

N00164.AR.001690
NSA CRANE
5090.3a

U S NAVY RESPONSE TO ADDITIONAL COMMENTS FROM U S EPA REGION V
REGARDING DRAFT RCRA FACILITY INVESTIGATION REPORT SOLID WASTE
MANAGEMENT UNIT 1 (SWMU1) MUSTARD GAS BURIAL GROUND REVISION 0 NSA
CRANE IN
12/1/2002
U S NAVY

18

RESPONSES TO ADDITIONAL U.S. EPA COMMENTS DATED 24 JULY, 2003 ON THE DRAFT RFI
REPORT FOR SWMU 01 – MUSTARD GAS BURIAL GROUND, REVISION 0, DATED DECEMBER
2002

NAVAL SURFACE WARFAR CENTER
CRANE, INDIANA
U.S. EPA ID NO. IN5170023498

GENERAL RFI COMMENTS

GENERAL COMMENT

Comment GC-1-A:

The response does not appear to adequately address the original comment. While it appears that the extent of the volatile organic constituent (VOC) contamination has been determined, the nature of this contamination has not. Clearly there are hydrogeological factors at play which are causing massive fluctuations in contaminant levels in the most contaminated portion of the VOC plume. It would seem that proceeding to a Corrective Measures Study (CMS) without a full understanding of the causes and implications of these fluctuations could potentially result in a flawed corrective action. Does the Navy feel it has enough information on the bedrock groundwater contamination to properly evaluate remedial options in a CMS? The RFI suspects that a DNAPL source could be present in fractured bedrock. How would this lack of information affect an evaluation of the effectiveness of remedies in a CMS at this SWMU?

Revise Section 9.2 of the RFI Report to indicate "A round of samples within the next two years to evaluate the large concentration fluctuations that were observed between select wells between 2001 and 2002 are warranted."

U.S. EPA acknowledges NSWC Crane's indication that the statement was incorrect that "All wells are screened in the Upper Pennsylvanian aquifer between 600 feet above mean sea level and 655 feet amsl." However, that was not the intent of the comment. The comment referred only to the list of wells with the highest VOC contamination, including monitoring wells 01-02, 01-05, 01-11, 01-12, 01-15, 01-19, 01-22, and 01-25, which are all screened within that interval. The intention of this comment was to pose the question of whether the fact that the highest levels of contamination are found within a relatively narrow portion of the aquifer should be more fully investigated prior to the initiation of CMS activities.

Response to General Comment GC-1-A:

The elevation of the ground water VOC contamination source is known to sufficient vertical resolution to proceed to a Corrective Measures Study (CMS). Per the teleconference agreement of 14 August 2003 between EPA and the Navy, the Navy plans to collect additional samples during the CMS to supplement current MGBG data. This sampling is planned to include the installation of at least one shallow well and ground water sampling for VOCs and natural attenuation parameters in ground water across the MGBG. In addition, test pitting near the VOC source area accompanied by soil VOC monitoring is planned as a final attempt at locating a source of soil VOCs. With these added data, the Navy believes that all information necessary for implementing a CMS will be available.

The ground water sampling is planned to occur at the outset of the CMS to provide the data requested in the U.S. EPA comment. The actual timing of the CMS will depend on funding. To address this timing concern, the fourth sentence of Section 9.2 has been revised to the following:

"A round of samples collected at the beginning of the CMS for VOC and natural attenuation parameter analyses is recommended."

SPECIFIC RFI COMMENTS

RFI July 24, 2003 Comment 1-A:

The first full paragraph on page 5-20 states that "the parent compound (2,4,6 - trinitrotoluene) for this chemical was not detected in soil or groundwater samples." This seems to contradict what is noted in the first bullet under Energetics on page 5-19 (i.e. four energetic compounds were detected in ground water including 2,4,6 - trinitrotoluene in sample 01GW1701 at 0.127 µg/L). Please revise text as needed to correct this apparent discrepancy and provide explanation on the effect of this detection on RFI conclusions for energetics.

