40-8948

PTI
ENVIRONMENTAL SERVICES

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(206) 643-9803 FAX (206) 643-9827

September 30, 1996

Olen Ackman
Ohio Environmental Protection Agency
Southeast District Office
2195 Front Street
Logan, Ohio 43138

Subject: Shieldalloy Metallurgical Corporation Site, Cambridge, Ohio
Submittal of Final Remedial Investigation/Feasibility Study
PTI Project CA38-05-09

Dear Olen:

Please find enclosed two copies of the final Remedial Investigation/Feasibility Study report. One copy is for you as Site Coordinator, and one is for Mr. Peter Whitehouse, Ohio EPA, Columbus, Ohio. These submittals meet the requirements of Section XI of the Consent Order for Preliminary Injunction (COPI) filed July 11, 1995, in the Court of Common Pleas, Guernsey County, Ohio. Copies of the report will be distributed to the cooperating agencies following your approval.

As we discussed, all correspondence and supporting documentation regarding the independent validation of radiological data conducted by the Ohio Department of Health has been included in the final RI/FS report as Appendix R of Volume III.

Please call me at (206) 643-9803 or Jim Valenti, Site Coordinator, at (609) 692-4200 if you have any questions or comments.

Cordially,

Walter J. Shields

Walter J. Shields, Ph.D.
Principal

NL 10/1

Enclosures

cc without enclosure: Brian Blair, OEPA
Dave Altfater, OEPA
Mark Thaggard, USNRC
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Michael MacMullen, USEPA
Robert Karl, Ohio AG
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September 30, 1996

Ruth H. Vandegrift
Bureau of Radiation Protection
Ohio Department of Health
246 North High Street
Columbus, Ohio 43266-0118

Subject: Shieldalloy Metallurgical Corporation Site, Cambridge, Ohio
Radiological Data Validation
Response to ODH Letter of September 20, 1996
PTI Contract CA38-15-29

Dear Ms. Vandegrift:

To complete the radiological data evaluation process, and in accordance with PTI Environmental Services' (PTI's) August 30, 1996, letter, we are implementing the recommendations presented in your September 20, 1996, letter to James Valenti and Patrick Lee. The purpose of this letter is to identify the actions taken and to finalize the series of correspondence regarding Ohio Department of Health's (ODH's) review of the quality of the radiological data collected during the remedial investigation at the Shieldalloy Metallurgical Corporation site. The four recommendations and ODH's discussion from the attachment to the September 20 letter are reproduced below in bold type. PTI's actions to implement these recommendations are presented following each recommendation.

The correspondence (including this letter) and ancillary data sets and statistical output relating to ODH's independent review of the quality of the radiological data used in the remedial investigation and feasibility study (RI/FS) are included in the final RI/FS report as Appendix R in Volume III.

Recommendation #1. Use the entire valid data set of net results and uncertainties for the data analysis. It is our understanding that PTI has included all net results and uncertainties (irrespective of detection limit and regardless of level) in the data set used for statistical analysis less any rejected data. This data set will be presented in the final RI Report. This response is acceptable subject to review of the final RI Report.

As requested by ODH, the minimum detectable activities (MDAs) reported by the analytical laboratories and included in the primary RI/FS database were replaced by the net results and associated uncertainties. This "non-MDA" data set was submitted in electronic form to Ohio EPA and the U.S. Nuclear Regulatory Commission on May 30, 1996, and to ODH on June 13, 1996, and included, as requested, in the final RI/FS report (Volume III, Appendix R-15). This data set, less rejected values,

was used for the statistical analyses requested by ODH. The specific input data for the statistical analysis (i.e., the Wilcoxon Rank Sum Test) are presented in Attachment A to this letter.

Recommendation #2. Remove data qualified as rejected from the data set and document this data set. It is our understanding that the data set used for statistical analysis will be clearly identified in the final RI Report. All data will be presented in the tables of the final RI Report but rejected data will be identified with an R qualifier indicating that this data was not used in the analysis. This response is acceptable subject to review of the final RI Report.

