IOWA ARMY AMMUNITION PLANT

**FINAL**

# TECHNICAL MEMORANDUM
# CESIUM SOURCE EVALUATION
**for**
# IOWA ARMY AMMUNITION PLANT
# MIDDLETOWN, IA

**Prepared For:**


**IOWA ARMY AMMUNITION PLANT**
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**February 2009**

**Technical Memorandum**
**Cesium Source Evaluation**
**Iowa Army Ammunition Plant**

## Overview

Calculations were performed using the *Residual Radioactivity (RESRAD) for Windows, Version* 6.22 model (USDOE 2004) developed by the Environmental Assessment Division of Argonne National Laboratory, and guidance provided in the *User's Manual for RESRAD Version 6* (USDOE 2001) to determine the maximum dose (in mrem/yr) that could be anticipated from exposure to the residual cesium-137 ($Cs^{137}$) contamination remaining at the Iowa Army Ammunition Plant (IAAAP) under reasonable future use scenarios. Two contaminant source terms were defined (based on data collected during the 2004 FUSRAP screening survey) and were used to form the basis for the two sets of input parameters for the RESRAD calculations. The RESRAD model was run using site-specific information where available (e.g., annual rainfall, hydraulic conductivity, watershed area, etc.) rather than default parameters within RESRAD. Site specific input parameters are included as an attachment to this summary.

## Methodology

Typically, soil guidelines that are developed to determine the residual concentrations of radioactivity that should remain at a site are based on the "resident farmer" exposure scenario. For this reason the RESRAD calculations were performed utilizing the potential exposure scenario that was considered to be comparable to that of the resident farmer scenario. The pathways of exposure that were included in the calculations were 1) direct external gamma radiation exposure, 2) internal radiation exposure from the inhalation of contaminated dust (without radon), and 3) internal radiation exposure from ingestion of plants, meat, aquatic foods, drinking water, and incidental soil (contained on the surfaces of ingested plants) from the site. The only pathway that was suppressed in the RESRAD calculations was the radon pathway since the source term did not include any radionuclides in the uranium or thorium decay series (i.e., the only radionuclide included in the calculations was $Cs^{137}$).

The first set of calculations were performed (results summarized in Table 1) based on the assumption that the entire impacted area was homogeneous and contaminated with $Cs^{137}$ at the average concentration (16.27 pCi/g), as calculated in the draft final *Summary of the Radiological Survey Findings for the Iowa Army Ammunition Plant Explosive Disposal Area, Inert Disposal Area, Demolition Area/Deactivation Furnace, and Line 1 Former Waste Water Impoundment Area* (USACE 2005). The average concentration was determined as the mean concentration of 14 samples collected in the Inert Disposal Area (IDA). It should be noted that the draft final summary report has not been issued as a final document pending resolution of comments from the U.S. Environmental Protection Agency (USEPA), and therefore has not been made available to the public.

The second set of calculations were performed (results summarized in Table 2) based on the assumption that the entire impacted area was homogeneous and contaminated with $Cs^{137}$ at the maximum detected concentration (226 pCi/g). This maximum concentration was determined from the analysis of a single soil sample collected directly below (approximately 8 inches below ground surface) the area where a metallic $Cs^{137}$ source was removed.

Calculations were performed for both contaminant concentrations (i.e., both 16.27 pCi/g and 226 pCi/g) varying the area of homogeneous contamination from 0.79 square meters ($m^2$) (the immediate area, measuring one meter in diameter, where the source was recovered) to 56.93 $m^2$ (the 6 meter radius emanating from the point where the source was recovered). The maximum area (i.e., 56.93 $m^2$) was determined based on information suggesting that the area of elevated radioactivity (as determined by survey measurements obtained with direct reading radiation detectors) was circular with a radius of 6 meters (m). It should be noted however that the actual area has not been bounded with soil sample data and therefore it is suspected that the area of impacted soils is far less than 56.93 $m^2$. In addition, the amount of cover was varied for both scenarios from a thickness of 0 m (i.e., no cover), to 0.76 m (approximately 2.5 feet of soil placed over the contaminated area).

The results of the two scenarios are summarized in Tables 1 and 2 below.

**Table 1 – RESRAD Summary for $Cs^{137}$ Concentration of 16.27 pCi/g**

| Contaminated Area ($m^2$) | Thickness of Contaminated Lens (m) | Cover Depth (m) | Average Cs-137 Conc. (pCi/g) | Maximum Total Dose[(1)] t=0 years (mrem/yr) | Total Dose at t=1000 years (mrem/yr) |
|---|---|---|---|---|---|
| 0.79 | 0.30 | 0.00 | 16.27 | 3.043 | 0.000E+00 |
| 0.79 | 0.30 | 0.30 | 16.27 | 0.116 | 0.000E+00 |
| 0.79 | 0.30 | 0.60 | 16.27 | 0.003 | 0.000E+00 |
| 0.79 | 0.30 | 0.76 | 16.27 | 0.001 | 5.293E-11 |
| 56.93 | 0.30 | 0.00 | 16.27 | 23.720 | 0.000E+00 |
| 56.93 | 0.30 | 0.30 | 16.27 | 0.481 | 0.000E+00 |
| 56.93 | 0.30 | 0.60 | 16.27 | 0.064 | 0.000E+00 |
| 56.93 | 0.30 | 0.76 | 16.27 | 0.028 | 5.139E-10 |

[(1)] "Total Dose" is the sum of the external radiation dose [i.e., the effective dose equivalent ("EDE")] and the internal radiation dose [i.e., the committed effective dose equivalent (CEDE)]. This summation is referred to as the total effective dose equivalent (TEDE).