Response to RFI July 24, 2003 Comment 1-A:

The second to last sentence of paragraph 1 on page 5-20 (under Energetics) has been revised to read as follows:

"Finally, the parent compound (2,4,6-trinitrotoluene) for this chemical was not detected in soil, it was detected in just one ground water sample (01GW1701) at 0.127 µg/L, which is close to the nominal 0.09 µg/L detection limit, and it was not detected in the duplicate of that sample (01GW1701-D)."

DATA QUALITY COMMENTS

Comment DQ-GC-2-A:

The response appears to adequately address the original comment. However, Table 3-7 indicates that gross beta has a maximum observed non-detect value of 5.16 and a risk-based target limit (RBTL) of 4 mrem. The RBTL cell is not shaded. Revise the table to clarify this apparent discrepancy or provide additional information regarding the values listed for gross beta.

Response to Comment DQ-GC-2-A:

The 4 millirem (mrem) numerical limit provided in Table 3-7 is in units of radiation dose. This limit was obtained from the current Safe Drinking Water Act (SDWA) maximum contaminant level for beta particle and photon activity and is applicable to public drinking water supplies. The 4 mrem value was presented because there are no EPA Region 9 Preliminary Remediation Goals for gross beta activity. Certain public drinking water supplies are required to speciate for radionuclides (and to calculate the associated dose) when monitoring for gross beta activity (i.e., screening) indicates that the gross beta activity exceeds 50 pCi/L. The maximum value observed for gross beta activity at the MGBG was 50.2 J pCi/L. This value was qualified as an estimated value during data validation and was greater than two times the next greatest detection. Only four out of 39 ground water gross beta detections exceeded 15 pCi/L (12 results were non-detects), which caused the 50.2 pCi/L value to appear to be anomalous. Therefore, the same location was resampled in the Round 2 field event. The Round 2 value for gross beta was 12.3 pCi/L (no qualifications). Therefore, because the gross beta data fell well below the 50 pCi/L limit, dose was not calculated and the gross beta results were concluded not to represent detections greater than the applicable screening levels. The following footnote will be inserted at the bottom of Table 3-7:

"The value presented is for dose, which was provided in lieu of available EPA Region 9 PRGs. The corresponding applicable concentration limit is 50 pCi/L. The 50 pCi/L limit is applicable to drinking water supplies and, therefore, is a conservative limit."

HUMAN HEALTH RISK ASSESSMENT COMMENTS

GENERAL COMMENTS

Comment HHRA-GC-1-A:

The response appears to adequately address the original comment. As requested, the RFI Report has been revised to include text discussing why analysis for thiodiglycol was not performed. However, delete the phrase "occurs naturally in the environment" as this statement is misleading. Thiodiglycol is a synthetic compound, but occurs as a degradation product of mustard gas.

Response to Comment HHRA-GC-1-A:

The sentence stating that thiodiglycol is a naturally occurring chemical will be deleted.

SPECIFIC COMMENTS

Comment HHRA-SC-1-A:

The response appears to partially address the original comment. The original comment requested that summary tables be provided for all mediums, however the revised tables E-1 and E-2 only address surface and subsurface soils. According to the responses to comments, thallium in groundwater was also eliminated based on a comparison to background. Therefore, a summary table for groundwater should also be provided.

Response to Comment HHRA-SC-1-A:

With the revised Tables E-1 and E-2, all background samples in the various media are represented in the Appendix E tables. There are no background (upgradient) ground water samples for the Mustard Gas Burial Ground. Consequently, a background ground water summary table can not be added to Appendix E. No additional changes were made to address this comment.

Comment HHRA-SC-18-A:

Consider omitting the following sentence from the revised text: "No changes have been made in response to this comment." It is unclear how and why this statement was made; it seems inappropriately stated. Otherwise, the response appears to adequately address the original comment.