See response to Recommendation #1.

Recommendation #3. Fully document the parameters and results of the Wilcoxon Rank Sum Test and use these results to identify the radionuclides to include in the risk analysis. It is our understanding that results of the Wilcoxon Rank Sum Test will be included in the final RI Report including the number of sample results used for each parameter, the statistical assumptions, and a presentation of the statistical results. This response is acceptable subject to review of the final RI Report.

The output for the Wilcoxon Rank Sum Test summarized in the PTI letter of June 26, 1996, is contained in Volume III, Appendix R-14. The input data for the Wilcoxon Rank Sum Test for surface water and groundwater samples are also included in Appendix R-14.

In our final review of the June 26 analysis in response to this recommendation, we discovered that several samples including three samples from the deep boreholes into the West Slag Pile (WPBO-10, WPBO-11, and WPBO-14) were inadvertently included in the surface soil data set. Accordingly, these data points were removed and the corrected input data set is presented (as stated above) in Attachment A to this letter. The results of the Wilcoxon Rank Sum Test on these data are presented in Attachment B.

Using the revised data set, the only radionuclide in the uranium-238 series that was significantly ($P < 0.05$) elevated above background was thorium-230, which is consistent with the conclusions of the baseline risk assessment. In the current evaluation, none of the "actinium series" (i.e., uranium-235 series) radionuclides was found to be significantly elevated. This finding differs from the June 26 evaluation, where actinium-227 was found to be significantly ($P < 0.05$) greater than background. The principal reason for the change is that the West Slag Pile borehole samples, with their relatively elevated actinium-227 concentrations, skewed the results of the analysis. When these samples, which did not belong in the surface soil data set, were removed, the significance of actinium-227 disappeared.

For the thorium-232 series, thorium-232, radium-228, and thorium-228 results were found to be significantly ($P < 0.05$) greater than background based on the Wilcoxon Rank Sum Test. Thorium-228 and thorium-232 became significant ($P < 0.05$) in this current analysis only when the West Slag Pile borehole samples (which showed very low results for these two radionuclides) were removed from the data set. These findings do not change the risk assessment conclusions (see response to Recommendation #4), however, because the entire thorium-232 and uranium-235 decay chains had already been included in the previous analysis (as requested by ODH).

Recommendation #4. Include the Th-232 and U-235 (at least starting at Pa-231) decay chains in the risk assessment at the 95% upper confidence level of their mean concentration because of lack of sensitivity of detection at background levels. The pathway and exposure assumptions should be the same as those assumed in the final RI Report. It is our understanding that PTI will include the Th-232 and U-235 decay chains in the risk assessment presented in the final RI Report.

The response to Recommendation #4 was submitted to ODH in PTI's August 30, 1996, letter to ODH. This response included the requested risk assessment calculations. Given the change in the underlying data set, the calculations were redone as discussed below.

It is recommended that PTI either 1) perform the risk assessment at the 95% upper confidence level (based on analytical uncertainty) of the maximum result rather than the mean for radionuclides for which fewer than ten analysis results are available, or 2) include the results for other samples based on analysis results for other radionuclides in the decay chain and appropriate equilibrium assumptions.

Part two of the above recommendation was done for the requested risk assessment calculations for the full thorium-232 decay chain. These results are presented in Attachment C to this letter.

As stated in the response to Recommendation #3, the previous calculations for the soil pathway inadvertently included data from the deep boreholes in the West Slag Pile. The risk assessment calculations were repeated with input data shown in Attachment A. The results of this reevaluation show again that, even under overly conservative assumptions, the calculated risk is within an order of magnitude of that shown in the baseline risk assessment and is consistent with the risk assessment calculations presented in the June 26 and August 30 letters. A discussion of the results of these calculations is presented in Attachment C to this letter.

Furthermore, it is recommended that the calculated standard deviation of the mean for the samples be compared to the propagated analytical result uncertainty for the mean.

