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Prepared for CH2M HILL Hanford Group, Inc.
and the U.S. Department of Energy
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Richland, Washington 99352

Summary

As directed by Congress, the U.S. Department of Energy (DOE) established the Office of River Protection in 1998 to manage DOE's largest, most complex environmental cleanup project – retrieval of radioactive waste from Hanford Site tanks for treatment and eventual disposal. Sixty percent by volume of the nation's high-level radioactive waste is stored at Hanford in aging deteriorating tanks. If not cleaned up, this waste is a threat to the Columbia River and the Pacific Northwest.

CH2M HILL Hanford Group, Inc. is the Office of River Protection prime contractor responsible for the storage, retrieval, and disposal of Hanford tank waste. As part of this effort, CH2M HILL Hanford Group, Inc. contracted with Pacific Northwest National Laboratory (PNNL) to develop release models for key contaminants present in residual waste remaining in Hanford tank 241-C-103 (C-103). This report tabulates data generated by laboratory characterization and testing of three samples collected from this tank. The data presented here forms the basis of the release models developed for tank C-103. These release models were developed to support the tank performance assessments performed by CH2M HILL Hanford Group, Inc. for DOE.

Results of the Tier 1 laboratory characterization and testing of the C-103 samples indicate that Al is the largest single metal component of the waste (12 to 16 wt% for the three samples). Based on this result and assuming the Al occurs primarily as gibbsite [$Al(OH)_3$], aluminum phases would account for 35 to 46 wt% of the residual waste. Other major metal components (Fe, Na, Si, and U) occurred at significantly lower concentrations (0.90 to 1.7%, 0.7 to 0.9%, 0.8 to 1.0%, and 0.3 to 0.4%, respectively). Uranium (^{238}U) was the most concentrated contaminant of concern in the C-103 residual waste samples, occurring at 3,300 to 4,200 µg/g-dry waste. Other residual waste components had the following concentration ranges: ^{99}Tc (0.19 to 0.28 µg/g), Cd (61 to 69 µg/g), Cr (143 to 183 µg/g), Pb (669 to 1,070 µg/g), ^{137}Cs (28 to 69 µCi/g), ^{90}Sr (396 to 753 µCi/g), ^{239}Pu (0.40 to 0.62 µCi/g), ^{241}Am (<0.11 (estimated quantitation limit) to 0.28 µCi/g), ^{237}Np (0.72 to 1.24 nCi/g). ^{129}I concentrations were below the EQLs of 0.042 to 0.085 µCi/g.

Leach tests were conducted with three leachant solutions; double deionized water, $Ca(OH)_2$-saturated water , and $CaCO_3$-saturated. Two types of leach tests were conducted with each of these three leachants, 1 month single-contact leach tests and periodic replenishment tests. Key results from the leach tests are that the future release of the primary contaminants of concern from C-103 residual waste typically represents less than 10% of the total contaminant concentration in the residual waste. That is, the contaminants are not appreciably soluble in the DDI water, $Ca(OH)_2$, and $CaCO_3$ leachants. For example, the cumulative amount of U leached by the DDI water leaching solution during six sequential stages of leaching ranged from 3.8 to 6.9% of the total U. The corresponding percentages of U leached by the $Ca(OH)_2$ leaching solution were significantly lower, ranging from 0.0 to 0.006%. The percentages of U leached by the $CaCO_3$ leaching solution were higher, ranging from 12.6 to 13.8%. The cumulative leachable percentages for ^{99}Tc were also low, ranging from 3.7 to 7.1% for all samples and extract solutions. The cumulative leachable percentages for Cr were also low, ranging from 1.0 to 6.4% for all samples and extract solutions.

X-ray diffraction (XRD) results indicate that gibbsite [$Al(OH)_3$] is the major component of the C-103 samples, which is consistent with the bulk chemical analysis. Scanning electron microscopy/energy dispersive spectrometry (SEM/EDS) results suggest that the samples of C-103 residual waste consist primarily (possibly more than 80 to 90%) of an Al oxyhydroxide phase, such as gibbsite [$Al(OH)_3$]. Based on these results, the total aluminum concentrations appear to be underestimated. The reason for this discrepancy could not be determined. SEM/EDS analyses also show that the C-103 samples contained trace concentrations (possibly a few percent each) of one or two Fe-O phases (usually also containing minor concentrations of Mn, Cr, Ni, and possibly Pb), possibly two Ag±Hg-O phases, a U-O phase, infrequently a U±Ca-O phase (possibly also containing Na, Al, and Si), and a Ca-P-O phase. Geochemical modeling suggests that this U-O phase may be schoepite ($UO_3{\bullet}2H_2O$). The SEM/EDS results for the 1-month single-contact double deionized (DDI) water-leached, 1-month single-contact $Ca(OH)_2$-leached, and 1-month single-contact $CaCO_3$-leached samples were consistent with those for the unleached samples. SEM/EDS analyses of 1-month single-contact $Ca(OH)_2$-leached samples also indicated the presence of three other phases. These new phases include a Ca-O±C phase with a composition consistent with calcite ($CaCO_3$), a Si-Al-Na-Ca-O phase that commonly has the morphology (crystal habit) of balls of twine, and a Ca-Al-Si-O phase that forms platy-like particles (sometimes also forming rosettes).

In addition to these solid phase characterization results, technetium was identified by EDS in three Fe oxide/hydroxide particles. These Tc-containing particles (marked by arrows in the SEM micrographs in Figure 3.14) were found by SEM/EDS in samples of unleached, DDI water-leached, and $CaCO_3$-leached C-103 residual waste. The Tc concentrations in these particles ranged from 0.6 to 1.0 wt%. This is the first time in our project studies of pre-retrieval and post-retrieval residual wastes from Hanford underground SSTs that there has been direct evidence for the presence of Tc in any phase in actual waste solids.

The primary product of sludge testing and model development is the measured total contaminant concentrations in the residual sludge and the estimated maximum release concentrations of the key contaminants for two tank closure scenarios. In the first scenario, it is assumed that the tank is filled with a relatively inert material such as quartz (SiO_2) sand or other material that does not significantly impact the chemistry of infiltration water that will contact the post-retrieval sludge. In the second tank scenario, it is assumed that the tanks are filled with a cementitious grout. The release data for these two scenarios are compiled in Table 5.2. They can be used as source term values for tank closure performance assessments.

Acknowledgments

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Acronyms and Abbreviations

AEA	alpha energy analysis
ASTM	American Society for Testing and Materials
AMU	atomic mass unit
BL	B Plant low-level waste
BSE	backscattered electron
CCV	continuing calibration verification
DDI	double deionized (water)
DOE	U.S. Department of Energy
DRC	dynamic reaction cell
DST	double-shell tank
Dup (or dup)	duplicate
EDS	energy dispersive spectrometry
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
$\Delta_f G_{298}^o$	Gibbs energy of formation from the elements in their reference states at 298.15 K
GEA	gamma energy analysis
GWB	Geochemist's Workbench®
HASQARD	Hanford Analytical Services Quality Assurance Requirements Document
IC	ion chromatography (chromatograph)
ICP-MS	inductively coupled plasma-mass spectrometry (spectrometer)
ICP-OES	inductively coupled plasma-optical emission spectroscopy (same as ICP-AES)
ICDD	International Center for Diffraction Data
JCPDS	Joint Committee on Powder Diffraction Standards
K_{298}^o	equilibrium constant at 298.15 K
K_{sp}	solubility product
LSC	liquid scintillation
MW	metal waste
NDIR	non-dispersive infrared
NIST	National Institute of Standards and Technology

PDF™	powder diffraction file
pH	measure of the acidity (or alkalinity) of a solution, where pH is the negative of the logarithm of the activity of H+ in solution
PNNL	Pacific Northwest National Laboratory
PUREX	plutonium-uranium extraction
Q	activity product
QA	quality assurance
SBMS	Standards-Based Management System
SE	secondary electron
SEM	scanning electron microscopy (or microscope)
SI	saturation index
SRM	Standard Reference Material
SST	single-shell tank
TC	total carbon
TIC	total inorganic carbon
TOC	total organic carbon
XRD	x-ray powder diffractometry analysis (commonly called x-ray diffraction)

Units of Measure

Å	angstrom (or ångström) equal to 0.1 nanometer (nm) or 1 x 10^{-10} m. Also known as tenthmeter.
at%	atomic percent
θ	angle of incidence (Bragg angle)
ºC	temperature in degrees Celsius [T(ºC) = T(K) – 273.15)]
eV	electron volt
°F	temperature in degrees Fahrenheit {T(°F) = [T(°C) × 9/5] + 32}
ft	foot
g	gram
K	temperature in degrees (without degree symbol) Kelvin [T(K) = T(ºC) + 273.15]
kcal	kilocalorie, one calorie equals 4.1840 joules
keV	kilo-electron volt
kgal	kilogallon
kJ	kilojoule, one joule equals 4.1840 thermochemical calories
kL	kiloliter
L	liter
µ	micro (prefix, 10^{-6})
µeq	microequivalent
µg	microgram
µm	micrometer
M	molarity, mol/L
m	meter
mg	milligram
mL	milliliter
mM	molarity, millimol/L
mol	mole
ng	nanogram (10^{-9} grams)
pg	picogram (10^{-12} grams)
rpm	revolution per minute
µmol	micromole
I/I_o	relative intensity of an XRD peak to the most intense peak
λ	wavelength
wt%	weight percent

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1.0 Introduction

This report presents testing results conducted on residual waste in Hanford tank 241-C-103 (C-103) after final waste retrieval. These tests were conducted to characterize the residual waste and assess the leachability of contaminants from the solids. These data were used to develop contaminant release models that are necessary components of the tank performance assessments.

1.1 Scope of Work

Initial (Tier 1) laboratory tests were conducted to characterize the residual waste and identify water-leachable constituents. The Tier 1 tests consisted primarily of acid digestions to measure elemental concentrations in the solid, and water leaching of contaminants from the residual waste to evaluate their mobility in infiltrating water. Water leaching was conducted with double deionized water (DDI), $Ca(OH)_2$-saturated water, and $CaCO_3$-saturated water. The $Ca(OH)_2$ and $CaCO_3$ saturated solutions were used to mimic the initial and final status of a tank chemical system in which the void space above the residual waste is filled with cementitious grout, which is a possible tank fill material. X-ray diffraction (XRD) analyses of the solids were also included in the Tier 1 tests to identify crystalline mineral phases present in the residual waste. For this C-103 investigation, the only Tier 2 analyses conducted were SEM/EDS. Results of the SEM/EDS analyses were completed to characterize the morphologies and compositions of solid phases in the leached and leached residual waste samples.

The laboratory results of Tier 1 and Tier 2 testing on C-103 residual tank waste were used to develop source term models that describe the release of contaminants as infiltrating water contacts the solids in the future. These models simulate the geochemical system in the tank residual waste and take into account interactions between the solution phase and the contaminant-containing solids. The geochemical models will be used in future tank performance assessments.

1.2 C-100 Series Tank Description

The C Tank Farm was constructed from 1943 to 1944 in the 200 East Area and contains twelve 100-series and four 200-series, dish bottom design, single-shell tanks (SSTs) (Brevick et al. 1997); see Figure 1.1. Tank C-103 has a design capacity of 2,006 kL (530 kgal) and a diameter of 22.9 m (75 ft). Tank C-103 was passively ventilated and originally designed to hold non-boiling waste at a maximum temperature of 104°C (220°F). Figure 1.2 presents a generalized profile view of a 100-series tank such as C-103 (RPP 2007). Tank C-103 is the last in a three-tank cascade series that includes tanks 241-C-101 and 241-C-102.

Tank C-103 went into service during the third quarter of 1946 when it began receiving metal waste (MW) generated from the $BiPO_4$ process (Agnew 1993). In the fourth quarter of 1952, the supernatant was transferred to tank 241-C-109 and the MW was sluiced out of the tank so U could be extracted at the U Plant. In the third quarter of 1953, tank C-103 began receiving tributyl phosphate waste from tank 241-C-101, which was stored until the second quarter of 1957 when the tributyl phosphate waste was transferred to tanks 241-C-111 and 241-C-112, leaving tank 241-C-103 nearly empty. Neutralized Plutonium Uranium Extraction (PUREX) Plant high-level waste (PUREX high-level waste) was received from tank 241-A-102 during the third and fourth quarters of 1957; however, shortly afterward, nearly all

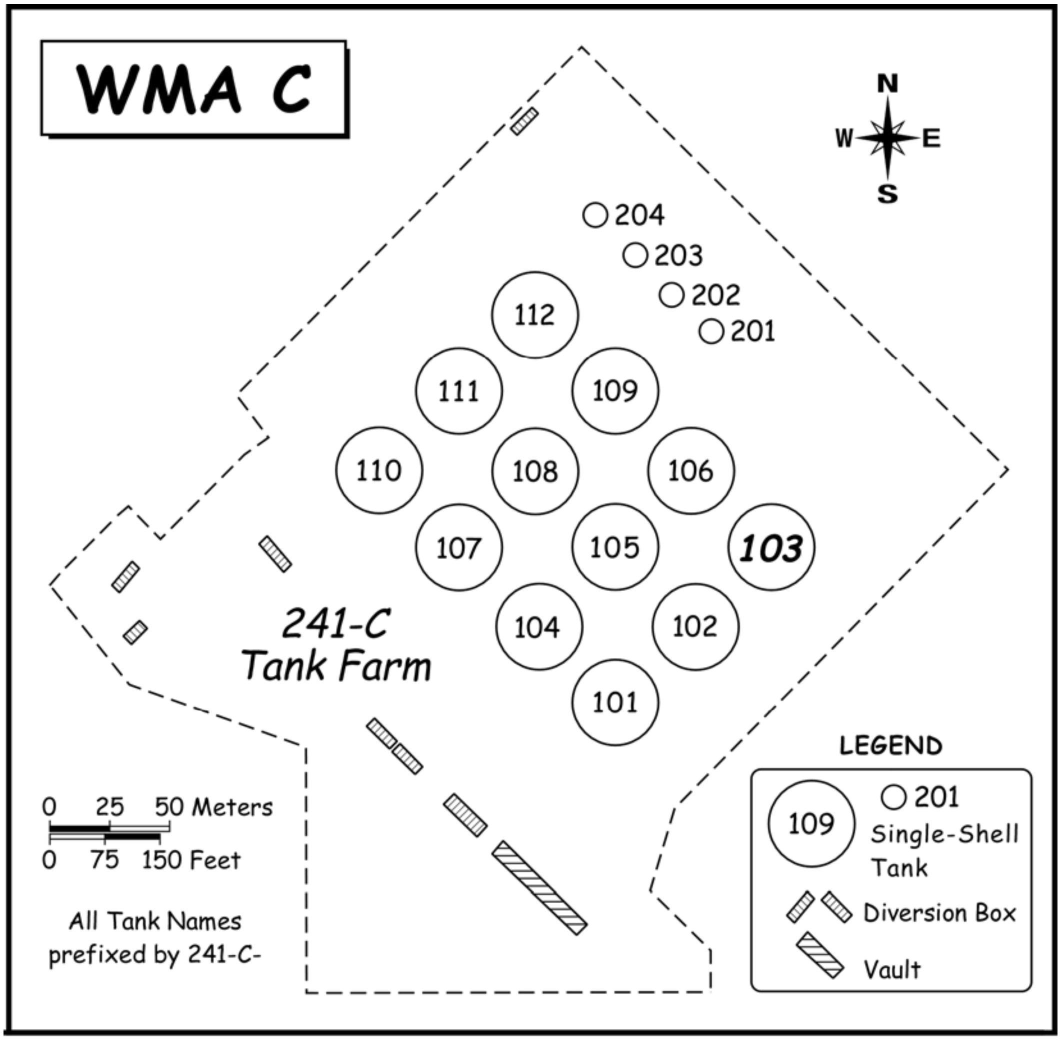

Figure 1.1. Hanford C Tank Farm

of this waste was transferred to tank 241-BY-103 during the first quarter of 1958. These transfers most likely consisted of supernatant transfers that contained few solids. Tank C-103 then remained static until the second quarter of 1960 when transfers of Al cladding waste from PUREX were received and held until 1962 when most of the tank contents were transferred to various tanks within the BX Tank Farm.

Beginning the second quarter of 1963 and extending though 1968, numerous receipts and transfers of PUREX high-level waste supernatant occurred for Cs recovery resulting in a gradual inventory reduction. During the third quarter of 1969, the majority of the supernatant waste was transferred to tank 241 C-105, which allowed for the receipt of B Plant low-level waste (BL) from tank 241 BX-101 and evaporator bottoms liquid decanted from tank 241-B-102. Most of the waste accumulated in tank C-103 was then staged to tank 241-C-105 as feed for the B Plant Cs recovery process. During 1970 and 1971, tank C-103 received BL waste and PUREX sludge supernatant (Agnew et al. 1997). From 1973 to 1978, tank C-103 received waste transfers from other tanks in the C Tank Farm (Agnew et al. 1997). In 1979, supernatant was transferred to tank 241-C-104, and C-103 was declared inactive. The remaining waste volume at this point was 757 kL. Interim stabilization was completed in 2003.

Retrieval operations began on November 6, 2005, and were completed on June 30, 2006. The waste in tank C-103 was retrieved using a modified sluicing retrieval system consisting of two sluicers and a slurry pump. Supernatant from double-shell tank (DST) 241-AN-106 (AN-106) was used as the sluicing fluid to mobilize the solids in tank C-103. The resulting slurry was pumped to AN-106. The retrieval system and its operation are described in Process Control Plan for Tank C-103 Waste Retrieval (RPP 2005). Final water rinses of the residual solids were completed on August 23, 2006. The final supernatant is primarily residual liquid from the final triple rinse with water. Based on the Best-Basis Inventory for Tank 241 C-103 (RPP 2006), 8.64 kL of residual sludge and 0.93 kL of supernaturant remained in the tank after retrieval.

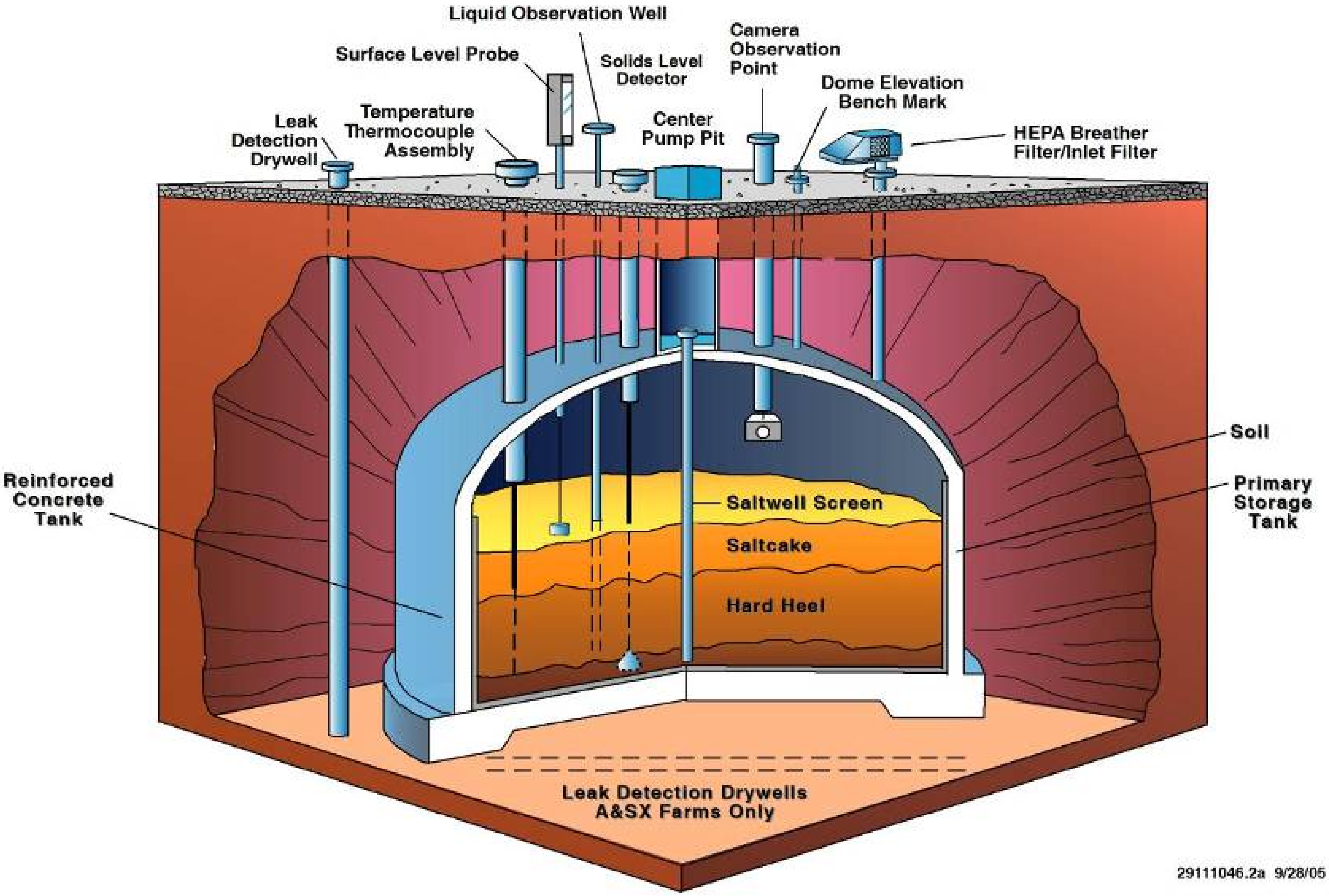

Figure 1.2. Generalized Profile View of a 100-Series Tank Such as Tank C-103 (RPP 2007)

2.0 Materials and Laboratory Test Methods

This section describes the residual waste samples provided to Pacific Northwest National Laboratory (PNNL), and the analytical methods and various tests used to characterize the material, measure contaminant release, and identify controlling solids.

2.1 C-103 Residual Waste Samples

Residual waste samples from tank C-103 were collected by CH2M HILL Hanford Group, Inc. during post-retrieval activities in September 2006. The material from tank C-103 (samples 19845, 19849, and 19850) was provided to PNNL on January 10, 2007 (Table 2.1). Figure 2.1 is a photograph of sample 19845, Figure 2.2 shows sample 19849, and Figure 2.3 shows sample 19850.

Table 2.1. Tank C-103 Samples Provided to PNNL by 222-S Laboratory

Sample Number	Jar Size (mL)	Labcore Number	Net Weight of Sample Received (g)
19845	125	S06T008781	60.5
19849	125	S06T008782	60.0
19850	125	S06T008783	60.2

Figure 2.1. C-103 Tank Residual Waste (Sample 19845)

Figure 2.2. C-103 Tank Residual Waste (Sample 19849)

Figure 2.3. C-103 Tank Residual Waste (Sample 19850)

2.2 Tier 1 Tests

Tank waste samples were analyzed in a tiered approach similar to the one developed for investigating contaminant fate and transport issues associated with past single-shell tank leaks in the vadose zone (e.g., Brown et al. 2007). Such an approach allows for initial (Tier 1) screening of samples using relatively inexpensive analytical techniques. This is followed by an analysis of the data to determine the need for further testing (Tier 2). The Tier 1 tests are described in this section. At this time the only Tier 2 analyses conducted on C-103 residual waste were SEM/EDS.

All laboratory activities were conducted in accordance with the requirements of Title 10, Code of Federal Regulations, Part 830.120 “Quality Assurance” (10 FR 830.120) and the *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD; DOE 1998). These requirements were implemented using PNNL’s online quality assurance (QA) Plan, “Conducting Analytical Work in Support of Regulatory Programs.” PNNL’s QA Plan is based on the requirements of DOE Order 414.1A as described in PNNL’s Standards-Based Management System (SBMS), the HASQARD, relevant elements of NQA-1, as well as recognized industry standards (e.g., EPA, American Society for Testing and Materials [ASTM], American National Standards Institute).

2.2.1 Residual Waste Composition by Acid Digestion

The bulk compositions of the residual waste solids were determined using a modified version of U.S. Environmental Protection Agency (EPA) SW-846 Method 3052 (EPA 1996a). The modifications to EPA 3052 consist of 1) decreasing the concentrated nitric acid (HNO_3) volume from 9 mL to 5 mL and 2) increasing the DDI water volume from the recommended volume of 0 to 5 mL to 10 mL. This method was used to measure the elemental composition of the residual waste but is not appropriate for the anion concentrations due to the addition of acids used in the analyses. The anion compositions were measured separately in solutions obtained by water leaching of the solids (see Section 2.2.7).

The basic acid digestion procedure is described in EPA SW-846 Method 3052 (EPA 1996a). In this procedure, 300 mg of the sample is placed in a Teflon microwave digestion vessel; 10-mL water, 5-mL 16 M HNO_3, 2-mL 12 M HCl, and 1-mL 29 M HF are added to the sample, and the vessel is sealed and placed in a microwave-assisted digestion system. The samples are treated at the EPA-recommended temperatures and times. The sample is then allowed to cool, and 0.45 grams of boric acid (H_3BO_3) is added to the digestate and shaken by hand. Samples are filtered through a 0.45-µm pore-size syringe filter prior to analysis. There were no visible solids when the digestions were complete.

Table 2.2 lists the digestion factors (wet solid-to-solution ratios) for residual waste samples 19845, 19849, and 19850 used for the EPA acid digestions. These factors were calculated from the wet weight of waste material divided by the volume of extracting solution. The digestion factors were then multiplied by the percent solids, as determined from moisture content analysis, to convert to a dry weight basis. The dissolved metal concentrations and the total beta and total alpha activities for the filtered solutions were then analyzed by a combination of methods, including inductively coupled plasma-mass spectrometry (ICP-MS), inductively coupled plasma-optical emission spectroscopy (ICP-OES), and several radiochemical analytical techniques. These analytical methods are described in Lindberg and Deutsch (2003).

Table 2.2. Digestion Factors for Residual Waste Solids Used for the EPA Acid Digestion Treatment

Sample Number	Dry Weight Corrected Digestion Factor (g/L)
19845	9.81
19845 Dup[(a)]	9.07
19849	10.84
19849 Dup	9.98
19850	8.42
19850 Dup	11.13
Dup = Duplicate sample.	

2.2.2 Moisture Content

The moisture contents of the tank waste samples were measured to calculate dry weight concentrations for constituents in the waste. Dry weight concentrations provide a consistent measurement unit for comparison purposes that eliminates the effect of variable water content on sample concentrations.

Gravimetric water content of the waste material was determined using the ASTM procedure D2216-98, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass* (ASTM 1998) with the following minor exceptions: 1) the volume of sample recommended was decreased due to radiological concerns; and 2) the sample was dried at a lower oven temperature, 105°C, for a longer period of time to prevent dehydration of the solids.

Residual waste samples were placed in tared containers, weighed, and dried in an oven until a constant weight was achieved, usually 24 to 48 hours. The container was then removed from the oven, sealed, cooled, and weighed. All measurements were performed using a calibrated balance. The gravimetric water content is computed as the percentage change in waste sample weight before and after oven drying (i.e., [{wet weight - dry weight}/dry weight]).

2.2.3 Carbon Analysis

The analysis of the C content of solid and liquid samples is described in this section. Carbon analyses were conducted to determine total inorganic C (TIC) and total organic C (TOC) in the residual waste samples and liquid samples. TIC is used as an indirect measure of carbonate concentrations which are used for conducting the geochemical modeling (saturation index calculations).

2.2.3.1 Carbon Content of Solids

The C content of solid samples is determined by the hot persulfate method.(1) In this method, samples are treated by wet chemical oxidation by heating at 92 to 95°C with a solid potassium persulfate oxidant and liquid Ag-ion catalyst. Sulfuric acid (H_2SO_4) is also used to convert C to CO_2 (carbon dioxide). The CO_2 is swept away by an O_2 carrier gas and measured in a UIC Coulometrics Acid Module.

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(1) Unpublished internal technical procedure: *Carbon Measured in Solids, Sludge, and Liquid Matrices*. RPG-CMC-385, Pacific Northwest National Laboratory, Richland, Washington.

The method uses a two-step process allowing a separate measurement of total inorganic C (TIC) and total organic C (TOC) on the same sample. In this process, the sample is first acidified with heated sulfuric acid, converting inorganic carbonates to CO_2 (i.e., TIC analysis), then the persulfate solids and Ag-catalyst solution is added and the organic C remaining in the sample is converted to CO_2 for TOC measurement. Total C (TC) for a solid sample is calculated from the sum of TIC and TOC.

2.2.3.2 Carbon Content of Liquids

The C content of liquid samples is determined using PNNL's technical procedure,(2) which is similar to EPA SW-846 Method 9060A (EPA 2004b). A Shimadzu Carbon analyzer Model TOC-V CSN with ASI module (auto sampler) is used for the analysis.

Liquid samples are analyzed for TC by introducing a sample aliquot into a combustion chamber with an oxidation catalyst and heated to 680°C. The released C from the combustion is converted to CO_2, swept from the combustion chamber by ultra pure O_2, dehumidified and scrubbed to remove halogens. The carrier gas then delivers the sample combustion products to the cell of a non-dispersive infrared (NDIR) gas analyzer where the CO_2 is detected and measured. The amount of CO_2 is proportional the total C content of the sample.

Liquid samples are analyzed for total organic C by first acidifying a sample aliquot with 3-M HCl to a pH less than 3 with sparging to remove the evolved inorganic CO_2. The remaining acidified sample is introduced into a combustion chamber with an oxidation catalyst and heated to 680°C. The released C from the combustion is converted to CO_2, swept from the combustion chamber by ultra pure O_2, dehumidified and scrubbed to remove halogens. The carrier gas then delivers the sample combustion products to the cell of a NDIR gas analyzer where the CO_2 is detected and measured. The amount of CO_2 measured is proportional the TOC content of the sample.

Inorganic C for a liquid sample is calculated from the difference of the TC and TOC.

2.2.4 Single-Contact Residual Waste Extraction Tests

Water-soluble inorganic constituents were determined using a DDI water extraction method. The extract was prepared by adding 30 mL of DDI water to a quantity of residual waste ranging from 0.200 to 0.600 g contained in a 50-mL polypropylene centrifuge tube. The centrifuge tube was sealed, briefly shaken by hand, and then placed on a mechanical orbital shaker for 1 month. After shaking for the predetermined time, the tube was placed in a centrifuge and spun at 4,000 rpm for 20 minutes. The supernatant was carefully decanted and filtered through 0.45-μm pore size membrane. More details can be found in ASTM Procedure D3987-85, *Standard Test Method for Shake Extraction of Solid Waste with Water* (ASTM 1999).

To evaluate the leachability of constituents from residual waste by a leaching solution produced from water contacting cementitious grout filling the tank above the residual waste, a $Ca(OH)_2$-saturated solution was prepared to simulate a leachant produced by fresh cement. A sufficient quantity of fresh

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(2) Unpublished internal technical procedure: *Operating of Carbon Analyzer (TOC-V + SSM-5000A + ASI (Shimadzu)*. AGG-TOC-001, Pacific Northwest National Laboratory, Richland, Washington.

$Ca(OH)_2$ (~1.4 g/L @ 25°C) was added to deionized water to just saturate the solution. Excess solid $Ca(OH)_2$ is undesirable because it will buffer the pH at a higher than expected value. Because CO_2 in air is very soluble in water at high pH and the resulting dissolved CO_3 will precipitate as calcite ($CaCO_3$) in the $Ca(OH)_2$-saturated solution, care was taken to minimize contact of the solution with air. When possible, Teflon containers were used because they have low air diffusion coefficients. Air space in the containers was also minimized and the vessel was tightly sealed to limit leakage of air into the vessel. The pH of an aliquot of the $Ca(OH)_2$ solution was measured as well as the dissolved Ca concentration. This solution was used to leach the residual wastes in the same manner as the DDI water leachant discussed in the previous paragraph.

To evaluate the leachability of constituents from residual waste by a leaching solution produced from water contacting aged cement filling the tank above the residual waste, a $CaCO_3$-saturated solution was prepared to simulate a leachant produced by aged cement. The calcite-saturated solution was prepared by adding excess powdered calcite to deionized water and stirring or shaking the mixture for 24 hours. The temperature during equilibration was a few degrees above room temperature. By preparing the solution at a slightly elevated temperature, the possibility of calcite precipitation during the test at room temperature was minimized, because calcite undergoes retrograde solubility (i.e., solubility of calcite decreases with increasing temperature). There was no need to minimize contact of this solution with the atmosphere. This solution was also used to leach the residual wastes in the same manner as the DDI water and $Ca(OH)_2$ leachants discussed in the previous paragraphs.

2.2.5 Periodic Replenishment Residual Waste Extraction Tests

Periodic replenishment tests were conducted on the samples of as received residual wastes from tank C-103. These tests were conducted with each of the DDI water, $Ca(OH)_2$-saturated, and $CaCO_3$-saturated leachants. In these tests, the leachant was periodically removed and replaced with an equal volume of fresh solution. This test was conducted to evaluate whether solution concentration might be limited by the solubility of one or more solid phases. For these tests, the samples were contacted with the separate leachants for a total of six times. The lengths of time (contact periods) between replenishment of leachant solutions were 1 day for stages 1, 2, 4, and 5; 3 days for stage 3, and 30 days for stage 6. The residual waste samples were prepared and handled in the same manner as the single-contact water extracts for each repetitive step.

After these long-term tests, the samples were centrifuged and the supernatant carefully decanted and filtered through 0.45-µm pore size membranes prior to analysis for the same constituents as the shorter-term tests.

2.2.6 pH

The pH of the solutions was measured using EPA SW-846, Method 9040C (EPA 2004a) with a modification. The modification consists of using a solid-state pH electrode instead of the recommended glass electrode.

2.2.7 Anion Analysis

Anion analysis was performed using an ion chromatograph. Fluoride, acetate, formate, Cl, NO_2, Br, NO_3, CO_3, SO_4, oxalate, and PO_4 were separated on a Dionex AS17 column with a gradient elution technique from 1-mM to 35-mM NaOH and measured using a conductivity detector. This methodology is similar to EPA SW-846, Method 9056 (EPA 1994) with the exception of using gradient elution with NaOH instead of the recommended isocratic elution with a HCO_3 buffer.

2.2.8 Cations and Trace Metals

Major cation analysis (including Al, Si, Ca, Mg, Na, K, Fe, and Mn) was performed by ICP-OES EPA SW-846 Method 6010B (EPA 1996b). Trace metals analysis (including Cr, Mo, As, Se, Cd, Ag, Pb, ^{99}Tc, and U isotopes) was performed by ICP-MS. This method follows EPA Method 6020 (EPA 1996c).

For both ICP-OES and ICP-MS, high-purity calibration standards were used to generate calibration curves and to verify continuing calibration during the analysis. Dilutions of 10 and 5 times were made for each sample and analyzed to investigate and correct for matrix interferences.

2.2.9 ^{237}Np and ^{239}Pu Analysis

ICP-MS is a widely accepted method for the determination of trace metals in solution. The instrument requires user calibration using multi-element standards with concentrations ranging from 5 pg/mL to 20 ng/mL. One area of concern in utilizing ICP-MS to measure actinide elements in tank waste extracts is the proximity in atomic mass of the elements of interest. It can be difficult to measure elements separated by only one atomic mass unit (AMU) when one element is present in trace quantities (^{237}Np and ^{239}Pu) while another element is present in macroscopic concentrations (^{238}U). Under these circumstances, peak tailing from ^{238}U can extend into the regions corresponding to ^{237}Np and ^{239}Pu, resulting in erroneously high reporting of total ^{237}Np and ^{239}Pu. Standard ICP-MS analysis of the acid extracts of C-103 residual tank waste material for uranium ranged from 0.470 to 0.273 mg/L. Previous studies indicate that these concentrations of uranium do not cause an interferent at atomic mass unit of 237 or 239. With these low levels of uranium, ^{237}Np and ^{239}Pu were able to be quantitatively analyzed without special analytical techniques. The EQLs for ^{237}Np and ^{239}Pu were 0.1 and 2.5 µg/L, respectively.

2.2.10 Alkalinity

The sample alkalinity was measured by standard titration. A volume of standardized sulfuric acid was added to the sample to an endpoint of pH 4.5 to measure total alkalinity. Alkalinity is reported is terms of an equivalent mass of $CaCO_3$. The alkalinity procedure follows Standard Method 2320 B (Clesceri et al. 1998).

2.2.11 ^{129}I Extraction and Analysis

From a long-term risk standpoint, ^{129}I is a key potential contaminant in residual Hanford tank waste. For this reason, its presence in the waste material and mobility in infiltrating water is of interest. Although iodine (I) is generally considered mobile as a dissolved constituent in water, small partition coefficients (0.2 to 1 mL/g) are typically calculated when its uptake is measured on Hanford sediments (Cantrell et al. 2003; Um et al. 2004). Therefore, it is imperative to identify an extraction method that will enable quantitative measurement of total I in solid samples such as tank waste.

Previous research (Brown et al. 2005) has shown the potential applicability of water leaches and potassium hydroxide (KOH):potassium nitrate (KNO_3) water fusions for the removal of iodide (I^-) from solid samples spiked with ^{129}I. The results from Brown et al. (2005) have led to the modification of the accepted PNNL internal procedure,(3) to determine the ^{129}I concentration in residual waste solids. Using the updated procedure, 300 mg of the residual tank waste material was mixed with 6 mL of a 30% KOH and 3% KNO_3 solution as a fluxing agent in a Zr crucible. The crucible was then placed in a 95°C oven and allowed to evaporate to dryness, after which it was covered and transferred to a muffle furnace preheated to 550°C. Fusion was accomplished by heating the sample-flux mixture for 60 minutes at 550°C. After 60 minutes, the crucible was removed from the furnace and allowed to cool to ambient room temperature. The fused solid was then dissolved in DDI water. The resulting solution was transferred to a 50-mL centrifuge tube. The crucible was then triple-rinsed with a 1:1 mixture of concentrated sulfuric acid (H_2SO_4) and 1M sodium bisulfite ($NaHSO_3$), and these solutions were also added to the centrifuge tube. An additional 5 to 15 mL of the sulfuric acid:sodium bisulfite mixture was added to the centrifuge tubes to facilitate total sample dissolution. Once sample dissolution was complete, the final solution volume in each centrifuge tube was determined gravimetrically and corrected for solution density. Finally, the samples were diluted using a 1% (by volume) Spectrasol CFA-C solution to ensure the samples were alkaline prior to analysis via ICP-MS.

Table 2.3 lists the digestion factors (wet solid-to-solution ratios) for the samples of C-103 residual waste solids used for the modified KOH-KNO_3 water fusion treatments to measure ^{129}I. These factors were calculated from the wet weight of residual waste material divided by the volume of extracting solution. The digestion factors were then multiplied by the percent solids, as determined from moisture content analysis, to convert to a dry weight basis. The fused samples were analyzed for dissolved ^{129}I concentrations using a Perkin Elmer ELAN DRC II ICP-MS operated in the standard mode. Spectrasol CFA-C from Spectrasol, Inc. (Warwick, New York) was diluted in DDI water (18 MΩ-cm) to create a 1% working solution. Calibration standards were prepared by diluting a 1 mg/L ^{129}I certified stock standard (NIST, Gaithersburg, Maryland) into appropriate volumes of the 1% Spectrasol CFA-C solution containing 5 ng/mL ^{115}In as an internal standard to calibrate the ICP-MS for masses neighboring I. An independent calibration check standard was prepared from a 1-mg/L ^{129}I certified stock standard (Amersham, Piscataway, New Jersey) in 1% Spectrasol CFA-C. One percent Spectrasol CFA-C was used to prepare instrument blanks and was used as the rinse solution throughout each solution analysis.

Table 2.3. Digestion Factors for Samples of C-103 Residual Waste Solid Used for the Modified KOH-KNO_3 Water Fusion Treatment to Measure ^{129}I

Sample Number	Dry Weight Corrected Digestion Factor (g/L)
19845	10.31
19845 Dup	9.81
19849	9.43
19849 Dup	9.95
19850	9.10
19850 Dup	9.83
Dup = Duplicate.	

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(3) Unpublished internal technical procedure: *Solubilization of Metals from Solids Using a KOH-KNO3 Fusion*. AGG-ESL-001 Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

2.2.12 Radioanalysis

In addition to the radionuclides ^{99}Tc, ^{129}I, ^{237}Np, ^{238}U, and ^{239}Pu that were analyzed in solution by ICP-MS, short-lived radionuclides (^{137}Cs and ^{90}Sr) were analyzed by conventional counting methods as described below.

2.2.12.1 ^{137}Cs Analysis

^{137}Cs was measured in solution extracts by gamma energy analysis (GEA). The analyses were made using 60% efficient intrinsic-germanium gamma detectors. All germanium counters were efficiency calibrated for distinct geometries using mixed gamma standards traceable to the NIST. Direct solids, acid extracts, and water extracts were analyzed for gamma energy. Spectral analysis was conducted using libraries containing most mixed-fission products, activation products, and natural decay products. Control samples were run throughout the analysis to ensure correct operation of the detectors. The controls contained isotopes with photo peaks spanning the full detector range and were monitored for peak position, counting rate, and full-width half-maximum. Details are found in an internal PNNL procedure.(4)

2.2.12.2 ^{90}Sr Analysis

Aliquots of filtered acid extracts, fusions, and water extracts were diluted in 8 M HNO_3 and submitted for Sr separation and analysis by internal PNNL procedure.(5) A 0.1-5 mL aliquot of sample was spiked with ^{85}Sr tracer and passed through a SrSpec® column (Eichrom Technologies, Chicago) to capture Sr. The columns were washed with 10 column volumes (20 mL) of 8 M nitric acid. The Sr was eluted from the SrSpec column into glass liquid scintillation vials using 15 mL of deionized water. The vials were placed under a heat lamp overnight to evaporate the water to dryness. A 15 mL Optifluor® scintillation cocktail was added to each vial. Gamma spectroscopy was used to determine the chemical yield from the added ^{85}Sr tracer. The samples were then analyzed by liquid scintillation counting (LSC) to determine the amount of ^{90}Sr originally present in the residual waste sample. A matrix spike, a blank spike, a duplicate, and blanks were run with each sample set to determine the efficiency of the separation procedure as well as the purity of reagents.

2.2.13 XRD

Standard bulk powder XRD techniques were used to identify crystalline phases present in the following tank C-103 residual waste samples:

- Unleached samples 19845, 19849, 19850
- 1-month single-contact DDI water-leached solids from samples 19845, 19849, and 19850
- 1-month single-contact $Ca(OH)_2$-leached solids from samples 19845, 19849, and 19850
- 1-month single-contact $CaCO_3$-leached solids from samples 19845, 19849, and 19850

The DDI water extraction, $Ca(OH)_2$, and $CaCO_3$ leach tests are described in Sections 2.2.4 and 2.2.5.

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(4) Unpublished internal technical procedure: *Gamma Energy Analysis, Operation, and Instrument Verification using Genie2000 Support Software*. RRK-001, Pacific Northwest National Laboratory, Richland, Washington.

(5) Unpublished internal technical procedure: *Tc99 and Sr90 Analysis Using Eichrom TEVA-Spec and Sr-Spec Resin*. PNL-RRL-003.2, Pacific Northwest National Laboratory, Richland, Washington.

Because the residual waste samples were highly radioactive dispersible powders, it was necessary to prepare the XRD mounts of these samples inside a fumehood regulated for handling radioactive materials. Residual waste samples were prepared for XRD analysis by placing milligram quantities of each sample into a mixture of water and collodion solution. The collodion solution consists of 2% nitrocellulose dissolved in amyl acetate, and is an x-ray amorphous, viscous binder commonly used to make random powder mounts for XRD when only a limited amount of sample is available. A trace quantity of reference-material corundum powder (α-Al_2O_3, alumina) (National Institute of Standards and Technology Standard Reference Material [NIST SRM] 676) was added to each sample slurry as internal 2θ standard to correct for any observed peak shifts due to slight misalignments of the mounted samples.

A pipette was used to transfer each slurry onto a circular-shaped platform (1-cm [0.39-in.] diameter) and which was then placed on top of the post located on the base inside a disposable XRD specimen holder (Figure 2.4). This specimen holder was designed specifically for safe handling of dispersible powders containing highly radioactive or hazardous materials (Strachan et al. 2003). After allowing samples to air-dry overnight, the holder was assembled and a piece of Kapton® film was placed between the cap and the retainer. The holder was sealed with wicking glue and removed from the fumehood.

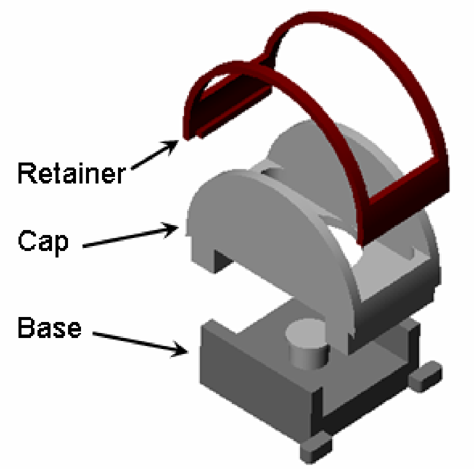

Figure 2.4. Exploded Schematic View of the XRD Sample Holder (Kapton® film not shown) (see Strachan et al. 2003)

Each sample was analyzed using a Scintag XRD unit equipped with a Peltier thermoelectrically cooled detector and a copper x-ray tube. The diffractometer was operated at 45 kV and 40 mA. Individual scans were obtained from 2 to 65°2θ with a step size of 0.02° and dwell time of 2 seconds. Scans were collected electronically and processed using the JADE® XRD pattern-processing software.

A sample consisting of only a dry film of the collodion solution was previously prepared and analyzed by XRD by Krupka et al. (2004) so that its contribution relative to the background signals of the XRD patterns for the residual waste samples could be quantified. The resulting XRD pattern for the collodion solution film is shown in Figure 2.5. The most obvious feature of this diffraction pattern is the broad peak positioned between 10° and 30°2θ. The symmetry of this peak is characteristic of those resulting from the XRD of amorphous (noncrystalline) material. Although subtracting the collodion background from residual waste XRD patterns allows for better phase matching, this process may eliminate minor reflections and inconspicuous features of a pattern. Therefore, each as-measured XRD

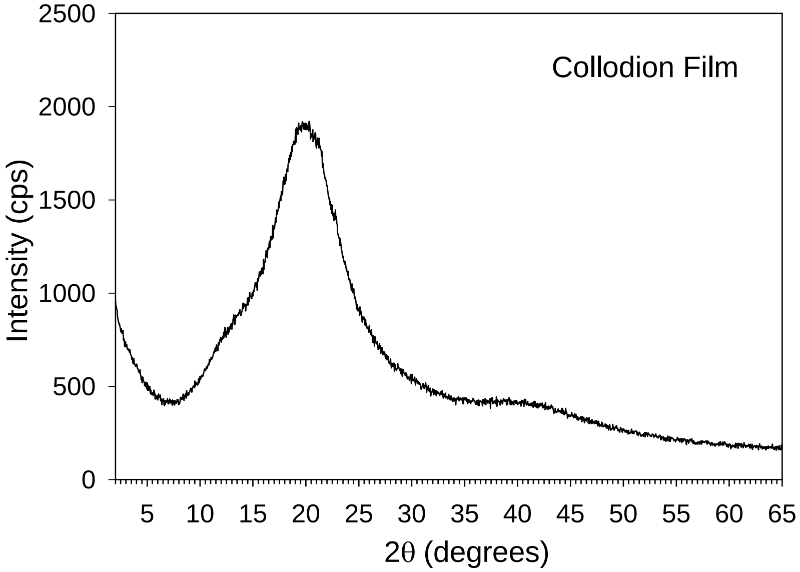

Figure 2.5. XRD Pattern for Collodion Film Measured in the Absence of Any Residual Waste Material (from Krupka et al. 2004)

pattern was examined before and after background subtraction to ensure that the integrity of the pattern was maintained. For background subtraction, the JADE® software provides the user with control over the selection of background-subtraction points. This process allows a better fit to 2θ regions under broad reflections, such as those resulting from amorphous materials. On average, 30 to 40 background points were selected from each XRD pattern, and a cubic-spline curve was then fit through each set of points. Adjustments to this curve were made by selecting additional background points in regions of a pattern that were difficult to fit. Once a well-matched curve was fitted to a pattern, the background was subtracted from each as-measured XRD pattern, resulting in a smooth tracing.

Identification of the mineral phases in the background-subtracted patterns was based on a comparison of the XRD patterns measured for the residual waste samples with the mineral powder diffraction files (PDF™) published by the Joint Committee on Powder Diffraction Standards (JCPDS) International Center for Diffraction Data (ICDD). As a rule of thumb, a crystalline phase must be present at greater than ~5-10 wt% of the total sample mass (greater than 1 wt% under optimum conditions) to be readily detected by XRD. In general, the measured peak intensities depend on several factors, including the combined mass of each crystalline phase in the sample. Due to the physical characteristics of these residual waste samples, such as high radioactivity, high dispersibility, and variable moisture content, the mass of residual waste combined with the collodion solution for each XRD mount could not be controlled or easily determined. Dissimilarities in mineral segregation (settling) resulting from the different densities of minerals mixed with the collodion solution and associated effects on relative peak intensities also influence the overall pattern intensity. The combined effect of these factors could have some effect on the characteristic mineral peak intensities, which precluded quantitative comparisons of peak intensities for equivalent reflections in background-subtracted XRD patterns for different residual waste samples.

2.3 SEM/EDS Analysis

SEM/energy dispersive spectrometry (EDS) analyses were used to characterize the morphologies and compositions of solid phases present in the following C-103 residual waste samples:

- Unleached samples 19845, 19849, and 19850
- 1-month single-contact DDI water-leached solids from samples 19845, 19849, and 19850
- 1-month single-contact $Ca(OH)_2$-leached solids from samples 19845, 19849, and 19850
- 1-month single-contact $CaCO_3$-leached solids from samples 19845, 19849, and 19850.

Two mounts were prepared of each sample to compensate for the possibility that one less-than-optimum mount of a sample might occur, thus improving the likelihood of obtaining representative SEM images of each sample. The mounts used for SEM/EDS consisted of double-sided C tape attached to standard Al mounting stubs. For each mount, small aliquots of each residual waste sample were placed on the exposed upper surface of the C tape using a micro spatula. Each mount was then coated with C using a vacuum sputter-coater to improve the conductivity of the samples and thus the quality of the SEM images and EDS signals.

A JEOL JSM-840 SEM was used for high-resolution imaging of micrometer/submicrometer-sized particles in the residual waste samples. The EDS system provided qualitative elemental analysis for scanned areas of particles. The SEM is equipped with an INCA Energy EDS System(6) to automate the collection of EDS spectra over multi-micrometer-sized areas of an SEM-imaged sample. The EDS software was calibrated to a copper reference standard mounted on a specimen holder. Operating conditions consisted of 20 keV for SEM imaging and 20 keV, 100 live seconds(7) for the EDS analyses. The EDS analyses are limited to elements with atomic weights heavier than boron (B). Compositions determined by EDS are qualitative and have large uncertainties resulting from alignment artifacts caused by the variable sample and detector configurations that exist when different particles are imaged by SEM.

Photomicrographs of high-resolution secondary electron (SE) images and backscattered electron (BSE) images were obtained as digital images and stored in electronic format. To help identify particles that contain elements with large atomic numbers, such as U, the SEM was typically operated in the BSE mode. Secondary electrons are low-energy electrons ejected from the probed specimen as a result of inelastic collisions with beam electrons, whereas backscattered electrons are primary electrons emitted as a result of elastic collisions. Backscattered electron emission intensity is a function of the element's atomic number – the larger the atomic number, the brighter the signal. Backscattered electron images are obtained in exactly the same way as secondary electron images.

The entire area of each SEM mount was examined by SEM at low magnification (typically 10 to 30 times) to identify those particles and surface features that were typical or unusual for the sample. During this examination, SEM micrographs were recorded at low magnification for one or more representative areas of the mount to provide a general perspective of the sizes, types, and distributions of

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(6) Oxford Instruments, Concord, Massachusetts.

(7) Live time is when (real time less dead time) the EDS system is available to detect incoming x-ray photons. Dead time is the portion of the total analyzing time that is actually spent processing or measuring x-rays. While each x-ray pulse is being measured, the system cannot measure another x-ray that may enter the detector and is, therefore, said to be "dead."

particles that make up each SEM mount. Within these imaged regions, additional SEM micrographs were recorded of several particles at greater magnifications to provide a more detailed representation of the particles' characteristics, and selected points on these particles were then analyzed by EDS. Depending on the perceived importance of such particles, regions on these particles were sometimes analyzed by SEM and EDS at even greater magnifications.

3.0 Laboratory Results

This section includes the results of tests conducted on the residual waste samples from tank C-103 (samples 19845, 19849, and 19850). Section 3.1 includes a description of the residual waste composition obtained from acid digestion methods. ^{129}I results are provided in Section 3.2. The results of the residual waste leaching tests that included batch and sequential leaching with DDI water and leaching using $Ca(OH)_2$ and $CaCO_3$ leachates are described in Sections 3.3.1. Residual waste characterization data generated by using XRD and SEM/EDS are discussed in Sections 3.6 and 3.7, respectively.

3.1 Residual Waste Composition

An important component of contaminant release rate calculations is an accurate measurement of the total concentrations of the contaminants in the source material. As described in Section 2.2, the total metals and radionuclide concentrations of the residual wastes were measured using an acid digestion method. The results of these analyses are described in this section. The anionic (nonmetal) composition of the residual waste was estimated by water extraction as part of the Tier 1 analyses (Section 2.2.7). Tier 1 anion results are discussed in Section 3.3.1.

Table 3.1 lists the moisture content [((wet wt – dry wt)/dry wt) x 100%] of the C-103 residual waste samples used for the EPA acid digestions. These values are used with the digestion factors (Table 2.2) to convert the solution analyses of the extracts from the treatments to dry weight solid concentrations. The moisture contents of the residual waste samples ranged from 8.7 to 17.3%.

Table 3.1. Moisture Contents of C-103 Residual Waste Samples [(wet wt – dry wt)/dry wt]

Sample Number	Moisture Content
19845	8.73%
19845 Dup	10.17%
19849	12.14%
19849 Dup	12.23%
19850	16.73%
19850 Dup	17.26%
Dup = Duplicate sample.	

Concentrations listed in parentheses in the following tables are defined as less than the EQL but greater than a zero instrument signal (concentration of zero). These values are reported for informational purposes only. They may reflect actual concentrations that are real but have larger associated uncertainties than values above the EQL or may reflect values that were calculated from the instrument's background signal and are not representative of actual residual waste composition. The EQL of an element is determined by analyzing a suite of CCV standards at the beginning and end of each analytical run. The lowest CCV standard that is within ±10% of its certified value is multiplied by the dilution factor for the sample to determine the EQL for the element for the particular analytical run. The EQL may vary with each analysis depending on sample matrix, dilution factors, and instrument performance. Concentrations listed as less-than (<) values in the tables refer to instrument measurements that are less than zero. In these instances, the reported analyte concentration is assigned a value of "<EQL" using the EQL value appropriate for that particular analyte and set of analytical conditions.

The following discussion of element concentrations of the residual waste is organized in terms of the analytical method used to measure concentrations in the solution extract. These methods were C analyzer, ICP-OES, ICP-MS, ion chromatography (IC), GEA (^{137}Cs), and wet chemical separations and liquid scintillation counting (^{90}Sr). For the tables, the solution concentrations have been converted from a mass per-liter basis to a dry residual solid mass basis.

Table 3.2 lists the C contents on the dry residual waste basis for the C-103 residual waste samples. Average total C (TC) content of sample 19845 was 8.25 x 10^2 µg/g waste, sample 19849 was 1.10 x 10^3 µg/g waste and sample 19850 was 1.87 x 10^3 µg/g waste. In sample 19845, the average total organic C (TOC) and total inorganic C (TIC) contents were 5.68 x 10^2 and 2.57 x 10^2 µg/g waste, respectively. In sample 19849, the average organic and inorganic C contents were 8.30 x 10^2 and 2.80 x 10^2 µg/g waste, respectively. In sample 19850, the average organic and inorganic C contents were 1.60 x 10^3 and 2.57 x 10^2 µg/g waste, respectively. For these three C-103 samples, the bulk of the total C was mainly in the organic form, ranging from 69 to 85%. The composition of this organic material could not be determined with the analyses that were performed.

The results of elemental analyses by ICP-OES are listed in Table 3.3 through Table 3.5. Boron values from acid digestion are not reported because boric acid was used in the digestion process. Among the suite of thirty elements that were analyzed, only fifteen elements were present above the instrumental detection limits in all samples. These elements included Al, Ba, Ca, Cd, Cr, Fe, Mn, Na, Ni, Pb, Si, Sr, Ti, Zn, and Zr. Additionally, Cu and P were present in detectable concentrations in residual waste sample 19850. Average concentrations of the elements that were present in measurable concentrations are listed in Table 3.6.

Table 3.2. Carbon Contents of Tank C-103 Residual Waste Samples

	TC	**TOC**	**TIC**	**TIC**
Sample Number	**µg C/g Dry Waste**			**µg CO_3/g**
19845	1.00E+03	6.85E+02	3.15E+02	1.58E+03
19845 Dup	6.50E+02	4.52E+02	1.98E+02	9.92E+02
19849	1.18E+03	8.97E+02	2.92E+02	1.46E+03
19849 Dup	1.03E+03	7.63E+02	2.69E+02	1.35E+03
19850	1.74E+03	1.48E+03	2.45E+02	1.23E+03
19850 Dup	1.99E+03	1.72E+03	2.70E+02	1.35E+03
19845 Average	8.25E+02	5.68E+02	2.57E+02	1.28E+03
19849 Average	1.10E+03	8.30E+02	2.80E+02	1.40E+03
19850 Average	1.87E+03	1.60E+03	2.57E+02	1.29E+03

Dup = Duplicate.
TC = Total C.
TIC = Total inorganic C.
TOC = Total organic C.
µg C/g = Microgram of C per gram of dry residual waste.
µg CO_3/g = Microgram of CO_3 (carbonate) per gram of dry residual waste.

Table 3.3. Residual Waste Composition Measured by ICP-OES (Al through Cr)

Sample Number	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr
	µg/g Dry Waste									
EPA Acid Digestion										
19845	1.10E+05	(1.08E+02)	NA	1.34E+02	(1.04E+01)	<5.10E+03	3.66E+02	5.27E+01	<1.27E+02	1.66E+02
19845 Dup	1.26E+05	(1.54E+02)	NA	1.43E+02	(8.18E+00)	<5.51E+03	4.84E+02	6.99E+01	<1.38E+02	1.92E+02
19849	1.11E+05	(1.03E+02)	NA	1.59E+02	(6.84E+00)	<4.61E+03	3.38E+02	6.73E+01	<1.15E+02	1.51E+02
19849 Dup	1.99E+05	(1.44E+01)	NA	1.78E+02	(4.85E+00)	<5.01E+03	7.24E+02	6.15E+01	<1.25E+02	1.90E+02
19850	1.63E+05	(5.63E+01)	NA	2.37E+02	(4.88E+00)	<5.94E+03	1.22E+03	6.92E+01	<1.48E+02	2.37E+02
19850 Dup	1.05E+05	(8.45E+01)	NA	2.36E+02	(4.02E+00)	<4.49E+03	5.69E+02	6.81E+01	<1.12E+02	2.23E+02
19845 Average	1.18E+05	(1.31E+02)	NA	1.39E+02	(9.29E+00)	<5.30E+03	4.25E+02	6.13E+01	<1.33E+02	1.79E+02
19849 Average	1.55E+05	(5.87E+01)	NA	1.68E+02	(5.85E+00)	<4.81E+03	5.31E+02	6.44E+01	<1.20E+02	1.70E+02
19850 Average	1.34E+05	(7.04E+01)	NA	2.37E+02	(4.45E+00)	<5.22E+03	8.92E+02	6.87E+01	<1.30E+02	2.30E+02

Dup = Duplicate.
EQL = Estimated quantitation limit.
NA = Not analyzed; boric acid used in acid digestion.
Concentrations listed in parentheses were <EQL.

Table 3.4. Residual Waste Composition Measured by ICP-OES (Cu through Pb)

Sample Number	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	P	Pb
	µg/g Dry Waste									
EPA Acid Digestion										
19845	(8.55E+01)	7.49E+03	<1.27E+04	(1.44E+01)	(2.64E+01)	2.73E+02	(7.73E+00)	4.00E+02	(7.84E+02)	6.35E+02
19845 Dup	(9.35E+01)	1.05E+04	<1.38E+04	(1.21E+01)	(3.13E+01)	3.45E+02	<5.51E+01	4.38E+02	(9.02E+02)	8.73E+02
19849	(8.56E+01)	8.33E+03	<1.15E+04	<9.23E+01	(2.16E+01)	2.62E+02	(9.09E+00)	2.93E+02	(7.25E+02)	6.24E+02
19849 Dup	(8.22E+01)	1.24E+04	<1.25E+04	<1.00E+02	(6.08E+01)	3.71E+02	(7.51E+00)	4.11E+02	(8.02E+02)	8.00E+02
19850	(1.03E+02)	1.66E+04	<1.48E+04	<1.19E+02	(8.65E+01)	4.88E+02	<5.94E+01	5.09E+02	1.31E+03	1.23E+03
19850 Dup	1.07E+02	1.70E+04	<1.12E+04	<8.99E+01	(2.56E+01)	4.85E+02	<4.49E+01	4.70E+02	1.14E+03	1.18E+03
19845 Average	(8.95E+01)	9.00E+03	<1.33E+04	(1.32E+01)	(2.88E+01)	3.09E+02	<3.14E+01	4.19E+02	(8.43E+02)	7.54E+02
19849 Average	(8.39E+01)	1.03E+04	<1.20E+04	<9.62E+01	(4.12E+01)	3.16E+02	(8.30E+00)	3.52E+02	(7.63E+02)	7.12E+02
19850 Average	1.05E+02	1.68E+04	<1.30E+04	<1.04E+02	(5.60E+01)	4.86E+02	<5.22E+01	4.90E+02	1.22E+03	1.21E+03

Dup = Duplicate.
EQL = Estimated quantitation limit.
Concentrations listed in parentheses were <EQL.

Table 3.5. Residual Waste Composition Measured by ICP-OES (Se through Zr)

Sample Number	Se	Sr	Tl	V	Zn	Na	Si	S	Ti	Zr
	µg/g Dry Waste									
EPA Acid Digestion										
19845	<1.02E+04	5.11E+01	<5.10E+02	<5.10E+01	1.90E+02	7.15E+03	8.07E+03	(3.08E+02)	1.35E+02	8.75E+02
19845 Dup	<1.10E+04	7.65E+01	<5.51E+02	<5.51E+01	2.49E+02	7.96E+03	9.90E+03	(2.86E+02)	9.02E+01	1.30E+03
19849	<9.23E+03	5.35E+01	<4.61E+02	<4.61E+01	2.38E+02	6.49E+03	7.05E+03	(2.95E+02)	1.27E+02	9.19E+02
19849 Dup	<1.00E+04	1.07E+02	<5.01E+02	<5.01E+01	2.03E+02	8.38E+03	9.65E+03	(2.38E+02)	1.33E+02	1.02E+03
19850	<1.19E+04	1.53E+02	<5.94E+02	<5.94E+01	2.72E+02	8.47E+03	9.70E+03	(3.41E+02)	2.49E+02	1.44E+03
19850 Dup	<8.99E+03	1.03E+02	<4.49E+02	<4.49E+01	2.45E+02	8.60E+03	1.01E+04	(1.31E+02)	1.09E+02	1.33E+03
19845 Average	<1.06E+04	6.38E+01	<5.30E+02	<5.30E+01	2.20E+02	7.55E+03	8.98E+03	(2.97E+02)	1.13E+02	1.09E+03
19849 Average	<9.62E+03	8.02E+01	<4.81E+02	<4.81E+01	2.20E+02	7.43E+03	8.35E+03	(2.66E+02)	1.30E+02	9.71E+02
19850 Average	<1.04E+04	1.28E+02	<5.22E+02	<5.22E+01	2.58E+02	8.53E+03	9.89E+03	(2.36E+02)	1.79E+02	1.38E+03

Dup = Duplicate.
EQL = Estimated quantitation limit.
Concentrations listed in parentheses were <EQL.

Table 3.6. Average Residual Waste Composition Measured by ICP-OES

Element	19845	19849	19850
	µg/g Dry Waste		
Al	118,000	155,000	134,000
Ba	139	168	237
Ca	425	531	892
Cd	61.3	64.4	68.7
Cr	179	170	230
Cu	(89.5)	(83.9)	105
Fe	9,000	10,300	16,800
Mn	309	316	486
Na	7,550	7,430	8,530
Ni	419	352	490
P	(843)	(763)	1,220
Pb	754	712	1,210
Si	8,980	8,350	9,890
Sr	63.8	80.2	128
Ti	113	130	179
Zn	220	220	258
Zr	1,090	971	1,380

Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.

A comparison of the elemental composition between the three residual waste samples (Table 3.6) indicates that the three samples are generally quite similar, with all elemental concentrations being well within ±40% of the average for the three samples. Aluminum is clearly the dominant metal component, with an average concentration of 13.6% (for the three samples). Other significant components include Fe, Na, and Si, with average concentrations of 1.2%, 0.8%, and 0.9%, respectively.

The elemental concentrations analyzed by ICP-MS are listed in Table 3.7 and Table 3.8. Because ICP-MS uses isotopic measurements, this analytical method for some metals can attain lower detection limits than ICP-OES, and thus allow more accurate measurements of trace metal concentrations in the residual waste samples. Among the trace elements listed in the tables, Ag, Cd, Cr, Cu, Mo, Pb, and Ru were present in concentrations greater than their respective EQLs. The average concentrations of these elements based on isotopic measurements are listed in Table 3.9. Comparisons of the ICP-MS results can be made with the ICP-OES results for Cd, Cr, and Pb. The average ICP-MS Cd concentrations (based on the average of ^{111}Cd and ^{114}Cd) in the residual waste measured by acid digestion were similar to those values measured by ICP-OES (Table 3.6). For sample 19845, the average Cd concentration determined by ICP-MS was 64.5 µg/g waste compared to the ICP-OES result of 61.3 µg/g waste. For sample 19849, the average Cd concentration determined by ICP-MS was 65.4 µg/g waste compared to the ICP-OES result of 64.4 µg/g waste. For sample 19850, the average Cd concentration determined by ICP-MS was 72.3 µg/g waste compared to the ICP-OES result of 68.7 µg/g waste.

Table 3.7. Residual Waste Concentrations of Cr, Cu, As, Se, and Mo Determined from ICP-MS Analysis

Sample Number	Cr – Total[a]	Cu - Total[b]	As - Total Based on	Se - Total Based on	Mo - Total Based on		
			^{75}As	^{82}Se	^{95}Mo	^{97}Mo	^{98}Mo[c]
	µg/g Dry Waste						
EPA Acid Digestion							
19845	1.62E+02	6.11E+01	<5.10E+00	<5.10E+00	3.40E+00	1.51E+00	8.63E-01
19845 Dup	1.65E+02	6.69E+01	(9.51E-01)	(6.84E-02)	4.36E+00	1.78E+00	1.21E+00
19849	1.28E+02	6.35E+01	(1.68E-01)	(2.86E-01)	4.84E+00	2.01E+00	1.26E+00
19849 Dup	1.58E+02	5.89E+01	(9.12E-01)	(7.69E-01)	6.33E+00	3.05E+00	1.77E+00
19850	1.93E+02	7.46E+01	(3.30E-01)	<5.94E+00	1.15E+01	4.12E+00	2.39E+00
19850 Dup	1.72E+02	7.36E+01	(7.67E-01)	<4.49E+00	1.15E+01	4.25E+00	2.75E+00
19845 Average	1.63E+02	6.40E+01	(3.02E+00)	(2.58E+00)	3.88E+00	1.65E+00	1.03E+00
19849 Average	1.43E+02	6.12E+01	(5.40E-01)	(5.28E-01)	5.59E+00	2.53E+00	1.52E+00
19850 Average	1.83E+02	7.41E+01	(5.49E-01)	<5.22E+00	1.15E+01	4.19E+00	2.57E+00

(a) Cr results are based on the average of ^{52}Cr and ^{53}Cr.
(b) Cu results are based on the average of ^{63}Cu and ^{65}Cu.
(c) The indicated isotope is the suggested isotope for use to quantify the total concentration of that element.
Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.