Response to Comment HHRA-SC-18-A:

Instead of reissuing revised responses to the original set of EPA comments, the Navy acknowledges here that the statement "No changes have been made in response to this comment" for original EPA Comment HHRA-SC-18" is out of place. To remedy this confusion, the following sentence has been added to the end of the first paragraph in Section 7.3.4.6 under "Exposure of Workers to Volatiles in a Construction/Utility Trench":

"A copy of the Foster and Chrostowski model is provided in Appendix G-5."

HHRA July 24, 2003 Comment 1:

Page 7-44, Exposure to Soil, states that cumulative HI's for all future receptors exposed to surface and/or subsurface soil under the RME and CTE scenarios were less than 1.0. However, Table 7-9 indicates a HI of 1.1 for the Incidental Ingestion of Surface Soil for the Future Child Resident. Please revise text as needed to correct this apparent discrepancy and provide explanation on the affect of this detection on HHRA and RFI conclusions.

Response to HHRA July 24, 2003 Comment 1:

The text on page 7-44 actually states that "Cumulative HIs for all current and future receptors exposed to surface and/or subsurface soil under the RME and CTE scenarios were less than unity (1.0) on a target organ basis...". However, Table 7-9 is a summary table presenting the total HI for the receptors. HIs calculated on a target organ/effect basis are presented in Appendix G. The following footnote has been

added to Table 7-9 to clarify that total HIs are summarized in Table 7-9 whereas HIs determined on a target organ basis are presented in Appendix G:

"Total HIs are summarized in this table; HIs determined on a target organ basis are presented in Appendix G."

ECOLOGICAL RISK ASSESSMENT COMMENTS

Comment ERA-SC-4-A:

The response does not appear to adequately address the original comment. While it is stated that only VOCs will be examined, as per the U.S. EPA approved QAPP, additional clarification is needed regarding why other detected analytes were not examined. Additional analytes were detected in groundwater (i.e., eight semi-volatile organic compounds [SVOCs], four energetic compounds, one pesticide, and twenty-four inorganic compounds), however surface water was only analyzed for VOCs. Revise the RFI Report to include further discussion regarding the lack of investigation of SVOCs, energetic compounds, pesticides and inorganics in surface water at the Mustard Gas Burial Grounds (MGBG) and any data gap this may present.

Response to Comment ERA-SC-4-A:

The surface water exposure pathway for ecological receptors at the MGBG is incomplete most of the year. As noted in the existing response to Comment EPA-SC-4, surface water only exists at the MGBG *in times of heavy rain events*. The ditches in the immediate vicinity of the MGBG are best described as storm water drainage channels. These channels drain to intermittent streams north and south of the site. Because of the generally dry conditions in these ditches and streams, aquatic receptors and terrestrial receptors would have very limited contact with surface water at the MGBG. Thus, the Navy has relied primarily on an evaluation of receptor exposure to *site soils and sediments (always present at the site)* to determine the potential for adverse ecological effects. The Navy analyzed surface water samples collected during Round 2 (a particularly wet period for the site) for volatile organic chemicals (VOCs) to investigate the potential for chemical migration from ground water to surface water. (VOCs are the primary COPCs in the ground water at the MGBG. None were detected.)

Attachment 1 to these responses to additional EPA comments will be added as Table 8-6 in Section 8.0 to compare the chemical concentrations in the ground water samples to water quality screening values. The following paragraph will be inserted immediately before the last paragraph of Section 8.7.2 of the ERA to discuss the comparison:

"As indicated in Section 8.5.2, the surface water samples were only analyzed for VOCs because those were the primary contaminants detected in the ground water samples. However, because other chemicals were detected in the ground water, it is possible that they may have been present in the surface water samples. Table 8-6 presents a comparison of the chemical concentrations detected in the ground water samples (except for the VOCs) to selected water quality screening values. VOCs are not included on Table 8-6 because the surface water samples were analyzed for VOCs. Two EEQs are calculated on the table; one for a comparison to the screening values directly and one for a comparison to the screening values after the screening values were multiplied by a dilution factor of 100. The dilution factor of 100 is conservative because the drainage channels receive very little ground water discharge and typically only flow after there is a significant rainfall event. As indicated by the black shading on the table, several chemicals exceed the screening values before the dilution factor was applied, but none of the chemicals exceeded the screening values after the dilution factor was applied. Because the dilution factor of 100 is considered to be conservative, risks to aquatic receptors from chemicals in the surface water (other than VOCs) are negligible. Therefore, the fact that the surface water samples were only analyzed for VOCs does not affect the results of the ERA."