Data are presented in the RI/FS report if ODH wishes to conduct various ancillary analyses such as the recommended comparison.

It is our understanding that PTI will include in the final RI Report a description of all assumptions made for the risk analysis, a listing of the concentrations assumed for each radionuclide, a full description of the data from which the concentrations were derived, a list of all parameter values used in the risk assessment, and a description of all equations used in the risk assessment.

Assumptions for the risk assessment are presented, either directly or by reference, in the RI/FS report. Specific radiological risk assessment assumptions, the list of parameters, and the equations used are presented in the attachments to this letter. Radiological data used for the baseline risk assessment are presented in Volume II of the RI/FS. Radiological data used for ODH's requested analyses (i.e., the non-MDA data set) are presented in Appendix R-15. Radionuclide concentrations used for the requested risk assessment calculations are presented, as stated, in Attachment A to this letter.

We request that this material be provided in advance of the final RI Report as expeditiously as practicable. Disposition of these recommendations will be subject to review of the final RI Report.

The requested material will be included in the proofing version of the final RI/FS report submitted to OEPA.

Additional radiological sampling of the media surrounding the piles and of background may be needed during the RD/RA phase to confirm the validity of the values used as the basis for the radiological risk calculations for this media.

Comment noted.

Recommendations made in the August 23 Letter.

PTI's response to the recommendations made in the August 23 letter are acceptable subject to a review of the data presented in the final RI Report.

Comment noted.

In addition, we do not have a version of Table 107 which matches the data presented in the responses. We request that the most recent version of Table 107 be provided in advance of the final RI Report as expeditiously as practicable and that any differences from previous versions be explained.

The version of Table 107 that matches the assumptions used in the final baseline risk assessment was submitted to OEPA on December 7, 1995, as a redline/strikeout draft of Section 6 of the remedial investigation report. This is the same version of Table 107 that is included in the final remedial investigation report (now numbered Table 113 in the final). A copy of this table is attached for your convenience.

Based on our discussions, this letter completes the documentation regarding issues raised during ODH's independent validation of radiological data. Please call me at (206) 643-9803 or Jim Valenti, Site Coordinator, at (609) 692-4200 if you have any questions.

Very truly yours,

Walter J. Shields, Ph.D.
Principal

Attachments

cc (agency representatives):

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John House, USNRC
Jennifer Wendel, USEPA
Murray Wade, ORNL
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Carol Berger, IEM
Laura Jones, PTI
Greg Bawden, PTI

TABLE 113. SUMMARY OF EXPOSURE AND RISK ESTIMATES FOR THE RADIOLOGICAL HHRA

Pathway	Current Onsite Worker	Hypothetical Future Onsite Resident: Child (0–6 years)	Child (6–9 years)	Child (9–18 years)	Adult	Adult Recreational User
Soil ingestion (pCi)	7,340	9,870	2,470	7,400	9,870	0
Soil inhalation (pCi)	9.75	2.9	1.4	1.7	1.2	0
Sediment ingestion (pCi)	0	0	0	1,570	0	226
Sediment inhalation (pCi)	0	0	0	0.73	0	0.11
External exposure rate (μR/h)	26.7	0.15	0.15	0.15	0.15	0.16
Total Ingested (pCi)	7,340	9,870	2,470	9,000	9,870	226
Total Inhaled (pCi)	9.75	2.9	1.4	2.4	1.2	0.11
Lifetime external exposure (mrem)	34.3	0.315	0.158	1.28	0.63	0.94

Exposure Pathway	Upper-bound Lifetime Excess Cancer Risk Estimate					
Ingestion	1×10^{-7}	1×10^{-7}	3×10^{-8}	1×10^{-7}	1×10^{-7}	3×10^{-9}
Inhalation	3×10^{-7}	8×10^{-8}	4×10^{-8}	7×10^{-8}	3×10^{-8}	3×10^{-9}
External exposure	1×10^{-5}	1×10^{-7}	6×10^{-8}	5×10^{-7}	3×10^{-7}	4×10^{-7}
Subtotal for age category		3×10^{-7}	1×10^{-7}	7×10^{-7}	4×10^{-7}	
Total for scenario	1×10^{-5}		2×10^{-6}			6×10^{-7}

Note: HHRA - human health risk assessment

[a] These exposure values reflect an assumption that the receptor would receive one-half of his total sediment exposure from onsite sediments and one-half from wetland soil.