Table 3.8. Residual Waste Concentrations of Ru, Ag, Cd, Sb, and Pb Determined from ICP-MS Analysis

Sample Number	Ru – Total Based on Sum of		Ag – Total[(a)]	Cd – Total[(b)]	Sb – Total Based on ^{121}Sb	Pb – Total[(c)]
	^{101}Ru	^{102}Ru				
	μg/g Dry Waste					
EPA Acid Digestion						
19845	1.37E+02	6.44E+01	2.79E+02	5.59E+01	(4.09E-01)	5.92E+02
19845 Dup	1.71E+02	7.91E+01	3.88E+02	7.30E+01	(4.70E-01)	7.79E+02
19849	1.92E+02	9.02E+01	2.92E+02	6.81E+01	(4.01E-01)	5.83E+02
19849 Dup	2.47E+02	1.17E+02	3.51E+02	6.27E+01	(5.14E-01)	7.54E+02
19850	5.12E+02	2.41E+02	4.29E+02	7.39E+01	(8.47E-01)	1.14E+03
19850 Dup	4.83E+02	2.28E+02	3.13E+02	7.07E+01	(8.92E-01)	9.75E+02
19845 Average	1.54E+02	7.17E+01	3.33E+02	6.45E+01	(4.39E-01)	6.86E+02
19849 Average	2.20E+02	1.04E+02	3.21E+02	6.54E+01	(4.58E-01)	6.69E+02
19850 Average	4.98E+02	2.35E+02	3.71E+02	7.23E+01	(8.70E-01)	1.06E+03

(a) Ag results are based on the average of ^{107}Ag and ^{109}Ag.
(b) Cd results are based on the average of ^{111}Cd and ^{114}Cd.
(c) Pb results are based on the average of ^{206}Pb and ^{208}Pb.
Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.

Table 3.9. Average Residual Waste Composition Measured by ICP-MS

Elements	19845	19849	19850
	μg/g Dry Waste		
Ag – Total	3.33E+02	3.21E+02	3.71E+02
As – Total	(3.02E+00)	(5.40E-01)	(5.49E-01)
Cd – Total	6.45E+01	6.54E+01	7.23E+01
Cr – Total	1.63E+02	1.43E+02	1.83E+02
Cu – Total	6.40E+01	6.12E+01	7.41E+01
Mo – Total	3.88E+00	5.59E+00	1.15E+01
Pb – Total	6.86E+02	6.69E+02	1.06E+03
Ru – Total	1.54E+02	2.02E+02	4.98E+02
Sb – Total	(4.39E-01)	(4.58E-01)	(8.70E-01)
Se – Total	(2.58E+00)	(5.28E-01)	<5.22E+00)

Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.

The average ICP-MS Cr concentrations (based on the average of ^{52}Cr and ^{53}Cr) in the residual waste measured by acid digestion were similar but slightly lower than those values measured by ICP-OES (Table 3.6). For sample 19845, the average Cr concentration determined by ICP-MS was 163 μg/g waste compared to the ICP-OES result of 179 μg/g waste. For sample 19849, the average Cr concentration determined by ICP-MS was 143 μg/g waste compared to the ICP-OES result of 170 μg/g waste. For sample 19850, the average Cr concentration determined by ICP-MS was 183 μg/g waste compared to the ICP-OES result of 230 μg/g waste.

As with Cr, the average ICP-MS Pb concentrations (based on the average of ^{206}Pb and ^{208}Pb) in the residual waste measured by acid digestion were similar but slightly lower than those values measured by ICP-OES (Table 3.6). For sample 19845, the average Pb concentration determined by ICP-MS was 686 μg/g waste compared to the ICP-OES result of 754 μg/g waste. For sample 19849, the average Pb concentration determined by ICP-MS was 669 μg/g waste compared to the ICP-OES result of 712 μg/g waste. For sample 19850, the average Pb concentration determined by ICP-MS was 1,060 μg/g waste compared to the ICP-OES result of 1,210 μg/g waste.

The average Ag concentrations (based on the average concentration of ^{107}Ag and ^{109}Ag) in the three C-103 samples (19845, 19849, and 19850) were similar, ranging from 321 and 371 μg/g waste. The average Cu concentrations (based on the average concentration of ^{63}Cu and ^{65}Cu) in the three C-103 samples (19845, 19849, and 19850) were also similar, ranging from 61.2 and 74.1 μg/g waste. Concentrations of Mo (based on ^{95}Mo) in the three samples ranged from 3.88 to 11.5 μg/g waste. Ru concentrations (based on ^{101}Ru) varied significantly among the three samples from 154 μg/g waste in sample 19845 to 498 μg/g waste in sample 19850. Results for As, Sb, and Se were below the EQL.

The concentrations of ^{99}Tc and ^{238}U measured by ICP-MS are listed in Table 3.10. The average ^{99}Tc concentrations determined by acid digestion for the three samples (19845, 19849, and 19850) were 0.185, 0.225, and 0.283 μg/g waste, respectively. The average ^{238}U concentrations determined by acid digestion for the three samples (19845, 19849, and 19850) were 3,320, 3,690, and 4,180 μg/g waste, respectively.

Table 3.10. Concentrations of ^{99}Tc and ^{238}U Measured in C-103 Residual Waste by ICP-MS

Sample Number	^{99}Tc	^{238}U
	µg/g Dry Waste	
EPA Acid Digestion		
19845	1.61E-01	2.78E+03
19845 Dup	2.08E-01	3.87E+03
19849	2.23E-01	2.78E+03
19849 Dup	2.27E-01	4.60E+03
19850	2.66E-01	4.13E+03
19850 Dup	3.00E-01	4.23E+03
19845 Average	1.85E-01	3.32E+03
19849 Average	2.25E-01	3.69E+03
19850 Average	2.83E-01	4.18E+03
Dup = Duplicate.		

The elemental data from the ICP-OES and ICP-MS analyses indicated that the dominant constituents in C-103 residual waste, in decreasing order, were Al, Fe, Si, Na, and U (Table 3.11). Al concentrations ranged from 11.8% (sample 19845) to 15.5% (sample 19849). Fe concentrations ranged from 0.9% (sample 19845) to 1.7% (sample 19850). Si concentrations ranged from 0.8% (sample 19849) to 1.0% (sample 19850). Na concentrations ranged from 0.7% (sample 19849) to 0.9% (sample 19850). U concentrations ranged from 0.3% (sample 19845) to 0.4% (sample 19850). These values are generally consistent with those determined by the 222S Lab (RPP-RPT 2007), except for those of aluminum. The average aluminum result determined from the 222S Lab results was 23.9% which is more consistent with our XRD and SEM/EDS results (see sections 3.6 and 3.7). Based on these comparisons our total aluminum concentrations appear to be underestimated. The reason for this discrepancy could not be determined.

Table 3.11. Dominant Elemental Concentrations in C-103 Residual Wastes (% dry weight)

Element	19845	19849	19850
	% Dry Mass of Waste		
Al	11.8	15.5	13.4
Fe	0.90	1.03	1.68
Na	0.76	0.74	0.85
Si	0.90	0.84	0.99
U	0.33	0.37	0.42

The concentrations of ^{137}Cs and ^{90}Sr in residual wastes were measured on acid digested samples using GEA and liquid scintillation counting, respectively. The average ^{137}Cs concentrations in acid digested residual waste samples 19845, 19849, and 19850 in terms of activities were 52.7, 28.0, and 60.2 µCi/g waste, respectively (Table 3.12). The average ^{90}Sr concentrations in acid residual waste samples 19845, 19849, and 19850 in terms of activities were 2.83, 2.91, and 5.38 µCi/g waste, respectively (Table 3.13).

Table 3.12. ^{137}Cs Concentrations in C-103 Residual Waste

Sample Number	^{137}Cs µCi/g Dry Waste	^{137}Cs µg/g Dry Waste
EPA Acid Digestion		
19845	46.4	0.533
19845 Dup	59.0	0.678
19849	28.3	0.326
19849 Dup	27.7	0.319
19850	66.2	0.761
19850 Dup	54.2	0.623
19845 Average	52.7	0.606
19849 Average	28.0	0.322
19850 Average	60.2	0.692
Dup = Duplicate.		

Table 3.13. ^{90}Sr Concentrations in C-103 Residual Waste

Sample Number	^{90}Sr µCi/g Dry Residual Waste	^{90}Sr µg/g Dry Residual Waste
EPA Acid Digestion		
19845	305	2.18
19845 Dup	487	3.48
19849	305	2.18
19849 Dup	509	3.64
19850	904	6.46
19850 Dup	603	4.30
19845 Average	396	2.83
19849 Average	407	2.91
19850 Average	753	5.38
Dup = Duplicate.		

The concentrations of transuranic elements in the residual waste samples were determined using ICP-MS analysis of acid digested samples (Table 3.14). The average ^{237}Np activities in the residual waste samples 19845, 19849, 19850 that were determined to be 8.18 x 10^{-4}, 7.21 x 10^{-4}, and 1.24 x 10^{-3} µCi/g waste, respectively. Average ^{239}Pu activities were significantly higher than those of ^{237}Np. Average ^{239}Pu in the residual waste samples 19845, 19849, 19850 were 0.40, 0.48, and 0.62 µCi/g waste, respectively. The ^{241}Am activities were more similar to those of ^{239}Pu than ^{237}Np. Average ^{241}Am activities in the residual waste samples 19845, 19849, 19850 were (0.11), 0.15, and 0.28 µCi/g waste, respectively.

Table 3.14. Actinide Concentrations in Residual Waste (measured using ICP-MS unless footnoted)

Sample Number	^{237}Np$^{(a)}$ µCi/g Dry Waste	^{237}Np$^{(a)}$ µg/g Dry Waste	^{239}Pu$^{(a)}$ µCi/g Dry Waste	^{239}Pu$^{(a)}$ µg/g Dry Waste	^{241}Am µCi/g Dry Waste	^{241}Am µg/g Dry Waste
EPA Acid Digestion						
19845	7.77E-04	1.09E+00	3.95E-01	6.37E+00	(8.32E-02)	(2.45E-02)
19845 Dup	8.58E-04	1.21E+00	3.99E-01	6.43E+00	(1.39E-01)	(4.08E-02)
19849	6.73E-04	9.48E-01	4.29E-01	6.92E+00	(1.07E-01)	(3.14E-02)
19849 Dup	7.69E-04	1.08E+00	5.21E-01	8.41E+00	1.98E-01	5.81E-02
19850	1.25E-03	1.76E+00	6.46E-01	1.04E+01	3.55E-01	1.05E-01
19850 Dup	1.23E-03	1.73E+00	5.96E-01	9.62E+00	2.08E-01	6.11E-02
19845 Average	8.18E-04	1.15E+00	3.97E-01	6.40E+00	(1.11E-01)	(3.26E-02)
19849 Average	7.21E-04	1.02E+00	4.75E-01	7.66E+00	1.52E-01	4.47E-02
19850 Average	1.24E-03	1.74E+00	6.21E-01	1.00E+01	2.82E-01	8.28E-02

(a) Results may be biased high due to interferences from U.
Concentrations listed in parentheses were <EQL.
Dup = Duplicate.
EQL = Estimated quantitation limit.

3.2 ^{129}I Results

Table 3.15 contains results of the ^{129}I analysis of the modified KOH:KNO$_3$ fusion/water extraction of residual waste material from the three tank C-103 samples. The data are reported as µCi ^{129}I per gram of residual waste (calculated on a dry weight basis). Results for all three samples were determined to be less than the EQLs. The instrument EQLs resulted in dilution-corrected sample estimated concentrations ranging from 0.023 to 0.11 µCi/g waste. Because ^{129}I concentrations in the residual waste samples were below the EQLs, ^{129}I was not analyzed in the water extract samples described below.

Table 3.15. Summary of ^{129}I Concentrations Determined with Modified KOH-KNO$_3$ Fusion Method for Tank C-103 Residual Waste Samples

Sample Number	^{129}I µCi/g Dry Waste	^{129}I µg/g Dry Waste
EPA Acid Digestion		
19845	(2.27E-02)	(4.03E-06)
19845 Dup	(6.19E-02)	(1.10E-05)
19849	(6.30E-02)	(1.12E-05)
19849 Dup	(5.65E-02)	(9.99E-06)
19850	(1.13E-01)	(2.00E-05)
19850 Dup	(5.73E-02)	(1.01E-05)
19845 Avg	(4.23E-02)	(7.49E-06)
19849 Avg	(5.97E-02)	(1.06E-05)
19850 Avg	(8.51E-02)	(1.51E-05)

Avg = Average.
Dup = Duplicate.
Concentrations listed in parentheses were <EQL.

3.3 Water Leaching Tests

The data obtained from the water leaching tests on the three residual waste samples [19845, 19849, and 19850] are presented and discussed in this section. The concentrations of the constituents in the water extracts tabulated in this section are expressed in units of µCi or µg per gram of dry residual waste.

3.3.1 1-Month Single-Contact Test Results

The single-contact water-leach tests were run in duplicate with an equilibration time of 1 month. DDI water was used as a leachant. The results of these experiments are presented in this section. In addition to the 1-month single-contact tests, the first stage of the sequential extraction tests (Section 3.3.2) represents a 1-day water contact test. These results are discussed in the sequential extraction testing Section (3.3.2).

3.3.1.1 Digestion Factors and Moisture Contents – Single-Contact DDI Water Extracts

In these tests, 30 ml of DDI water was contacted with about 0.3 g of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17.3% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the dry residual waste to DDI water ratios (Table 3.16). These ratios ranged from about 9.2 to 10.9 g/L.

Table 3.16. Residual Waste to DDI Ratios Used in Water Leaching Tests

Sample Number	Waste to DDI Water Ratio (g/L)
19845	10.81
19845 Dup	10.89
19849	10.80
19849 Dup	9.22
19850	9.81
19850 Dup	9.95

Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

3.3.1.2 Water Extract pH and Alkalinity – Single-Contact DDI Water Extracts

The average alkalinities and pH values measured in duplicate samples of each residual waste DDI water extract are listed in Table 3.17. The pH values of the water extracts for all three samples were mildly alkaline in nature ranging from 7.82 to 8.04. The total alkalinities were fairly similar for all three samples ranging from 3.64 to 4.43 mg $CaCO_3$/g residual waste.

3.3.1.3 Extractable ^{99}Tc and ^{238}U – Single-Contact Water Extracts

The radionuclides ^{99}Tc and ^{238}U pose a long-term environmental risk because of their long half lives and high mobility in the dissolved state. The concentrations of these two constituents mobilized in DDI water after 1 month of contact with the three residual waste samples are listed in Table 3.18. The concentrations of ^{99}Tc extracted from the single-contact extracts for the three samples were quite low with a fairly narrow range (0.013 µg/g waste [sample 19850] to 0.018 µg/g waste [sample 19845]). When compared to the total ^{99}Tc in the residual waste as measured by acid digestion of the residual wastes, these water leachable concentrations represent about 4.6 to 9.8% of the ^{99}Tc in the residual wastes (Table 3.19).

Table 3.17. C-103 Residual Waste Water Extract pH and Alkalinity Values

Sample Number	pH	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint
		(mg/L)	(mg/g solid)
19845 1 Month	8.00	40.3	3.73
19845 1 Month Dup	8.04	42.6	3.91
19849 1 Month	7.82	42.6	3.94
19849 1 Month Dup	7.96	38.0	4.12
19850 1 Month	7.90	35.7	3.64
19850 1 Month Dup	7.85	44.1	4.43
Dup = Duplicate. All concentrations are corrected for the dry waste basis.			

Table 3.18. ^{99}Tc and ^{238}U Concentrations Extracted from C-103 Residual Waste from Single-Contact Water Leach Tests

Sample Number	^{99}Tc	^{238}U	^{99}Tc	^{238}U
	µg/g Dry Waste		µCi/g Dry Waste	
19845 1 Month Average	1.80E-02	1.93E+02	3.06E-04	6.47E-05
19849 1 Month Average	1.31E-02	2.35E+02	2.22E-04	7.89E-05
19850 1 Month Average	1.30E-02	2.48E+02	2.20E-04	8.35E-05

Table 3.19. Water-Leachable Percentages of ^{99}Tc and ^{238}U Extracted from C-103 Residual Waste

Sample Number	^{99}Tc	^{238}U
	Percent Water Leachable	
19845 1 Month Average	9.76%	5.80%
19849 1 Month Average	5.80%	6.36%
19850 1 Month Average	4.58%	5.95%
Total concentrations from acid extracts.		

The DDI water extracts from these residual wastes contained moderate concentrations of ^{238}U. The average ^{238}U concentration for the three samples was fairly consistent, ranging from 193 to 248 µg/g waste. The percentages of leachable U for the samples have been calculated using the acid digestion concentrations for the total values. The leachable percentages range from 5.8 to 6.4% (Table 3.19) suggesting that ^{238}U, like ^{99}Tc, is present in the residual wastes in a solid with a relatively low solubility or slow dissolution rate.

3.3.1.4 Extractable Metals Concentrations – Single-Contact DDI Water Extracts

Concentrations of a number of metals, such as Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the DDI water extracts were measured by ICP-OES. Among these, only about a dozen metals were present in measurable concentrations (Table 3.20). The concentrations listed within parentheses indicate values that are less than EQL. In

Table 3.20. DDI Water-Leachable Average Metal Concentrations in Single-Contact Water Extractions

Sample Number	Al	Ca	Cr	Fe	K	Mn	Na	Ni	P	Pb	Si	Sr	Zr
	µg/g Dry Waste												
19845 1 Month	619	12.79	(1.61)	21.34	(41.5)	2.43	1,450	4.49	49.5	3.70	651	(1.37)	12.3
19845 1 Month Dup	584	12.23	(1.49)	19.41	(39.4)	2.28	1,420	3.88	48.7	4.12	642	(1.28)	11.3
19849 1 Month	377	10.72	(1.34)	17.78	(42.2)	2.32	1,480	(2.70)	41.9	4.03	551	(1.38)	8.00
19849 1 Month Dup	666	16.45	(1.74)	29.69	(48.5)	3.81	1,670	4.61	62.7	4.33	697	1.90	13.4
19850 1 Month	592	54.83	3.83	94.19	(31.9)	9.84	1,500	11.8	87.4	14.2	456	4.21	36.5
19850 1 Month Dup	500	38.63	2.90	63.55	(37.5)	6.52	1,760	7.73	84.8	9.66	461	2.86	24.5
19845 1 Month Avg	601	12.51	(1.55)	20.37	(40.4)	2.35	1,440	4.18	49.1	3.91	647	(1.33)	11.8
19849 1 Month Avg	522	13.58	(1.54)	23.73	(45.4)	3.06	1,580	(3.66)	52.3	4.18	624	(1.64)	10.7
19850 1 Month Avg	546	46.73	3.36	78.87	(34.7)	8.18	1,630	9.76	86.1	11.9	458	3.54	30.5

Concentrations listed in parentheses were <EQL.
Avg = Average.
Dup = Duplicate.
EQL = Estimated quantitation limit.

general, the concentrations of leachable metals for the C-103 residual waste samples are low. The major DDI water leachable element in all three residual waste samples was Na. Extraction concentrations of Na in all three residual waste samples were similar in magnitude, ranging from 1,420 to 1,760 µg/g waste. Significant concentrations of Si and Al were also leachable from these samples. Leachable Si concentrations ranged from 458 to 697 µg/g waste. Leachable Al concentrations ranged from 377 to 666 µg/g waste. Other elements with low measurable leachability included Ca, Fe, Cr, Mn, Ni, P, Pb, Sr, and Zr.

Percentages of total metals that were DDI water extractable are listed in Table 3.21. These results were computed on the basis of the total metal concentrations as measured in the acid digestion residual waste extractions (Table 3.3 to Table 3.5). The results indicate that only minor amounts of metals are leachable. For Na, 19 to 20% of the total Na in the three C-103 samples (19845, 19849, and 19850) is present in readily leachable forms. Water leachable fractions of Si range from 4.6 to 7.5%. Water leachable fractions of P range from 5.8 to 7.0%. Water leachable fractions of Ca range from 2.6 to 5.2%. All other measurable leachable metal in the C-103 residual tank waste samples are leachable at approximately 2% or less.

3.3.1.5 Extractable Anion Concentrations – Single-Contact Water Extracts

The concentrations of anions that were present in the DDI water extracts after 1-month contact were measured by ion chromatography (Table 3.22). Among the halides, F in the DDI water extracts of all residual wastes was present in significantly higher concentrations than Cl. Average F concentrations for the three C-103 sample extracts were similar, ranging from 24.0 to 31.7 µg/g waste. Average Cl concentrations for the three C-103 sample extracts ranged from <6.7 to 4.4 µg/g waste.

Nitrate concentrations in the extracts were about three times higher than NO_2 concentrations. Average NO_3 concentrations for the three C-103 sample extracts were similar, ranging from 155 to 196 µg/g waste. Average NO_2 concentrations for the three C-103 sample extracts were also similar, ranging from 50.4 to 62.9 µg/g waste.

Carbonate and SO_4 concentrations were generally less than the detection limit. Phosphate was the most variable of the extractable anions. Average PO_4 concentrations in the three C-103 sample extracts ranged from 77 to 150 µg/g waste. These values are nearly 50% lower than those determined by ICP-OES (Table 3.20) when compared on a molar basis.

3.3.1.6 Extractable ^{137}Cs and ^{90}Sr in Single-Contact DDI Water Extracts

The concentrations of ^{137}Cs and ^{90}Sr leachable in the 1 month DDI water extracts are shown in Table 3.22). The extractable ^{137}Cs concentrations are relatively low and consistent between the three samples. The average leachable ^{137}Cs determined from the 1 month DDI water extracts in terms of activities ranged from 2.5 to 2.6 µCi/g waste. These values constitute a range of average leachable concentrations of 4.1 to 9.3% of the total ^{137}Cs (Table 3.24).

Significantly higher extractable ^{90}Sr concentrations were measured in the 1 month DDI water extracts than for ^{137}Cs (Table 3.22), about 20 times higher (on a mass basis). The average leachable ^{90}Sr concentrations determined from the 1-month DDI water extracts in terms of activities ranged from 75 to 96 µCi/g waste. These values constitute a range of average leachable concentrations of 13 to 22% of the total ^{90}Sr (Table 3.24).

Table 3.21. Percentages of DDI Water-Leachable Metals in Single-Contact Water Extractions

Sample Number	Al	Ca	Cr	Fe	K	Mn	Na	Ni	P	Pb	Si	Sr	Zr
	Percent Water Leachable												
19845 1 Month Avg	0.5%	2.9%	(0.9%)	0.2%	(0.3%)	0.8%	19.0%	1.0%	5.8%	0.5%	7.2%	(2.1%)	1.1%
19849 1 Month Avg	0.3%	2.6%	(0.9%)	0.2%	(0.4%)	1.0%	21.2%	(1.0%)	6.9%	0.6%	7.5%	(2.0%)	1.1%
19850 1 Month Avg	0.4%	5.2%	1.5%	0.5%	(0.3%)	1.7%	19.1%	2.0%	7.0%	1.0%	4.6%	2.8%	2.2%

Concentrations listed in parentheses were <EQL.
Avg = Average.
EQL = Estimated quantitation limit.

Table 3.22. Average Extractable Anion Concentrations Determined from Single-Contact DDI Water Extractions

Sample Number	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
19845 1 Month	31.5	4.18	58.8	158	<462	<13.9	91.4
19845 1 Month Dup	31.8	4.54	57.1	152	<459	<13.8	104
19849 1 Month	27.1	<4.63	49.5	194	<4,630	<13.9	55.8
19849 1 Month Dup	32.7	15.5	51.3	199	<5,420	<16.3	98.6
19850 1 Month	23.3	8.31	58.6	145	<5,100	18.3	183
19850 1 Month Dup	24.8	<5.03	67.1	192	<5,030	<15.1	117
19845 1 Month Avg	31.7	4.36	57.9	155	<461	<13.8	97.7
19849 1 Month Avg	29.9	<10.1	50.4	196	<5,030	<15.1	77.2
19850 1 Month Avg	24.0	<6.67	62.9	169	<5,060	16.7	150

Avg = Average.
Dup = Duplicate.

Table 3.23. Extractable Concentrations ^{137}Cs and ^{90}Sr from 1 Month Single-Contact DDI Water Extractions

Sample Number	^{137}Cs		^{90}Sr	
	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
19845 1 Month	2.62	0.0301	74.1	0.530
19845 1 Month Dup	2.49	0.0286	75.8	0.542
19849 1 Month	2.47	0.0284	79.7	0.569
19849 1 Month Dup	2.75	0.0316	96.8	0.691
19850 1 Month	2.42	0.0279	97.6	0.697
19850 1 Month Dup	2.53	0.0291	94.6	0.675
19845 1 Month Avg	2.55	0.0293	75.0	0.536
19849 1 Month Avg	2.61	0.0300	88.2	0.630
19850 1 Month Avg	2.48	0.0285	96.1	0.686

All concentrations are corrected for the dry waste basis.
Avg = Average.
Dup = Duplicate.

Table 3.24. Extractable ^{137}Cs and ^{90}Sr from 1 Month Single-Contact DDI Water Extractions as a Percentage of Total Residual Waste Concentration

Sample Number	^{137}Cs	^{90}Sr
	--------% DDI Water Leachable-----	
19845 Average	4.8%	18.9%
19849 Average	9.3%	21.7%
19850 Average	4.1%	12.8%

All concentrations are corrected for the dry waste basis.
Total waste concentrations from acid digested samples.

3.3.1.7 Extractable Transuranics - Single-Contact DDI Water Extracts

The DDI water leachable extractable transuranic concentrations are listed in Table 3.25. Only ^{239}Pu had concentrations that were above the EQL. The average ^{239}Pu concentrations in the 1-month single-contact DDI water extracts for residual waste samples 19845, 19849, and 19850 were 4.0 x 10^{-3}, 6.6 x 10^{-3}, and 1.8 x 10^{-2} µCi/g waste, respectively. These concentrations indicated that 1.0, 1.4, and 2.9% of the total ^{239}Pu contained in these residual waste samples were in DDI-water extractable forms (Table 3.26).

Table 3.25. Extractable Transuranic Concentrations Determined from Single-Contact DDI Water Extractions

Sample Number	^{237}Np		^{239}Pu		^{241}Am	
	µCi/g Dry Waste	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**
19845	(1.60E-05)	(2.26E-02)	4.08E-03	6.59E-02	(3.46E-03)	(1.02E-03)
19845 Dup	(1.56E-05)	(2.19E-02)	3.94E-03	6.35E-02	(2.50E-03)	(7.34E-04)
19849	(2.38E-05)	(3.35E-02)	4.94E-03	7.96E-02	(2.83E-03)	(8.33E-04)
19849 Dup	(2.26E-05)	(3.18E-02)	8.19E-03	1.32E-01	(6.64E-03)	(1.95E-03)
19850	(4.23E-05)	(5.95E-02)	2.11E-02	3.40E-01	(1.63E-02)	(4.79E-03)
19850 Dup	(3.82E-05)	(5.38E-02)	1.47E-02	2.37E-01	(9.57E-03)	(2.82E-03)
19845 Average	(1.58E-05)	(2.23E-02)	4.01E-03	6.47E-02	(2.98E-03)	(8.76E-04)
19849 Average	(2.32E-05)	(3.27E-02)	6.56E-03	1.06E-01	(4.74E-03)	(1.39E-03)
19850 Average	(4.02E-05)	(5.67E-02)	1.79E-02	2.88E-01	(1.29E-02)	(3.80E-03)
Concentrations listed in parentheses were <EQL. Dup = Duplicate. EQL = Estimated quantitation limit.						

Table 3.26. Water-Leachable Percentage for Actinides in Single-Contact DDI Water Extractions

Sample Number	^{237}Np	^{239}Pu	^{241}Am
	% Water Leachable		
19845 1 Month Average	(1.9%)	1.0%	(2.7%)
19849 1 Month Average	(3.2%)	1.4%	(3.1%)
19850 1 Month Average	(3.2%)	2.9%	(4.6%)
Concentrations listed in parentheses were <EQL. Total concentrations from EPA acid digestions. EQL = Estimated quantitation limit.			

3.3.2 Water Extraction Periodic Replenishment Test Results

The periodic replenishment tests were conducted by repeatedly equilibrating duplicate residual waste samples with 30 mL aliquots of fresh DDI water. Contact stages, 1, 2, 4, and 5 were for 1 day each, whereas, contact stages 3 and 6 lasted 3 and 30 days respectively (Table 3.27). The goal of the sequential leaching tests was to assess the long-term leaching characteristics of key contaminants and other constituents from these residual waste samples. The results of these tests are presented in this section.

Table 3.27. Contact Times, pH Values, and Alkalinities for DDI Water Contact Periodic Replenishment Extractions

Contact Stage	Contact Duration (days)	pH	Total Alkalinity as $CaCO_3$ (mg/g Waste)
Sample 19845			
1	1	7.88	2.23
2	1	6.08	1.89
3	3	6.73	1.78
4	1	5.08	0.91
5	1	5.52	0.91
6	30	8.04	3.21
Sample 19849			
1	1	6.58	2.41
2	1	6.60	1.68
3	3	6.91	2.07
4	1	6.48	1.17
5	1	6.15	0.95
6	30	7.82	2.54
Sample 19850			
1	1	7.42	2.45
2	1	6.60	1.63
3	3	6.71	1.68
4	1	6.29	1.02
5	1	6.18	1.15
6	30	7.44	2.32

3.3.2.1 Digestion Factors and Moisture Contents from Periodic Replenishment DDI Water Extractions

In these tests, 30 ml of DDI water was contacted with about 0.3 g of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17.3% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the dry residual waste to DDI water ratios (Table 3.28). These ratios ranged from about 8.72 to 9.89.

3.3.2.2 Water Extract pH and Alkalinity from Periodic Replenishment Water Extractions

The average alkalinities and pH values measured in duplicate aliquots of DDI water extracts of each residual waste sample at the end of each contact stage are listed in Table 3.27. The pH values typically were mildly alkaline initially and then followed a general trend of becoming increasingly acidic with each subsequent sequential extraction, except in the last extraction (stage 6, 30-day contact), where the pH rebounded to mildly alkaline values. A smaller rebound effect was observed for stage 3 which had a 30-day contact period. For the three C-103 residual waste samples (19845, 19849, and 19850), the pH range over the course of the extractions was 5.08 to 8.04, 6.15 to 7.82, and 6.18 to 7.44, respectively.

Table 3.28. Residual Waste to DDI Ratios Used in Periodic Replenishment Leaching Tests

Sample Number	Waste to DDI Water Ratio (g/L)
19845	9.09
19845 Dup	9.34
19849	8.90
19849 Dup	8.72
19850	8.74
19850 Dup	9.89

Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

For all samples, the initial and final extractions mobilized the highest total alkalinity. Alkalinity generally decreased with each subsequent extraction stages, but a small but noticeable rebound affect was observed in the third contact. During the second extraction, the total alkalinity dropped to about 67 to 85% of that in the initial extraction. For the three C-103 residual waste samples (19845, 19849, and 19850), the sum of the extractable total alkalinity for all six stages was 10.9, 10.8, and 10.3 mg/g, respectively. These six stages of sequential extractions mobilized more than twice the amount of alkalinity from each residual waste sample as compared to the alkalinities released by the 1-month single water extraction (Table 3.17). The rebound in both pH and alkalinity values during the last extraction stage indicate that there are slowly water-releasable alkalinity components in all these residual waste samples even after considerable water leaching.

3.3.2.3 ^{99}Tc and ^{238}U from Periodic Replenishment DDI Water Extracts

The concentrations of ^{99}Tc and ^{238}U mobilized in periodic replenishment DDI water extractions of the residual waste samples are listed in Table 3.29. Quantifiable concentrations of ^{99}Tc were measured only in the first stage extracts of the C-103 residual waste samples. The measured concentrations in these extracts were extremely low, ranging from 0.010 to 0.013 µg/g waste. Concentrations of ^{99}Tc above the detection limit but below the EQL were measured in the last (stage 6) extracts of the C-103 residual waste samples. Concentrations of ^{99}Tc for all other stages for this sample were below detection limits. The amount of ^{99}Tc that leached during the DDI water replenishment tests for tank C-103 samples 19845, 19849, and 19850 were 7.1%, 4.6%, and 3.7%, respectively for stage 1 (Table 3.30). As indicated previously all other stages were either below the detection limit or less than the EQL. These results suggest that release of leachable ^{99}Tc occurs essentially immediately upon contact with the leachant. It is possible that this leachable ^{99}Tc may have been present in the pore waster of the residual waste and waste not released from the solid phase.

For ^{238}U, measurable concentrations were detected in nearly all extracts from the six stages of the three C-103 residual waste samples (Table 3.29). Two of three of the initial extracts (stage 1) contained the highest ^{238}U concentrations. For C-103 samples 19845, 19849, and 19850, the stage 1 ^{238}U concentrations were 73, 17, and 205 µg/g waste, respectively. Concentrations in the extracts from stages 2 through 5 were typically considerably less than those from stage 1. These concentrations ranged from 5.9 to 8.7 µg/g waste for sample 19845, 7.9 to 11 µg/g waste for sample 19849, and 2.9 to 9.9 µg/g waste for sample 19850. The stage 6 ^{238}U concentrations samples 19845, 19849, and 19850 were 55, 80, and 52 µg/g waste, respectively.

Table 3.29. ^{99}Tc and ^{238}U Concentrations in Periodic Replenishment DDI Water Extractions

Contact Stage	Contact Duration (days)	^{99}Tc	^{238}U	^{99}Tc	^{238}U
		µg/g Dry Waste		µCi/g Dry Waste	
Sample 19845					
1	1	1.31E-02	7.30E+01	2.22E-04	2.45E-05
2	1	<1.09E-02	(8.41E+00)	<1.85E-04)	(2.83E-06)
3	3	<1.09E-02	8.27E+00	<1.85E-04)	2.78E-06
4	1	<1.09E-02	8.68E+00	<1.85E-04	2.92E-06
5	1	<1.09E-02	5.89E+00	<1.85E-04	1.98E-06
6	30	(1.46E-03)	5.49E+01	(2.48E-05)	1.84E-05
Sample 19849					
1	1	1.04E-02	1.73E+01	1.77E-04	5.81E-06
2	1	<1.13E-02	1.02E+01	<1.93E-04	3.43E-06
3	3	<1.13E-02	1.06E+01	<1.93E-04	3.57E-06
4	1	<1.13E-02	7.85E+00	<1.93E-04	2.64E-06
5	1	<1.13E-02	1.14E+01	<1.93E-04	3.83E-06
6	30	(9.57E-04)	8.04E+01	(1.63E-05)	2.70E-05
Sample 19850					
1	1	1.05E-02	2.05E+02	1.79E-04	6.88E-05
2	1	<1.08E-02	2.93E+00	<1.83E-04	9.84E-07
3	3	<1.08E-02	6.45E+00	<1.83E-04	2.17E-06
4	1	<1.08E-02	8.30E+00	<1.83E-04	2.79E-06
5	1	<1.08E-02	9.85E+00	<1.83E-04	3.31E-06
6	30	(1.65E-04)	5.22E+01	(2.80E-06)	1.75E-05

Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.

The total ^{238}U leachable from all six sequential DDI water extractions constituted 4.6, 3.8, and 6.9% of the total ^{238}U present in samples 19845, 19849, and 19850, respectively (Table 3.30). These data indicate that the sums of ^{238}U leached from all six stages of sequential extraction of these residual wastes were similar to the ^{238}U extracted in the 1-month single-contact test (Table 3.19). The variation in percent ^{238}U leached closely parallels that of pH (Table 3.27) with leachates with higher pH having higher percent leachable ^{238}U. These results suggest that ^{238}U release may be controlled through dissolution rate of one or more U phases. Uranium in the initial porewater of the residual waste may have contributed to the high U concentrations in contact stage 1.

3.3.2.4 Selected Metal Concentrations from Periodic Replenishment DDI Water Extractions

Concentrations of a number of metals, such as Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the DDI water extracts were measured by ICP-OES. Among these, only about nine metals were present in measurable concentrations (Table 3.31). The concentrations listed within parentheses indicate values that are less than the EQL. These data show that the two major leachable elements in all three residual waste samples were Na and Si. Extractable concentrations of Na in these residual waste samples from all six DDI water extraction

Table 3.30. Average Sum of Water Leachable Percentages of ^{99}Tc and ^{238}U in Periodic DDI Water Replenishment Extractions

Contact Stage	Contact Duration (days)	^{99}Tc	^{238}U
		Percent Water Leachable	
Sample 19845			
1	1	7.1%	2.2%
2	1	<5.9%	(0.3%)
3	3	<5.9%	0.2%
4	1	<5.9%	0.3%
5	1	<5.9%	0.2%
6	30	(0.8%)	1.7%
Sample 19849			
1	1	4.6%	0.5%
2	1	<5.0%	0.3%
3	3	<5.0%	0.3%
4	1	<5.0%	0.2%
5	1	<5.0%	0.3%
6	30	(0.4%)	2.2%
Sample 19850			
1	1	3.7%	4.9%
2	1	<3.8%	0.1%
3	3	<3.8%	0.2%
4	1	<3.8%	0.2%
5	1	<3.8%	0.2%
6	30	(0.1%)	1.3%

Concentrations listed in parentheses were <EQL.
EQL = Estimated quantitation limit.
Total concentrations from EPA acid digestions.

stages of the three samples ranged form 82 to 982 µg/g waste and Si ranged from (35) to 727 µg/g waste. The sequential leaching behaviors of Na and Si from these residual wastes were similar to other constituents in that, following high concentrations in the first stage, significantly lower concentrations were observed in the subsequent four stages of extraction and then concentrations increased noticeably in the final leach stage. Other elements in these residual wastes with measurable leachable concentrations were Al and Ca. The other metals listed in Table 3.31 (Cr, Fe, Mn, and Ni) had leachable concentrations that were quantifiable only in the first and/or last stages.

Table 3.31. Water-Leachable Average Metals (ICP-OES) in Periodic Replenishment DDI Water Extractions

Contact Stage	Al	Ca	Cr	Fe	Mn	Na	Ni	Pb	Si
	µg/g Dry Waste								
Sample 19845									
1	127	15.1	1.22	18.1	1.93	600	(4.20)	(3.10)	(66.8)
2	11.3	(4.78)	<2.04	<3.26	<0.814	480	(1.39)	<1.74	208
3	10.2	(5.24)	<2.04	<3.26	<0.814	507	(1.45)	<3.26	266
4	5.03	9.93	<2.04	<3.26	<0.814	146	(1.34)	(58.6)	(74.7)
5	4.94	(7.20)	<2.04	<3.26	<0.814	123	(1.09)	<1.72	(59.7)
6	496	(5.34)	<2.04	(2.47)	(0.336)	982	(1.27)	<2.00	727
Sample 19849									
1	18.2	(5.44)	(0.260)	(0.349)	(0.0462)	714	(0.880)	<3.26	(101)
2	7.79	(6.13)	(0.078)	(0.268)	(0.0284)	278	(0.819)	<1.67	(135)
3	10.7	(4.85)	(0.170)	(0.410)	<0.485	487	(0.721)	(0.787)	262
4	5.87	(5.21)	(0.125)	(0.374)	(0.0746)	198	(0.691)	<1.96	(99.1)
5	(3.01)	10.5	(0.170)	(0.266)	(0.135)	82.2	(0.794)	(0.216)	(34.6)
6	472	17.8	(1.06)	16.4	202	771	(2.70)	(3.73)	541
Sample 19850									
1	211	39.5	2.51	64.7	6.66	740	8.11	9.05	(51.6)
2	10.2	15.5	(0.153)	(0.727)	(0.140)	358	(0.746)	(2.02)	(124)
3	11.7	18.8	(0.146)	(1.88)	(0.0783)	462	(0.455)	(0.727)	216
4	6.35	26.2	(0.151)	(0.859)	(0.0579)	194	(0.452)	<3.26	(94.0)
5	4.89	17.9	(0.101)	(0.291)	(0.0340)	136	(0.488)	<3.26	(61.3)
6	336	9.50	(0.277)	4.57	(0.452)	779	(1.27)	(0.928)	521

Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Based on duplicate measurements.

The percentages of metals that were cumulatively extractable during the six-stage sequential DDI water leaching are listed in Table 3.32. These results were computed on the basis of the total metal concentrations as measured in the acid digested samples of the residual waste (Table 3.3 to Table 3.5). The data show that about 38%, 34%, and 31% of the total Na present in samples 19845, 19849, and 19850, respectively, were present in readily water leachable forms. These data indicate that the six stages of sequential extractions of these residual waste samples released about 1.6 to 2 times the amount of Na that was leached during the 1-month single-contact extractions (Table 3.20). The data also show that the sequential extractions of these residual wastes released 16%, 14%, and 11% of the total Si present in samples 19845, 19849, and 19850, respectively. The cumulative Si released from these residual wastes by the sequential extractions was about twice the amount of Si released from the single 1-month extraction.

Sequential extractions also cumulatively mobilized higher percentages of Ca, Cr, Ni, and Pb as compared to the 1-month single extractions. The percentages of Al, Fe, and Mn that were mobilized during the six stages of the sequential extractions were comparable to those released during the 1-month water leaches.

Table 3.32. Cumulative Percentages of Leachable Metals from Periodic Replenishment DDI Water Extractions

Element	Sample 19845	Sample 19849	Sample 19850
	Cumulative % - DDI Water Soluble		
Al	0.6	0.3	0.4
Ca	11.2	9.4	14.3
Cr	6.4	1.1	1.5
Fe	0.4	0.2	0.5
Mn	1.8	0.9	1.6
Na	37.6	34.1	31.3
Ni	2.6	1.9	2.4
Si	15.6	14.1	10.8
Pb	1.7	1.7	1.6
Values calculated on the dry waste basis. Total concentrations from EPA acid digestions.			

3.3.2.5 Anion Concentrations – Replenishment Water Extractions

The concentrations of anions extracted by the DDI water leaches after each stage of sequential extraction were measured by IC are listed in Table 3.33. In general, the concentrations of anions leached during the extractions were quite low. Nitrate was the most significant anion to be leached from the C-103 samples, with leachable concentrations ranging from less than detection to 158 µg/g waste. Small amounts of F, Cl, and NO_2 were occasionally measured, but most extract concentrations of these anions were less than the detection limit. All CO_3 and SO_4 measurements were less than the detection limit. Most PO_4 measurements were less than the detection limit; however, a few quantifiable measurements were made, particularly in sample 19850. The third stage of sample 19850 contained 112 µg/g waste of PO_4.

3.3.2.6 Concentrations ^{137}Cs and ^{90}Sr from Periodic Replenishment DDI Water Extractions

The concentrations of ^{137}Cs in the residual waste as determined from all sequential extraction stages using DDI water indicated that this radioisotope had very low leachability at the hundredths of a µg per gram residual waste level (Table 3.34). The leachable ^{137}Cs activities were fairly similar across all six contact stages and for all three samples. The leachable ^{137}Cs activity range for all stages and samples in terms of activity was 0.54 to 2.7 µCi/g waste. The leachable percentages of ^{137}Cs in the three C-103 samples 19845, 19849, and 19850 were 12, 25, and 10%, respectively (Table 3.35).

^{90}Sr data for the periodic replenishment extractions are available for only the first, third, fifth, and sixth extractions (Table 3.34). The concentrations of ^{90}Sr in the residual waste as determined from all sequential extraction stages using DDI water indicated that ^{90}Sr was significantly more leachable than ^{137}Cs (about fifty times greater on a mass basis). The leachable ^{90}Sr concentrations were very similar across all six contact stages and for all three samples. The overall leachability of ^{90}Sr in terms of activity ranged from 73 to 98 µCi/g waste for all stages and samples. These results indicate that ^{90}Sr in these residual wastes exists in a continuously leachable form. The cumulative leachable percentages of ^{90}Sr in the three C-103 samples 19845, 19849, and 19850 were 75, 93, and 48%, respectively (Table 3.35).

Table 3.33. Average Extractable Concentrations of Anions from Periodic Replenishment DDI Water Extractions

Contact Stage	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
Sample 19845							
1	9.71	<5.43	40.5	34.1	<543	<16.3	<16.3
2	6.81	<4.89	4.56	38.6	<543	<16.3	<31.9
3	7.65	4.68	7.54	60.8	<543	<16.3	<62.0
4	<2.17	<5.43	<10.9	12.2	<543	<16.3	<16.3
5	<2.17	<4.23	<10.9	9.84	<543	<16.3	<16.3
6	19.3	6.93	18.9	141	<543	<16.3	12.9
Sample 19849							
1	10.3	4.64	32.9	36.2	<567	<17.0	11.9
2	3.89	<8.67	<11.3	29.6	<567	<17.0	<17.0
3	7.29	<5.67	8.61	65.5	<567	<17.0	<30.9
4	<2.27	<5.67	<11.3	21.4	<5,670	<17.0	<17.0
5	<2.27	<5.67	<11.3	<15.3	<5,670	<18.0	<17.0
6	<16.7	<5.67	<16.8	<124	<5,670	<17.0	<17.0
Sample 19850							
1	7.63	<5.39	43.2	25.5	<5,390	<16.2	39.7
2	<2.15	<5.39	<10.8	25.7	<5,390	<16.2	<22.9
3	6.12	<5.39	<10.8	62.3	<5,390	<16.2	112
4	<2.15	<5.39	<10.8	19.0	<5,390	<16.2	<16.2
5	<2.15	<5.39	<10.8	14.4	<5,390	<16.2	<16.2
6	15.4	<5.39	19.7	158	<5,390	<16.2	22.1

3.3.2.7 Transuranic Concentrations from Periodic Replenishment DDI Water Extractions

The concentrations of sequentially leachable actinides are listed in Table 3.36. Quantifiable concentrations of ^{237}Np were found in all extract stages. The ^{237}Np concentrations were generally very low, ranging from 3.6×10^{-6} to 2.9×10^{-5} µCi/g waste. The highest concentration for each sample was generally measured in the first or sixth stage. The cumulative leachable fraction of ^{237}Np ranged from 5.1 to 7.1% for the three samples (Table 3.37). Quantifiable concentrations of ^{239}Pu were found only in the first stage of sample 19850 (0.014 µCi/g waste), which equates to 2.2% of the total in the residual waste (Table 3.37). The concentrations of ^{241}Am in all stages of sequential leaching were below the EQL and/or instrument detection limits.

Table 3.34. Concentrations of ^{137}Cs and ^{90}Sr from Periodic Replenishment Extractions with DDI Water

Contact Stage	Duration (Days)	^{137}Cs		^{90}Sr	
		µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
Sample 19845					
1	1	8.73E-01	1.00E-02	73.8	0.527
2	1	8.96E-01	1.03E-02	NM	NM
3	3	1.24E+00	1.42E-02	72.7	0.520
4	1	6.92E-01	7.95E-03	NM	NM
5	1	5.39E-01	6.20E-03	74.3	0.531
6	30	2.16E+00	2.48E-02	74.8	0.534
Sample 19849					
1	1	8.19E-01	9.41E-03	93.1	0.665
2	1	8.86E-01	1.02E-02	NM	NM
3	3	1.27E+00	1.46E-02	93.3	0.666
4	1	8.22E-01	9.45E-03	NM	NM
5	1	5.98E-01	6.88E-03	96.0	0.686
6	30	2.70E+00	3.11E-02	98.0	0.700
Sample 19850					
1	1	1.23E+00	1.41E-02	97.4	0.696
2	1	8.01E-01	9.20E-03	NM	NM
3	3	1.11E+00	1.28E-02	87.3	0.623
4	1	7.90E-01	9.08E-03	NM	NM
5	1	6.36E-01	7.32E-03	89.2	0.637
6	30	1.72E+00	1.97E-02	89.5	0.639

All concentrations are corrected for the dry waste basis.
NM = Not measured.
Values based on duplicate measurements.

Table 3.35. Cumulative Percentages of ^{137}Cs and ^{90}Sr Leached by Periodic Replenishment DDI Water Extractions

Sample Number	^{137}Cs	^{90}Sr
	% Leachable	
19845 Average	12.2	74.7
19849 Average	25.3	93.4
19850 Average	10.4	48.3

All concentrations are corrected for the dry waste basis.
Total waste concentrations from acid digested samples.

Table 3.36. Transuranic Analysis for C-103 Periodic Replenishment DDI Water Extractions

Contact Stage	^{237}Np		^{239}Pu		^{241}Am	
	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
Sample 19845						
1	1.24E-05	1.75E-02	(2.49E-03)	(4.01E-02)	<1.10E-02	<3.23E-03
2	5.76E-06	8.11E-03	<1.68E-03	<2.71E-02	<1.85E-02	<5.43E-03
3	6.98E-06	9.83E-03	<1.68E-03	<2.71E-02	<1.85E-02	<5.43E-03
4	6.36E-06	8.96E-03	<1.68E-03	<2.71E-02	<1.85E-02	<5.43E-03
5	3.58E-06	5.05E-03	<1.68E-03	<2.71E-02	<1.82E-02	<5.35E-03
6	6.75E-06	9.51E-03	(4.55E-04)	(7.34E-03)	<1.85E-02	<5.43E-03
Sample 19849						
1	9.51E-06	1.34E-02	<1.76E-03	<2.84E-02	<1.93E-02	<5.67E-03
2	1.14E-05	1.60E-02	<1.76E-03	<2.84E-02	<1.93E-02	<5.67E-03
3	6.85E-06	9.65E-03	<1.76E-03	<2.84E-02	<1.93E-02	<5.67E-03
4	8.68E-06	1.22E-02	<1.04E-03	<1.68E-02	<1.93E-02	<5.67E-03
5	4.47E-06	6.30E-03	<1.76E-03	<2.84E-02	<1.95E-02	<5.73E-03
6	1.00E-05	1.41E-02	(3.74E-03)	(6.04E-02)	<1.22E-02	<3.60E-03
Sample 19850						
1	2.92E-05	4.11E-02	1.36E-02	2.20E-01	(9.24E-03)	(2.72E-03)
2	1.13E-05	1.59E-02	(1.11E-04)	(1.79E-03)	<1.83E-02	<5.39E-03
3	1.33E-05	1.87E-02	(1.88E-04)	(3.03E-03)	<1.83E-02	<5.39E-03
4	1.27E-05	1.79E-02	(2.48E-04)	(4.01E-03)	<1.83E-02	<5.39E-03
5	8.89E-06	1.25E-02	(1.84E-04)	(2.97E-03)	<1.72E-02	<5.06E-03
6	8.23E-06	1.16E-02	(9.33E-04)	(1.50E-02)	<1.83E-02	<5.39E-03

Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Based on duplicate measurements.

3.4 $Ca(OH)_2$ Solution Leaching Tests

The data obtained from the saturated $Ca(OH)_2$ solution leaching tests on the three C-103 residual waste samples (19845, 19849, and 19850) are presented and discussed in this section. These tests were designed to evaluate the leaching of residual waste constituents using a leaching solution derived from infiltrating water contacting fresh cement filling the tank above the residual waste. Section 3.4.1 provides the results of 1-month single contacts of the leachant and residual waste, and Section 3.4.2 discusses the periodic replenishment tests in which the residual waste was contacted six times with the leaching solution. The concentrations of the constituents in the $Ca(OH)_2$ extracts tabulated in this section are expressed in units of µCi or µg per gram of dry residual waste.

Table 3.37. Water-Leachable Percentages of Actinides in C-103 Periodic Replenishment DDI Water Extractions

Contact Stage	^{237}Np	^{239}Pu	^{241}Am
Percent Water Leachable			
Sample 19845			
1	1.5%	(0.6%)	<16.6%
2	0.7%	<0.4%	<16.6%
3	0.9%	<0.4%	<16.6%
4	0.8%	<0.4%	<16.6%
5	0.4%	<0.4%	<16.4%
6	0.8%	(0.1%)	<16.6%
Sample 19849			
1	1.3%	<0.4%	<12.7%
2	1.6%	<0.4%	<12.7%
3	1.0%	<0.4%	<12.7%
4	1.2%	<0.2%	<12.7%
5	0.6%	<0.4%	<12.8%
6	1.4%	(0.8%)	<12.7%
Sample 19850			
1	2.4%	2.2%	(3.3%)
2	0.9%	(0.02%)	<6.5%
3	1.1%	(0.03%)	<6.5%
4	1.0%	(0.04%)	<6.5%
5	0.7%	(0.03%)	<6.1%
6	0.7%	(0.2%)	<6.5%

BDL = Below detection limit.
EQL = Estimated quantitation limit.
Values within parentheses were <EQL.
Based on duplicate measurements.
Total concentrations from EPA acid digestions.

3.4.1 Single-Contact $Ca(OH)_2$ Solution Test Results

The single-contact water-leach tests were run in duplicate with an equilibration time of 1 month. Saturated $Ca(OH)_2$ solution was used as a leachant. The results of these experiments are presented in this section.

3.4.1.1 Residual Waste to $Ca(OH)_2$ Solution Ratios Used in Single-Contact Extractions

In these tests, 30 ml of saturated $Ca(OH)_2$ solution were contacted with about 0.3 g of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17.3% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the ratios of dry residual waste to $Ca(OH)_2$ solution (Table 3.38). These ratios ranged from about 12.5 to 16.8.

Table 3.38. Residual Waste to $Ca(OH)_2$ Solution Ratios Used in Leaching Tests

Sample Number	Waste to $Ca(OH)_2$ Solution Ratio (g/L)
19845	16.75
19845 Dup	13.91
19849	13.22
19849 Dup	15.45
19850	14.53
19850 Dup	12.50
Dup = Duplicate. Waste mass based on dry weight.	

3.4.1.2 Alkalinity and pH of Single-Contact $Ca(OH)_2$ Solution Extracts

The average alkalinities and pH values measured in duplicate extracts for each of the residual waste samples are listed in Table 3.39. The pH values of leachates from all three residual waste samples (19845, 19849, and 19850) were, as expected, highly alkaline, ranging from 11.1 to 11.8. The total alkalinity concentrations measured in the extract solutions for all the samples are fairly consistent, ranging from 1,980 to 2,660 mg/L. For these highly alkaline extracts, total alkalinity on a mg/g waste basis is not especially meaningful and will not be elaborated upon here. Note that the leachable alkalinities determined from the DDI water extracts were very small in comparison (~4 mg/g, Table 3.17).

Table 3.39. Alkalinity and pH Values after 1 Month of $Ca(OH)_2$ Solution Extraction

Sample Number	pH	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint (mg/L)	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint (mg/g waste)
19845 1 Month	11.14	1,980	118
19845 1 Month Dup	11.23	2,660	191
19849 1 Month	11.80	2,010	152
19849 1 Month Dup	11.83	2,130	138
19850 1 Month	11.32	1,980	136
19850 1 Month Dup	11.38	2,170	173
Dup = Duplicate.			

3.4.1.3 Extractable ^{99}Tc and ^{238}U Determined from Single-Contact $Ca(OH)_2$ Solution Extractions

The concentrations of ^{99}Tc and ^{238}U mobilized in the $Ca(OH)_2$ solution after 1 month of contact with the residual waste samples obtained from tank C-103 are listed in Table 3.40. The extractable concentrations of ^{99}Tc for these residual waste samples were very similar and quite low, ranging from 0.010 to 0.013 µg/g waste. The percentage of total ^{99}Tc leached from these samples is low, ranging from 4.4% to 5.8 (Table 3.41). These values are similar to the low percentage of ^{99}Tc leached using DDI water (Table 3.19).

Table 3.40. Extractable ^{99}Tc and ^{238}U from 1-Month Single-Contact Ca(OH)$_2$ Solution Extractions

Sample Number	^{99}Tc	^{238}U	^{99}Tc	^{238}U
	µg/g Dry Waste		µCi/g Dry Waste	
19845 1 Month	1.07E-02	1.19E-03	1.83E-04	4.01E-10
19845 1 Month Dup	1.05E-02	1.28E-02	1.78E-04	4.30E-09
19849 1 Month	1.07E-02	1.03E-02	1.83E-04	3.46E-09
19849 1 Month Dup	1.00E-02	1.05E-02	1.71E-04	3.52E-09
19850 1 Month	1.28E-02	3.58E-02	2.18E-04	1.20E-08
19850 1 Month Dup	1.18E-02	3.08E-02	2.01E-04	1.03E-08
19845 1 Month Avg	1.06E-02	6.99E-03	1.81E-04	2.35E-09
19849 1 Month Avg	1.04E-02	1.04E-02	1.77E-04	3.49E-09
19850 1 Month Avg	1.23E-02	3.33E-02	2.09E-04	1.12E-08

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.41. Percentages[(a)] of ^{99}Tc and ^{238}U from 1-Month Single-Contact Ca(OH)$_2$ Solution Extractions

Sample Number	^{99}Tc	^{238}U
	Percent Cement Leachable	
19845 1 Month Average	5.75%	0.0002%
19849 1 Month Average	4.61%	0.0003%
19850 1 Month Average	4.35%	0.0008%

Total concentrations in waste based on acid digestion extractions.

The extractable concentrations of ^{238}U for these residual waste samples were fairly similar and quite low (Table 3.40), ranging from 0.0012 to 0.036 µg/g waste. The percentage of total ^{238}U leached from these samples is very low, ranging from 0.0002% to 0.0008 (Table 3.41). These values are much lower than the ^{238}U leached by DDI water (Table 3.19).

3.4.1.4 Extractable Metals Concentrations in Ca(OH)$_2$ Solution Water Extractions

Concentrations of a number of metals, including Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the Ca(OH)$_2$ solution after extracting for 1 month were analyzed by ICP-OES. Among these, only a limited number of metals were present in measurable concentrations (Table 3.42). The concentrations listed within parentheses indicate values that are less than their respective EQLs. These data showed that Na was the only major leachable element in Ca(OH)$_2$ leach solutions in all three residual waste samples. Average extraction concentrations of Na in all three residual waste samples were fairly similar in magnitude, namely 1,430 µg/g waste in 19845, 1,770 µg/g waste in 19849, and 2,230 µg/g waste in 19850. Other elements with measurable leachability included Al, Ba, Mo, and Sr. Calcium is not discussed because it is in the extract solution.

Percentages of metals that were Ca(OH)$_2$ extractable are listed in Table 3.43. These results were computed on the basis of the total metal concentrations as measured in the acid digested samples (Table 3.3 through Table 3.5). The data show that 19 to 26% of the total Na present in the C-103 samples

Table 3.42. Concentrations of Selected Metals from 1-Month of $Ca(OH)_2$ Solution Extractions

Sample Number	Al	Ca	Cr	Ba	Mo	Na	Sr	Zn
	µg/g Dry Waste							
19845 1 Month	61.2	3,740	<0.746	13.6	3.86	1,810	55.9	(3.93)
19845 1 Month Dup	13.9	5,640	(0.774)	(7.29)	5.89	1,050	54.6	(3.57)
19849 1 Month	50.5	4,600	<0.945	24.2	4.93	1,880	76.5	(4.90)
19849 1 Month Dup	22.6	3,990	<0.809	29.4	5.25	1,650	66.2	(2.74)
19850 1 Month	31.8	4,190	(0.262)	31.9	4.34	2,270	78.5	(5.45)
19850 1 Month Dup	107	5,260	(0.193)	29.8	5.29	2,190	82.5	(5.12)
19845 1 Month Avg	37.6	4,690	(0.760)	10.4	4.87	1,430	55.2	(3.75)
19849 1 Month Avg	36.5	4,300	(0.877)	26.8	5.09	1,770	71.3	(3.82)
19850 1 Month Avg	69.3	4,720	(0.228)	30.9	4.81	2,230	80.5	(5.29)

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.43. Percentages[(a)] of Extractable Metals from 1-Month Single-Contact $Ca(OH)_2$ Solution Extraction

Sample Number	Al	Ca	Cr	Ba	Mo	Na	Sr	Zn
	Percent Water Leachable							
19845 1 Month Avg	0.02%	NA	(0.4%)	7.5%	15.5%	18.9%	86.5%	(1.7%)
19849 1 Month Avg	0.03%	NA	(0.5%)	15.9%	61.3%	23.8%	88.9%	(1.7%)
19850 1 Month Avg	0.05%	NA	(0.1%)	13.0%	9.2%	26.1%	63.0%	(2.0%)

Avg = Average.
NA = Not applicable, Ca used in extract.
All concentrations are corrected for the dry waste basis.
Total concentrations in residual wastes based on acid digestion extractions.

is present in readily leachable forms. A major portion of Sr was leached in the $Ca(OH)_2$ extracts (63 to 89%); however, it was determined that the high Ca concentrations in these sample resulted in interference from Ca and these results should be considered as suspect. Note the comparatively low percentages of ^{90}Sr leached from these samples (Table 3.46). Measurable concentrations of Ba (7.5 to 16%) and Mo (9.2 to 61%) were found to leach from the C-103 samples. Very little Al leached from these samples (0.02 to 0.05%). Cr and Zn leached at concentrations that were below the EQL. For Cr the estimated values ranged from [(0.1) to (0.5%)] and are similar to those determined in the DDI water extracts (0.9) to 1.5% (Table 3.21).

3.4.1.5 Anion Concentrations in Single-Contact $Ca(OH)_2$ Solution Extractions

The concentrations of anions that were present in $Ca(OH)_2$ solution extracts after 1 month were measured by ion chromatography. The extractable anion concentrations calculated for the residual wastes are presented in Table 3.44. Average extractable concentrations of F for three C-103 samples ranged from 11 to 23 µg/g waste. Average extractable concentrations of Cl for three C-103 samples ranged from 8.9 to 11 µg/g waste. Average extractable concentrations of NO_2 for three C-103 samples ranged from 36 to 47 µg/g waste. Nitrate concentrations in these waste extracts were on average about 5 to 7 times higher

Table 3.44. Concentrations Anions from 1-Month Single-Contact of $Ca(OH)_2$ Solution Extractions

Sample Number	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
19845 1 Month	13.5	7.29	36.2	258	<2,980	<8.95	<8.95
19845 1 Month Dup	11.4	15.0	35.4	104	<3,590	<10.8	<10.8
19849 1 Month	11.0	10.7	38.8	269	11,100	<11.3	<11.3
19849 1 Month Dup	11.2	7.06	37.4	240	10,100	<9.71	<9.71
19850 1 Month	24.7	8.68	48.4	337	<3,440	<10.3	<10.3
19850 1 Month Dup	20.7	9.53	45.4	313	<4,000	<12.0	<12.0
19845 1 Month Avg	12.5	11.2	35.8	181	<3,290	<9.87	<9.87
19849 1 Month Avg	11.1	8.90	38.1	255	10,600	<10.5	<10.5
19850 1 Month Avg	22.7	9.11	46.9	325	<3,720	<11.2	<11.2

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

than NO_2 concentrations. Average extractable NO_3 ranged from 181 to 325 µg/g waste. Extractable concentrations of CO_3 were above the detection limit only for sample 19849, which had an average value of 10,600 µg/g waste. All SO_4 and PO_4 values were below the detection limit.

3.4.1.6 Concentrations ^{137}Cs and ^{90}Sr in Single-Contact $Ca(OH)_2$ Solution Extractions

The concentrations of ^{137}Cs in the $Ca(OH)_2$ solution extracts indicate that this radioisotope had low leachability with concentrations that were in the tenths of microgram per gram residual waste levels (Table 3.45). In terms of activity, the average ^{137}Cs concentrations for the C-103 samples ranged from 10 to 19 µCi/g waste. The leachable percentage of ^{137}Cs in these residual waste samples constituted on average 19, 55, and 31% of the total ^{137}Cs present in the three residual waste samples 19845, 19849, and 19850, respectively (Table 3.46), indicating significant leachability.

Table 3.45. Average Extractable Concentrations of ^{137}Cs and ^{90}Sr from 1-Month $Ca(OH)_2$ Solution Extractions

Sample Number	^{137}Cs		^{90}Sr	
	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
19845 1 Month	14.1	0.163	82.9	0.592
19845 1 Month Dup	6.11	0.0703	75.6	0.540
19849 1 Month	16.5	0.189	117	0.835
19849 1 Month Dup	14.5	0.167	109	0.778
19850 1 Month	20.1	0.231	102	0.728
19850 1 Month Dup	17.3	0.199	107	0.763
19845 1 Month Avg	10.1	0.116	79.2	0.566
19849 1 Month Avg	15.5	0.178	113	0.807
19850 1 Month Avg	18.7	0.215	104	0.746

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.46. Percentage of Extractable ^{137}Cs and ^{90}Sr from 1-Month of $Ca(OH)_2$ Solution Extractions

	^{137}Cs	**^{90}Sr**
Sample Number	**Percent $Ca(OH)_2$ Leachable**	
19845 1 Month Avg	19.2%	20.0%
19849 1 Month Avg	55.2%	27.7%
19850 1 Month Avg	31.1%	13.9%

Avg = Average.
All concentrations are corrected for the dry waste basis.
Total residual waste concentrations from acid digested samples.

^{90}Sr concentrations in the $Ca(OH)_2$ solution extracts were present at slightly higher (3 to 8 times on a mass basis) concentrations than ^{137}Cs. The average extractable ^{90}Sr concentrations of the three residual waste samples in terms of activity ranged from 79 to 113 µCi/g waste, respectively (Table 3.45). These concentrations represent 20%, 28%, and 14% of the total ^{90}Sr present in the waste samples 19845, 19849, and 19850, respectively (Table 3.46), indicating a fraction of the ^{90}Sr is leachable from waste in contact with a $Ca(OH)_2$ saturated solution. These values are considerably less that those determined for total Sr by ICP-OES (Table 3.43). This suggests that an interference likely occurred in the Sr analysis by ICP-OES as a result of the $Ca(OH)_2$ extraction solution.

3.4.1.7 Extractable Transuranics Determined from Single-Contact $Ca(OH)_2$ Solution Extractions

The concentrations of $Ca(OH)_2$ solution leachable transuranics (^{237}Np, ^{239}Pu, and ^{241}Am) are listed in Table 3.47. None of these actinides were $Ca(OH)_2$ solution leachable at concentrations above the instrument detection limits. The maximum percentage of these transuranics that could have leached from the waste samples and still be below the detection limits are listed in Table 3.48.

Table 3.47. Transuranic Analysis for 1-Month Single-Contact $Ca(OH)_2$ Solution Extractions

	^{237}Np		**^{239}Pu**		**^{241}Am**	
Sample Number	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**
19845	<4.24E-07	<5.97E-04	<9.25E-04	<1.49E-02	<1.01E-02	<2.98E-03
19845 Dup	<5.10E-07	<7.19E-04	<1.11E-03	<1.80E-02	<1.22E-02	<3.59E-03
19849	<5.37E-07	<7.56E-04	<1.17E-03	<1.89E-02	<1.29E-02	<3.78E-03
19849 Dup	<4.60E-07	<6.47E-04	<1.00E-03	<1.62E-02	<1.10E-02	<3.24E-03
19850	<4.89E-07	<6.88E-04	<1.07E-03	<1.72E-02	<1.17E-02	<3.44E-03
19850 Dup	<5.68E-07	<8.00E-04	<1.24E-03	<2.00E-02	<1.36E-02	<4.00E-03
19845 Average	<4.67E-07	<6.58E-04	<1.02E-03	<1.64E-02	<1.12E-02	<3.29E-03
19849 Average	<4.98E-07	<7.02E-04	<1.09E-03	<1.75E-02	<1.19E-02	<3.51E-03
19850 Average	<5.28E-07	<7.44E-04	<1.15E-03	<1.86E-02	<1.26E-02	<3.72E-03

Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.48. Percentages of Transuranics from 1-Month Single-Contact $Ca(OH)_2$ Solution Extractions

	^{237}Np	**^{239}Pu**	**^{241}Am**
Sample Number	**Percent Cement Leachable**		
19845 Average	<0.06%	<0.26%	<10%
19849 Average	<0.07%	<0.23%	<7.8%
19850 Average	<0.04%	<0.19%	<4.5%
Total concentrations from EPA acid digestions.			