Comment ERA-SC-6-A:

The response does not appear to adequately address the original comment. Section 8.2.4.1 indicates that upper level receptors will not be investigated due to the fact that solid waste management unit (SWMU) 1 is very small and represents only a small portion of the receptor's potential home range. However, on the October 9, 2002 conference call, it was agreed that food-chain modeling for upper trophic receptors (i.e., red-tailed hawk and fox) would be conducted in the screening level ecological risk assessment (SERA) for persistent, bioaccumulative, and toxic (PBT) chemicals. This approach is especially important in that a number of threatened and endangered (T&E) species were identified as potentially occurring within the site area. Therefore, this information should be provided, as agreed. Revise the RFI Report to include food-chain modeling for upper trophic level receptors for SWMU 1.

In addition, it should be noted that although it is agreed that it is problematic to investigate risk to reptiles receptors at the site, the potential for chemical exposures to these receptors should be discussed in the Uncertainties Section. Revise the RFI Report to include this information.

Finally, while it is understood that the potential risk to certain receptors is considered "low" at the site, further qualification of "low" risk is required. This is especially important for the American robin, since it is used as a surrogate receptor for potential bird T&E species at the site, and T&E endpoints should be examined as individual assessment endpoints, and not as population endpoints. Information should be provided to quantify potential risk at the site in the same manner as the information provided in the revised SMDP section. For example, the frequency of ecological effect quotients (EEQs) should be presented, along with a discussion of spatial distribution of EEQs. Revise the RFI Report to discuss the quantification of effects determinations.

Response to first paragraph of Comment ERA-SC-6-A:

Although the Navy agreed to conduct food-chain modeling for upper trophic receptors (i.e., hawk and fox) in the 9 October 2002 teleconference, it was subsequently agreed in a November 15, 2002 phone call between TiNUS (Aaron Bernhardt) and TechLaw (Robyn Blackburn) that the Navy could provide a qualitative discussion of the potential risks to the carnivores in the ERA. EPA may then choose to conduct food-chain modeling if they determine that there is a need based on the presence of bioaccumulative chemicals. Also, in a phone call between TiNUS (Aaron Bernhardt) and TechLaw (Matt Lary) on 20 August, 2003, TechLaw indicated that if there are no PBTs, or the PBT concentrations are less than the EDQL, then food-chain modeling to upper trophic level receptors is not necessary. Also, if the PBTs are detected infrequently or at low concentrations, then food-chain modeling to upper trophic level receptors may not be necessary. Based on previous discussions between the Navy (TiNUS) and U.S. EPA (TechLaw), the following paragraph has been modified from the initial response to comments and added to the end of Section 8.7.1 to discuss the uncertainties associated with not conducting food-chain modeling for the upper trophic level receptors (i.e., large carnivorous mammals):

"Food-chain modeling was not conducted for large carnivorous mammals and birds for several reasons including the uncertainty of estimating contaminant uptake into the diet source (small mammal tissue) and the large home range for carnivorous wildlife. Six chemicals were detected in the surface soil at concentrations that exceeded EDQLs; Isosafrole, 2,4-D, and four metals. Herbicide detections such as 2,4-D are typical of spot applications rather than burial activities associated with SWMU 01. 2,4-D does not have a high potential for accumulating in animal tissue based on its log K_{ow} of 0.45 (converted from K_{ow} of 2.81 in Table 6-1) which is below the log K_{ow} threshold (>3.5) that is commonly used to identify bioaccumulative chemicals (U.S. EPA, 2000a). Also, the low detection frequency and relatively low concentration does not warrant concern for carnivorous mammals and birds. Isosafrole has a low Log K_{ow} value of 2.66 (converted from K_{ow} of 457 in Table 6-1) which is also below the log K_{ow} threshold (>3.5). Therefore, neither of these two chemicals are bioaccumulative and do not need to be carried through the food-chain model for large carnivorous wildlife. Three of the inorganic chemicals that were detected in the surface soil at concentrations that exceeded EDQLs (copper, selenium, and zinc) are considered important bioaccumulative chemicals (U.S.

