersible material was summed with the dose that would result from the external radiation emanating from the remaining 90% that was non-dispersible. No credit was taken for those portions of the material that were scattered elsewhere from the crash and fire, except with respect to the estimate of interred material in AOC-167.

(8) Sensitivity analyses indicated that the contribution from direct radiation was far more significant than ingestion pathways for all tested scenarios. However, all ingestion pathways were left intact, as the contribution was negligible, even though the areas are not suitable for food crops and the groundwater was reported not to be potable without treatment.

#### 4. Dose Assessment:

a. For the assumed distributed 10% dispersible alloy buried in a 300 m<sup>3</sup> volume in AOC-168, the maximum TEDE was estimated to be about 0.66 mrem per year maximum in about the 179<sup>th</sup> year after burial. The maximum TEDE for AOC-167 was about 0.28 mrem per year in about the same year after burial.

b. For the assumed 90% remaining as fragments scattered across a surface of 100 m<sup>2</sup>, the maximum TEDE was estimated to be 4.67 mrem per year for AOC-168 and 1.95 mrem per year for AOC-167, with these maximum doses occurring in about the 179<sup>th</sup> year after burial.

c. The concentrations and burial volumes were recalculated in several different configurations to determine the bounds of the model with respect to self-absorption and other potentially confounding factors. When the material was presumed to all be dispersible and available for plant uptake (which artificially increases solubility of the thorium), the calculated maximum TEDE rose due to the increase in the source term of dispersible materials and the plant uptake, but decreased overall as compared with the fragments all in one layer (4.b, above), to about 3.37 mrem per year. For simplicity of illustration, the analyses from RESRAD 6.3 using the listed site-specific parameters were modified to assume all the material was dispersible, distributed over the depth of 3 meters at AOC-168. The overburden was calculated to have eroded to 1.4 meters ( $1.8 \text{ m} - (40 \text{ y} \times 1 \text{ cm/y}) = 1.4 \text{ m}$ ) over the approximately 40 years since burial. This assessment is shown in Atch 2, following the summary of inputs. The resulting maximum TEDE was 6.64 mrem/y in about the 179<sup>th</sup> year after burial. Graphs of the 10% dispersible, 90% dispersible, and 100% dispersible and available for uptake, are included after the summary report. The corresponding result for AOC-167 was a maximum TEDE of 1.57 mrem per year in the same year after burial.

#### 5. Conclusions:

a. Access to either AOC-167 or AOC-168 does not present a radiological hazard to personnel, even with the material partially or wholly exposed by erosion.

b. The projected total effective dose equivalent to the public from the material present at either of the two sites evaluated, under the default scenario described in NUREG/CR-1757, Vol.

1, is far less than the 25 mrem/y criterion deemed As Low As Reasonably Achievable (ALARA) per 10 CFR 20.1402 and AFI 40-201 section 1.11.4.

c. As the estimated dose noted above represents a conservative upper bound on the potential dose from burial of a single CIM-10 missile, any other individual crash sites or similar burials not containing other radioactive materials could reasonably be expected to exhibit results similar to or less than the calculated doses noted above.

6. Recommendations:

a. 30 MDOS/SGOA should prepare a request to AFMSA/SGPR for a possession-only permit under AFI 40-201, consistent with 10 CFR 40, "Source Material Licensing," separately from any current permits from AFMSA/SGPR under the Air Force Master Materials License.

b. Concurrent with or upon issuance of the possession only permit from AFMSA/SGPR, 30 MDOS/SGOA should obtain from AFMSA/SGPR the parameters to be used (such as determination of the critical group consistent with 10 CFR 20.1401(d)) for a formal assessment of the residual radioactivity for calculation of the TEDE resulting from the MgTh alloy remaining on site, to conclude that the sites are acceptable by AFMSA/SGPR for release under conditions of unrestricted use consistent with 10 CFR 20.1402.

c. Depending on the results of the formal determination of the TEDE as noted above, 30 MDOS/SGOA may prepare a request for termination of the permit under AFI 40-201, consistent with release for unrestricted use under the criteria in 10 CFR 20.1402.

7. If you have any comments or questions regarding this matter, please contact Mr. Brian Harcek at 210-536-4263 (DSN 240-4263), or email to [brian.harcek@brooks.af.mil](mailto:brian.harcek@brooks.af.mil).

//signed//

SCOTT M. NICHELSON, Lt Col, USAF, BSC, CHP, CIH  
Chief, Radiation Surveillance Division

cc:  
AFMOA/SPGR  
30 MDOS/SGOA

Atchs:  
1. References  
2. Dose Assessment Input Parameters and Analyses  
3. Calibration Certificat

Attachment 1  
References

10 CFR 20, Subpart E.

Framatome ANP. 2003. "Microshield Version 6 User's Manual." March 2003. Framatome ANP, dba Grove Engineering, Rockville, MD.

NUREG/CR-1757, Vol. 1. 2006. "Consolidated Decommissioning Guidance – Decommissioning Process for Materials Licensees." Rev. 2, Final Report, September 2006. U.S. Nuclear Regulatory Commission. Washington, DC.

NUREG/CR-5512, Vol. 1. 1992. "Residual Radioactive Contamination from Decommissioning Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent." Final Report, October 1992. U.S. Nuclear Regulatory Commission. Washington, DC.

NUREG/CR-5512, Vol. 2. 2001. "Residual Radioactive Contamination from Decommissioning User's Manual." April 2001. U.S. Nuclear Regulatory Commission. Washington, DC.

NUREG/CR-5512, Vol. 3. 1999. "Residual Radioactive Contamination from Decommissioning Parameter Analysis." Draft Report for Comment, October 1999. U.S. Nuclear Regulatory Commission. Washington, DC.

NUREG/CR-5512, Vol. 4. 1999. "Comparison of the Models and Assumptions used in the DandD 1.0, RESRAD 5.61, and RESRAD-Build Computer Codes with Respect to the Residential Farmer and Industrial Occupant Scenarios Provided in NUREG/CR-5512." October 1999. U.S. Nuclear Regulatory Commission. Washington, DC.

NUREG-1549. 1998. "Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination." Draft, July 1998. U.S. Nuclear Regulatory Commission. Washington, DC.

RESRAD Version 6.3<sup>1</sup> (August, 2005) – Dose modeling: "A computer code developed by the U.S. Department of Energy and designed to estimate radiation doses and risks from RESidual RADioactive materials in soils. was used to characterize the potential dose to a member of the public."<sup>2</sup>

Schleien, et al. Editors. 1998. "Handbook of Health Physics and Radiological Health." 3rd Ed. Baltimore, MD.

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<sup>1</sup> USDOE. 2001. "User's Manual for RESRAD Version 6." ANL/EAD-4, July 2001. Argonne National Laboratory, U.S. Department of Energy, Argonne, Illinois.

<sup>2</sup> NUREG-1757, Vol. 1, Rev. 2, pg xxxiv, GLOSSARY.

