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INTERIM REPORT ON THE CHARACTERIZATION OF SOIL SAMPLES FROM THE TONAWANDA SITE

USEPA Work Assignment Manager

[redacted]

Technical Reviewer

[redacted]

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1.0 INTRODUCTION

This is an interim report presenting the results of the first phase of an initial characterization study for the Tonawanda FUSRAP Site. A plan for the study was prepared and approved with several decision points identified in order to adjust the direction of the study in a stepwise fashion based on data generated. This interim report presents a discussion of the results of the initial characterization and makes recommendations for further study, based on these results. This report should be read with caution since it contains some unrefined data that may be different from those to be presented in the final report of the initial study. For example, the Ra-226 data, because of the presence of elevated uranium, may be adjusted after a second gamma spectrometry analysis of the samples, following a Rn-222 ingrowth period. However, we believe that the recommendations contained in this report will not be affected by these refinements.

For this study, the National Air and Radiation Environmental Laboratory (NAREL) received eight whole soil samples of approximately 3 kg each from four individual sites collectively referred to as the Tonawanda FUSRAP Site. The four sites are Ashland 1, Ashland 2, Linde, and Seaway. Two samples were received from each site, one sample collected to represent the maximum levels of radioactivity (Bias) and one to represent the average levels (Systematic). The samples were designated as Ash I Bias, Ash I Systematic, Ash II Bias, Ash II Systematic, Linde Bias, Linde Systematic, Seaway Bias, and Seaway Systematic.

The primary objectives of the initial characterization study are to provide characterization of the Tonawanda Site samples and determine if particle-size separation techniques can be effective in reducing the volume of contaminated soil in these samples. A flowchart for the proposed initial study is given in Figure 1-1.

2.0 EXPERIMENTAL

2.1 Sample Preparation

The eight whole soil samples for this study were received at the NAREL. The samples were initially screened for gross beta/gamma activity using a Geiger-Mueller portable survey instrument. After initial screening, each sample was thoroughly mixed and split into 400-mL aliquots using a riffler. The aliquots were weighed, dried at 60°C for 48 hr, and then

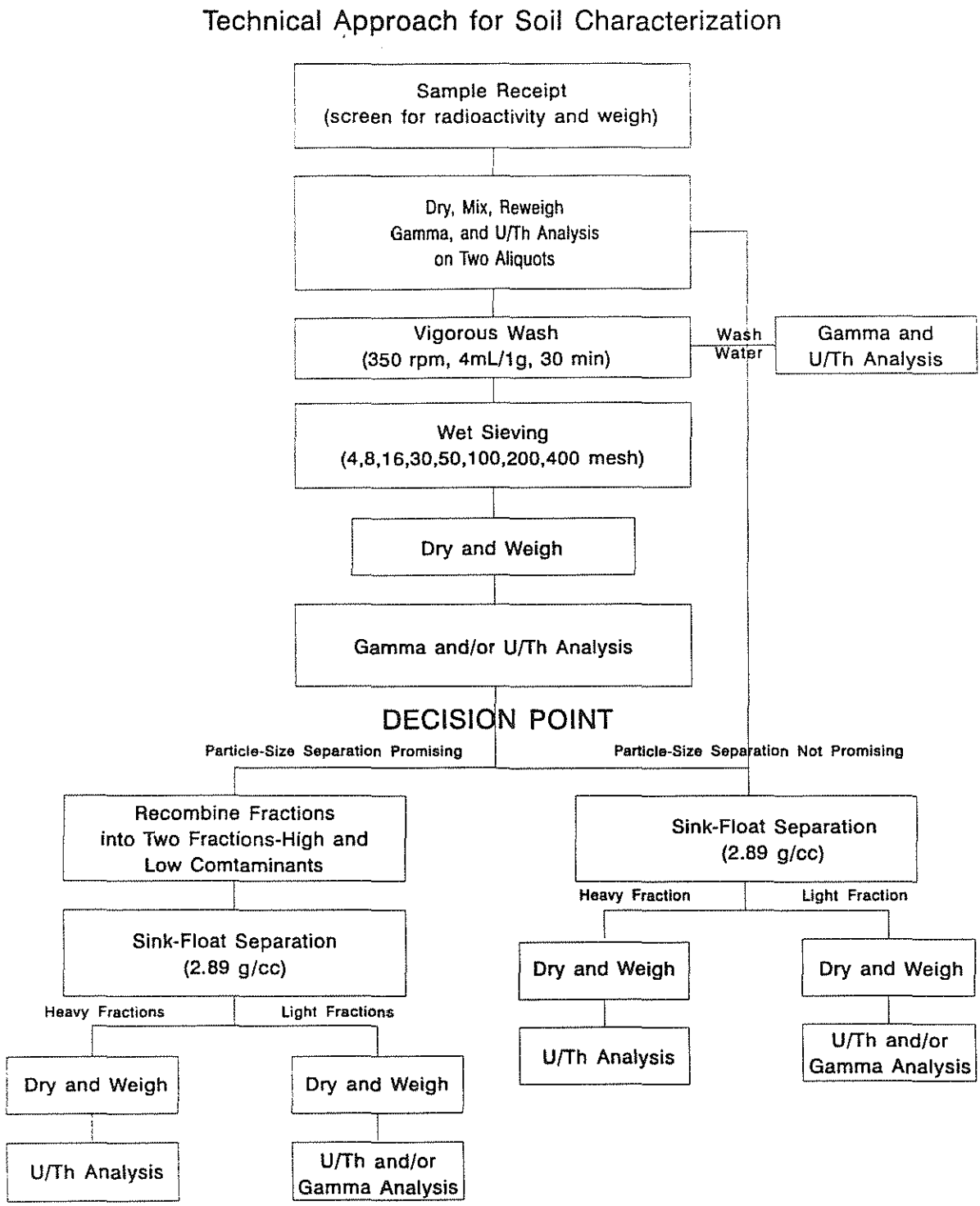

Figure 1-1 Flowchart for Tonawanda Initial Characterization.

reweighed. Four aliquots from each whole soil were analyzed by gamma spectrometry (see Section 2.5). The whole-soil samples taken from Ashland 1 and Linde (Ash I Bias, Ash I Systematic, Linde Bias, and Linde Systematic) were also analyzed for uranium and thorium by alpha spectrometry after they were ashed at 565°C for 72 hr (see Section 2.6).

2.2 Vigorous Wash

The vigorous washing process liberates small particles from large particles without generating excessive fines. After sample preparation, each aliquot from every soil was vigorously washed in water for 30 min at a rotational velocity of 350 rpm with a liquid-to-solid ratio of 4 mL/1g (SCA91a).

2.3 Wet Sieving

After vigorous washing, an aliquot of each soil sample was fractionated by size using wet sieving with American Standard Testing of Materials (ASTM) standard sieves (SCA91b). The aliquots were separated into size fractions at 4.75 mm (4 mesh), 2.38 mm (8 mesh), 1.19 mm (16 mesh), 0.590 mm (30 mesh), 0.297 mm (50 mesh), 0.149 mm (100 mesh), 0.074 mm (200 mesh), and 0.037 mm (400 mesh). The resulting fractions were dried at 60°C for 48 hr, weighed, and analyzed for radionuclide content by gamma spectrometry. Alpha spectrometry was performed only on fractions from two of the four sites, Ashland 1 and Linde.

2.4 Wash Water

Water from the vigorous wash and separation procedures for each sample was collected and a Percol 788N flocculant was added to settle suspended material. The water was then filtered through a 0.025-mm pore filter paper to separate suspended solids from the wash water. The material retained on the filter was analyzed by gamma spectrometry and , if called for, by alpha spectrometry and reported as the -400 activity. An aliquot of filtered wash water from each of the eight whole soil samples was analyzed by gamma spectrometry.

2.5 Gamma Spectrometry

Whole soil samples, particle-size fractions, and wash waters were analyzed for gamma-emitting radionuclides using high-purity germanium detectors (EPA80). The wash water

samples were counted for 1000 min, and the soil samples were counted for 100 or 1000 min, according to the levels of radioactivity.

2.6 Alpha Spectrometry

Analyses for uranium and thorium radionuclides were performed by alpha spectrometry (EPA84). Uranium was extracted, coprecipitated with lanthanum fluoride carrier, and analyzed by alpha spectrometry. Thorium was separated by ion-exchange chromatography, coprecipitated with lanthanum fluoride carrier, and analyzed by alpha spectrometry.

3.0 RESULTS AND DISCUSSION

3.1 Particle-Size Distributions

The particle-size distributions for each site are given in Tables A-1 through A-8 and are illustrated in Figures 3-1 through 3-8. The particle-size distributions for Ash I, Ash II, and Seaway are similar with 49 percent or greater -400-mesh material, as illustrated in Figure 3-9. The Ash I Systematic soil contains notably more gravel and coarse sand-sized material.

The Linde Bias and Systematic soils are similar in their distributions with 41 and 37 percent -400-mesh material, respectively. These soils also have 45 percent +50-mesh material.

3.2 Radionuclide Distributions

The primary radionuclides identified in the Tonawanda samples are members of the U-238 and U-235 decay series. Radionuclides associated with the Th-232 series are present at quantities within the range of natural background. The nuclides of primary concern are U-234, -235, and -238; Th-234 and -230; and Ra-226. The concentrations, determined for the soil samples and their separated fractions, are given in Tables A-1 through A-8. The data are graphically presented as a function of particle size in Figures 3-1 through 3-8.