3.4.2 Periodic Replenishment $Ca(OH)_2$ Solution Test Results

The periodic replenishment extraction tests were conducted by repeatedly equilibrating duplicate residual waste samples with 30 mL aliquots of fresh $Ca(OH)_2$ solution. Contact stages 1, 2, 4, and 5 had a duration of 1 day each, whereas contact stages 3 and 6 lasted 3 and 30 days, respectively. The goal of these sequential leaching tests was to assess the long-term leaching characteristics of key contaminants and other constituents from these residual waste samples. The results of these tests are presented in this section.

3.4.2.1 Residual Waste to $Ca(OH)_2$ Solution Ratios Used in Periodic Replenishment Extractions

In these tests, 30 ml aliquots of saturated $Ca(OH)_2$ saturated solutions were contacted with about 0.3 g of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the dry residual waste to $Ca(OH)_2$ solution ratios (Table 3.49). These ratios ranged from about 8.45 to 10.9.

Table 3.49. Residual Waste to Solution Ratios Used in Periodic Replenishment $Ca(OH)_2$ Leaching Tests

Sample Number	**Dry Waste to $Ca(OH)_2$ Solution Ratios (g/L)**
19845	8.70
19845 Dup	10.42
19849	8.45
19849 Dup	10.91
19850	8.50
19850 Dup	10.28

3.4.2.2 Alkalinity and pH of $Ca(OH)_2$ Solution Periodic Replenishment Extractions

The average alkalinities and pH values measured in duplicate samples of residual waste from each tank at the end of each contact stage are listed in Table 3.50. As expected from the use of a saturated $Ca(OH)_2$ solution as the leachant, the pH values of all three residual waste samples at all stages of extraction were highly alkaline in nature ranging in values between 10.7 to 12.1.

Table 3.50. Alkalinity and pH Values from Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Contact Stage	Duration (Days)	pH	Total Alkalinity (as $CaCO_3$) @ pH 4.5 Endpoint	Total Alkalinity (as $CaCO_3$) @ pH 4.5 Endpoint
			mg/L	mg/g Dry Waste
19845				
1	1	12.0	2,490	263
2	1	12.1	2,620	277
3	3	12.1	2,570	271
4	1	12.1	2,700	284
5	1	12.1	2,740	288
6	30	11.0	2,170	231
19849				
1	1	11.5	2,580	272
2	1	11.7	2,700	283
3	3	10.7	2,640	278
4	1	11.4	2,740	287
5	1	11.6	2,620	277
6	30	11.8	2,190	230
19850				
1	1	11.5	2,490	267
2	1	11.6	2,490	267
3	3	11.6	2,450	264
4	1	11.7	2,620	282
5	1	11.7	2,570	275
6	30	11.4	2,170	234

The total alkalinity concentrations measured in the extract solutions for all the samples are fairly consistent, ranging from 2,170 to 2,740 mg/L. For these highly alkaline extracts, total alkalinity on mg/g waste basis is not especially meaningful and will not be elaborated upon here. Note that the leachable alkalinities determined from the DDI water extracts were very small in comparison (~4 mg/g, Table 3.17).

3.4.2.3 Concentrations of ^{99}Tc and ^{238}U in $Ca(OH)_2$ Solution Periodic Replenishment Extractions

The concentrations of ^{99}Tc and ^{238}U mobilized in periodic replenishment $Ca(OH)_2$ solution extractions of C-103 residual waste samples 19845, 19849, and 19850 are listed in Table 3.51. Only the first stage of sample 19845 had a quantifiable concentration of ^{99}Tc (0.012 μg/g waste). All other extracts from the three residual waste samples were below the EQL or the instrumental detection limits. The estimated percentage leachability of ^{99}Tc from stage one of sample 19845 was 6.7% (Table 3.52).

The concentrations of ^{238}U in the $Ca(OH)_2$ solution extractions were all below the EQL (Table 3.51). Based on these EQLs, less than 0.006% of the U could have leached from these C-103 samples (Table 3.52).

Table 3.51. Concentrations of Extractable ^{99}Tc and ^{238}U from Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Contact Stage	Duration (Days)	^{99}Tc	^{238}U	^{99}Tc	^{238}U
		µg/g Dry Waste		µCi/g Dry Waste	
Sample 19845					
1	1	1.24E-02	(4.44E-02)	2.11E-04	(1.49E-08)
2	1	<1.05E-02	(5.50E-03)	<1.79E-04	(1.85E-09)
3	3	<1.05E-02	(7.01E-03)	<1.79E-04	(2.36E-09)
4	1	<1.05E-02	(2.08E-02)	<1.79E-04	(7.00E-09)
5	1	<1.05E-02	(8.69E-03)	<1.79E-04	(2.92E-09)
6	30	(7.43E-03)	(1.38E-02)	(1.26E-04)	(4.64E-09)
Sample 19849					
1	1	(1.08E-02)	(1.65E-01)	(1.83E-04)	(5.54E-08)
2	1	<1.05E-02	(1.30E-02)	<1.78E-04	(4.38E-09)
3	3	<1.05E-02	(9.63E-03)	<1.78E-04	(3.24E-09)
4	1	<1.05E-02	(8.59E-03)	<1.78E-04	(2.89E-09)
5	1	<1.05E-02	(1.64E-04)	<1.78E-04	(5.51E-11)
6	30	(5.65E-03)	(2.88E-02)	(9.60E-05)	(9.67E-09)
Sample 19850					
1	1	(9.11E-03)	(1.51E-01)	(1.55E-04)	(5.07E-08)
2	1	<1.07E-02	(1.11E-02)	<1.83E-04	(3.73E-09)
3	3	<1.07E-02	(1.44E-02)	<1.83E-04	(4.84E-09)
4	1	<1.07E-02	(2.91E-02)	<1.83E-04	(9.77E-09)
5	1	<1.07E-02	(2.55E-03)	<1.83E-04	(8.56E-10)
6	30	(6.78E-03)	(2.64E-02)	(1.15E-04)	(8.87E-09)

All concentrations are corrected for the dry waste basis.
BDL = Below detection limit.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Based on duplicate measurements.

3.4.2.4 Extractable Metals Concentrations Determined from $Ca(OH)_2$ Solution Sequential Extractions

Concentrations of a number of metals, including Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the extracts of six stage sequential leaching using $Ca(OH)_2$ solution were analyzed by ICP-OES. Among these, only seven elements (Al, Ba, Ca, Cr, Mo, Na, and Sr) were present in measurable concentrations throughout the majority of the extractions (Table 3.53). The concentrations listed within parentheses indicate values that are less than the EQL. These data showed that the major leachable element in all three residual waste samples was Na (Ca was in the extract solution). Initial extraction concentrations of Na from residual waste samples 19845, 19849, and 19850 were 1,280, 1,140, and 1,130 ppm, respectively. For each of the three samples, the sequential leaching behaviors of Na following the high concentrations in the first stage exhibited significant reductions in concentration in the subsequent four stages of extraction, with an increase in concentration in the third (3-day) extractions and a significant rebound for the final stages (30-day extraction) to concentrations near that of the first stages. Similar trends were observed for Al and Sr, but the differences in concentrations between stages were relatively small.

Table 3.52. Percentages of ^{99}Tc and ^{238}U in Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Contact Stage (duration, days)	Contact Duration (days)	^{99}Tc	^{238}U
		% Cement Leachable	
Sample 19845			
1	1	6.7%	(0.001%)
2	1	<5.7%	(0.0002%)
3	3	<5.7%	(0.0002%)
4	1	<5.7%	(0.0006%)
5	1	<5.7%	(0.0003%)
6	30	(4.0%)	(0.0004%)
Sample 19849			
1	1	(4.8%)	(0.004%)
2	1	<4.7	(0.0004%)
3	3	<4.7	(0.0003%)
4	1	<4.7	(0.0002%)
5	1	<4.7	(0.000004%)
6	30	(2.5%)	(0.0008%)
Sample 19850			
1	1	(3.2%)	(0.004%)
2	1	<3.8%	(0.0003%)
3	3	<3.8%	(0.0003%)
4	1	<3.8%	(0.0007%)
5	1	<3.8%	(0.0001%)
6	30	(2.4%)	(0.0006%)

BDL = Below detection limit.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Based on duplicate measurements.
Total concentrations from EPA acid digestions.

Percentages of metals that were cumulatively extractable during the six stage sequential leaching with $Ca(OH)_2$ solution are listed in Table 3.54. These results were computed on the basis of the total metal concentrations as measured in the acid digested samples of the residual wastes (Table 3.3 through Table 3.5). The $Ca(OH)_2$ extractions mobilized between 44 and 53% of the total Na present in sample 19845, 19849, and 19850 (Table 3.54). The data indicate that the six stage sequential extraction of these residual waste samples released about two to three times the amount of Na that was leached in the 1-month single-contact extraction (Table 3.43). Very little Al (0.2%) was released during the sequential extractions. These results suggest that significantly more for Mo and Sr were released during the sequential extractions than the total concentrations of these elements measured for the unleached samples. This suggests that an analytical interference occurred for these two metals as a result of the $Ca(OH)_2$ extraction solution as noted previously.

Table 3.53. Average Extractable Concentrations of Selected Metals from Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Contact Stage	Al	Ba	Ca	Cr	Mo	Na	Sr
	µg/g Dry Waste						
Sample 19845							
1	38.7	(12.9)	83,800	1.49	7.94	1,280	81.9
2	32.7	(7.44)	90,100	(1.35)	9.57	374	73.7
3	39.8	(10.1)	86,200	(1.11)	8.08	664	74.6
4	28.6	(4.54)	92,100	1.67	8.56	181	69.9
5	26.9	(4.00)	92,100	1.53	7.43	150	65.6
6	75.8	28.7	69,100	<1.32	8.05	1,300	76.2
Sample 19849							
1	35.7	18.2	85,800	1.34	7.47	1,140	90.3
2	27.8	(7.06)	90,900	(1.31)	7.93	269	74.0
3	40.1	(11.9)	87,200	(0.900)	7.50	516	77.7
4	25.8	(4.10)	90,400	1.54	7.61	153	65.4
5	27.8	(3.51)	90,800	1.67	9.05	139	66.2
6	66.1	21.3	68,900	<1.31	7.40	1,050	79.7
Sample 19850							
1	41.2	21.8	88,000	1.58	7.25	1,130	89.2
2	36.1	15.0	90,300	1.46	7.41	381	80.4
3	37.5	(15.1)	88,600	(1.45)	8.06	561	79.2
4	33.3	(7.46)	91,700	1.67	7.29	234	71.8
5	27.0	(5.10)	91,400	2.01	9.08	184	67.9
6	53.2	35.1	73,200	(28.1)	7.98	1,350	87.3

Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Based on duplicate measurements.

Table 3.54. Cumulative Fractions of Leachable Metals from Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Element	Sample 19845	Sample 19849	Sample 19850
	---Cumulative % $Ca(OH)_2$ Leachable ----		
Al	0.2	0.2	0.2
Ba	(49)	(39)	(42)
Ca	NA	NA	NA
Cr	(4.7)	(4.8)	(3.7)
Mo	156	566	90
Na	53	44	45
Sr	692	565	373

NA = Not applicable (Ca in extract solution).
Values calculated on the dry waste basis.

3.4.2.5 Extractable Anions Determined from $Ca(OH)_2$ Solution Periodic Replenishment Extractions

The concentrations of anions that were present in the $Ca(OH)_2$ solution leachates after each stage of sequential extraction were measured by ion chromatography and are listed in Table 3.55. Average F in the $Ca(OH)_2$ extracts for the three C-103 samples was present at about half the concentration of Cl. Average F concentrations for the three C-103 sample extracts ranged from 4.7 to 20.4 µg/g waste, with the highest concentrations occurring in stage six (30-day contact). Average Cl concentrations for the three C-103 sample extracts ranged from <10.4 to 29.4 µg/g waste. Nitrite concentrations were only detectable in the first and sixth extractions in all three samples. Concentrations in the first extract ranged from 38 to 45 µg/g waste, and 14 to 18 µg/g waste for the sixth extracts. In a similar fashion to that observed for F, the highest NO_3 concentrations occurred in the sixth extraction. For the three samples NO_3 concentrations ranged from 15 to 235 µg/g waste. Most of the CO_3 concentrations were below the detection limit; however, a few quantifiable measurements were made. It is likely that these concentrations resulted from dissolution of $CO_2(g)$ from the air into the solutions (no special precautions were taken to prevent this). Sulfate concentrations ranged from 19 to 148 µg/g waste for all extracts of the three samples. No discernable trend with regard to the contact sequence was apparent. All PO_4 values were below the detection limit.

Table 3.55. Average Leachable Anion Concentrations from Periodic Replenishment Extraction Tests with $Ca(OH)_2$ Solution

Contact Stage	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
Sample 19845							
1	12.3	28.2	41.4	70.2	<9,690	83.2	<15.8
2	8.72	14.9	<10.5	38.1	<5,270	75.3	<15.8
3	12.2	15.3	<10.5	117	<5,270	43.4	<15.8
4	5.99	16.0	<10.5	22.2	<5,270	101	<15.8
5	4.74	13.8	<10.5	16.1	<5,270	96.3	<15.8
6	19.9	12.8	14.9	234	<5,270	19.2	<15.8
Sample 19849							
1	11.4	16.3	37.8	59.7	<5,250	70.9	<15.7
2	6.14	20.3	<10.5	30.4	<5,250	101	<15.7
3	12.2	19.5	10.9	79.3	<5,250	49.1	<15.7
4	5.83	13.2	<10.5	15.4	5,610	106	<15.7
5	5.61	13.8	<10.5	15.0	<5,730	117	<15.7
6	20.4	10.1	14.3	177	8,730	<15.7	<15.7
Sample 19850							
1	10.7	22.4	44.8	47.2	6,930	118	<16.1
2	8.24	16.0	<10.7	33.2	6,760	112	<16.1
3	10.3	17.0	<10.7	85.5	<5,370	89.5	<16.1
4	6.92	29.4	<10.7	27.8	<5,370	139	<16.1
5	5.42	14.5	<10.7	20.6	<5,370	148	<16.1
6	18.4	10.4	18.2	235	<5,370	<33.2	<16.1
Based on duplicate measurements.							

3.4.2.6 Extractable ^{137}Cs and ^{90}Sr Determined from $Ca(OH)_2$ Solution Periodic Replenishment Extractions

The extractable concentrations of ^{137}Cs (in terms of activity) determined from the $Ca(OH)_2$ solution extracts were at the microcurie per gram level for all sequential extraction stages (Table 3.56). Extractable ^{137}Cs concentrations were very similar for each of the three C-103 samples (19845, 19849, 19850). For example, stage 1 extract concentrations ranged from 4.4 to 5.0 µCi/g waste for the three samples. The highest extractable ^{137}Cs concentrations occurred in the final stage extracts for all three samples, and ranged from 14 to 18 µCi/g waste. The cumulative leachable fractions of ^{137}Cs in these residual waste samples were on average 64, 105, and 62% of the total ^{137}Cs present in the samples 19845, 19849, and 19850, respectively (Table 3.57). The sequential extractions cumulatively leached two to three times ^{137}Cs than was leached in the 1-month single-contact extraction process (Table 3.46). ^{137}Cs was significantly more leachable in the $Ca(OH)_2$ extracts than the DDI water extracts (Table 3.34).

The extractable ^{90}Sr concentrations determined from the first, third, fifth and sixth stages of the sequential extractions are listed in Table 3.56. The extractable ^{90}Sr concentrations varied over a fairly narrow range for all extract stages and samples (59 to 125 µCi/g waste). For each residual waste sample, the highest concentrations measured in the first and sixth extractions. The leachable concentrations measured for the four extraction stages represent 109% of the total ^{90}Sr in sample 19845, 106% of the total in sample 19849, and 43% of the total ^{90}Sr in 19850 (Table 3.57). These results indicate that ^{90}Sr is highly leachable from these residual wastes by a $Ca(OH)_2$ saturated solution.

3.4.2.7 Extractable Actinides Determined from $Ca(OH)_2$ Solution Periodic Replenishment Extractions

The extractable actinide concentrations by the sequential extractions are listed in Table 3.58. The concentrations of the three actinides ^{237}Np, ^{239}Np, and ^{241}Am in these residual waste extracts were all below their respective instrument detection limits during all six stages of extraction indicating that $Ca(OH)_2$ is an ineffective leachant for mobilizing these actinides from these residual waste samples. It is possible that any of the Np and Am that was leachable may have precipitated as highly insoluble hydroxides.

3.5 $CaCO_3$ Solution Leaching Tests

The data obtained from the saturated $CaCO_3$ solution leaching tests on the three tank C-103 residual waste samples (19845, 19849 and 19850) are presented and discussed in this section. These tests were designed to evaluate the leaching of residual waste constituents by a leaching solution derived from contact of infiltrating water with aged cement filling the tank above the residual waste. It is anticipated that calcite ($CaCO_3$) will control the major ion chemistry of water passing through aged cement overlying the residual waste and that a $CaCO_3$ saturated leachant will be the appropriate leachant for mobilizing contaminants during this stage of a performance assessment. Section 3.5.1 provides the results of 1-month single-contact tests of the solution and residual wastes, and Section 3.5.2 discusses the periodic replenishment tests in which the residual waste was contacted 6 times with the leaching solution. The concentrations of the constituents in the saturated $CaCO_3$ solution extracts tabulated in this section are expressed in units of µCi or µg per gram of dry residual waste.

Table 3.56. Concentrations of ^{137}Cs and ^{90}Sr from Periodic Replenishment Extractions with $Ca(OH)_2$ Solution

Contact Stage	Duration (Days)	^{137}Cs µCi/g Dry Waste	^{137}Cs µg/g Dry Waste	^{90}Sr µCi/g Dry Waste	^{90}Sr µg/g Dry Waste
Sample 19845					
1	1	5.03	0.0579	116	0.827
2	1	2.82	0.0324	NM	NM
3	3	7.02	0.0807	101	0.718
4	1	1.69	0.0194	NM	NM
5	1	1.40	0.0161	93.3	0.666
6	30	15.9	0.183	122	0.868
Sample 19849					
1	1	5.03	0.0578	121	0.863
2	1	2.16	0.0248	NM	NM
3	3	5.33	0.0613	98.4	0.703
4	1	1.47	0.0169	NM	NM
5	1	1.33	0.0153	88.9	0.635
6	30	14.0	0.161	125	0.895
Sample 19850					
1	1	4.44	0.0510	87.6	0.626
2	1	3.25	0.0373	NM	NM
3	3	6.38	0.0733	70.5	0.504
4	1	2.66	0.0305	NM	NM
5	1	2.13	0.0245	58.8	0.420
6	30	18.4	0.211	103	0.738
All concentrations are corrected for the dry waste basis. Values within parentheses were <EQL. EQL = Estimated quantitation limit. NM = Not measured. Values based on duplicate measurements.					

Table 3.57. Cumulative Percentages of ^{137}Cs and ^{90}Sr Leached by $Ca(OH)_2$ Solution

Sample Number	^{137}Cs % $Ca(OH)_2$ Leachable	^{90}Sr % $Ca(OH)_2$ Leachable
19845 Average	64.3%	109%
19849 Average	105%	106%
19850 Average	61.8%	42.5%
All concentrations are corrected for the dry waste basis. Total residual waste concentrations from acid digested samples.		

Table 3.58. Extractable Actinides Determined from Periodic Replenishment $Ca(OH)_2$ Solution Extractions

Contact Stage	^{237}Np		^{239}Pu		^{241}Am	
	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
Sample 19845						
1	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.79E-02	<5.27E-03
2	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.79E-02	<5.27E-03
3	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.79E-02	<5.27E-03
4	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.79E-02	<5.27E-03
5	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.63E-02	<4.80E-03
6	<7.49E-07	<1.05E-03	<1.63E-03	<2.64E-02	<1.79E-02	<5.27E-03
Sample 19849						
1	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.78E-02	<5.25E-03
2	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.78E-02	<5.25E-03
3	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.78E-02	<5.25E-03
4	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.78E-02	<5.25E-03
5	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.56E-02	<4.58E-03
6	<7.45E-07	<1.05E-03	<1.63E-03	<2.62E-02	<1.78E-02	<5.25E-03
Sample 19850						
1	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.83E-02	<5.37E-03
2	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.83E-02	<5.37E-03
3	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.83E-02	<5.37E-03
4	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.83E-02	<5.37E-03
5	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.65E-02	<4.87E-03
6	<7.63E-07	<1.07E-03	<1.67E-03	<2.69E-02	<1.83E-02	<5.37E-03
Based on duplicate measurements.						

3.5.1 Single-Contact $CaCO_3$ Solution Contact Test Data

The single-contact water-leach tests were run in duplicate with an equilibration time of 1 month. A saturated $CaCO_3$ solution was used as a leachant. The results of these experiments are presented in this section.

3.5.1.1 Residual Waste to $CaCO_3$ Solution Ratios Used in Single-Contact Extractions

In these tests, 30 ml of $CaCO_3$ saturated solution was contacted with about 0.3 of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the dry residual waste to $CaCO_3$ solution ratios (Table 3.59). These ratios ranged from about 8.51 to 11.9 g/L.

Table 3.59. Residual Waste to $CaCO_3$ Solution Used in Leaching Extractions

Sample Number	Waste to $CaCO_3$ Solution Ratios (g/L)
19845	9.43
19845 Dup	9.28
19849	11.88
19849 Dup	8.51
19850	9.35
19850 Dup	8.53
Dup = Duplicate. All concentrations are corrected for the dry waste basis.	

3.5.1.2 Alkalinity and pH of Single-Contact $CaCO_3$ Solution Extractions

The average leachable alkalinities and pH values measured in duplicate leachates of each residual waste sample are listed in Table 3.60. The pH values of the leachate for each of the three C-103 samples (19845, 19849, and 19850) are all slightly alkaline, ranging from 7.3 to 7.7.

Table 3.60. Leachable Alkalinity and pH Values from 1-Month Single-Contact $CaCO_3$ Solution Extractions

		Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint
Sample Number	pH	mg/L	mg/g Dry Waste
19845	7.26	38.0	4.03
19845 Dup	7.42	41.0	4.42
19849	7.44	41.0	3.46
19849 Dup	7.26	36.5	4.29
19850	7.53	46.4	4.96
19850 Dup	7.73	36.5	4.28
19845 Average	7.34	39.5	4.23
19849 Average	7.35	38.8	3.87
19850 Average	7.63	41.5	4.62
Dup = Duplicate.			

The total alkalinities measured in the extract solutions for all the samples are fairly consistent, ranging from 35.5 to 46.4 mg/L. Because the $CaCO_3$ extraction solutions contain alkalinity, total alkalinities on an mg/g waste basis is not especially meaningful and will not be elaborated upon here. Note that the leachable alkalinities determined from the DDI water extracts were similar in comparison (~4 mg/g, Table 3.17).

3.5.1.3 Extractable ^{99}Tc and ^{238}U Determined from Single-Contact $CaCO_3$ Solution Extractions

The concentrations of ^{99}Tc and ^{238}U mobilized in $CaCO_3$ saturated leachates after a 1-month contact with the C-103 residual waste samples 19845, 19849, and 19850 are listed in Table 3.61. The leachable concentrations of ^{99}Tc in the three samples were similar and low, ranging from 0.011 to 0.014 µg/g waste. The calculated percentages of leachable ^{99}Tc from samples 19845, 19849, and 19850 were 7.0, 6.1, and 4.1%, respectively (Table 3.62).

Table 3.61. Extractable ^{99}Tc and ^{238}U from 1-Month Single-Contact $CaCO_3$ Solution Extractions

	^{99}Tc	**^{238}U**	**^{99}Tc**	**^{238}U**
Sample Number	**µg/g Dry Waste**		**µCi/g Dry Waste**	
19845	1.26E-02	1.99E+02	2.15E-04	6.69E-05
19845 Dup	1.30E-02	2.32E+02	2.22E-04	7.78E-05
19849	1.31E-02	1.57E+02	2.22E-04	5.27E-05
19849 Dup	1.42E-02	1.95E+02	2.42E-04	6.54E-05
19850	1.11E-02	4.33E+02	1.89E-04	1.46E-04
19850 Dup	1.18E-02	2.45E+02	2.01E-04	8.24E-05
19845 Average	1.28E-02	2.15E+02	2.18E-04	7.23E-05
19849 Average	1.36E-02	1.76E+02	2.32E-04	5.90E-05
19850 Average	1.15E-02	3.39E+02	1.95E-04	1.14E-04
Dup = Duplicate. All concentrations are corrected for the dry waste basis.				

Table 3.62. $CaCO_3$ Solution-Leachable Percentages of ^{99}Tc and ^{238}U

	^{99}Tc	**^{238}U**
Sample Number	**Percent Leachable**	
19845 Average	6.95%	6.48%
19849 Average	6.05%	4.76%
19850 Average	4.06%	8.12%

The $CaCO_3$ saturated leachates from the three C-103 sample contained ^{238}U concentrations (Table 3.61) that were similar to those of the DDI water extracts (Table 3.18) but over 100 times higher than the amount leachable by the $Ca(OH)_2$ extractant (Table 3.40), ranging from 157 to 433 µg/g waste. The calculated percentages of leachable ^{238}U from samples 19845, 19849, and 19850 were 6.5, 4.8, and 8.1%, respectively (Table 3.62). These data suggest that ^{238}U concentrations in leachate from these residual wastes will be high during the $CaCO_3$ stage of release, but that the U solids in contact with the solution control the water leaching.

3.5.1.4 Extractable Metals Determined from $CaCO_3$ Solution Extractions

Concentrations of a number of metals, including Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the $CaCO_3$ solution after extracting for 1 month were analyzed by ICP-OES. Among these, only a limited number of metals were present in measurable concentrations (Table 3.63). The concentrations listed within parentheses indicate values that are less than EQL. These data show that the major leachable element by the $CaCO_3$ leach solution in all three residual waste samples was Na. Average extractable concentrations of Na in all three C-103 samples were similar in magnitude, namely 1,610 µg/g waste in 19845, 1,410 µg/g waste in 19849, and 1,730 µg/g waste in 19850. Significant concentrations of Al and Si were also measured in the $CaCO_3$ extracts. Average Al concentrations for the three samples ranged from 189 to 398 µg/g waste. Average Si concentrations for the three samples ranged from 253 to 378 µg/g waste. Other elements with measurable leachability, in at least some of the samples, included Cr, Fe, Mg, Mn, Ni, Sr, and Zr.

Percentages of metals that were $CaCO_3$ extractable are listed in Table 3.64. These results were computed on the basis of the total metal concentrations as measured in the acid digested samples (Table 3.3 through Table 3.5). The data show that 19 to 21% of the Na was extracted from the three C-103 samples. Significant fractions of Mg also appear to have been extractable [(15) to 34%]. Small amounts of Si and Sr were extractable [(3) to 4%], and [(1.5) to 2.8%], respectively. The extractability of other metals (Al, Cr, Fe, Mn, Ni, and Zr) was less than 1%.

3.5.1.5 Extractable Anions Determined from Single-Contact $CaCO_3$ Solution Extractions

The extractable concentrations of anions determined in $CaCO_3$ saturated leachates after 1 month of contact were measured by ion chromatography and the results are provided in Table 3.65. Fluoride extracted from the three C-103 residual waste samples was present at concentrations that were about double that of Cl. Average concentrations of F and Cl in these samples ranged from 19 to 24 µg/g waste, and 11 to 12 µg/g waste, respectively. Extractable NO_3 concentrations in these waste samples were on average about 3 times higher than NO_2 concentrations. Average NO_3 and NO_2 concentrations in the three samples ranged from 136 to 164 µg/g waste and 49 to 53 µg/g waste, respectively. Relatively low concentrations of extractable SO_4 were found in these residual waste samples. The average concentrations ranged from <18.5 to 29 µg/g waste. Except for sample 19845 Dup (27.2 µg/g waste), all PO_4 concentrations were all less than the instrument detection limit.

3.5.1.6 Extractable ^{137}Cs and ^{90}Sr Determined from Single-Contact $CaCO_3$ Solution Extractions

The concentrations of ^{137}Cs in the $CaCO_3$ solution leachates indicate that this radioisotope had low leachability with concentrations that were on the order of a few hundredths of a microgram per gram residual waste (Table 3.66). In terms of activity, the average ^{137}Cs concentrations for the C-103 samples ranged from 2.2 to 3.0 µCi/g waste. The leachable percentage of ^{137}Cs in these residual waste samples constituted on average 4.7, 7.9, and 5.0% of the total ^{137}Cs present in the three residual waste samples 19845, 19849, and 19850, respectively (Table 3.67).

^{90}Sr concentrations in the $Ca(OH)_2$ solution extracts were present at significantly higher concentrations than ^{137}Cs (approximately twenty times higher on a mass basis). The average extractable ^{90}Sr concentrations of the three residual waste samples in terms of activity ranged from 81 to 108 µCi/g residual waste (Table 3.66). These concentrations represent 21%, 23%, and 14% of the total ^{90}Sr present in the residual waste samples 19845, 19849, and 19850, respectively (Table 3.67). The values are similar to those found in the $Ca(OH)_2$ extracts (Table 3.46) and the DDI water extracts (Table 3.24).

Table 3.63. Extractable Metals Concentrations from 1-Month Single-Contact $CaCO_3$ Solution Extractions

Sample Number	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	Si	Sr	Zr
	µg/g Dry Waste										
19845	410	40.9	(1.59)	17.5	(5.15)	1.91	1,530	3.60	346	(1.14)	9.05
19845 Dup	386	27.1	(1.26)	14.8	(4.33)	1.74	1,700	3.97	409	(1.03)	8.10
19849	240	45.5	1.07	12.3	(4.39)	1.56	1,310	2.39	246	(1.14)	4.78
19849 Dup	138	78.6	(0.749)	8.0	(7.59)	(1.03)	1,520	(1.86)	(259)	(1.32)	3.08
19850	119	155	(1.20)	21.2	23.1	2.37	1,830	3.36	328	4.20	7.47
19850 Dup	359	119	2.06	40.7	15.1	4.24	1,620	5.84	(270)	2.89	14.8
19845 Average	398	34.0	(1.42)	16.1	(4.74)	1.82	1,610	3.78	378	(1.08)	8.58
19849 Average	189	62.1	(0.908)	10.1	(5.99)	1.30	1,410	2.12	(253)	(1.23)	3.93
19850 Average	239	13.7	(1.63)	30.9	19.1	3.31	1,730	4.60	(299)	3.54	11.1

All concentrations are corrected for the dry waste basis.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.

Table 3.64. Percentages of Extractable Metals from 1-Month Single-Contact $CaCO_3$ Solution Extractions

Sample Number	Al	Ca	Cr	Fe	Mg	Mn	Na	Ni	Si	Sr	Zr
	% $CaCO_3$ Solution Leachable										
19845 Average	0.3%	8.0%	(0.8%)	0.2%	(16%)	0.6%	21.4%	0.9%	4.2%	(1.7%)	0.8%
19849 Average	0.1%	11.7%	(0.5%)	0.1%	(15%)	0.4%	19.0%	0.6%	(3.0%)	(1.5%)	0.4%
19850 Average	0.2%	15.3%	(0.7%)	0.2%	34.1%	0.7%	20.2%	0.9%	(3.0%)	2.8%	0.8%

Table 3.65. Extractable Anion Concentrations from 1-Month Single-Contact $CaCO_3$ Solution Extractions

Sample Number	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
19845 1 Month	23.2	11.8	46.9	151	<5,300	26.9	<15.9
19845 1 Month Dup	24.7	11.2	51.9	177	<5,390	31.0	27.2
19849 1 Month	20.6	9.86	47.1	124	<4,210	19.3	<12.6
19849 1 Month Dup	21.2	12.0	53.2	147	<5,870	<17.6	<17.6
19850 1 Month	18.2	10.4	56.6	160	<5,350	28.9	<16.0
19850 1 Month Dup	18.9	12.8	49.0	126	<5,860	27.3	<17.6
19845 1 Month Avg	23.9	11.5	49.4	164	<5,350	29.0	<21.5
19849 1 Month Avg	20.9	10.9	50.2	136	<5,040	<18.5	<15.1
19850 1 Month Avg	18.6	11.6	52.8	143	<5,600	28.1	<16.8

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.66. Extractable Concentrations ^{137}Cs and ^{90}Sr from 1-Month Single-Contact $CaCO_3$ Solution Extractions

Sample Number	^{137}Cs		^{90}Sr	
	µCi/g Dry Waste	µg/g Dry Waste	µCi/g Dry Waste	µg/g Dry Waste
19845 1 Month	2.35	0.0270	79.9	0.571
19845 1 Month Dup	2.56	0.0294	82.8	0.592
19849 1 Month	1.78	0.0205	75.7	0.541
19849 1 Month Dup	2.66	0.0306	108	0.771
19850 1 Month	3.44	0.0395	104	0.742
19850 1 Month Dup	2.62	0.0302	112	0.802
19845 1 Month Avg	2.45	0.0282	81.4	0.581
19849 1 Month Avg	2.22	0.0256	91.9	0.656
19850 1 Month Avg	3.03	0.0348	108	0.772

Avg = Average.
Dup = Duplicate.
All concentrations are corrected for the dry waste basis.

Table 3.67. Extractable ^{137}Cs and ^{90}Sr as a Percentage of Total Residual Waste Concentration

Sample Number	^{137}Cs	^{90}Sr
	% $CaCO_3$ Leachable	
19845 Average	4.7%	20.5%
19849 Average	7.9%	22.5%
19850 Average	5.0%	14.3%

All concentrations are corrected for the dry waste basis.
Total waste concentrations from acid digested samples.

3.5.1.7 Extractable Transuranics Determined from Single-Contact $CaCO_3$ Solution Extractions

The $CaCO_3$ solution leachable transuranics are listed in Table 3.68. The concentrations of ^{237}Np and ^{239}Pu in the extracts were at measurable levels in all cases, except for ^{239}Pu in the primary 19845 sample. The average concentrations of ^{237}Np in the three C-103 samples in terms of activity ranged from 2.0 x 10^{-5} to 4.0 x 10^{-5} µCi/g waste. The average concentrations of ^{239}Pu in the three C-103 samples in terms of activity ranged from (2.0 x 10^{-3}) to 7.1 x 10^{-5} µCi/g waste. Concentrations of ^{241}Am in these extracts were all below the EQL.

These concentrations indicate that the actinides have a fairly low leachability from C-103 residual waste in $CaCO_3$ solution (Table 3.69). The estimated leachability of ^{237}Np ranged from 2.4 to 3.2% of the total. For ^{239}Pu the estimated leachability ranges from 0.5 to 1.1% of the total. The estimated leachability for ^{241}Am ranged from (1.2%) to (1.8%) of the total. These extractable percentages are similar to those for the DDI water extractions for all samples (Table 3.26), but higher than those of the $Ca(OH)_2$ extractions (Table 3.48).

Table 3.68. Extractable Transuranics Determined from 1-Month Single-Contact $CaCO_3$ Solution Extractions

	^{237}Np		^{239}Pu		^{241}Am	
Sample Number	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**
19845	1.79E-05	2.52E-02	(8.02E-04)	(1.29E-02)	(7.21E-04)	(2.12E-04)
19845 Dup	2.17E-05	3.05E-02	3.15E-03	5.09E-02	(1.83E-03)	(5.39E-04)
19849	1.92E-05	2.70E-02	3.25E-03	5.24E-02	(2.58E-03)	(7.58E-04)
19849 Dup	2.69E-05	3.78E-02	3.71E-03	5.98E-02	(2.80E-03)	(8.22E-04)
19850	5.02E-05	7.07E-02	4.85E-03	7.82E-02	(4.00E-03)	(1.18E-03)
19850 Dup	2.87E-05	4.04E-02	9.37E-03	1.51E-01	(6.38E-03)	(1.88E-03)
19845 Average	1.98E-05	2.79E-02	(1.98E-03)	(3.19E-02)	(1.28E-03)	(3.75E-04)
19849 Average	2.30E-05	3.24E-02	3.48E-03	5.61E-02	(2.69E-03)	(7.90E-04)
19850 Average	3.95E-05	5.56E-02	7.11E-03	1.15E-01	(5.19E-03)	(1.53E-03)

All concentrations are corrected for the dry waste basis.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.

Table 3.69. Percentage of Extractable Transuranics Determined from 1-Month Single-Contact $CaCO_3$ Solution Extractions Compared with Acid Analysis

	^{237}Np	^{239}Pu	^{241}Am
Sample Number	**% $CaCO_3$ Leachable**		
19845 Average	2.4%	0.5%	(1.2%)
19849 Average	3.2%	0.7%	(1.8%)
19850 Average	3.2%	1.1%	(1.8%)

3.5.2 Periodic Replenishment $CaCO_3$ Solution Extraction Data

The sequential extraction tests were conducted by repeatedly equilibrating duplicate residual waste samples with 30 mL aliquots of fresh $CaCO_3$-saturated solution. Contact stages 1, 2, 4, and 5 had a duration of 1 day each, whereas, contact stages 3 and 6 lasted 3 and 30 days, respectively. The goal of these sequential leaching tests was to assess the long-term leaching characteristics of key contaminants and other constituents from the residual waste samples. The results of these tests are presented in this section.

3.5.2.1 Residual Waste to $CaCO_3$ Solution Ratios Used in Periodic Replenishment Extractions

In these tests, 30 ml aliquots of saturated $CaCO_3$ solution were contacted with about 0.3 to 0.4 g of moist residual waste. The moisture contents of these residual waste samples ranged from 8.7 to 17.3% by mass (Table 3.1). The dry residual waste masses calculated from moisture content measurements were used to compute the dry residual waste to $CaCO_3$ solution ratios (Table 3.70). These ratios ranged from about 9.2 to 12.1.

Table 3.70. Residual Waste to Solution Ratios Used in Periodic Replenishment $CaCO_3$ Leaching Tests

Sample Number	Waste to $CaCO_3$ Solution Ratio (g/L)
19845	11.55
19845 Dup	9.15
19849	9.29
19849 Dup	12.09
19850	10.53
19850 Dup	11.38
All concentrations are corrected for the dry waste basis.	

3.5.2.2 Alkalinity and pH of $CaCO_3$ Solution Periodic Replenishment Extractions

The average alkalinities and pH values measured in duplicate leachates of each residual waste sample at the end of each contact stage are listed in Table 3.71. The pH and alkalinity value of stage 1 for sample 19850 is anomalous relative to the other extract results. It is believed that stage 1 of sample 19850 was inadvertently extracted with the $Ca(OH)_2$ rather than the $CaCO_3$ solution. This is supported by the results for the $Ca(OH)_2$ extracts (Table 3.50) and the Ca results presented later in Table 3.74. As a result, all discussion of results for the $CaCO_3$ results will be confined to samples 19845 and 19849. Results for 19850 are included in the tables in gray font.

The pH values of the C-103 residual waste leachates at all stages of extraction for samples 19845 and 19849 were slightly acidic to mildly alkaline in nature ranging in values from 6.28 to 8.11. The pH values were generally highest in the first and last stages of the extractions.

The total alkalinity concentrations measured in the extract solutions in the two samples range from 19 to 39 mg/L. Because alkalinity is introduced with the extraction solution, total alkalinity on mg/g waste basis is not especially meaningful and will not be elaborated upon here.

Table 3.71. Alkalinity and pH Values – Period Replenishment Extraction with $CaCO_3$ Solution

Contact Stage	Duration (Days)	pH	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint mg/L	Total Alkalinity (as $CaCO_3$) at pH 4.5 Endpoint mg/g Dry Waste
Sample 19845				
1	1	8.11	39.1	3.72
2	1	6.28	22.0	2.41
3	3	6.66	23.6	2.31
4	1	6.81	20.9	2.06
5	1	6.95	20.1	1.96
6	30	6.97	27.4	2.68
Sample 19849				
1	1	7.14	28.9	2.72
2	1	6.96	22.4	2.13
3	3	7.03	23.2	2.21
4	1	7.05	23.2	2.21
5	1	6.95	19.0	1.80
6	30	7.29	26.2	2.49
Sample 19850[(a)]				
1	1	11.79	1,940	179
2	1	9.40	114	10.7
3	3	8.01	45.6	4.18
4	1	7.50	31.9	2.92
5	1	7.21	28.1	2.57
6	30	7.62	32.7	2.98

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
Values based on duplicate measurements.

3.5.2.3 Extractable ^{99}Tc and ^{238}U Determined from $CaCO_3$ Solution Periodic Replenishment Extractions

The concentrations of ^{99}Tc and ^{238}U mobilized in sequential $CaCO_3$ solution extractions of the C-103 residual waste samples are listed in Table 3.72. The concentration of ^{99}Tc in all stages of extraction from samples 19845 and 19849 were below the EQL or instrumental detection limits. Estimates of the percentages of ^{99}Tc released by the $CaCO_3$ solution are low [(4.3%) to (5.6%)] (Table 3.73). Similar low levels of ^{99}Tc leachability were measured or estimated for the DDI water and $Ca(OH)_2$ solution extractions (Table 3.30 and Table 3.52).

For ^{238}U, measurable concentrations were present in nearly all extracts from the six stages of the three C-103 residual waste samples (Table 3.72). In general, the initial extracts (stage 1) contained the highest ^{238}U concentrations. For C-103 samples 19845 and 19849, the stage 1 ^{238}U concentrations were 148, and 215 µg/g waste, respectively. Concentrations in the stage 2-6 extracts were typically considerably less

Table 3.72. Extractable Concentrations of ^{99}Tc and ^{238}U from Periodic Replenishment Extraction with $CaCO_3$ Solution

Contact Stage	Duration (Days)	^{99}Tc	^{238}U	^{99}Tc	^{238}U
		µg/g Dry Waste		µCi/g Dry Waste	
Sample 19845					
1	1	(1.03E-02)	1.48E+02	(1.76E-04)	4.97E-05
2	1	<9.80E-03	4.00E+01	<1.67E-04	1.34E-05
3	3	<9.80E-03	4.72E+01	<1.67E-04	1.59E-05
4	1	<9.80E-03	6.19E+01	<1.67E-04	2.08E-05
5	1	<9.80E-03	5.33E+01	<1.67E-04	1.79E-05
6	30	<9.80E-03	7.07E+01	<1.67E-04	2.38E-05
Sample 19849					
1	1	(9.69E-03)	2.15E+02	(1.65E-04)	7.22E-05
2	1	<9.52E-03	5.80E+01	<1.62E-04	1.95E-05
3	3	<9.52E-03	4.14E+01	<1.62E-04	1.39E-05
4	1	<9.52E-03	7.81E+01	<1.62E-04	2.63E-05
5	1	<9.52E-03	3.18E+01	<1.62E-04	1.07E-05
6	30	<9.52E-03	8.48E+01	<1.62E-04	2.85E-05
Sample 19850[(a)]					
1	1	9.82E-03	(5.75E-01)	1.67E-04	(1.93E-07)
2	1	<9.14E-03	1.13E+01	<1.55E-04	3.78E-06
3	3	<9.14E-03	1.12E+02	<1.55E-04	3.77E-05
4	1	<9.14E-03	1.77E+02	<1.55E-04	5.96E-05
5	1	<9.14E-03	1.37E+02	<1.55E-04	4.61E-05
6	30	<9.14E-03	1.63E+02	<1.55E-04	5.49E-05

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
Values within parentheses were <EQL.
< = Values were less than instrumental detection limit.

than stage 1. These concentrations ranged from 40 to 71 µg/g waste for sample 19845 and 32 to 85 µg/g waste for sample 19849. The total ^{238}U leachable from all six sequential DDI water extractions constituted 12.6% and 13.8% of the total ^{238}U present in samples 19845 and 19849, respectively (Table 3.73).

3.5.2.4 Extractable Metals Determined from $CaCO_3$ Solution Sequential Extractions

Concentrations of a number of metals, including Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, Tl, V, Zn, and Zr, in the extracts of the six stage sequential leaching using $CaCO_3$ solution were analyzed by ICP-OES. Among these, only five elements, namely Al, Ba, Ca, Na, Sr, and Zr, had measurable concentrations in at least some of the extracts. The extractable concentrations are shown in Table 3.74. Concentrations listed within parentheses indicate values that are less than the EQL. These data show that the major leachable element in C-103 residual waste samples was Na. Initial extractable concentrations of Na for samples 19845 and 19849 were 962 and 879 µg/g waste, respectively. Al was the only other metal with consistently measurable concentrations. For samples 19845 and 19849, Al concentrations ranged from 19 and 58 µg/g waste, and 12 to 82 µg/g waste, respectively. Low concentrations of Sr were measurable in sample 19849 [(1.5) to 3.4 µg/g waste]. The first stage of sample 19849 also had a measurable Zr concentration (3.1 µg/g waste).

Table 3.73. $CaCO_3$ Solution Extractable Percentages of ^{99}Tc and ^{238}U in Periodic Replenishment Extractions

Contact Stage (duration, days)	Contact Duration (days)	^{99}Tc	^{238}U
		% Leachable in $CaCO_3$ Solution	
Sample 19845			
1	1	(5.6%)	4.4%
2	1	<5.3%	1.2%
3	3	<5.3%	1.4%
4	1	<5.3%	1.9%
5	1	<5.3%	1.6%
6	30	<5.3%	2.1%
Sample 19849			
1	1	(4.3%)	5.8%
2	1	<4.2%	1.6%
3	3	<4.2%	1.1%
4	1	<4.2%	2.1%
5	1	<4.2%	0.9%
6	30	<4.2%	2.3%
Sample 19850[(a)]			
1	1	3.5%	(0.01%)
2	1	<3.2%	0.3%
3	3	<3.2%	2.7%
4	1	<3.2%	4.2%
5	1	<3.2%	3.3%
6	30	<3.2%	3.9%

(a) Samples considered suspect (see discussion).
BDL = Below detection limit.
All concentrations are corrected for the dry waste basis.
Values based on duplicate measurements.

Percentages of metals that were cumulatively extractable during the six-stage sequential leaching with $CaCO_3$ solution are listed in Table 3.75. These results were computed on the basis of the total metal concentrations as measured in the acid digested samples of the residual wastes (Table 3.3 through Table 3.5). These extractions mobilized about 32% of the total Na present in 19845 and about 29% in the 19849. The amount of Al that was mobilized was 0.2% for both samples 19845 and 19849. The percentage of other metals could not be quantified.

3.5.2.5 Extractable Anions in $CaCO_3$ Solution Periodic Replenishment Extractions

The concentrations of anions that were present in the $CaCO_3$ leachates after each stage of sequential extraction were measured by ion chromatograpy. Extractable concentrations are listed in Table 3.76. Relatively low concentrations of anions were mobilized in these leachates. Results for samples 19845 and 19849 were quite similar. The highest anion concentrations were generally found in the first stage extraction. Fluoride concentrations ranged from <1.9 to 8.2 µg/g waste in all extract stages of samples

Table 3.74. Average Extractable Concentrations Selected Metals from Periodic Replenishment Extraction with $CaCO_3$ Solution

Contact Stage	Al	Ba	Ca	Mg	Na	Sr	Zr
	µg/g Dry Waste						
Sample 19845							
1	47.2	(0.504)	(85.5)	(5.06)	962	(1.06)	(1.38)
2	19.1	(0.335)	237	(9.60)	364	(1.80)	(0.122)
3	20.4	(0.517)	311	(11.5)	358	(2.20)	<2.45
4	19.9	(0.626)	446	(11.9)	126	(2.31)	<2.45
5	24.6	(0.793)	463	(7.97)	85.1	(1.83)	<2.45
6	57.6	(0.810)	320	(9.28)	539	(3.32)	(0.362)
Sample 19849							
1	82.0	(0.770)	101	(6.65)	879	(1.54)	3.12
2	18.6	(0.478)	359	(10.3)	200	2.68	(0.0772)
3	19.1	(0.612)	293	(10.5)	369	2.58	(0.141)
4	22.7	(0.728)	454	12.2	135	3.41	(0.104)
5	11.6	(0.678)	423	(4.45)	75.2	(2.47)	(0.145)
6	72.2	(0.857)	337	(7.79)	465	3.17	(0.470)
Sample 19850(a)							
1	205	19.7	53,400	(1.74)	1,100	64.7	<2.28
2	619	(1.04)	2,120	(3.19)	278	4.37	<2.28
3	273	(0.634)	1,090	(6.29)	289	(2.46)	<2.28
4	38.3	(0.692)	835	(9.66)	120	(1.84)	<2.28
5	33.4	(0.892)	709	(9.14)	83.5	(1.67)	<2.28
6	108	(0.935)	566	(9.73)	429	2.69	(1.26)

(a) Samples considered suspect (see discussion).
Values within parentheses were <EQL.
Based on duplicate measurements.

Table 3.75. Cumulative Percentages of Extractable Metals from Periodic Replenishment Extractions with $CaCO_3$ Solution

Element	19845	19849	19850(a)
	Cumulative % $CaCO_3$ Leachable		
Al	0.2	0.2	1.0
Ba	(2.6)	(2.5)	(10)
Ca	NA	NA	NA
Mg	(192)	(126)	(71)
Na	32	29	27
Sr	(20)	(20)	(61)
Zr	(0.9)	(0.4)	(1.0)

(a) Samples considered suspect (see discussion).
NA = Not applicable; Ca in extraction solution.
Values calculated on the dry waste basis.

Table 3.76. Average Extractable Concentrations of Anions from Periodic Replenishment Extractions with $CaCO_3$ Solution

Contact Stage	F	Cl	NO_2	NO_3	CO_3	SO_4	PO_4
	µg/g Dry Waste						
Sample 19845							
1	8.05	10.0	37.3	58.7	<4,900	32.5	<14.7
2	<1.96	9.05	<9.80	37.2	<4,900	22.0	<15.1
3	3.46	7.22	<9.80	50.4	<4,900	17.6	<14.7
4	<1.96	8.00	<9.80	38.8	<4,900	<14.7	<14.7
5	<1.96	6.61	<9.80	30.2	<4,900	<14.7	<14.7
6	7.04	7.47	<9.80	85.7	<4,900	<16.1	<14.7
Sample 19849							
1	8.24	9.81	36.8	56.8	<4,760	23.6	<14.3
2	<1.90	7.66	<9.52	33.3	<4,760	<14.3	<14.3
3	3.82	10.5	<9.52	49.0	<4,760	<51.3	<14.3
4	<1.90	8.29	<9.52	32.4	<4,760	<14.3	<14.3
5	<1.90	7.85	<9.52	33.6	<4,760	<14.3	<14.3
6	6.62	7.61	<10.5	81.3	<4,760	<14.3	<14.3
Sample 19850[(a)]							
1	9.70	14.0	42.9	54.2	<12,300	65.6	<13.7
2	3.55	8.00	<9.14	37.2	<4,570	46.5	<13.7
3	3.72	7.40	<9.14	42.0	<4,570	<22.4	<13.7
4	<2.15	<10.3	<9.14	<28.3	<4,570	<13.7	<13.7
5	<1.83	6.96	<9.14	27.9	<4,570	<13.7	<13.7
6	5.31	7.06	<9.14	69.7	<4,570	<13.7	<13.7

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
Values based on duplicate measurements.

19845 and 19849. Chloride concentrations ranged from 6.6 to 10.5 µg/g waste for all extract stages of samples 19845 and 19849. Nitrite concentrations were less than the instrument detection limit except in the first stage which had a concentration of 37 µg/g waste for both samples 19845 and 19849.

3.5.2.6 Extractable ^{137}Cs and ^{90}Sr Determined from $CaCO_3$ Solution Periodic Replenishment Extractions

The extractable concentrations of ^{137}Cs (in terms of activity) determined from the $CaCO_3$ solution extracts were very similar for the C-103 samples (19845 and 19849) (Table 3.77). For example, stage 1 extract concentrations were 1.4 and 1.6 µCi/g waste for samples 19845 and 19849, respectively. The highest extractable ^{137}Cs concentrations occurred in the final stage (30 day) extracts for both samples 19845 and 19849. The cumulative leachable fractions of ^{137}Cs in these residual waste samples were on average 15 and 27% of the total ^{137}Cs present in samples 19845 and 19849, respectively (Table 3.78). The sequential extractions cumulatively leached about three times more ^{137}Cs than was leached in the 1-month single-contact extraction process (Table 3.67). ^{137}Cs was slightly more leachable in the $CaCO_3$ extracts than those of the DDI water extracts Table 3.34) and less leachable than those of the $Ca(OH)_2$ extracts Table 3.56).

Table 3.77. Extractable Concentrations of ^{137}Cs and ^{90}Sr from Periodic Replenishment Extractions with $CaCO_3$ Solution

		^{137}Cs		**^{90}Sr**	
Contact Stage	**Duration (Days)**	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**
Sample 19845					
1	1	1.39E+00	1.60E-02	5.33E+01	3.81E-01
2	1	1.25E+00	1.44E-02	NA	NA
3	3	1.49E+00	1.72E-02	5.51E+01	3.94E-01
4	1	8.54E-01	9.81E-03	NA	NA
5	1	6.06E-01	6.97E-03	7.47E+01	5.33E-01
6	30	2.06E+00	2.37E-02	7.66E+01	5.47E-01
Sample 19849					
1	1	1.64E+00	1.89E-02	7.43E+01	5.31E-01
2	1	9.83E-01	1.13E-02	NA	NA
3	3	1.43E+00	1.65E-02	7.58E+01	5.42E-01
4	1	9.09E-01	1.05E-02	NA	NA
5	1	6.20E-01	7.13E-03	7.37E+01	5.26E-01
6	30	1.94E+00	2.23E-02	7.59E+01	5.42E-01
Sample 19850(a)					
1	1	4.48E+00	5.15E-02	1.15E+02	8.24E-01
2	1	1.77E+00	2.03E-02	NA	NA
3	3	1.59E+00	1.82E-02	8.36E+01	5.97E-01
4	1	8.14E-01	9.36E-03	NA	NA
5	1	6.26E-01	7.20E-03	8.36E+01	5.97E-01
6	30	1.90E+00	2.18E-02	8.53E+01	6.09E-01

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
NA = Not analyzed.
Values based on duplicate measurements.

Table 3.78. Cumulative Percentages of ^{137}Cs and ^{90}Sr Leached by $CaCO_3$ Solution

	^{137}Cs	**^{90}Sr**
Sample Number	**% $CaCO_3$ Leachable**	
19845 Average	14.5	65.6
19849 Average	26.9	73.6
19850(a) Average	18.5	48.8

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
Total residual waste concentrations from acid digested samples.

The extractable ^{90}Sr concentrations determined from the first, third, fifth, and sixth stages of the sequential extractions are listed in Table 3.77. The extractable ^{90}Sr concentrations varied over a fairly narrow range for all extract stages and samples (0.53 to 0.77 µCi/g waste). For both residual waste sample, the highest concentrations were measured in the sixth extractions. The leachable concentrations measured for the four extractions represent 66% of the total ^{90}Sr in sample 19845 and 74% of the total in sample 19849. These results indicate that ^{90}Sr is fairly leachable from these residual wastes by the $CaCO_3$ solution, similar to that of DDI water (Table 3.35) but less leachable than for the $Ca(OH)_2$ saturated solution (Table 3.57).

3.5.2.7 Extractable Transuranic Concentrations Determined from $CaCO_3$ Solution Periodic Replenishment Extractions

The $CaCO_3$ leachate concentrations of sequentially leachable transuranics are listed in Table 3.79. Extractable concentrations of ^{237}Np were measurable but low at all stages for samples 19845 and 19849. Concentrations in terms of activities for samples 19845 and 19849 ranged from 3.9×10^{-6} to 1.5×10^{-5} µCi/g waste, and 2.8×10^{-6} to 1.6×10^{-5} µCi/g waste, respectively. The total extractable percentages of ^{237}Np in samples 19845 and 19849 were 6.7% and 7.5%, respectively (Table 3.80). Only one extract had a quantifiable concentration of ^{239}Pu (Stage 1 of sample 19849). The concentration for this extract was low at 1.9×10^{-3} µCi/g waste. This concentration represents 0.4% of the total for the sample (Table 3.80). The ^{241}Am concentrations in all the sequential extractions were below the instrument detection limit.

Table 3.79. Extractable Transuranics Determined from Periodic Replenishment $CaCO_3$ Extractions

	^{237}Np		^{239}Pu		^{241}Am	
Contact Stage	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**	**µCi/g Dry Waste**	**µg/g Dry Waste**
Sample 19845						
1	1.28E-05	1.80E-02	<1.38E-03	<2.22E-02	<1.67E-02	<4.90E-03
2	8.18E-06	1.15E-02	<1.52E-03	<2.45E-02	<1.67E-02	<4.90E-03
3	7.91E-06	1.11E-02	<1.52E-03	<2.45E-02	<1.67E-02	<4.90E-03
4	6.18E-06	8.70E-03	<1.52E-03	<2.45E-02	<1.67E-02	<4.90E-03
5	3.90E-06	5.50E-03	<1.52E-03	<2.45E-02	<1.86E-02	<5.46E-03
6	1.47E-05	2.07E-02	(2.87E-04)	(4.62E-03)	<1.67E-02	<4.90E-03
Sample 19849						
1	1.64E-05	2.31E-02	1.87E-03	3.02E-02	<1.62E-02	<4.76E-03
2	7.44E-06	1.05E-02	<1.48E-03	<2.38E-02	<1.62E-02	<4.76E-03
3	8.11E-06	1.14E-02	<1.48E-03	<2.38E-02	<1.62E-02	<4.76E-03
4	8.06E-06	1.13E-02	<1.48E-03	<2.38E-02	<1.62E-02	<4.76E-03
5	2.84E-06	3.99E-03	<1.48E-03	<2.38E-02	<1.41E-02	<4.14E-03
6	1.13E-05	1.59E-02	<1.48E-03	<2.38E-02	<1.62E-02	<4.76E-03
Sample 19850[(a)]						
1	<6.49E-07	<9.14E-04	<1.42E-03	<2.28E-02	<1.55E-02	<4.57E-03
2	<6.49E-07	<9.14E-04	<1.42E-03	<2.28E-02	<1.55E-02	<4.57E-03
3	<1.80E-06	<2.54E-03	<8.77E-04	<1.42E-02	<1.55E-02	<4.57E-03
4	4.31E-06	6.07E-03	<7.54E-04	<1.22E-02	<1.55E-02	<4.57E-03
5	4.58E-06	6.46E-03	<1.42E-03	<2.28E-02	<1.49E-02	<4.39E-03
6	4.89E-06	6.89E-03	(4.90E-04)	(7.90E-03)	<1.55E-02	<4.57E-03

(a) Samples considered suspect (see discussion).
All concentrations are corrected for the dry waste basis.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Values based on duplicate measurements.

Table 3.80. Extractable Percentages for Transuranics Determined from Periodic Replenishment $CaCO_3$ Extractions

Contact Stage	^{237}Np	^{239}Pu	^{241}Am
% $CaCO_3$ Extractable			
Sample 19845			
1	1.6%	<0.3%	<15%
2	1.0%	<0.4%	<15%
3	1.0%	<0.4%	<15%
4	0.8%	<0.4%	<15%
5	0.5%	<0.4%	<17%
6	1.8%	(0.1%)	<15%
Sample 19849			
1	2.3%	0.4%	<11%
2	1.0%	<0.3%	<11%
3	1.1%	<0.3%	<11%
4	1.1%	<0.3%	<11%
5	0.4%	<0.3%	<11%
6	1.6%	<0.3%	<11%
Sample 19850[(a)]			
1	<0.1%	<0.2%	<5.5%
2	<0.1%	<0.2%	<5.5%
3	<0.2%	<0.1%	<5.5%
4	0.3%	<0.1%	<5.5%
5	0.4%	<0.2%	<5.5%
6	0.4%	(0.1%)	<5.5%

(a) Samples considered suspect (see discussion).
BDL = Below detection limit.
All concentrations are corrected for the dry waste basis.
Values within parentheses were <EQL.
EQL = Estimated quantitation limit.
Values based on duplicate measurements.

3.6 XRD Results

Samples of unleached, 1-month single-contact DDI water-leached, 1-month single-contact $Ca(OH)_2$-leached, and 1-month single-contact $CaCO_3$-leached solids from samples 19845, 19849, and 19850 of C-103 residual waste were characterized by bulk XRD. Phase identification was based on a comparison of the peak reflections and intensities observed in each pattern to the mineral PDF™ published by the JCPDS ICDD. The following XRD patterns show, for comparison purposes, one or more schematic database (PDF) patterns considered for phase identification, such as gibbsite (PDF #00-033-0018) and corundum (PDF #00-010-0173). The XRD samples of C-103 residual waste included the addition of a trace quantity of reference-material corundum powder (α-Al_2O_3, alumina) (NIST Standard Reference Material [SRM] 676) as an internal 2θ standard for each XRD pattern. The height of each line in the schematic PDF patterns represents the relative intensity of an XRD peak (i.e., the most intense [the highest] peak has a relative intensity [I/I_o] of 100%). A crystalline phase typically must be present at greater than ~5-10 wt% of the total sample mass (greater than 1 wt% under optimum conditions) to be readily detected by XRD. Phase identification from the XRD patterns was done in an iterative fashion by considering the compositions of phases identified by SEM/EDS (Section 2.3) in the unleached and leached residual waste samples.

Figure 3.1 through Figure 3.4 show typical XRD patterns, respectively, for the unleached, DDI water-leached, $Ca(OH)_2$-leached, and $CaCO_3$-leached samples that have been corrected by background subtraction and calibration with respect to the internal 2θ standard. Figure 3.1 (see pattern A) also includes a typical as-measured XRD pattern before it was corrected by background subtraction and 2θ calibration. Each XRD pattern is shown as a function of degrees 2θ based on $Cu_{K\alpha}$ radiation (λ=1.5406 Å). The vertical axis in each pattern represents the intensity or relative intensity of the XRD peaks. All of the as-measured and corrected XRD patterns are included in Appendix A.

All of the as-measured XRD patterns (e.g., see pattern A in Figure 3.1) contain a broad diffraction profile (or hump) from approximately 10 to 30°2θ. This feature is indicative of diffraction from amorphous materials, which cannot be identified by XRD methods. For these samples, diffraction from the nitrocellulose binder is thought to be the main contributor to this broad profile. This is consistent with the SEM/EDS results (Section 3.7) which show that the majority of the particles (probably more than ~90%) have crystal faces and thus are likely crystalline. The maximum intensity (i.e., height) (see XRD patterns in Appendix A) of this broad diffraction profile varies between all samples (including unleached and leached), but not in any systematic fashion. Because the nitrocellulose binder is thought to be the main contributor to this broad profile (XRD pattern of a blank slide containing just binder is shown in Figure 2.5, the variability of the intensity of this broad diffraction profile in the different XRD patterns is likely due to variations in the relative amounts of nitrocellulose binder and waste solid used for each XRD mount. Given the difficulties associated with working with these radioactive materials, it is not possible to control the proportion of nitrocellulose binder to tank waste solid used for each XRD mount. Generally, the intensity of this broad diffraction profile appears to be lower in the as-measured XRD patterns for the $Ca(OH)_2$- and $CaCO_3$-leached samples than those for the unleached and DDI water-leached samples. This difference is likely due to less mass of sample being used relative to the amount of nitrocellulose binder for the XRD mounts. Although less likely, this decrease in the intensity of this broad diffraction profile might also suggest that the $Ca(OH)_2$- and $CaCO_3$-leaches dissolved more fine-grained amorphous solid in waste samples than occurred with the DDI water leaches.

Table 3.81 lists the phases whose PDF database patterns match the corrected XRD patterns for the unleached and leached waste samples. Corundum is also present in all XRD patterns as it was added to all XRD samples as an internal 2θ standard. The XRD results indicate that all of the unleached and leached C-103 samples contain predominately (probably more than ~90% or more) gibbsite [$Al(OH)_3$]. There is no indication from the XRD patterns that the unleached and leached C-103 waste samples contain böhmite [$AlO(OH)$]. The XRD patterns do not contain any reflections that correspond to the most intense reflection (I/I_o=100%) for böhmite (PDF 00-021-1307) at 14.49°2θ. Böhmite was previously identified in combination with gibbsite in oxalate-treated C-106 post retrieval waste from tank C-106 (Deutsch et al. 2006, 2007a).