Attachment 2  
Dose Assessment Input Parameters and Analyses

Part 1 – Summary Of Inputs

|   | Dispersible <sup>7</sup>           | Non-Dispersible                    |
|---|------------------------------------|------------------------------------|
| Input Parameters:   |                                    |                                    |
| Contaminated Zone Area  | 10 m x 10 m                        | 10 m x 10 m                        |
| Contaminated Zone Thickness                                     | 3 m                                | 0.002 m                            |
| Volume over which mass distributed                              | 3 E8 cm <sup>3</sup>               | 2 E5 cm <sup>3</sup>               |
| Overburden depth  | 1.8 m                              | 1.8 m                              |
| Erosion rate  | 10 cm/y                            | 10 cm/y                            |
| Soil (sand) density   | 1.5 g-cm <sup>-3</sup>             | 1.5 g-cm <sup>-3</sup>             |
| AOC 168   |                                    |                                    |
| Original mass of source term                                    | -                                  | 109,000 g                          |
| Mass of distributed material                                    | 10,900 g                           | 98,100 g                           |
| Total Activity from undistributed (3270 g of <sup>232</sup> Th) | -                                  | 13.3 MBq                           |
| Activity of distributed material                                | 1.33 MBq                           | 12 MBq                             |
| Concentration of distributed material                           | 2.96 E-3 Bq-g <sup>-1</sup>        | 33.4 Bq-g <sup>-1</sup>            |
| AOC 167   |                                    |                                    |
| Original mass of source term                                    | -                                  | 45400 g                            |
| Mass of distributed material                                    | 4540 g                             | 40860 g                            |
| Total Activity from undistributed (1360 g of <sup>232</sup> Th) | -                                  | 5.54 MBq                           |
| Activity of distributed material                                | 554 kBq                            | 4.98 MBq                           |
| Concentration of distributed material                           | 1.54 E-3 Bq-g <sup>-1</sup>        | 1.38 E-2 Bq-g <sup>-1</sup>        |
| Recalculation assuming all dispersible                          |                                    |                                    |
| Original mass of source term                                    | 109,000 g                          | -                                  |
| Mass of distributed material                                    | 109,000 g                          | -                                  |
| Activity of distributed material (3270 g of <sup>232</sup> Th)  | 13.3 MBq                           | -                                  |
| Concentration of distributed material                           | 1.54 E-2 Bq-g <sup>-1</sup>        | -                                  |
| Contaminated Zone Area  | 10 m x 10 m                        | -                                  |
| Contaminated Zone Thickness                                     | 3 m                                | -                                  |
| Volume over which mass distributed                              | 3 E8 cm <sup>3</sup>               | -                                  |
| Overburden depth  | 1.4 m                              | -                                  |
| Erosion rate  | 10 cm/y                            | -                                  |
| Soil (sand) density   | 1.5 g-cm <sup>-3</sup>             | -                                  |
| Analysis Results (mrem/y, approximate peak year):               | 38 <sup>th</sup> year <sup>8</sup> | 17 <sup>th</sup> year <sup>9</sup> |
| AOC-168   | 1.34                               | 0.014                              |
| AOC-167   | 0.33                               | 0.002                              |

<sup>7</sup> NOTE: RESRAD 6.3 uses a default K<sub>d</sub> of 60,000 for thorium (see pg E-16 of ANL/EAD-4), versus the previously-accepted K<sub>d</sub> of 3000. This significantly affects the postulated transport and uptake.

<sup>8</sup> NOTE: This is equivalent to 10% of the MgTh alloy being distributed over the described depth, then exposed on the surface, effectively all at once, from severe erosion, with exposure of the material on the surface in about 2007 (1969 + 38 years).

<sup>9</sup> NOTE: This is equivalent to 90% of the MgTh alloy surfaces being scattered in very small fragments over an area of 100 m<sup>2</sup>, then exposed on the surface, effectively all at once, from severe erosion.

Attachment 2  
Dose Assessment Input Parameters and Analyses

Part 2 – AOC-168 Summary of Results<sup>10</sup>

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 1  
Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

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<sup>10</sup> Based on entire mass (109 kg) of MgTh alloy evenly distributed within a 10 m x 10 m area, 3 m deep, with 1.4 meters of overburden, alloy at 3% by weight, erosion rate of 1 cm per year.

## Attachment 2

### Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 2  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

#### Dose Conversion Factor (and Related) Parameter Summary File: FGR 13 MORBIDITY

| Menu  | Parameter  | Current Value | Base Case* | Parameter Name |
|-------|--|---------------|------------|----------------|
| ----- |  |               |            |                |
| B-1   | Dose conversion factors for inhalation, mrem/mBq:        |               |            |                |
| B-1   | Ra-228+D   | 1.372E-04     | 1.289E-04  | DCF2( 1)       |
| B-1   | Th-228+D   | 9.334E-03     | 9.243E-03  | DCF2( 2)       |
| B-1   | Th-232   | 4.432E-02     | 4.432E-02  | DCF2( 3)       |
| D-1   | Dose conversion factors for ingestion, mrem/mBq:         |               |            |                |
| D-1   | Ra-228+D   | 3.898E-05     | 3.892E-05  | DCF3( 1)       |
| D-1   | Th-228+D   | 2.185E-05     | 1.070E-05  | DCF3( 2)       |
| D-1   | Th-232   | 7.378E-05     | 7.378E-05  | DCF3( 3)       |
| D-34  | Food transfer factors:                                   |               |            |                |
| D-34  | Ra-228+D , plant/soil concentration ratio, dimensionless | 4.000E-02     | 4.000E-02  | RTF( 1,1)      |
| D-34  | Ra-228+D , beef/livestock-intake ratio, (mBq/kg)/(mBq/d) | 1.000E-03     | 1.000E-03  | RTF( 1,2)      |
| D-34  | Ra-228+D , milk/livestock-intake ratio, (mBq/L)/(mBq/d)  | 1.000E-03     | 1.000E-03  | RTF( 1,3)      |
| D-34  | Th-228+D , plant/soil concentration ratio, dimensionless | 1.000E-03     | 1.000E-03  | RTF( 2,1)      |
| D-34  | Th-228+D , beef/livestock-intake ratio, (mBq/kg)/(mBq/d) | 1.000E-04     | 1.000E-04  | RTF( 2,2)      |
| D-34  | Th-228+D , milk/livestock-intake ratio, (mBq/L)/(mBq/d)  | 5.000E-06     | 5.000E-06  | RTF( 2,3)      |
| D-34  | Th-232 , plant/soil concentration ratio, dimensionless   | 1.000E-03     | 1.000E-03  | RTF( 3,1)      |
| D-34  | Th-232 , beef/livestock-intake ratio, (mBq/kg)/(mBq/d)   | 1.000E-04     | 1.000E-04  | RTF( 3,2)      |
| D-34  | Th-232 , milk/livestock-intake ratio, (mBq/L)/(mBq/d)    | 5.000E-06     | 5.000E-06  | RTF( 3,3)      |
| D-5   | Bioaccumulation factors, fresh water, L/kg:              |               |            |                |
| D-5   | Ra-228+D , fish  | 5.000E+01     | 5.000E+01  | BIOFAC( 1,1)   |
| D-5   | Ra-228+D , crustacea and mollusks                        | 2.500E+02     | 2.500E+02  | BIOFAC( 1,2)   |
| D-5   | Th-228+D , fish  | 1.000E+02     | 1.000E+02  | BIOFAC( 2,1)   |
| D-5   | Th-228+D , crustacea and mollusks                        | 5.000E+02     | 5.000E+02  | BIOFAC( 2,2)   |
| D-5   | Th-232 , fish  | 1.000E+02     | 1.000E+02  | BIOFAC( 3,1)   |
| D-5   | Th-232 , crustacea and mollusks                          | 5.000E+02     | 5.000E+02  | BIOFAC( 3,2)   |
| ----- |  |               |            |                |

\*Base Case means Default.Lib w/o Associate Nuclide contributions..