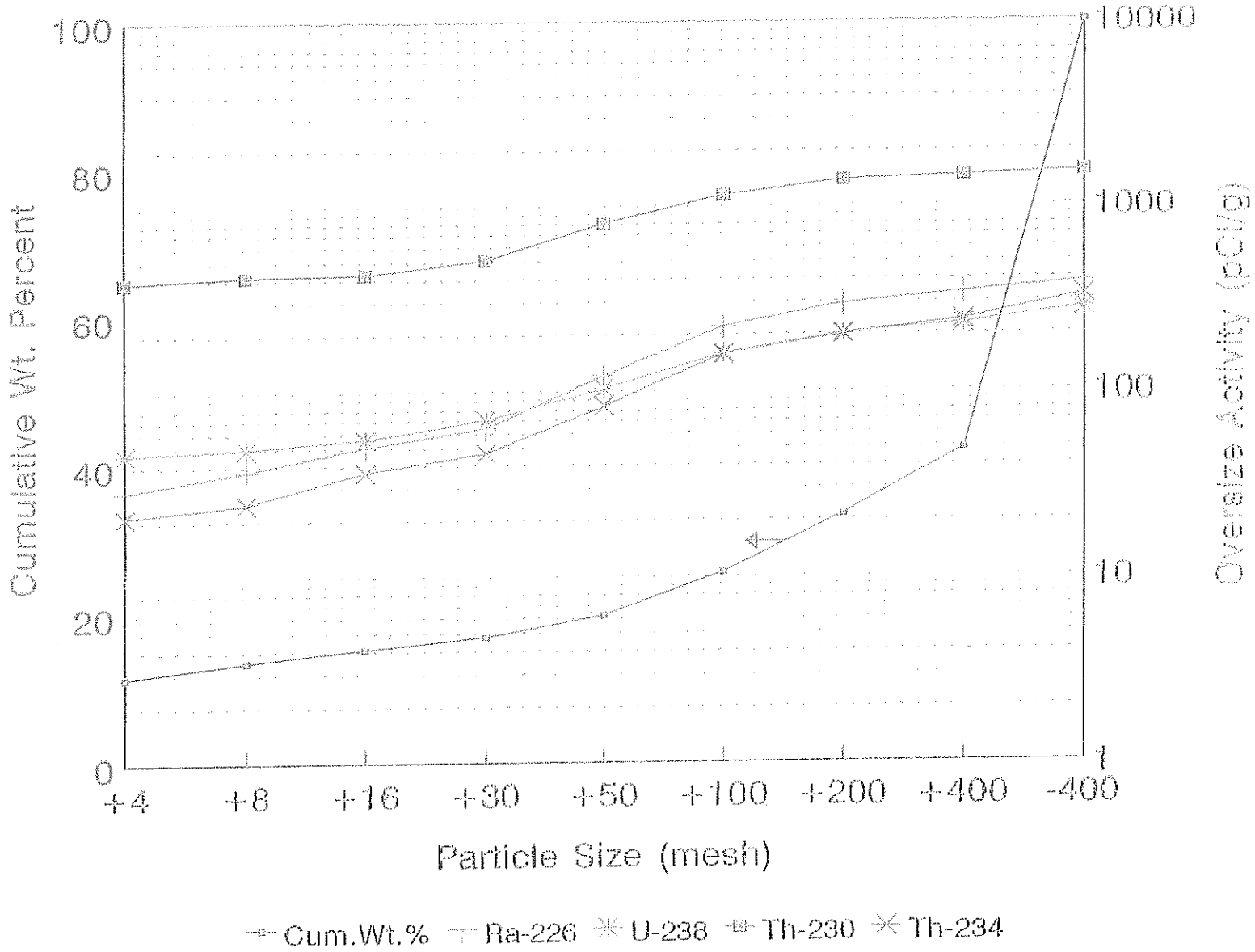

Figure 3-1 Ash I Bias Particle-Size and Radionuclide Distributions

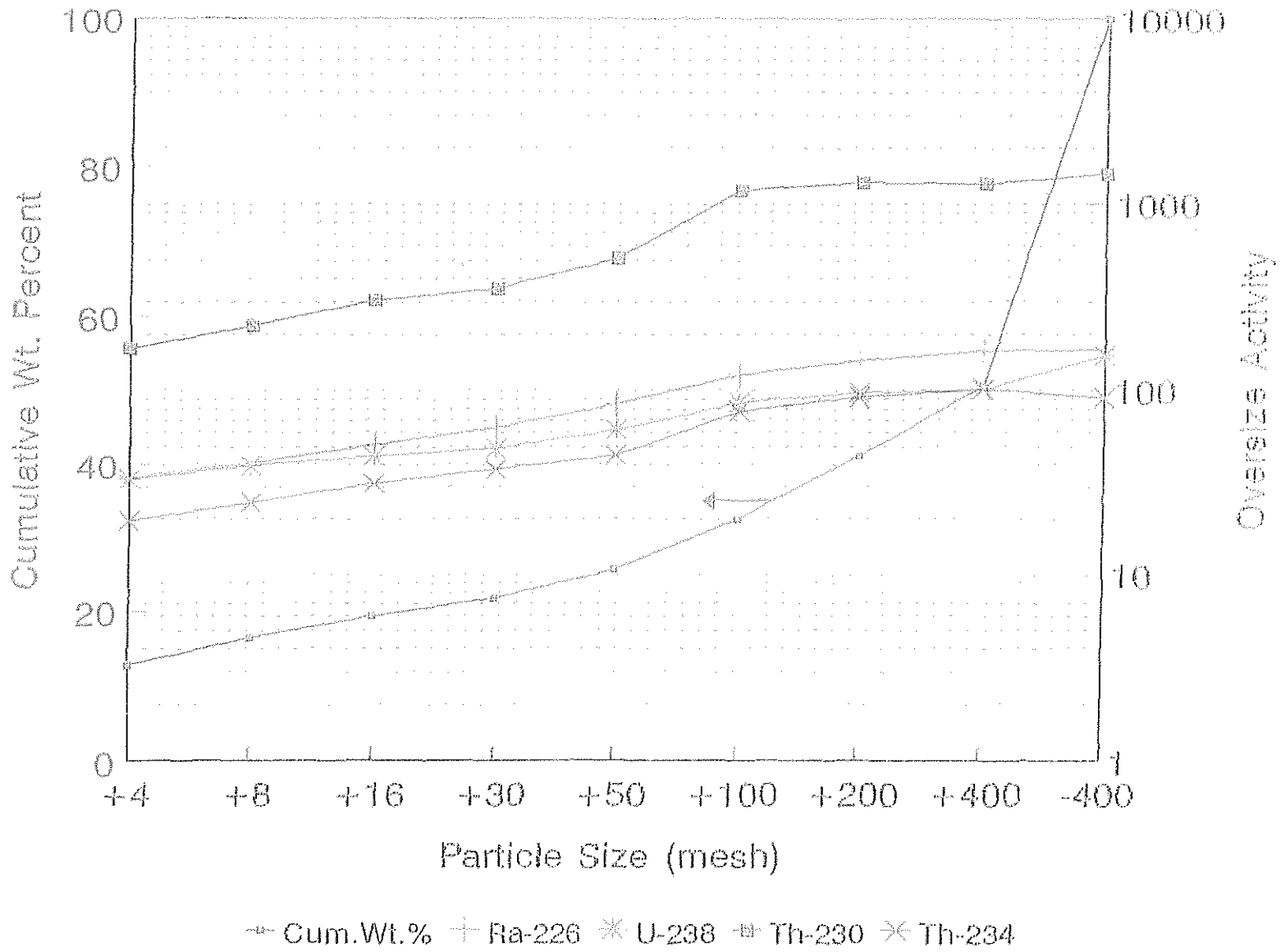

Figure 3-2 Ash I Systematic Particle-Size and Radionuclide Distributions

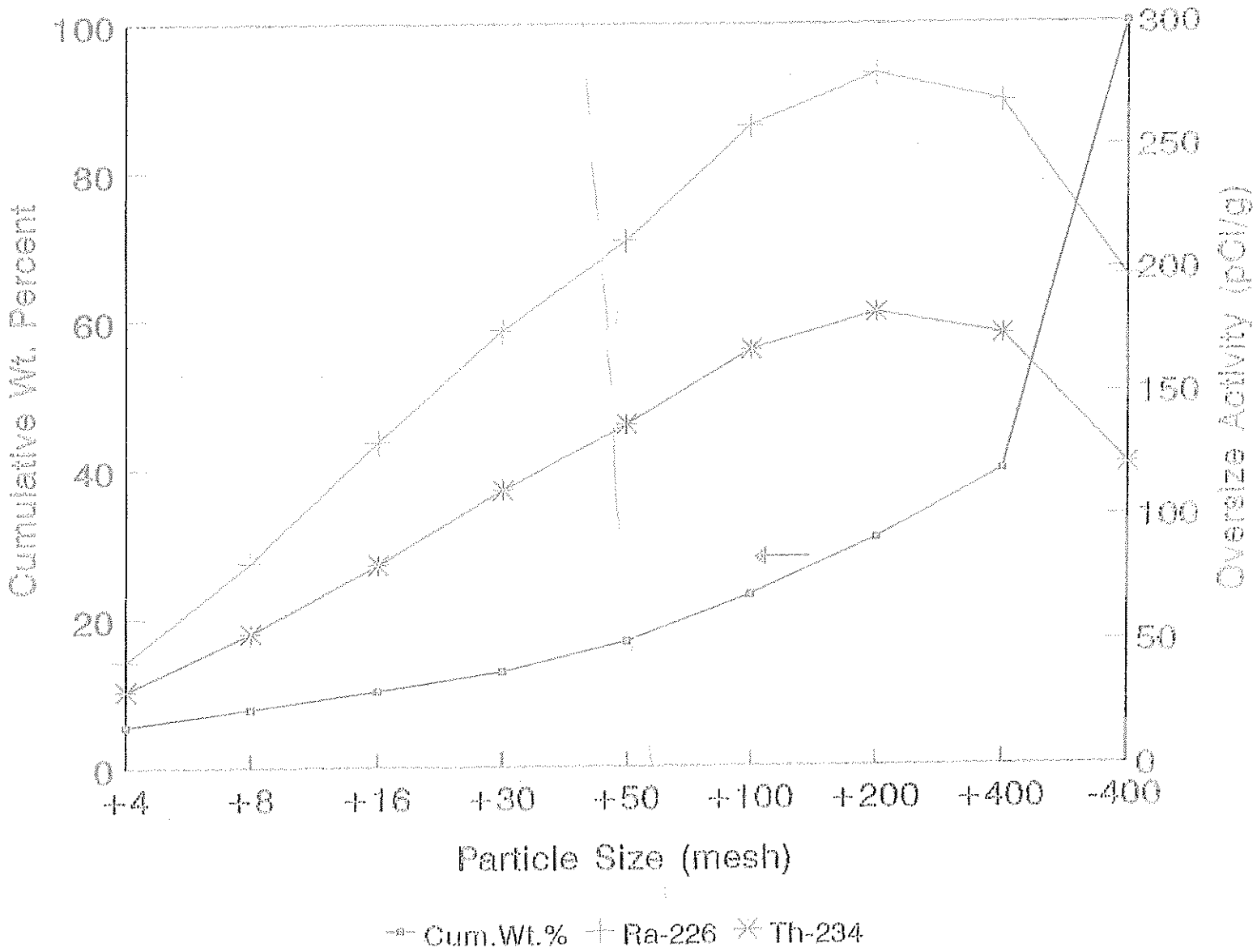

Figure 3-3 Ash II Bias Particle-Size and Radionuclide Distributions

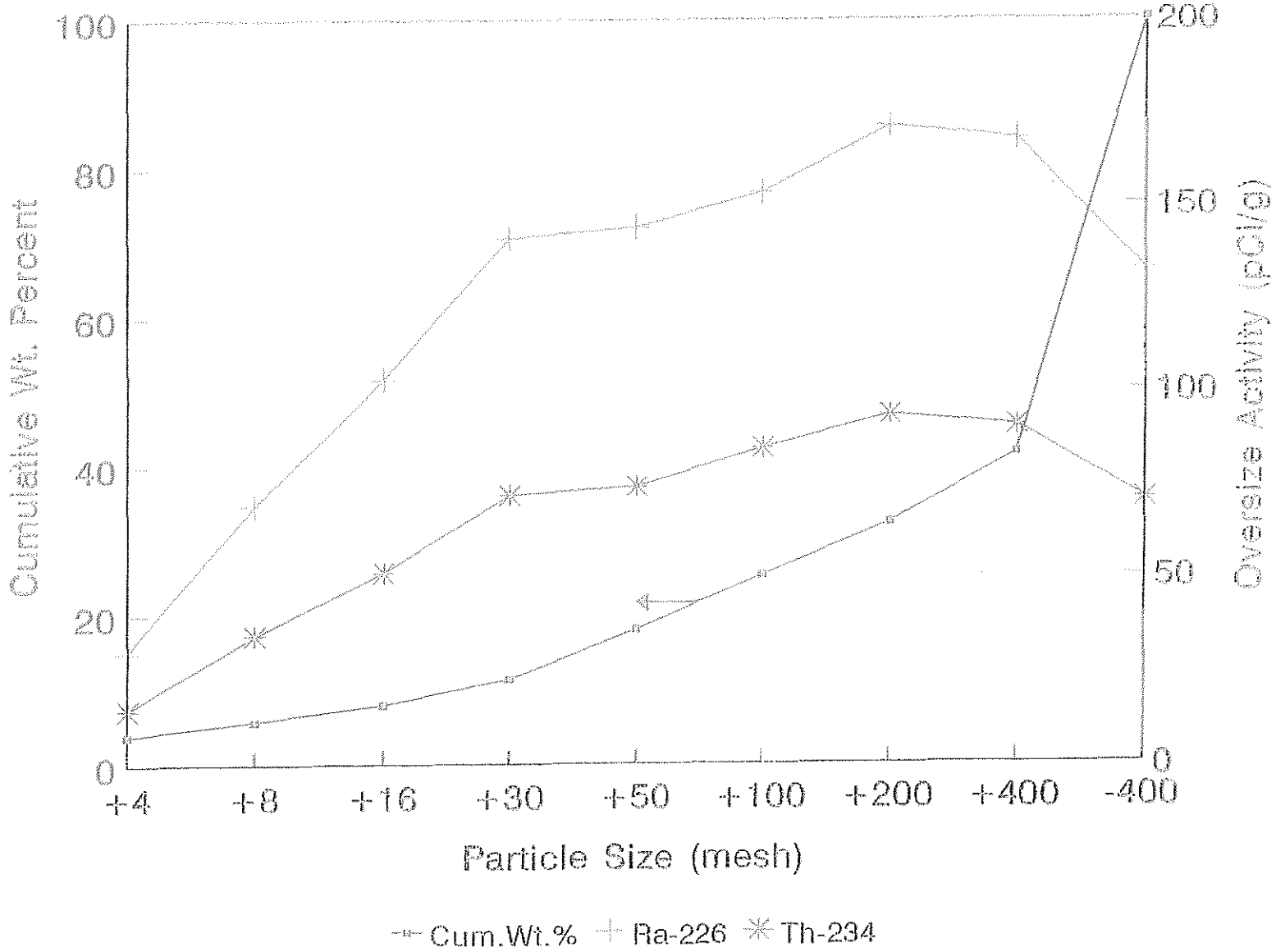

Figure 3-4 Ash II Systematic Particle-Size and Radionuclide Distributions

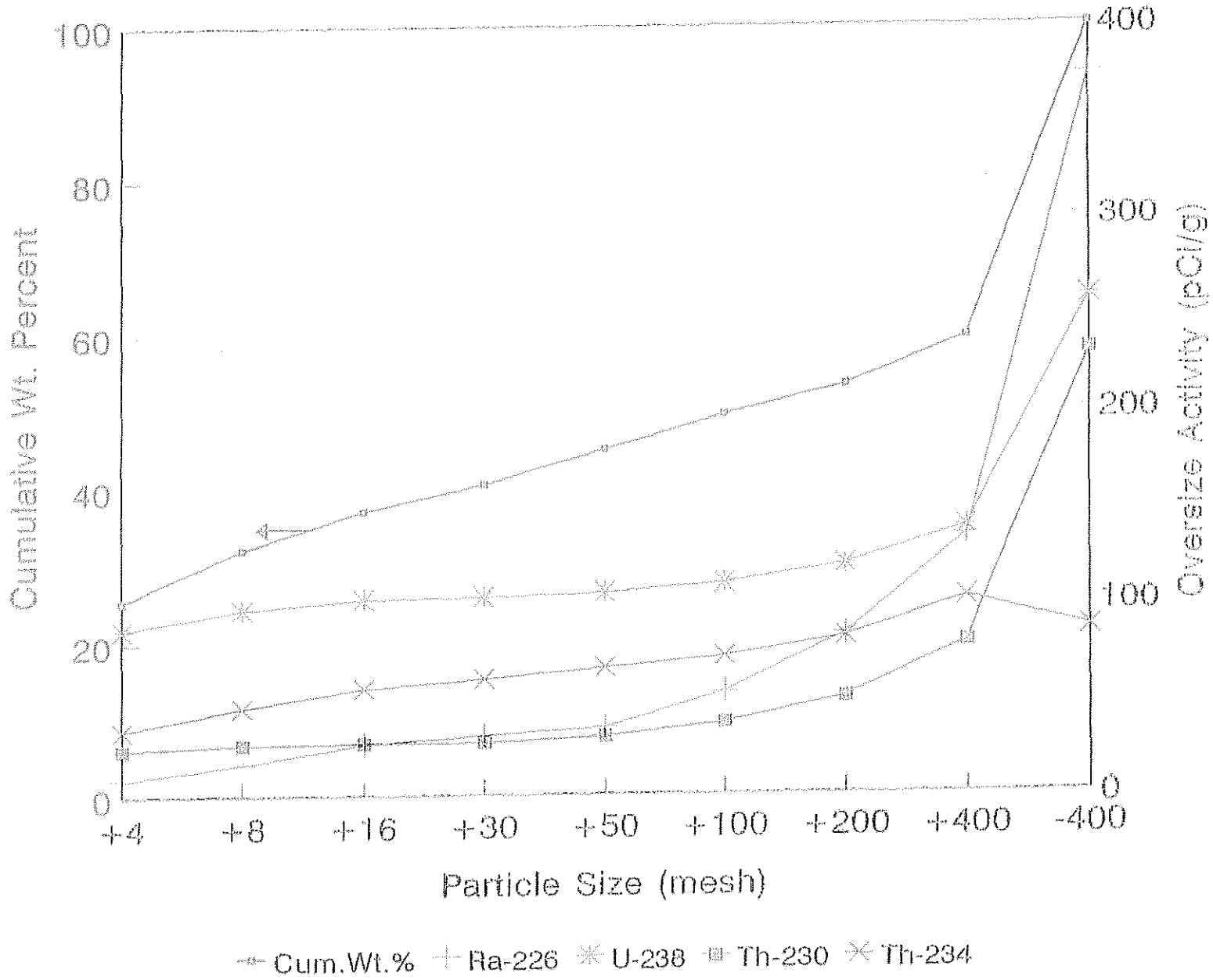

Figure 3-5 Linde Bias Particle-Size and Radionuclide Distributions

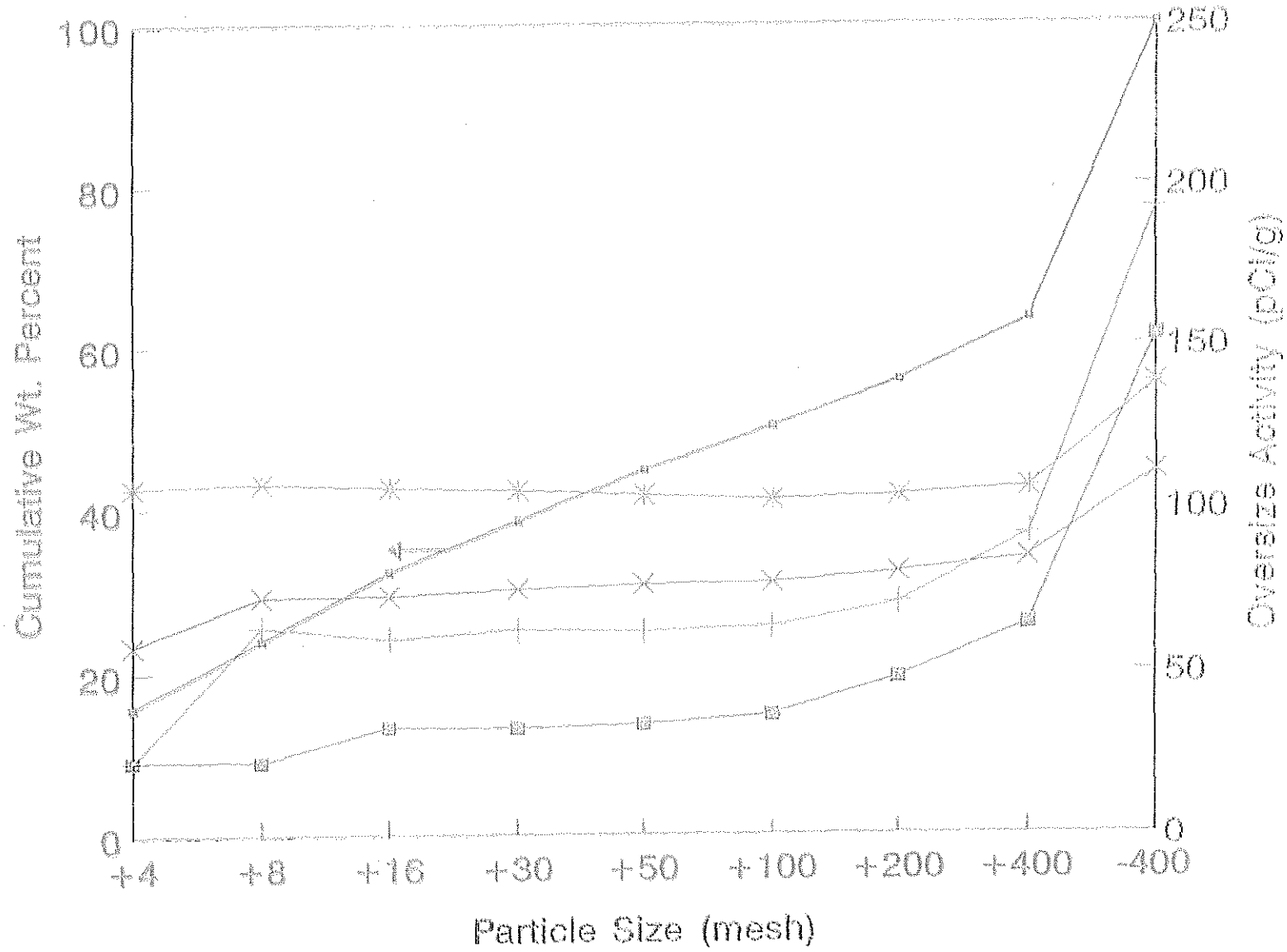