ATTACHMENT A

TABLE A-1. INPUT DATA FOR THE WILCOXON RANK SUM TEXT

TABLE A-1. SOIL INPUT DATA FOR THE WILCOXON RANK SUM TEST

Station	Uranium-238 Series						Uranium-235 Series				Thorium-232 Series						
	U-238	U-234	Th-230	Ra-226	Pb-214	Bi-214	U-235	Pa-231	Ac-227	Ra-223	Th-232	Ra-228	Th-228	Ra-224	Pb-212	Bi-212	Tl-208
PTI Onsite Sampling Stations																	
FSRBOP1	1.12	0.92	35.94		0.49	0.56	0.06	0.40	0.76	-6.95	1.38		0.85	6.90	0.95	0.19	0.24
FSRBOP2	0.47	0.54	0.72		0.90	0.71	0.02	-2.69	0.46	-2.26	0.08		0.14	4.28	0.52	0.62	0.12
WPSS-16			18.81		0.74	0.89		0.10	-0.02	0.61	1.72		1.75	3.37	1.26	1.26	0.56
WPSS-17			17.51		0.72	0.69		-1.13	0.27	1.82	1.27		1.49	1.84	1.16	0.65	0.37
WPSS-18			3.50		0.80	1.22		-1.57	0.36	0.33	1.48		2.11	11.25	1.16	1.37	0.57
UTEF-01	1.91	1.80	4.30		0.30	0.61	0.00	1.37	0.65	0.45	1.20		0.99	8.38	0.70	-0.66	0.19
UTNO-1			2.79		0.66	0.78		1.28	-0.12	0.31	1.29		1.28	4.34	1.09	1.74	0.50
Ohio EPA Onsite Sampling Stations																	
WWS-1	1.3	1.2	2.3	1.3							1.2	1.8	1.2				
WWS-2	1	1.2	2.5	1.5							1		0.81				
WSSW-1	3.8	4.1	6.2	0.93							1.2	1.3	1.4				
WSSW-2	1.5	1.4	1.3	0.81							1.3	1.5	1.3				
WSSW-4	1.7	1.8	2.1	1.1			0.11				1.1		1.1				
WSW-1	1.2	0.94	1.3	1.6							1.1	1.7	1.1				
WSW-2	1.1	1	1.2	0.99							1.2	1.5	1.1				
WSN-1	1.2	1.1	1.3	1.2							1.4	1.2	1.1				
WSN-2			1.3	0.72							1.2	1.1					
EWNW-1	2.2	1.9	1.7	1.3			0.44				1.1	1.5	1.4				
EWNW-2	1.1	1.5	1.3	1.5			0.09				1.2	1.1	0.92				
ESD 0.7				1.5								0.97					
ESD 0.55	2.9	3.5	2.8	0.87							1	1.5	1.1				
ESD 0.42	3.6	2.8	56	2.3							1.5	1.9	1.3				
ESD 0.02	1.2	1.5	1.4	1.4							1.1	1.4	1.2				
WSD 0.05			1.7	1.2								1.6	1.5				
CR 1.05	1	1.1		1.1								1.2					
CR 0.P6	1.6	1.8	1.4	1							1.1	1.8					
CR 0.45	1.1	1	1.2	1.1							1.1						
Ohio Background Stations (Myrick et al. 1983)																	
BG-1	2.2	2.2	2.2	2.5	2.5	2.5	0.10	0.10	0.10	0.10	0.71	0.71	0.71	0.71	0.71	0.71	0.26
BG-2	1.3	1.3	1.3	1.5	1.5	1.5	0.06	0.06	0.06	0.06	0.74	0.74	0.74	0.74	0.74	0.74	0.27
BG-3	1.2	1.2	1.2	1.1	1.1	1.1	0.05	0.05	0.05	0.05	1.1	1.1	1.1	1.1	1.1	1.1	0.40
BG-4	1.7	1.7	1.7	2	2	2	0.08	0.08	0.08	0.08	1	1	1	1	1	1	0.36
BG-5	1.6	1.6	1.6	1.3	1.3	1.3	0.07	0.07	0.07	0.07	1.5	1.5	1.5	1.5	1.5	1.5	0.54
BG-6	1.6	1.6	1.6	1.9	1.9	1.9	0.07	0.07	0.07	0.07	1.1	1.1	1.1	1.1	1.1	1.1	0.40
BG-7	1.7	1.7	1.7	1.5	1.5	1.5	0.08	0.08	0.08	0.08	1.5	1.5	1.5	1.5	1.5	1.5	0.54
BG-8	0.76	0.76	0.76	0.81	0.81	0.81	0.04	0.04	0.04	0.04	0.8	0.8	0.8	0.8	0.8	0.8	0.29
BG-9	1.2	1.2	1.2	1.3	1.3	1.3	0.06	0.06	0.06	0.06	0.93	0.93	0.93	0.93	0.93	0.93	0.33
BG-10	1.4	1.4	1.4	1.5	1.5	1.5	0.06	0.06	0.06	0.06	1	1	1	1	1	1	0.36
BG-11	0.96	0.96	0.96	1.2	1.2	1.2	0.04	0.04	0.04	0.04	0.99	0.99	0.99	0.99	0.99	0.99	0.36
BG-12	0.86	0.86	0.86	1	1	1	0.04	0.04	0.04	0.04	0.98	0.98	0.98	0.98	0.98	0.98	0.35
Ohio EPA Background Stations																	
WB-2	1.4	1.3	1.5	1.7			0.07				1.3	1.5	1.2				
WB-3	1.1	1.2	1.4	1.8							1	1.8	1				
CR-5.73			1	1.1								1					