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 3  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

### Site-Specific Parameter Summary

| Menu | Parameter                                       | User Input | Default   | Used by RESRAD<br>(If different from user input) | Parameter Name |
|------|---|------------|-----------|--|----------------|
| R011 | Area of contaminated zone (m**2)                | 1.000E+02  | 1.000E+04 | ---  | AREA           |
| R011 | Thickness of contaminated zone (m)              | 3.000E+00  | 2.000E+00 | ---  | THICK0         |
| R011 | Length parallel to aquifer flow (m)             | 1.000E+02  | 1.000E+02 | ---  | LCZPAQ         |
| R011 | Basic radiation dose limit (mrem/yr)            | 2.500E+01  | 3.000E+01 | ---  | BRDL           |
| R011 | Time since placement of material (yr)           | 4.000E+01  | 0.000E+00 | ---  | TI             |
| R011 | Times for calculations (yr)                     | 1.000E+00  | 1.000E+00 | ---  | T ( 2)         |
| R011 | Times for calculations (yr)                     | 3.000E+00  | 3.000E+00 | ---  | T ( 3)         |
| R011 | Times for calculations (yr)                     | 1.000E+01  | 1.000E+01 | ---  | T ( 4)         |
| R011 | Times for calculations (yr)                     | 3.000E+01  | 3.000E+01 | ---  | T ( 5)         |
| R011 | Times for calculations (yr)                     | 1.000E+02  | 1.000E+02 | ---  | T ( 6)         |
| R011 | Times for calculations (yr)                     | 3.000E+02  | 3.000E+02 | ---  | T ( 7)         |
| R011 | Times for calculations (yr)                     | 1.000E+03  | 1.000E+03 | ---  | T ( 8)         |
| R011 | Times for calculations (yr)                     | 2.000E+03  | 0.000E+00 | ---  | T ( 9)         |
| R011 | Times for calculations (yr)                     | 4.000E+03  | 0.000E+00 | ---  | T(10)          |
| R012 | Initial principal radionuclide (mBq/g): Th-232  | 1.540E+01  | 0.000E+00 | ---  | S1 ( 3)        |
| R012 | Concentration in groundwater (mBq/L): Th-232    | not used   | 0.000E+00 | ---  | W1 ( 3)        |
| R013 | Cover depth (m)                                 | 1.400E+00  | 0.000E+00 | ---  | COVER0         |
| R013 | Density of cover material (g/cm**3)             | 1.500E+00  | 1.500E+00 | ---  | DENSCV         |
| R013 | Cover depth erosion rate (m/yr)                 | 1.000E-02  | 1.000E-03 | ---  | VCV            |
| R013 | Density of contaminated zone (g/cm**3)          | 1.500E+00  | 1.500E+00 | ---  | DENSCZ         |
| R013 | Contaminated zone erosion rate (m/yr)           | 1.000E-03  | 1.000E-03 | ---  | VCZ            |
| R013 | Contaminated zone total porosity                | 4.000E-01  | 4.000E-01 | ---  | TPCZ           |
| R013 | Contaminated zone field capacity                | 2.000E-01  | 2.000E-01 | ---  | FCCZ           |
| R013 | Contaminated zone hydraulic conductivity (m/yr) | 1.000E+01  | 1.000E+01 | ---  | HCCZ           |
| R013 | Contaminated zone b parameter                   | 5.300E+00  | 5.300E+00 | ---  | BCZ            |
| R013 | Average annual wind speed (m/sec)               | 2.000E+00  | 2.000E+00 | ---  | WIND           |
| R013 | Humidity in air (g/m**3)                        | not used   | 8.000E+00 | ---  | HUMID          |
| R013 | Evapotranspiration coefficient                  | 5.000E-01  | 5.000E-01 | ---  | EVAPTR         |
| R013 | Precipitation (m/yr)                            | 1.000E+00  | 1.000E+00 | ---  | PRECIP         |
| R013 | Irrigation (m/yr)                               | 2.000E-01  | 2.000E-01 | ---  | RI             |
| R013 | Irrigation mode                                 | overhead   | overhead  | ---  | IDITCH         |
| R013 | Runoff coefficient                              | 2.000E-01  | 2.000E-01 | ---  | RUNOFF         |
| R013 | Watershed area for nearby stream or pond (m**2) | 1.000E+06  | 1.000E+06 | ---  | WAREA          |
| R013 | Accuracy for water/soil computations            | 1.000E-03  | 1.000E-03 | ---  | EPS            |
| R014 | Density of saturated zone (g/cm**3)             | 1.500E+00  | 1.500E+00 | ---  | DENSAQ         |
| R014 | Saturated zone total porosity                   | 4.000E-01  | 4.000E-01 | ---  | TPSZ           |
| R014 | Saturated zone effective porosity               | 2.000E-01  | 2.000E-01 | ---  | EPSZ           |
| R014 | Saturated zone field capacity                   | 2.000E-01  | 2.000E-01 | ---  | FCSZ           |
| R014 | Saturated zone hydraulic conductivity (m/yr)    | 1.000E+02  | 1.000E+02 | ---  | HCSZ           |
| R014 | Saturated zone hydraulic gradient               | 2.000E-02  | 2.000E-02 | ---  | HGWT           |
| R014 | Saturated zone b parameter                      | 5.300E+00  | 5.300E+00 | ---  | BSZ            |
| R014 | Water table drop rate (m/yr)                    | 1.000E-03  | 1.000E-03 | ---  | VWT            |
| R014 | Well pump intake depth (m below water table)    | 1.000E+01  | 1.000E+01 | ---  | DWIBWT         |
| R014 | Model: Nondispersion (ND) or Mass-Balance (MB)  | ND         | ND        | ---  | MODEL          |
| R014 | Well pumping rate (m**3/yr)                     | 2.500E+02  | 2.500E+02 | ---  | UW             |
| R015 | Number of unsaturated zone strata               | 1          | 1         | ---  | NS             |

## Attachment 2

### Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 4  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