Figure 3-6 Linde Systematic Particle-Size and Radionuclide Distributions

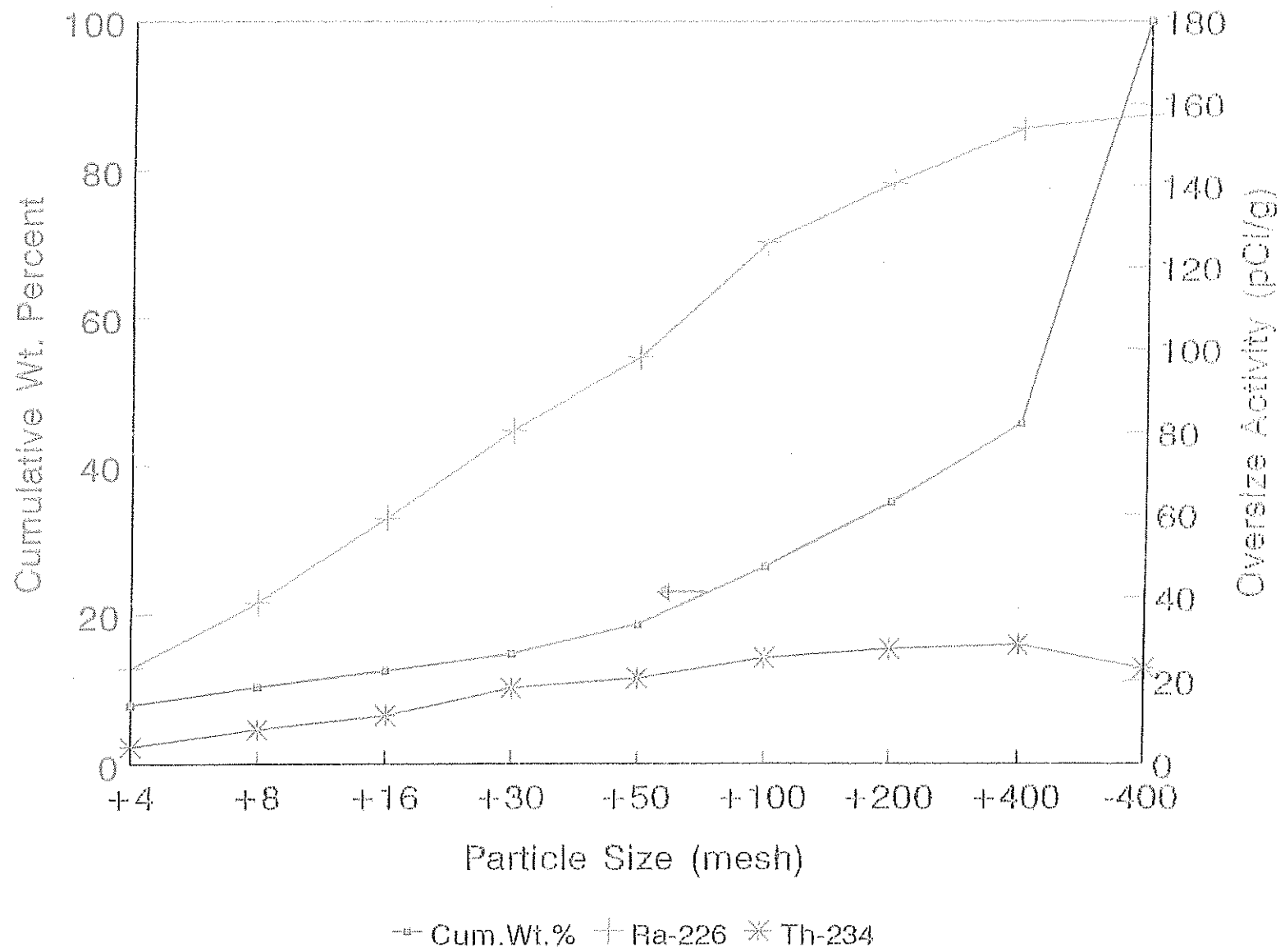

Figure 3-7 Seaway Bias Particle-Size and Radionuclide Distributions

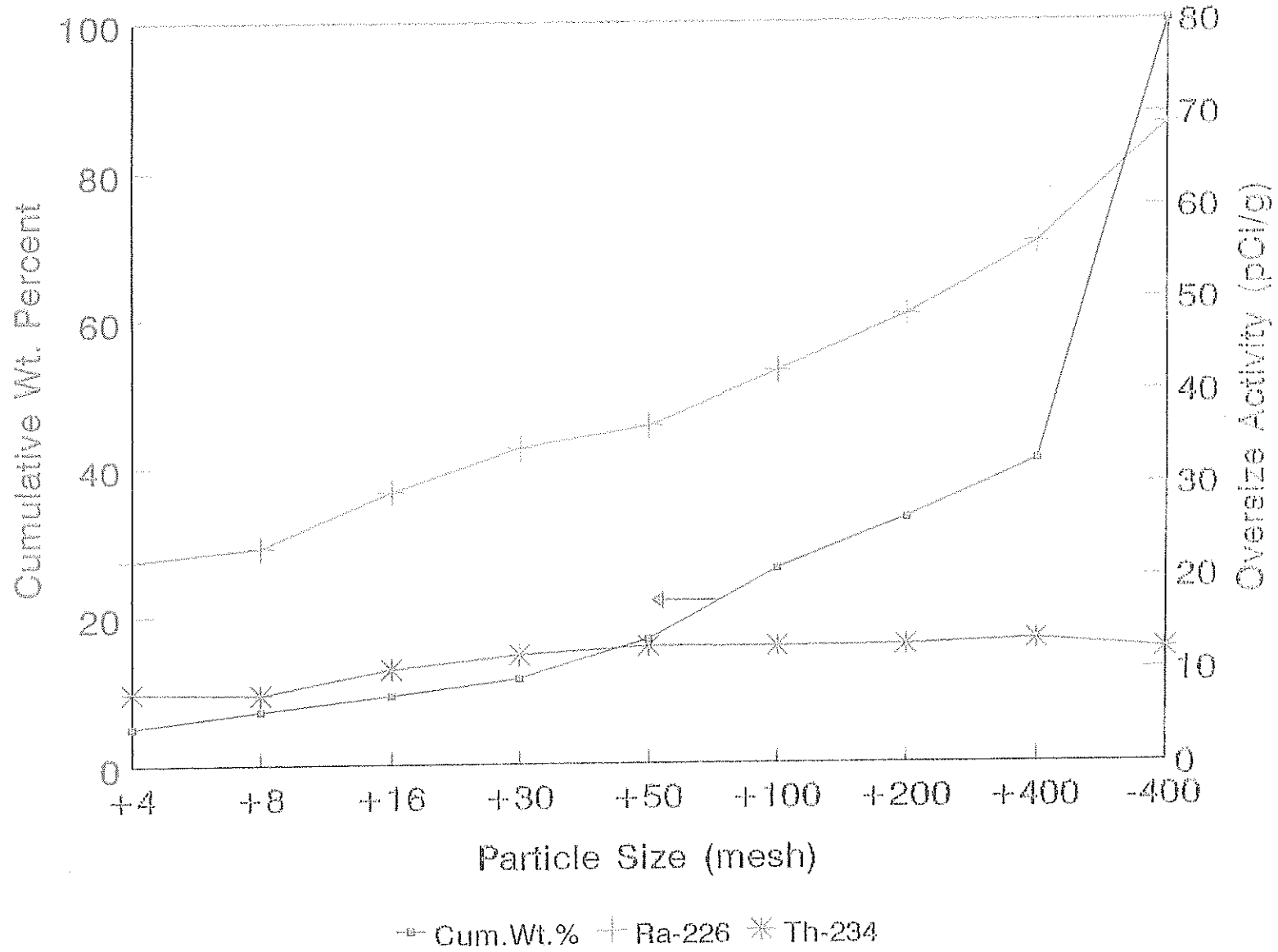

Figure 3-8 Seaway Systematic Particle-Size and Radionuclide Distributions

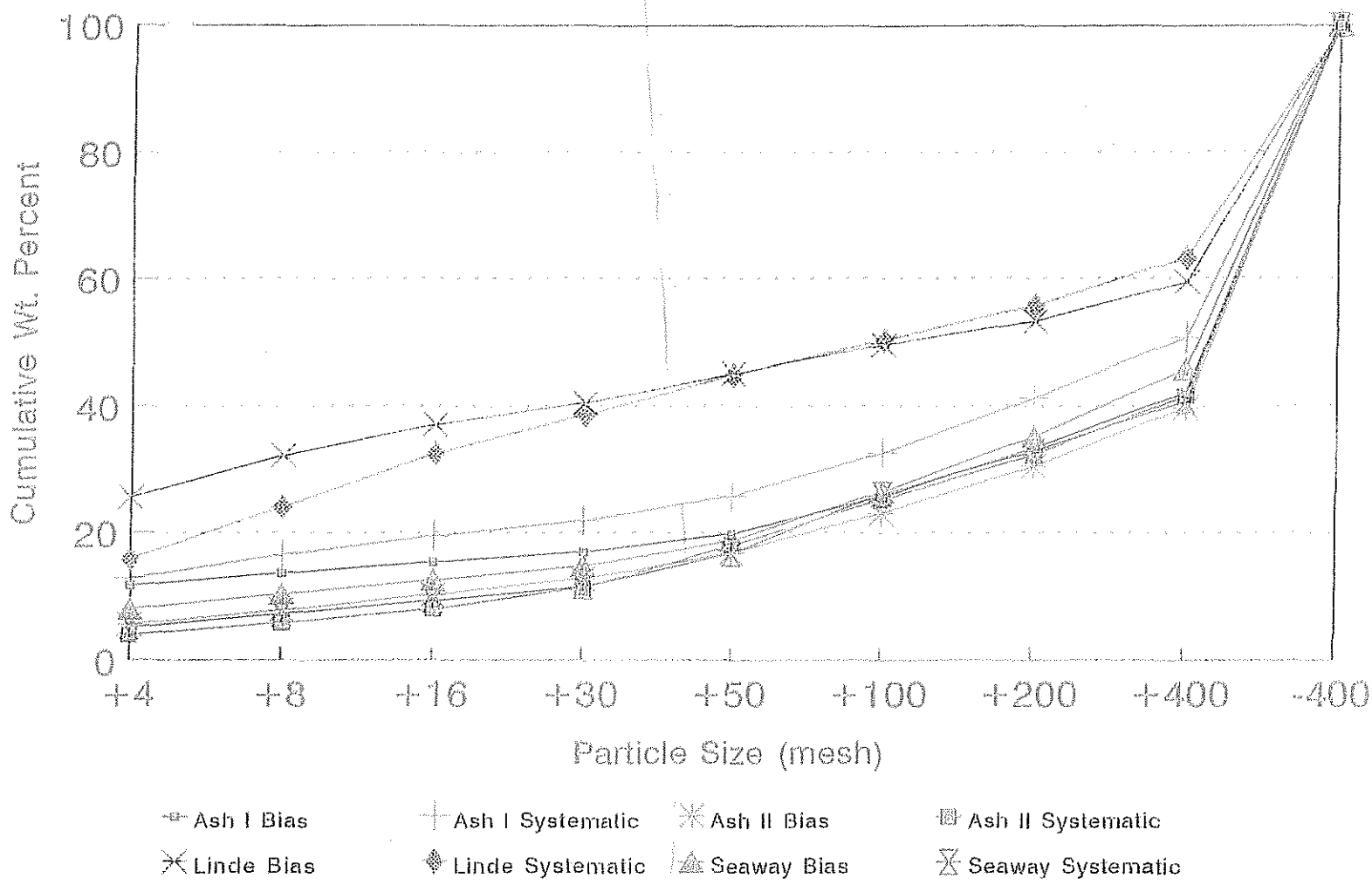

Figure 3-9 Particle Size Distributions of Tonawanda Soils

Data determined by gamma spectrometry[1] are presented for all whole soils and fractions and those from alpha spectrometry (U and Th) are given for the Ash I and Linde samples.

3.2.1 Ash I Samples

The radionuclide with the highest concentrations in the Ash I samples is Th-230. The average concentrations of Th-230 are 2,459 pCi/g and 1,724 pCi/g in the whole soils of Ash I Bias and Ash I Systematic, respectively. The values in the sieved fractions range from 406 to 1,748 pCi/g (coarse to fine) for Ash I Bias and from 179 to 1,637 pCi/g for Ash I Systematic (Tables A-1 and A-2). Ra-226, Th-234, U-234, and U-238 have approximately equal concentrations throughout all size fractions in both samples. They range from approximately 30 to 350 pCi/g (coarse to fine) for Ash I Bias and from approximately 30 to 170 pCi/g in Ash I Systematic (Tables A-1 and A-2 and Figures 3-1 and 3-2).