Note: Results outlined in a rectangular box were less than the minimum detectable act' rity (MDA) reported by the laboratory.
Stations B-1 through BG-12 represent Ohio background stations reported by T.E. Myrick, B.A. Berven, and F.F. Haywood. 1983. Determination of concentrations of selected radionuclides in surface soil in the U.S. Health Physics 43(3): 631-642. Myrick et al. provided surface soil data on uranium-238, thorium-232, and radium-226 mean concentrations; concentrations of other radionuclides were estimated by assuming secular equilibrium.

ATTACHMENT B

WILCOXON RANK SUM TEST PARAMETERS FOR REVISED SOIL INPUT DATA
(ATTACHMENT A, TABLE A-1)

................................SOIL DATA.................................

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 34 CASES
DEPENDENT VARIABLE IS U238
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	19	339.500
B	15	255.500

MANN-WHITNEY U TEST STATISTIC = 149.500
PROBABILITY IS 0.808
CHI-SQUARE APPROXIMATION = 0.059 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 34 CASES
DEPENDENT VARIABLE IS U234
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	19	342.500
B	15	252.500

MANN-WHITNEY U TEST STATISTIC = 152.500
PROBABILITY IS 0.728
CHI-SQUARE APPROXIMATION = 0.121 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 40 CASES
DEPENDENT VARIABLE IS TH230
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	24	567.500
B	16	252.500

MANN-WHITNEY U TEST STATISTIC = 267.500
PROBABILITY IS 0.037
CHI-SQUARE APPROXIMATION = 4.372 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 34 CASES
DEPENDENT VARIABLE IS RA226
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	19	281.500
B	15	313.500

MANN-WHITNEY U TEST STATISTIC = 91.500
PROBABILITY IS 0.075
CHI-SQUARE APPROXIMATION = 3.163 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS PB214
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	29.000
B	13	181.000