#### Site-Specific Parameter Summary (continued)

| Menu | Parameter                                      | User Input | Default   | Used by RESRAD<br>(If different from user input) | Parameter Name |
|------|--|------------|-----------|--|----------------|
| R015 | Unsat. zone 1, thickness (m)                   | 4.000E+00  | 4.000E+00 | ---  | H(1)           |
| R015 | Unsat. zone 1, soil density (g/cm**3)          | 1.500E+00  | 1.500E+00 | ---  | DENSUZ(1)      |
| R015 | Unsat. zone 1, total porosity                  | 4.000E-01  | 4.000E-01 | ---  | TPUZ(1)        |
| R015 | Unsat. zone 1, effective porosity              | 2.000E-01  | 2.000E-01 | ---  | EPUZ(1)        |
| R015 | Unsat. zone 1, field capacity                  | 2.000E-01  | 2.000E-01 | ---  | FCUZ(1)        |
| R015 | Unsat. zone 1, soil-specific b parameter       | 5.300E+00  | 5.300E+00 | ---  | BUZ(1)         |
| R015 | Unsat. zone 1, hydraulic conductivity (m/yr)   | 1.000E+01  | 1.000E+01 | ---  | HCUZ(1)        |
| R016 | Distribution coefficients for Th-232           |            |           |  |                |
| R016 | Contaminated zone (cm**3/g)                    | -1.000E+00 | 6.000E+04 | 1.378E+03  | DCNUCC( 3)     |
| R016 | Unsaturated zone 1 (cm**3/g)                   | -1.000E+00 | 6.000E+04 | 1.378E+03  | DCNUCU( 3,1)   |
| R016 | Saturated zone (cm**3/g)                       | -1.000E+00 | 6.000E+04 | 1.378E+03  | DCNUCS( 3)     |
| R016 | Leach rate (/yr)                               | 0.000E+00  | 0.000E+00 | 8.062E-05  | ALEACH( 3)     |
| R016 | Solubility constant                            | 0.000E+00  | 0.000E+00 | not used   | SOLUBK( 3)     |
| R016 | Distribution coefficients for daughter Ra-228  |            |           |  |                |
| R016 | Contaminated zone (cm**3/g)                    | 7.000E+01  | 7.000E+01 | ---  | DCNUCC( 1)     |
| R016 | Unsaturated zone 1 (cm**3/g)                   | 7.000E+01  | 7.000E+01 | ---  | DCNUCU( 1,1)   |
| R016 | Saturated zone (cm**3/g)                       | 7.000E+01  | 7.000E+01 | ---  | DCNUCS( 1)     |
| R016 | Leach rate (/yr)                               | 0.000E+00  | 0.000E+00 | 1.582E-03  | ALEACH( 1)     |
| R016 | Solubility constant                            | 0.000E+00  | 0.000E+00 | not used   | SOLUBK( 1)     |
| R016 | Distribution coefficients for daughter Th-228  |            |           |  |                |
| R016 | Contaminated zone (cm**3/g)                    | 6.000E+04  | 6.000E+04 | ---  | DCNUCC( 2)     |
| R016 | Unsaturated zone 1 (cm**3/g)                   | 6.000E+04  | 6.000E+04 | ---  | DCNUCU( 2,1)   |
| R016 | Saturated zone (cm**3/g)                       | 6.000E+04  | 6.000E+04 | ---  | DCNUCS( 2)     |
| R016 | Leach rate (/yr)                               | 0.000E+00  | 0.000E+00 | 1.852E-06  | ALEACH( 2)     |
| R016 | Solubility constant                            | 0.000E+00  | 0.000E+00 | not used   | SOLUBK( 2)     |
| R017 | Inhalation rate (m**3/yr)                      | 8.400E+03  | 8.400E+03 | ---  | INHALR         |
| R017 | Mass loading for inhalation (g/m**3)           | 1.000E-04  | 1.000E-04 | ---  | MLINH          |
| R017 | Exposure duration                              | 3.000E+01  | 3.000E+01 | ---  | ED             |
| R017 | Shielding factor, inhalation                   | 4.000E-01  | 4.000E-01 | ---  | SHF3           |
| R017 | Shielding factor, external gamma               | 7.000E-01  | 7.000E-01 | ---  | SHF1           |
| R017 | Fraction of time spent indoors                 | 5.000E-01  | 5.000E-01 | ---  | FIND           |
| R017 | Fraction of time spent outdoors (on site)      | 2.500E-01  | 2.500E-01 | ---  | FOTD           |
| R017 | Shape factor flag, external gamma              | 1.000E+00  | 1.000E+00 | >0 shows circular AREA.                          | FS             |
| R017 | Radii of shape factor array (used if FS = -1): |            |           |  |                |
| R017 | Outer annular radius (m), ring 1:              | not used   | 5.000E+01 | ---  | RAD-SHAPE( 1)  |
| R017 | Outer annular radius (m), ring 2:              | not used   | 7.071E+01 | ---  | RAD-SHAPE( 2)  |
| R017 | Outer annular radius (m), ring 3:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 3)  |
| R017 | Outer annular radius (m), ring 4:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 4)  |
| R017 | Outer annular radius (m), ring 5:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 5)  |
| R017 | Outer annular radius (m), ring 6:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 6)  |
| R017 | Outer annular radius (m), ring 7:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 7)  |
| R017 | Outer annular radius (m), ring 8:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 8)  |
| R017 | Outer annular radius (m), ring 9:              | not used   | 0.000E+00 | ---  | RAD-SHAPE( 9)  |
| R017 | Outer annular radius (m), ring 10:             | not used   | 0.000E+00 | ---  | RAD-SHAPE(10)  |
| R017 | Outer annular radius (m), ring 11:             | not used   | 0.000E+00 | ---  | RAD-SHAPE(11)  |
| R017 | Outer annular radius (m), ring 12:             | not used   | 0.000E+00 | ---  | RAD-SHAPE(12)  |

## Attachment 2

### Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 5  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

#### Site-Specific Parameter Summary (continued)

| Menu | Parameter  | User Input | Default   | Used by RESRAD<br>(If different from user input) | Parameter Name |
|------|--|------------|-----------|--|----------------|
| R017 | Fractions of annular areas within AREA:          |            |           |  |                |
| R017 | Ring 1   | not used   | 1.000E+00 | ---  | FRACA ( 1)     |
| R017 | Ring 2   | not used   | 2.732E-01 | ---  | FRACA ( 2)     |
| R017 | Ring 3   | not used   | 0.000E+00 | ---  | FRACA ( 3)     |
| R017 | Ring 4   | not used   | 0.000E+00 | ---  | FRACA ( 4)     |
| R017 | Ring 5   | not used   | 0.000E+00 | ---  | FRACA ( 5)     |
| R017 | Ring 6   | not used   | 0.000E+00 | ---  | FRACA ( 6)     |
| R017 | Ring 7   | not used   | 0.000E+00 | ---  | FRACA ( 7)     |
| R017 | Ring 8   | not used   | 0.000E+00 | ---  | FRACA ( 8)     |
| R017 | Ring 9   | not used   | 0.000E+00 | ---  | FRACA ( 9)     |
| R017 | Ring 10  | not used   | 0.000E+00 | ---  | FRACA (10)     |
| R017 | Ring 11  | not used   | 0.000E+00 | ---  | FRACA (11)     |
| R017 | Ring 12  | not used   | 0.000E+00 | ---  | FRACA (12)     |
| R018 | Fruits, vegetables and grain consumption (kg/yr) | 1.600E+02  | 1.600E+02 | ---  | DIET (1)       |
| R018 | Leafy vegetable consumption (kg/yr)              | 1.400E+01  | 1.400E+01 | ---  | DIET (2)       |
| R018 | Milk consumption (L/yr)                          | 9.200E+01  | 9.200E+01 | ---  | DIET (3)       |
| R018 | Meat and poultry consumption (kg/yr)             | 6.300E+01  | 6.300E+01 | ---  | DIET (4)       |
| R018 | Fish consumption (kg/yr)                         | 5.400E+00  | 5.400E+00 | ---  | DIET (5)       |
| R018 | Other seafood consumption (kg/yr)                | 9.000E-01  | 9.000E-01 | ---  | DIET (6)       |
| R018 | Soil ingestion rate (g/yr)                       | 3.650E+01  | 3.650E+01 | ---  | SOIL           |
| R018 | Drinking water intake (L/yr)                     | 5.100E+02  | 5.100E+02 | ---  | DWI            |
| R018 | Contamination fraction of drinking water         | 1.000E+00  | 1.000E+00 | ---  | FDW            |
| R018 | Contamination fraction of household water        | not used   | 1.000E+00 | ---  | FHHW           |
| R018 | Contamination fraction of livestock water        | 1.000E+00  | 1.000E+00 | ---  | FLW            |
| R018 | Contamination fraction of irrigation water       | 1.000E+00  | 1.000E+00 | ---  | FIRW           |
| R018 | Contamination fraction of aquatic food           | 5.000E-01  | 5.000E-01 | ---  | FR9            |
| R018 | Contamination fraction of plant food             | -1         | -1        | 0.500E-01  | FPLANT         |
| R018 | Contamination fraction of meat                   | -1         | -1        | 0.500E-02  | FMEAT          |
| R018 | Contamination fraction of milk                   | -1         | -1        | 0.500E-02  | FMILK          |
| R019 | Livestock fodder intake for meat (kg/day)        | 6.800E+01  | 6.800E+01 | ---  | LFI5           |
| R019 | Livestock fodder intake for milk (kg/day)        | 5.500E+01  | 5.500E+01 | ---  | LFI6           |
| R019 | Livestock water intake for meat (L/day)          | 5.000E+01  | 5.000E+01 | ---  | LWI5           |
| R019 | Livestock water intake for milk (L/day)          | 1.600E+02  | 1.600E+02 | ---  | LWI6           |
| R019 | Livestock soil intake (kg/day)                   | 5.000E-01  | 5.000E-01 | ---  | LSI            |
| R019 | Mass loading for foliar deposition (g/m**3)      | 1.000E-04  | 1.000E-04 | ---  | MLFD           |
| R019 | Depth of soil mixing layer (m)                   | 1.500E-01  | 1.500E-01 | ---  | DM             |
| R019 | Depth of roots (m)                               | 9.000E-01  | 9.000E-01 | ---  | DROOT          |
| R019 | Drinking water fraction from ground water        | 1.000E+00  | 1.000E+00 | ---  | FGWDW          |
| R019 | Household water fraction from ground water       | not used   | 1.000E+00 | ---  | FGWHH          |
| R019 | Livestock water fraction from ground water       | 1.000E+00  | 1.000E+00 | ---  | FGWLW          |
| R019 | Irrigation fraction from ground water            | 1.000E+00  | 1.000E+00 | ---  | FGWIR          |
| R19B | Wet weight crop yield for Non-Leafy (kg/m**2)    | 7.000E-01  | 7.000E-01 | ---  | YV (1)         |
| R19B | Wet weight crop yield for Leafy (kg/m**2)        | 1.500E+00  | 1.500E+00 | ---  | YV (2)         |
| R19B | Wet weight crop yield for Fodder (kg/m**2)       | 1.100E+00  | 1.100E+00 | ---  | YV (3)         |
| R19B | Growing Season for Non-Leafy (years)             | 1.700E-01  | 1.700E-01 | ---  | TE (1)         |
| R19B | Growing Season for Leafy (years)                 | 2.500E-01  | 2.500E-01 | ---  | TE (2)         |
| R19B | Growing Season for Fodder (years)                | 8.000E-02  | 8.000E-02 | ---  | TE (3)         |
| R19B | Translocation Factor for Non-Leafy               | 1.000E-01  | 1.000E-01 | ---  | TIV (1)        |