EPA, 2000a). However, metals typically do not biomagnify in terrestrial systems (Newman, 1998), thereby limiting the exposure to carnivorous wildlife. Also, carnivorous birds and mammals are expected to obtain only a small portion of their food from SWMU 01 [boundaries of SWMU 01 are approximately 2 acres and home ranges of the red fox and red-tailed hawk are 193 acres and 370 acres, respectively (U.S. EPA, 1993)]. The food-chain EEQs assumed that the small herbivorous or insectivorous mammals and birds at SWMU 01 obtain all of their food from the site. Therefore, risks to carnivorous birds and mammals are expected to be much lower than the risks to small herbivorous or insectivorous mammals and birds. ”

For the reasons discussed above, food-chain modeling to upper trophic level receptors will not be conducted as part of the ERA.

Response to second paragraph of comment ERA-SC-6-A

The second paragraph of Section 8.7.1 already states that “risks to reptiles and amphibians were not evaluated because exposure factors are not established for most species and toxicity data are limited”. The following text has been added as the third sentence to the paragraph: “*Small reptiles and amphibians may be prevalent at the MGBG and among the ecological receptors most exposed to surface soil, sediment, and surface waters (intermittently) at this site because of their limited home range*”. Also, the words “In addition” at the beginning of the new fourth sentence have been changed to: “*However*”.

Response to third paragraph of comment ERA-SC-6-A

Based on the 14 August 2003 teleconference, no further response is necessary. Adequate information is already presented in the RFI report. The spatial distribution of the COPCs (and, thus, the EEQs) is displayed in figures included within Section 5 of the RFI, the Nature and Extent of Contamination. A discussion of the vertical and horizontal extent of contamination is also presented in Section 5.

Comment ERA-SC-8-A

The response appears to partially address the original comment. It is recommended that a brief discussion be presented in the SERA discussing why calcium, magnesium, potassium, and sodium were not carried through as COPCs. As outlined in the U.S. EPA Bulletin entitled The Role of Screening Level Risk Assessment and Refining Contaminants of Concern in Baseline Ecological Risk Assessments dated January 24, 2001, a number of chemicals that may be site-related function as nutrients in organisms such as calcium, iron, magnesium, sodium and potassium. The guidance goes on to state that prior to eliminating these chemicals from further assessment, additional information regarding the following must be presented: 1) The suite of chemicals relevant to the range of ecological receptors considered at the site; 2) the potential for toxic effects resulting from site concentrations relative to the toxicological benchmarks for nutrients; 3) whether contaminant interactions may result in a nutrient deficiency for organisms of concern; 4) whether the nutrient deficiency level and toxicity benchmarks are similar in magnitude; and, 5) an evaluation of the potential for the nutrient to bioaccumulate, bioconcentrate, and/or biomagnify. Revise the RFI Report to address these issues.

Response to Comment ERA-SC-8-A

Per the 14 August 2003 teleconference among EPA and Navy, no response is necessary. Adequate information is already present in the RFI report. No changes have been made in response to this comment.

Comment ERA-SC-15

The response appears to partially address the original comment. It is recommended that a brief discussion be presented in the SERA discussing why calcium, magnesium, potassium, and sodium were not carried through as COPCs. See Comment ERA-SC-8.

Response to Comment ERA-SC-15-A

Per the August 14, 2003 teleconference among EPA and Navy, no response is necessary. Adequate information is already present in the RFI report. No changes have been made in response to this comment.