Because of the radionuclide concentrations found in all fractions for both Ash I samples, particle-size separation alone will not achieve the remediation factors required to meet site cleanup criteria. Further characterization is needed to determine if density differences between the host soil and the contaminant exist and could be exploited as a volume reduction process. Scout tests could determine if the radioactive contaminants exist in chemical forms that would permit volume reduction to be achieved through chemical extraction. A relative large extraction factor would be required for successful Th-230 removal and a moderate one for Ra-226 and uranium.

3.2.2 Ash II Samples

Only gamma spectrometry analyses were performed on the Ash II samples, thus no data are available for Th-230. The results of the gamma counts are provided in Tables A-3 and A-4 and illustrated in Figures 3-3 and 3-4. The Th-234 values may be used to estimate the U-238 concentrations since these two nuclides should be in equilibrium. The average ratio of Th-234 to U-238 as determined on the samples for which alpha spectrometry was performed (Ash I Bias, Ash I Systematic, Linde Bias, and Linde Systematic) is 0.88; therefore, the

[1]Because of the large amount of uranium present in the samples, especially in the Linde samples, the Ra-226 values as determined by gamma spectrometry may be in error. We attempted to correct the values by several calculational methods, but were unsuccessful. We have sealed aliquots of the samples to allow for ingrowth of radon in order to arrive at a more accurate determination of the Ra-226. The results of the second gamma counts were not available at the time of this interim report, but will be in the final report.

uranium concentration can be estimated from the Th-234 values derived from gamma analysis. There is no valid way to estimate the Th-230 concentrations. For further studies on these samples, the Th-230 concentrations must be determined by alpha spectrometry.

The Ra-226 concentrations in the whole soil samples are 180 pCi/g for Ash II Bias and 128 pCi/g in the Systematic sample (Tables A-3 and A-4). Based on the Th-234 gamma values, the U-234 and U-238 concentrations are approximately 120 and 70 pCi/g in the Ash II Bias and Systematic samples, respectively. The Ra-226 concentrations in the size fractions range from 43 to 197 pCi/g (coarse to fine) in the Bias sample and from 30 to 132 pCi/g in the Systematic sample.

Since none of the particle-size fractions of either the Bias or Systematic samples contain Ra-226 concentrations at or below 15 pCi/g, particle-size separation alone will not serve as a volume reduction technique to achieve site cleanup criteria. Continuation of the initial characterization study to evaluate the potential for density separation, as outlined in the original proposal, and to perform chemical extraction tests is recommended (Section 4.0) to evaluate these techniques as potential remediation methods.

3.2.3 Linde Samples

The Linde Bias whole-soil sample contains concentrations of U-234 and U-238 of approximately 300 pCi/g, Ra-226 of 410 pCi/g, and Th-230 of 245 pCi/g. The +50 material, which represents 45 percent of the sample, has concentrations of U-234 and U-238, Ra-226, and Th-230 of 105, 35, and 31 pCi/g, respectively. The uranium is virtually evenly distributed in the fractions with particle-sizes greater than 100 mesh. The analytical results are listed in Table A-5 and are shown in Figure 3-5.

The Ra-226 and Th-230 concentrations are greater than 15 pCi/g and the uranium above 60 pCi/g; therefore, particle-size separation techniques alone will not achieve results consistent with cleanup criteria. However, these results suggest a significant potential for volume reduction by attrition scrubbing of the +50 material in a solution that will extract the uranium. Attrition has the potential to reduce the radium and thorium concentrations by removing contaminated surface material from the coarse fractions. If the uranium can be removed so that it is primarily concentrated in the -50 material, volume-reduction may be possible.

The Linde Systematic whole-soil sample contains concentrations of U-234 and U-238 of approximately 150 pCi/g, Ra-226 of 270 pCi/g, and Th-230 of 140 pCi/g. The +100-mesh material, which represents 50 percent of the sample, has concentrations of U-234 and U-238, Ra-226, and Th-230 of 102 and 103, 64, and 37 pCi/g, respectively. The uranium and Ra-226 are approximately evenly distributed in the fractions with particle sizes greater than 200 mesh. The radioanalytical results are listed in Table A-6 and are illustrated in Figure 3-6.

Results from the Linde Systematic samples also suggest, as do the Linde Bias samples, that testing the effectiveness of attrition scrubbing to reduce the radioactivity in the +100-mesh material and chemically extracting the uranium would be reasonable studies to perform.

3.2.4 Seaway Samples

Only gamma analyses were performed on the Seaway samples, thus, it is not possible to determine the Th-230 concentrations.

The Seaway Bias sample data for Ra-226 and Th-234 are given in Table A-7 and illustrated in Figure 3-7. The Ra-226 and Th-234 concentrations in the whole-soil sample are 119 and 13 pCi/g, respectively. The U-238 and U-234 are expected to be below 60 pCi/g, based on the Th-234 values as determined by gamma spectrometry. None of the particle-size fractions have a Ra-226 concentration of 15 pCi/g or less. As previously stated, the Th-230 concentrations are unknown.

The Seaway Systematic sample data for Ra-226 and Th-234 concentrations are given in Table A-8 and illustrated in Figure 3-8. The Ra-226 and Th-234 concentrations in the whole-soil sample are 68 and 13 pCi/g, respectively. The U-238 and U-234 are expected to be below 60 pCi/g, based on the Th-234 values determined by gamma spectrometry. None of the particle-size fractions have a Ra-226 concentration of 15 pCi/g or less. However, the Ra-226 concentrations in the +100 and +200 fractions are the lowest encountered in the Tonawanda samples and may have the most potential for application of density separation or chemical extraction techniques as volume reduction methods, depending upon the Th-230 concentrations in this soil.

Continuation of the initial characterization study to evaluate the potential for density separation, as outlined in the original proposal, and performance of chemical extraction tests as potential remediation methods for the Seaway samples would allow for the evaluation of these techniques as potential remediation methods for this study, following alpha spectrometry analysis of the Systematic samples (see Section 4.0).

4.0 RECOMMENDATIONS

Analysis of data from the eight Tonawanda samples examined in this study (Section 3.0) demonstrates that particle-size separation alone will not provide a successful remediation solution for any of the sites. (The data indicate, however, that other physical and/or chemical properties of the samples might provide an approach to volume reduction, reducing the contaminants to acceptable levels.) Specific tests are recommended to evaluate the potential for remediation using these properties and provide additional information to assess the radionuclide concentrations of several samples:

1. In an effort to control the cost of radioanalysis in this study, alpha spectrometry analyses of Ash II and Seaway samples were not performed. The study demonstrates that Ash I contains high levels of Th-230 relative to U-238 and Ra-226. High levels of Th-230 might make remediation by simple physical separation or chemical extraction procedures difficult. Ash II and Seaway samples likely contain similar concentrations of Th-230 to those of Ash I, since those sites received material from Ashland 1 in the past. However, the actual concentrations of Th-230 in these soil samples are not known. With only whole-soil material remaining from Ash II Bias and Seaway Systematic soil samples after the study, the following recommendation is made:

   Perform thorium-230 analysis on all Ash II Systematic fractions, the Ash II whole soil sample, all Seaway Bias fractions, and the Seaway Systematic whole soil sample.

2. The Linde Bias and Systematic soils contain 45 percent +50-mesh material with Ra-226, Th-230, and U-238 at concentrations that might be reduced to proposed standard levels (5/15 pCi/g for Ra-226 and Th-230 and 60 pCi/g for U-238) by additional physical or chemical treatment. To reach acceptable concentrations, the Ra-226 and Th-230 must be reduced by approximately one-half to one-fourth and the

U-238 by less than one-half. The following recommendations are made to evaluate two methods to reduce the contaminant levels in the +50-mesh fraction, one based on chemical extraction experience with radium, thorium, and uranium contaminated soils (EPA89) and the other based on experience with soil washing in the presence of mild solubilizing solutions (RIC89):

(a) Perform a scout chemical extraction procedure by treating Linde Bias and Systematic +50-mesh fractions with nitric acid under conditions that maximize removal of radium, thorium, and uranium. Hot, dilute nitric acid solutions have been very effective in removing these radionuclides in previous soil studies (EPA89). If successful, the nitric acid process might be substituted with sequential extraction procedures that duplicate the extractive capacity of the acid but use less corrosive salt and acid solutions. Gamma and alpha spectrometry analyses will be performed on starting material (+50-mesh fractions), extracted fractions, extracting solution, and filters used to separate the solution.

(b) Perform an attrition study on Linde Bias and Systematic +50-mesh fractions using a mild (0.5 molar) uranium solubilizing agent of aqueous sodium bicarbonate solution to remove surface coatings on the particles of the fractions and to solubilize uranium contaminants. The +50-mesh material will be collected on a 50-mesh sieve and the -50-mesh material will collected by filtration. Gamma and alpha spectrometry analyses will be performed on both fractions and the filtered solution.

3. Other physical properties might be used to separate the contaminating material from the host soil. One candidate property is density or gravity concentration (Bur84). Several radiominerals and contaminated process material have a density greater than typical soil (2.8 g/cc) and might be separated using this density difference. Linde and Seaway soils have a higher potential for remediation by this method since they contain lower concentrations of thorium-230 than do the Ash I and Ash II soils. The following recommendation is made for a scout density separation study of the Linde and Seaway Bias and Systematic soils and the Ash I and Ash II Systematic soils:

Combine the particle-size separation fractions from the soils into three fractions: +50-mesh (+0.297-mm), -50/+200-mesh (-0.297/+0.074-mm), and -200/+400-mesh (-0.074/+0.037-mm). Separate aliquots of the three fractions by the sink-float method

using a sodium polytungstate solution with a density of 2.89 g/cc. Perform alpha spectrometry analysis on both heavy and light fractions (the less-dense and more-dense fractions), and gamma spectrometry analysis on the light fraction only. If density separation appears to be a promising remediation technique, perform the separation on the Ash I and Ash II Bias soils also.

4. Petrographic studies have been successful in identifying radiominerals and radionuclide-contaminated process materials (EPA93 and EPA94). Specific identification of contaminant material will provide information that might be useful in selecting alternate remediation techniques. The following recommendation is made for petrographic analyses:

   Examine aliquots from the three combined fractions of Linde and Seaway Bias and Systematic soils, described above in recommendation three, as well as aliquots from the heavy fractions produced by heavy-liquid separation of both soils using both binocular and polarizing petrographic microscopes. Make a statistical count of 150 to 300 grains on each size fraction and heavy mineral fraction to determine the mineral composition of the soil.

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SCA91a S. Cohen and Associates, Inc. Procedure for Vigorous Washing of Soil Samples. SCA-301. January 1991.

SCA91b S. Cohen and Associates, Inc. Procedure for Separating Soils by Particle Size - Hand Sieving. SCA-401. January 1991.