## Attachment 2

### Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 6  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

#### Site-Specific Parameter Summary (continued)

| Menu | Parameter  | User Input | Default    | Used by RESRAD<br>(If different from user input) | Parameter Name |
|------|--|------------|------------|--|----------------|
| R19B | Translocation Factor for Leafy                   | 1.000E+00  | 1.000E+00  | ---  | TIV(2)         |
| R19B | Translocation Factor for Fodder                  | 1.000E+00  | 1.000E+00  | ---  | TIV(3)         |
| R19B | Dry Foliar Interception Fraction for Non-Leafy   | 2.500E-01  | 2.500E-01  | ---  | RDRY(1)        |
| R19B | Dry Foliar Interception Fraction for Leafy       | 2.500E-01  | 2.500E-01  | ---  | RDRY(2)        |
| R19B | Dry Foliar Interception Fraction for Fodder      | 2.500E-01  | 2.500E-01  | ---  | RDRY(3)        |
| R19B | Wet Foliar Interception Fraction for Non-Leafy   | 2.500E-01  | 2.500E-01  | ---  | RWET(1)        |
| R19B | Wet Foliar Interception Fraction for Leafy       | 2.500E-01  | 2.500E-01  | ---  | RWET(2)        |
| R19B | Wet Foliar Interception Fraction for Fodder      | 2.500E-01  | 2.500E-01  | ---  | RWET(3)        |
| R19B | Weathering Removal Constant for Vegetation       | 2.000E+01  | 2.000E+01  | ---  | WLAM           |
| C14  | C-12 concentration in water (g/cm**3)            | not used   | 2.000E-05  | ---  | C12WTR         |
| C14  | C-12 concentration in contaminated soil (g/g)    | not used   | 3.000E-02  | ---  | C12CZ          |
| C14  | Fraction of vegetation carbon from soil          | not used   | 2.000E-02  | ---  | CSOIL          |
| C14  | Fraction of vegetation carbon from air           | not used   | 9.800E-01  | ---  | CAIR           |
| C14  | C-14 evasion layer thickness in soil (m)         | not used   | 3.000E-01  | ---  | DMC            |
| C14  | C-14 evasion flux rate from soil (1/sec)         | not used   | 7.000E-07  | ---  | EVSN           |
| C14  | C-12 evasion flux rate from soil (1/sec)         | not used   | 1.000E-10  | ---  | REVSN          |
| C14  | Fraction of grain in beef cattle feed            | not used   | 8.000E-01  | ---  | AVFG4          |
| C14  | Fraction of grain in milk cow feed               | not used   | 2.000E-01  | ---  | AVFG5          |
| C14  | DCF correction factor for gaseous forms of C14   | not used   | 0.000E+00  | ---  | CO2F           |
| STOR | Storage times of contaminated foodstuffs (days): |            |            |  |                |
| STOR | Fruits, non-leafy vegetables, and grain          | 1.400E+01  | 1.400E+01  | ---  | STOR-T(1)      |
| STOR | Leafy vegetables                                 | 1.000E+00  | 1.000E+00  | ---  | STOR-T(2)      |
| STOR | Milk   | 1.000E+00  | 1.000E+00  | ---  | STOR-T(3)      |
| STOR | Meat and poultry                                 | 2.000E+01  | 2.000E+01  | ---  | STOR-T(4)      |
| STOR | Fish   | 7.000E+00  | 7.000E+00  | ---  | STOR-T(5)      |
| STOR | Crustacea and mollusks                           | 7.000E+00  | 7.000E+00  | ---  | STOR-T(6)      |
| STOR | Well water                                       | 1.000E+00  | 1.000E+00  | ---  | STOR-T(7)      |
| STOR | Surface water                                    | 1.000E+00  | 1.000E+00  | ---  | STOR-T(8)      |
| STOR | Livestock fodder                                 | 4.500E+01  | 4.500E+01  | ---  | STOR-T(9)      |
| R021 | Thickness of building foundation (m)             | not used   | 1.500E-01  | ---  | FLOOR1         |
| R021 | Bulk density of building foundation (g/cm**3)    | not used   | 2.400E+00  | ---  | DENSFL         |
| R021 | Total porosity of the cover material             | not used   | 4.000E-01  | ---  | TPCV           |
| R021 | Total porosity of the building foundation        | not used   | 1.000E-01  | ---  | TPFL           |
| R021 | Volumetric water content of the cover material   | not used   | 5.000E-02  | ---  | PH2OCV         |
| R021 | Volumetric water content of the foundation       | not used   | 3.000E-02  | ---  | PH2OFL         |
| R021 | Diffusion coefficient for radon gas (m/sec):     |            |            |  |                |
| R021 | in cover material                                | not used   | 2.000E-06  | ---  | DIFCV          |
| R021 | in foundation material                           | not used   | 3.000E-07  | ---  | DIFFL          |
| R021 | in contaminated zone soil                        | not used   | 2.000E-06  | ---  | DIFCZ          |
| R021 | Radon vertical dimension of mixing (m)           | not used   | 2.000E+00  | ---  | HMIX           |
| R021 | Average building air exchange rate (1/hr)        | not used   | 5.000E-01  | ---  | REXG           |
| R021 | Height of the building (room) (m)                | not used   | 2.500E+00  | ---  | HRM            |
| R021 | Building interior area factor                    | not used   | 0.000E+00  | ---  | FAI            |
| R021 | Building depth below ground surface (m)          | not used   | -1.000E+00 | ---  | DMFL           |
| R021 | Emanating power of Rn-222 gas                    | not used   | 2.500E-01  | ---  | EMANA(1)       |
| R021 | Emanating power of Rn-220 gas                    | not used   | 1.500E-01  | ---  | EMANA(2)       |
| TITL | Number of graphical time points                  | 32         | ---        | ---  | NPTS           |
| TITL | Maximum number of integration points for dose    | 17         | ---        | ---  | LYMAX          |
| TITL | Maximum number of integration points for dose    | 17         | ---        | ---  | LYMAX          |

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 7  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

### Site-Specific Parameter Summary (continued)

| Menu | Parameter                                     | User Input | Default | Used by RESRAD<br>(If different from user input) | Parameter Name |
|------|---|------------|---------|--|----------------|
| TITL | Maximum number of integration points for risk | 257        | ---     | ---  | KYMAX          |