Additional USEPA Comment 2-A

Changing the unit designation from mg/kg to pCi/g for Table 3-13 brings the numerical values down closer to expected background levels. However, the major Thorium Decay Series decay product concentrations are about twice what would be expected for common background. For the Uranium Decay Series the decay product concentrations are at about background levels except for Ra-226 which is three to four times common background. No explanation is given for this Ra-226 deviation but it could be an analytical issue associated with the 186 keV energy line in the gamma scan. It could also be elevated Ra-226 in the soil, which is important.

Ra-226 and Th-230 are considerably out of equilibrium (max Ra-226 = 3.68 pCi/g, max Th-230 = 0.289 pCi/g). For background soils, we would expect them to be numerically equal.

The unit of measurement error (mg/kg instead of pCi/g) on Table 3-13 has been corrected. Per the teleconference agreement of 14 August, 2003, additional text has been added to the RFI report to address the apparent inconsistencies between radium-226 and other thorium-230 data. The text has been added to the end of Section 3.4.2.1 of the RFI report. This added text constitutes a revision to the text originally proposed in responses to EPA comments dated May 6, 2003 as presented in attachment 7 of the corresponding Responses to USEPA Comments. Therefore, the entire revised section of proposed additional text for the end of Section 3.4.2.1 is included as Attachment 2 of these responses to comments.

Response to Additional USEPA Comment 2-A

Per the teleconference among EPA and the Navy representatives on 14 August 2003, additional text to address this concern has been added to the RFI report. The text has been added to the end of Section 3.4.2.1 of the RFI report. This added text, being combined with the Attachment 7 of the original responses to U.S. EPA Comments, constitutes a revision to that attachment. Therefore, the revised attachment is provided as Attachment 2 to these responses to comments.

Additional USEPA Comment 3-A

Same Comment as for 2 just above.

Response to Additional USEPA Comment 3-A

Please refer to the response to Additional U.S. EPA Comment 2-A.

Additional USEPA Comment 4-A

The yields for Eu-155 are not especially low as asserted in the response [86.54 keV (30.9%); 105.3 keV (20.6%); 43.0 keV (11.9%)]. Much lower yields are handled quite well by most gamma spectroscopy. This is not a strong reason for Eu-155 being anomalously identified.

It is agreed that peaks at energies similar to Eu-155 energies may be incorrectly identified as Eu-155. This could be due to the energy width for detection not being set narrow enough on the gamma spectrometry equipment, thus it could be an analytical issue.

The new text is speculative. It should be determined conclusively if Eu-155 is present. If it is actually there then that is extremely significant and may indicate fission products in the soil. If it is not, it should not be reported in the data set.

The fact that Eu-155 was reported in the background data (Table 3-13) is a further indication that Eu-155 has been incorrectly identified. Eu-155 is not a constituent of background soils.

Response to Additional USEPA Comment 4-A

In accordance with the agreement reached in the 14 August 2003 teleconference among EPA and Navy representatives to provide additional interpretation of europium-155 data, the following new subsection has been added to Section 3.0 of the RFI report:

“3.4.13 Additional Europium-155 Evaluation

Europium-155 normally appears as two energy peaks in the gamma spectrometry analysis. To be conservative, europium-155 was reported as detected even when only one of the peaks was present. This resulted in the “detection” of europium-155 in two samples, even though the relatively short half-life of this radionuclide suggests that it should not be detected except if fission products had been disposed at the site. The detected values were less than many europium-155 non-detect values for similar samples and were equal to detection limits for the samples. Furthermore, no fission products were known or suspected to have been discarded at the MGBG and the two europium detections (0.08 pCi/g each) were far less than the conservative soil screening level for this project (3.8 pCi/g). Therefore, europium-155 detections are considered to be false detections and were also within measured background values, so they were not investigated further.”