APPENDIX A

TABLES OF RESULTS

TABLE
Ash I E
Gamma Spectrometry A is Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8344	Whole Soil-Aliquot	358.46		421	7.3	1.1	0.4	90.1	1.9	355	6.6	25.7	0.4
8345	Whole Soil-Aliquot	369.35		192	5.4	0	0	81.6	2.2	288	6.5	12.2	0.3
8346	Whole Soil-Aliquot	381.72		338	6.5	1.1	0.4	72.3	1.7	284	5.9	20.7	0.4
8347	Whole Soil-Aliquot	397.8		386	7.9	0	0	83.1	2.2	358	7.3	23.6	0.5
	Total	2070.16											
8348	+4 mesh	236.71	11.73	29.2	0.6	0.8	0.1	3.5	0.1	21.4	0.5	1.8	0.0
8349	-4/+8 mesh	39.61	1.96	86.3	10.4	0	0	17.2	3.0	45.6	6.6	5.4	0.6
8350	-8/+16 mesh	34.22	1.70	158	11.2	0	0	43.7	4.1	134	15.4	9.7	0.7
8351	-16/+30 mesh	31.94	1.58	196	10.8	0	0	58.2	3.5	144	10.8	11.9	0.6
8352	-30/+50 mesh	57.29	2.84	455	14.7	0	0	128	4.6	305	14.7	28.1	0.9
8353	-50/+100 mesh	117	5.80	566	12.8	0	0	141	3.6	405	13	34.9	0.7
8354	-100/+200 mesh	155.23	7.69	523	10.5	1.4	0.6	112	2.9	341	8.4	31.9	0.6
8355	-200/+400 mesh	178.68	8.85	497	11.8	0	0	105	3.0	381	9.3	30.3	0.7
8356	-400 mesh	1167.77	57.85	413	6.9	1.6	0.4	85.1	1.8	386	7.0	25.3	0.4
	Total	2018.45											

Alpha Spectrometry Analyses Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	U-234		U-235		U-238		Th-227		Th-228		Th-230		Th-232	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8344	Whole Soil-Aliquot	358.46		329.5	40.4	19.8	8.9	335.5	40.7	85.6	27.4	-1.7	-16.1	2063.8	102.0	23.9	10.3
8345	Whole Soil-Aliquot	369.35		391.0	29.2	17.8	4.1	396.1	29.6	49.8	28.3	19.2	18.8	1470.3	109.5	12.6	10.4
8346	Whole Soil-Aliquot	381.72		421.8	53.6	18.7	10.1	375.7	49.8	115.8	35.0	10.3	18.4	2597.1	126.5	19.3	9.7
8347	Whole Soil-Aliquot	397.8		361.1	46.7	25.1	11.2	353.5	45.9	65.6	23.2	-8.8	-13.6	2267.5	104.5	8.3	6.4
	Total	2070.16															
8348	+4 mesh	236.71	11.73	43.2	6.0	2.3	1.3	46.7	6.3	15.3	5.9	0.0	4.2	393.8	22.4	3.1	2.0
8349	-4/+8 mesh	39.61	1.96	71.2	10.2	2.0	1.7	66.3	9.9	20.3	6.0	3.4	3.8	580.5	25.9	1.6	1.2
8350	-8/+16 mesh	34.22	1.70	116.7	17.2	4.1	3.2	107.5	16.4	18.4	6.0	2.0	4.0	507.4	25.0	2.4	1.6
8351	-16/+30 mesh	31.94	1.58	238.4	20.5	9.1	2.9	215.2	19.0	66.3	32.8	-77.2	-21.9	1295.8	102.8	3.7	8.1
8352	-30/+50 mesh	57.29	2.84	302.8	18.0	14.1	2.6	294.8	17.6	87.1	36.7	-88.4	-16.0	2585.0	144.5	13.4	10.2
8353	-50/+100 mesh	117	5.80	358.2	22.2	17.8	3.1	342.2	21.4	83.8	34.1	-82.2	-15.5	2289.4	131.6	3.7	5.7
8354	-100/+200 mesh	155.23	7.69	363.1	23.7	16.7	3.2	349.7	22.9	61.8	32.2	-78.9	-20.0	2164.9	140.9	2.0	4.0
8355	-200/+400 mesh	178.68	8.85	309.9	19.8	14.0	2.9	319.9	20.3	125.2	45.0	-72.6	-20.7	1698.2	117.2	8.9	9.9
8356	-400 mesh	1167.77	57.85	311.1	31.3	9.5	4.4	307.4	31.0	50.2	14.0	1.0	7.9	1583.4	68.6	0.9	2.5
	Total	2018.45															

TABLE A-1 (continued)
Ash 1 B
Oversize A

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity									
		Gamma Spectrometry			Alpha Spectrometry						
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)	U-234 (pCi/gdry)	U-235 (pCi/gdry)	U-238 (pCi/gdry)	Th-227 (pCi/gdry)	Th-228 (pCi/gdry)	Th-230 (pCi/gdry)	Th-232 (pCi/gdry)
+4	11.73	29.2	0.8	21.4	43.2	2.3	46.7	15.3	0.0	393.8	3.1
+8	13.69	37.4	0.7	24.9	47.2	2.3	49.5	15.9	0.5	420.5	2.9
+16	15.39	50.7	0.6	36.9	54.9	2.5	55.9	16.0	0.7	430.1	2.9
+30	16.97	64.2	0.6	46.9	72.0	3.1	70.8	20.9	-6.6	510.8	3.0
+50	19.81	120.2	0.5	83.9	105.1	4.7	102.9	30.4	-18.3	808.1	4.5
+100	25.60	221.2	0.4	156.6	162.4	7.6	157.1	42.5	-32.8	1143.5	4.3
+200	33.29	290.9	0.6	199.2	208.8	9.7	201.6	46.9	-43.4	1379.4	3.8
+400	42.15	334.2	0.5	237.4	230.0	10.6	226.4	63.4	-49.5	1446.4	4.8
-400	100.00	379.8	1.1	323.4	276.9	10.0	273.3	55.8	-20.3	1525.6	2.6

TABLE A
Ash I Syst
Gamma Spectrometry A is Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8358	Whole Soil-Aliquot	415.55		176	4.8	1.0	0.4	56.5	1.5	98.1	4.2	10.7	0.3
8359	Whole Soil-Aliquot	434.7		180	6.0	0	0	48.5	1.8	74.7	4.1	10.9	0.4
8360	Whole Soil-Aliquot	375.5		201	5.2	1.0	0.4	63.6	1.6	95.8	3.8	12.4	0.3
8361	Whole Soil-Aliquot	379.16		206	1.9	1.1	0.2	62.9	0.5	101	1.5	12.7	0.1
	Total	1969.82											
8362	+4 mesh	251.04	12.80	34	2.2	0.6	0.2	6.8	0.6	19.5	2.0	2.1	0.1
8363	-4/+8 mesh	71.91	3.67	63.9	5.6	0	0	17.3	1.8	42	4.5	3.9	0.3
8364	-8/+16 mesh	57.26	2.92	112	2.9	1.1	0.3	33.9	0.9	69.6	2.5	6.9	0.2
8365	-16/+30 mesh	47.79	2.44	164	10.9	0	0	50.9	3.4	86.9	7.6	10.0	0.6
8366	-30/+50 mesh	75.97	3.87	202	14.1	0	0	66.4	4.9	86.1	9.1	12.4	0.8
8367	-50/+100 mesh	133.2	6.79	258	8.2	0	0	80.6	2.5	203	10.8	15.9	0.5
8368	-100/+200 mesh	170.57	8.70	230	7.2	0	0	73.3	2.2	144	7.5	14.1	0.4
8369	-200/+400 mesh	183.94	9.38	244	8.4	1.4	0.6	81.2	2.6	144	7.9	15.1	0.5
8370	-400 mesh	969.52	49.44	167	6.9	1.5	0.6	48.3	2.1	80	4.6	9.9	0.4
	Total	1961.2											

Alpha Spectrometry Analyses Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	U-234		U-235		U-238		Th-227		Th-228		Th-230		Th-232	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8358	Whole Soil-Aliquot	415.55		87.7	21.5	1.6	3.5	80.9	19.9	50.1	27.0	-1.8	-21.1	1254.4	95.5	12.9	9.1
8359	Whole Soil-Aliquot	434.7		153.3	29.5	5.6	5.8	105.5	24.2	71.0	34.0	-8.0	-17.7	1670.8	110.9	3.1	6.6
8360	Whole Soil-Aliquot	375.5		135.6	23.9	5.5	4.7	140.9	24.4	56.7	30.7	20.2	23.7	1984.3	127.6	18.8	23.4
8361	Whole Soil-Aliquot	379.16		98.4	13.6	4.8	2.8	93.9	13.3	43.7	11.9	2.3	7.1	1206.0	52.6	10.0	4.2
	Total	1969.82															
8362	+4 mesh	251.04	12.80	38.2	8.2	2.3	2.0	33.1	7.5	4.5	5.8	-2.0	-7.1	168.2	18.2	0.9	1.7
8363	-4/+8 mesh	71.91	3.67	59.3	7.7	2.4	1.4	62.0	7.8	16.0	5.8	-0.5	-3.7	419.6	22.7	1.9	1.4
8364	-8/+16 mesh	57.26	2.92	73.3	8.5	6.0	2.2	71.0	8.3	27.4	7.5	1.1	3.9	764.0	33.5	4.5	2.1
8365	-16/+30 mesh	47.79	2.44	79.9	9.4	5.2	2.1	86.0	9.7	32.5	16.4	-0.3	-6.8	734.5	53.2	2.8	3.5
8366	-30/+50 mesh	75.97	3.87	143.2	12.9	8.8	2.6	135.3	12.4	57.9	28.7	-71.5	-15.4	1400.0	103.2	4.5	6.0
8367	-50/+100 mesh	133.2	6.79	178.8	18.2	10.3	3.8	177.2	18.0	141.5	60.0	4.2	25.7	3722.8	233.0	17.7	15.5
8368	-100/+200 mesh	170.57	8.70	133.1	12.4	5.2	2.0	137.2	12.7	48.3	27.8	5.1	15.4	1737.4	122.1	5.7	6.6
8369	-200/+400 mesh	183.94	9.38	112.8	12.6	7.5	2.7	118.9	13.0	42.0	24.9	2.8	12.7	1189.7	94.2	7.9	8.6
8370	-400 mesh	969.52	49.44	188.7	111.4	22.6	32.0	208.1	112.3	70.6	18.5	-1.1	-8.4	1608.4	78.7	4.5	3.3
	Total	1961.2															

TABLE A-2 (c
Ash I Syste
Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity									
		Gamma Spectrometry			Alpha Spectrometry						
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)	U-234 (pCi/gdry)	U-235 (pCi/gdry)	U-238 (pCi/gdry)	Th-227 (pCi/gdry)	Th-228 (pCi/gdry)	Th-230 (pCi/gdry)	Th-232 (pCi/gdry)
+4	12.80	34.0	0.6	19.5	38.2	2.3	33.1	4.5	-2.0	168.2	0.9
+8	16.47	40.7	0.5	24.5	42.9	2.3	39.6	7.0	-1.7	224.1	1.1
+16	19.39	51.4	0.6	31.3	47.5	2.9	44.3	10.1	-1.3	305.5	1.6
+30	21.82	64.0	0.5	37.5	51.1	3.1	49.0	12.6	-1.2	353.4	1.8
+50	25.70	84.8	0.4	44.8	65.0	4.0	62.0	19.4	-11.8	511.1	2.2
+100	32.49	121.0	0.3	77.9	88.8	5.3	86.1	44.9	-8.4	1182.5	5.4
+200	41.19	144.0	0.3	91.9	98.1	5.3	96.9	45.6	-5.6	1299.7	5.5
+400	50.56	162.6	0.5	101.5	100.9	5.7	100.9	45.0	-4.0	1279.3	5.9
-400	100.00	164.8	1.0	90.9	144.3	14.1	153.9	57.6	-2.6	1442.0	5.2