### Summary of Pathway Selections

| Pathway                     | User Selection |
|-----------------------------|----------------|
| 1 -- external gamma         | active         |
| 2 -- inhalation (w/o radon) | active         |
| 3 -- plant ingestion        | active         |
| 4 -- meat ingestion         | active         |
| 5 -- milk ingestion         | active         |
| 6 -- aquatic foods          | active         |
| 7 -- drinking water         | active         |
| 8 -- soil ingestion         | active         |
| 9 -- radon                  | suppressed     |
| Find peak pathway doses     | active         |

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 8  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

|                                 |                                    |
|---------------------------------|------------------------------------|
| Contaminated Zone Dimensions    | Initial Soil Concentrations, mBq/g |
| Area:      100.00 square meters | Th-232      1.540E+01              |
| Thickness:      3.00 meters     |                                    |
| Cover Depth:      1.40 meters   |                                    |

Total Dose TDOSE(t), mrem/yr  
 Basic Radiation Dose Limit = 2.500E+01 mrem/yr  
 Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

|            |           |           |           |           |           |           |           |           |           |           |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| t (years): | 0.000E+00 | 1.000E+00 | 3.000E+00 | 1.000E+01 | 3.000E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 | 2.000E+03 | 4.000E+03 |
| TDOSE(t):  | 2.554E-08 | 1.618E-07 | 7.564E-07 | 5.390E-06 | 5.853E-05 | 1.780E-01 | 3.325E+00 | 3.142E+00 | 2.899E+00 | 0.000E+00 |
| M(t):      | 1.022E-09 | 6.472E-09 | 3.026E-08 | 2.156E-07 | 2.341E-06 | 7.118E-03 | 1.330E-01 | 1.257E-01 | 1.159E-01 | 0.000E+00 |

Maximum TDOSE(t): 3.371E+00 mrem/yr at t = 139.7 ± 0.3 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.397E+02 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|------------------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                              | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232                       | 3.115E+00 | 0.9240 | 3.216E-02  | 0.0095 | 0.000E+00 | 0.0000 | 2.170E-01 | 0.0644 | 6.157E-04 | 0.0002 | 7.204E-04 | 0.0002 | 5.558E-03 | 0.0016 |
| Total                        | 3.115E+00 | 0.9240 | 3.216E-02  | 0.0095 | 0.000E+00 | 0.0000 | 2.170E-01 | 0.0644 | 6.157E-04 | 0.0002 | 7.204E-04 | 0.0002 | 5.558E-03 | 0.0016 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.397E+02 years

Water Dependent Pathways

| Radio-<br>Nuclide<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|------------------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                              | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232                       | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.371E+00     | 1.0000 |
| Total                        | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.371E+00     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 9  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 2.554E-08 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 2.554E-08 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.554E-08     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.554E-08     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 10  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 1.618E-07 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 1.618E-07 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.618E-07     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.618E-07     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 11  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 7.564E-07 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 7.564E-07 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 7.564E-07     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 7.564E-07     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 12  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 5.390E-06 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 5.390E-06 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.390E-06     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.390E-06     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 13  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 5.853E-05 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 5.853E-05 | 1.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.853E-05     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 5.853E-05     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 14  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 5.516E-02 | 0.3100 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 1.222E-01 | 0.6866 | 2.813E-04 | 0.0016 | 3.285E-04 | 0.0018 | 0.000E+00 | 0.0000 |
| Total             | 5.516E-02 | 0.3100 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 1.222E-01 | 0.6866 | 2.813E-04 | 0.0016 | 3.285E-04 | 0.0018 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.780E-01     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 1.780E-01     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 15  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 3.071E+00 | 0.9239 | 3.187E-02  | 0.0096 | 0.000E+00 | 0.0000 | 2.144E-01 | 0.0645 | 6.092E-04 | 0.0002 | 7.124E-04 | 0.0002 | 5.509E-03 | 0.0017 |
| Total             | 3.071E+00 | 0.9239 | 3.187E-02  | 0.0096 | 0.000E+00 | 0.0000 | 2.144E-01 | 0.0645 | 6.092E-04 | 0.0002 | 7.124E-04 | 0.0002 | 5.509E-03 | 0.0017 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.325E+00     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.325E+00     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 16  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 2.903E+00 | 0.9239 | 3.012E-02  | 0.0096 | 0.000E+00 | 0.0000 | 2.027E-01 | 0.0645 | 5.758E-04 | 0.0002 | 6.733E-04 | 0.0002 | 5.206E-03 | 0.0017 |
| Total             | 2.903E+00 | 0.9239 | 3.012E-02  | 0.0096 | 0.000E+00 | 0.0000 | 2.027E-01 | 0.0645 | 5.758E-04 | 0.0002 | 6.733E-04 | 0.0002 | 5.206E-03 | 0.0017 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 1.811E-29 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.142E+00     | 1.0000 |
| Total             | 1.811E-29 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 3.142E+00     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 17  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 2.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 2.678E+00 | 0.9239 | 2.779E-02  | 0.0096 | 0.000E+00 | 0.0000 | 1.870E-01 | 0.0645 | 5.312E-04 | 0.0002 | 6.212E-04 | 0.0002 | 4.803E-03 | 0.0017 |
| Total             | 2.678E+00 | 0.9239 | 2.779E-02  | 0.0096 | 0.000E+00 | 0.0000 | 1.870E-01 | 0.0645 | 5.312E-04 | 0.0002 | 6.212E-04 | 0.0002 | 4.803E-03 | 0.0017 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 2.000E+03 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.899E+00     | 1.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 2.899E+00     | 1.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 18  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 4.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

| Radio-<br>Nuclide | Ground    |        | Inhalation |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | Soil      |        |
|-------------------|-----------|--------|------------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|
|                   | mrem/yr   | fract. | mrem/yr    | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00  | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 |

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)  
 As mrem/yr and Fraction of Total Dose At t = 4.000E+03 years

Water Dependent Pathways

| Radio-<br>Nuclide | Water     |        | Fish      |        | Radon     |        | Plant     |        | Meat      |        | Milk      |        | All Pathways* |        |
|-------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|---------------|--------|
|                   | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr   | fract. | mrem/yr       | fract. |
| Th-232            | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00     | 0.0000 |
| Total             | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00 | 0.0000 | 0.000E+00     | 0.0000 |

\*Sum of all water independent and dependent pathways.

## Attachment 2 Dose Assessment Input Parameters and Analyses

RESRAD, Version 6.3      T« Limit = 180 days      06/19/2007 09:52 Page 19  
 Summary : RESRAD Default Parameters      File: AOC168-alldispersible.RAD

Dose/Source Ratios Summed Over All Pathways  
 Parent and Progeny Principal Radionuclide Contributions Indicated

| Parent<br>(i) | Product<br>(j) | Thread<br>Fraction | DSR(j,t) At Time in Years (mrem/yr)/(mBq/g) |           |           |           |           |           |           |           |           |           |
|---------------|----------------|--------------------|---|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|               |                |                    | 0.000E+00                                   | 1.000E+00 | 3.000E+00 | 1.000E+01 | 3.000E+01 | 1.000E+02 | 3.000E+02 | 1.000E+03 | 2.000E+03 | 4.000E+03 |
| Th-232        | Th-232         | 1.000E+00          | 8.662E-25                                   | 1.183E-24 | 2.208E-24 | 1.960E-23 | 1.004E-20 | 3.571E-04 | 2.541E-03 | 2.402E-03 | 2.216E-03 | 0.000E+00 |
| Th-232        | Ra-228+D       | 1.000E+00          | 1.494E-10                                   | 4.749E-10 | 1.263E-09 | 6.265E-09 | 1.019E-07 | 8.092E-03 | 8.709E-02 | 8.231E-02 | 7.593E-02 | 0.000E+00 |
| Th-232        | Th-228+D       | 1.000E+00          | 1.509E-09                                   | 1.003E-08 | 4.785E-08 | 3.437E-07 | 3.698E-06 | 3.106E-03 | 1.262E-01 | 1.193E-01 | 1.101E-01 | 0.000E+00 |
| Th-232        | -DSR(j)        |                    | 1.658E-09                                   | 1.051E-08 | 4.912E-08 | 3.500E-07 | 3.800E-06 | 1.156E-02 | 2.159E-01 | 2.040E-01 | 1.882E-01 | 0.000E+00 |