MANN-WHITNEY U TEST STATISTIC = 1.000
PROBABILITY IS 0.000
CHI-SQUARE APPROXIMATION = 12.482 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS BI214
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	38.000
B	13	172.000

MANN-WHITNEY U TEST STATISTIC = 10.000
PROBABILITY IS 0.005
CHI-SQUARE APPROXIMATION = 7.944 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS U235
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	6	65.000
B	14	145.000

MANN-WHITNEY U TEST STATISTIC = 44.000
PROBABILITY IS 0.869
CHI-SQUARE APPROXIMATION = 0.027 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS PA231
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	77.000
B	13	133.000

MANN-WHITNEY U TEST STATISTIC = 49.000
PROBABILITY IS 0.781
CHI-SQUARE APPROXIMATION = 0.077 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS AC227
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	93.000
B	13	117.000

MANN-WHITNEY U TEST STATISTIC = 65.000
PROBABILITY IS 0.122
CHI-SQUARE APPROXIMATION = 2.391 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS RA223
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	94.000
B	13	116.000

MANN-WHITNEY U TEST STATISTIC = 66.000
PROBABILITY IS 0.104
CHI-SQUARE APPROXIMATION = 2.643 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 38 CASES
DEPENDENT VARIABLE IS TH232
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	23	520.500
B	15	220.500

MANN-WHITNEY U TEST STATISTIC = 244.500
PROBABILITY IS 0.030
CHI-SQUARE APPROXIMATION = 4.690 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 31 CASES
DEPENDENT VARIABLE IS RA228
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	16	326.000
B	15	170.000

MANN-WHITNEY U TEST STATISTIC = 190.000
PROBABILITY IS 0.005
CHI-SQUARE APPROXIMATION = 7.774 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 36 CASES
DEPENDENT VARIABLE IS TH228
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	21	443.000
B	15	223.000

MANN-WHITNEY U TEST STATISTIC = 212.000
PROBABILITY IS 0.079
CHI-SQUARE APPROXIMATION = 3.086 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS RA224
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	112.000
B	13	98.000

MANN-WHITNEY U TEST STATISTIC = 84.000
PROBABILITY IS 0.002
CHI-SQUARE APPROXIMATION = 9.329 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS PB212
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	73.000
B	13	137.000

MANN-WHITNEY U TEST STATISTIC = 45.000
PROBABILITY IS 0.968
CHI-SQUARE APPROXIMATION = 0.002 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS BI212
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	63.000
B	13	147.000

MANN-WHITNEY U TEST STATISTIC = 35.000
PROBABILITY IS 0.405
CHI-SQUARE APPROXIMATION = 0.694 WITH 1 DF

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE FOR 20 CASES
DEPENDENT VARIABLE IS TL208
GROUPING VARIABLE IS SAMPTYPE$

GROUP	COUNT	RANK SUM
S	7	74.000
B	13	136.000

MANN-WHITNEY U TEST STATISTIC = 46.000
PROBABILITY IS 0.968
CHI-SQUARE APPROXIMATION = 0.002 WITH 1 DF

ATTACHMENT C

RISK ASSESSMENT CALCULATIONS FOR THORIUM-232 DECAY SERIES RESULTS PRESENTED IN ATTACHMENT A.

As requested in Recommendation #4, specific details on the risk assessment assumptions are included in this attachment.

Based on the information contained in the response to Recommendation #3, the risk assessment calculations for the thorium-232 decay series are presented below. This risk assessment assumes equilibria for the following radionuclides in the decay chain:

Initial Radionuclide	Radionuclides Assumed To Be in Equilibrium
Th-232	Th-232
Ra-228	Ra-228, Ac-228
Th-228	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208

The risk estimates associated with these radionuclides were evaluated at the concentration of the initial radionuclide in each sequence. Concentrations for these radionuclides at the site were represented by the 95 percent upper confidence level (UCL) of their means, because the sample set for each radionuclide contains more than 10 data points.