TABLE A
Ash II B
Gamma Spectrometry A[illegible]s Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8400	Whole Soil-Aliquot	494.72		180.0	4.2	0.9	0.3	57.9	1.3	125.0	3.9	11.0	0.2
8401	Whole Soil-Aliquot	488.82		190.0	8.1	0.0	0.0	58.5	2.3	98.2	6.1	11.5	0.5
8402	Whole Soil-Aliquot	485.3		178.0	4.5	1.0	0.3	55.6	1.3	118.0	4.2	10.9	0.3
8403	Whole Soil-Aliquot	490.1		176.0	4.8	1.0	0.3	59.3	1.3	144.0	4.7	10.7	0.3
	Total	1958.94											
8404	+4 mesh	106.28	5.59	42.8	2.7	0.0	0.0	11.0	0.9	31.0	2.5	2.6	0.2
8405	-4/+8 mesh	42.88	2.25	180.0	12.8	0.0	0.0	69.5	4.3	111.0	10.0	11.1	0.7
8406	-8/+16 mesh	45.1	2.37	292.0	14.1	0.0	0.0	106.0	4.5	171.0	11.4	17.8	0.8
8407	-16/+30 mesh	48.47	2.55	355.0	17.3	0.0	0.0	125.0	5.7	232.0	13.8	22.1	1.0
8408	-30/+50 mesh	75.53	3.97	329.0	9.6	0.0	0.0	108.0	2.9	223.0	8.1	20.4	0.6
8409	-50/+100 mesh	118.81	6.25	385.0	10.4	0.0	0.0	121.0	2.9	248.0	8.1	23.7	0.6
8410	-100/+200 mesh	140.51	7.39	345.0	8.7	0.0	0.0	102.0	2.6	228.0	7.9	21.1	0.5
8411	-200/+400 mesh	175.87	9.25	232.0	7.6	0.0	0.0	76.3	2.4	144.0	5.2	14.2	0.4
8412	-400 mesh	1148.25	60.38	150.0	4.4	1.5	0.3	52.7	1.4	86.6	3.6	9.2	0.3
	Total	1901.7											

Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity Gamma Spectrometry		
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)
+4	5.59	42.8	0.0	31.0
+8	7.84	82.2	0.0	54.0
+16	10.22	130.9	0.0	81.2
+30	12.76	175.7	0.0	111.3
+50	16.74	212.1	0.0	137.8
+100	22.98	259.1	0.0	167.8
+200	30.37	280.0	0.0	182.4
+400	39.62	268.8	0.0	173.4
-400	100.00	197.1	0.9	121.0

TABLE A
Ash II Syst
Gamma Spectrometry A s Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8414	Whole Soil-Aliquot	530.05		122.0	3.7	0.8	0.2	27.6	0.9	60.8	2.8	7.4	0.2
8415	Whole Soil-Aliquot	529.25		111.0	3.4	0.9	0.2	31.4	1.1	54.7	2.7	6.8	0.2
8416	Whole Soil-Aliquot	503.97		154.0	5.1	0.0	0.0	41.5	1.6	94.2	3.7	9.3	0.3
8417	Whole Soil-Aliquot	515.74		126.0	4.5	1.2	0.3	35.2	1.3	69.6	3.8	7.6	0.3
	Total	2079.01											
8418	+4 mesh	80.2	3.99	30.2	2.5	0.7	0.2	4.8	0.7	14.9	2.4	1.8	0.2
8419	-4/+8 mesh	37.61	1.87	154.0	11.6	0.0	0.0	54.1	3.7	76.5	7.6	9.5	0.7
8420	-8/+16 mesh	43.63	2.17	194.0	10.9	0.0	0.0	65.3	3.6	96.4	7.7	12.0	0.6
8421	-16/+30 mesh	67	3.33	233.0	11.0	0.0	0.0	66.0	3.0	122.0	8.4	14.5	0.6
8422	-30/+50 mesh	132.42	6.59	149.0	5.6	0.0	0.0	41.6	1.6	78.0	4.5	9.1	0.3
8423	-50/+100 mesh	143.53	7.14	177.0	7.8	0.0	0.0	46.5	2.3	111.0	7.1	10.8	0.5
8424	-100/+200 mesh	142.16	7.07	235.0	7.1	0.0	0.0	62.2	2.2	125.0	5.6	14.3	0.4
8425	-200/+400 mesh	189.28	9.42	156.0	6.1	0.0	0.0	41.7	1.8	80.8	4.0	9.5	0.4
8426	-400 mesh	1174.4	58.42	107.0	4.8	0.8	0.4	28.0	1.2	56.3	3.3	6.4	0.3
	Total	2010.23											

Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity Gamma Spectrometry		
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)
+4	3.99	30.2	0.7	14.9
+8	5.86	69.7	0.5	34.6
+16	8.03	103.3	0.3	51.3
+30	11.36	141.3	0.2	72.0
+50	17.95	144.2	0.2	74.2
+100	25.09	153.5	0.1	84.7
+200	32.16	171.4	0.1	93.5
+400	41.58	167.9	0.1	90.7
-400	100.00	132.3	0.5	70.6

TABLE A
Linde B
Gamma Spectrometry A s Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8372	Whole Soil-Aliquot	594.05		455.0	6.8	0.9	0.5	12.7	1.5	317.0	4.6	26.3	0.4
8373	Whole Soil-Aliquot	619.04		375.0	1.7	0.9	0.1	4.9	0.3	288.0	1.3	22.1	0.1
8374	Whole Soil-Aliquot	615.42		405.0	6.9	0.0	0.0	11.0	1.6	291.0	6.6	23.5	0.4
8375	Whole Soil-Aliquot	607.66		405.0	6.4	0.6	0.4	7.0	1.0	224.0	5.2	23.5	0.4
	Total	2436.17											
8376	+4 mesh	614.52	25.49	8.9	2.0	0.8	0.1	0.0	0.0	34.9	1.8	2.4	0.1
8377	-4/+8 mesh	160.22	6.64	45.4	7.3	0.0	0.0	0.0	0.0	92.1	5.0	5.8	0.4
8378	-8/+16 mesh	119.38	4.95	93.1	8.9	0.0	0.0	0.0	0.0	120.0	5.4	7.0	0.5
8379	-16/+30 mesh	81.46	3.38	80.0	10.8	0.0	0.0	0.0	0.0	113.0	6.2	8.9	0.6
8380	-30/+50 mesh	109.79	4.55	71.2	8.9	0.0	0.0	0.0	0.0	115.0	7.2	6.9	0.5
8381	-50/+100 mesh	107.37	4.45	237.0	9.5	0.0	0.0	2.5	1.8	127.0	7.9	13.7	0.6
8382	-100/+200 mesh	89.65	3.72	482.0	13.4	0.0	0.0	0.0	0.0	213.0	8.9	27.7	0.8
8383	-200/+400 mesh	148.79	6.17	569.0	12.3	0.0	0.0	19.2	3.3	279.0	6.6	32.5	0.7
8384	-400 mesh	980.01	40.64	723.0	8.1	0.0	0.0	21.1	2.0	61.9	6.7	42.0	0.5
	Total	2411.19											

Alpha Spectrometry Analyses Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	U-234		U-235		U-238		Th-227		Th-228		Th-230		Th-232	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8372	Whole Soil-Aliquot	594.05		314.8	31.5	13.4	5.3	308.3	31.0	11.3	6.2	-4.3	-5.8	233.9	19.2	1.2	1.5
8373	Whole Soil-Aliquot	619.04		289.8	29.6	9.5	4.5	277.8	28.7	11.4	7.7	0.3	8.5	306.6	28.1	7.1	4.1
8374	Whole Soil-Aliquot	615.42		293.5	26.9	16.6	5.2	318.5	28.4	11.2	4.7	-1.0	-3.2	185.3	12.9	0.6	0.9
8375	Whole Soil-Aliquot	607.66		310.2	25.1	9.6	3.5	300.9	24.6	13.1	7.2	-3.4	-6.1	254.3	20.7	1.1	1.8
	Total	2436.17															
8376	+4 mesh	614.52	25.49	87.4	10.9	3.9	2.0	87.1	10.9	3.5	3.1	2.7	4.1	24.7	5.3	3.5	3.6
8377	-4/+8 mesh	160.22	6.64	127.0	10.3	8.1	2.2	136.6	10.8	1.5	2.6	1.7	4.3	36.0	6.4	2.1	1.6
8378	-8/+16 mesh	119.38	4.95	133.5	11.0	5.7	1.9	135.4	11.2	3.6	3.8	-0.3	-4.2	30.4	6.2	0.6	0.9
8379	-16/+30 mesh	81.46	3.38	110.1	11.3	6.5	2.6	113.0	11.7	13.1	18.5	2.8	14.3	28.8	23.1	0.0	0.0
8380	-30/+50 mesh	109.79	4.55	134.7	12.2	5.2	2.0	123.2	11.5	7.0	4.1	-1.3	-4.0	56.9	8.4	1.3	1.4
8381	-50/+100 mesh	107.37	4.45	157.6	15.1	9.3	3.0	154.8	14.8	16.0	20.6	2.9	12.8	107.3	30.5	2.1	6.6
8382	-100/+200 mesh	89.65	3.72	230.8	20.5	9.2	3.0	242.5	21.3	10.5	16.5	-64.3	-14.3	226.4	39.5	5.1	5.9
8383	-200/+400 mesh	148.79	6.17	301.3	22.3	14.0	3.3	304.9	22.5	16.4	6.7	-18.6	-3.0	324.4	21.7	2.5	1.8
8384	-400 mesh	980.01	40.64	468.7	43.2	19.0	6.5	431.4	40.7	19.8	9.7	-1.3	-8.4	449.8	33.7	2.5	3.0
	Total	2411.19															

TABLE A-5 (co[illegible])
Linde B[illegible]
Oversize Act[illegible]

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity									
		Gamma Spectrometry			Alpha Spectrometry						
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)	U-234 (pCi/gdry)	U-235 (pCi/gdry)	U-238 (pCi/gdry)	Th-227 (pCi/gdry)	Th-228 (pCi/gdry)	Th-230 (pCi/gdry)	Th-232 (pCi/gdry)
+4	25.49	8.9	0.8	34.9	87.4	3.9	87.1	3.5	2.7	24.7	3.5
+8	32.13	16.4	0.6	46.7	95.5	4.8	97.3	3.1	2.5	27.1	3.2
+16	37.08	26.7	0.6	56.5	100.6	4.9	102.4	3.2	2.1	27.5	2.9
+30	40.46	31.1	0.5	61.2	101.4	5.0	103.3	4.0	2.2	27.6	2.7
+50	45.01	35.2	0.5	66.7	104.8	5.0	105.3	4.3	1.8	30.6	2.5
+100	49.47	53.3	0.4	72.1	109.5	5.4	109.7	5.3	1.9	37.5	2.5
+200	53.18	83.3	0.4	81.9	118.0	5.7	119.0	5.7	-2.7	50.7	2.7
+400	59.36	133.8	0.3	102.4	137.1	6.6	138.3	6.8	-4.3	79.1	2.6
-400	100.00	373.3	0.2	86.0	271.8	11.6	257.5	12.1	-3.1	229.8	2.6