The DSR includes contributions from associated (half-life « 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in mBq/g  
 Basic Radiation Dose Limit = 2.500E+01 mrem/yr

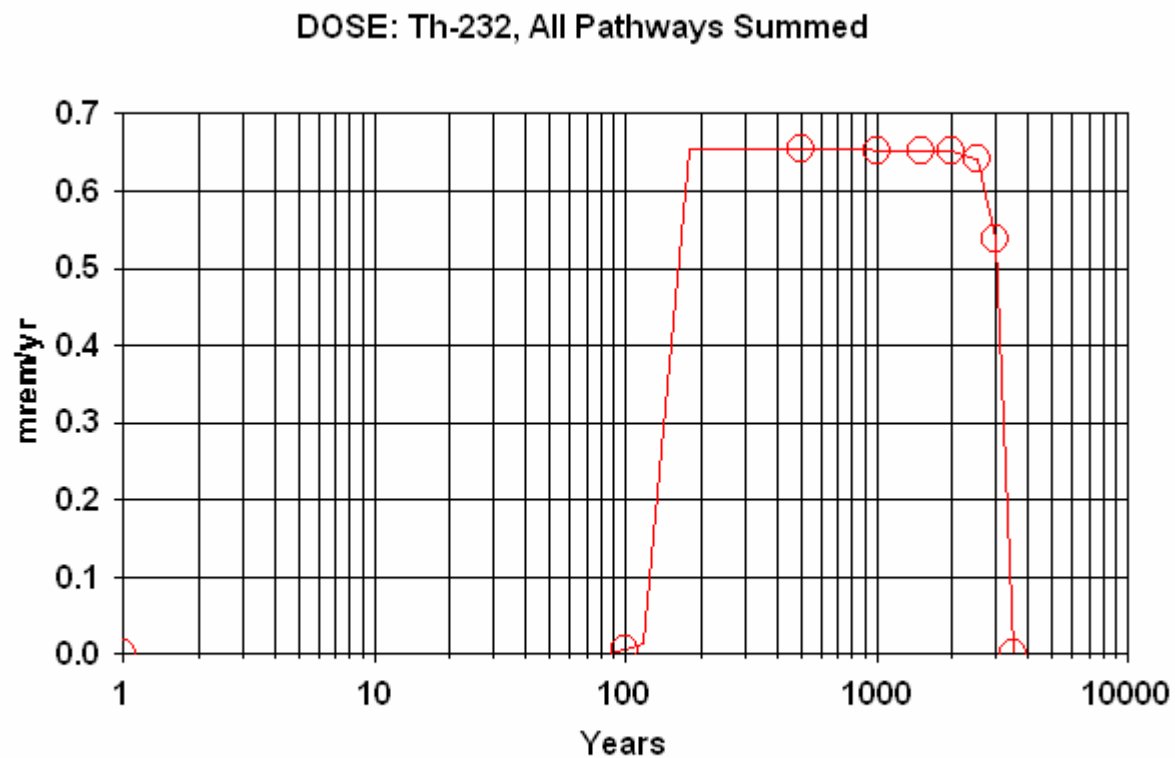
| Nuclide<br>(i) | t=         | 0.000E+00  | 1.000E+00  | 3.000E+00  | 1.000E+01  | 3.000E+01  | 1.000E+02 | 3.000E+02 | 1.000E+03 | 2.000E+03 | 4.000E+03  |
|----------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|------------|
| Th-232         | *4.057E+06 | *4.057E+06 | *4.057E+06 | *4.057E+06 | *4.057E+06 | *4.057E+06 | 2.164E+03 | 1.158E+02 | 1.225E+02 | 1.328E+02 | *4.057E+06 |

\*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(mBq/g)  
 and Single Radionuclide Soil Guidelines G(i,t) in mBq/g  
 at tmin = time of minimum single radionuclide soil guideline  
 and at tmax = time of maximum total dose = 139.7 « 0.3 years

| Nuclide<br>(i) | Initial<br>(mBq/g) | tmin<br>(years) | DSR(i,tmin) | G(i,tmin)<br>(mBq/g) | DSR(i,tmax) | G(i,tmax)<br>(mBq/g) |
|----------------|--------------------|-----------------|-------------|----------------------|-------------|----------------------|
| Th-232         | 1.540E+01          | 139.7 « 0.3     | 2.189E-01   | 1.142E+02            | 2.189E-01   | 1.142E+02            |

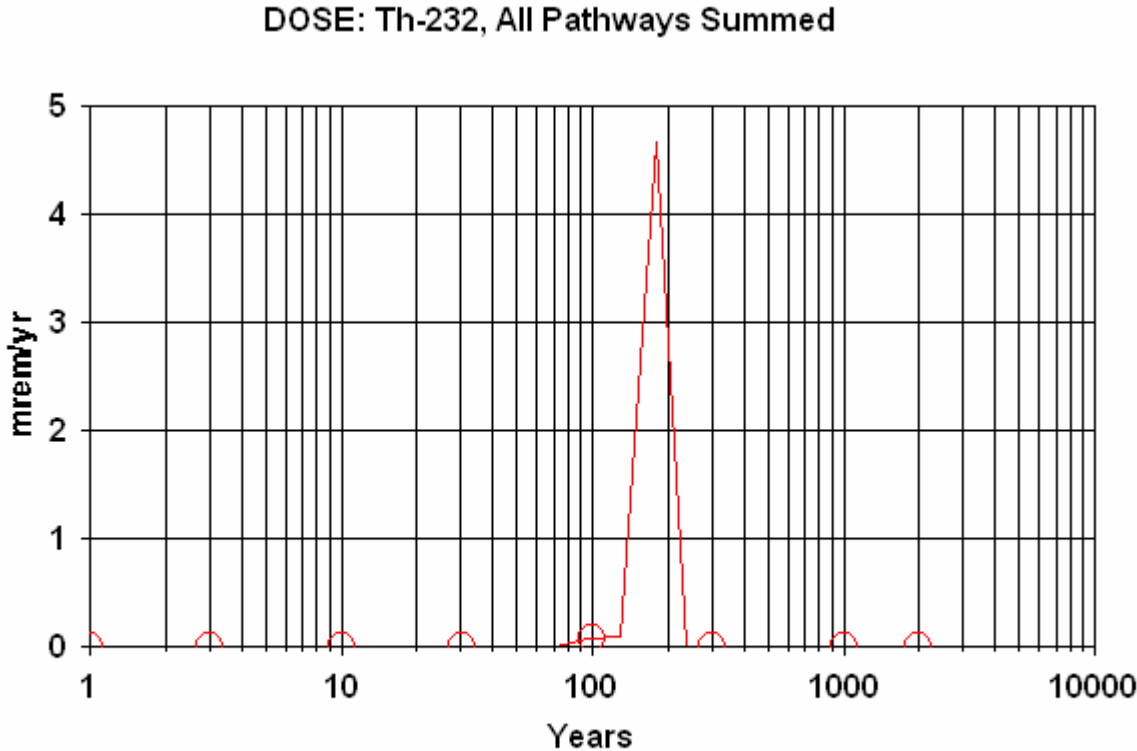
Attachment 2  
Dose Assessment Input Parameters and Analyses