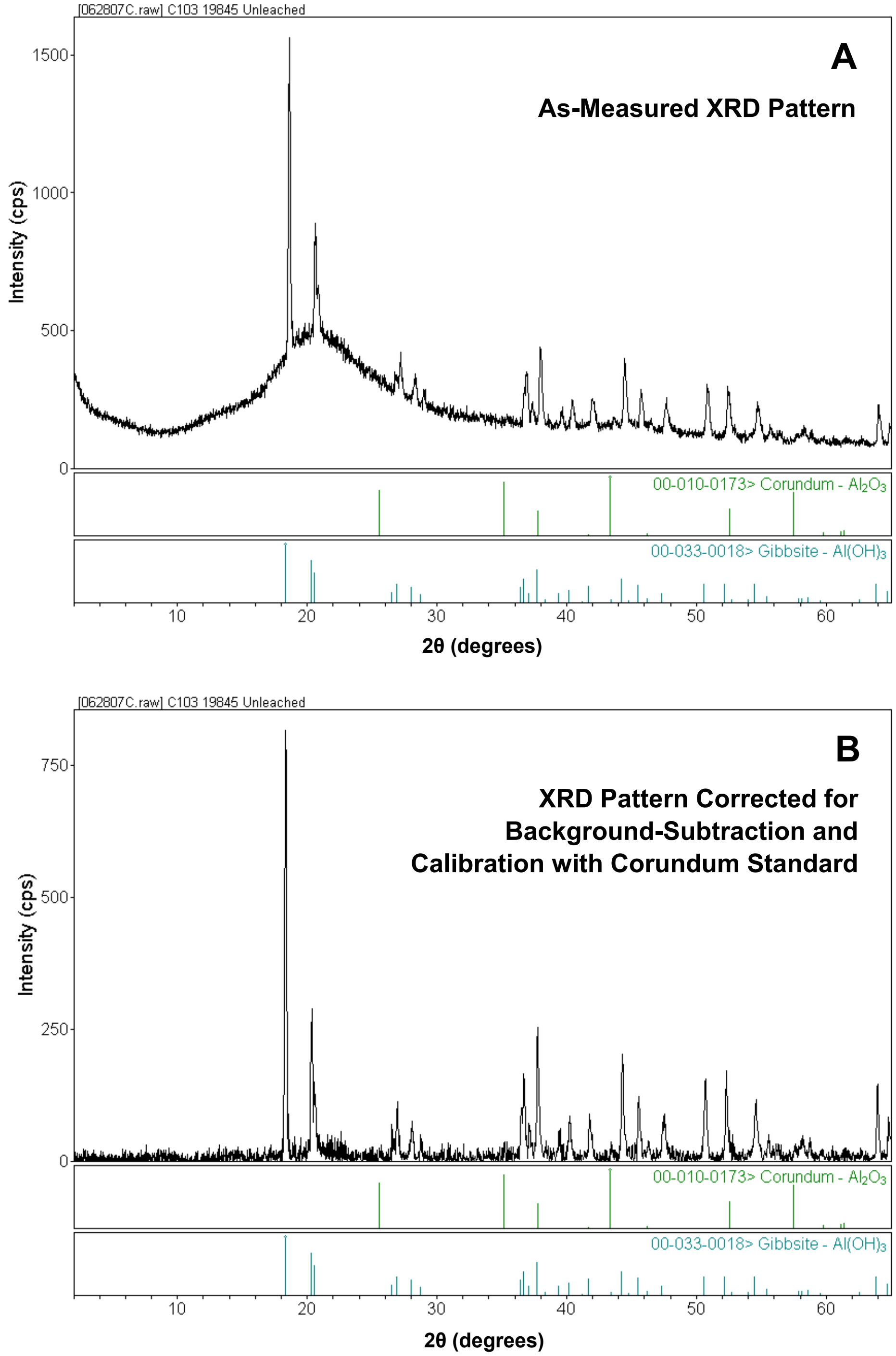

Figure 3.1. As-Measured (A) and Corrected (B) XRD Patterns (based on $Cu_{K\alpha}$ radiation, λ=1.5406 Å) for Sample 19845 of Unleached C-103 Residual Waste

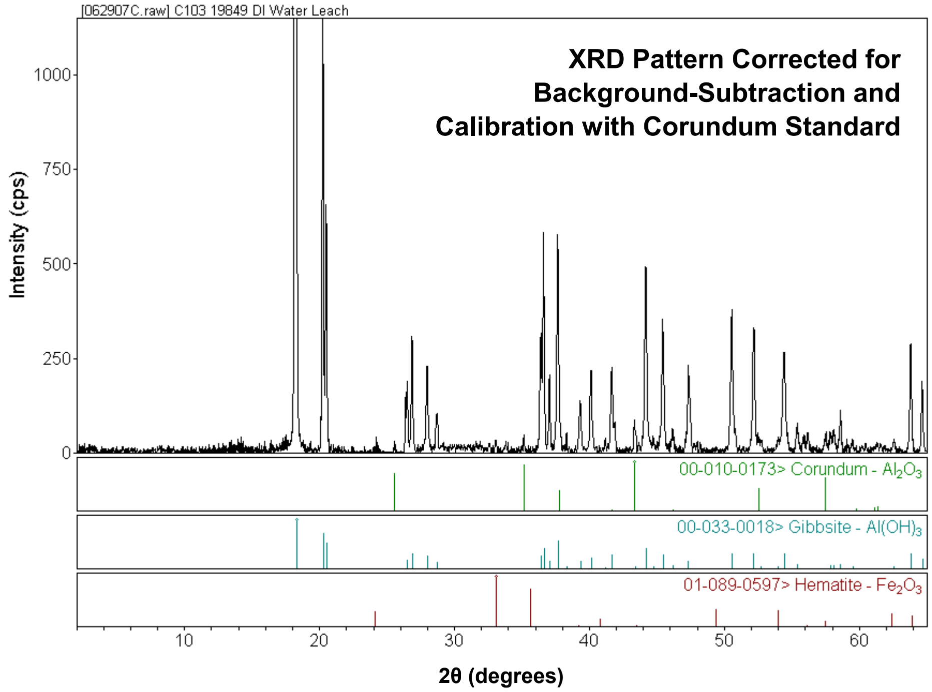

Figure 3.2. As-Measured (top) and Corrected (bottom) XRD Patterns (based on $Cu_{K\alpha}$ radiation, λ=1.5406 Å) for Sample 19849 of 1-Month Single-Contact DDI Water-Leached C-103 Residual Waste

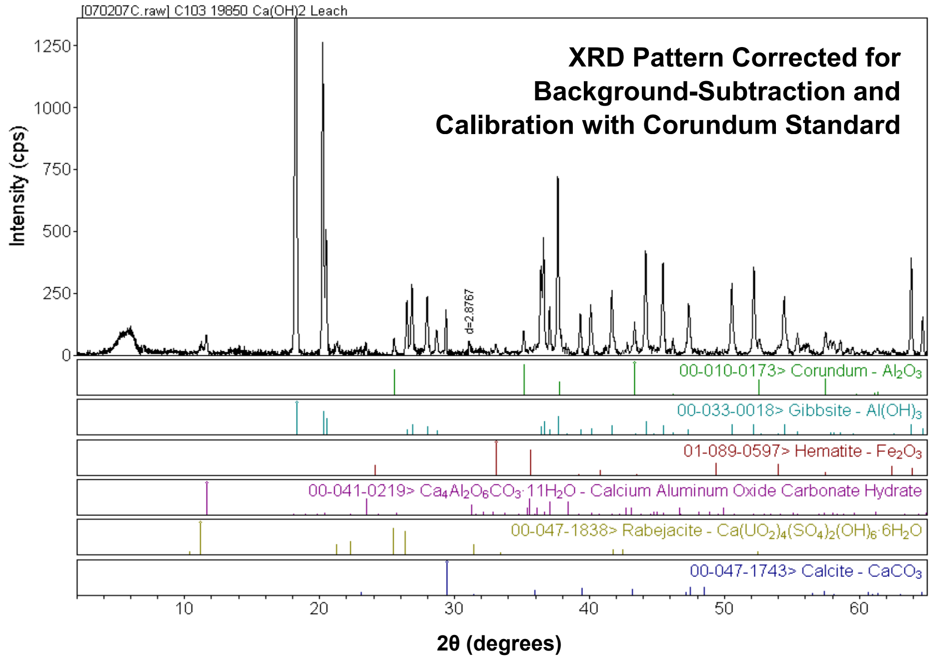

Figure 3.3. As-Measured (top) and Corrected (bottom) XRD Patterns (based on $Cu_{K\alpha}$ radiation, λ=1.5406 Å) for Sample 19850 of 1-Month Single-Contact $Ca(OH)_2$-Leached C-103 Residual Waste

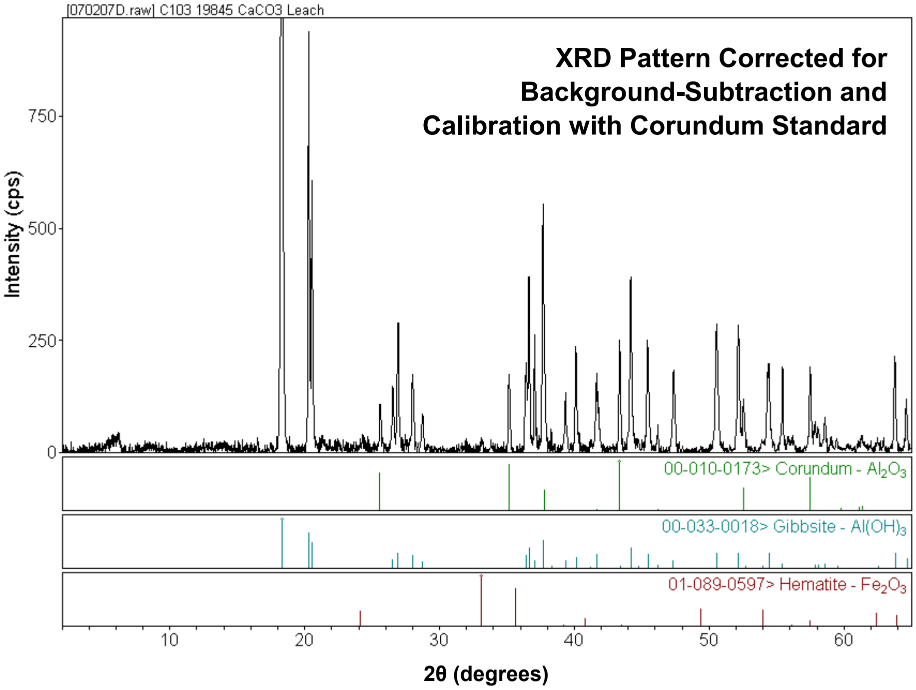

Figure 3.4. As-Measured (top) and Corrected (bottom) XRD Patterns (based on $Cu_{K\alpha}$ radiation, λ=1.5406 Å) for Sample 19845 of 1-Month Single-Contact $CaCO_3$-Leached C-103 Residual Waste

The XRD patterns (Table 3.81) for the leached samples are also consistent with the presence of hematite (Fe_2O_3, PDF 01-089-0597). The agreement is based primarily on the presence of one peak at 33.28°2θ which corresponds to the most intense reflection (I/I_o=100%) for hematite. The reflection that matches the pattern for hematite is significantly less intense than those for gibbsite, which indicates that hematite is present at a significantly lower concentration than gibbsite in these samples. The reason why reflections for hematite were not identified in the XRD patterns for unleached samples is not known. Hematite is likely present in the unleached samples, but at concentrations too low to be detected by XRD.

The XRD patterns for the $Ca(OH)_2$-leached samples contain additional reflections that are not present in the unleached, DDI water-leached, and $CaCO_3$-leached samples. In addition to gibbsite and hematite, the XRD patterns for the 1-month single-contact $Ca(OH)_2$-leached samples are also consistent with the presence of a small quantity of calcite ($CaCO_3$). As with the major reflection for hematite, the reflections for calcite are significantly less intense than those for gibbsite, which indicates that calcite is also present at a significantly lower concentration than gibbsite.

The XRD patterns for the $Ca(OH)_2$-leached samples also contain a few minor reflections that could not be assigned to gibbsite, hematite, calcite, or corundum (the internal 2θ standard). These remaining reflections are consistent with the major reflections in the database patterns (Table 3.81) for cancrinite [$Na_6CaAl_6Si_6(CO_3)O_{24}\bullet 2H_2O$], katoite [$Ca_2Al_2(OH)_{12}$], calcium aluminum oxide carbonate hydrate $Ca_4Al_2O_6CO_3\bullet 11H_2O$, and rabejacite [$Ca(UO_2)_4(SO_4)_2(OH)_6\bullet 6H_2O$].

Table 3.81. Summary of Phases that Match the XRD Patterns for the Unleached, DDI Water-Leached, $Ca(OH)_2$-Leached, and $CaCO_3$-Leached Solids from Samples 19845, 19849, and 19850 of C-103 Residual Waste [Corundum (α-Al_2O_3, PDF 00-010-0173) was also present in all XRD samples as it was added as an internal 2θ standard.]

Phase Identification, Formula, and PDF Pattern Number	**Unleached**			**DDI Water-Leached**			**$Ca(OH)_2$-Leached**			**$CaCO_3$-Leached**		
	19845	**19849**	**19850**	**19845**	**19849**	**19850**	**19845**	**19849**	**19850**	**19845**	**19849**	**19850**
Gibbsite $Al(OH)_3$ PDF 00-033-0018	X	X	X	X	X	X	X	X	X	X	X	X
Hematite Fe_2O_3 PDF 01-089-0597				X	X			X	X	X	X	X
Calcite $CaCO_3$ PDF 00-047-1743							X	X	X			
Cancrinite $Na_6CaAl_6Si_6(CO_3)O_{24}$•$2H_2O$ PDF 00-048-1862							X					
Katoite $Ca_3Al_2(OH)_{12}$ PDF 00-024-0217							X	X				
Calcium aluminum oxide carbonate hydrate $Ca_4Al_2O_6CO_3$•$11H_2O$ PDF 00-041-0219								X	X			
Rabejacite $Ca(UO_2)_4(SO_4)_2(OH)_6$•$6H_2O$ PDF 00-047-1838									X			

X = Indicates that PDF pattern for that phase is consistent with the corrected XRD pattern for the corresponding C-103 waste sample.

Except for a few minor (i.e., small in intensity) reflections, all major reflections in the XRD patterns measured for the unleached and leached C-103 samples could be assigned to possible matches with XRD database patterns. The minor reflections (based on $Cu_{K\alpha}$ radiation [λ=1.5406 Å]) that could not be assigned to database patterns include the following:

- Reflections at 6.86°2θ (d-spacing of 12.61 Å) and 33.85°2θ (2.646 Å d-spacing) in the XRD pattern for $Ca(OH)_2$-leached sample 19845 of C-103 residual waste
- Reflection at 31.05°2θ (d-spacing of 2.877 Å) in the XRD pattern for $Ca(OH)_2$-leached sample 19850 of C-103 residual waste
- Reflection at 33.85°2θ (d-spacing of 2.646 Å) in the XRD pattern for $CaCO_3$-leached sample 19850 of C-103 residual waste (this reflection is also in the pattern for $Ca(OH)_2$-leached sample 19845 – see first bullet).

3.7 SEM/EDS Results

Samples of unleached, 1-month single-contact DDI water-leached, 1-month single-contact $Ca(OH)_2$-leached, and 1-month single-contact $CaCO_3$-leached solids from samples 19845, 19849, and 19850 of residual waste from tank C-103 were characterized by SEM/EDS. The SEM micrographs, EDS spectra, and the phase compositions (in wt%) calculated from these EDS analyses are given in Appendices B, C, D, and E for the unleached, DDI water-leached, $Ca(OH)_2$-leached, and $CaCO_3$-leached samples, respectively.

The majority of the SEM micrographs shown in this section and Appendices B through E are images from the BSE signal. As noted in previous project reports, SEM micrographs obtained using the BSE signal have proved invaluable for rapidly distinguishing phases containing elements with large atomic numbers, such as U, Fe, Cr, Mn, Ag, and Hg, within the complex assemblage of particles that make up each waste sample. SEM micrographs may be obtained as either high-resolution SE or BSE images. However, backscattered electron emission intensity is a function of the element's atomic number (i.e., size of the nuclei), where the larger the atomic number, the brighter the signal. This characteristic is readily apparent in the low magnification SEM micrographs of $CaCO_3$-leached C-103 residual waste shown in Figure 3.5. Micrograph A in Figure 3.5 is based on the SE signal, and provides a higher resolution, more three-dimensional type of image of the sample. Micrograph B in Figure 3.5 is from the BSE signal, and readily shows the contrast between the particles containing mostly lighter elements (gray) (e.g., most are Al-containing particles) versus the heavier elements (light gray to white) (e.g., those containing U, Fe, Cr, Mn, Ag, and/or Hg). This type of information in an SEM image helps to identify and prioritize the different types of particles, especially those containing contaminants of interest such as U and Cr, which should be characterized by SEM/EDS. The specific phases shown in Figure 3.5 are discussed below.

The SEM and EDS results suggest the presence of a large number of different phases in the samples of leached and unleached C-103 residual waste. These phases are summarized in Table 3.82. Because H is not detectable by EDS and C was used for coating the SEM samples, it is possible that some of the phases listed in Table 3.82 may also contain H as hydroxide and/or structural water, and/or C as CO_3 and/or another C molecule such as oxalate. Some of the phases in Table 3.82 are somewhat speculative and noted appropriately in the table. A significant amount of solid material studied by EDS consisted of fine-grained particle aggregates and/or micrometer-to-submicrometer-sized individual particles. Therefore, it was not always possible to determine if a recorded EDS spectrum represents the composition of a single phase or more likely, that of a combination of two or more phases.

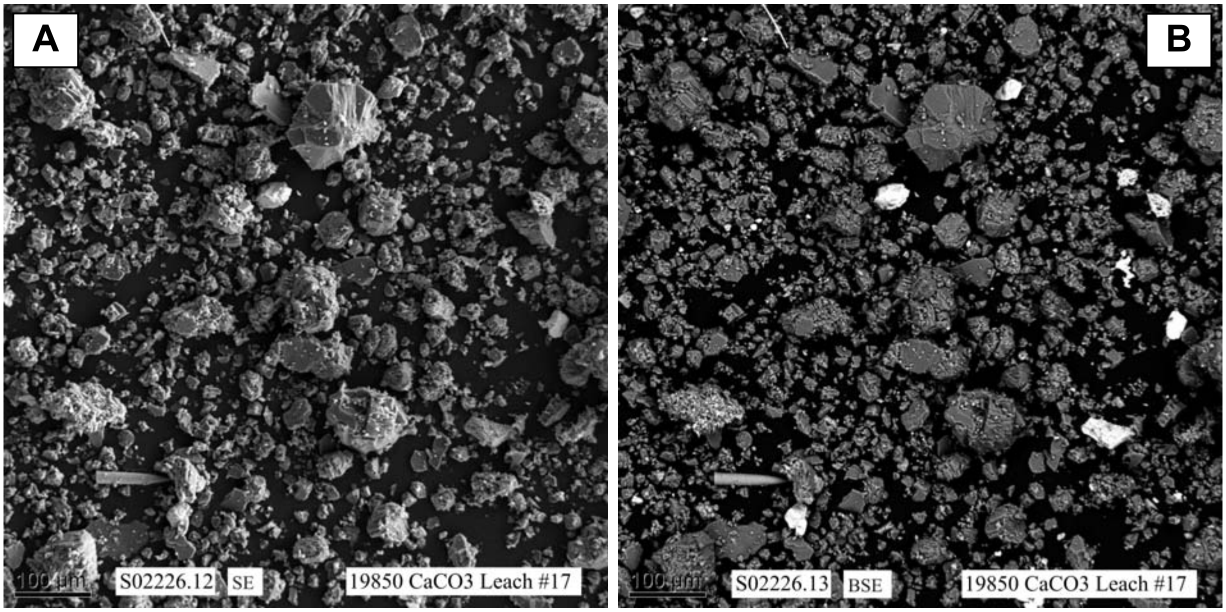

Figure 3.5. Low Magnification Secondary (SE) (A) and Backscattered Electron (BSE) (B) SEM Micrographs of Solids Present in $CaCO_3$-Leached C-103 Residual Waste [Except for the bullet-shaped particle in the lower left corner of each micrograph, the solids shown in these micrographs are typical for material present in unleached and leached C-103 residual waste. The bullet-shaped particle is composed of Si and O, and is part of a fiber from filter material used to minimize dispersion of the dried residual waste during storage.]

The SEM/EDS analyses did not indicate any significant differences between the common phases (i.e., Al oxide/hydroxide, Fe oxide/hydroxide, Ag and/or Ag-Hg oxide, U oxide, Na-Ca-Al silicate, and a Ca phosphate/oxide phases) identified in unleached samples 19845, 19849, and 19850 versus any type of leached waste samples. Except for two phases (i.e., Ca oxide [probably a CO_3 phase] and Ca-Al-Si oxide [probably a silicate]) only identified in the $Ca(OH)_2$-leached samples, the SEM/EDS results also suggest that the common phases were present in the unleached and all leached samples. Some phases in Table 3.82 were identified based on the presence of only a few (sometimes only one) particles in one sample. It is generally assumed that even though these phases were not observed due their rarity (e.g., Th-O, Zr-O, etc.) in all waste samples, they may be present in all the waste samples. However, there is no definitive information to ignore the possibility that one or more of these rare phases might have precipitated as a reaction product during the leach tests.

The samples of unleached and leached C-103 residual waste consist primarily (probably more than 90%) of Al oxide/hydroxide phase(s), such as gibbsite [$Al(OH)_3$]. Some minor amounts of böhmite [$AlO(OH)$] could also possibly be present. Micrograph A in Figure 3.6 shows a low magnification BSE micrograph of typical material present in the C-103 unleached samples. Micrographs B through D in Figure 3.6 show higher magnification SEM images of particles marked by the magenta outlined squares in micrograph A. The SEM/EDS analyses did not indicate any significant differences in the compositions and morphologies of particles in samples

Table 3.82. Summary of Phases Indicated by SEM/EDS and XRD Results for Unleached and Leached Samples of C-103 Residual Waste

Compositions of Phases Identified by SEM/EDS	Phases Identified by XRD	Information Regarding Occurrence Based on SEM/EDS Analyses
Because H is not detectable by EDS and C was used for coating the SEM mounts, all of the phases listed below at being identified by SEM/EDS may also contain H and/or C.		
Phases Thought to be Present in All Unleached and Leached C-103 Residual Waste Samples		
Al – O	gibbsite	• Overwhelmingly the most dominant phase(s) in all unleached and leached samples • Possibly two phases based on calculated EDS-based compositions
Fe – O	hematite	• Second most common phase; present in all unleached and leached samples • Two Fe oxyhydroxides phases may be present based on morphology • When Cr, Ni, Pb, and Mn are detected by EDS, these metals are always associated with the Fe oxide phase • A few wt% U may also sometimes be associated with some Fe oxide particles
Ag ± Hg – O		• Present in all unleached and leached samples • May have two Ag phases – one being Ag oxide (with no detectable Hg) and the other being Ag-Hg oxide
U – O		• Most common U-containing particle • Typically present as micrometer- or submicrometer-sized particles
Na – Ca - Al – Si – O	Cancrinite – only identified by XRD in $Ca(OH)_2$-leached sample 19845	• Probably a silicate • Morphology similar to "balls of twine," which is similar to the crystal habit identified by others as being the mineral cancrinite • One particle also found to include U, Ce, La, and Nd
Ca – P – O		• Probably a phosphate phase • Present in the unleached, DDI water-leached, $CaCO_3$-leached, and possibly the $Ca(OH)_2$-leach samples

Table 3.82. (contd)

Compositions of Phases Identified by SEM/EDS	**Phases Identified by XRD**	**Information Regarding Occurrence Based on SEM/EDS Analyses**
Because H is not detectable by EDS and C was used for coating the SEM mounts, all of the phases listed below at being identified by SEM/EDS may also contain H and/or C.		
Rare Phases – Only One Particle Detected in One or Two Samples Phases Possibly Present in All Unleached and Leached Samples		
Na – Ca – U – O		• Rare; only identified in unleached residual waste samples
Si – Al – Mg – Na – Fe – O		• Rare; probably a silicate
Na – S – O		• Rare; only 1 particle observed in a DDI water-leached samples • Possibly a Na sulfate phase
Zr – O		• Rare; only a few particles observed in unleached and $CaCO_3$-leached samples
Th – O		• Rare; only a couple particles observed in one $CaCO_3$-leached sample
Fe – Pb - O		• Rare; only a couple particles observed in DDI water-leached samples
Phases Only Observed in the 1-Month Single-Contact $Ca(OH)_2$-Leached Samples and Thought to Have Formed from Contact with $Ca(OH)_2$ Leachant		
Ca – O		• Common phase • Has well-formed crystal faces • Calculated EDS-based composition agrees with that of $CaCO_3$
Ca – Al – Si – O		• Probably a silicate • Common phase • Has platy crystal habit; platy crystals often form as clusters • Angles on corners of platelets appear to be ~120°
Ca – Al – O	Katoite (or hydrogrosslarite) $Ca_3Al_2(OH)_{12}$	• Rare phase; only few particles in one $Ca(OH)_2$-leached samples • Appears to be spherical intergrowth of interlocking cubic crystals
	Calcium aluminum oxide carbonate hydrate $Ca_4Al_2O_6CO_3 \cdot 11H_2O$	
	Rabejacite $Ca(UO_2)_4(SO_4)_2(OH)_6 \cdot 6H_2O$	

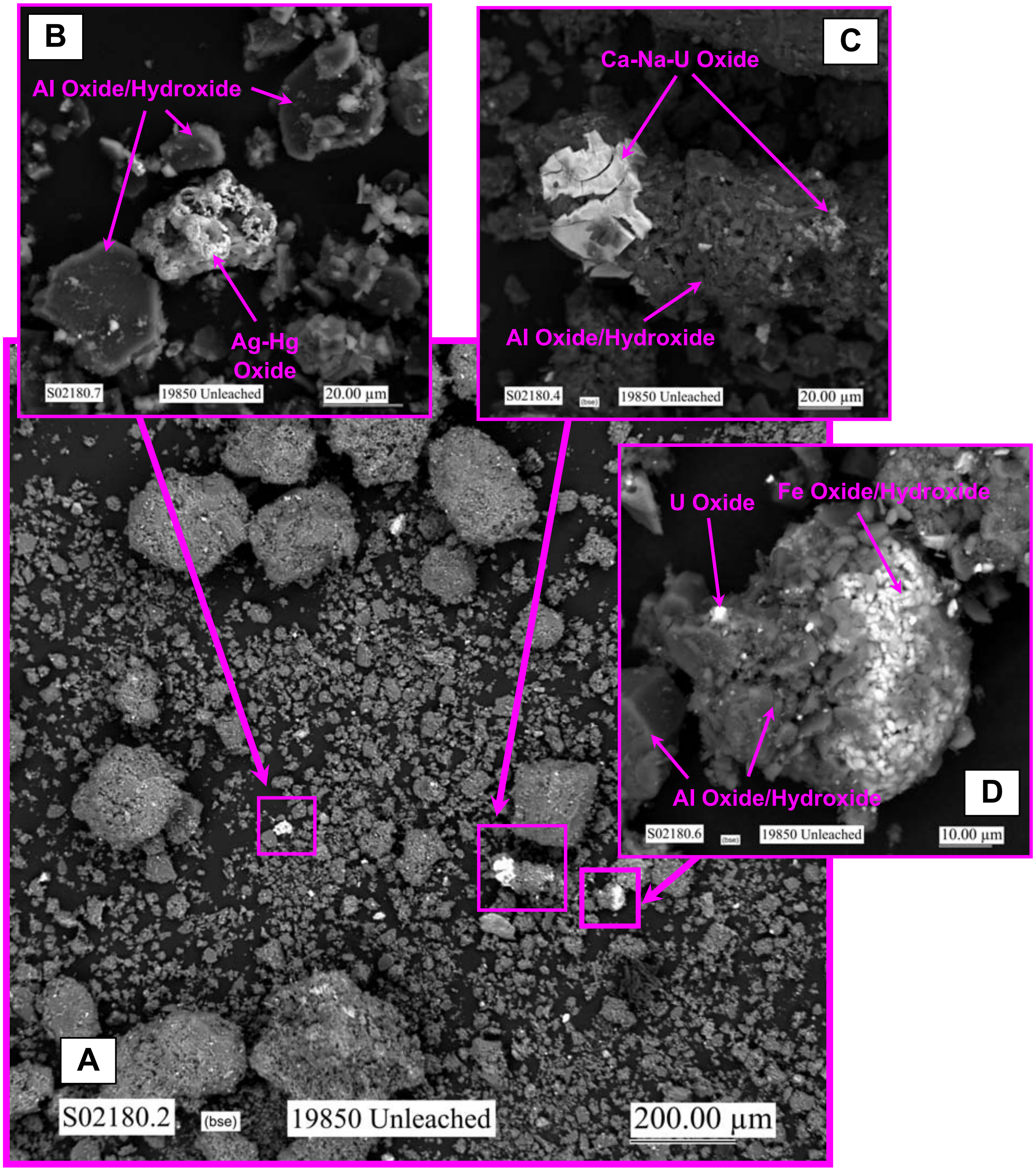

Figure 3.6. Low (A) and High (B, C, and D) Magnification Backscattered Electron (BSE) SEM Micrographs of Typical Solids Present in Unleached C-103 Residual Waste

19845, 19849, and 19850 of unleached C-103 residual waste. Most of the dark gray particles in micrograph A in Figure 3.6 are Al oxide/hydroxide phases. The morphology of most of the Al oxide/hydroxide particles are consistent with gibbsite, which forms monoclinic prismatic-tabular crystals with perfect {001} cleavage and produces a near hexagonal form. EDS analyses indicate that the range of highest Al concentrations measured for these Al oxide/hydroxide particles are consistent with the ideal Al concentrations of 36.0 wt% and 45.7% for gibbsite and böhmite, respectively (see calculated EDS-based compositions in Appendices B through E). The SEM/EDS results (see Appendices B through E) also suggest that the phases shown in Figure 3.6 are also common to all the DDI water-leached, $Ca(OH)_2$-leached, and $CaCO_3$-leached solids from C-103 residual waste.

It is estimated that the remaining phases in Table 3.82 make up in total less than ~10% of the solids in the unleached and leached C-103 residual waste samples. The most common phases in this group include (in approximate order from most to less common) one or two Fe oxide/hydroxides, a Ag and/or Ag-Hg oxide, one or two U oxides (one phase also containing possibly Ca and Na), a Na-Ca-Al silicate, and a Ca phosphate or oxide phases. Based on morphology, the SEM results suggest the presence of possibly two different Fe oxide phases. Examples of the different forms of Fe oxide/hydroxides are shown in Figure 3.7 and micrograph D in Figure 3.6. Both forms are present in the unleached and leached samples. The surface of one form of Fe oxide/hydroxide (micrographs A, B, and D in Figure 3.7) appears to consist of an aggregate of rounded stubby particles (or crystals) of the Fe oxide/hydroxide. It is not known if this is a surface feature or an intergrowth of particles that extends throughout the matrix of these large aggregates. The other form (micrograph C in Figure 3.7) is more massive in shape, void of these rounded stubby particles, and sometimes exhibiting flat surfaces that might be crystal faces. Both forms of Fe oxide exist in each type of unleached and leached samples, as shown in micrograph D in Figure 3.7. These Fe oxides/hydroxides are often intergrown with the Al oxide/hydroxide particles as shown in micrograph E in Figure 3.7. When Cr, Ni, Pb, and Mn (typically a couple weight percent or less) are detected by EDS in these samples, these metals are always associated with the Fe oxide/hydroxide phases. It is assumed that these metals likely coprecipitated with the Fe oxide/hydroxide phases. Trace concentrations of U were also sometimes detected in the Fe oxides/hydroxides. It is not known if the U coprecipitated within the crystal structure of the Fe oxide/hydroxides or occurs as discrete, submicrometer-sized particles intergrown with the Fe oxide/hydroxides. Duff et al. (2002) studied the coprecipitation of U(VI) with Fe-oxide minerals. They found persuasive evidence for the incorporation of U in the structure of hematite (α-Fe_2O_3). Hematite was identified by XRD in samples of unleached and leached C-103 residual waste (see Section 2.3), and was also identified in samples of unleached pre-retrieval AY-102 waste (Krupka et al. 2004) and oxalate-treated C-106 post retrieval waste (Deutsch et al. 2006, 2007a).

The unleached and leached C-103 residual waste samples also contain particles of Ag and/or Ag-Hg oxide phase. Because the concentrations of Hg in this phase appear variable and may be below detection level in some particles, it is not certain if there are one or two Ag-containing phases – one having no Hg and the other containing Hg. Examples of SEM micrographs of this type of particle are shown in micrograph B in Figure 3.6 and micrograph B in Figure 3.7.

Uranium is present in the unleached and leached C-103 samples as one or more discrete phases. One phase (shown in Figure 3.8) appears to be a U oxide (probably hydrated). Examples of the U oxide (or hydrate) identified in the leached and unleached C-103 residual waste samples are shown in Figure 3.8. Typically, the particles containing U were much smaller (~few micrometers or less in size) than those shown in Figure 3.8.

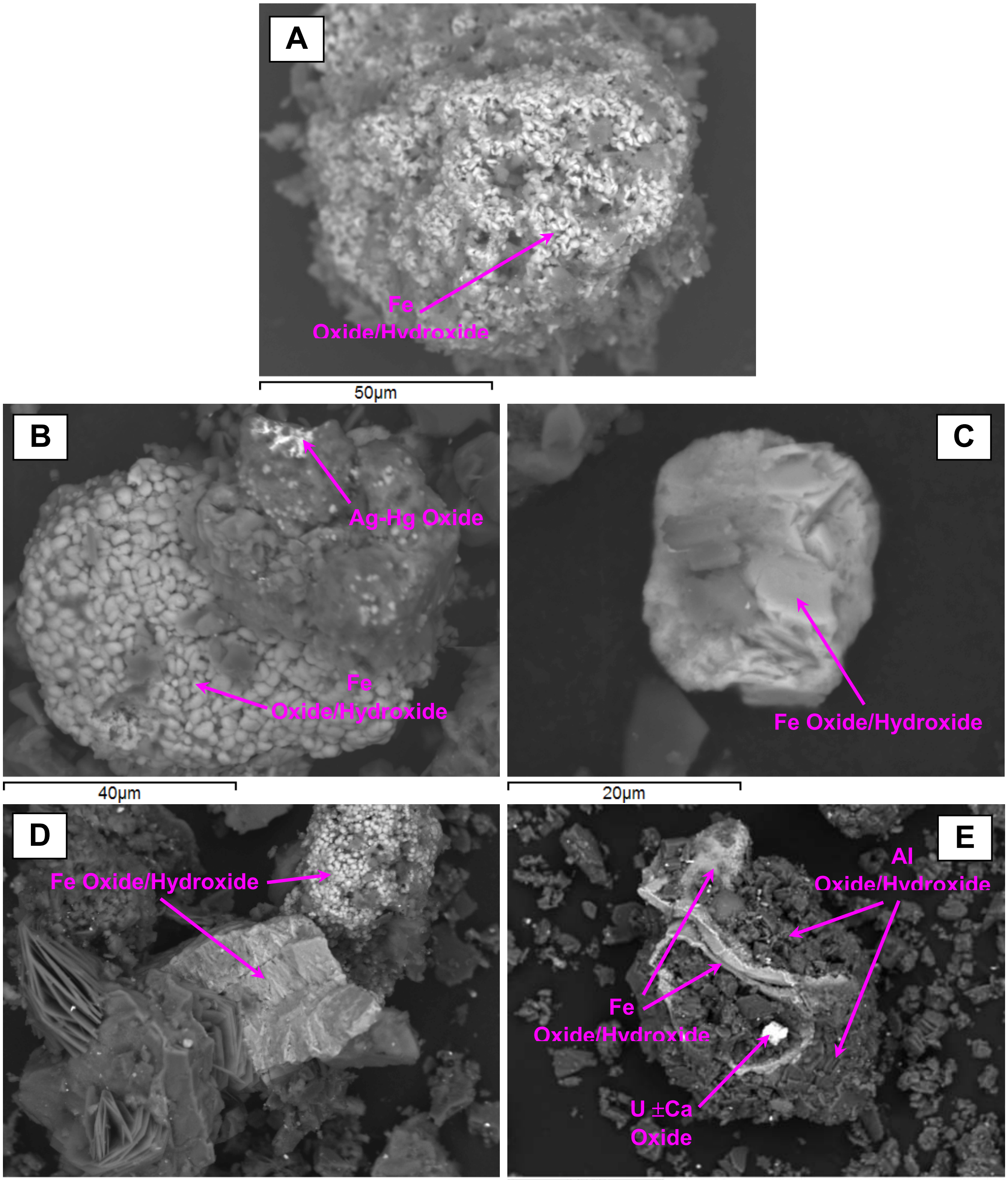

Figure 3.7. Backscattered Electron (BSE) SEM Micrographs of Fe Oxide/Hydroxide Solids Present in Unleached (A), DDI Water-Leached (B and C), $Ca(OH)_2$-Leached (D), and $CaCO_3$-Leached (E) C-103 Residual Waste [The majority of the gray solids seen in above micrographs (especially the dark gray, prismatic-tabular crystals in micrograph E) are particles of Al oxide/hydroxide solids.]

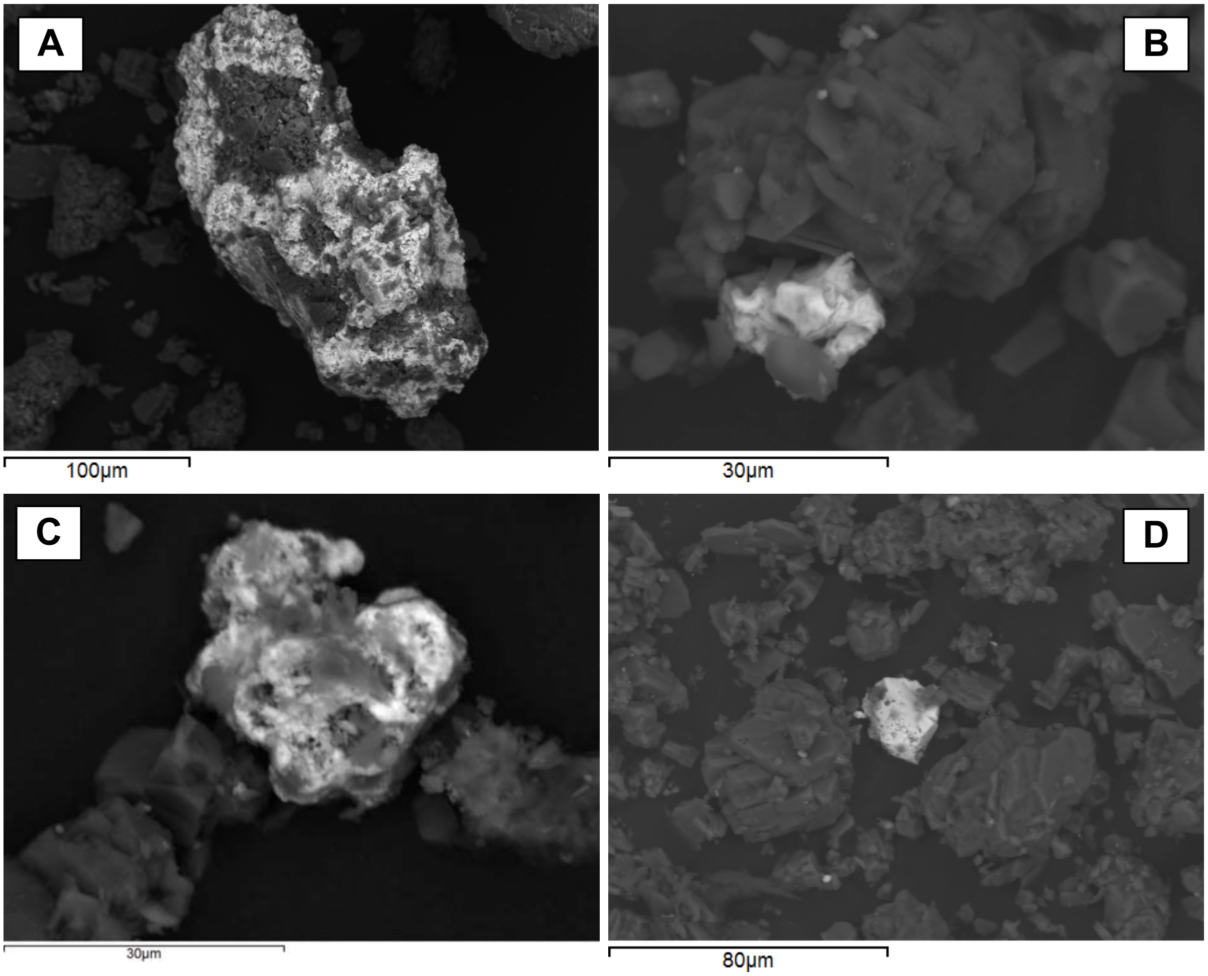

Figure 3.8. Backscattered Electron (BSE) SEM Micrographs of U Oxide (Probably Hydrated) Phase in Unleached (A), DDI Water-Leached (B), $Ca(OH)_2$-Leached (C), and $CaCO_3$-Leached (D) C-103 Residual Waste

Figure 3.9 shows a unique occurrence of U particles identified in $Ca(OH)_2$-leached samples. These particles are less than 1 micrometer in diameter and appear to be void of any crystal form. Micrograph B in Figure 3.9 shows at higher magnification the U particles in the area identified by the magenta outlined square in micrograph A. At higher magnification, these particles appear to be on the surface of the Al oxide/hydroxide solid, such as the particle located in the fracture of the Al oxide/hydroxide (see light blue dotted arrow in micrograph B), as opposed to being precipitated as a separate phase within the Al oxide/hydroxide solid. These particles show up in other areas of this solid aggregate, such as near the top of micrograph A in Figure 3.9 as indicated by the yellow dotted arrow. Due to their small size, the EDS analyses only confirm the presence of U in these particles but provide no addition information regarding their composition. Little is known about this phase as it was identified late in the study and there was no opportunity for further analyses. It is not known if this form of U phase is a fine-grained variety of the U oxide (hydrate) shown in Figure 3.8, or if it occurs in the unleached or other types of leached samples of C-103 residual waste.

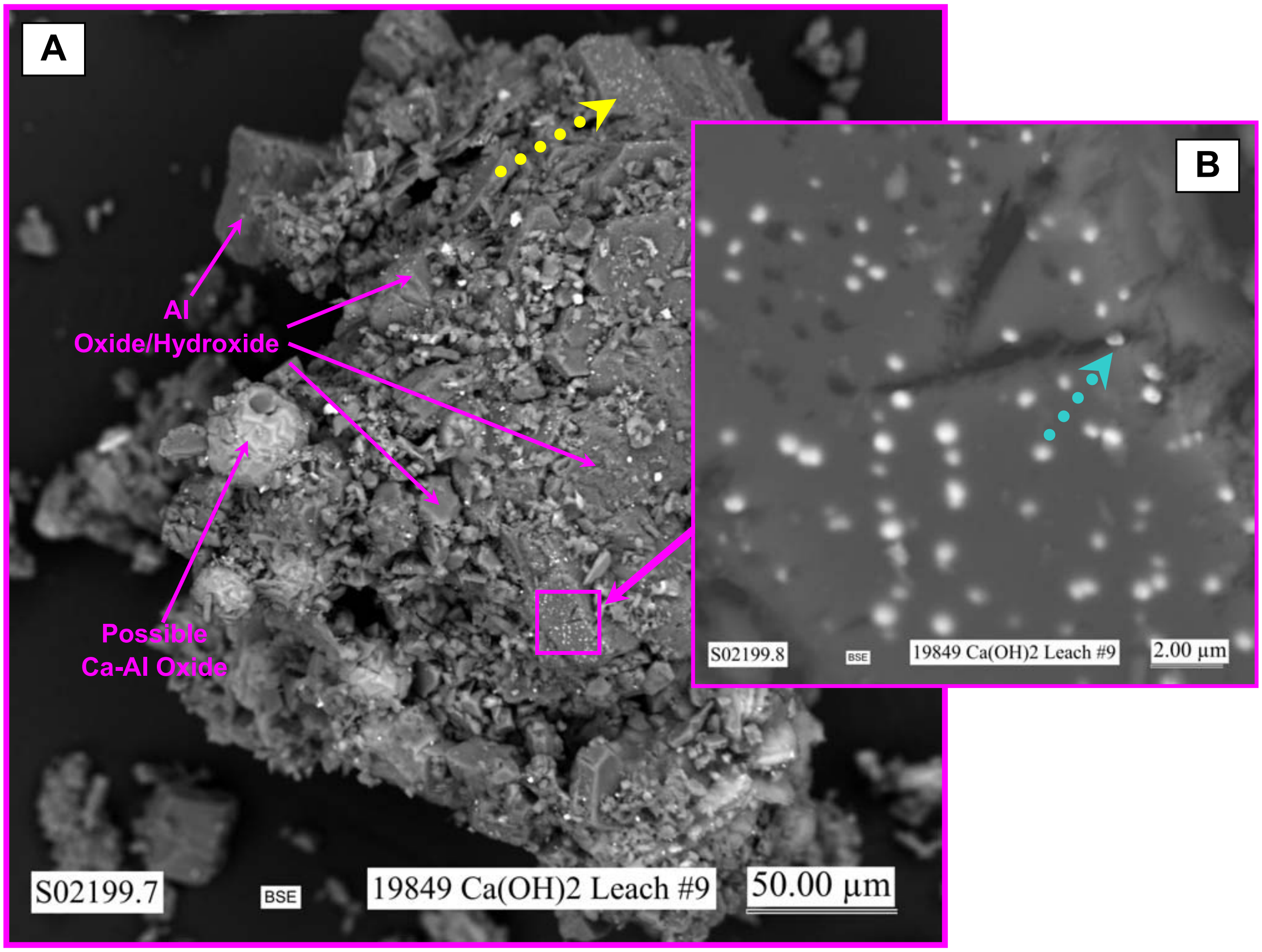

Figure 3.9. Backscattered Electron (BSE) SEM Micrographs Showing at Lower (A) and Higher (B) Magnification Unusual Occurrence of Fine Particles (less than 1 micrometer in diameter) of U-containing Phase [This occurrence of these U-containing fine particles is also shown at the top of micrograph A as indicated by the yellow dotted arrow.]

A third form of U-containing phase is shown in Figure 3.10. This phase was only identified in the unleached C-103 residual waste, and consists of Na, Ca, U, and O. The calculated composition for the dense area indicated by the yellow dotted arrow in the top micrograph in Figure 3.10is approximately 6.7 wt% Na, 5.3 wt% Ca, 39.8 wt% U, 47.6 wt% O, and less that 0.5 wt% Al. This agrees well with the ideal composition for andersonite [$Na_2Ca(UO_2)(CO_3)_3•6H_2O$] of 7.1 wt% Na, 6.2 wt% Ca, 37.0 wt% U, and 42.2 wt% O. This U phase appears to be intergrown with the Al oxide/hydroxide phase. This Na-Ca-U oxide was not identified by morphology or composition in any of the leached samples of C-103 residual waste.

Although not common, a Na-Ca-Al silicate phase was also identified in the leached C-103 samples. Examples of this phase are shown in the micrographs (see yellow arrows) in Figure 3.11. The form of this phase is comparable to poorly crystallized or eroded "balls of twine" (see micrograph D in Figure 3.11), which is similar to the crystal habit identified by others as being the mineral cancrinite

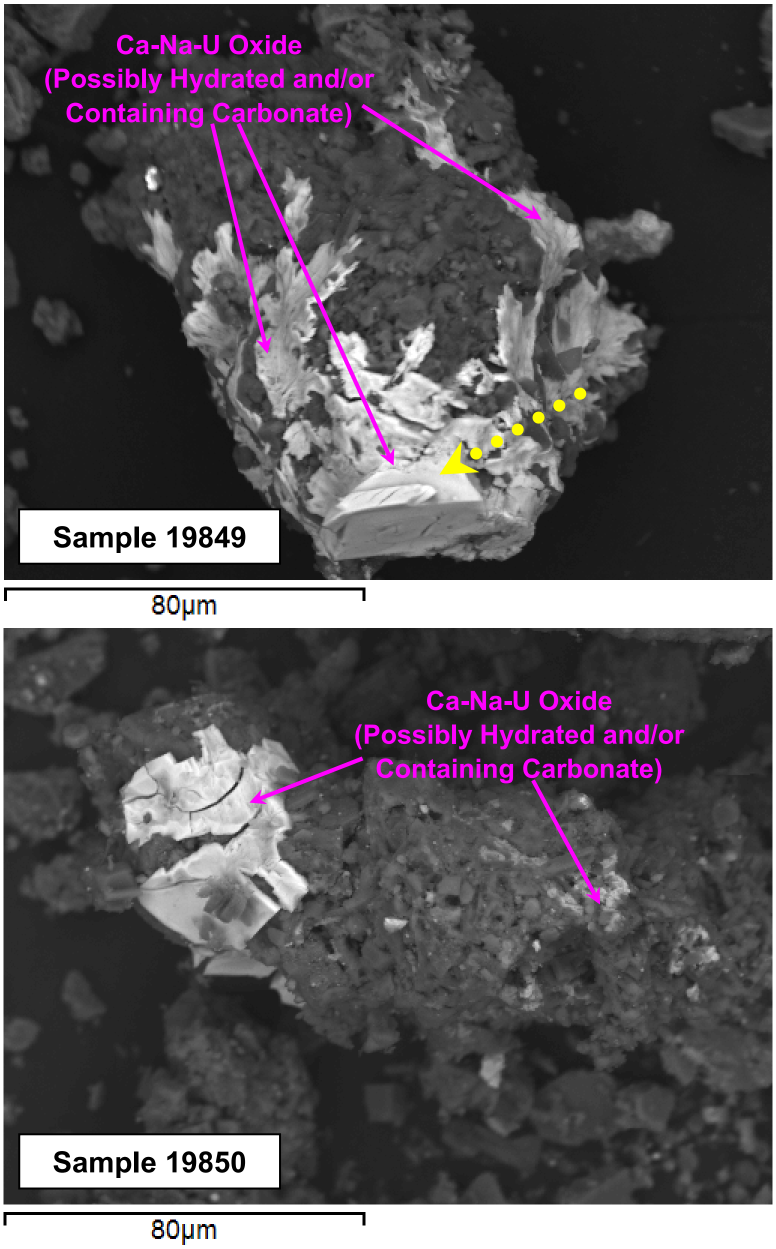

Figure 3.10. Backscattered Electron (BSE) SEM Micrographs Showing Na-Ca-U Oxide (possibly hydrated and/or containing CO_3) in Unleached Samples of C-103 Residual Waste

(Bickmore et al. 2001; Bredt et al. 2003; Buck and McNamara 2004). The NO_3-form of cancrinite [ideal formula $Na_6Ca_2Al_6Si_6O_{24}(NO_3)_2$] has been identified as a precipitate in Hanford tank sludge (Buck and McNamara 2004; Bredt et al. 2003) and in laboratory studies where simulated Hanford tank waste leachants are reacted with vadose zone sediments (Bickmore et al. 2001). Nitrogen however was not detected by EDS in the particles of this Na-Ca-Al silicate phase found in our C-103 residual waste samples. Although the Na-Ca-Al silicate phase was not observed in the sample mounts of unleached C-103 residual waste, it may also occur in the unleached waste.

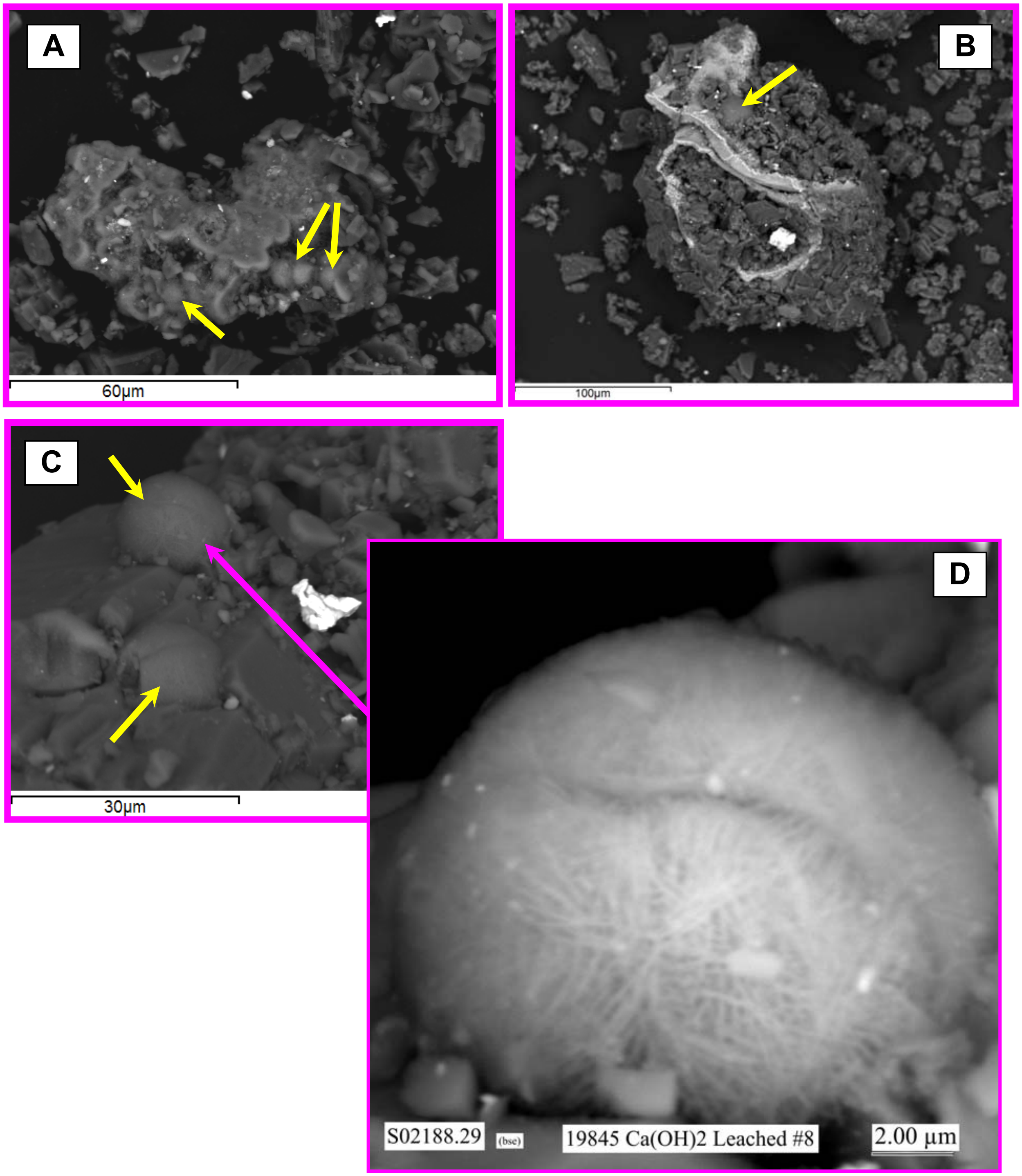

Figure 3.11. Backscattered Electron (BSE) SEM Micrographs Showing Na-Ca-Al Silicate Phase Identified DDI Water-Leached (A), $Ca(OH)_2$-Leached (B), and $CaCO_3$-Leached (C) C-103 Residual Waste [Micrograph D shows at higher magnification the Na-Ca-Al silicate particle indicated in micrograph C.]

A Ca-P-O phase (probably a phosphate) was also identified in the C-103 residual waste samples. The majority of the large white particle aggregate that takes up most of the center area of Figure 3.12 is thought to be this phase. The morphology of this phase (Figure 3.12) is generally nondescript. Although this phase was identified in the SEM samples of unleached and leached waste solids, these particles were generally not common and appeared to be less common in the $Ca(OH)_2$-leached samples. It is not known if this was due to the general rarity of this phase or to possible dissolution of this phase from contact with the $Ca(OH)_2$ leachant. This phase does not correspond to any of the phases identified by XRD.

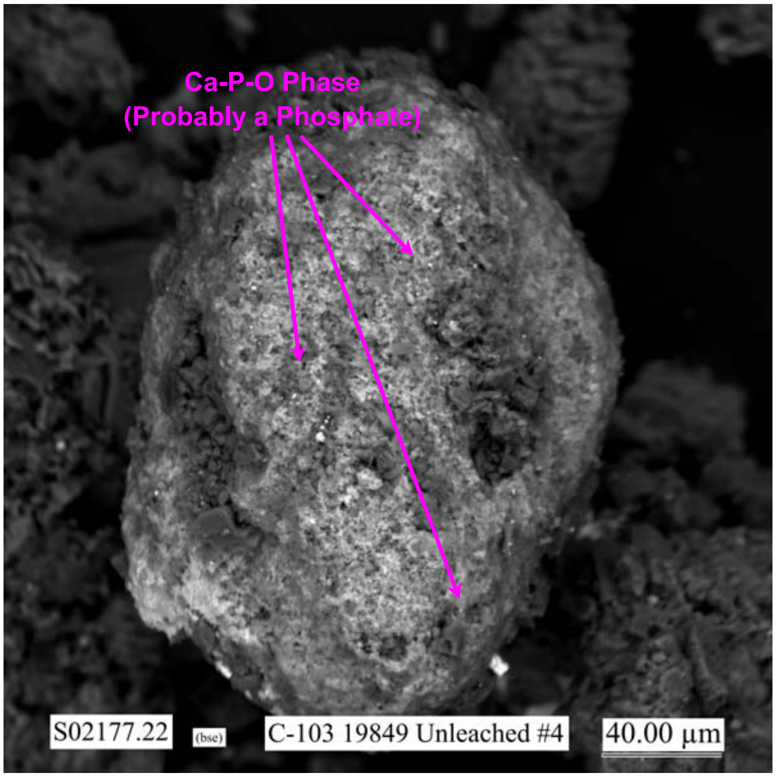

Figure 3.12. Backscattered Electron (BSE) SEM Micrographs Showing Ca-P-O Phase (probably phosphate) Identified in C-103 Residual Waste

The SEM/EDS analyses of the 1-month single-contact $Ca(OH)_2$-leached samples also identified three additional phases not observed in the unleached and other leached samples of C-103 residual waste. One phase contains Ca, O, and possibly C, and is therefore thought to be a Ca carbonate mineral. Examples of this Ca carbonate phase are shown in micrographs A and B in Figure 3.13. Another phase is a Ca-Al silicate (possibly hydrated and/or containing CO_3) (see micrographs C and D in Figure 3.13). This phase has a platy crystal habit, and usually occurs as clusters of intersecting individual crystals. A few particle clusters of a Ca-Al oxide (little or no Si) were also observed in $CaCO_3$-leached sample 19849 (see Ca-Al oxide phase indicated on the center left of Figure 3.9). Unlike the platy Ca-Al silicate phase, this phase in Figure 3.9 appears to form a spherical-like intergrowth of interlocking cubic crystals. The calculated composition from the EDS analysis of the Ca-Al oxide phase shown in Figure 3.9 is 15 at% Ca, 12 at% Al, and 72 at% O. This composition is very close to the Ca:Al:O atomic ratio for OH-only form of katoite [$Ca_3Al_2(OH)_{12}$]. This particle type is not apparent in any of the other micrographs of unleached or leached C-103 residual waste. However, if this phase more commonly forms spherical clusters and/or

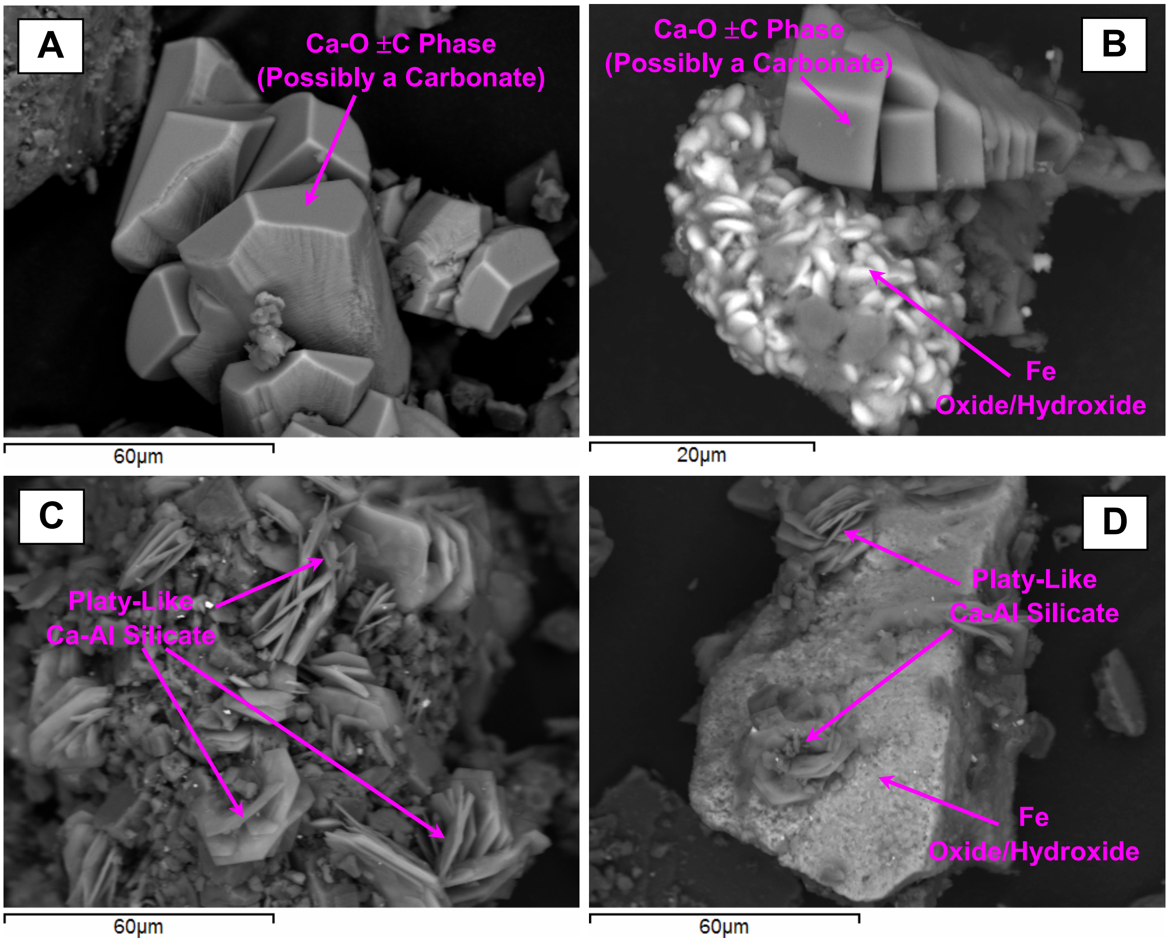

Figure 3.13. Backscattered Electron (BSE) SEM Micrographs Showing the Ca Carbonate (A and B) and Ca-Al Silicate (C and D) Phases Identified in the 1-Month Single-Contact $Ca(OH)_2$-Leached Samples of C-103 Residual Waste

individual crystals much smaller than those shown in Figure 3.9, they may be difficult to delineate within the particle aggregates in the SEM micrographs. Given the absence of these three phases in the unleached, DDI water-leached, and $CaCO_3$-leached samples, these phases are likely new reaction products that precipitated during the 1-month contact of the $Ca(OH)_2$ leachant with the C-103 residual waste solid.

3.8 Phases Containing Contaminants of Interest

Uranium was detected by EDS in three types of solid phases. Uranium was present as a U oxide (probably hydrated) in the unleached and leached C-103 residual waste samples, and also as a Na-Ca-U oxide (possibly as the CO_3-phase andersonite) in the unleached sample. Because the Na-Ca-U oxide or CO_3-phase was not present in the leached samples, it is not known if this is due to the rarity of this phase or to its dissolution during the 1-month leach tests. Trace concentrations of U (usually less than a couple weight percent) were also detected by EDS in some of the Fe oxide/hydroxide particles.

Technetium was identified by EDS in three Fe oxide/hydroxide particles. These Tc-containing particles (marked by arrows in the SEM micrographs in Figure 3.14) were found by SEM/EDS in samples of unleached, DDI water-leached, and $CaCO_3$-leached C-103 residual waste. The Tc concentrations in these particles ranged from 0.6 to 1.0 wt%. This is the first time in our project studies of pre-retrieval and post retrieval residual wastes from Hanford underground SSTs that there has been direct evidence for the presence of Tc in any phase in actual waste solids. Previously, the evidence of the Tc with Fe oxides present in the waste samples was indirect. Based on results from their selective extraction experiments, Deutsch et al. (2007c) concluded that the recalcitrant fraction of ^{99}Tc in the pre-retrieval C-203 and C-204 sludges was incorporated into an Fe oxyhydroxide solid phase. For their conceptual model for ^{99}Tc release from these sludges, they assumed that the ^{99}Tc would be released in proportion to the dissolution of the Fe solid. However, other studies of pertechnetate and perrhenate (as an analogue of pertechnetate) sorption and incorporation suggest that the recalcitrant pertechnetate in tank wastes could also be associated with Al oxyhydroxides (Wakoff and Nagy 2004; Zhang et al 2000). The EDS spectra for the three Tc-containing Fe oxide/hydroxide particles (Figure 3.14) indicate the presence of Al, which likely comes from emissions from the adjacent particles of Al oxide/hydroxide material. The highest Tc concentration (~1 wt%) was measured from an area of the large Fe oxide/hydroxide particle (see bottom micrograph and supporting EDS spectrum in Figure 3.14) that appears to be a single homogeneous phase. Therefore, of the three particles, its EDS analysis should be the least affected by emissions from other phases. The Al concentration for this particle shown in the bottom micrograph in Figure 3.14 is 4.8 wt%. This suggests that the Fe oxide/hydroxide phase, and not the Al oxide/hydroxide solids, is the host for the measured Tc. Possibly more importantly, Tc was never identified in any of the numerous Al oxide/ hydroxide particles analyzed by EDS in any of the unleached or unleached C-103 residual waste samples. These C-103 samples consist primarily (~>90%) of Al oxide/hydroxide solids. Therefore, if Tc is concentrated in the Al oxide/hydroxide phase, at least a few Al oxide/hydroxide particles containing Tc should have been discovered given the large number of Al oxide/hydroxide particles that were examined in our study by EDS.

When detected by EDS, Cr was always associated with the Fe oxide/hydroxide phases. The concentrations of Cr ranged typically from ~0.1 to ~3 wt% when detected in these Fe-containing particles.

Iodine was not detected by EDS in any of the analyzed samples of unleached or leached C-103 residual waste samples. Given the presence of Ag and/or Ag-Hg oxide phases in these solids and the low solubility of AgI compounds, the Ag and/or Ag-Hg oxide phases are strong candidates for potentially sequestering trace quantities of any I that remains in the C-103 residual waste. Unfortunately, none of the SEM/EDS results support this hypothesis.

3.9 Comparison of XRD and SEM/EDS Results

Table 3.82 provides a comparison of the XRD results to those from the SEM/EDS analysis. The XRD results indicate that all of the unleached and leached C-103 samples contain predominately (probably more than ~90% or more) gibbsite [$Al(OH)_3$], which is consistent with what was observed by SEM analysis. The XRD analyses also identified the presence of hematite which likely corresponds to one of two possible Fe oxide/hydroxide phases detected in the unleached and leached C-103 waste samples by SEM/EDS.

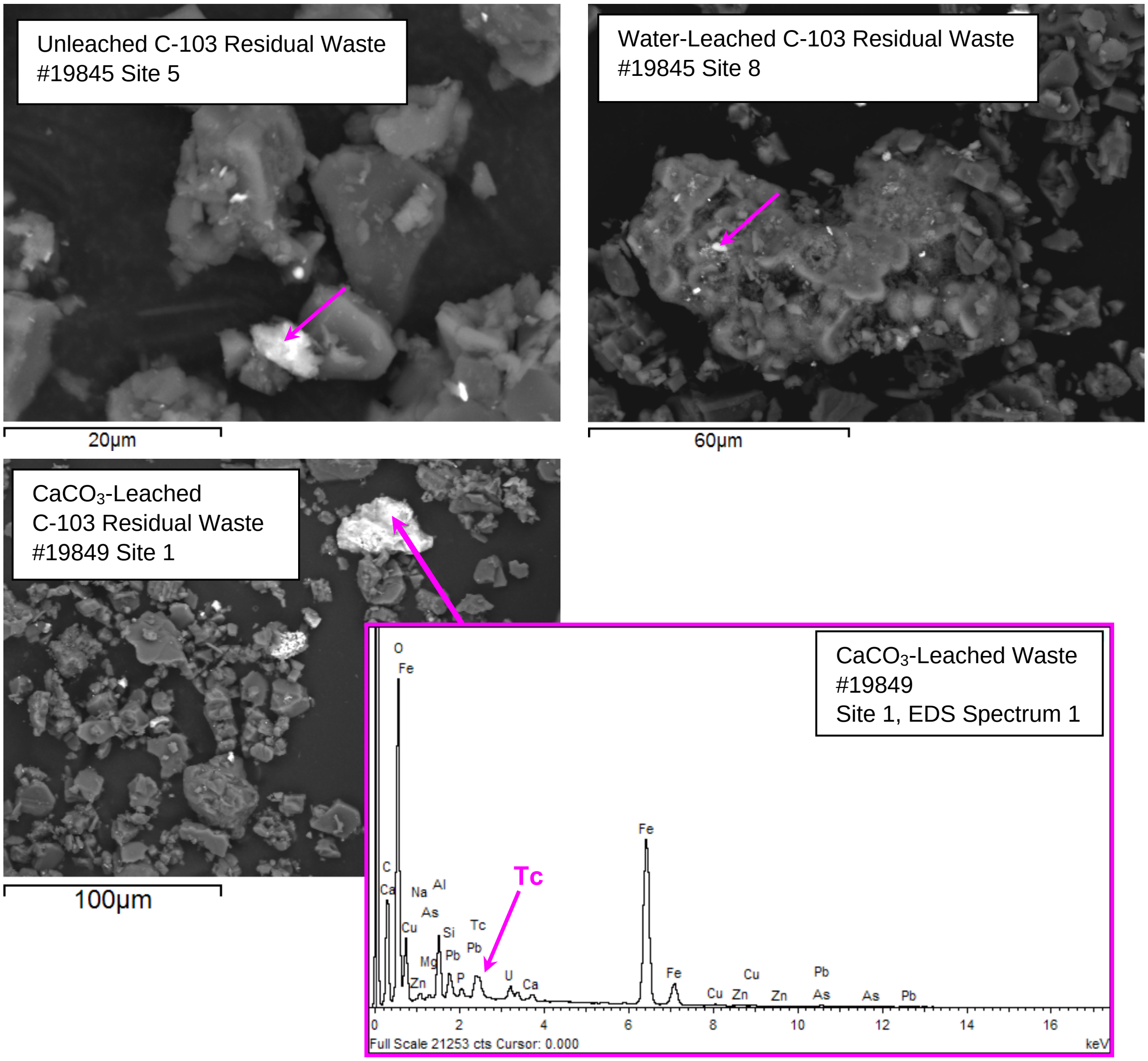

Figure 3.14. Backscattered Electron (BSE) SEM Micrographs for the Three Fe-Oxide/Hydroxide Particles that were Identified by EDS as Containing Tc and an EDS Spectrum Measured for the Particle Having the Highest Concentration of Tc [Magenta arrows identify location of Fe oxide/hydroxide particles that contain Tc.]