TABLE A
Linde Syst
Gamma Spectrometry s Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8386	Whole Soil-Aliquot	484.76		300.0	6.3	0.0	0.0	10.1	1.6	176.0	5.2	17.6	0.4
8387	Whole Soil-Aliquot	532.4		260.0	4.8	0.9	0.3	2.9	0.9	160.0	3.3	14.9	0.3
8388	Whole Soil-Aliquot	520.72		244.0	4.9	0.0	0.0	8.1	1.2	123.0	4.0	14.2	0.3
8389	Whole Soil-Aliquot	468.06		274.0	4.9	1.1	0.4	3.1	0.9	160.0	3.8	15.9	0.3
	Total	2005.94											
8390	+4 mesh	313.74	15.82	23.5	3.0	0.8	0.2	0.0	0.0	58.3	2.4	4.6	0.2
8391	-4/+8 mesh	161.12	8.12	145.0	4.3	0.0	0.0	0.0	0.0	102.0	3.4	8.3	0.2
8392	-8/+16 mesh	167.44	8.44	50.3	3.3	0.0	0.0	0.0	0.0	74.4	2.6	4.0	0.2
8393	-16/+30 mesh	122.09	6.16	78.0	8.1	0.0	0.0	0.0	0.0	85.3	6.1	5.4	0.4
8394	-30/+50 mesh	123.7	6.24	58.6	6.7	0.9	0.5	0.0	0.0	84.8	5.0	5.2	0.4
8395	-50/+100 mesh	107.04	5.40	74.9	9.0	0.0	0.0	0.0	0.0	80.7	5.3	6.1	0.5
8396	-100/+200 mesh	108.03	5.45	136.0	14.3	0.0	0.0	0.0	0.0	109.0	7.9	6.9	0.8
8397	-200/+400 mesh	149.91	7.56	247.0	10.3	0.0	0.0	4.1	2.2	117.0	9.0	14.2	0.6
8398	-400 mesh	730.29	36.82	365.0	6.2	1.0	0.5	8.5	1.3	156.0	4.4	21.1	0.4
	Total	1983.36											

Alpha Spectrometry Analyses Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	U-234		U-235		U-238		Th-227		Th-228		Th-230		Th-232	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8386	Whole Soil-Aliquot	484.76		148.4	13.3	4.9	2.0	143.7	13.1	11.6	5.2	-1.0	-3.6	162.9	13.5	4.8	3.8
8387	Whole Soil-Aliquot	532.4		154.9	14.7	6.5	2.4	158.6	14.9	6.7	3.7	-2.2	-3.3	125.7	11.2	1.8	1.3
8388	Whole Soil-Aliquot	520.72		150.2	13.2	9.4	2.7	148.4	13.1	5.9	3.4	-5.4	-2.9	152.0	12.4	1.5	1.3
8389	Whole Soil-Aliquot	468.06		134.5	13.0	5.9	2.5	147.4	13.9	7.8	3.8	-1.9	-3.3	112.9	10.1	2.4	1.8
	Total	2005.94															
8390	+4 mesh	313.74	15.82	102.7	9.5	5.3	1.9	107.6	9.8	3.2	3.0	-0.1	-4.4	23.1	5.4	0.8	1.3
8391	-4/+8 mesh	161.12	8.12	110.5	12.9	5.3	2.4	110.5	12.9	2.2	2.6	0.8	3.9	21.8	4.6	0.9	1.0
8392	-8/+16 mesh	167.44	8.44	119.1	13.6	6.3	2.6	103.7	12.3	3.6	3.8	-1.4	-4.2	63.2	9.0	2.2	1.6
8393	-16/+30 mesh	122.09	6.16	86.4	10.6	5.1	2.3	101.4	11.7	5.8	3.8	1.0	4.3	30.9	6.3	1.0	1.2
8394	-30/+50 mesh	123.7	6.24	90.4	9.9	2.6	1.5	93.2	10.0	4.3	3.6	2.2	4.5	40.2	7.0	0.6	0.8
8395	-50/+100 mesh	107.04	5.40	89.6	8.7	5.7	1.9	90.5	8.7	5.0	3.5	0.7	4.3	60.5	8.6	1.1	1.4
8396	-100/+200 mesh	108.03	5.45	115.9	10.9	6.4	2.2	115.1	10.9	10.4	4.8	0.0	-3.9	151.5	13.1	0.9	1.6
8397	-200/+400 mesh	149.91	7.56	137.5	12.3	5.0	1.9	124.4	11.5	6.5	4.0	-3.0	-2.2	184.8	13.6	1.9	1.4
8398	-400 mesh	730.29	36.82	170.5	16.4	7.0	2.6	192.5	17.9	21.8	6.3	1.6	4.0	304.2	18.6	3.7	1.9
	Total	1983.36															

TABLE A-6 (continued)
Linde System
Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity									
		Gamma Spectrometry			Alpha Spectrometry						
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)	U-234 (pCi/gdry)	U-235 (pCi/gdry)	U-238 (pCi/gdry)	Th-227 (pCi/gdry)	Th-228 (pCi/gdry)	Th-230 (pCi/gdry)	Th-232 (pCi/gdry)
+4	15.82	23.5	0.8	58.3	102.7	5.3	107.6	3.2	-0.1	23.1	0.8
+8	23.94	64.7	0.5	73.1	105.4	5.3	108.6	2.8	0.2	22.6	0.8
+16	32.38	61.0	0.4	73.5	109.0	5.6	107.3	3.1	-0.2	33.2	1.2
+30	38.54	63.7	0.3	75.4	105.4	5.5	106.3	3.5	0.0	32.8	1.2
+50	44.78	63.0	0.4	76.7	103.3	5.1	104.5	3.6	0.3	33.9	1.1
+100	50.17	64.3	0.4	77.1	101.8	5.2	103.0	3.7	0.3	36.7	1.1
+200	55.62	71.3	0.3	80.2	103.2	5.3	104.2	4.4	0.3	48.0	1.1
+400	63.18	92.3	0.3	84.6	107.3	5.2	106.6	4.6	-0.1	64.3	1.2
-400	100.00	192.7	0.5	110.9	130.6	5.9	138.2	11.0	0.5	152.7	2.1

TABLE A-7
Seaway [illegible]
Gamma Spectrometry [illegible] Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8428	Whole Soil-Aliquot	402.4		153.0	6.1	0.0	0.0	24.6	1.6	7.5	2.4	9.0	0.4
8429	Whole Soil-Aliquot	421.96		138.0	4.3	0.9	0.3	22.8	1.2	18.5	2.5	8.3	0.3
8430	Whole Soil-Aliquot	407.2		158.0	5.4	0.0	0.0	29.8	1.5	17.6	3.2	9.3	0.3
8431	Whole Soil-Aliquot	406.75		150.0	5.2	0.8	0.3	25.1	1.2	23.8	3.0	8.8	0.3
	Total	2063.47											
8432	+4 mesh	160.5	8.04	23.3	2.0	0.5	0.2	0.0	0.0	4.4	1.2	1.4	0.1
8433	-4/+8 mesh	47.44	2.38	92.3	6.9	0.0	0.0	8.6	1.8	22.6	4.9	5.6	0.4
8434	-8/+16 mesh	43.53	2.18	157.0	8.7	0.0	0.0	27.4	2.4	28.1	4.8	8.9	0.5
8435	-16/+30 mesh	44.05	2.21	203.0	16.0	0.0	0.0	30.6	3.9	55.7	9.5	12.2	0.9
8436	-30/+50 mesh	78.63	3.94	164.0	6.6	0.0	0.0	38.9	1.8	29.5	3.8	9.9	0.4
8437	-50/+100 mesh	152.93	7.66	195.0	7.0	0.0	0.0	39.3	1.9	37.3	4.7	11.4	0.4
8438	-100/+200 mesh	174.3	8.73	185.0	6.3	0.0	0.0	34.6	1.8	34.3	3.9	10.8	0.4
8439	-200/+400 mesh	212.66	10.65	198.0	6.9	0.0	0.0	38.9	1.9	31.9	4.4	12.0	0.4
8440	-400 mesh	1082.95	54.23	160.0	5.3	1.1	0.4	23.0	1.2	18.4	2.8	9.5	0.3
	Total	1996.99											

Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity Gamma Spectrometry		
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)
+4	8.04	23.3	0.5	4.4
+8	10.41	39.0	0.4	8.5
+16	12.59	59.5	0.3	11.9
+30	14.80	80.9	0.3	18.5
+50	18.74	98.3	0.2	20.8
+100	26.39	126.4	0.2	25.6
+200	35.12	140.9	0.1	27.7
+400	45.77	154.2	0.1	28.7
-400	100.00	157.4	0.6	23.1

TABLE A
Seaway Syst
Gamma Spectrometry A s Results

Sample Id	Sample Description	Weight (gdry)	Weight Percent (%)	Ra-226		Ra-228		Th-227		Th-234		U-235	
				Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)	Activity (pCi/gdry)	Error (pCi/gdry)
8442	Whole Soil-Aliquot	491.29		66.8	2.9	1.0	0.2	9.3	0.8	11.2	2.1	4.0	0.2
8443	Whole Soil-Aliquot	524.03		58.1	2.8	0.7	0.2	6.9	0.7	10.9	1.7	3.5	0.2
8444	Whole Soil-Aliquot	507.17		69.9	3.6	0.0	0.0	8.8	1.1	13.3	2.1	4.1	0.2
8445	Whole Soil-Aliquot	520.97		76.3	3.8	0.9	0.2	15.3	1.1	17.4	2.8	4.6	0.2
	Total	2043.46											
8446	+4 mesh	103.74	5.19	21.9	2.9	1.3	0.5	0.0	0.0	7.8	2.3	1.3	0.2
8447	-4/+8 mesh	41.89	2.09	26.8	4.2	0.0	0.0	0.0	0.0	7.1	3.2	1.6	0.2
8448	-8/+16 mesh	41.11	2.06	50.7	6.5	0.0	0.0	9.6	1.8	19.8	4.6	3.0	0.4
8449	-16/+30 mesh	43.49	2.17	54.7	6.1	0.0	0.0	9.6	1.9	18.1	4.1	3.3	0.4
8450	-30/+50 mesh	104.16	5.21	41.6	3.0	0.0	0.0	5.2	0.8	14.5	2.4	2.5	0.2
8451	-50/+100 mesh	186.99	9.35	52.9	3.3	0.0	0.0	7.1	0.9	12.5	2.0	3.1	0.2
8452	-100/+200 mesh	134.82	6.74	71.5	4.6	0.0	0.0	9.2	1.2	13.1	2.0	4.3	0.3
8453	-200/+400 mesh	158.29	7.92	88.5	5.3	0.0	0.0	20.5	1.6	15.5	3.1	5.4	0.3
8454	-400 mesh	1185.18	59.27	77.7	3.2	1.2	0.3	10.7	0.9	11.5	1.9	4.7	0.2
	Total	1999.67											

Oversize Activity

Cumulative Sample	Cumulative Weight Percent (%)	Oversize Activity Gamma Spectrometry		
		Ra-226 (pCi/gdry)	Ra-228 (pCi/gdry)	Th-234 (pCi/gdry)
+4	5.19	21.9	1.3	7.8
+8	7.28	23.3	0.9	7.6
+16	9.34	29.3	0.7	10.3
+30	11.51	34.1	0.6	11.8
+50	16.72	36.5	0.4	12.6
+100	26.07	42.4	0.3	12.6
+200	32.82	48.3	0.2	12.7
+400	40.73	56.1	0.2	13.2
-400	100.00	68.9	0.8	12.2