AOC168redo10.RAD 06/19/2007 08:32 GRAPHICS.ASC Includes All Pathways

Figure 1 – 10% Dispersible

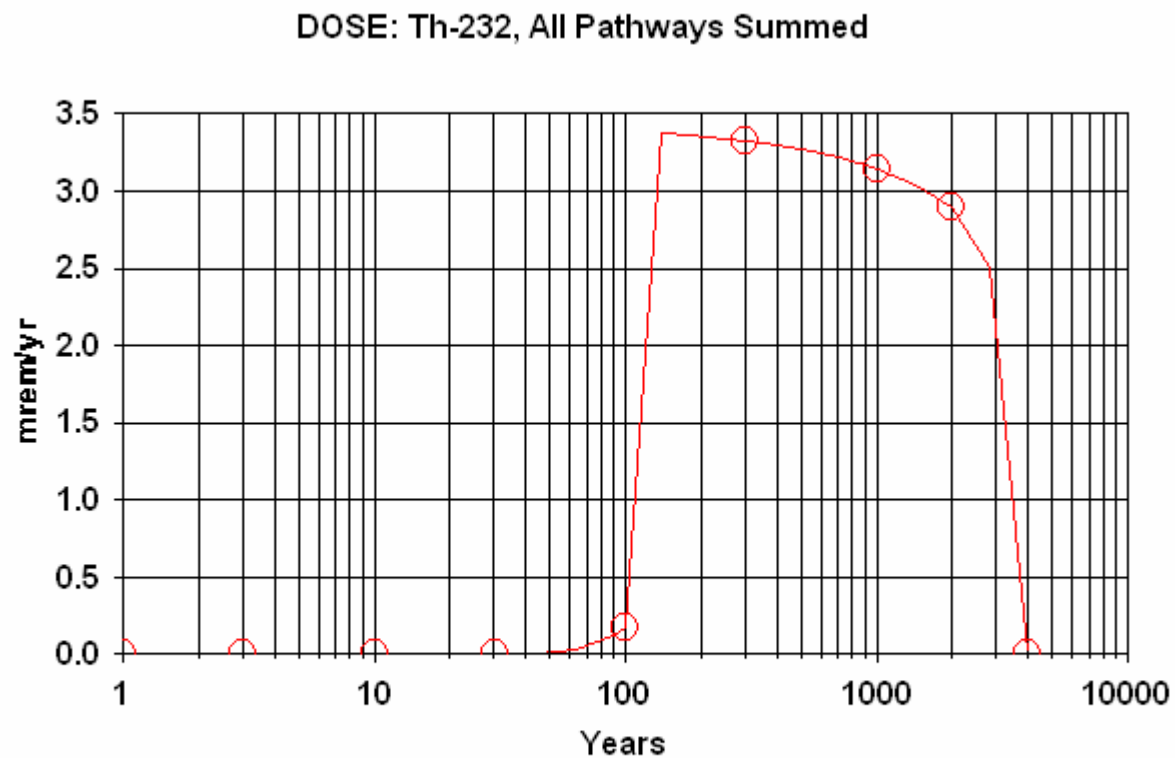
Attachment 2  
Dose Assessment Input Parameters and Analyses



AOC168redo90.RAD 06/19/2007 08:34 GRAPHICS.ASC Includes All Pathways

Figure 2 – 90% Fragment Layer

Attachment 2  
Dose Assessment Input Parameters and Analyses



AOC168-alldispersible.RAD 06/19/2007 09:52 GRAPHICS.ASC Includes All Pathways

Figure 3 – 100% Dispersible

Attachment 3  
Calibration Certificate

**AIR FORCE PRIMARY STANDARDS LABORATORY**

**CERTIFICATE OF CALIBRATION**

**Report Number:** 063030046    **Department:** Photonics/Nucleonics    **Date of Issue:** 20061106

**Calibration Item:**

Manufacturer: NUCLEAR RESEARCH CORP.  
Model/Part No.: ADM-300A  
Equipment Type: RADIAC METER, MULTI-FUNCTION  
Serial Number: ADM-59381  
ID Number: A744377

**Equipment Submitted by:**

YULISTA MGMT SERVICES INC  
340 AIRFIELD RD BLDG 1737  
VANDENBERG AFB, CA 93437-0308

**Item Condition/Special Customer Requirements:**

As Received:

- In Tolerance  
 Out of Tolerance  
 Inoperative

As Returned:

- In Tolerance  
 Out of Tolerance  
 Adjusted/Repaired in Tolerance (See Service Report)

**Room Ambient Conditions:**

Temperature: 70 °F    Relative Humidity: 30 %    Barometric Pressure: N/A

**Remarks:** None

**Traceability:** Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

**General Conditions:**

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations; complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

**Calibrated By:**

Curtis A. Brissette **Metrology Technician**



**Approved By:**

Donald M. Hayes **Metrology Shift Leader**



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Attachment 3  
Calibration Certificate

Report Number: 063030046  
Date of Issue: 20061106  
Model/Part No.: ADM-300A  
Serial Number: ADM-59381

**Procedures and Equipment Used**

**PROCEDURES**

Procedure  
33K7-4-170-1

Date  
30 Sep 2005

**EQUIPMENT**

Nomenclature  
CESIUM-137 STANDARD

Model/Part No.  
81-10

ID No.  
P71209

NIST Report No.  
N/A

Cal Due Date  
20080907

The reported value(s) and uncertainties resulting from the measurement process are:

**Report of Measurement**

**Gamma Calibration**

| Applied   | Actual Reading |
|-----------|----------------|
| 250 R/hr  | 247R/hr        |
| 100 R/hr  | 101R/hr        |
| 25 R/hr   | 24.9R/hr       |
| 250 mR/hr | 252mR/hr       |
| 2 mR/hr   | 1.94mR/hr      |

- The instrument calibration results are accurate to within  $\pm 15\%$  of true dose.



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Attachment 3  
Calibration Certificate

**AIR FORCE PRIMARY STANDARDS LABORATORY**  
**CERTIFICATE OF CALIBRATION**

**Report Number:** 063030048    **Department:** Photonics/Nucleonics    **Date of Issue:** 20061106

**Calibration Item:**

Manufacturer: NUCLEAR RESEARCH CORP.  
Model/Part No.: BP-100  
Equipment Type: BETA PROBE  
Serial Number: BP- 59397  
ID Number: F012217

**Equipment Submitted by:**

YULISTA MGMT SERVICES INC  
340 AIRFIELD RD BLDG 1737  
VANDENBERG AFB, CA 93437-0308

**Item Condition/Special Customer Requirements:**

As Received:

- In Tolerance  
 Out of Tolerance  
 Inoperative

As Returned:

- In Tolerance  
 Out of Tolerance  
 Adjusted/Repaired in Tolerance (See Service Report)

**Room Ambient Conditions:**

Temperature: 70 °F    Relative Humidity: 30 %    Barometric Pressure: N/A

**Remarks:** None

**Traceability:** Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

**General Conditions:**

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations, complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

**Calibrated By:**

Curtis A. Brissette Metrology Technician



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**Approved By:**

Donald M. Hayes Metrology Shift Leader



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Attachment 3  
Calibration Certificate

Report Number: 063030048  
Date of Issue: 20061106  
Model/Part No.: BP-100  
Serial Number: BP- 59397

**Procedures and Equipment Used**

**PROCEDURES**

Procedure  
33K7-4-170-1

Date  
30 Sep 2005

**EQUIPMENT**

Nomenclature  
BETA SOURCE SET

Model/Part No.  
BF-090-A

ID No.  
P71032

NIST Report No.  
N/A

Cal Due Date  
ICO

The reported value(s) and uncertainties resulting from the measurement process are:

**Report of Measurement**

- The Beta probe efficiency is 50.74% of the  $2\pi$  emission rate of a Sr-90 source.
- The instrument calibration results are accurate to within  $\pm 15\%$  of previously certified value.



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