ATTACHMENT 1
REVISED TABLE 8-6

Attachment 2

This text will be inserted immediately after the last paragraph of Section 3.4.2.1 of the draft RFI report:

"In addition to the non-statistical background comparisons, the relationship of thorium-230 to other radionuclides measured at the MGBG was exploited. This was done by comparing the thorium-230 results obtained from alpha spectroscopy to the results obtained using gamma spectrometry for other radionuclides that are in the same natural decay chain (i.e., thorium-234, uranium-234, protactinium-234, radium-226, lead-214, lead-210, and bismuth-214). If radionuclides in a given decay chain represent background radiation levels and are in secular equilibrium, the activities of the individual radionuclides should be similar.

Thorium-230 (Th-230) is a radioactive decay daughter of Uranium-234 (U-234). When secular equilibrium is established between U-234 and Th-230, the activity concentrations of each of these radionuclides per unit mass of sample is identical. For actual radioactivity measurements the activities will not necessarily be identical because of sampling and measurement uncertainties. Nevertheless, if the specific activity of either radionuclide is known, the mass concentration may be calculated by recognizing that the radioactivity concentration divided by the specific activity yields the mass concentration:

$$\frac{\text{g radionuclide}}{\text{g soil sample}} = \frac{\frac{\text{pCi}}{\text{g soil sample}}}{\frac{\text{pCi}}{\text{g radionuclide}}} \quad (1)$$

The reverse calculation may also be performed to obtain a radioactivity concentration from a mass concentration. From the above relationship, the expected radioactivity of Th-230 in soil (assuming the condition of secular equilibrium) can be computed from the typical mass concentration of naturally occurring uranium in soil (i.e., approximately 3 mg/kg, of which 0.0055 percent is U-234 by mass).

$$\frac{3 \text{ mg U - Nat}}{\text{kg soil}} * \frac{0.000055 \text{ mg U - 234}}{\text{mg U - Nat}} = \frac{0.000165 \text{ mg U - 234}}{\text{kg soil}} \quad (2)$$

Multiplying the mass concentration of U-234 by its specific activity yields the activity concentration of U-234:

$$\frac{0.000165 \text{ mg U - 234}}{\text{kg soil}} * \frac{6.25 \text{ E6 pCi}}{\text{mg U - 234}} * \frac{\text{kg}}{1000 \text{ mg}} = \frac{1.03 \text{ pCi}}{\text{g soil}} \quad (3)$$

The U-234 and Th-230 are assumed to be in secular equilibrium, so:

$$\text{Thorium Activity} = \frac{1.03 \text{ pCi}}{\text{g soil}} \quad (4)$$

This value is consistent with the observed thorium-230 radioactivities at the MGBG and the background samples collected from soil boring 01SB21, thus demonstrating that the observed radioactivities are representative of naturally occurring background radioactivities. Allowing for sampling and measurement uncertainties, the same approximate radioactivity levels would be expected of the other radionuclides in this

decay chain, and similar activities were observed. In some cases, the thorium-230 results were lower than expected but this is attributed, at least in part, to the different samples preparations used for gamma spectrometry versus alpha spectroscopy. The gamma spectrometry samples were ground, homogenized, sealed in a container for 30 days, and then counted. The results for the gamma spectrometry radionuclides represent the entire sample matrix plus any contamination that is present. The alpha spectroscopy samples were digested using the same acid leach procedure used for the other non-gamma spectrometry metals. The results from the acid leach represent surface contamination on the soil matrix plus a small amount of soil matrix. As observed, this would be expected to yield concentrations that are less than or equal to the gamma spectrometry data.

Some of the radium-226 results appear to be slightly elevated relative to an expected 1 pCi/g typical background concentration, but this has been attributed to the radium detection energy range being slightly wider than was perhaps necessary. Overlap between the 186 keV radium-226 energy and the 183 keV uranium-235 energy would also explain the existence of slightly elevated radium values. Because of this and because the radium-226 concentrations were well below soil cleanup levels (e.g., 15 pCi/g in subsurface soil), this was not investigated further."