The XRD patterns for the $Ca(OH)_2$-leached samples contain additional XRD reflections that are not present in the unleached, DDI water-leached, and $CaCO_3$-leached samples. These remaining reflections are consistent with the major reflections in the database patterns (Table 3.81) for cancrinite, calcite, silica-free katoite, calcium aluminum oxide carbonate hydrate, and rabejacite. Identification of cancrinite by XRD is consistent with its identification by crystal form and elemental composition by SEM/EDS analysis of the $Ca(OH)_2$-leached samples as well as DDI water-leached and $CaCO_3$-leached samples. XRD analysis also detected the presence of a small quantity of calcite in the 1-month single-contact $Ca(OH)_2$-leached samples. This result agrees with the presence of a small quantity of a Ca carbonate phase determined by SEM/EDS results.

The PDF database pattern for katoite (also known as hydrogrossularite or hydrogrossular), which is a possible match for the XRD patterns for $Ca(OH)_2$-leached C-103 waste solids, is for a silica-free composition of this mineral. The calculated composition from the EDS analysis of the Ca-Al oxide phase shown in Figure 3.9 is 15 at% Ca, 12 at%, Al, and 72 at% O. This composition is very close to the Ca:Al:O atomic ratio for silica-free form of katoite [$Ca_3Al_2(OH)_{12}$], which was identified by XRD. References, such as Fleischer and Mandarino (1995), list katoite as a member of the garnet mineral group with structural SiO_4 being partly replaced by $(OH)_4$. Katoite is in the isometric (cubic) crystal system and has an ideal formula of $Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$ where x varies between 1.5 and 3. The tricalcium aluminate hexahydrate end-member of this composition series is a well-known product of hydration in Portland cement (Hewlett 1998). Such a chemical environment should be similar to the conditions during the 1-month single-contact of the high pH, $Ca(OH)_2$-saturated leachant with the high Al (i.e., gibbsite) C-103 residual waste solid. A few particle clusters of a Ca-Al oxide ±H±C phase were identified by SEM/EDS analyses in one sample of $Ca(OH)_2$-leached waste solids. This phase occurs as a spherical intergrowth of interlocking individual crystallites that appear to be cubic in crystal form. Given the composition and the cubic-like form of these crystallites, this Ca-Al oxide ±H±C phase might correspond to the silica-free katoite identified by XRD. A platey Ca-Al silicate phase (see micrographs C and D in Figure 3.13 was also determined by SEM/EDS in the $Ca(OH)_2$-leached samples, but this platey crystal form is inconsistent with katoite which has an isometric (cubic) crystal form.

Calcium aluminum oxide carbonate hydrate was also identified as a possible match for the XRD patterns for the $Ca(OH)_2$-leached samples. Because EDS cannot detect H and identification of C is tenuous as it was used to coat the SEM mounts, it is not possible to ascertain if any of the Ca-Al oxide ±H±C phase identified by SEM/EDS corresponds to calcium aluminum oxide carbonate hydrate. We also have no information regarding the chemical conditions required for the formation of calcium aluminum oxide carbonate hydrate or know if this phase is related to the formation of silica-free katoite [$Ca_2Al_2(OH)_{12}$].

Identification by XRD of the possible presence of rabejacite is not consistent with the SEM/EDS results. The SEM/EDS analyses indicate that one or two U phases are present in the unleached and leached C-103 waste solids, but the EDS data are not consistent with the possible presence of the SO_4-phase rabejacite. The EDS results suggest that Ca might sometimes be present with some particles of the U phases, but S was never detected at greater than a few tenths of a weight percent in any of the U phases.

3.10 Comparison of Solid-Phase Characterization Results to Those for Other Residual Waste Samples

Table 3.83 shows a comparison between the solid phases identified in this study by XRD and SED/EDS in unleached and leached samples of C-103 residual waste versus those identified in unleached and leached samples of C-106 post retrieval residual waste. The solid-phase characterization data for the C-106 residual waste is described in Deutsch et al. (2006, 2007a). Some fundamental differences in the chemistry of these two residual wastes due to methods used for final sludge removal should be noted. Final sludge recovery from tank C-106 included the use of a 0.9 M oxalic acid solution to dissolve and suspend the solids and assist sludge removal during pumping. Final waste retrieval from tank C-103 however involved using the supernatant from DST AN-106 as the sluicing fluid to mobilize the solids from tank C-103.

Table 3.83. Comparison between the Solid Phases Identified in this Study by XRD and SED/EDS in Unleached and Leached Samples of C-103 Residual Waste versus Those Identified in Unleached and Leached Samples of C-106 Residual Waste

Unleached and Leached C-103 Residual Waste (This Study)		**Unleached and Leached C-106 Sludge Treated by Oxalic Acid During Retrieval (from Deutsch et al. 2006, 2007a)**	
XRD Analyses	**SEM/EDS Analyses (Phases may also contain ±H and/or ±C)**	**XRD Analyses**	**SEM/EDS Analyses (Phases may also contain ±H and/or ±C)**
			Mn-Al-Fe-Na-P-Si-Ca-O (*1,2*)
Gibbsite [$Al(OH)_3$] (*1,2,3,4*)	Al-O (*1,2,3,4*)	Gibbsite (*1,2,3,4*)	Al-O (*1,2,3,4*)
		Böhmite [$AlO(OH)$] (*1,2,3*)	
		Dawsonite [$NaAl(CO_3)(OH)_2$] (*1,2,4*)	Al-Na-O (*1,2*)
Hematite (α-Fe_2O_3) (*2,3,4*)	Possibly 1 or 2 phases with Fe-O ±Cr ±Tc ±Ni ±Pb ±Mn ±U (*1,2,3,4*)	Hematite (*1,2*)	Fe-Cr-O (*1,2*) Fe-Mn-O (*1,2*)
	Possibly 1 or 2 phases with Ag ± Hg-O (*1,2,3,4*)	Possible Ag-Hg phase (*1,2*)	Possibly 1 or 2 phases with Ag-Hg±Fe±Pb±Cu±O±H (*1,2,3,4*)
	U – O (*1,2,3,4*)		
	Na-Ca-U-O [probably andersonite, $Na_2Ca(UO_2)(CO_3)_3 \bullet 6H_2O$] (*1*)		
Cancrinite (*3*)	Na-Ca-Al-Si-O (probably silicate cancrinite) (*1,2,3,4*)		
	Ca-P-O (probably phosphate) (*1,2,4*)		
Calcite ($CaCO_3$) (*3*)	Ca-O (*3*)	Calcite (*3,4*)	Ca-O (*1,2,3,4*)
		Whewellite ($CaC_2O_4 \cdot H_2O$) (*1,2,3,4*)	
	Ca-Al-Si-O (platy phase) (*3*)		Ca-Al-Si-O (*1,2*)
	Si-Al-Mg-Na-Fe-O (*1,2*)		
	Na-S-O (*2*)		
	Zr-O (*1,4*)		
	Th-O (*4*)		
	Fe-Pb-O (*2*)		

Table 3.83. (contd)

Unleached and Leached C-103 Residual Waste (This Study)		**Unleached and Leached C-106 Sludge Treated by Oxalic Acid During Retrieval (from Deutsch et al. 2006, 2007a)**	
XRD Analyses	**SEM/EDS Analyses (Phases may also contain ±H and/or ±C)**	**XRD Analyses**	**SEM/EDS Analyses (Phases may also contain ±H and/or ±C)**
Katoite (or hydrogrosslarite) $Ca_3Al_2(OH)_{12}$ (*3*)	Ca-Al-O (*3*)		Ca-Al-O (*3*,*4*)
Calcium aluminum oxide carbonate hydrate $Ca_4Al_2O_6CO_3 \cdot 11H_2O$ (*3*)			
Rabejacite $Ca(UO_2)_4(SO_4)_2(OH)_6 \cdot 6H_2O$ (*3*)			
			Ca-Mn-Al-Si-Fe-±Pb±REE(Ce) ±Cr -P-O (*3*,*4*)
			Si-Al-Na-O (*1*,*2*)
			REE-rich oxide (*1*,*2*)
			Pb-containing phase (*1*,*2*)
		Rhodochrosite ($MnCO_3$) (*1*,*2*)	Mn-O (possibly two different phases based on morphology) (*1*,*2*)
		Lindbergite ($MnC_2O_4 \cdot 2H_2O$) (*1*,*2*)	
			Mn-O-P±Al (*1*,*2*)
			Mn-Na-P-O (*3*)

1 = Identified in Unleached Samples by Indicated Method.
2 = Identified in Water leached Samples by Indicated Method.
3 = Identified in $Ca(OH)_2$-Leached Samples by Indicated Method.
4 = Identified in $CaCO_3$-Leached Samples by Indicated Method.

There are some major similarities in the phases identified in the C-103 and C-106 residual waste samples. These include the presence of gibbsite, hematite, and Ag-Hg oxide in the unleached and leach samples, and the presence of calcite in $Ca(OH)_2$-leached samples. Calcite was also identified in the $CaCO_3$-leached C-106 residual waste solids.

Compared to the C-103 waste samples, the C-106 contained considerably more Mn, including the presence of distinct Mn-containing phases such as rhodochrosite ($MnCO_3$), and also oxalate-containing phases such as whewellite ($CaC_2O_4 \cdot H_2O$) and lindbergite ($MnC_2O_4 \cdot 2H_2O$). These Mn- and oxalate-containing phases were absent from the unleached and leached C-103 residual waste samples.

Unlike the C-103 residual waste samples, no U- or Tc-containing phases were identified in any of the samples of C-106 residual waste. When detected by EDS, Cr was always associated with the Fe oxide/

hydroxide phase(s) (probably hematite) in both the C-103 and C-106 residual waste samples. No I-containing phase was identified in the C-103 or C-106 residual waste samples.

Deutsch et al. (2007b) present the results of contaminant release and solid-phase characterization studies of unleached, DDI water-leached, $Ca(OH)_2$-leached, and $CaCO_3$-leached post-retrieval residual waste from Hanford Tanks 241-C-202 (C-202) and 241-C-203 (C-203). The XRD and SEM analyses of these samples indicate that they contain mostly amorphous solids and no significant quantities of any crystalline phases. The C-202 and C-203 residual wastes consist of individual particles and aggregates generally having one of two common compositions. One composition consists of U, Na, O, P, and possibly H and/or C. The other composition is an Fe oxide/hydroxide phase that often contains trace quantities of Mn, Cr, and sometimes Pb. Except for the presence of the Fe oxide/hydroxide phase and the possible coprecipitation of Cr with this phase, there are no other similarities between the phases identified by XRD and SEM/EDS in the C-103 residual waste samples and those in the C-202 and C-203 residual waste samples described in Deutsch et al. (2007b).

4.0 Geochemical Modeling

The compositions of leachates from the single-contact and periodic replenishment extraction tests were used to calculate mineral saturation indices (SIs) to identify solid phases in equilibrium with the leachate compositions. The saturation index is defined as SI = log (Q/K_{sp}), were Q is the activity product and K_{sp} is the mineral solubility product at equilibrium. Minerals with SI values near zero (within ±0.5) are generally considered to be near equilibrium with the solution composition, more positive values are considered oversaturated and more negative values are considered undersaturated.

Appendix F contains the solution composition data used for the calculations. The React module of Geochemist's Workbench® (GWB) version 6.02 (Bethke 2006) was used to calculate the mineral SIs for these solutions. The thermodynamic database thermo.com.V8.R6+.dat was used with modifications that include solubility data for čejkaite [$Na_4(UO_2)(CO_3)_3$] (Felmy et al. 2005), becquerelite [$Ca(UO_2)_6O_4(OH)_6{\bullet}8H_2O$] (Rai et al. 2002), sodium diuranate hydrate [$Na_2U_2O_7{\bullet}xH_2O$] (Yamamura et al. 1998), andersonite [$Na_2Ca(UO_2)(CO_3)_3{\bullet}5H_2O$] and urancalcarite [$Ca(UO_2)_3(CO_3)(OH)_6{\bullet}3H_2O$ (Chen et al. 1999), an estimated value for Ca-autunite [$Ca(UO_2)_2(PO_4)_2$] (Langmuir 1978), and the stability constant for the dissolved species $Ca_2UO_2(CO_3)_3(aq)$ (Kalmykov and Choppin 2000).

Calculated saturation indices for the 1-month single-contact and periodic replenishment extraction tests for phases considered to be important or potentially important with respect to contaminant release for sample 19845 are presented in Table 4.1 through Table 4.3. The modeling results for DDI, $Ca(OH)_2$, and $CaCO_3$ extracts are shown in Table 4.1, Table 4.2, and Table 4.3, respectively. Comparison of the saturation indices calculated for the primary and duplicate extractions are generally in close agreement for the three leachants. For the phases presented in Table 4.1 through Table 4.3, the saturation indices are highest in the 1-month single contacts. These results suggest that equilibrium requires longer contact periods than occurs during stages 1 through 5 of the periodic replenishment extractions (1 to 3 days). The stage 6 (30-day contact time) periodic replenishment extractions are close to those of the 1-month single-contact extractions and may have reached equilibrium.

Saturation indices for significant phases calculated for the DDI 1-month single-contact extracts for all three samples are presented in Table 4.4. Analogous results for the $Ca(OH)_2$ saturated extracts and the $CaCO_3$ saturated extracts are shown in Table 4.5 and Table 4.6, respectively. Because the saturation indices for many of significant phases appear to be closest to equilibrium in the 1-month single-contacts extractions, most of the following discussion will focus on these results.

Saturation index results for the DDI 1-month single-contact and periodic replenishment extraction tests presented in Table 4.4 indicate that schoepite ($UO_3{\bullet}2H_2O$) may be near equilibrium in the 1-month single-contact extractions. This suggests that this phase may be present in the C-103 residual waste and may be an important phase with respect to release of U from C-103 residual waste. Due to the low U concentrations in these samples (0.3 to 0.4%, Table 3.11), no U phases were positively identified by XRD. SEM/EDS analysis indicated that the most common U phase in these samples had a composition which was consistent with schoepite (Table 4.4). In the 1-month single-contact $Ca(OH)_2$ extractions, the concentrations of ^{238}U released were much lower than that of the DDI water extracts (below the EQL). This suggests that release of ^{238}U from C-103 residual waste will be controlled by another phase with a much lower solubility than schoepite, if the residual waste is in contact with fresh cement. The

Table 4.1. Calculated Saturation Indices for Significant Phases in Tank C-103 Determined from Primary and Duplicate Water Extractions

DDI Water Extracts (Sample 19845)							
Phase	**1 Month**	**Stage 1 (1 day)**	**Stage 2 (1 day)**	**Stage 3 (3 days)**	**Stage 4 (1 day)**	**Stage 5 (1 day)**	**Stage 6 (30 days)**
schoepite $UO_3{\bullet}2H_2O$	–0.51 –0.53	–0.80 –0.66	<EQL –1.30	–1.56 –1.43	–2.04 –1.96	–2.23 –1.47	–0.82 –0.82
plattnerite PbO	0.05 0.05	1.51 –2.11	<EQL <EQL	<EQL <EQL	<DL <DL	<DL <DL	<EQL <–3
cerussite $PbCO_3$	0.16 0.14	0.32 <–3	<EQL <EQL	<EQL <EQL	<DL <DL	<DL <DL	<EQL <–3
hydrocerussite $Pb_3(CO_3)_2(OH)_2$	0.11 0.09	1.91 <–3	<EQL <EQL	<EQL <EQL	<DL <DL	<DL <DL	<EQL <–3
ferrihydrite $Fe(OH)_3$	0.94 0.90	0.89 0.33	<DL <DL	<DL <DL	<DL <DL	<DL <DL	<EQL 0.06
hematite Fe_2O_3	13.1 13.0	13.0 11.9	7.80 7.64	9.59 7.59	7.29 5.33	7.21 6.89	10.7 11.3
Böhmite AlO(OH)	3.69 3.63	2.07 3.15	1.87 2.97	2.93 2.90	1.38 1.45	1.33 2.63	3.46 3.51
gibbsite $Al(OH)_3$	3.49 3.43	1.88 2.96	1.68 2.77	2.74 2.71	1.19 1.25	1.14 2.44	3.27 3.32
dawsonite $NaAlCO_3(OH)_2$	0.60 0.56	–1.71 –0.74	–2.25 –0.88	–0.95 –1.20	<–3 <–3	<–3 –2.27	–0.03 0.10
calcite $CaCO_3$	–2.50 –2.45	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3

EQL = Estimated quantitation limit.
DL = Detection limit.

geochemical modeling did not indicate that any of the U phases in the thermodynamic database were near equilibrium for the 1-month single-contact $Ca(OH)_2$ extractions. In the 1-month single-contact $CaCO_3$ extractions, the concentrations of ^{238}U released are again in equilibrium with schoepite. This suggests that release concentrations of ^{238}U from C-103 residual waste are likely to be much higher for residual waste in contact with aged cement relative to fresh cement. Schoepite was the only phase identified by geochemical modeling to have the potential to exert solubility control for any of the primary contaminants of concern (i.e., ^{238}U). No potential solubility controls were predicted by geochemical modeling for the other contaminants of concern, such as Cr, ^{99}Tc, and ^{129}I. However, the SEM/EDS results did indicate that Cr and ^{99}Tc are coprecipitated in an Fe oxide/hydroxide phase (possibly hematite). Unfortunately, thermodynamic data does not exist for solid-solution models (or dissolution rates) for Cr- or ^{99}Tc-substituted hematite [or other relevant Fe(III) oxides/hydroxides] that would be necessary to model solubility limits for such coprecipitated phases.

Geochemical modeling also indicated that Pb is near equilibrium with several phases in the DDI 1-month single contacts (Table 4.4). Plattnerite (PbO), cerussite ($PbCO_3$), and hydrocerussite [$Pb_3(CO_3)(OH)_2$] are all near equilibrium in the 1-month single-contact DDI extractions. These results suggest that Pb may occur as one or more of these phases in the C-103 residual waste. However, very

Table 4.2. Calculated Saturation Indices for Significant Phases in Tank C-103 Determined from Primary and Duplicate $Ca(OH)_2$ Extractions

$Ca(OH)_2$ Extractions (Sample 19845)							
Phase	**1 Month**	**Stage 1 (1 day)**	**Stage 2 (1 day)**	**Stage 3 (3 days)**	**Stage 4 (1 day)**	**Stage 5 (1 day)**	**Stage 6 (30 days)**
schoepite $UO_3 \cdot 2H_2O$	<EQL <EQL	<EQL <EQL	<EQL <EQL	<EQL <EQL	<EQL <EQL	<EQL <EQL	<EQL <EQL
plattnerite PbO	2.14 1.92	1.48 1.54	1.33 1.44	1.24 1.36	1.01 1.07	0.86 0.86	1.79 2.14
cerussite $PbCO_3$	–0.98 –1.26	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	–0.88 –0.77
hydrocerussite $Pb_3(CO_3)_2(OH)_2$	–0.08 –0.85	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	–0.22 0.35
ferrihydrite $Fe(OH)_3$	–2.21 –2.31	–2.71 –2.82	–2.97 –2.92	<–3 <–3	<–3 <–3	<–3 <–3	–1.88 –2.02
hematite Fe_2O_3	6.78 6.58	5.78 5.57	5.26 5.36	5.14 5.13	5.01 4.96	5.09 4.77	7.44 7.17
Böhmite AlO(OH)	–0.30 –1.12	–1.56 –1.59	–1.74 –1.79	–1.67 –1.72	–1.85 –1.87	–1.86 –1.95	–0.37 –0.26
gibbsite $Al(OH)_3$	–0.49 –1.31	–1.75 –1.79	–1.94 –1.98	–1.86 –1.91	–2.04 –2.06	–2.05 –2.14	–0.56 –0.45
dawsonite $NaAlCO_3(OH)_2$	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3	<–3 <–3
calcite $CaCO_3$	3.27 3.38	3.31 3.37	3.31 3.40	3.38 3.37	3.41 3.41	3.41 3.41	3.31 3.27

EQL = Estimated quantitation limit.

low concentrations of Pb occurred in stages 2 through 6 of the DDI periodic replenishment extractions (Table 4.4), suggesting that any solubility control of Pb by these phases would be of short duration and that another mechanism may control Pb release from C-103 over the long term (possibly desorption or dissolution of a host phase). For the $Ca(OH)_2$ 1-month single contacts, the saturation index calculations indicate that the extracts are generally highly undersaturated with respect to cerussite and hydrocerussite and highly oversaturated with respect to plattnerite. These results indicate that if cerussite and/or hydrocerussite occur in C-103 residual waste, they would dissolve after contact with fresh cement. Because the extracts are highly oversaturated with respect to plattnerite, these results suggest that this phase does not precipitate in the presence of fresh cement. For the $CaCO_3$ 1-month single contacts, the saturation index calculations indicate that these extracts are generally highly undersaturated with respect to plattnerite and hydrocerussite and near equilibrium with respect to cerussite. This suggests that cerussite could potentially control Pb release concentrations from C-103 residual waste in contact with aged cement.

Potentially important Fe and Al phases were included in the saturation index results shown in Table 4.4 through Table 4.6. Although these two metals are not contaminants, they are major components of the C-103 residual waste (Table 3.6) and could potentially influence release of contaminants of concern that were either adsorbed or coprecipitated within these phases.

Table 4.3. Calculated Saturation Indices for Significant Phases in Tank C-103 Determined from Primary and Duplicate $CaCO_3$ Extractions

$CaCO_3$ Extractions (Sample 19845)							
Phase	**1 Month**	**Stage 1 (1 day)**	**Stage 2 (1 day)**	**Stage 3 (3 days)**	**Stage 4 (1 day)**	**Stage 5 (1 day)**	**Stage 6 (30 days)**
schoepite	–0.50	–0.71	NA	–0.86	–0.72	–0.78	–0.72
$UO_3 \bullet 2H_2O$	–0.49	–0.60	–0.88	–0.76	–0.63	–0.63	–0.66
plattnerite	–1.11	0.21	NA	<–3	<–3	<–3	–1.96
PbO	–0.86	–2.85	<–3	<–3	<–3	<–3	–2.74
cerussite	–0.29	–0.43	NA	<–3	–2.83	–2.85	–1.22
$PbCO_3$	–0.17	–2.29	<–3	<–2.55	–2.76	–2.93	–1.52
hydrocerussite	–1.94	–0.90	NA	<–3	<–3	<–3	<–3
$Pb_3(CO_3)_2(OH)_2$	–1.45	<–3	<–3	<–3	<–3	<–3	<–3
ferrihydrite	0.76	0.34	NA	–0.86	–0.98	–0.95	–0.22
$Fe(OH)_3$	0.70	–0.67	–1.00	–0.87	–1.07	–1.02	–0.72
hematite	12.7	11.9	NA	9.49	9.24	9.29	10.8
Fe_2O_3	12.6	9.87	9.20	9.46	9.06	9.17	9.77
Böhmite	3.50	1.89	NA	3.00	3.09	3.17	3.38
$AlO(OH)$	3.57	2.93	2.88	3.12	3.13	3.17	3.14
gibbsite	3.31	1.70	NA	2.81	2.90	2.97	3.19
$Al(OH)_3$	3.38	2.74	2.69	2.93	2.94	2.98	2.94
dawsonite	0.36	–1.42	NA	–0.89	–1.38	–1.44	–0.32
$NaAlCO_3(OH)_2$	0.50	–0.43	–1.08	–0.84	–1.28	–1.47	–0.56
calcite	–2.80	–0.56	NA	–2.85	–2.74	–2.25	–2.09
$CaCO_3$	–2.80	–2.96	<–3	–2.57	–2.31	–2.31	–2.52
NA = Not analyzed.							

Table 4.4. Calculated Saturation Indices for Significant Phases in Tank C-103 DDI Water Extractions (1-Month Single-Contact)

1-Month DDI Water Extracts						
Phase	**19845**	**19845 dup**	**19849**	**19849 dup**	**19850**	**19850 dup**
schoepite $UO_3 \bullet 2H_2O$	–0.51	–0.53	–0.45	–0.49	–0.45	–0.46
plattnerite PbO	0.05	0.05	–0.27	0.04	0.51	0.23
cerussite $PbCO_3$	0.16	0.14	0.04	0.16	0.66	0.53
hydrocerussite $Pb_3(CO_3)_2(OH)_2$	0.11	0.09	–0.44	0.11	1.59	1.05
ferrihydrite $Fe(OH)_3$	0.94	0.90	0.86	1.01	1.54	1.38
hematite Fe_2O_3	13.1	13.0	12.9	13.2	14.3	14.0
Böhmite $AlO(OH)$	3.69	3.63	3.64	3.69	3.72	3.69
gibbsite $Al(OH)_3$	3.49	3.43	3.45	3.50	3.52	3.50
dawsonite $NaAlCO_3(OH)_2$	0.60	0.56	0.59	0.57	0.55	0.70
calcite $CaCO_3$	–2.50	–2.45	–2.73	–2.52	–2.06	–2.17

Table 4.5. Calculated Saturation Indices for Significant Phases in Tank C-103 $Ca(OH)_2$ Extractions (1-Month Single-Contact)

1-Month DDI $Ca(OH)_2$ Extracts						
Phase	**19845**	**19845 dup**	**19849**	**19849 dup**	**19850**	**19850 dup**
schoepite $UO_3 \cdot 2H_2O$	<EQL	<EQL	<EQL	<EQL	<EQL	<–3
plattnerite PbO	2.14	1.92	2.23	2.20	2.03	2.05
cerussite $PbCO_3$	–0.98	–1.26	–2.20	–2.29	–1.44	–1.51
hydrocerussite $Pb_3(CO_3)_2(OH)_2$	–0.08	–0.85	–2.41	–2.63	–1.11	–1.23
ferrihydrite $Fe(OH)_3$	–2.21	–2.31	–1.50	–1.87	–2.42	–2.47
hematite Fe_2O_3	6.78	6.58	8.19	7.47	6.37	6.26
Böhmite $AlO(OH)$	–0.30	–1.12	–0.52	–0.94	–0.83	–0.43
gibbsite $Al(OH)_3$	–0.49	–1.31	–0.71	–1.13	–1.02	–0.62
dawsonite $NaAlCO_3(OH)_2$	<–3	<–3	<–3	<–3	<–3	<–3
calcite $CaCO_3$	3.27	3.38	3.25	3.26	3.26	3.29
EQL = Estimated quantitation limit.						

Table 4.6. Calculated Saturation Indices for Significant Phases in Tank C-103 $CaCO_3$ Extractions (1-Month Single-Contact)

1-Month DDI $CaCO_3$ Extracts						
Phase	**19845**	**19845 dup**	**19849**	**19849 dup**	**19850**	**19850 dup**
schoepite $UO_3 \cdot 2H_2O$	–0.50	–0.49	–0.53	–0.49	–0.35	–0.46
plattnerite PbO	–1.11	–0.86	–0.90	–1.05	–0.75	–0.45
cerussite $PbCO_3$	–0.29	–0.17	–0.23	–0.24	–0.11	–0.11
hydrocerussite $Pb_3(CO_3)_2(OH)_2$	–1.94	–1.45	–1.61	–1.78	–1.23	–0.92
ferrihydrite $Fe(OH)_3$	0.76	0.70	0.73	0.38	0.86	1.11
hematite Fe_2O_3	12.7	12.6	12.7	12.0	12.9	13.4
Böhmite $AlO(OH)$	3.50	3.57	3.56	3.48	3.35	3.60
gibbsite $Al(OH)_3$	3.31	3.38	3.37	3.29	3.16	3.41
dawsonite $NaAlCO_3(OH)_2$	0.36	0.50	0.49	0.28	0.37	0.43
calcite $CaCO_3$	–2.80	–2.80	–2.45	–2.58	–1.88	–1.94

In the case of Fe, ferrihydrite [$Fe(OH)_3$] was determined to be fairly oversaturated in both the DDI and $CaCO_3$ 1-month single-contact extractions. The $Ca(OH)_2$ extracts are significantly undersaturated with respect to ferrihydrite. Hematite was highly oversaturated in all extracts. These results suggest that neither ferrihydrite nor hematite are controlling Fe concentration in these extracts. It may be possible that for the DDI extracts a $Fe(OH)_3$ phase that is somewhat more amorphous than ferrihydrite is controlling the Fe concentrations.

In the case of Al, results for the DDI and $CaCO_3$ 1-month single-contact extractions are similar, with dawsonite [$NaAlCO_3(OH)_2$] being near equilibrium, and gibbsite [$Al(OH)_3$] and böhmite [$AlO(OH)$] being highly oversaturated. The XRD results confirmed that the dominant Al phase in the C-103 residual waste samples is gibbsite. The SEM/EDS results suggest that in addition to gibbsite, minor amounts of böhmite may be present as well. The possible presence of dawsonite as suggested from the modeling results for is inconsistent with the XRD and SEM/EDS results for the C-103 unleached and leached solids, which did not identify dawsonite in the solids. However, dawsonite was detected by XRD and SEM/EDS in the oxalate-treated C-106 post retrieval waste (Deutsch et al. 2006, 2007a).

Geochemical modeling provided no information regarding the identity of the platy Ca-Al silicate phase (see micrographs C and D in Figure 3.13) identified by SEM/EDS in the 1-month single-contact $Ca(OH)_2$ leached solids. Precipitation of this phase during the $Ca(OH)_2$ extractions would explain the decrease in the release of Al and Si relative to the concentrations measured for the 1-month single-contact DDI and $CaCO_3$ leachates.

SI values for calcite ($CaCO_3$) were included in the tables because of the possibility of its formation during extraction with the $Ca(OH)_2$ and $CaCO_3$ saturated solutions and its possible occurrence in the residual waste. The DDI extracts and $CaCO_3$ extracts are both highly undersaturated with respect to calcite, indicating that calcite does not occur in C-103 residual waste. The $Ca(OH)_2$ extracts are highly oversaturated with respect to calcite, suggesting the possibility that this phase has precipitated. This is consistent with the SEM/EDS results.

5.0 Contaminant Release Models

The primary objective of this project is to develop source release models for contaminants of concern present in residual tank waste. As shown in Figure 5.1, this consists of laboratory testing to produce contaminant release data and development of a conceptual source release model based on the contaminant release and associated solids characterization data. The release model can then be incorporated into a fate and transport model as part of long-term performance assessment for the tanks. This section describes the conceptual release models developed for the primary contaminants of concern (^{238}U, Cr, and ^{99}Tc) from the laboratory testing of residual waste from the post-retrieved tank C-103. Because ^{129}I results in the three C-103 residual waste samples were below the EQLs, ^{129}I was not measured in the extract samples.

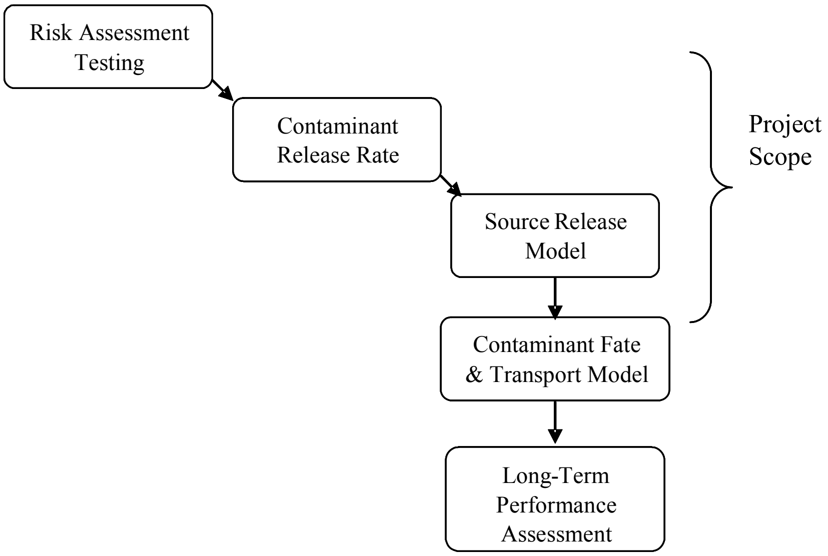

Figure 5.1. Source Release Model Development for Long-Term Performance Assessments

5.1 Uranium, Chromium, and ^{99}Tc Release Models

Two tank scenarios have been considered as part of the development of the contaminant release models for retrieved tank C-103. In the first scenario, it is assumed that the tank is filled with a relatively inert material such as quartz (SiO_2) sand or other material that does not significantly impact the chemistry of infiltration water that will contact the post-retrieval sludge. In this case, the composition of water contacting the post-retrieval sludge is assumed to be largely controlled by the solubility of $CaCO_3$ (calcite). Calcite is a ubiquitous component of most Hanford vadose zone sediments and future infiltrating water will likely equilibrate with this relatively soluble, reactive mineral.

In the second tank scenario, it is assumed that the tanks are filled with a cementitious grout. CaO is a major component of cement and readily reacts with water to form portlandite [$Ca(OH)_2$]. It is assumed that, once the grout sets up, some portion of its hydration product [$Ca(OH)_2$], will remain unreacted in the grout, and it will control the pH of the system. During this timeframe, the pH of the leaching solution generated by the grout is expected to be about 12.

As dissolved CO_2 in water contacts the grout, $Ca(OH)_2$ will react to form $CaCO_3$ (calcite). After all the available $Ca(OH)_2$ has been converted to calcite, the grout will be considered to have been aged. At this point, the characteristics of the leaching solution generated by water contacting grout will be largely controlled by the solubility of calcite and the partial pressure of CO_2 gas in the system. If the CO_2 partial pressure is the same as that in the atmosphere, the pH of the solution will be approximately 8.3.

An empirical solubility release model was selected to describe contaminant release for residual sludges in tank C-103. A solubility release model could also be applied for some constituents (U and possibly Tc). This is discussed further in Section 5.2. $CaCO_3$ extract compositions are expected to provide the most representative release concentrations of contaminants for the first scenario in which the pore water is in equilibrium with calcite. $Ca(OH)_2$ extract compositions are expected to provide the most representative release concentrations of contaminants for the first phase of the second scenario (fresh cement) and the $CaCO_3$ extract compositions are expected to provide the most representative release concentrations of contaminants for the second phase of the second scenario (aged cement/grout in which the $Ca(OH)_2$ has been converted to $CaCO_3$).

The maximum dissolved concentrations measured in the multiple extraction experiments and total concentrations present for the contaminants of concern (U, Cr, and ^{99}Tc) for the $Ca(OH)_2$ and $CaCO_3$ extracts are shown in Table 5.1 for each of the residual sludge samples. For ^{238}U and ^{99}Tc, the maximum values measured in each of the extraction experiments usually occurred in the 1-month single-contact extraction. The extraction step that had the highest Cr concentration was much less predictable. Chemical composition data for all the extraction experiments are tabulated in Appendix F. Total sludge concentrations shown in Table 5.1 were determined from the average of the acid digestion results (Table 3.6 and Table 3.10 contains the results of the sludge composition measurements).

Because three C-103 residual waste samples were analyzed, the highest contaminant concentration measured in the respective leachates and residual waste of the three samples were used for the release model. These values are provided in Table 5.2. Scenario 1 and Phase 2 of scenario 2 are indicated as calcite [$CaCO_3$]. Phase 1 of scenario 2 is indicated as fresh cement [$Ca(OH)_2$]. The contaminant concentrations in the C-103 residual waste determined for the model are 4,200 μg ^{238}U/g residual waste, 230 μg Cr/g residual waste, and 0.28 μg ^{99}Tc/g residual waste. The release concentration of ^{238}U for the calcite scenario is 4,100 μg/L and 0.39 μg/L for the fresh cement scenario. Cr release concentrations are similar for both scenarios at 18 μg/L for the calcite scenario and 19 μg/L for the fresh cement scenario. Release concentrations for ^{99}Tc are also similar for both scenarios at 0.16 μg/L for the calcite scenario and 0.19 μg/L for the fresh cement scenario.

Table 5.1. Maximum Dissolved Concentrations Measured in Extraction Experiments and Total Sludge Concentrations Measured for U, Cr, and ^{99}Tc in C-103 Samples

Tank C-103 Sample	Extract Solution	Component	Waste Conc. µg/g Dry Waste	Max. Release Conc. µg/L
19845	$CaCO_3$	U	3,300	2,200
	$Ca(OH)_2$	U	3,300	(0.71)
	$CaCO_3$	Cr	180	11
	$Ca(OH)_2$	Cr	180	17
	$CaCO_3$	^{99}Tc	0.19	0.12
	$Ca(OH)_2$	^{99}Tc	0.19	0.18
19849	$CaCO_3$	U	3,700	2,800
	$Ca(OH)_2$	U	3,700	(2.0)
	$CaCO_3$	Cr	170	13
	$Ca(OH)_2$	Cr	170	17
	$CaCO_3$	^{99}Tc	0.23	0.16
	$Ca(OH)_2$	^{99}Tc	0.23	0.16
19850	$CaCO_3$	U	4,200	4,100
	$Ca(OH)_2$	U	4,200	(1.8)
	$CaCO_3$	Cr	230	18
	$Ca(OH)_2$	Cr	230	19
	$CaCO_3$	^{99}Tc	0.28	0.11
	$Ca(OH)_2$	^{99}Tc	0.28	0.19
Values in parentheses indicate measurements were below instrument EQL.				

Table 5.2. Maximum C-103 Residual Waste and Contaminant Release Concentrations for Release Model

Release Scenario	Component	Waste Conc. µg/g Dry Waste	Max. Release Conc. µg/L
Calcite [$CaCO_3$]	U	4,200	4,100
Fresh cement [$Ca(OH)_2$]	U	4,200	2.0
Calcite [$CaCO_3$]	Cr	230	18
Fresh cement [$Ca(OH)_2$]	Cr	230	19
Calcite [$CaCO_3$]	^{99}Tc	0.28	0.16
Fresh cement [$Ca(OH)_2$]	^{99}Tc	0.28	0.19

5.2 Integration of the C-103 Release Data with Fate and Transport Modeling Codes

Selecting which release concentration data from Table 5.2 to use for scenario 1 in which the tank is filled with relatively inert solids is straightforward because the calcite ($CaCO_3$) values will be used for the entire modeling period. For scenario 2 in which a cementitious material is used to fill the tank, the decision on when to switch the release concentrations from those for fresh cement [$Ca(OH)_2$ stage] to those for aged grout ($CaCO_3$ stage) is somewhat problematic. The primary reason for this is the large uncertainty in how fast the grout will age. The aging process depends upon the rate of water infiltration as well as the surface area of grout that comes in contact with the water. Infiltration will be dependent upon precipitation, evaporation, effectiveness of surface barriers, etc. The surface area of grout will depend upon the size of the grout monolith, the physical integrity of the grout, and the geologic stability of the location where the grout monolith will exist. As cracks develop within the monolith, more surface area will become available to contact infiltrating water and to react with dissolved CO_2. Because the rates of these processes are largely unknown, an estimate of when to switch from the fresh cement to the aged cement scenario cannot be determined with confidence at this time. In the absence of a scientifically defensible method for selecting the time for this transition, a conservative approach is recommended. The most conservative approach would be to use the highest release concentration of the two scenarios for each contaminant listed in Table 5.2 over the entire modeling period.

Although an empirical release model has been selected here to represent contaminant release from residual tank waste, a reactive transport model could potentially be used to represent contaminant release for some contaminants. For example, saturation index calculations and SEM/EDS results suggest that the dominant form of U in the C-103 residual sludge is schoepite ($UO_3 \cdot 2H_2O$). These results suggest that a solubility release mechanism could be used to model U release from C-103 residual waste. A reactive transport model based on solubility could provide a more accurate and potentially less conservative approach to estimating contaminant release through time by taking into account evolving chemical conditions as a closed tank system transitions from fresh cement to aged cement.

6.0 Conclusions

This report provides the results of laboratory tests and solids characterization on three post-retrieval (residual) waste samples from Hanford tank C-103. These results were used to develop a contaminant release model to estimate the maximum release concentrations of the key contaminants from C-103 residual waste.

Results of the Tier 1 laboratory characterization and testing of the C-103 samples indicate that Al is the largest single metal component of the waste (12 to 16 wt% for the three samples). Based on this result and assuming the Al occurs primarily as gibbsite [$Al(OH)_3$], aluminum phases would account for 35 to 46 wt% of the residual waste. Other major metal components (Fe, Na, Si, and U) occurred at significantly lower concentrations (0.90 to 1.7%, 0.7 to 0.9%, 0.8 to 1.0%, and 0.3 to 0.4%, respectively). Uranium (^{238}U) was the most concentrated contaminant of concern in the C-103 residual waste samples, occurring at 3,300 to 4,200 µg/g-dry waste. Other residual waste components had the following concentration ranges: ^{99}Tc (0.19 to 0.28 µg/g), Cd (61 to 69 µg/g), Cr (143 to 183 µg/g), Pb (669 to 1,070 µg/g), ^{137}Cs (28 to 69 µCi/g), ^{90}Sr (396 to 753 µCi/g), ^{239}Pu (0.40 to 0.62 µCi/g), ^{241}Am (<0.11 (estimated quantitation limit) to 0.28 µCi/g), ^{237}Np (0.72 to 1.24 nCi/g). ^{129}I concentrations were below the EQLs of 0.042 to 0.085 µCi/g.

Leach tests were conducted with three leachant solutions; double deionized water, $Ca(OH)_2$-saturated water , and $CaCO_3$-saturated. Two types of leach tests were conducted with each of these three leachants, 1 month single-contact leach tests and periodic replenishment tests. Key results from the leach tests are that the future release of the primary contaminants of concern from C-103 residual waste typically represents less than 10% of the total contaminant concentration in the residual waste. That is, the contaminants are not appreciably soluble in the DDI water, $Ca(OH)_2$, and $CaCO_3$ leachants. For example, the cumulative amount of U leached by the DDI water leaching solution during six sequential stages of leaching ranged from 3.8 to 6.9% of the total U. The corresponding percentages of U leached by the $Ca(OH)_2$ leaching solution were significantly lower, ranging from 0.0 to 0.006%. The percentages of U leached by the $CaCO_3$ leaching solution were higher, ranging from 12.6 to 13.8%. The cumulative leachable percentages for ^{99}Tc were also low, ranging from 3.7 to 7.1% for all samples and extract solutions. The cumulative leachable percentages for Cr were also low, ranging from 1.0 to 6.4% for all samples and extract solutions.

X-ray diffraction (XRD) results indicate that gibbsite [$Al(OH)_3$] is the major component of the C-103 samples, which is consistent with the bulk chemical analysis. Scanning electron microscopy/energy dispersive spectrometry (SEM/EDS) results suggest that the samples of C-103 residual waste consist primarily (possibly more than 80 to 90%) of an Al oxyhydroxide phase, such as gibbsite [$Al(OH)_3$]. Based on these results, the total aluminum concentrations appear to be underestimated. The reason for this discrepancy could not be determined. SEM/EDS analyses also show that the C-103 samples contained trace concentrations (possibly a few percent each) of one or two Fe-O phases (usually also containing minor concentrations of Mn, Cr, Ni, and possibly Pb), possibly two Ag±Hg-O phases, a U-O phase, infrequently a U±Ca-O phase (possibly also containing Na, Al, and Si), and a Ca-P-O phase. Geochemical modeling suggests that this U-O phase may be schoepite ($UO_3•2H_2O$). The SEM/EDS results for the 1-month single-contact double deionized (DDI) water-leached, 1-month single-contact $Ca(OH)_2$-leached, and 1-month single-contact $CaCO_3$-leached samples were consistent with those for the unleached samples. SEM/EDS analyses of 1-month single-contact $Ca(OH)_2$-leached samples also indicated the presence of three other phases. These new phases include a Ca-O±C phase with a composition consistent with calcite ($CaCO_3$), a Si-Al-Na-Ca-O phase that commonly has the morphology (crystal habit) of balls of twine, and a Ca-Al-Si-O phase that forms platy-like particles (sometimes also forming rosettes).

In addition to these solid phase characterization results, technetium was identified by EDS in three Fe oxide/hydroxide particles. These Tc-containing particles (marked by arrows in the SEM micrographs in Figure 3.14) were found by SEM/EDS in samples of unleached, DDI water-leached, and $CaCO_3$-leached C-103 residual waste. The Tc concentrations in these particles ranged from 0.6 to 1.0 wt%. This is the first time in our project studies of pre-retrieval and post retrieval residual wastes from Hanford underground SSTs that there has been direct evidence for the presence of Tc in any phase in actual waste solids.

The primary product of sludge testing and model development is the measured total contaminant concentrations in the residual sludge and the estimated maximum release concentrations of the key contaminants for two tank closure scenarios. In the first scenario, it is assumed that the tank is filled with a relatively inert material such as quartz (SiO_2) sand or other material that does not significantly impact the chemistry of infiltration water that will contact the post-retrieval sludge. In the second tank scenario, it is assumed that the tanks are filled with a cementitious grout. The release data for these two scenarios are compiled in Table 5.2. They can be used as source term values for tank closure performance assessments.

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Appendix A

X-Ray Diffraction Patterns for Unleached and Leached Samples of Residual Waste from Tank C-103

Appendix A

X-Ray Diffraction Patterns for Unleached and Leached Samples of Residual Waste from Tank C-202

This appendix presents the as-measured and corrected X-ray powder diffraction (XRD) patterns for the unleached, one-month single-contact DDI water-leached, one-month single-contact $Ca(OH)_2$-leached, and one-month single-contact $CaCO_3$-leached solids from samples 19845, 19849, and 19850 of residual waste from tank C-103. For comparison to the background signal in the as-measured XRD patterns included in this appendix, Figure A.1 was also included to show the XRD pattern for collodion film measured in the absence of any sludge material and reported by Krupka et al. (2004).

The XRD patterns for the unleached and leached C-103 samples are given in the following figures:

- Unleached solids (samples 19845, 19849, 19850) – Figures A.2, A.3, and A.4, respectively
- One month single-contact DDI water-leached solids (samples 19845, 19849, 19850) – Figures A.5, A.6, and A.7, respectively
- One month single-contact $Ca(OH)_2$-leached solids (samples 19845, 19849, 19850) – Figures A.8, A.9, and A.10, respectively
- One month single-contact $CaCO_3$-leached solids (samples 19845, 19849, 19850) – Figures A.11, A.12, and A.13, respectively.

In Figures A.2 through A.13, the top and bottom XRD patterns show the as-measured pattern and that which has been corrected for background subtraction and calibration with the corundum internal standard, respectively.

The instrumentation and procedures used for measuring, subtracting background, and interpreting the XRD patterns for these materials are described in Section 2.3 of the main report. The vertical axis in each of the following patterns represents the intensity in counts per second (cps) of the XRD peaks. The horizontal axis is in terms of degrees 2θ based on $Cu_{K\alpha}$ radiation (λ=1.5406 Å), and is related to *d* spacing according to the Bragg law (Cullity 1956). The XRD patterns show, for comparison purposes, the schematic database (PDF) pattern for corundum (used as a 2θ internal standard) and any other phases thought to be present in the sample mount. The height of each line in the schematic PDF patterns represents the relative intensity of an XRD peak (i.e., the most intense [the highest] peak has a relative intensity [I/I_o] of 100%).

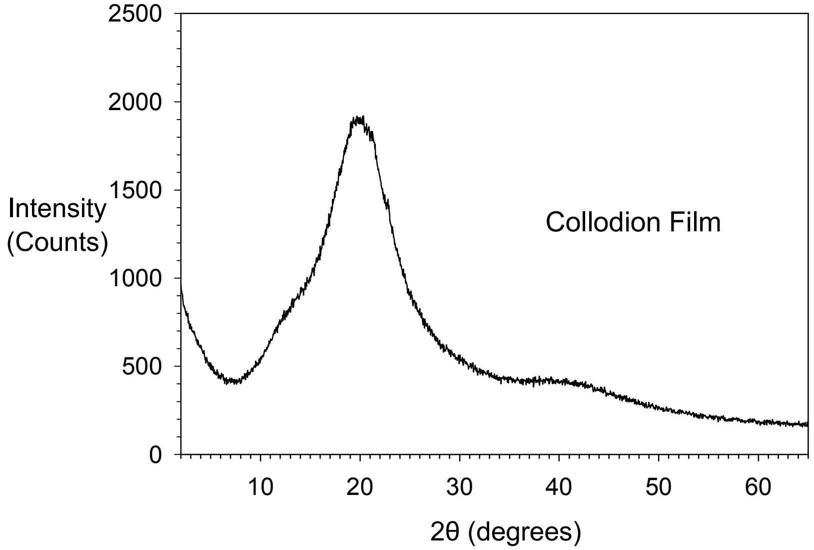


Figure A.1. XRD Pattern for Collodion-Solution Film (from Krupka et al. 2004)

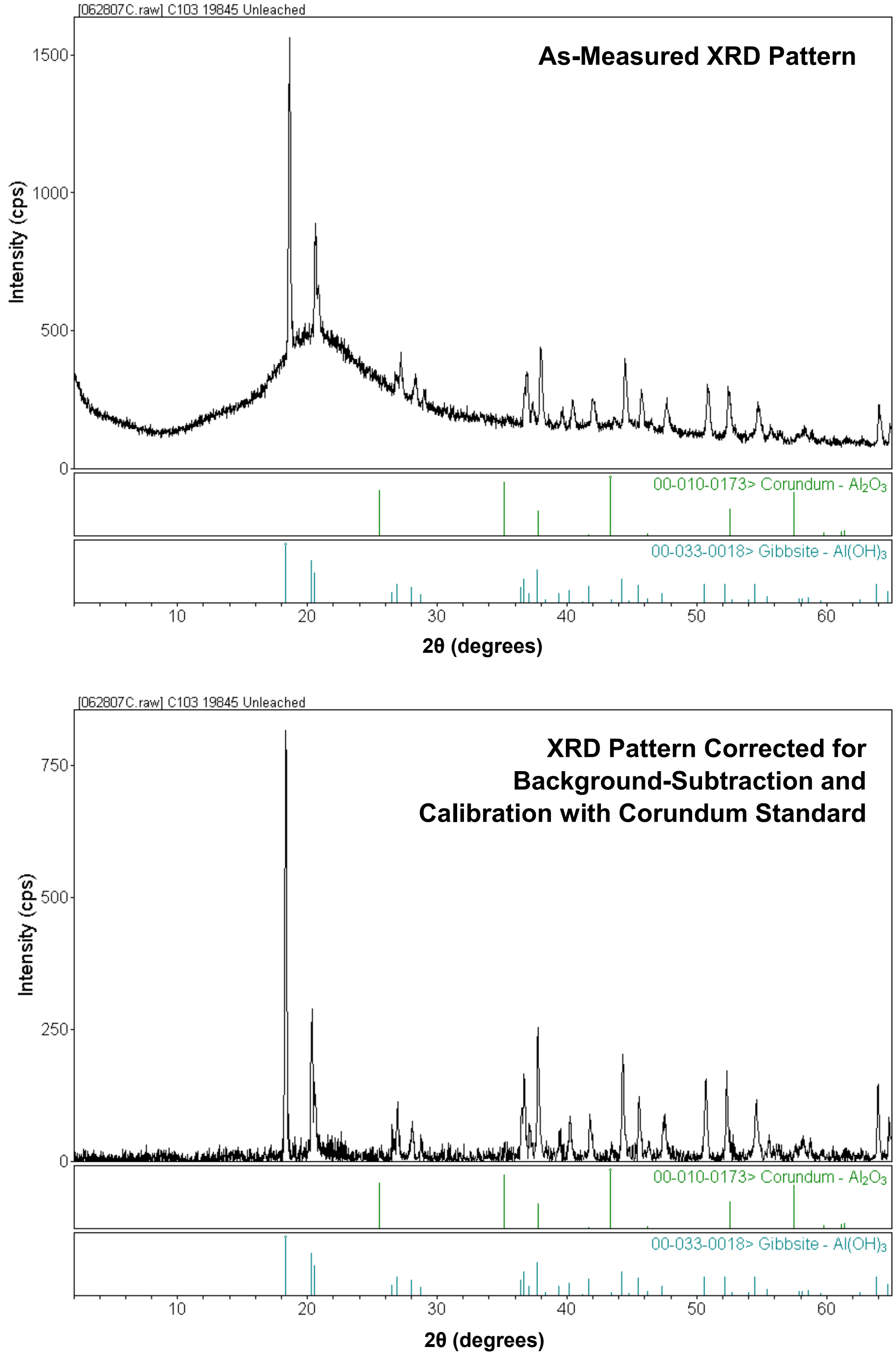


Figure A.2. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19845 of Unleached C-103 Residual Waste

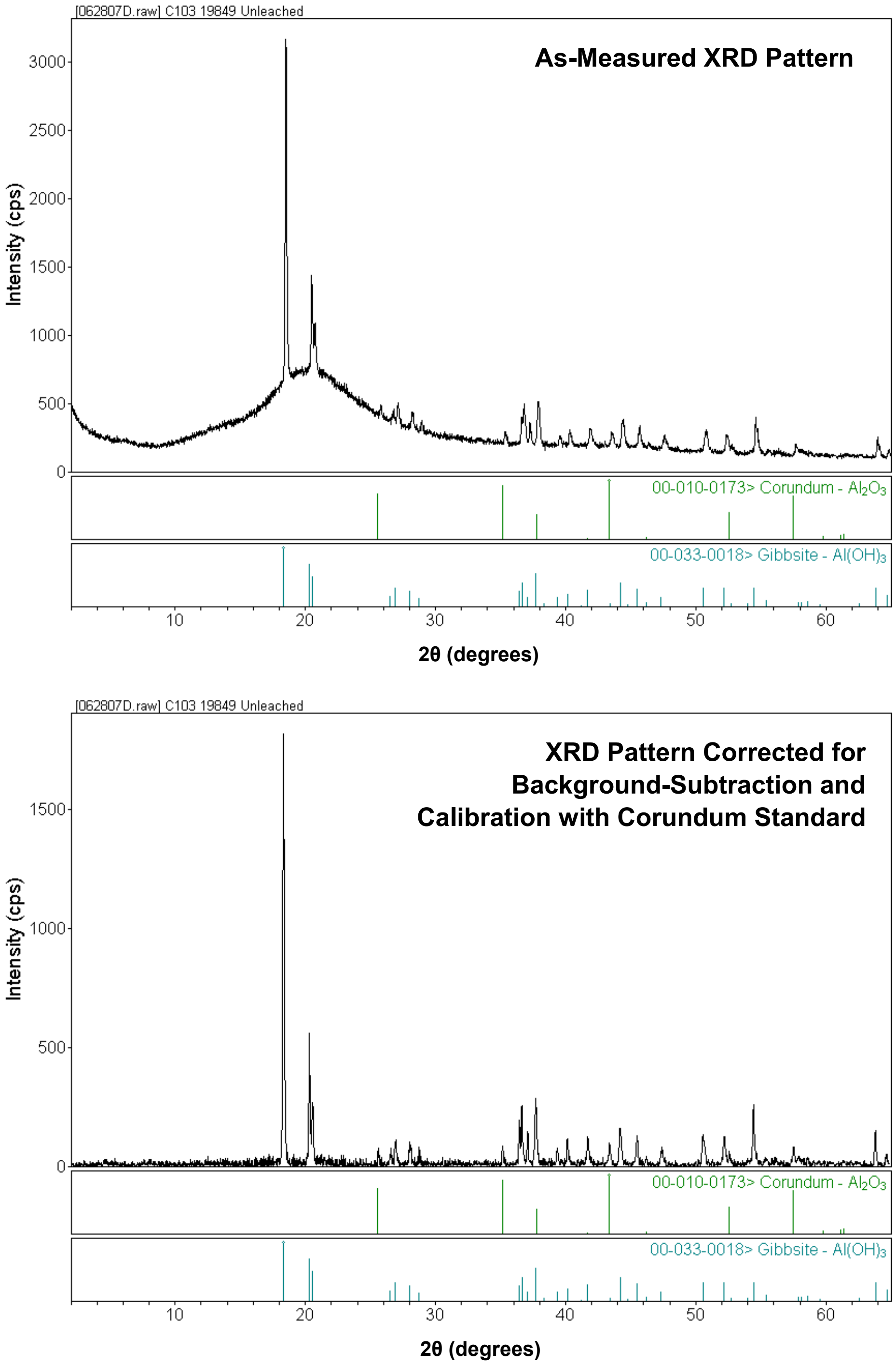


Figure A.3. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19849 of Unleached C-103 Residual Waste

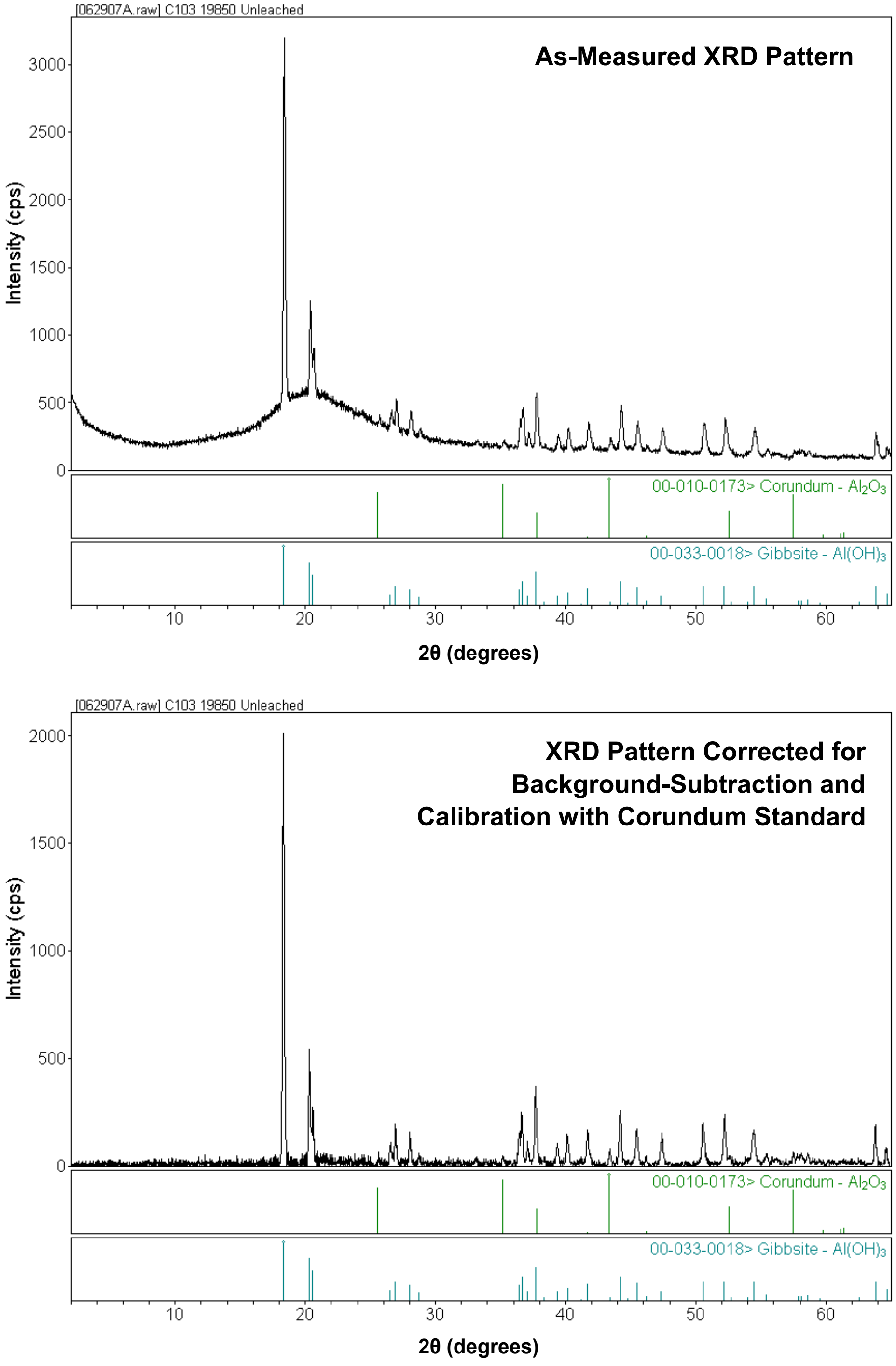


Figure A.4. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19850 of Unleached C-103 Residual Waste

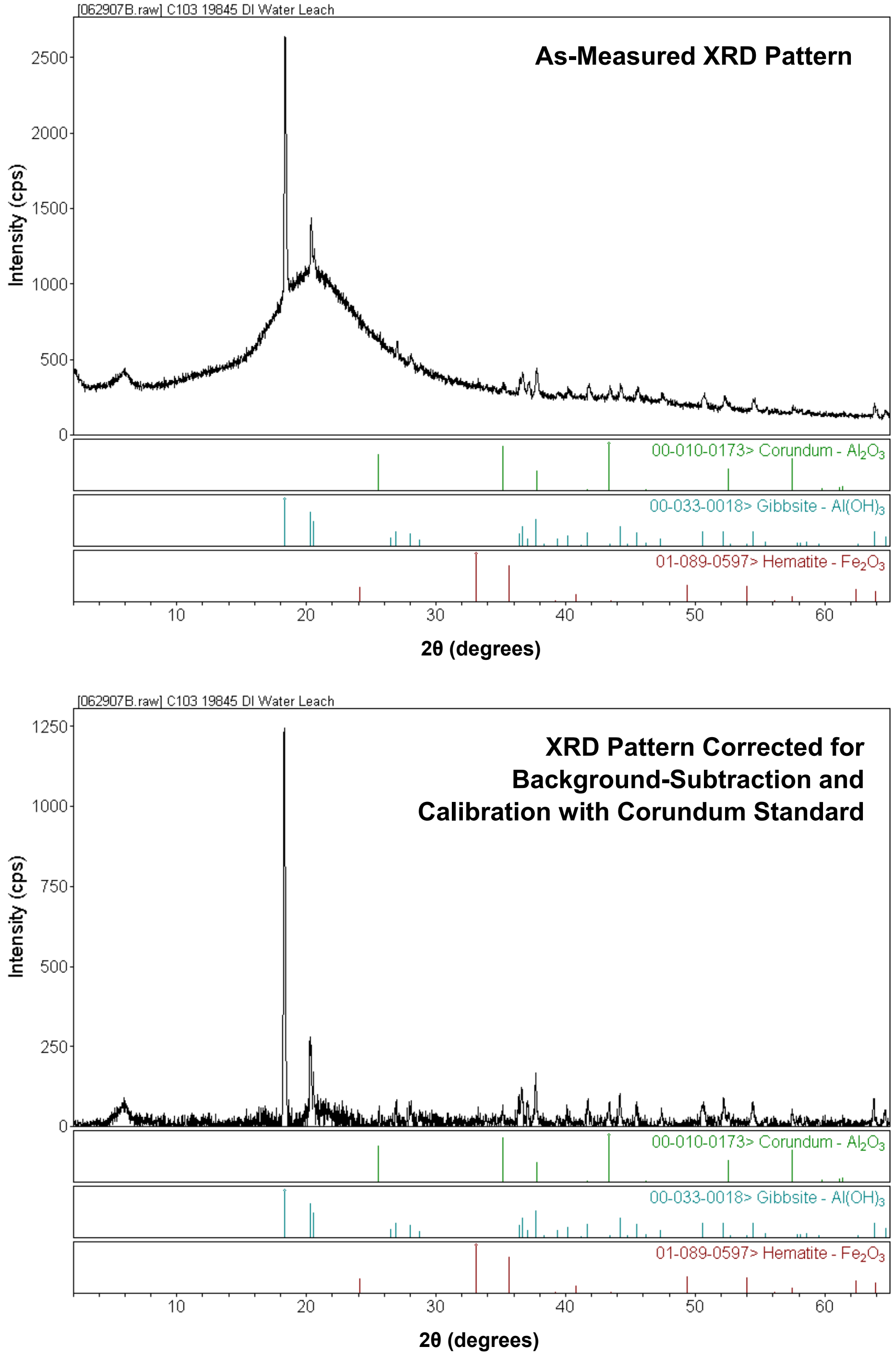


Figure A.5. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19845 of One-Month Single-Contact DDI Water-Leached C-103 Residual Waste

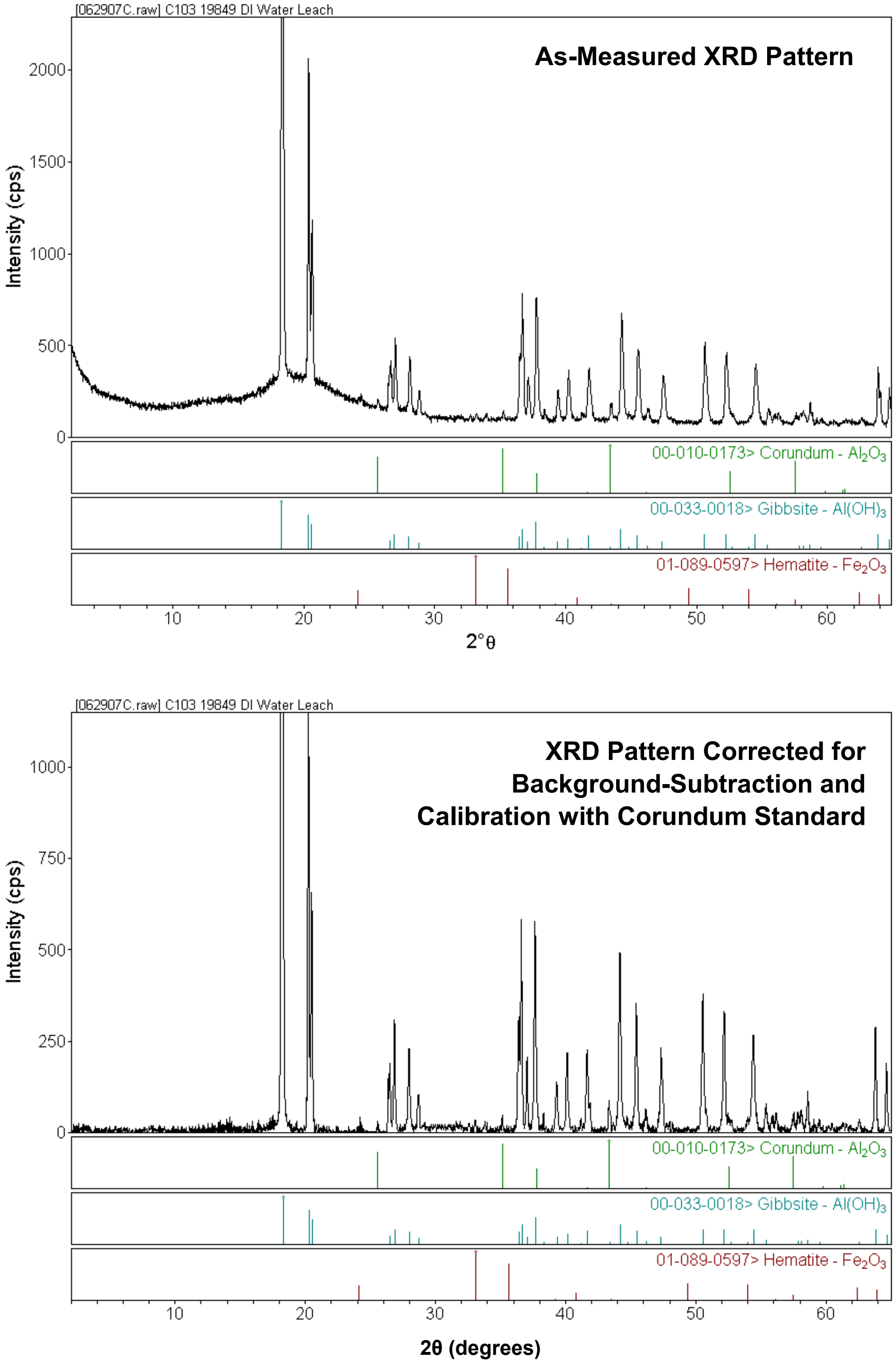


Figure A.6. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19849 of One-Month Single-Contact DDI Water-Leached C-103 Residual Waste