**Table 2 – RESRAD Summary for $Cs^{137}$ Concentration of 226 pCi/g**

| Contaminated Area ($m^2$) | Thickness of Contaminated Lens (m) | Cover Depth (m) | Maximum Cs-137 Conc. (pCi/g) | Maximum Total Dose[(1)] t=0 years (mrem/yr) | Total Dose at t=1000 years (mrem/yr) |
|---|---|---|---|---|---|
| 0.79 | 0.30 | 0.00 | 226.00 | **42.270** | 0.000E+00 |
| 0.79 | 0.30 | 0.30 | 226.00 | 1.620 | 0.000E+00 |
| 0.79 | 0.30 | 0.60 | 226.00 | 0.030 | 0.000E+00 |
| 0.79 | 0.30 | 0.76 | 226.00 | 0.008 | 7.352E-10 |
| 56.93 | 0.30 | 0.00 | 226.00 | **329.500** | 0.000E+00 |
| 56.93 | 0.30 | 0.30 | 226.00 | 6.690 | 0.000E+00 |
| 56.93 | 0.30 | 0.60 | 226.00 | 0.890 | 0.000E+00 |
| 56.93 | 0.30 | 0.76 | 226.00 | 0.387 | 7.138E-09 |

[(1)] "Total Dose" is the sum of the external radiation dose [i.e., the effective dose equivalent ("EDE")] and the internal radiation dose [i.e., the committed effective dose equivalent (CEDE)]. This summation is referred to as the total effective dose equivalent (TEDE).

The maximum exposure, for each of the scenarios, is for the first year of exposure (i.e., t = 0 years). RESRAD also calculated the exposure per year after 1000 years (i.e., t = 1000 years). Because this is a relatively short lived isotope, the activity level and exposure in 1000 years would be expected to be indistinguishable from background (i.e., approximately 0 mrem/yr).

## Conclusions

The final remedy in the area containing the residually contaminated soil will ultimately be the installation of an engineered cap. The current plan for the cap is, from bottom to top, 0.5 feet of soil (for leveling and contouring the site), followed by a Geosynthetic Clay Liner (3/16 inches thick), a 40 mil HDPE (or PVC) Geomembrane, a geocomposite drainage net (1/4 inch thick), and 2 feet of soil. The final soil cover will be medium-dense silty clay with 10% to 15% moisture by weight. For this reason, the RESRAD calculations performed with a cover thickness of 0.76 m (approximately 2.5 ft) are considered most reasonable and representative of actual site conditions after the remedial action. With this scenario, the total dose anticipated is less than the U.S. Department of Energy (DOE), the U.S. Nuclear Regulatory Commission (NRC), and the State of Iowa exposure limits (Iowa Administrative Code 2005) of 0.25 millisieverts (i.e., 25 millirem TEDE) per any one year as the general limit or constraint for soil cleanup or site decontamination. Conversely, it should be noted that for each of the scenarios, the only exceedences of the DOE, NRC, and State of Iowa exposure limit of 0.25 millisieverts (i.e., 25 millirem) per year, are where no cover material was included in the calculation (results shown in bold in both Table 1 and Table 2). Scenarios that include any cover material are also well below the USEPA's recommended dose limit of 15 mrem/yr EDE (USEPA 1997).

Using current concentration data, the two scenarios effectively bound the exposure range by utilizing a minimum and maximum area of residual contamination. Based on these calculations, it appears reasonable that the remaining soils that are residually contaminated with $Cs^{137}$ should remain in place.

**References**

Iowa Administrative Code 641-40(136C), *Standards for Protection Against Radiation, Rule 641-40.29(136C), Radiological criteria for unrestricted use,* March 30.

U.S. Army Corps of Engineers, 2005, *Summary of the Radiological Survey Findings for the Iowa Army Ammunition Plant Explosive Disposal Area, Inert Disposal Area, Demolition Area/Deactivation Furnace, and Line 1 Former Waste Water Impoundment Area*, DRAFT FINAL, May 24.

U.S. Department of Energy, 2004, *RESRAD for Windows, Version 6.22*, February.

U.S. Department of Energy, 2001, *User's Manual for RESRAD Version 6,* July.

U.S. Environmental Protection Agency, 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination,* OSWERE Memorandum No. August 22.

**ATTACHMENT 1**

**Site Specific Parameters Used in all RESRAD Computations**

| Parameter | Site Specific Value | Default Value |
|---|---|---|
| Area of contaminated zone ($m^2$) | 7.900E-01 / 5.693E+01 | 1.000E+04 |
| Thickness of contaminated zone (m) | 3.048E-01 | 2.000E+00 |
| Length parallel to aquifer flow (m) | 6.000E+00 | 1.000E+02 |
| Initial principle radionuclide (pCi/g) | 1.627E+01 (Cs137)_ | 0.000E+00 |
| Precipitation (m/yr)9.556E-01 | 9.556E-01 | 1.000E+00 |
| Irrigation (m/yr)0.000E+00 | 0.000E+00 | 2.000E-01 |
| Watershed Area ($m^2$) | 2.881E+06 | 1.000E+06 |
| Saturated zone effective porosity | 4.000E-01 | 2.000E-01 |
| Saturated zone hydraulic conductivity (m/yr) | 1.780E+01 | 1.000E+02 |
| Saturated zone hydraulic gradient | 3.000E-02 | 2.000E-02 |
| Unsaturated zone thickness (m) | 2.743E+00 | 4.000E+00 |