Consideration of Background

The risk assessment of a naturally occurring radioactive series (such as the thorium-232 series) is complicated by the fact that the series is already present in background concentrations. The assessment is further complicated in that the calculated risk associated with natural background for the thorium-232 series exceeds 1×10^{-4}. Therefore, without accounting for background, any risk assessment of the thorium series will result in a calculated risk above the range that the U.S. Environmental Protection Agency has determined to be acceptable.

To provide a meaningful estimate of the risks associated with the Shieldalloy Metallurgical Corporation site, in the risk assessment, background was accounted for by subtracting the mean background concentration for each radionuclide in the thorium-232 series from the 95 percent UCL of the mean for the corresponding site concentration. This difference was the input for each radionuclide in the risk assessment.

Risk Assessment Methodology

In conducting the risk assessment, the basic assumptions regarding intake parameters documented in Table 101 (copy attached) of the remedial investigation report were used. The concentrations and the intake parameters were inputs to the equations listed in Attachment D.

Summing Risks

Risks were calculated for each intake scenario using the radionuclides of concern. Risks were then summed by receptor, in the following categories:

- Onsite Resident Child (0–6 years)
- Onsite Resident Child (6–9 years)
- Onsite Resident Child (9–18 years)
- Onsite Resident Adult
- Onsite Recreator
- Onsite Worker

The first five receptor totals were summed to obtain the total risk to an onsite resident. The last two receptor totals were summed to obtain the total risk for a worker.

Results

Using the above methodology, the risks to the individual receptors were as follows:

Receptor	Estimated Risks: Recommendation #4 Calculations	Estimated Risks: Baseline Risk Assessment (Table 113)
Onsite Resident Child (0–6 years)	1×10^{-5}	3×10^{-7}
Onsite Resident Child (6–9 years)	6×10^{-6}	1×10^{-7}
Onsite Resident Child (9–18 years)	2×10^{-5}	7×10^{-7}
Onsite Resident Adult	2×10^{-5}	4×10^{-7}
Onsite Recreator	4×10^{-7}	6×10^{-7}
Onsite Worker	4×10^{-5}	1×10^{-5}
TOTAL - ONSITE RESIDENT	8×10^{-5}	2×10^{-6}
TOTAL - ONSITE WORKER	4×10^{-5}	1×10^{-5}

TABLE 101. EXPOSURE PARAMETERS FOR THE RADIOLOGICAL HHRA

Parameter	Hypothetical Future Onsite Residential Scenario: Child (0–6 years)	Child (6–9 years)	Child (9–18 years)	Adult (18–70 years)	Adult Recreational User	Current Onsite Worker
Duration of exposure (years)	6	3	9	12	25	25
Respiration rate (m^3/h)	0.83	0.83	0.83	0.83	0.83	0.83
Exposure time for sediments and/or wetland soils (h/day)[a]	0	0	4	0	4	0
Exposure time for West Slag Pile perimeter soils (h/day)	10	10	4	2	0	0.2
Exposure time for East Slag Pile (h/day)[b]	1	1	1	1	1	1.2
Soil ingestion rate (g/day)	0.2	0.1	0.1	0.1	0	0.05
Soil exposure frequency (days/year)	350	350	350	350	0	250
Dust concentration ($\mu g/m^3$)	7	7	7	7	7	400
Sediment ingestion rate (g/day)	0	0	0.05[c]	0	0.05[c]	0
Sediment exposure frequency (days/year)	0	0	150	0	50	0

Note: HHRA - human health risk assessment

[a] Exposures to external radiation from the East Slag Pile are also assumed to occur during this time (at an external exposure rate of 0.00015 mrem/h).

[b] Includes 1 h/day of exposure to external radiation from East Slag Pile during transit for all scenarios (at an external exposure rate of 0.00015 mrem/h). Worker scenario includes 1 h/week of exposure to direct radiation from East Slag Pile while in proximity to the pile (at an external exposure rate of 0.0267 mrem/h).