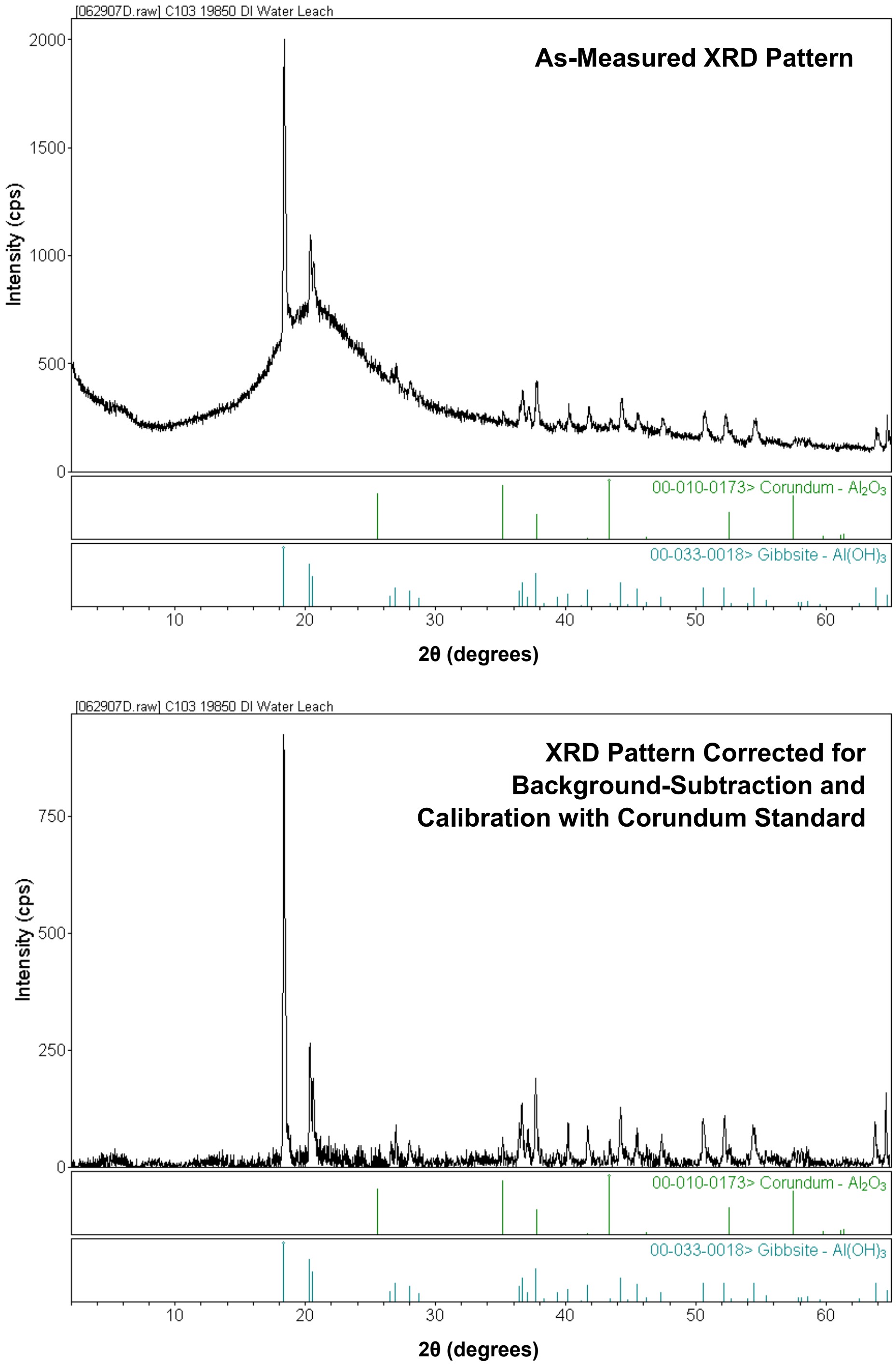


Figure A.7. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19850 of One-Month Single-Contact DDI Water-Leached C-103 Residual Waste

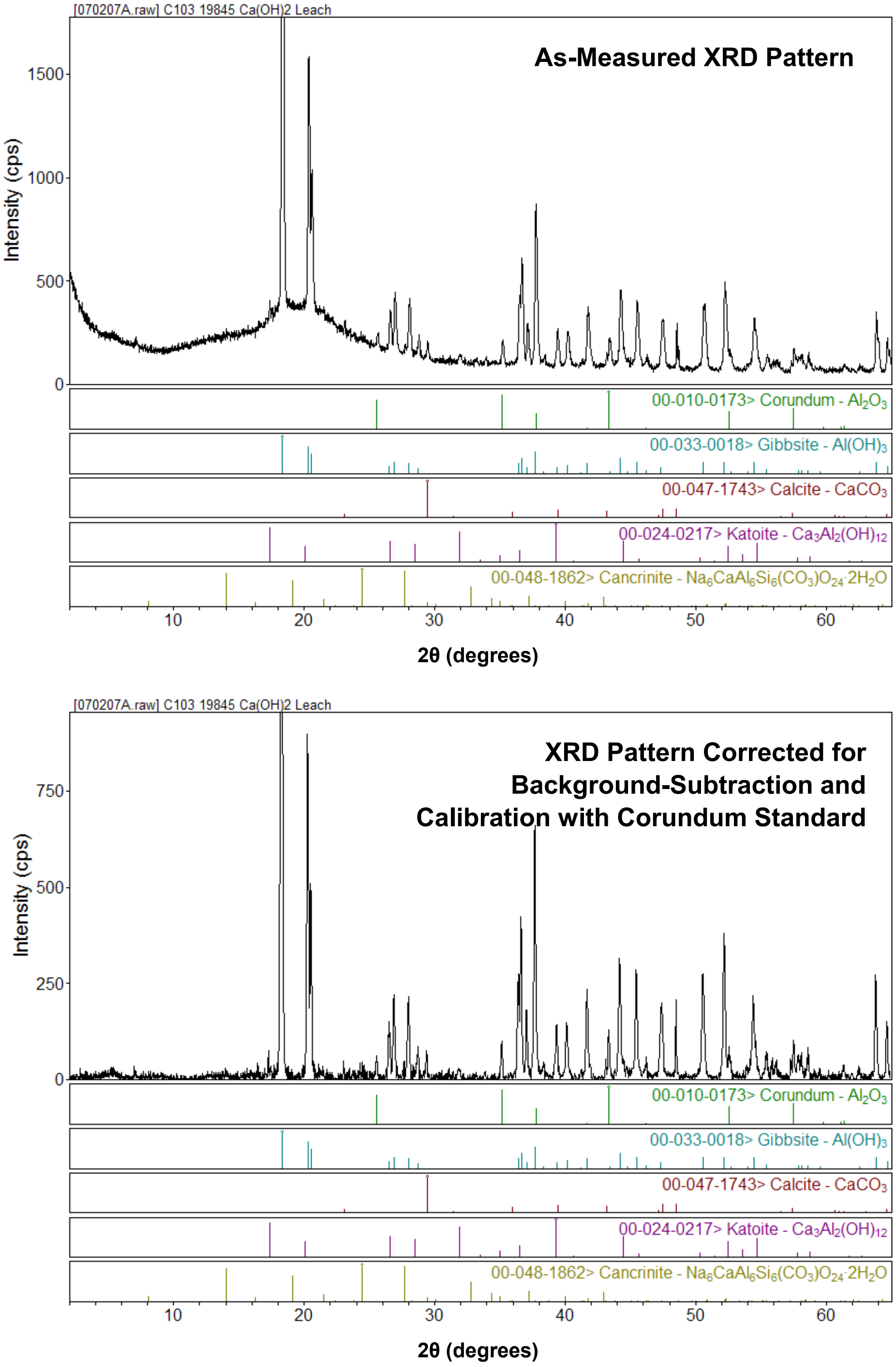
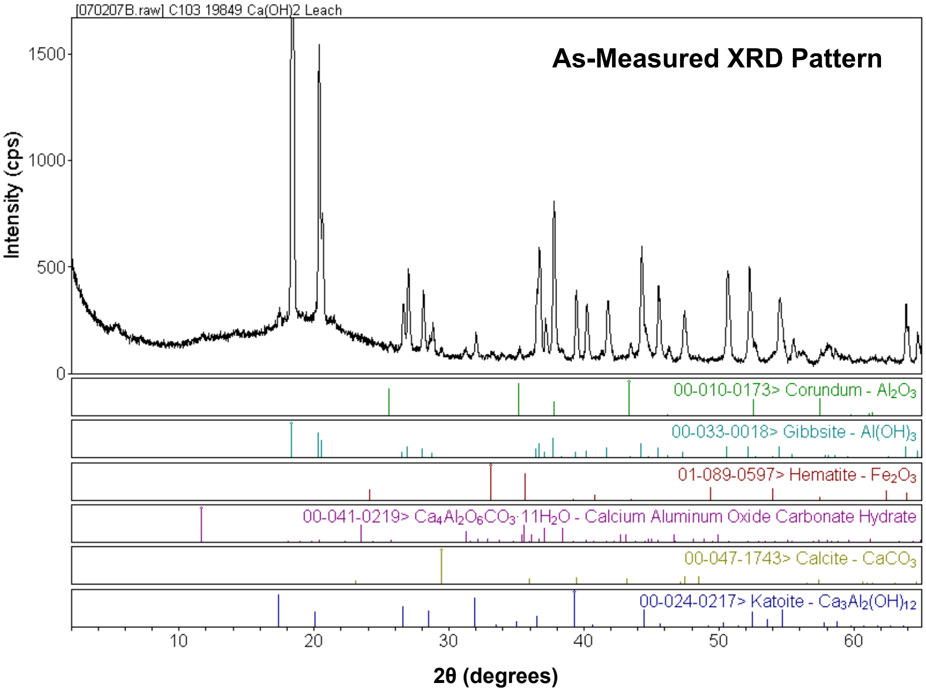


Figure A.8. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached C-103 Residual Waste



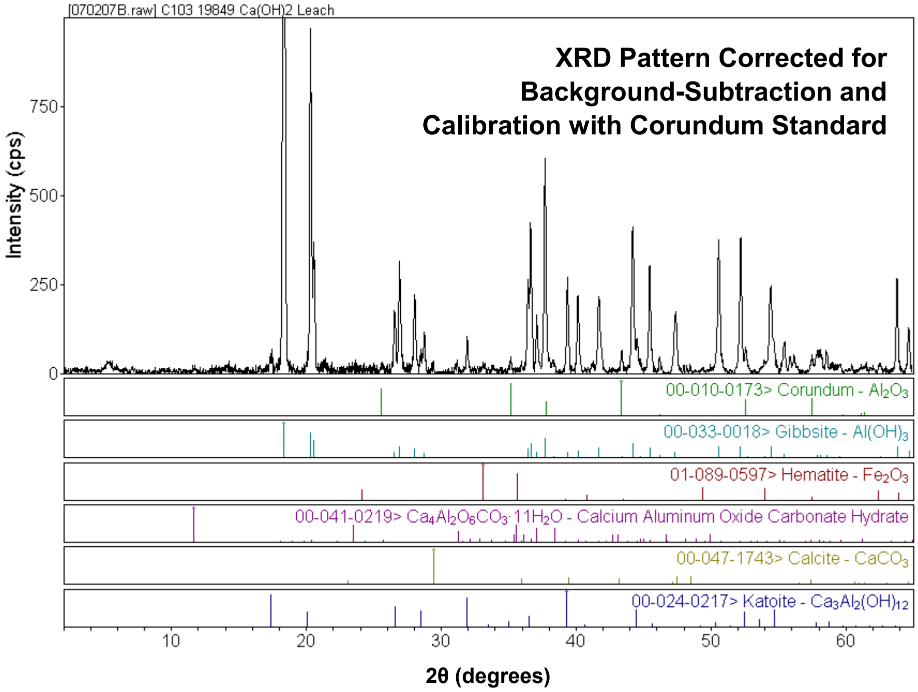


Figure A.9. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached C-103 Residual Waste

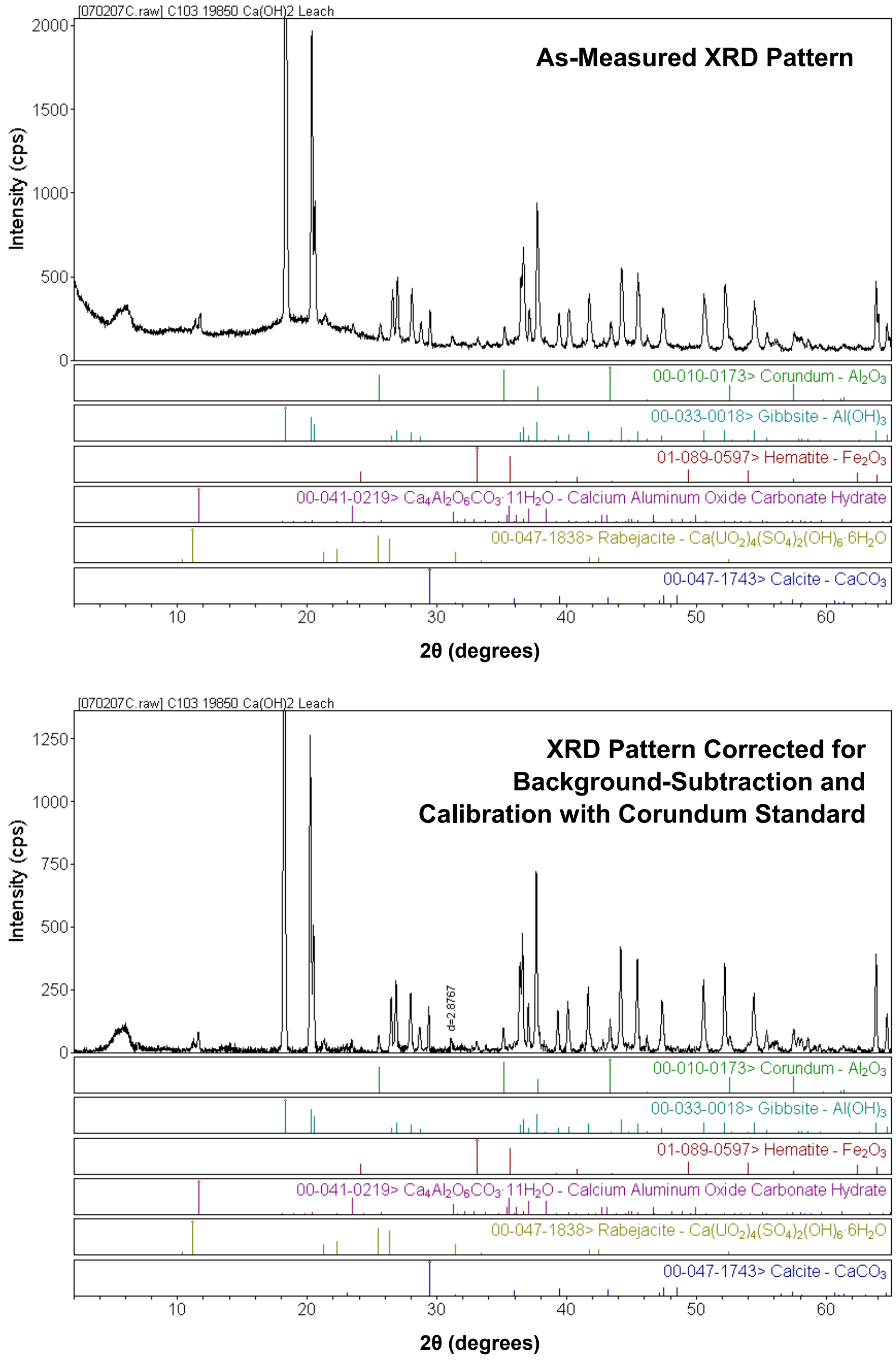


Figure A.10. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached C-103 Residual Waste

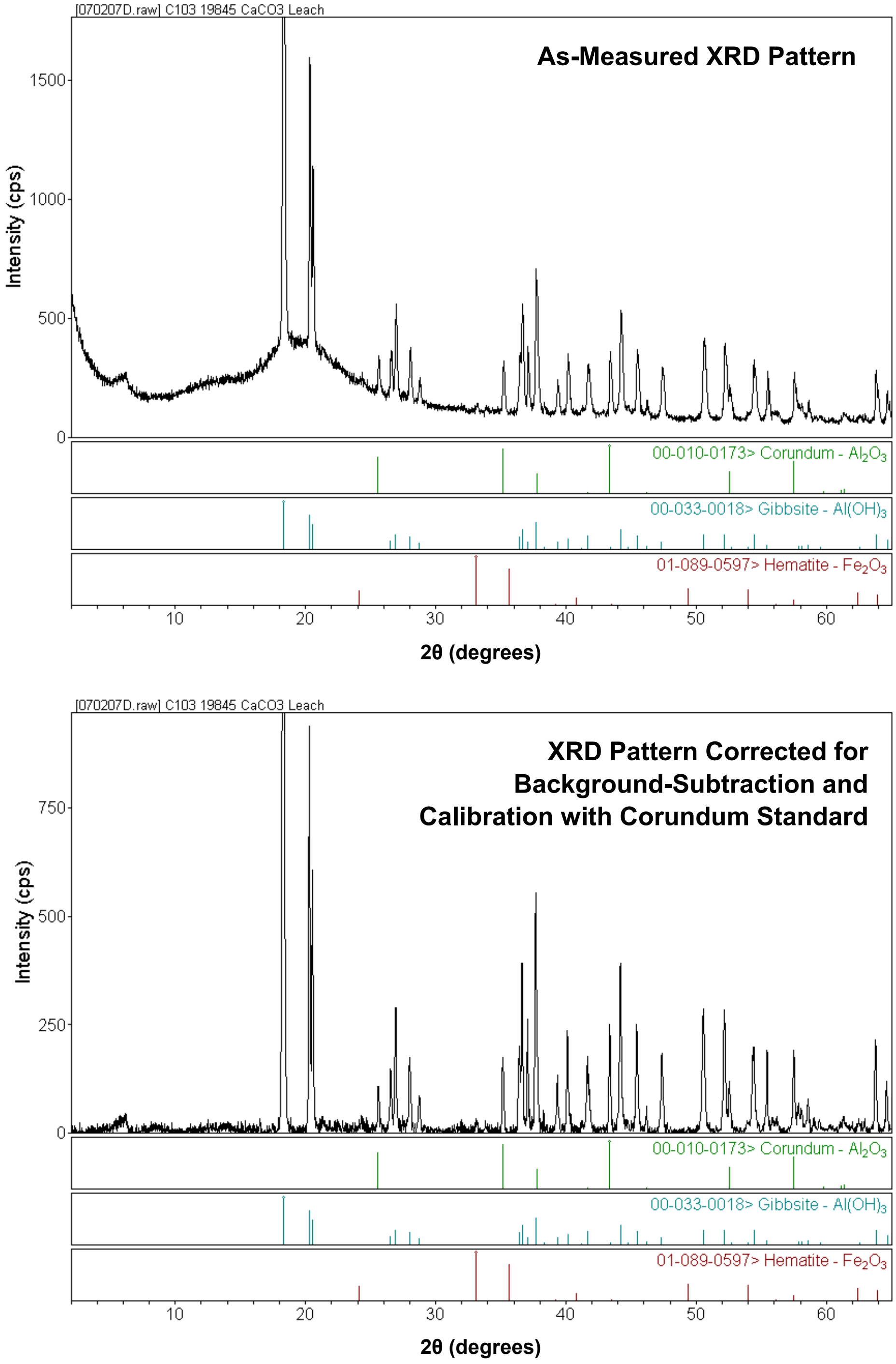


Figure A.11. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached C-103 Residual Waste

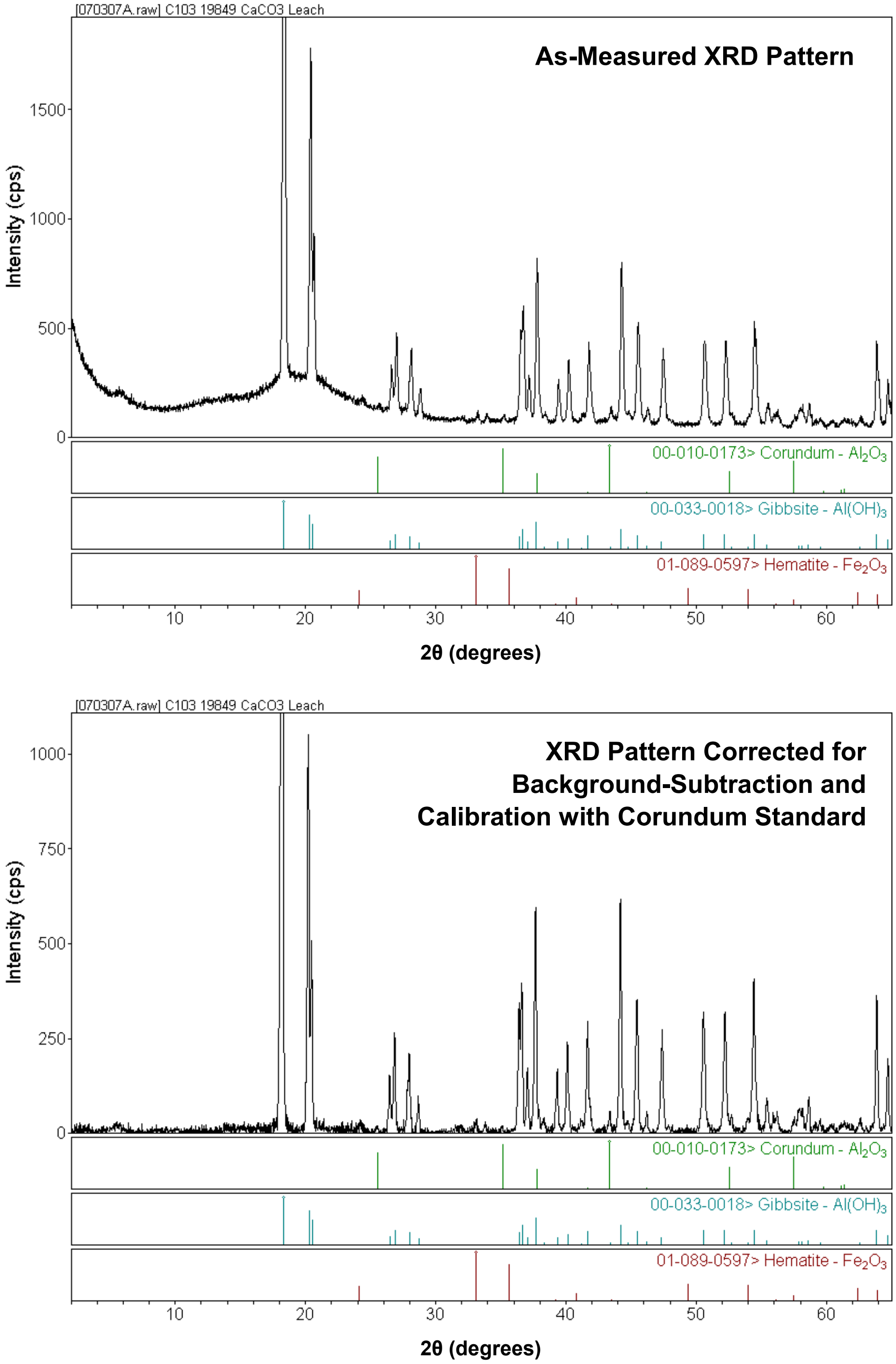
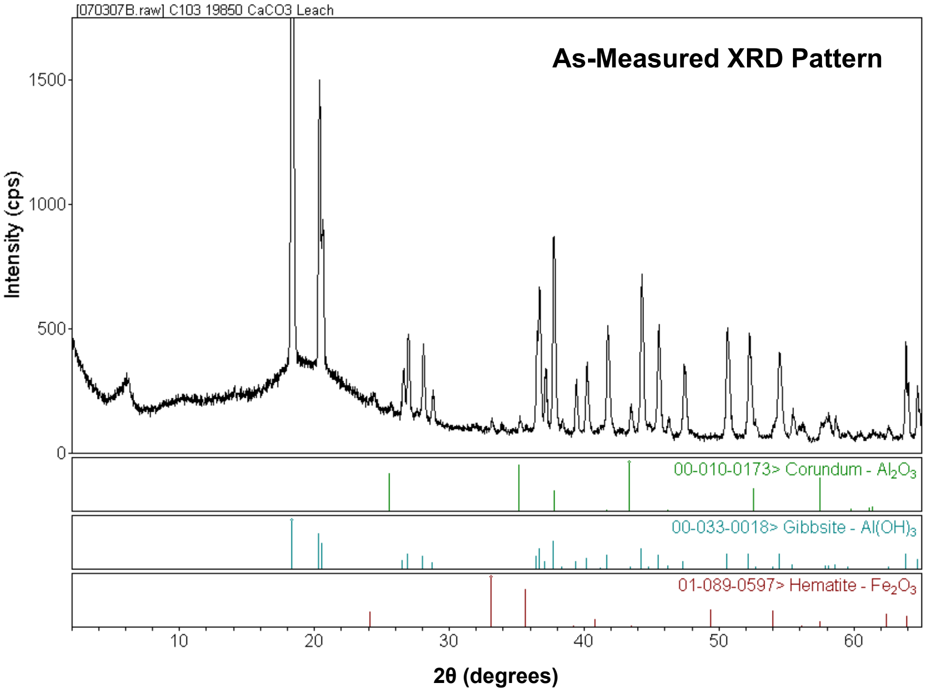


Figure A.12. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached C-103 Residual Waste



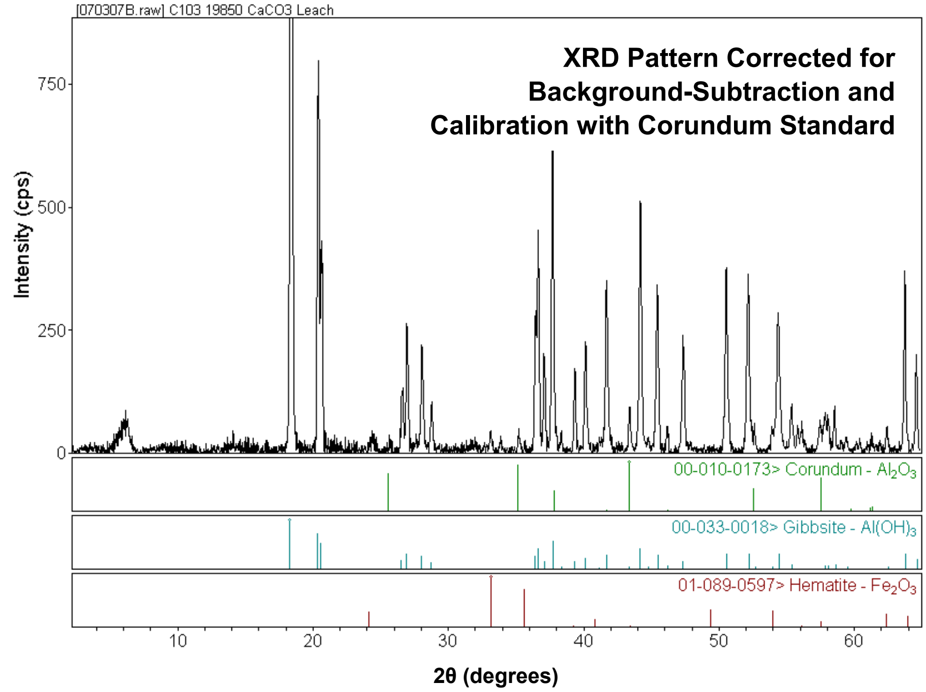


Figure A.13. As-Measured (top) and Corrected (bottom) XRD Patterns for Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached C-103 Residual Waste

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Appendix B

SEM Micrographs and EDS Results for Unleached Residual Waste from Tank C-103

Appendix B

SEM Micrographs and EDS Results for Unleached Residual Waste from Tank C-103

This appendix includes the scanning electron microscope (SEM) micrographs and the energy-dispersive spectroscopy (EDS) spectra for samples 19845, 19849, and 19850 of unleached residual waste from tank C-103. The operating conditions for the SEM and procedures used for mounting the SEM samples are described in Section 2.4 of the main report.

The identification number for the digital micrograph image file, descriptor for the type of sample, and a size scale bar are given at the bottom of each SEM micrograph. Micrographs labeled by “BSE” or “SE” to the immediate right of the digital image file number indicate that the micrograph was collected with backscattered electrons or secondary electrons, respectively. Sample areas or particles identified in a micrograph by a pink arrow or pink dotted-line square designate sample material that was imaged at higher magnification, which is typically shown in figure(s) that immediately follow in the series for that sample.

The SEM micrographs, EDS spectra, and corresponding calculated compositions (in weight percent) based on EDS analyses for material analyzed from samples 19845, 19849, and 19850 of unleached C-103 residual waste are shown in the following figures and tables:

- Sample 19845
  - SEM micrographs – Figures B.1 through B.7
  - EDS spectra – Figures B.8 through B.17
  - Calculated compositions based on EDS analyses – Table B.1 and B.2

- Sample 19849
  - SEM micrographs – Figures B.18 through B.31
  - EDS spectra – Figures B.32 through B.43
  - Calculated compositions based on EDS analyses – Table B.3 through B.5

- Sample 19850
  - SEM micrographs – Figures B.44 through B.53
  - EDS spectra – Figures B.54 through B.63
  - Calculated compositions based on EDS analyses – Table B.6 through B.8

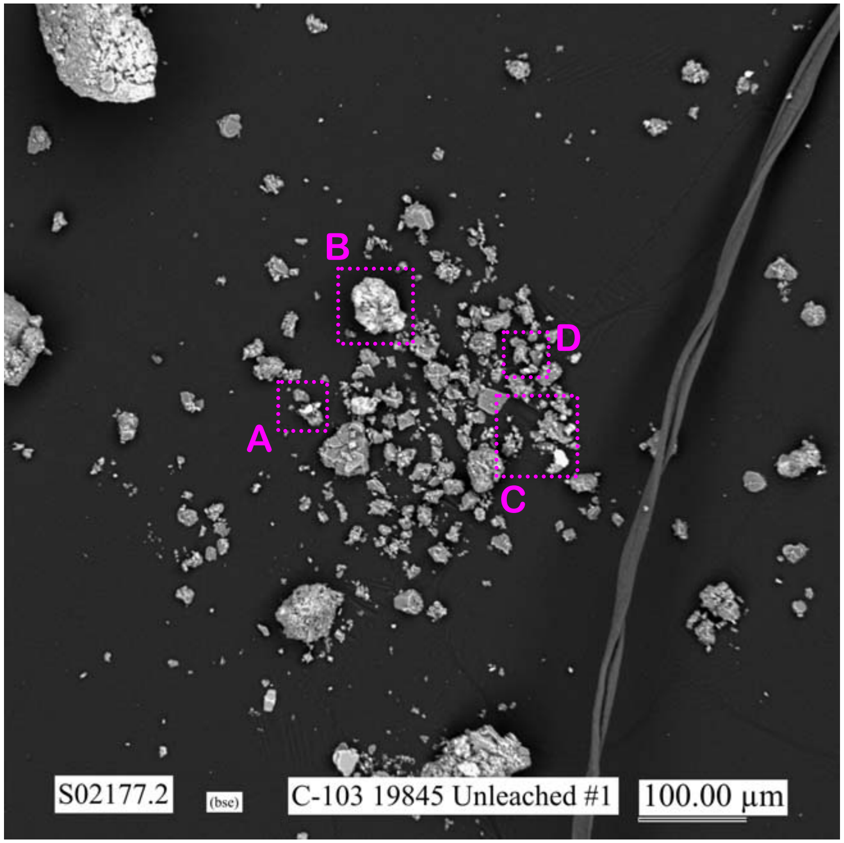

Figure B.1. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103 (Long fiber on right side of micrograph is impurity introduced during preparation of the sample mount.)

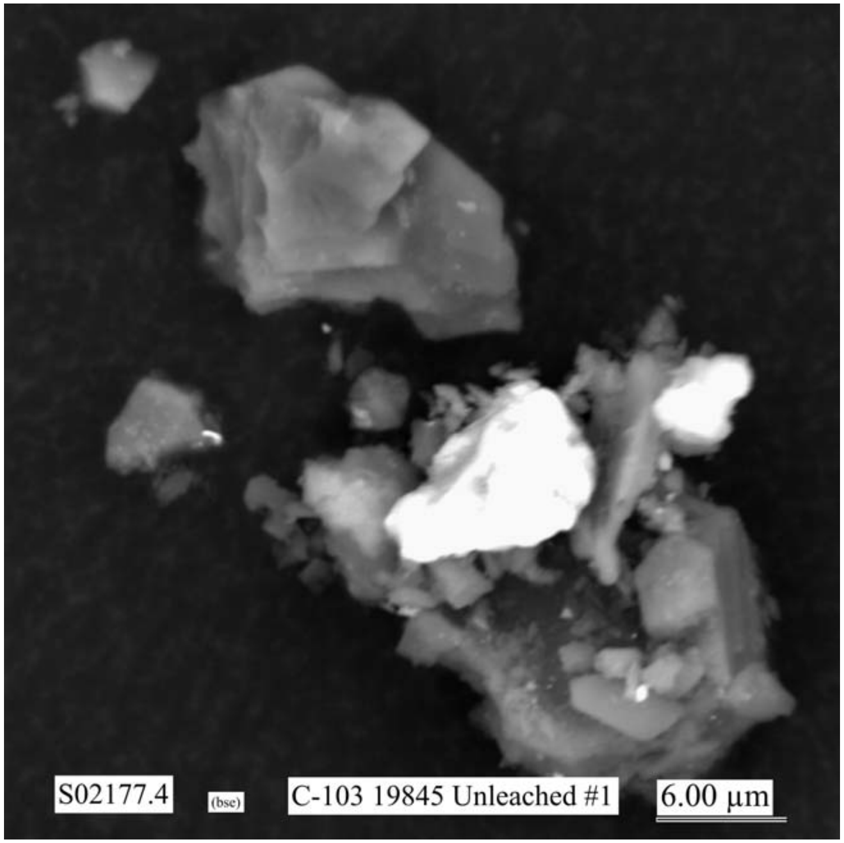

Figure B.2. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square A in Figure B.1 (Areas where EDS analyses were made are shown in Figure B.8.)

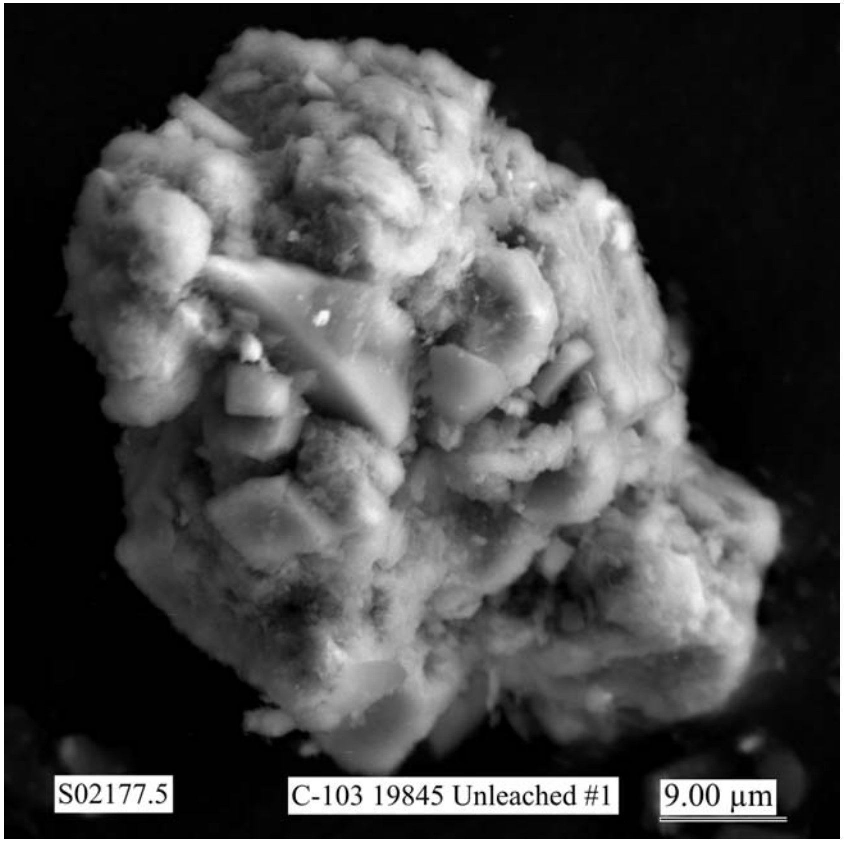

Figure B.3. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square B in Figure B.1 (Areas where EDS analyses were made are shown in Figure B.9.)

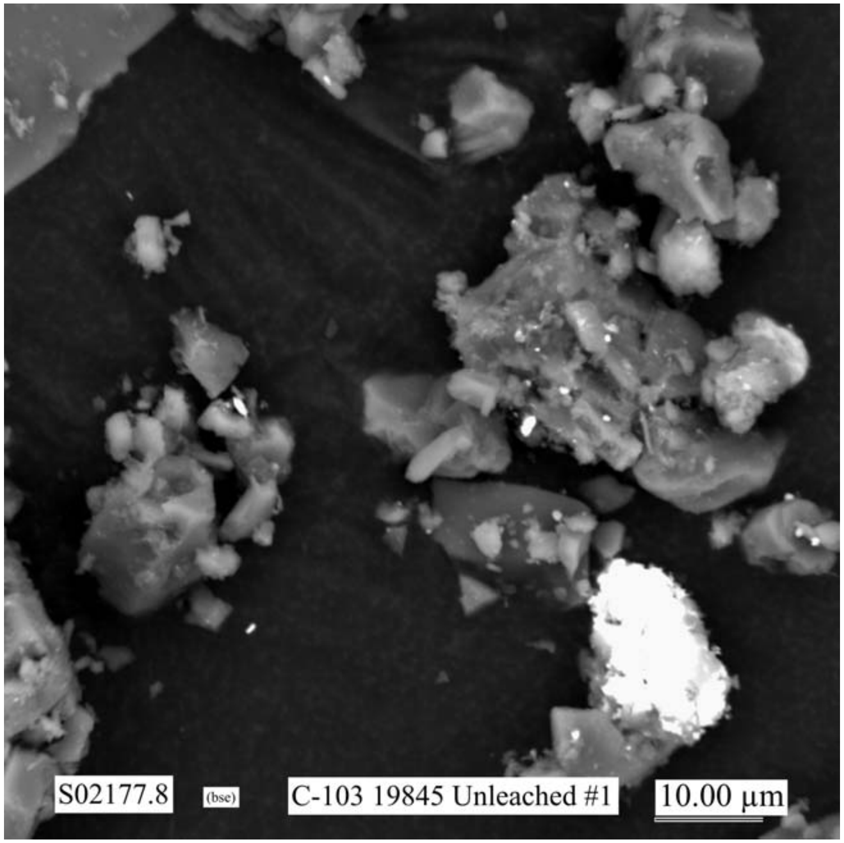

Figure B.4. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square C in Figure B.1 (Areas where EDS analyses were made are shown in Figures B.10 through B.12.)

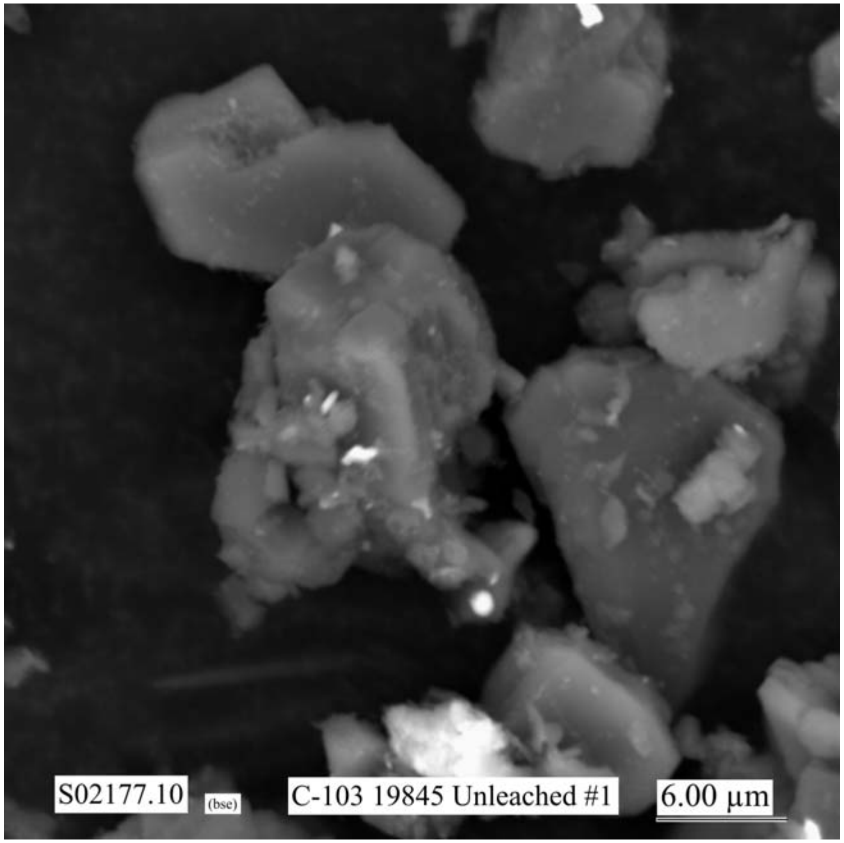

Figure B.5. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square D in Figure B.1 (Areas where EDS analyses were made are shown in Figures B.13 and B.14.)

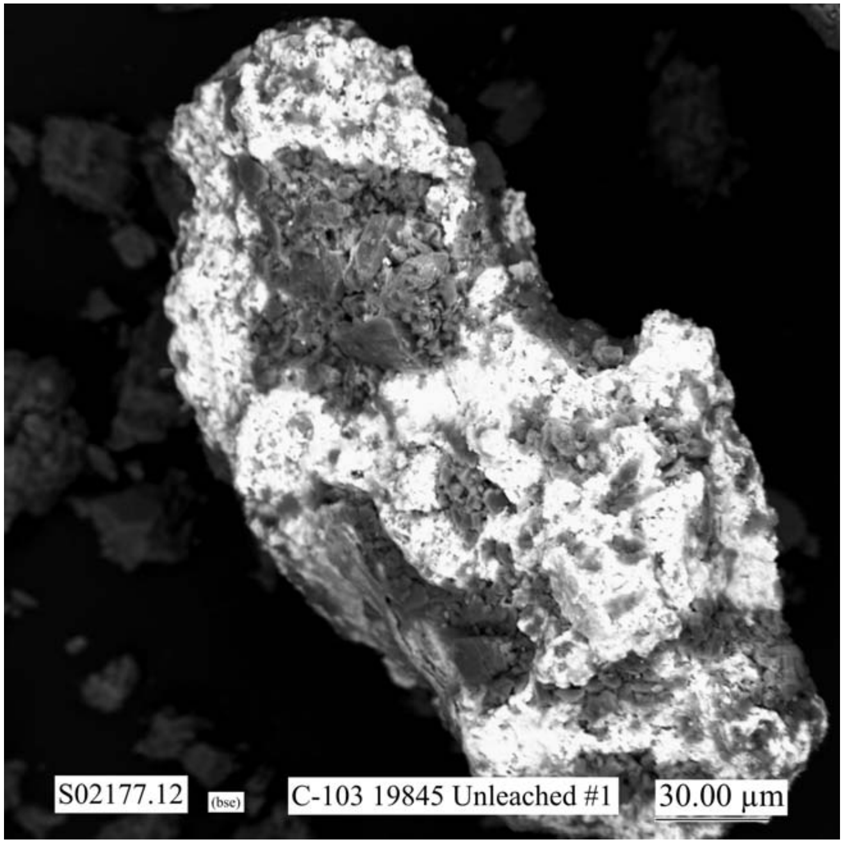

Figure B.6. Micrograph Showing Particle Aggregate in Sample 19845 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures B.15 and B.16.)

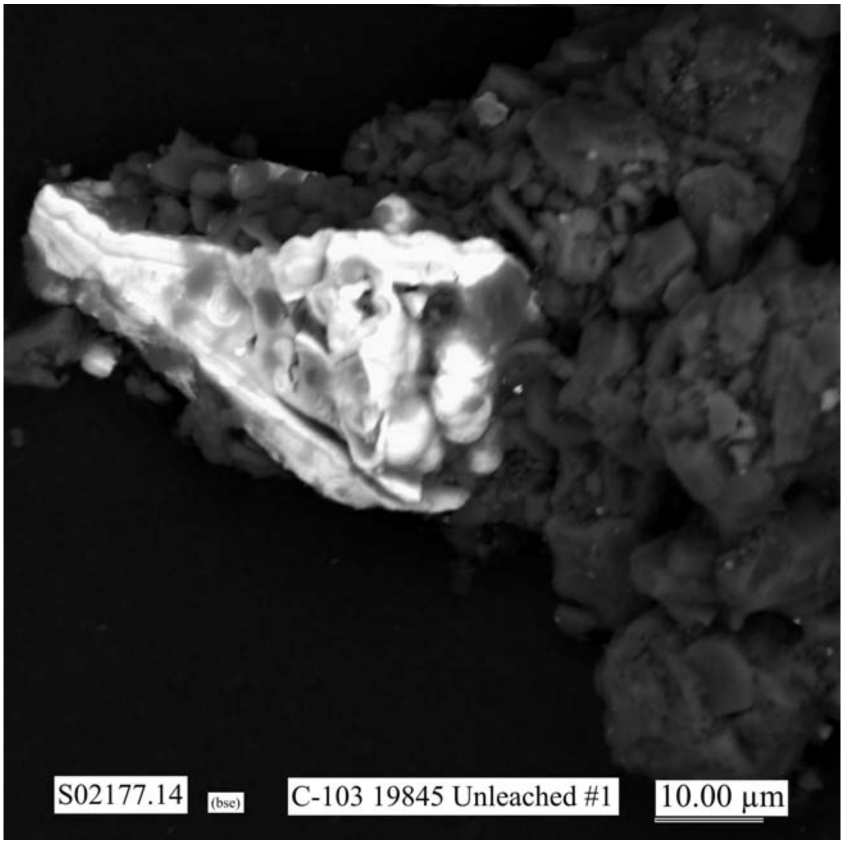

Figure B.7. Micrograph Showing Particle Aggregate in Sample 19845 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.17.)

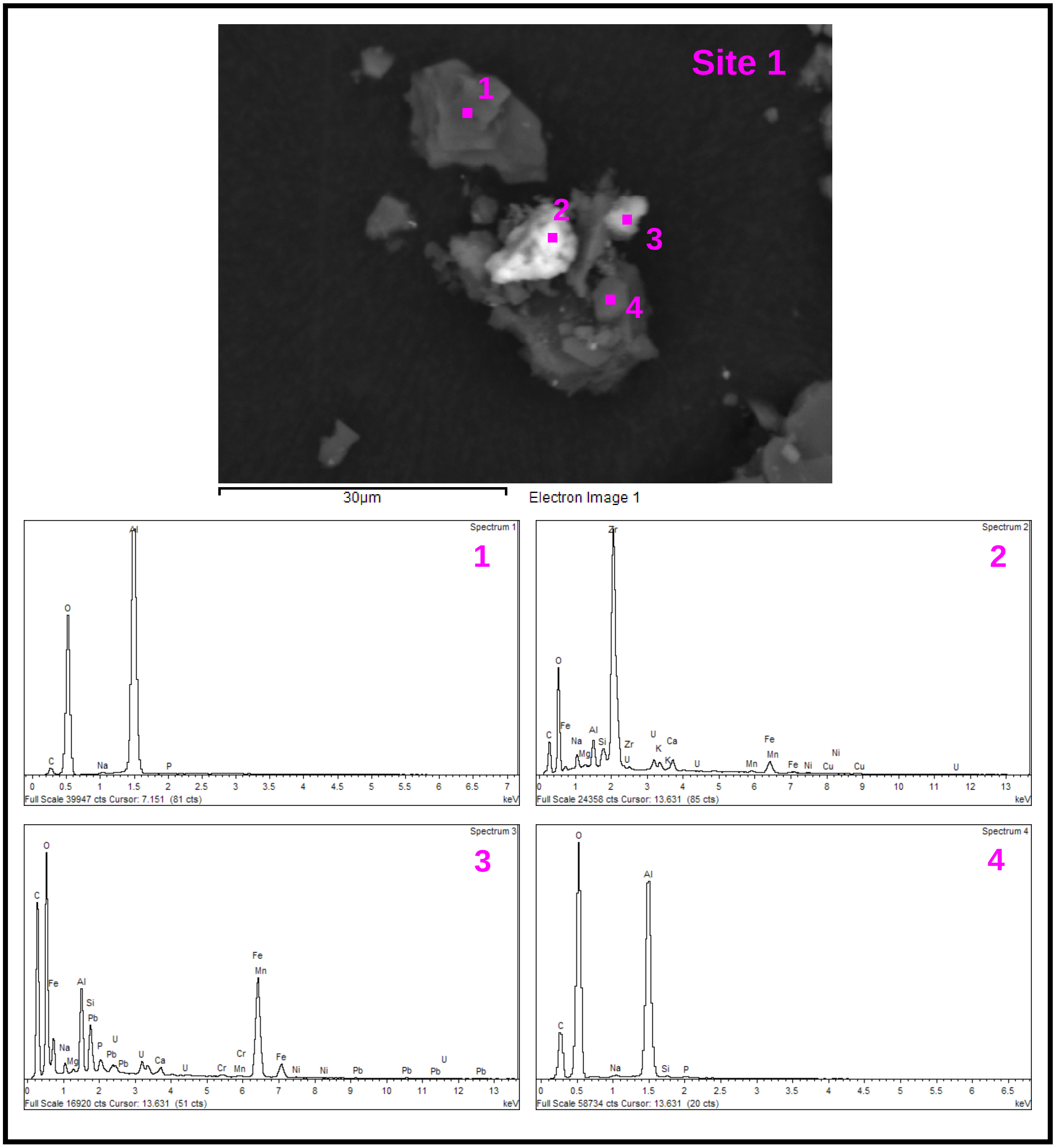

Figure B.8. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

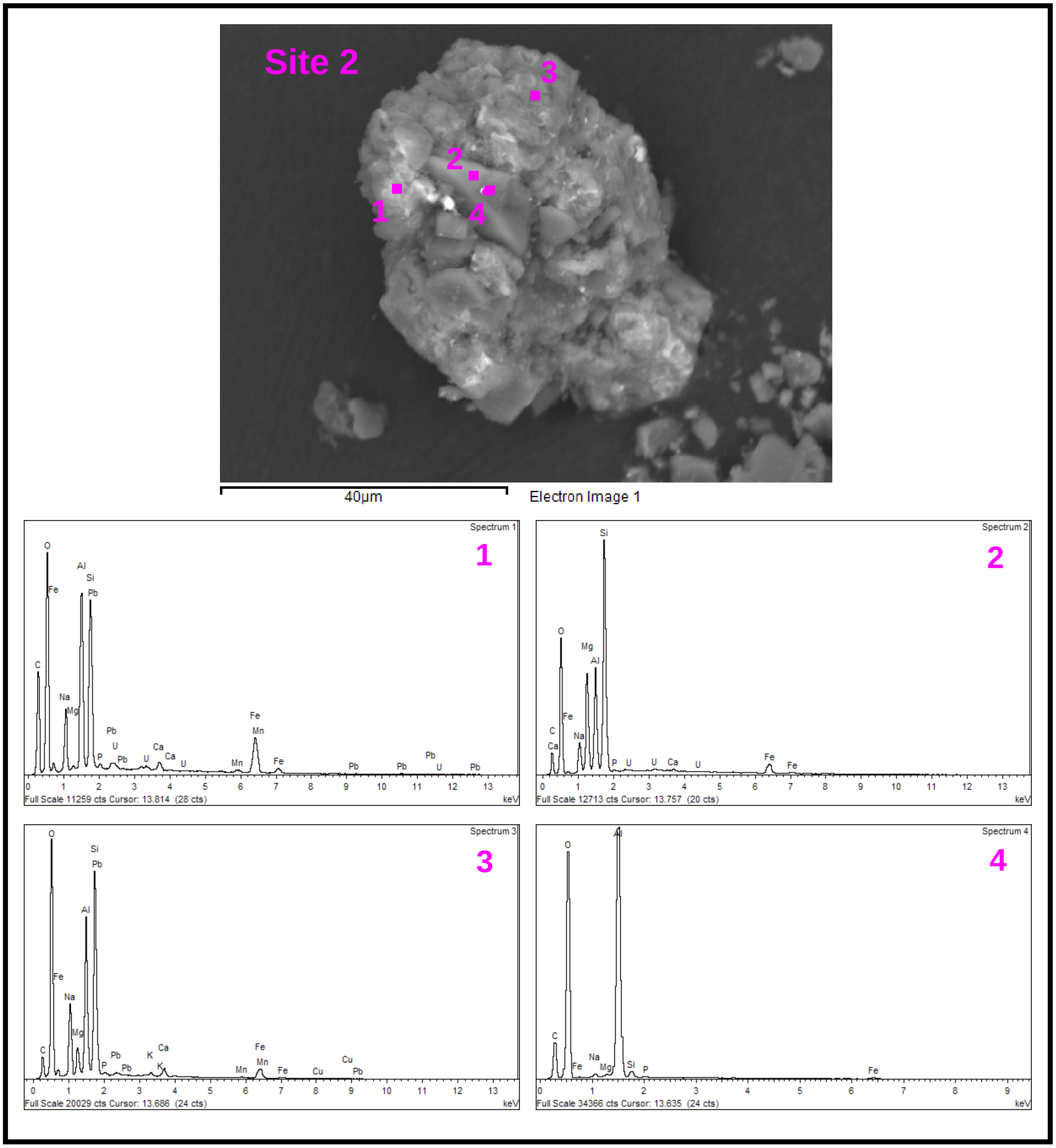

Figure B.9. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

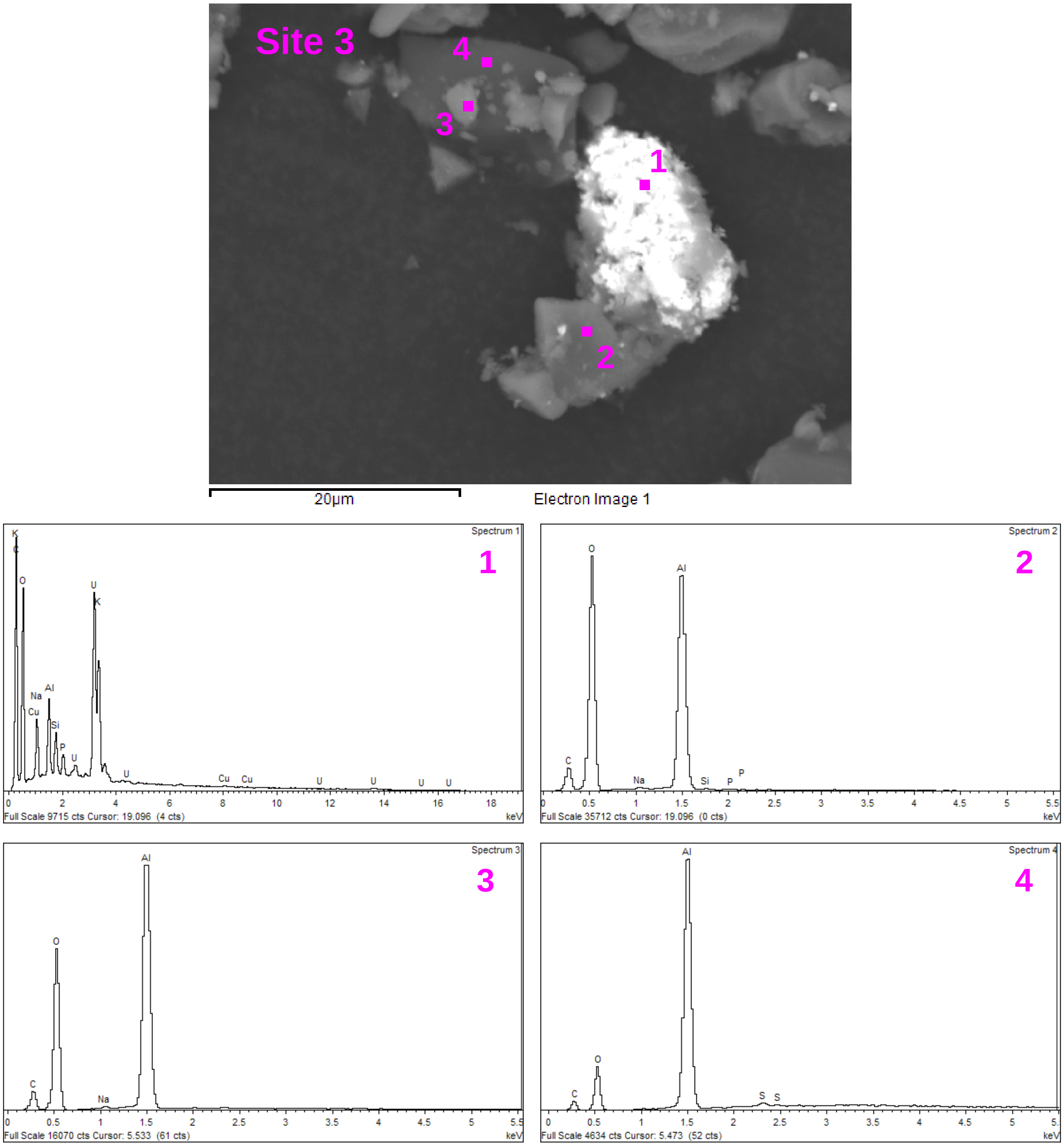

Figure B.10. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

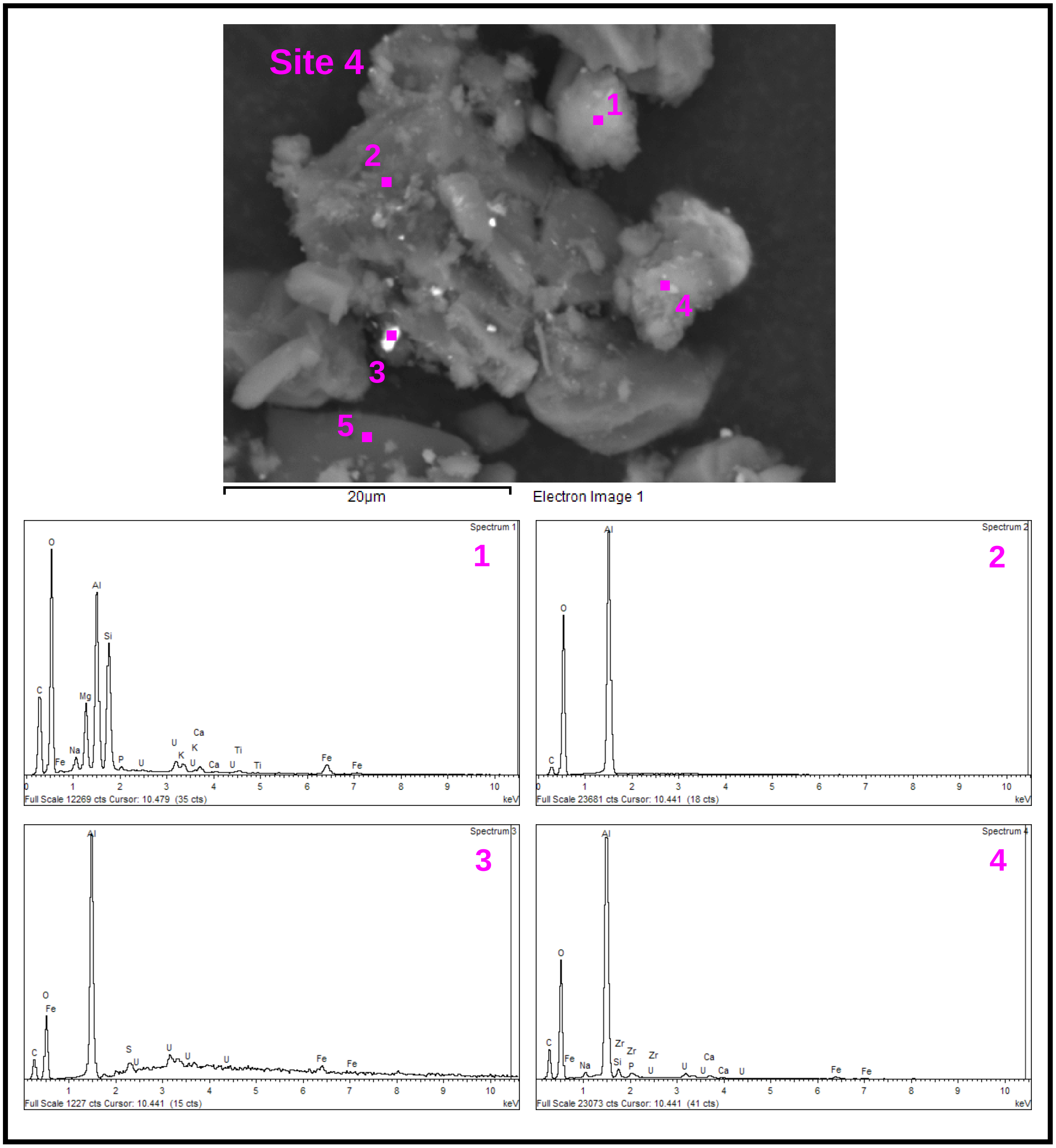

Figure B.11. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

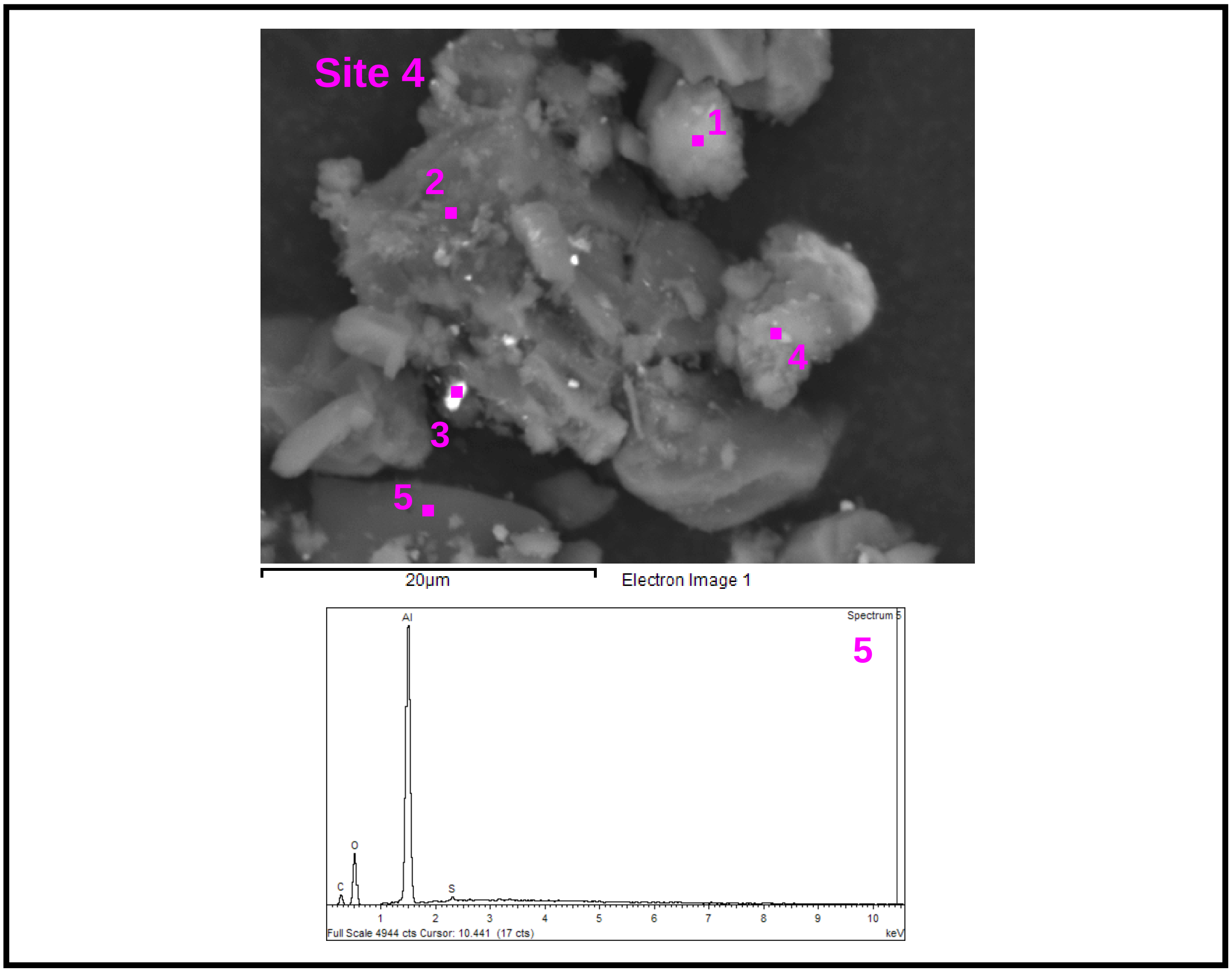

Figure B.12. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

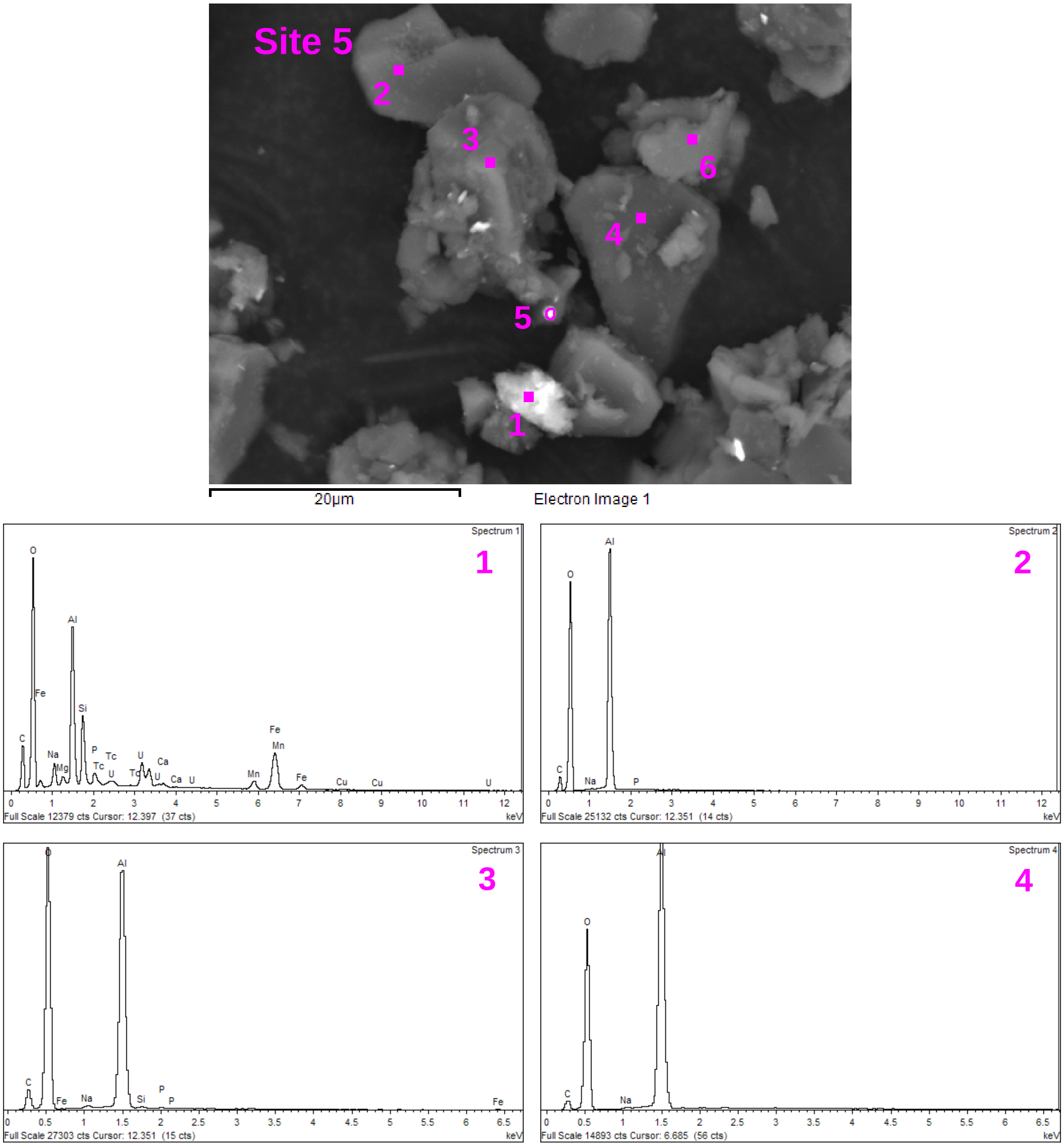

Figure B.13. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

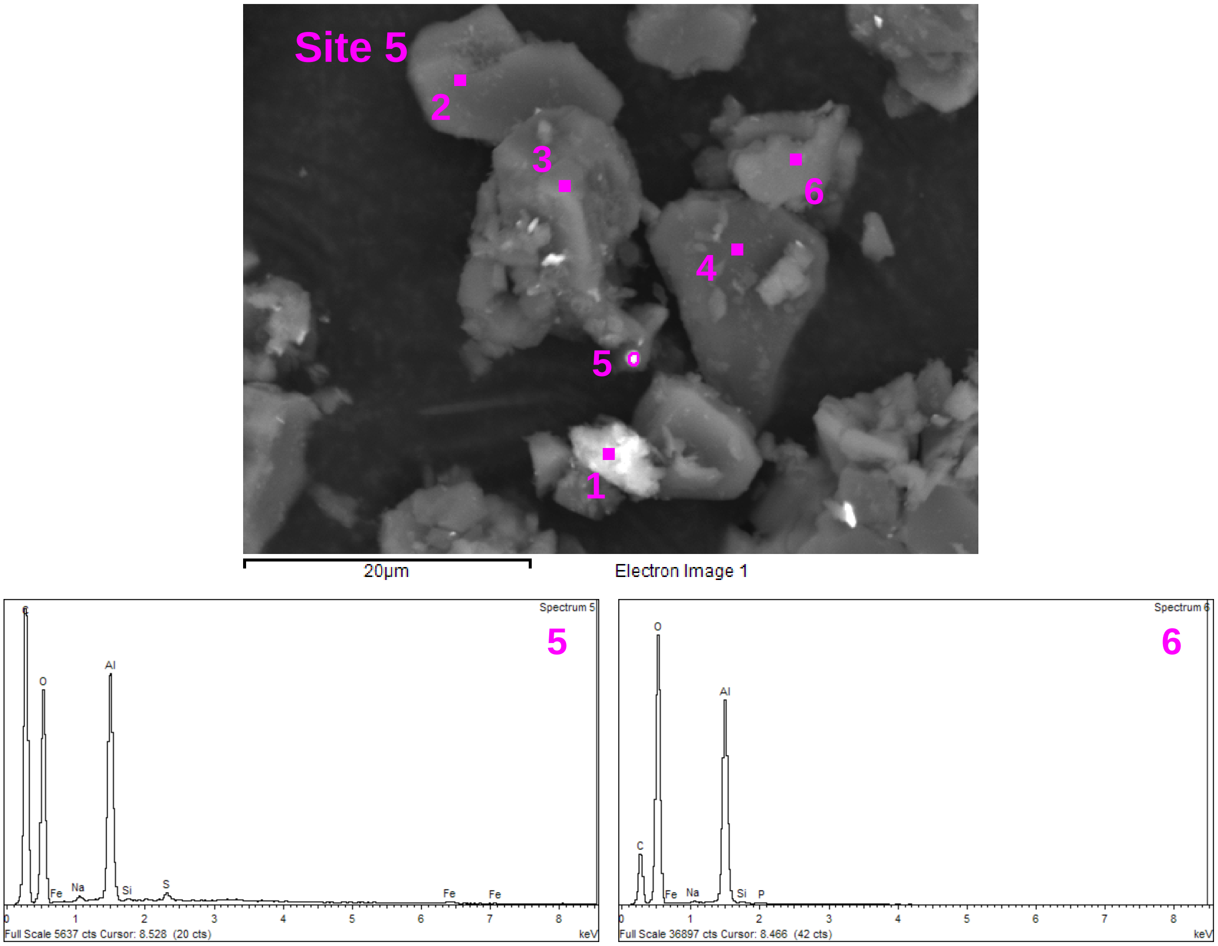

Figure B.14. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

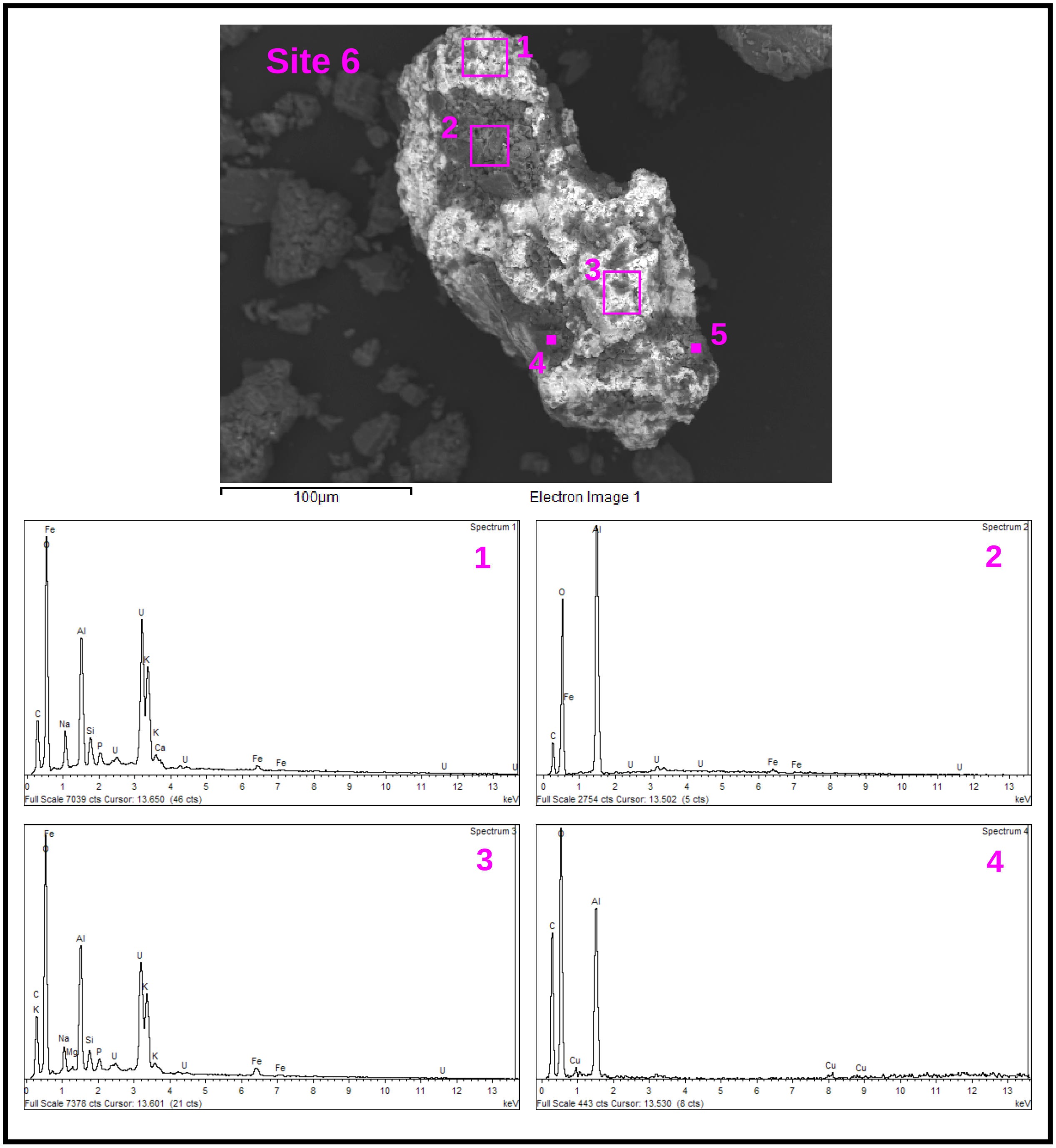

Figure B.15. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

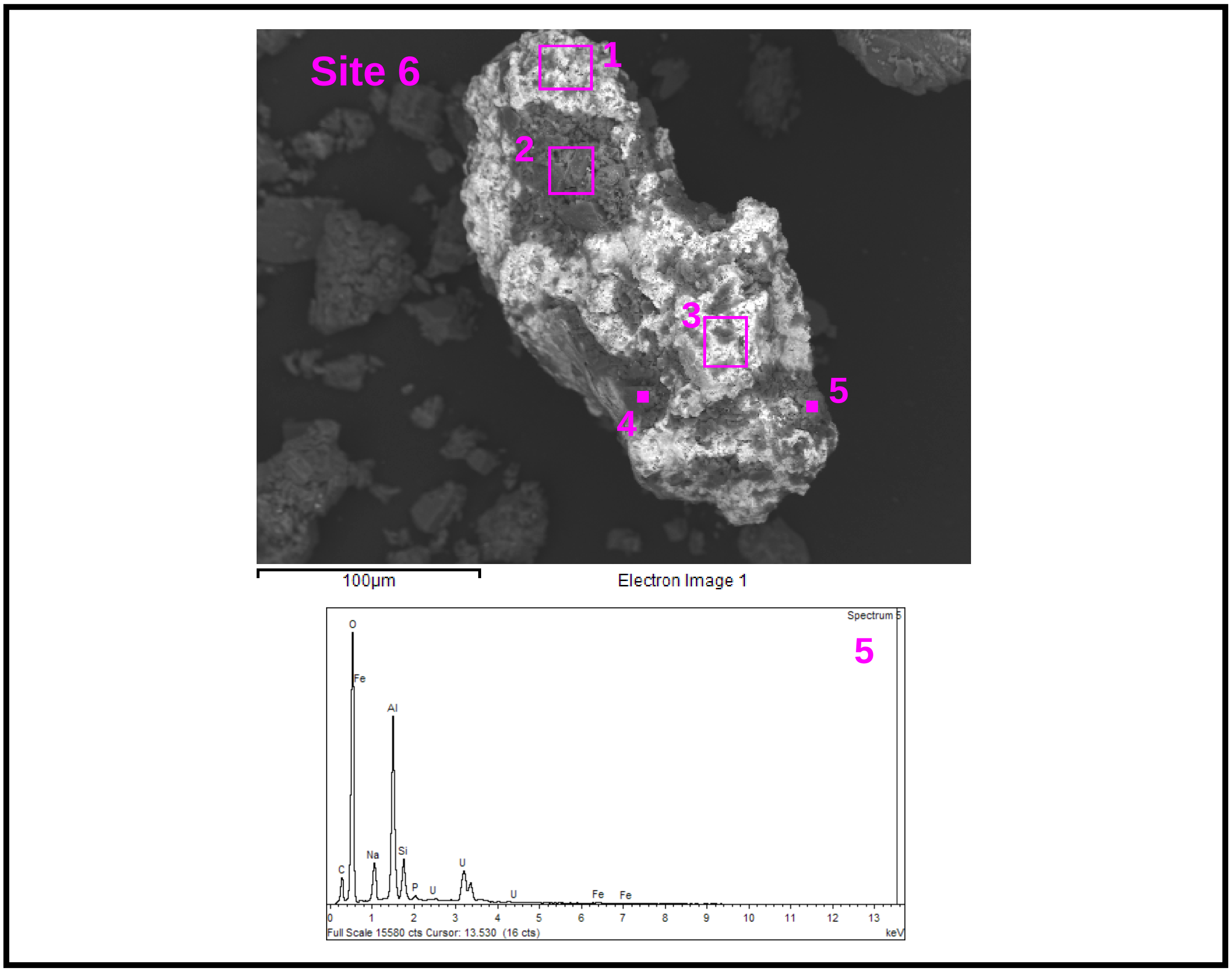

Figure B.16. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

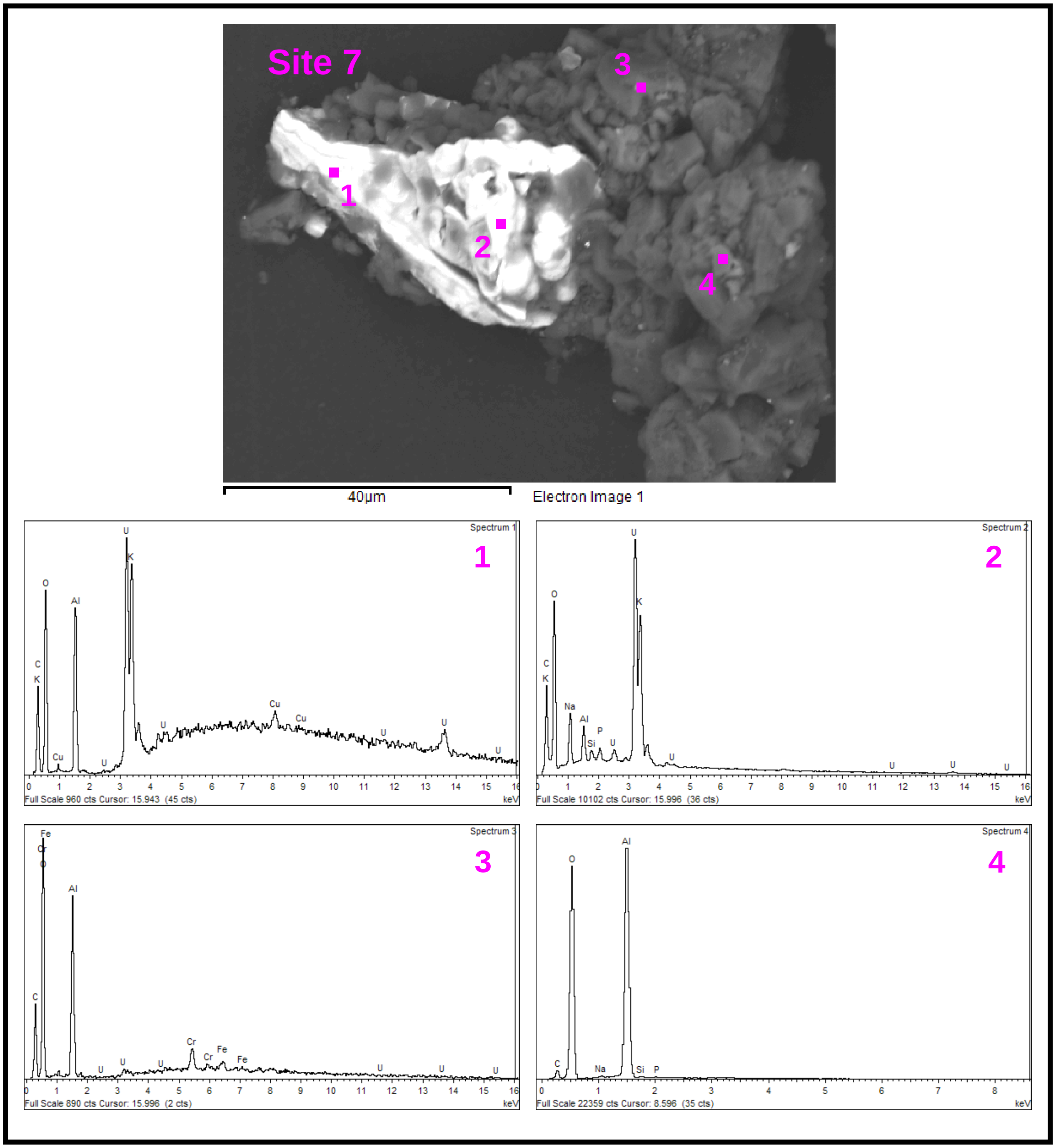

Figure B.17. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of Unleached Residual Waste from Tank C-103

Table B.1. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %(a)**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.8/1	1	35.9		0.2								63.7	0.1	
	2	2.0	0.9	1.9	1.3	4.2	3.2					44.9		Cu (0.4), K (0.2), Mg (0.2), Mn (0.4), Ni (0.2), Zr (40.2)
	3	8.3	4.4	2.1	0.8	4.6	29.9	0.3				45.4	1.0	Mg (0.4), Mn (0.3), Ni (0.3), Pb (2.1)
	4	26.9	0.2	0.5								72.1	0.2	
B.9/2	1	13.8	14.5	8.1	0.9	1.0	10.4					48.3	0.5	Mg (0.3), Mn (0.6), Pb (1.6)
	2	10.6	25.4	4.2	0.3	0.8	3.4					44.6	0.3	Mg (10.3)
	3	12.4	17.5	8.7	0.9		2.9					53.6	0.2	Cu (0.2), K (0.3), Mg (2.5), Mn (0.2), Pb (0.5)
	4	30.2	1.0	0.7			0.7					67.1	0.2	Mg (0.1)
B.10/3	1	5.2	2.6	6.0		44.0						39.9	1.4	Cu (0.5), K (0.4)
	2	28.4	0.2	0.4								70.9	0.1	
	3	35.8		0.5								63.7		
	4	56.7										42.0		S (1.3)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table B.2. Estimated EDS Compositions (atomic%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %[1]**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.11 and B.12 / 4	1	15.2	12.3	1.9	0.6	3.8	3.0					55.7	0.4	K (0.3), Mg (6.3), Ti (0.4)
	2	35.9										64.1		
	3	42.1				10.4	4.8					40.4		S (2.4)
	4	34.9	1.8	1.3	0.4	3.0	1.1					55.6	0.4	Zr (1.5)
	5	54.9										44.0		S (1.1)
B.13 and B.14 / 5	1	14.1	6.6	3.6	0.3	8.4	11.2		0.6			50.6	1.0	Cu (0.4), Mg (0.9), Mn (2.2)
	2	31.6		0.2								68.0	0.2	
	3	28.2	0.2	0.6			0.2					70.5	0.2	Cu (0.2)
	4	35.9		0.3								63.8		
	5	29.1	0.5	1.3			0.9					67.0		S (1.3)
	6	25.8	0.2	0.4			0.1					73.2	0.2	
B.15 and B.16 / 6	1	8.5	1.8	3.9	0.5	36.3	1.1					46.5	0.9	K (0.6)
	2	32.6				3.5	1.8					62.0		
	3	9.5	1.4	3.1		31.1	1.9					51.0	0.9	K (0.8), Mg (0.3)
	4	23.7										72.2		Cu (4.1)
	5	16.5	4.3	5.5		11.9	0.4					60.9	0.5	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

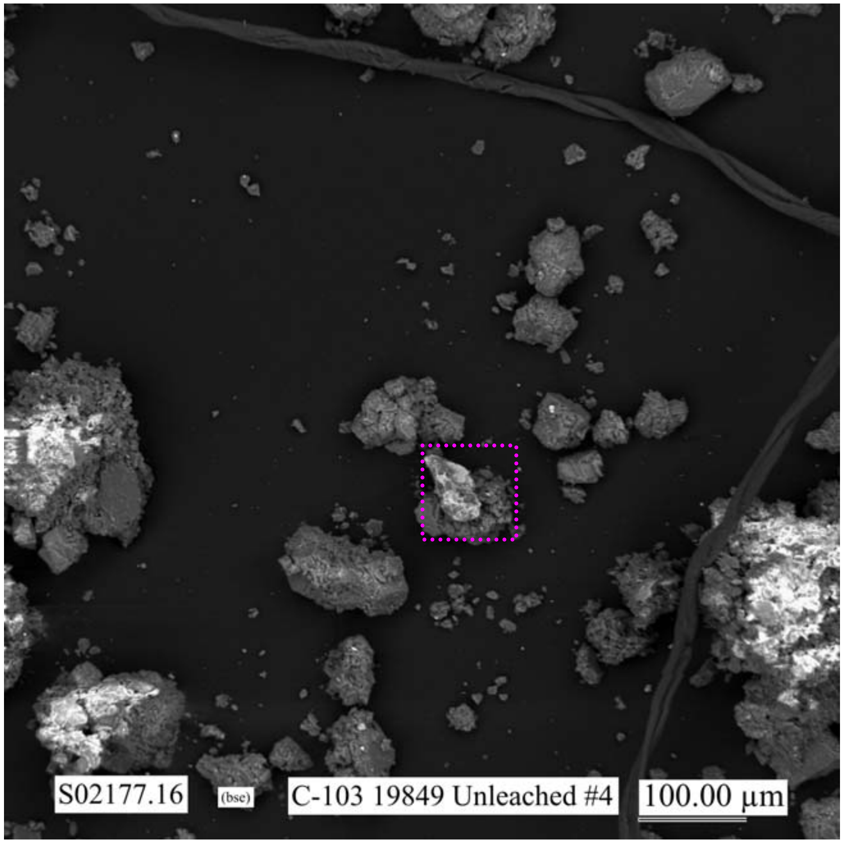

Figure B.18. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103 (Long fibers at top and on right side of micrograph are impurities introduced during preparation of the sample mount.)

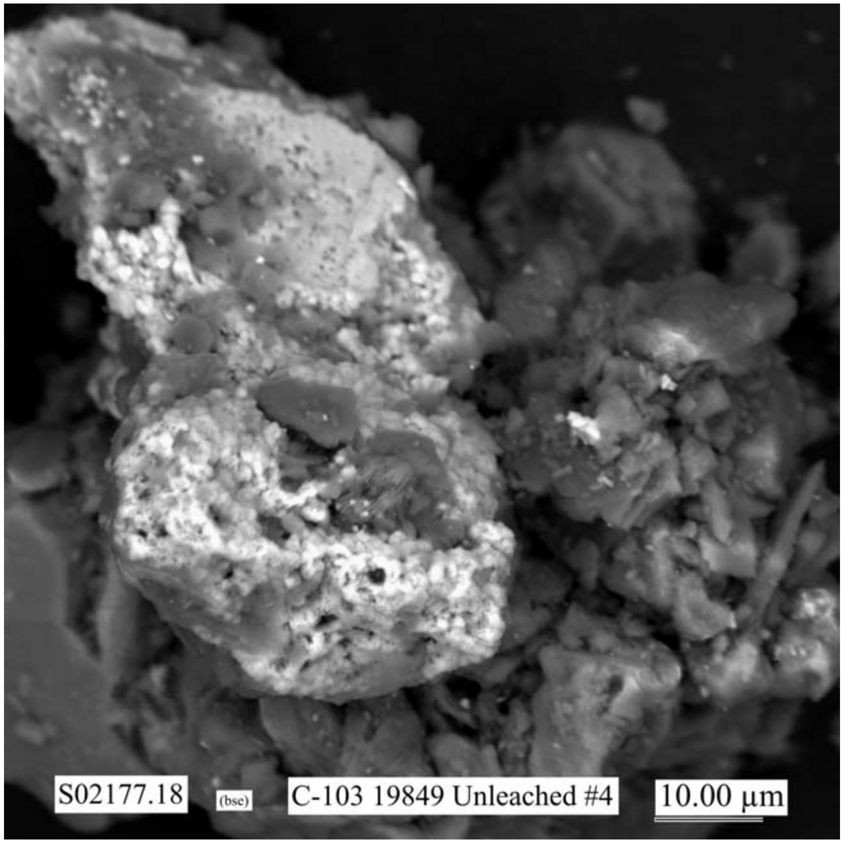

Figure B.19. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square in Figure B.18 (Areas where EDS analyses were made are shown in Figures B.32 and B.33.)

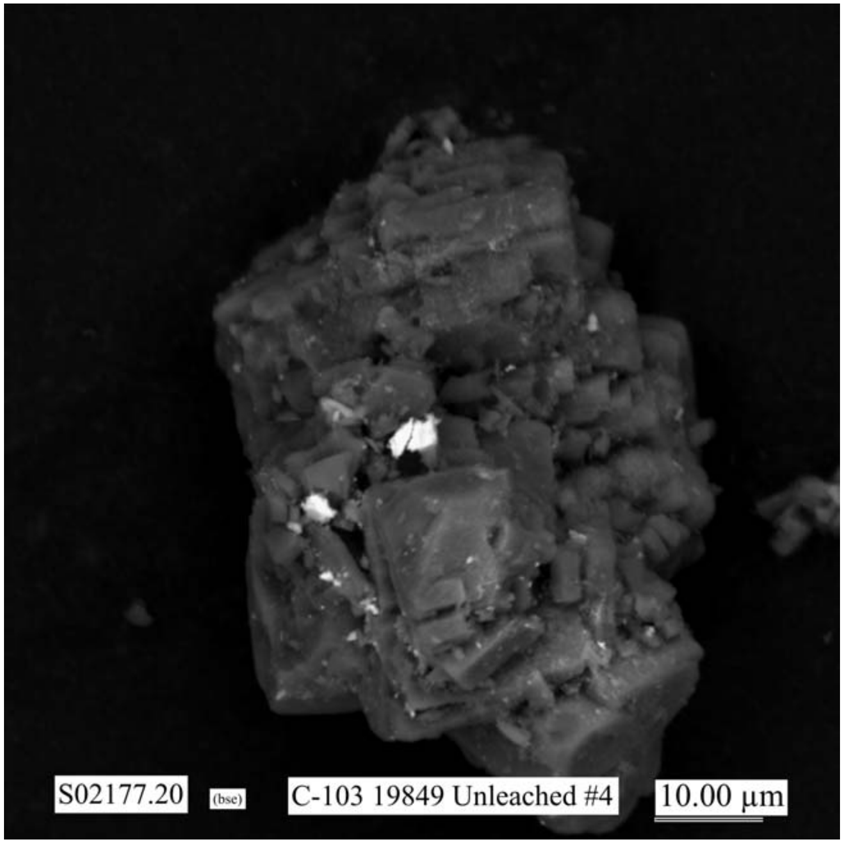

Figure B.20. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.34.)

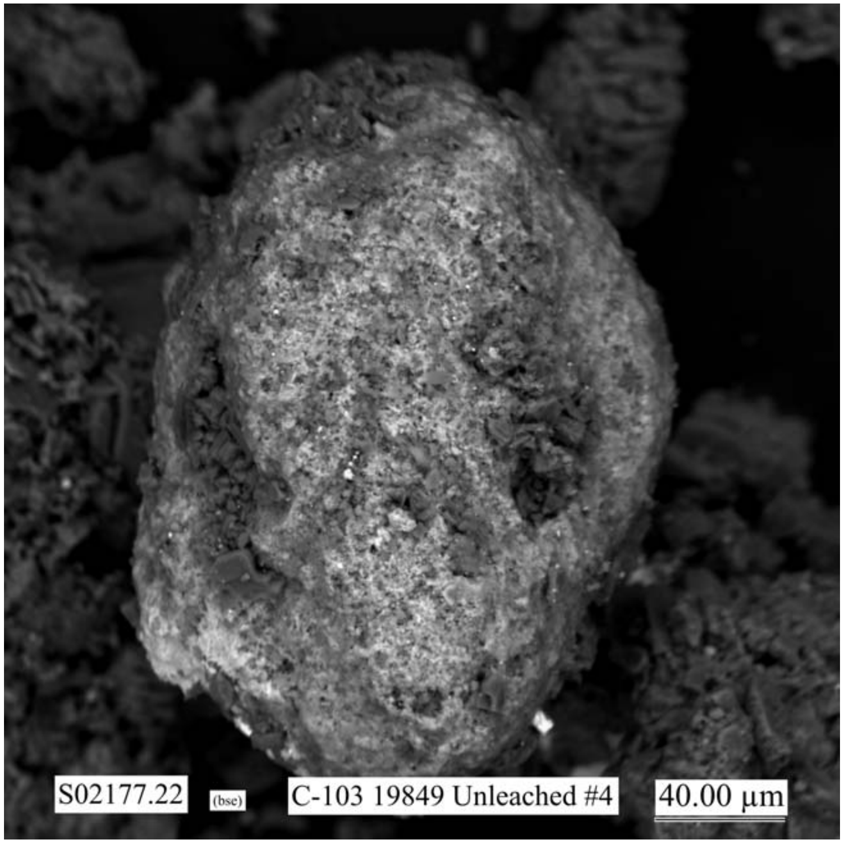

Figure B.21. Micrograph Showing Particle Aggregates in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.35.)

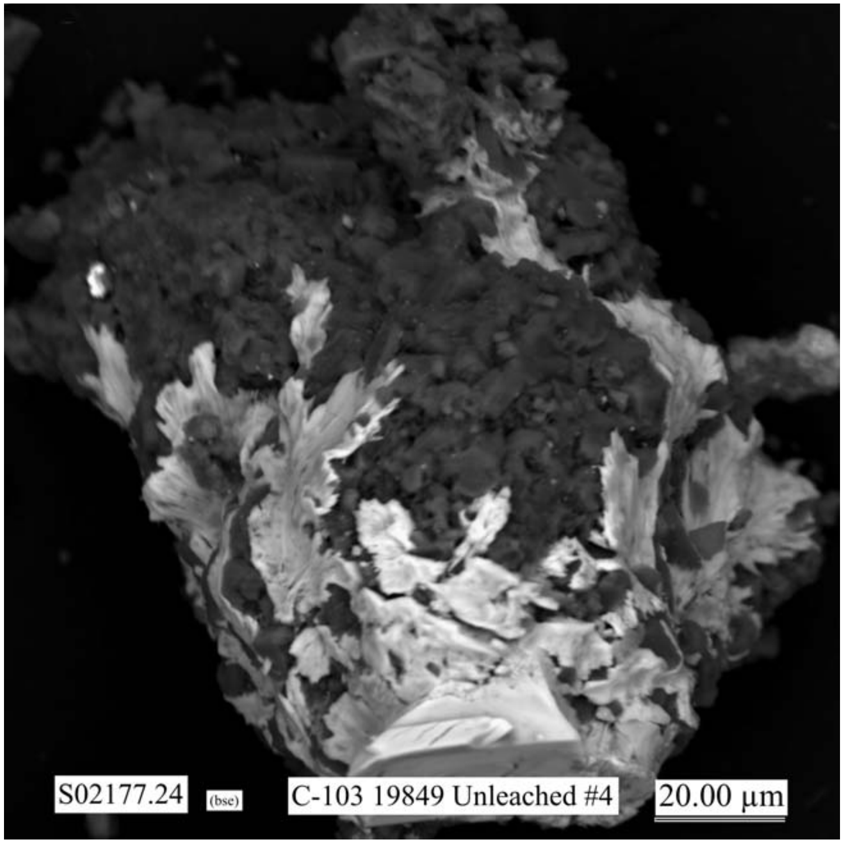

Figure B.22. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.36.)

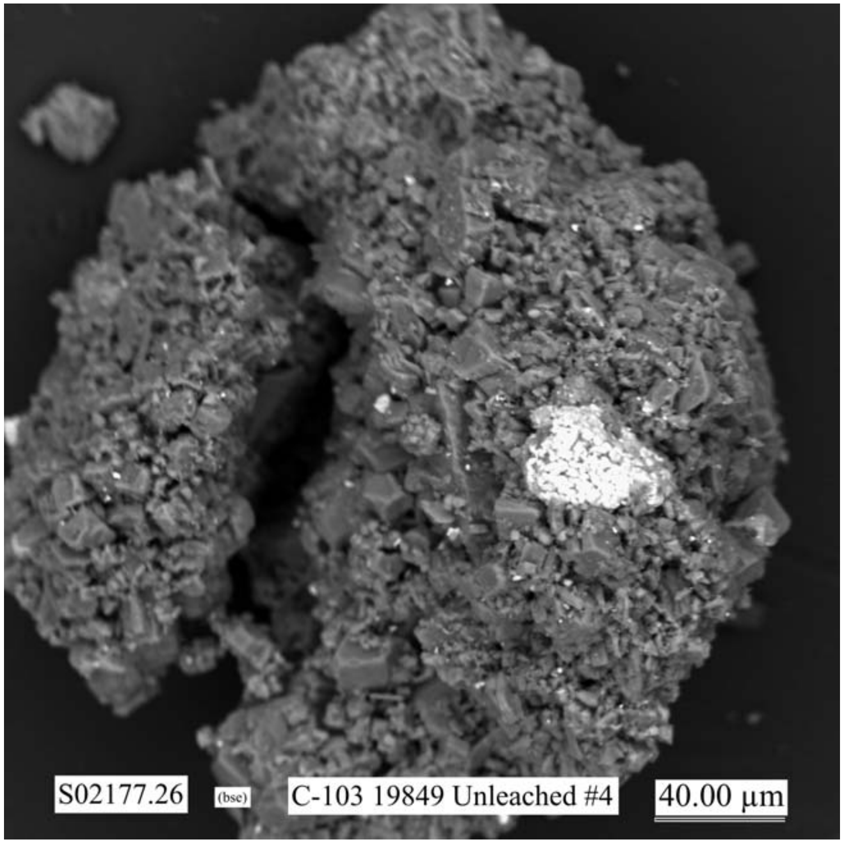

Figure B.23. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.37.)

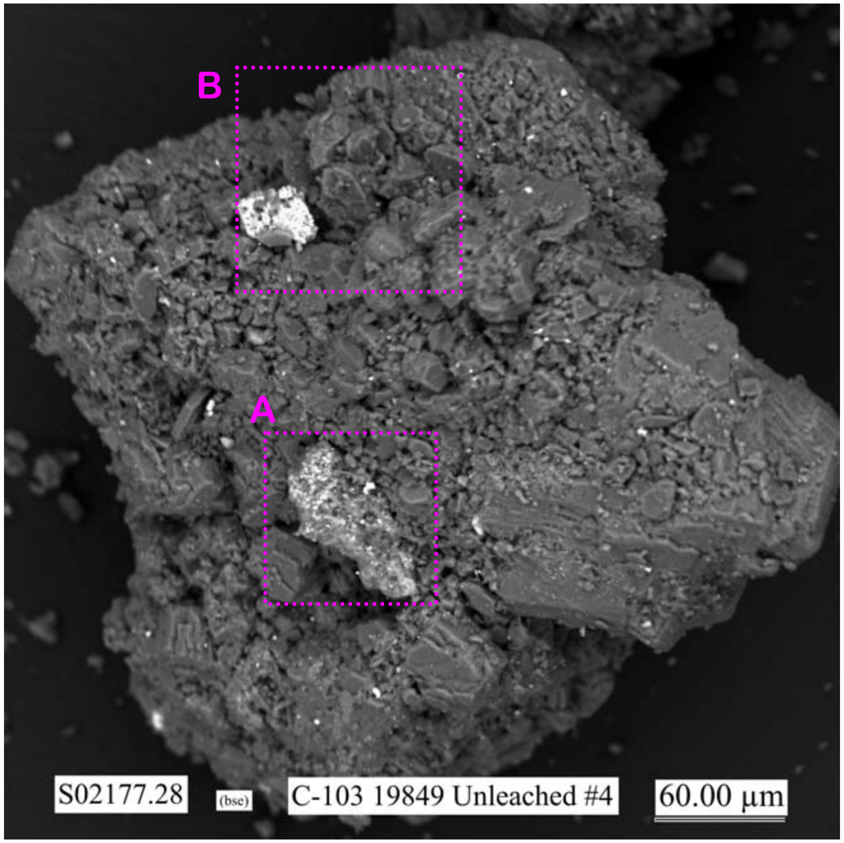

Figure B.24. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103

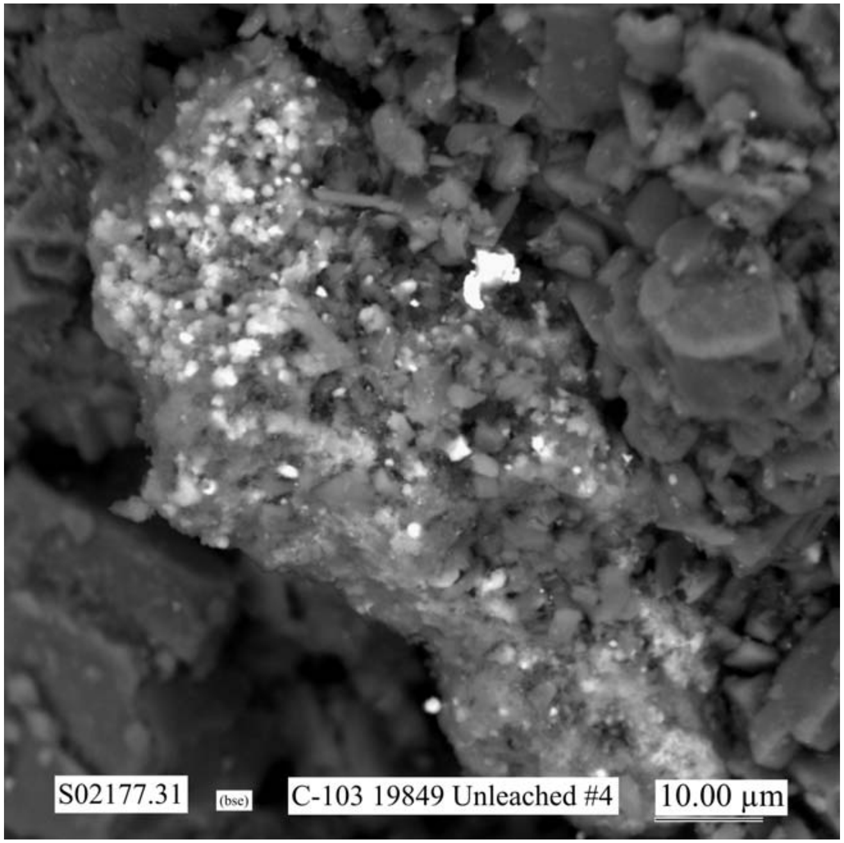

Figure B.25. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square A in Figure B.24 (Areas where EDS analyses were made are shown in Figure B.39.)

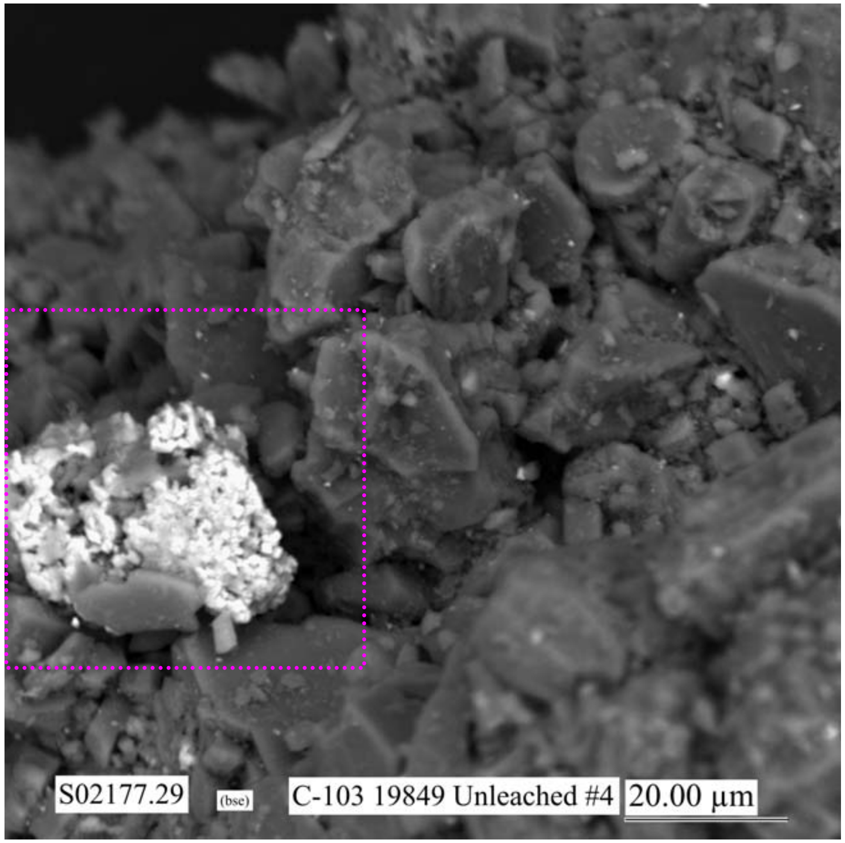

Figure B.26. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square B in Figure B.24 (Areas where EDS analyses were made are shown in Figure B.38.)

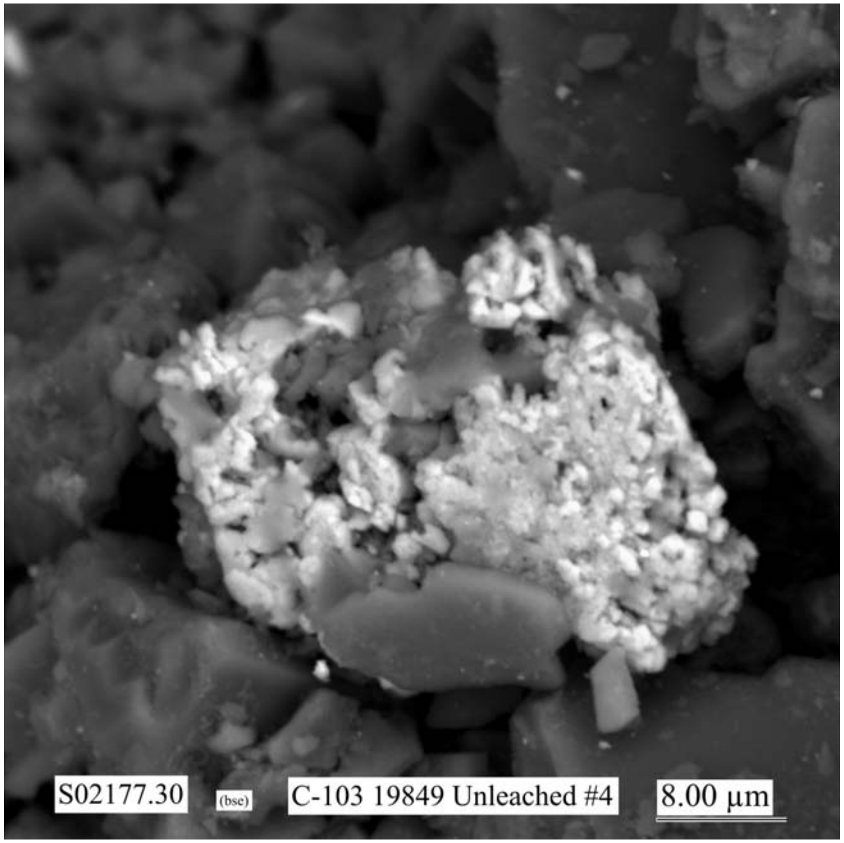

Figure B.27. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square in Figure B.26 (Areas where EDS analyses were made are shown in Figure B.38.)

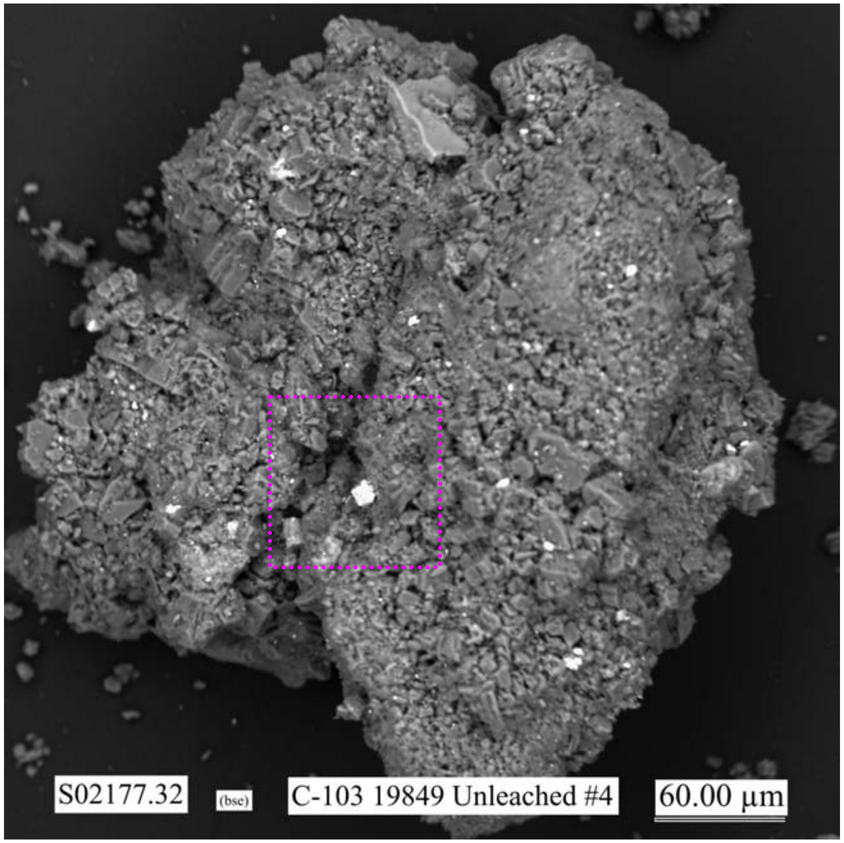

Figure B.28. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103

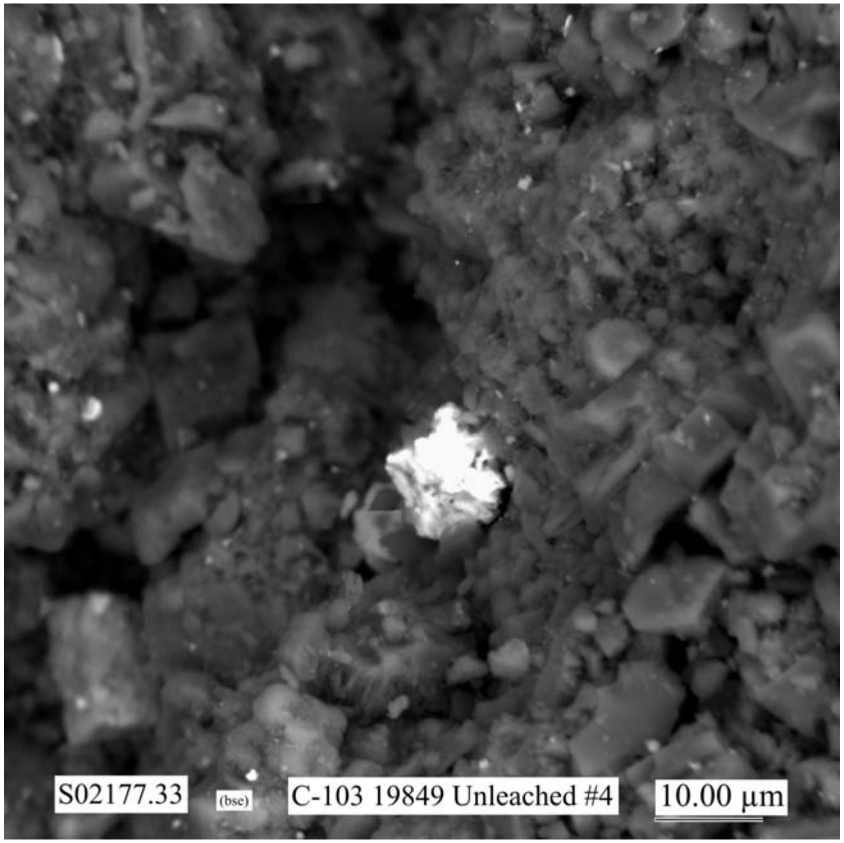

Figure B.29. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square in Figure B.28 (Areas where EDS analyses were made are shown in Figure B.40.)

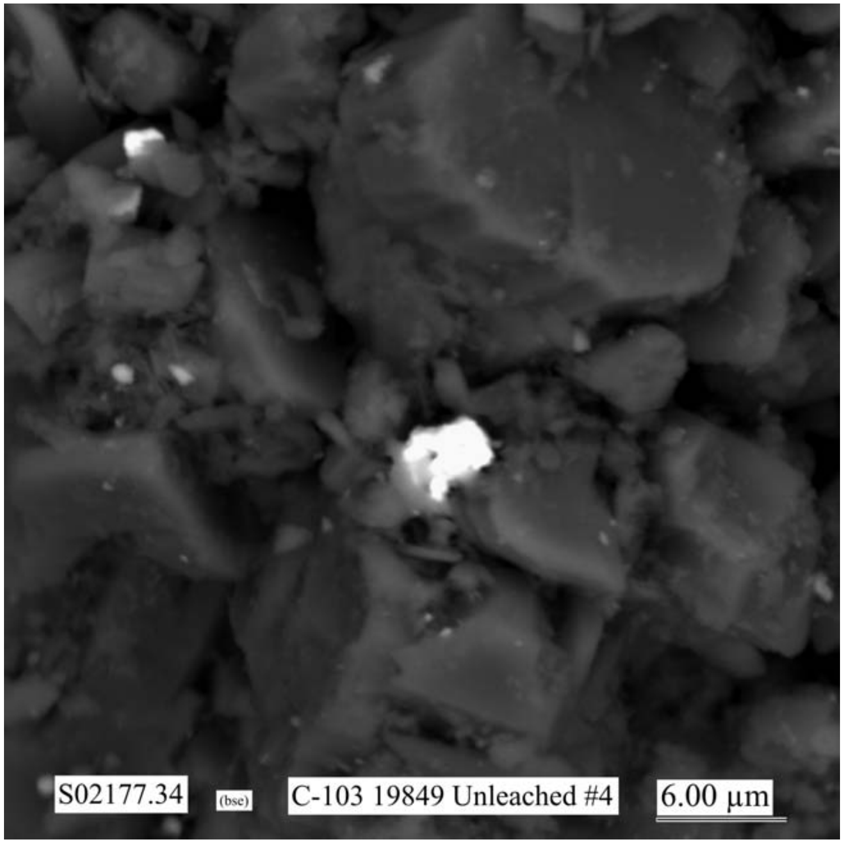

Figure B.30. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.41.)

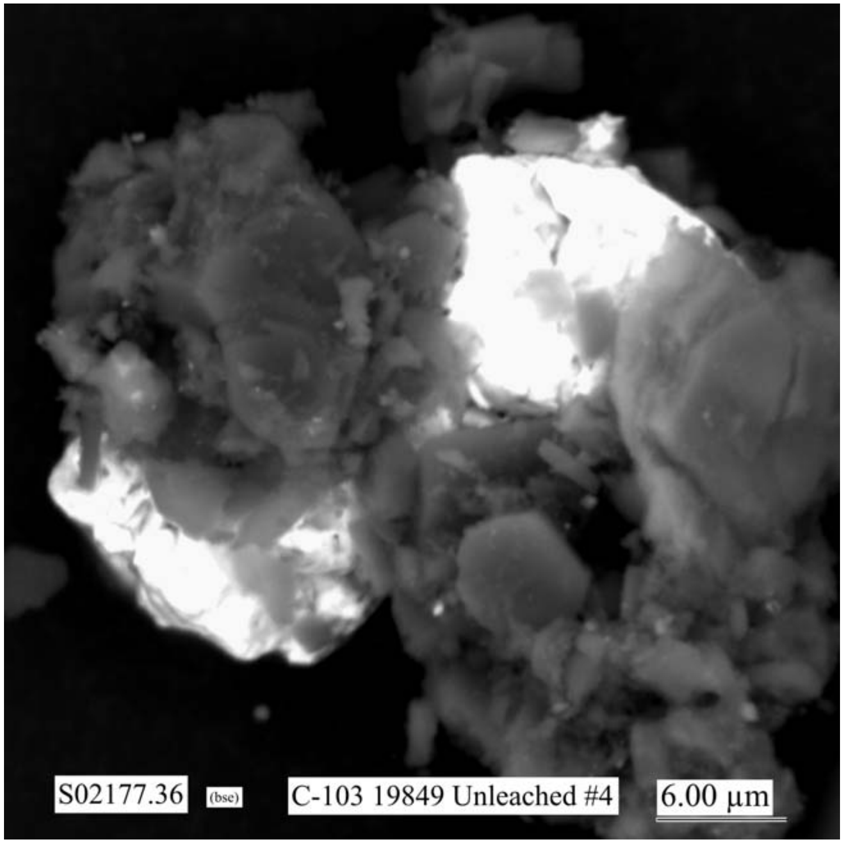

Figure B.31. Micrograph Showing Particle Aggregate in Sample 19849 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures B.42 and B.43.)