[c] Assumes a sediment intake rate of 0.1 g/day and a fractional intake of 0.5.

ATTACHMENT D

EQUATIONS USED FOR RADIOLOGICAL RISK ASSESSMENT CALCULATIONS

Inhalation

The equation used to calculate risks due to inhalation of dust is:

$$Risk = 1 \times 10^{-6} \times C_s \times DL \times RR \times ET \times EF \times ED \times SF_a$$

where

C_s	=	Concentration of the radionuclide in soil (pCi/g)
DL	=	Dust loading in air ($\mu g/m^3$)
RR	=	Respiration rate (m^3/hour)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Duration of exposure (years)
SF_a	=	Slope factor for inhalation (risk/pCi)

Risks were calculated for each radionuclide of concern.

Ingestion (soil or sediment)

The equation used to calculation risks due to ingestion of either soil or sediment is:

$$Risk = C_s \times IR \times EF \times ED \times SF_i$$

where

C_s	=	Concentration of the radionuclide in soil (pCi/g)
IR	=	Soil ingestion rate (grams/day)
EF	=	Exposure frequency (days/year)
ED	=	Duration of exposure (years)
SF_i	=	Slope factor for ingestion (risk/pCi)

Risks were calculated for each radionuclide of concern for both soil and sediment ingestion.

Radiation Exposure from Radionuclides on the Ground Surface

The equation used to calculation risks due to exposure to direct radiation from radionuclides on the ground surface is :

$$\text{Risk} = C_s \times \frac{[12 + (0.5 \times ET)]}{24} \times \frac{EF}{365} \times ED \times SF_d$$

where

C_s = Concentration of the radionuclide in soil (pCi/g)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Duration of exposure (years)
SF_d = Slope factor for direct radiation exposure (risk-g/pCi-year)

Risks were calculated for each radionuclide of concern.

Radiation Exposure from the East Slag Pile

In addition, risks from exposure to the radiation fields from the East Slag Pile were included for the different receptors. Exposure scenarios included:

- Exposure to radiation when entering and leaving the site
- Exposure due to proximity to the East Slag Pile during recreation in nearby wetlands
- Exposure of occupational receptors during inspections of the East Slag Pile.

The equation used to calculate risks due to direct exposure is:

$$\text{Risk} = [(DR_r \times ET_r \times EF_r) + (DR_v \times ET_v \times EF_v)] \times ED \times SF$$

where

DR_r = Dose rate at the road leading to/from the site (mrem/hour)
ET_r = Exposure time on the road (hours/day)
EF_r = Exposure frequency on the road (days/year)
DR_v = Dose rate adjacent to the East Slag Pile (mrem/hour)
EF_v = Exposure frequency (days/year)
ED = Duration of exposure (years)
SF = Slope factor for direct radiation exposure (risk/mrem)

To determine the dose rate at a specific receptor point near the East Slag Pile, the following approach was taken:

- Data from thermoluminescent dosimeters (TLDs) deployed along the East Slag Pile fence established the exposure rate adjacent to the pile.
- The computer code Microshield 4.21 was used to model the dose rates at the same distance as the TLDs and at the receptor point of interest, using average concentrations of radionuclide concentrations in slag, the dimensions of the pile, and its average density.
- The ratio of the Microshield results for the TLD and the receptor locations was used to adjust the TLD data to obtain a dose rate at the distance of interest.

Using this methodology, the following dose rates were calculated for receptor locations:

Receptor and Location	Dose Rate from East Slag Pile (μrem/hour)
Worker Adjacent to Pile	26.7
Recreator Adjacent to Northwest Corner of the Pile	0.16
Onsite Resident Passing the Pile While Entering/Leaving the Site	0.15

Given the time spent in the vicinity of the pile, lifetime doses were calculated. These doses were then converted into risks using a risk conversion factor of 4×10^{-7}/mrem.

The risk due to external exposure for each receptor was then added to the risks calculated for all radionuclides.