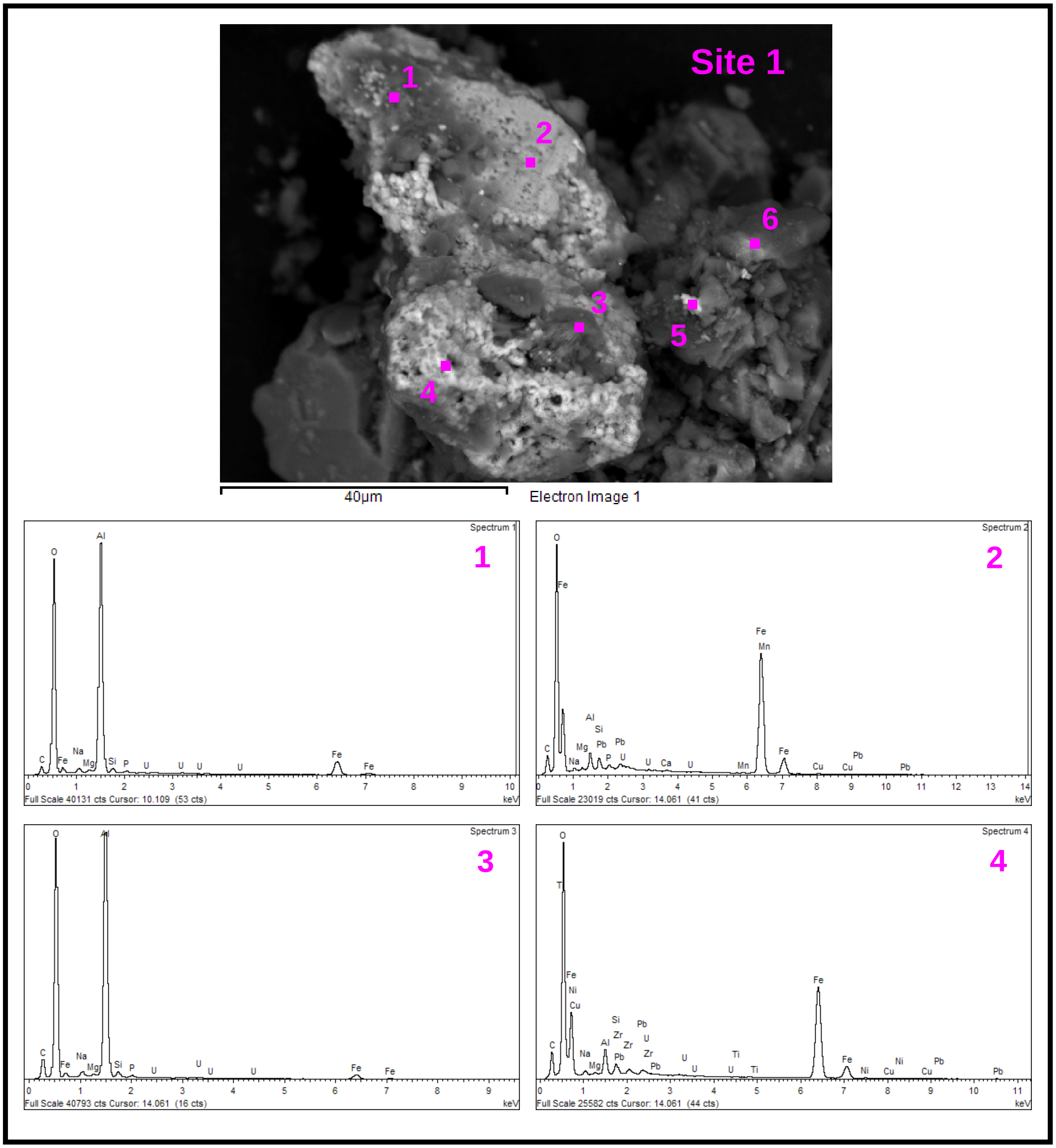

Figure B.32. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

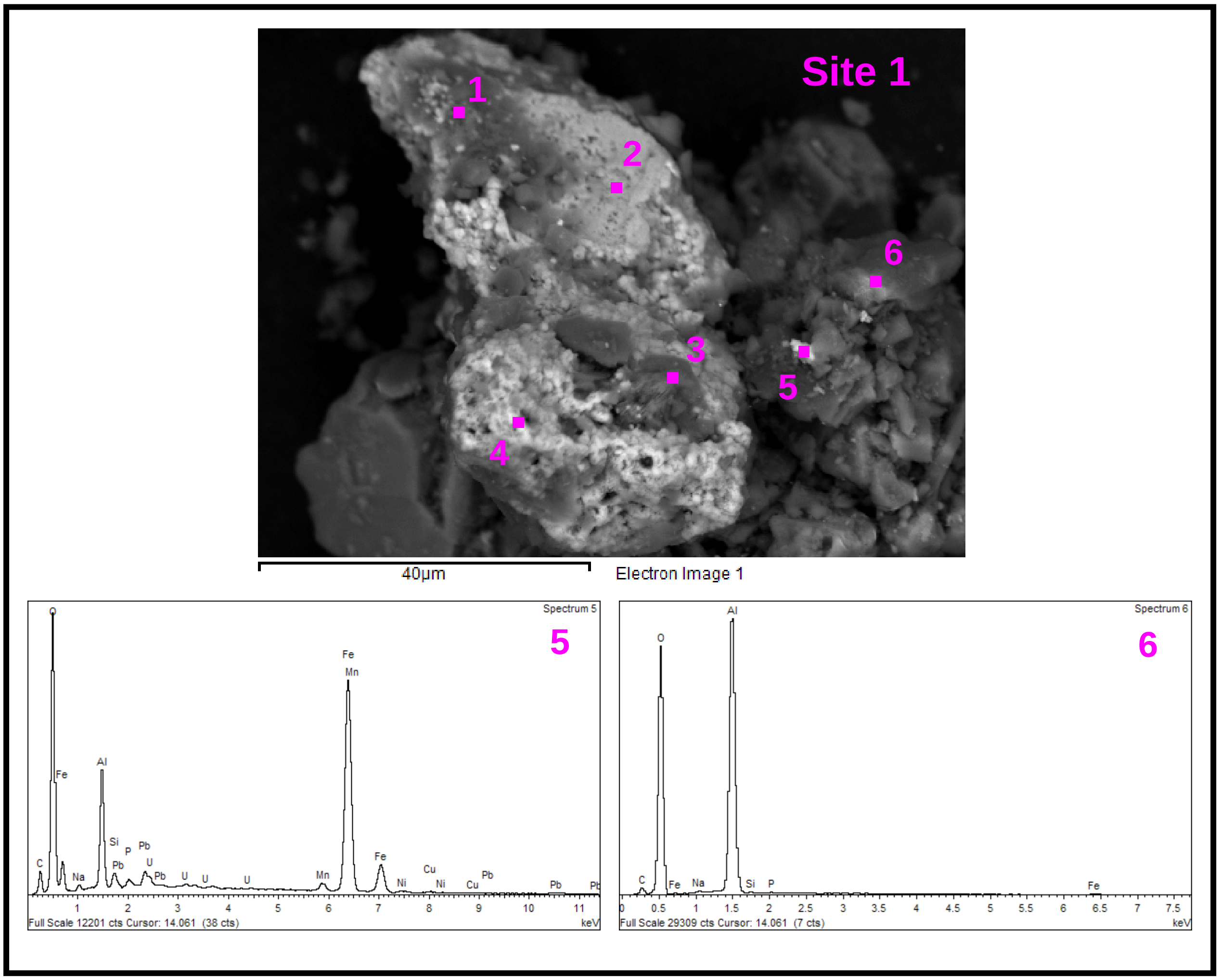

Figure B.33. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

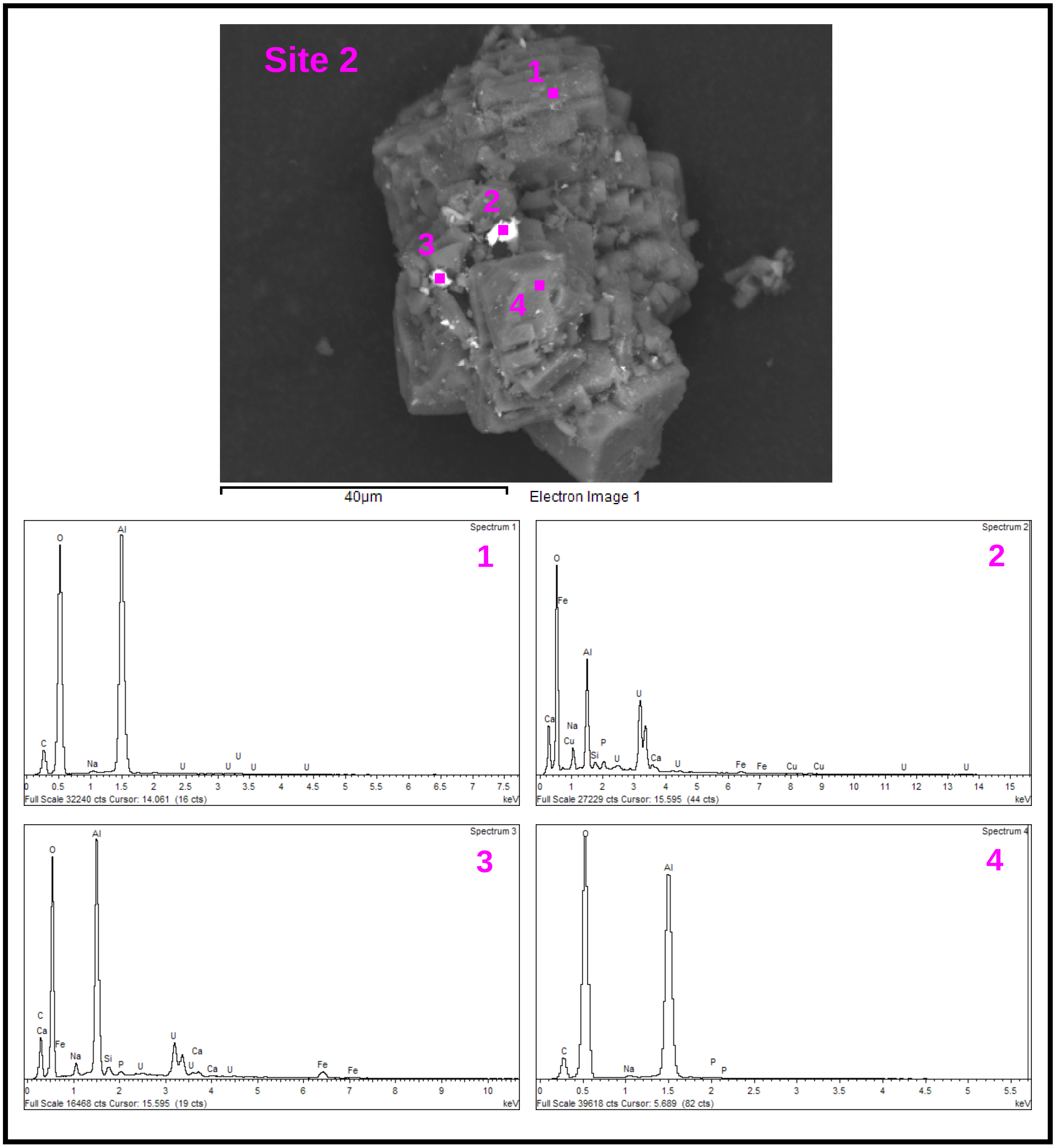

Figure B.34. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

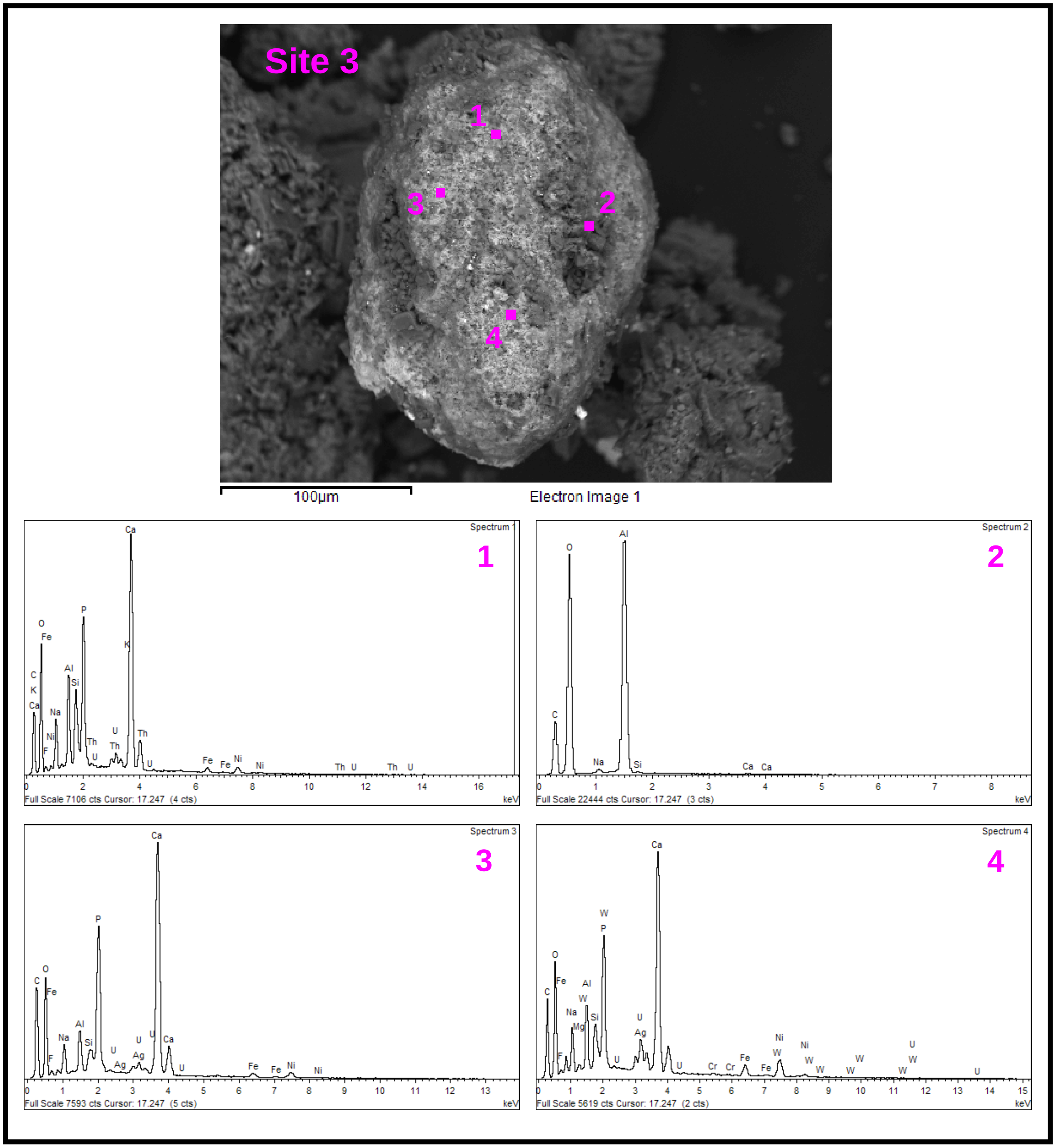

Figure B.35. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

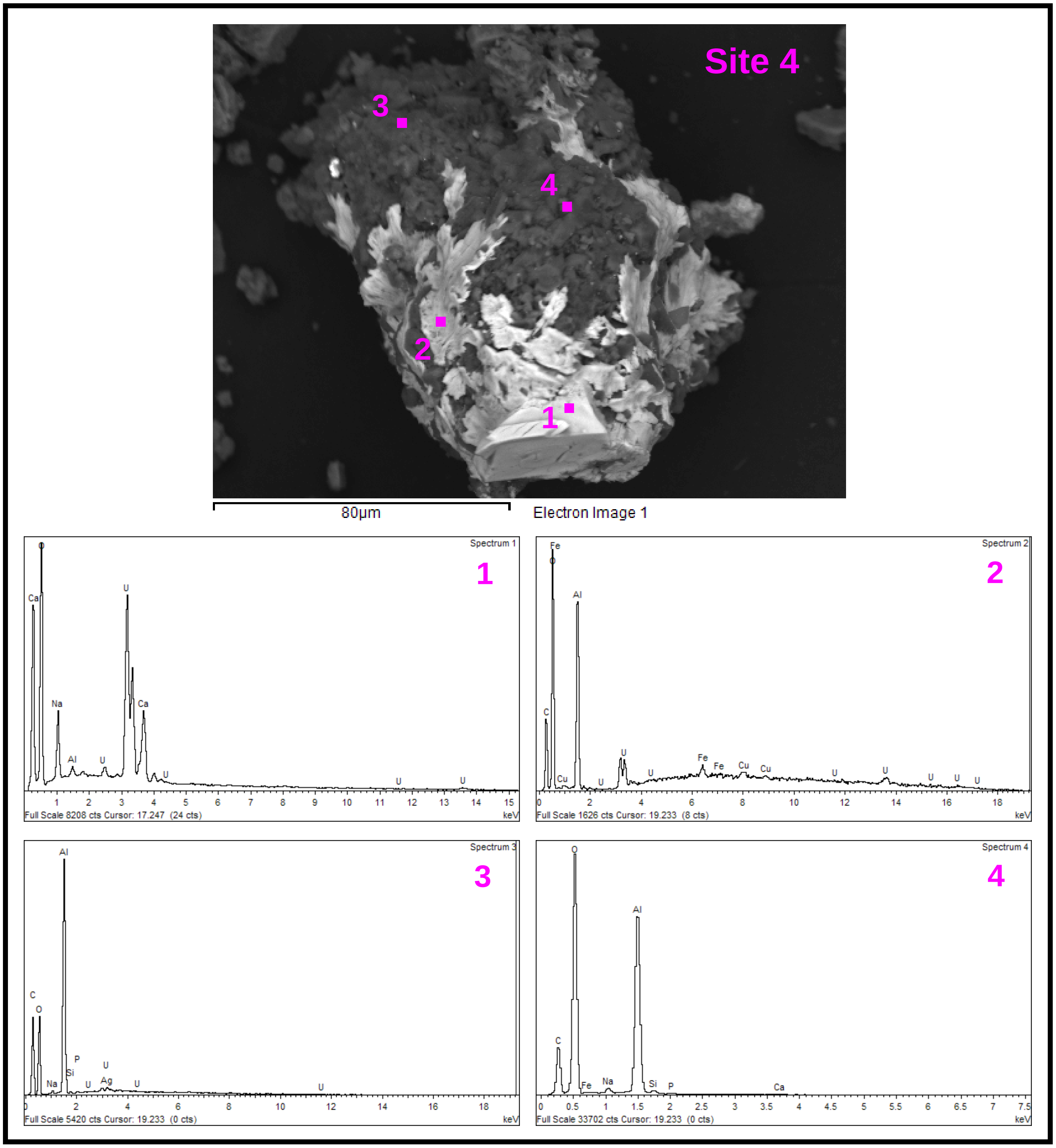

Figure B.36. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

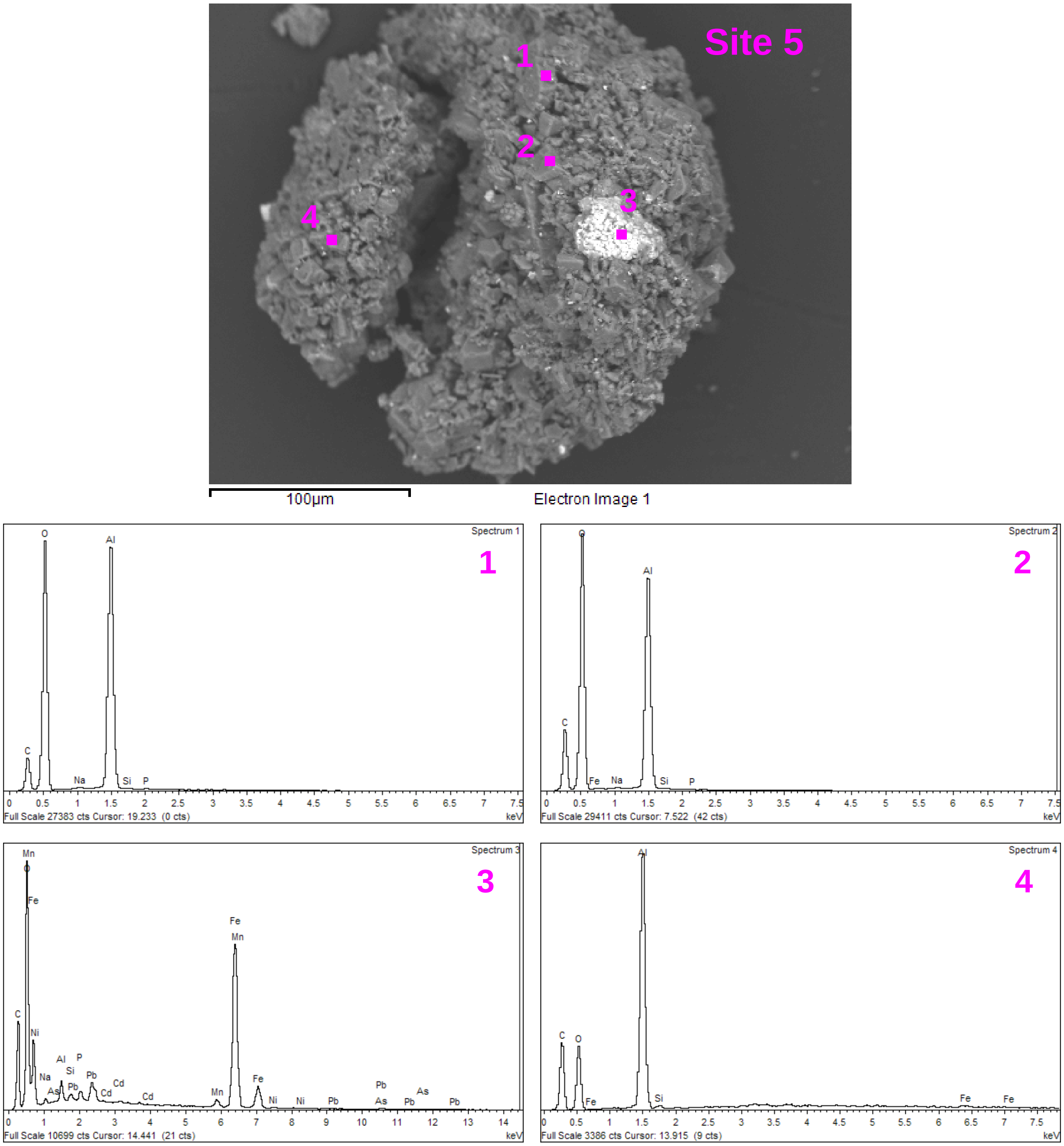

Figure B.37. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

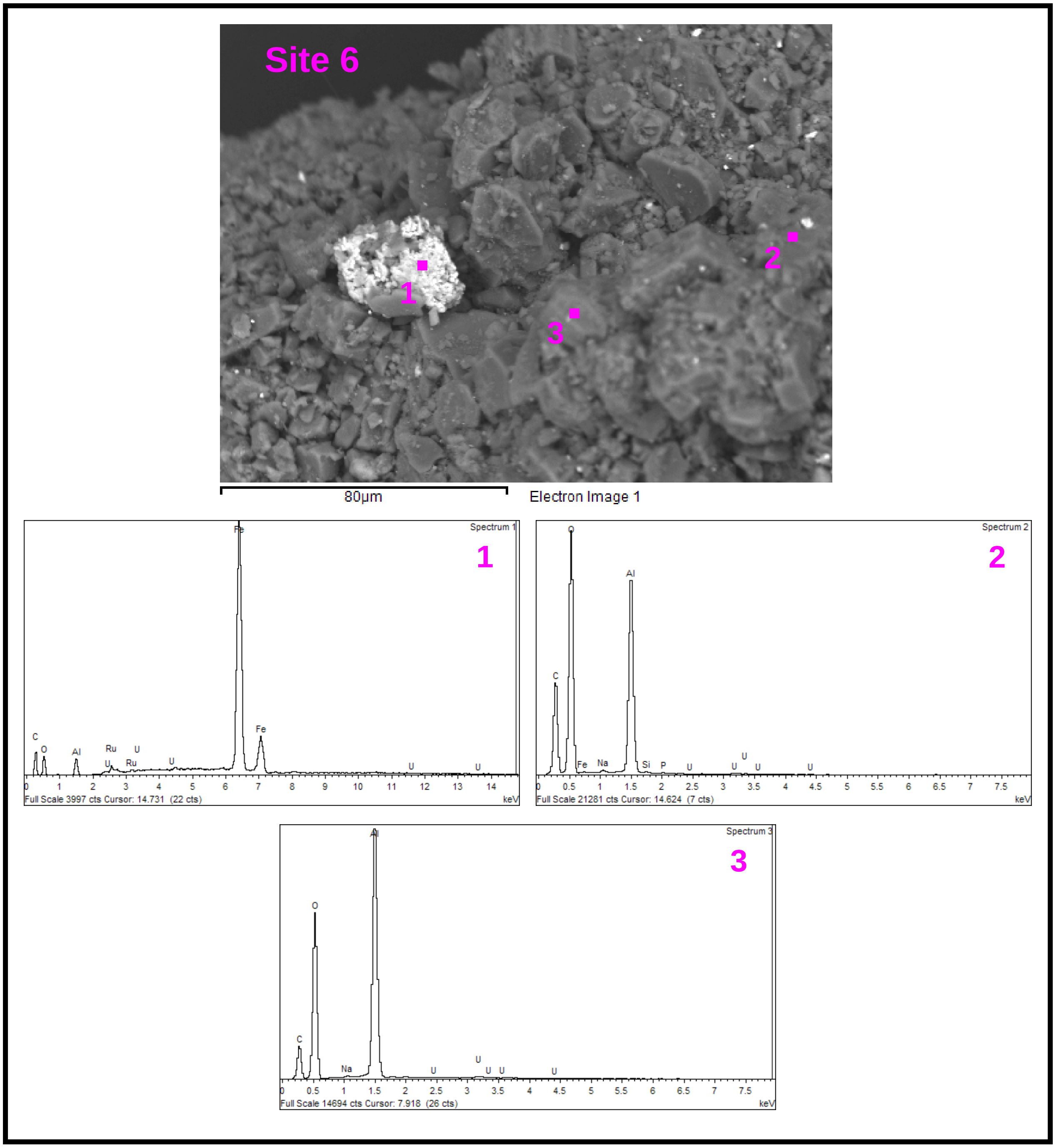

Figure B.38. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

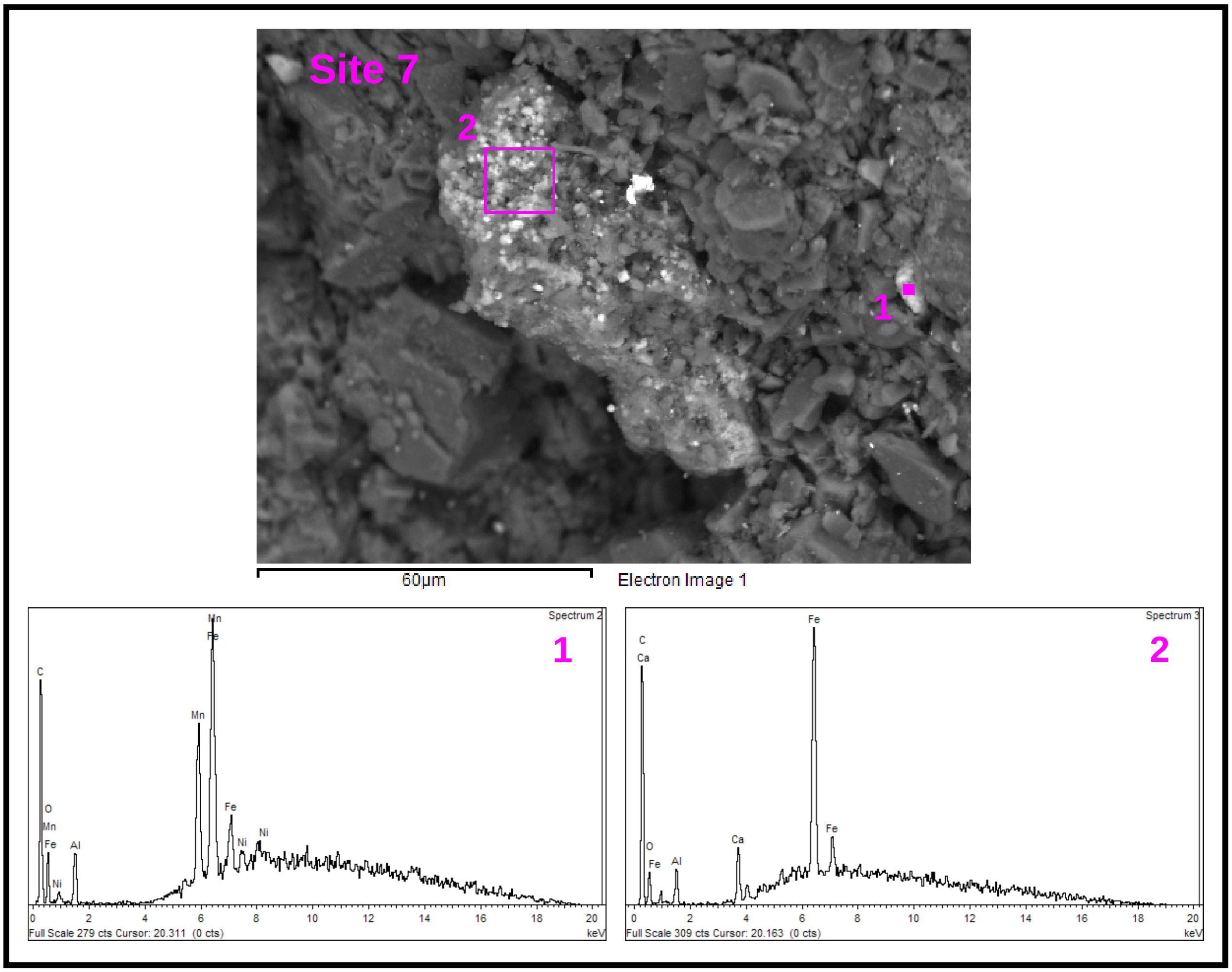

Figure B.39. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

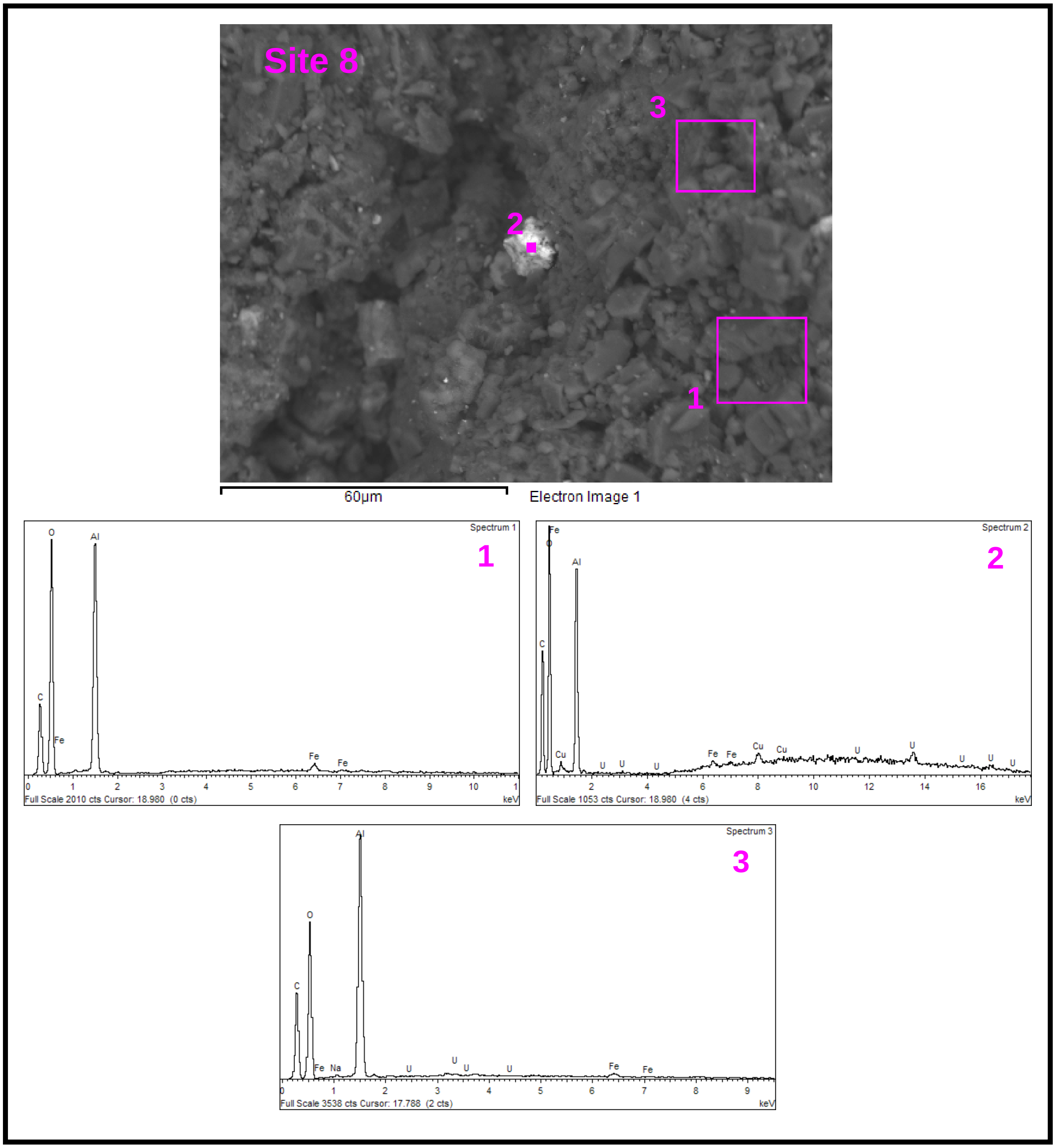

Figure B.40. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

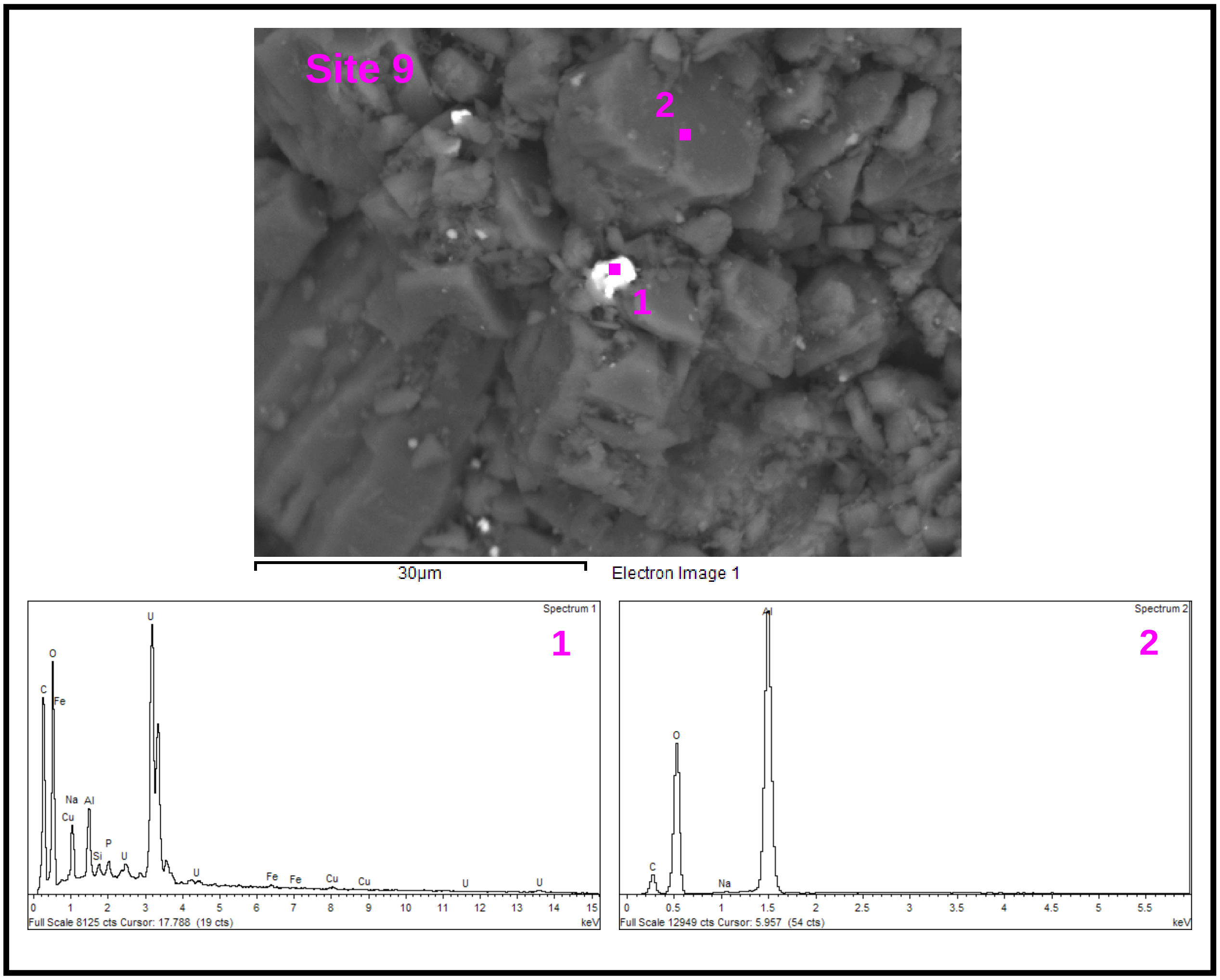

Figure B.41. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

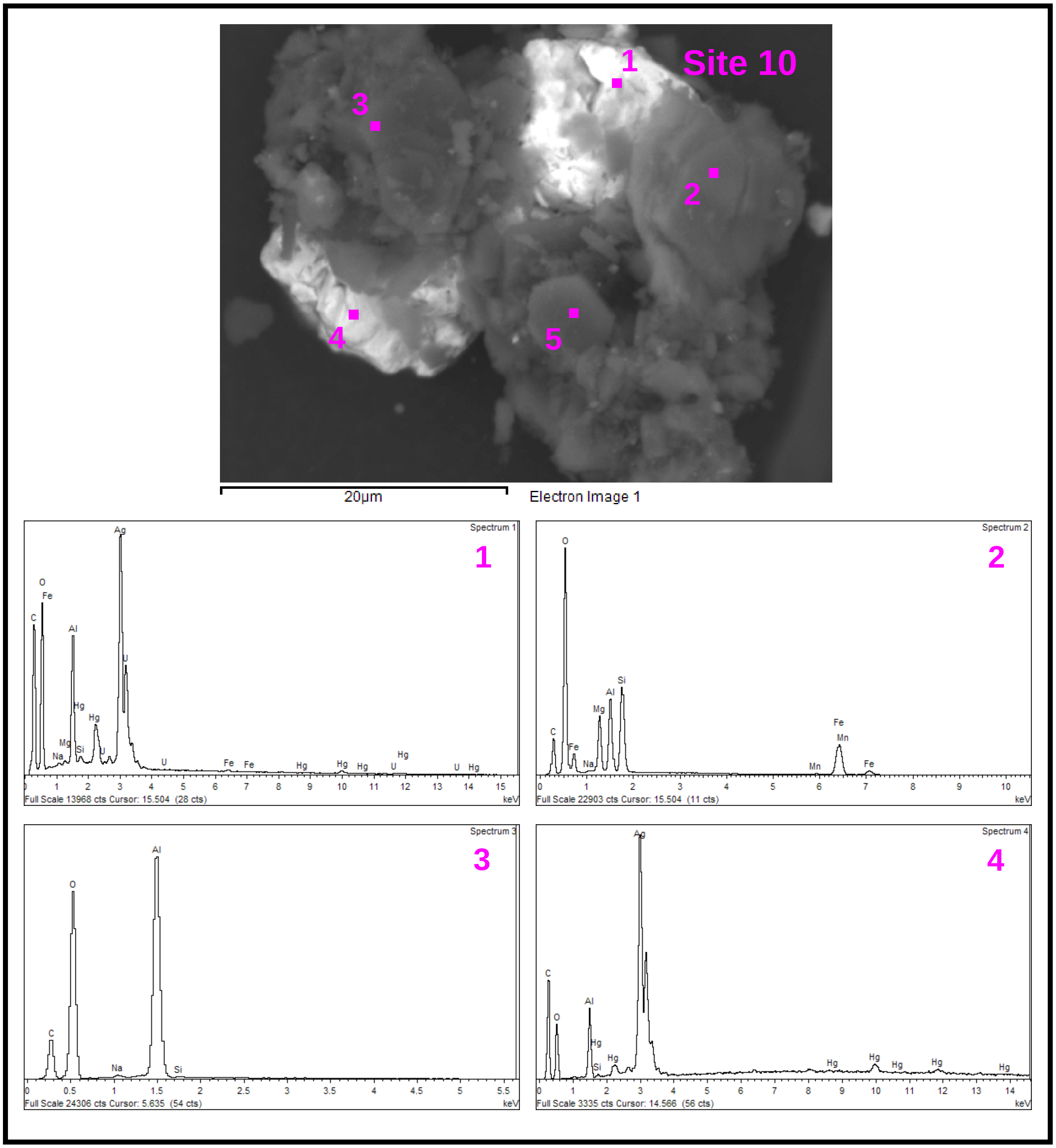

Figure B.42. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

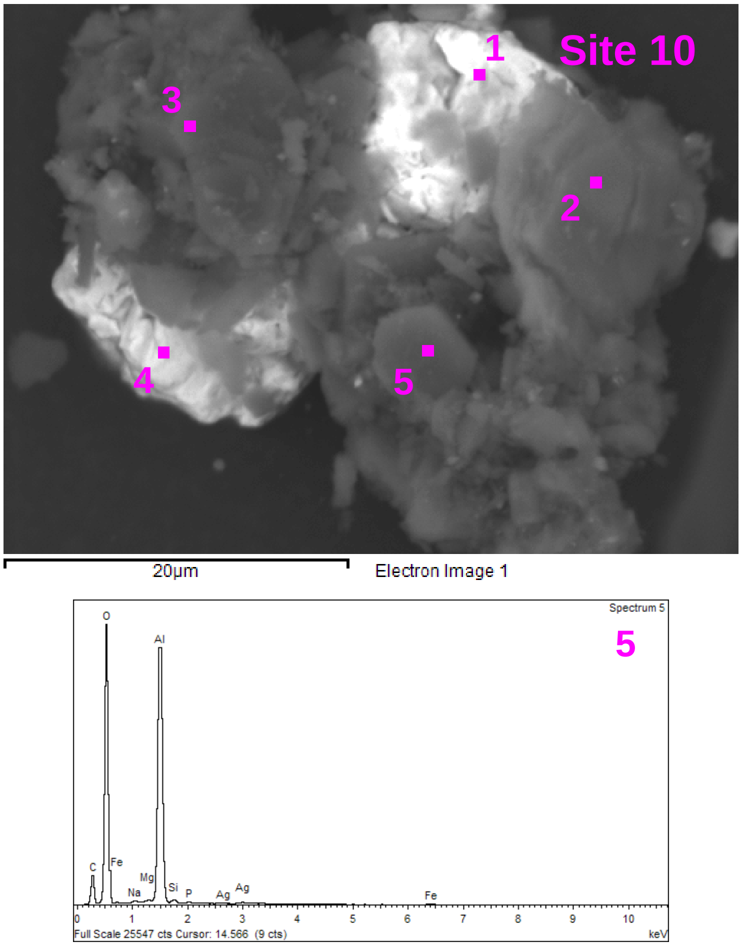

Figure B.43. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of Unleached Residual Waste from Tank C-103

Table B.3. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %(a)												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.32 and B.33/1	1	28.4	0.7	0.9		0.4	6.6					62.5	0.3	Mg (0.1)
	2	2.3	1.3	0.8	0.1	0.4	45.4					46.9	0.4	Cu (0.4), Mg (0.5), Mn (0.2), Pb (1.3)
	3	28.5	0.9	1.1		0.4	2.1					66.5	0.4	Mg (0.1)
	4	3.5	1.2	1.2		0.4	37.0					52.9		Cu (0.4), Mg (0.3), Ni (0.3), Pb (1.3), Ti (0.1), Zr (1.4)
	5	9.2	1.0	0.9		0.7	45.1					37.6	0.5	Cu (0.5), Mn (1.4), Ni (0.5), Pb (2.7)
	6	30.9	0.1	0.4			0.3					68.1	0.1	
B.34/2	1	30.1		0.5		0.4						69.1		
	2	11.0	0.6	3.4	0.4	27.7	0.5					55.2	0.8	Cu (0.3)
	3	22.7	0.9	2.0	0.5	13.8	2.1					57.5	0.5	
	4	27.4		0.3								72.1	0.2	
B.35/3	1	5.5	3.9	5.4	19.9	2.4	1.0					44.7	9.9	F (2.6), K (0.3), Ni (2.0), Th (2.4)
	2	30.1	0.2	0.8	0.1							68.8		
	3	3.2	0.6	4.2	24.1	2.6	1.1			0.9		46.0	11.3	F (3.9), Ni (2.0)
	4	4.3	1.6	5.3	18.2	7.0	2.4	0.3		1.8		38.0	8.8	F (2.7), Mg (0.5), Ni (5.6), and W (3.7)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table B.4. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %$^{(a)}$**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.36/4	1	0.5		6.7	5.3	39.8						47.6		
	2	19.5				13.7	3.6					59.9		Cu (3.3)
	3	42.5	0.6	1.0		1.9				2.5		51.0	0.5	
	4	25.0	0.5	1.3	0.1		0.2					72.7	0.2	
B.37/5	1	29.2	0.2	0.3								70.2	0.2	
	2	26.9	0.2	0.3			0.1					72.3	0.1	
	3	2.2	0.5	1.2			46.2					41.8	0.8	Ag (0.1), Cd (0.4), Mn (1.7), Ni (0.4), Pb (4.7)
	4	49.3	1.2				1.9					47.6		
B.38/6	1	2.9				1.0	89.6					5.0		Ru (1.6)
	2	26.2	0.1	0.6		0.5	0.2					72.2	0.2	
	3	35.2		0.3		0.7						63.8		
B.39/7	1	5.2					51.7					7.9		Mn (27.4), Ni (7.8)
	2	5.2			7.0		78.9					8.9		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table B.5. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.40/8	1	28.9					3.5					67.6		
	2	25.1				1.0	2.3					63.6		Cu (8.1)
	3	34.5		0.7		1.9	2.1					60.7		
B.41/9	1	3.9	0.5	4.8		49.7	0.4					39.1	0.9	Cu (0.7)
	2	38.9		0.3								60.7		
B.42 and B.43/10	1	7.0	0.2	0.2		1.3	0.3			33.7	6.4	50.6		Mg (0.2)
	2	9.3	11.0	0.3			12.9					58.3		Mg (8.1), Mn (0.3)
	3	31.9	0.2	0.6								67.2		
	4	6.4	0.2							54.3	2.8	36.2		
	5	27.6	0.5	0.2			0.6			0.5		70.3	0.2	Mg (0.1)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

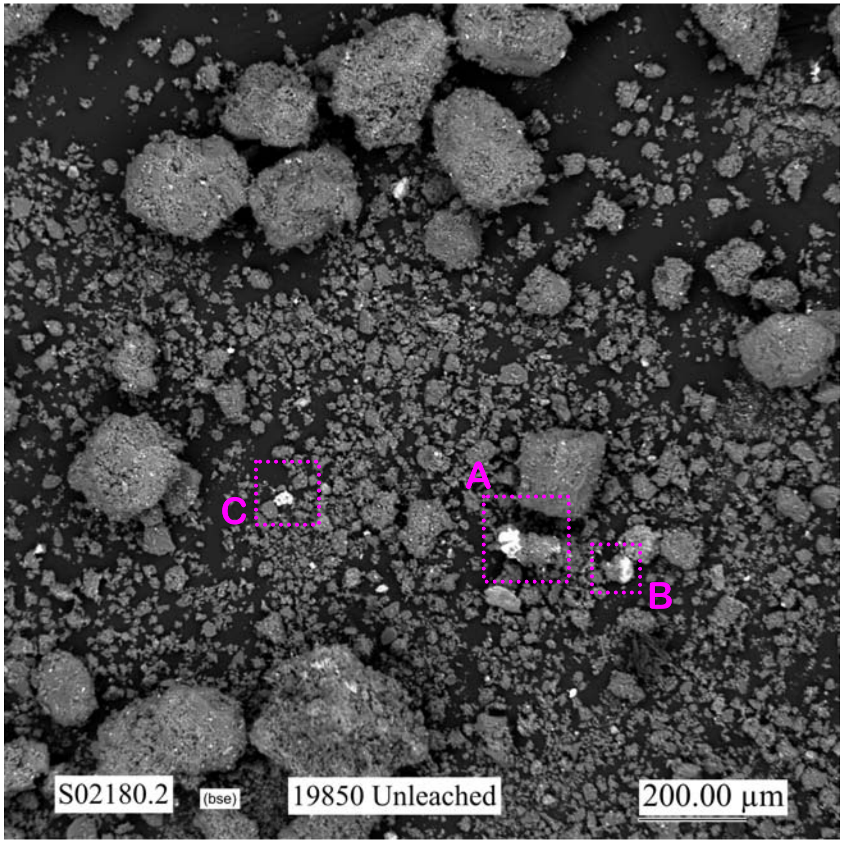

Figure B.44. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

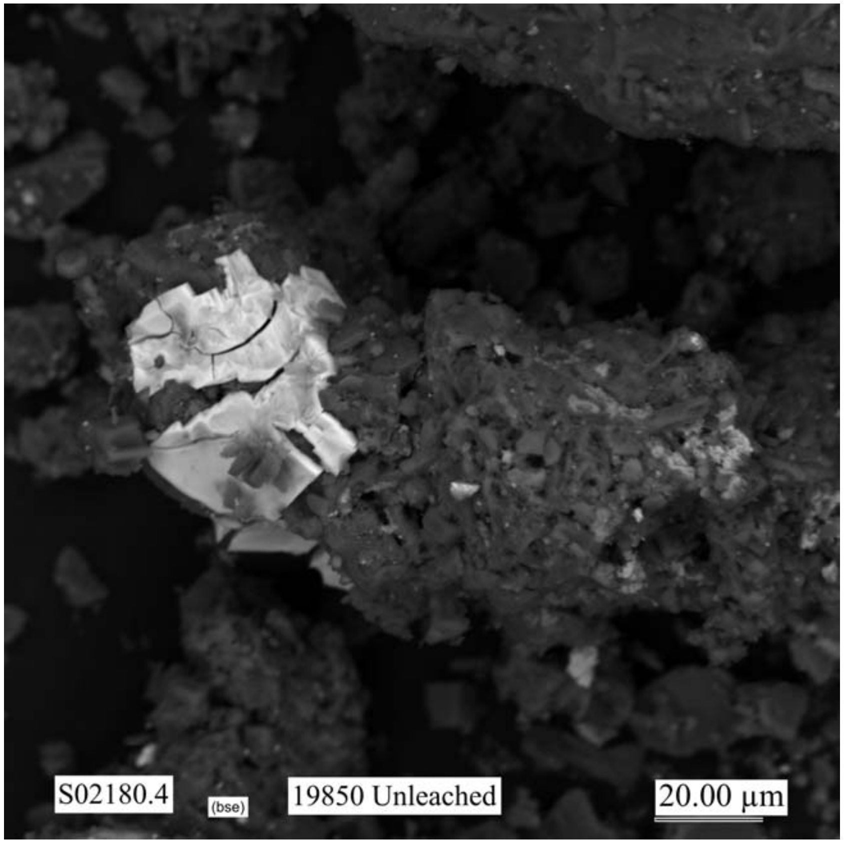

Figure B.45. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square A in Figure B.44 (Areas where EDS analyses were made are shown in Figure B.54.)

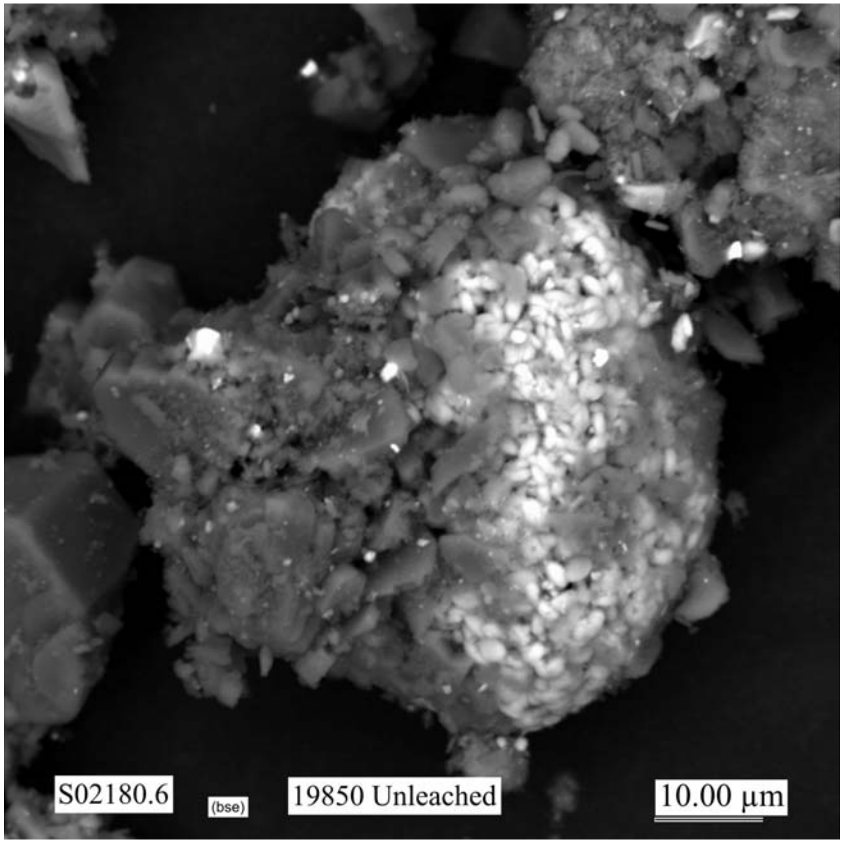

Figure B.46. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square B in Figure B.44 (Areas where EDS analyses were made are shown in Figures B.55 and B.56.)

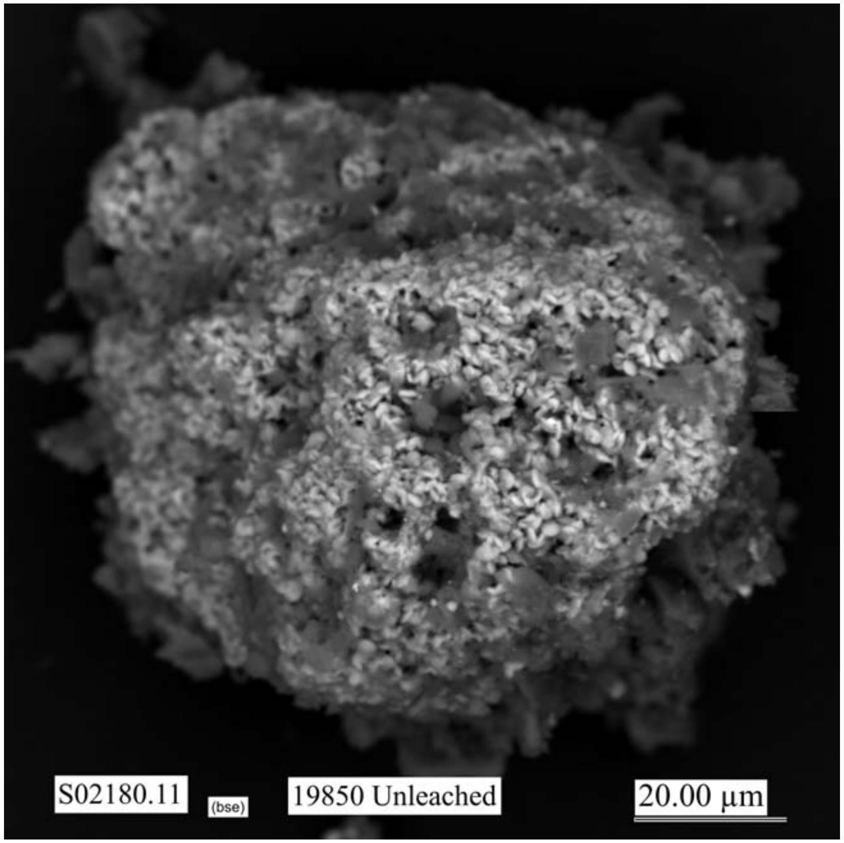

Figure B.47. Micrograph Showing Particle Aggregate in Sample 19850 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.58.)

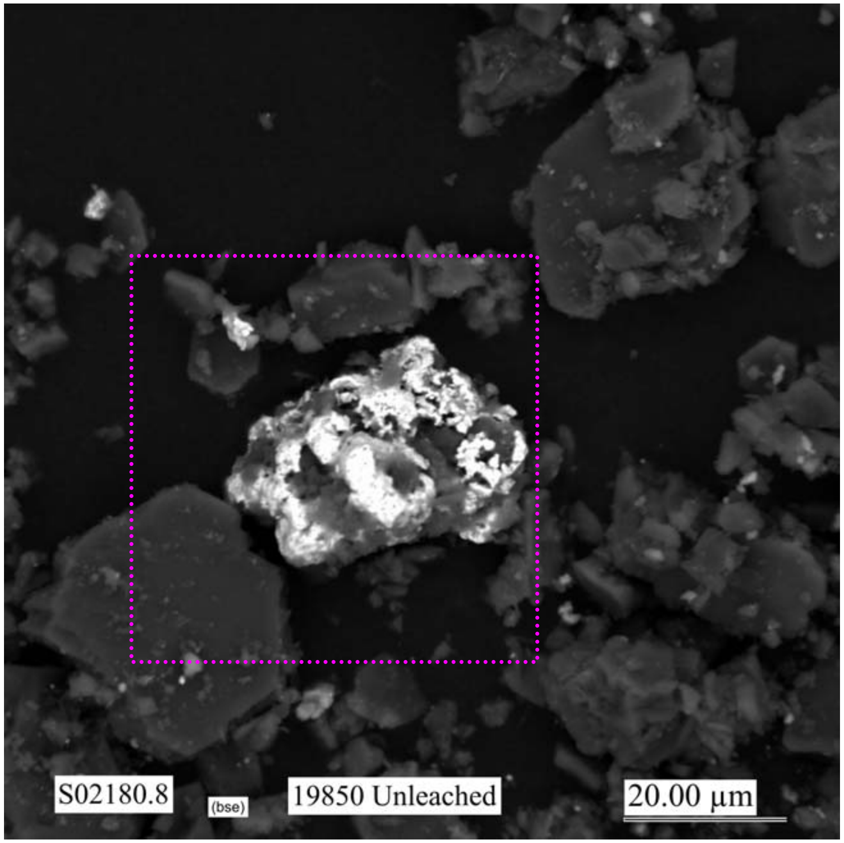

Figure B.48. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square C in Figure B.44 (Areas where EDS analyses were made are shown in Figure B.57.)

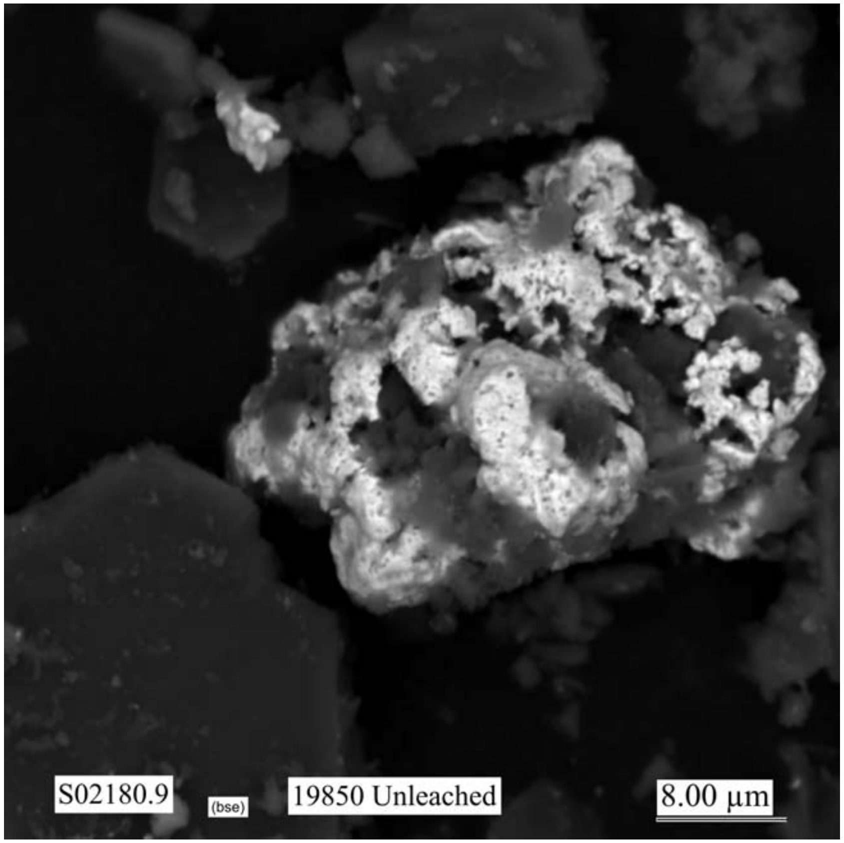

Figure B.49. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square Figure B.48 (Areas where EDS analyses were made are shown in Figure B.57.)

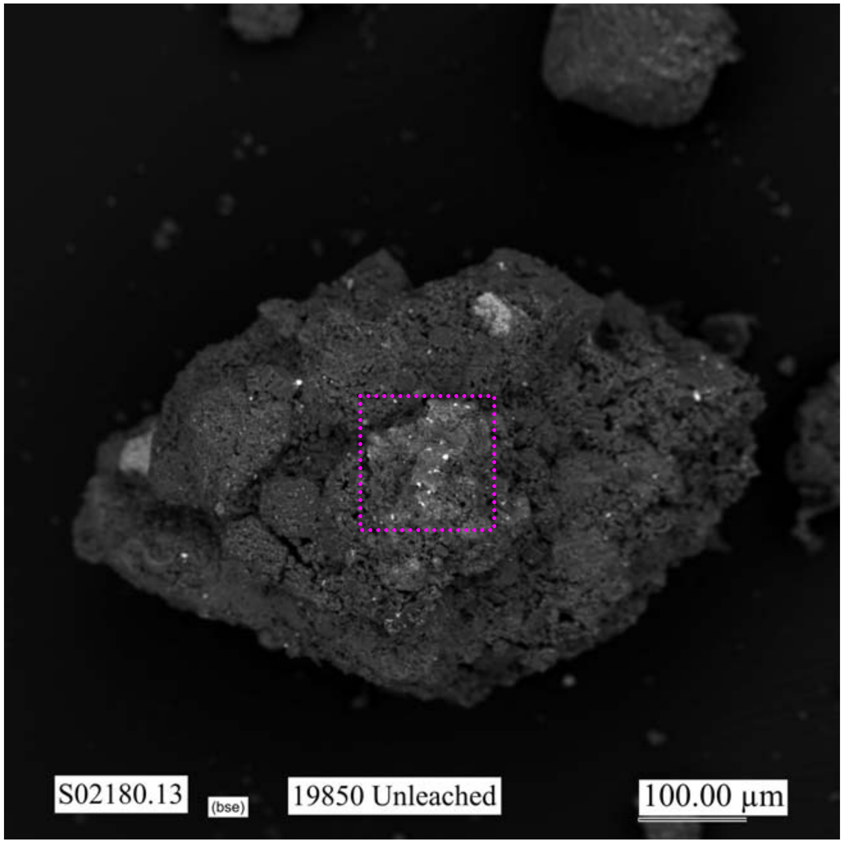

Figure B.50. Micrograph Showing Particle Aggregate in Sample 19850 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure B.59.)

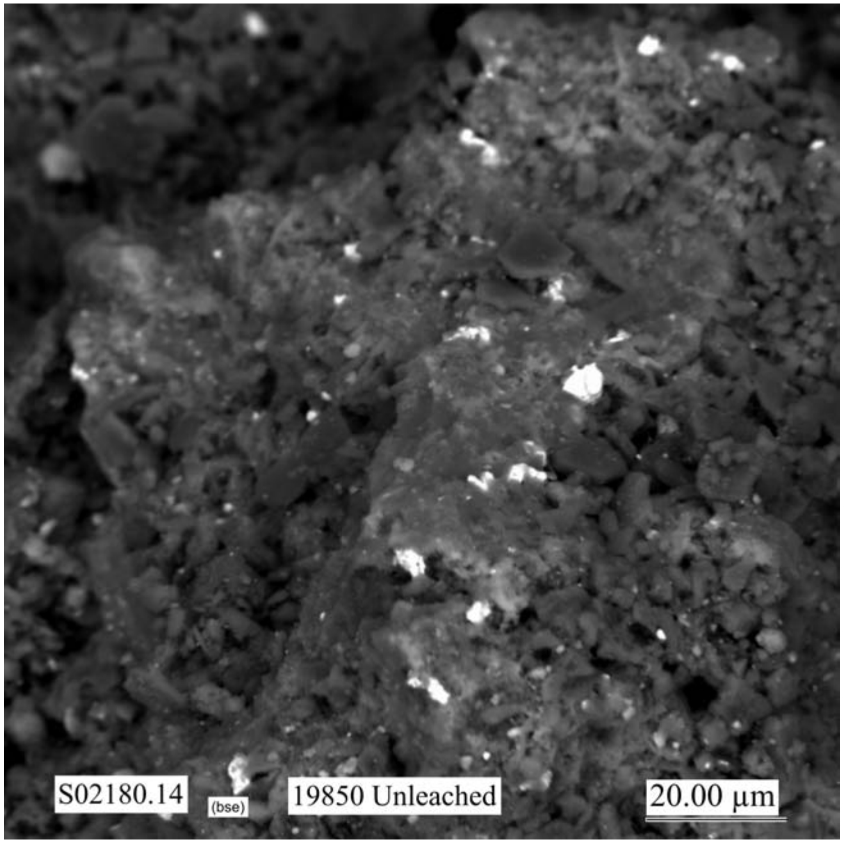

Figure B.51. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square Figure B.50 (Areas where EDS analyses were made are shown in Figure B.59.)

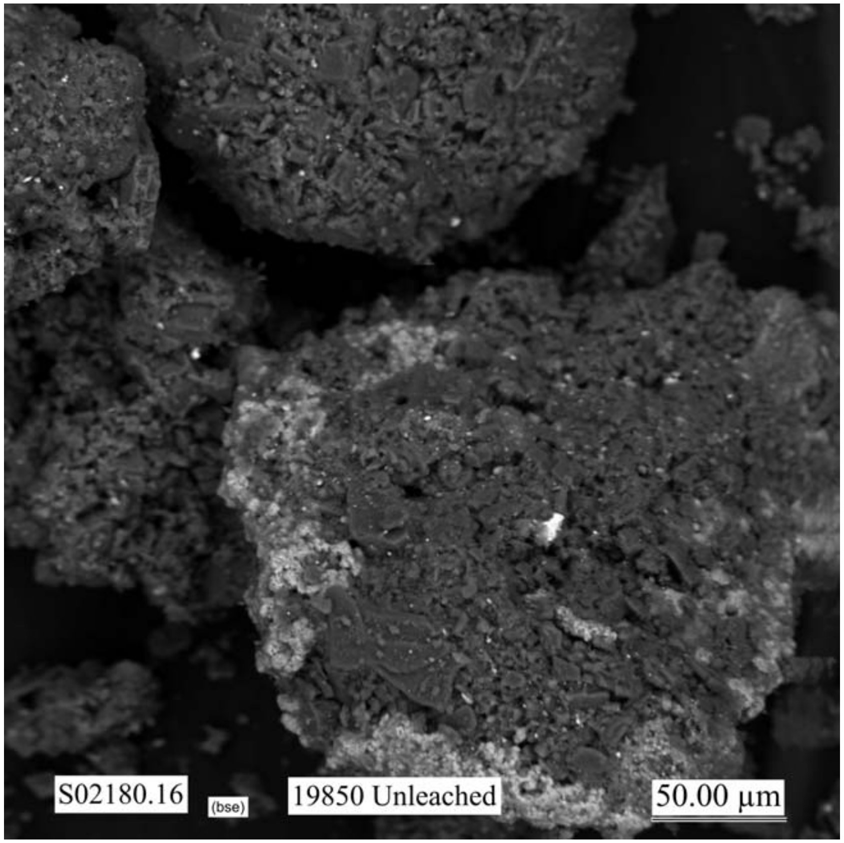

Figure B.52. Micrograph Showing Particle Aggregates in Sample 19850 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures B.60 and B.61.)

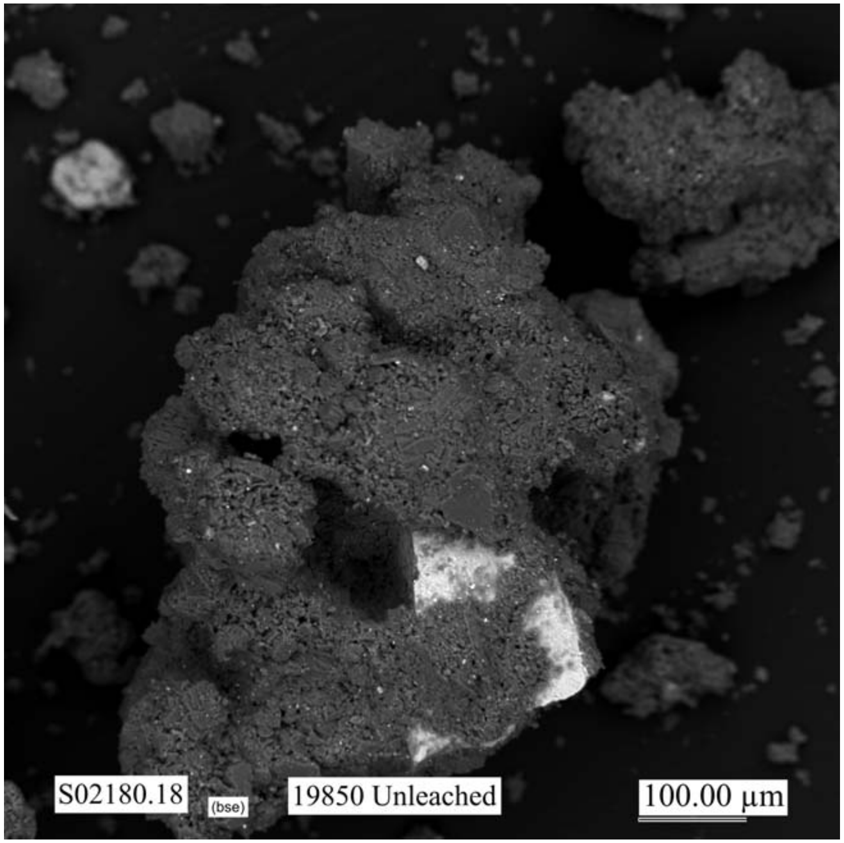

Figure B.53. Micrograph Showing Particle Aggregates in Sample 19850 of Unleached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures B.62 and B.63.)

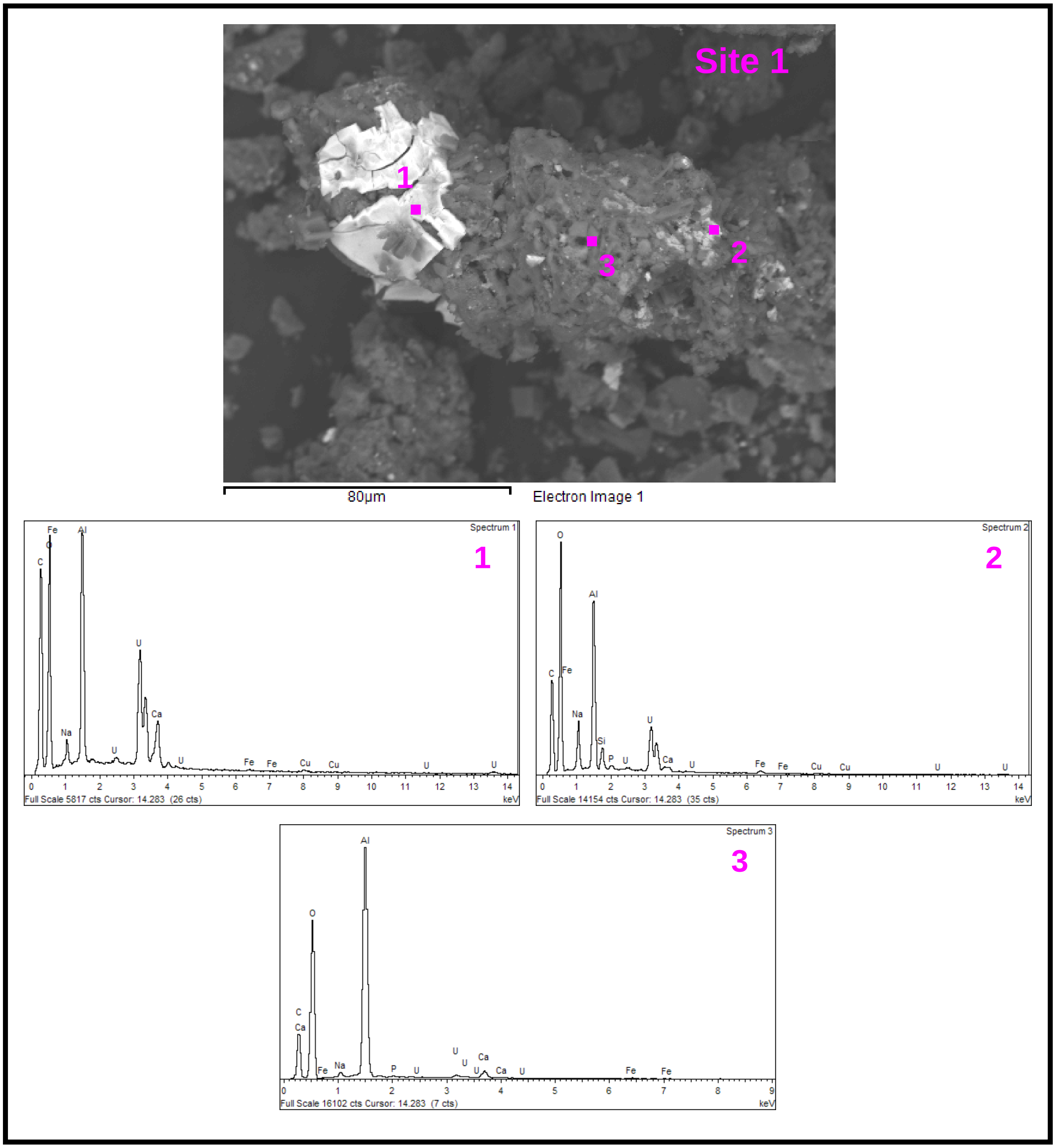

Figure B.54. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

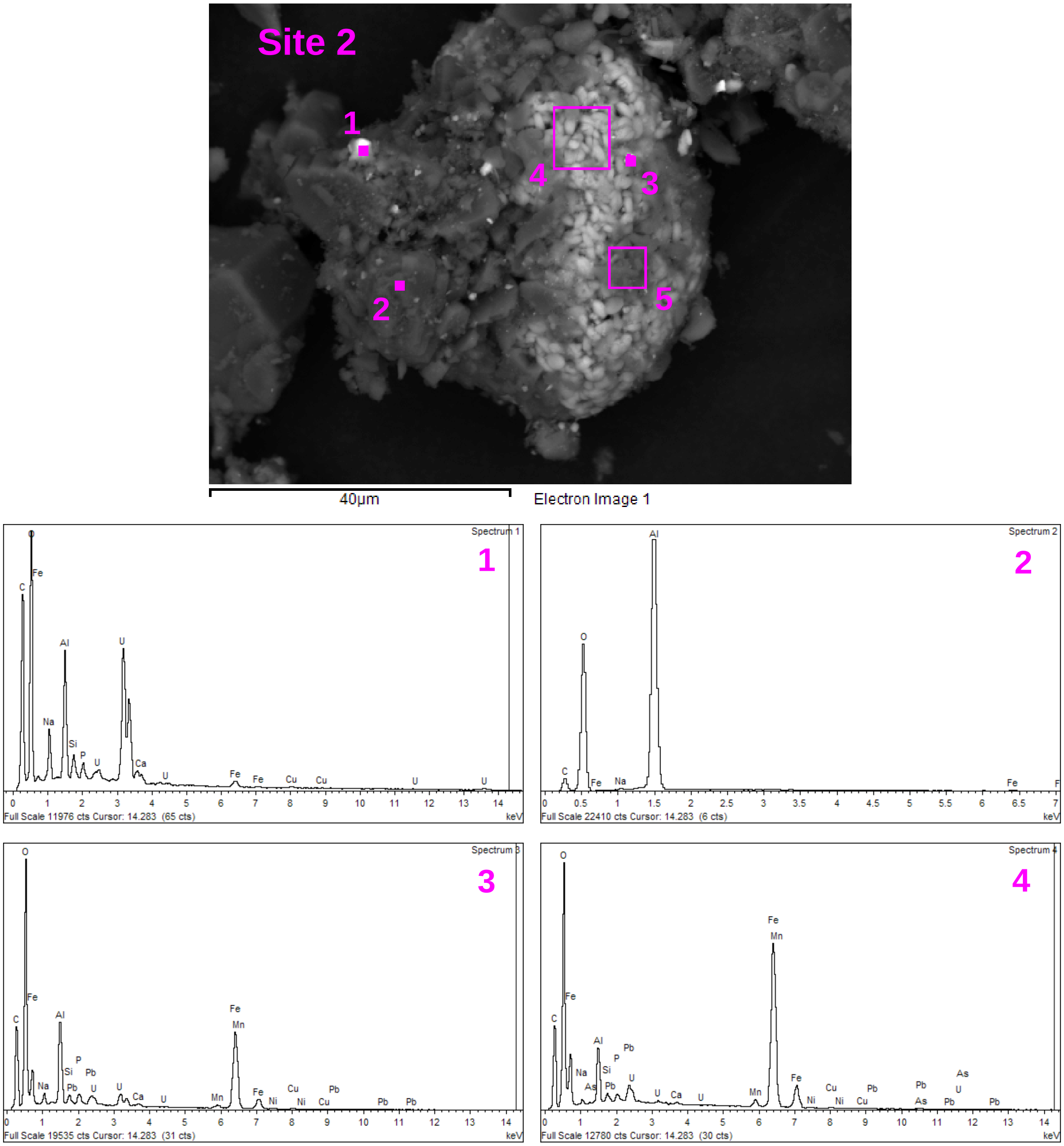

Figure B.55. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

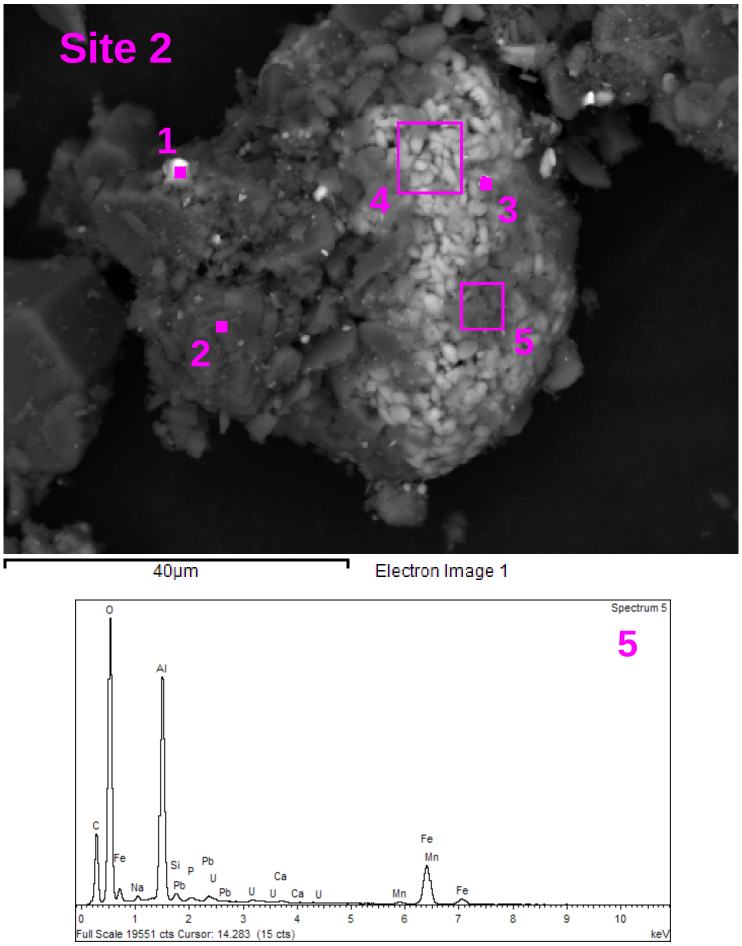

Figure B.56. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

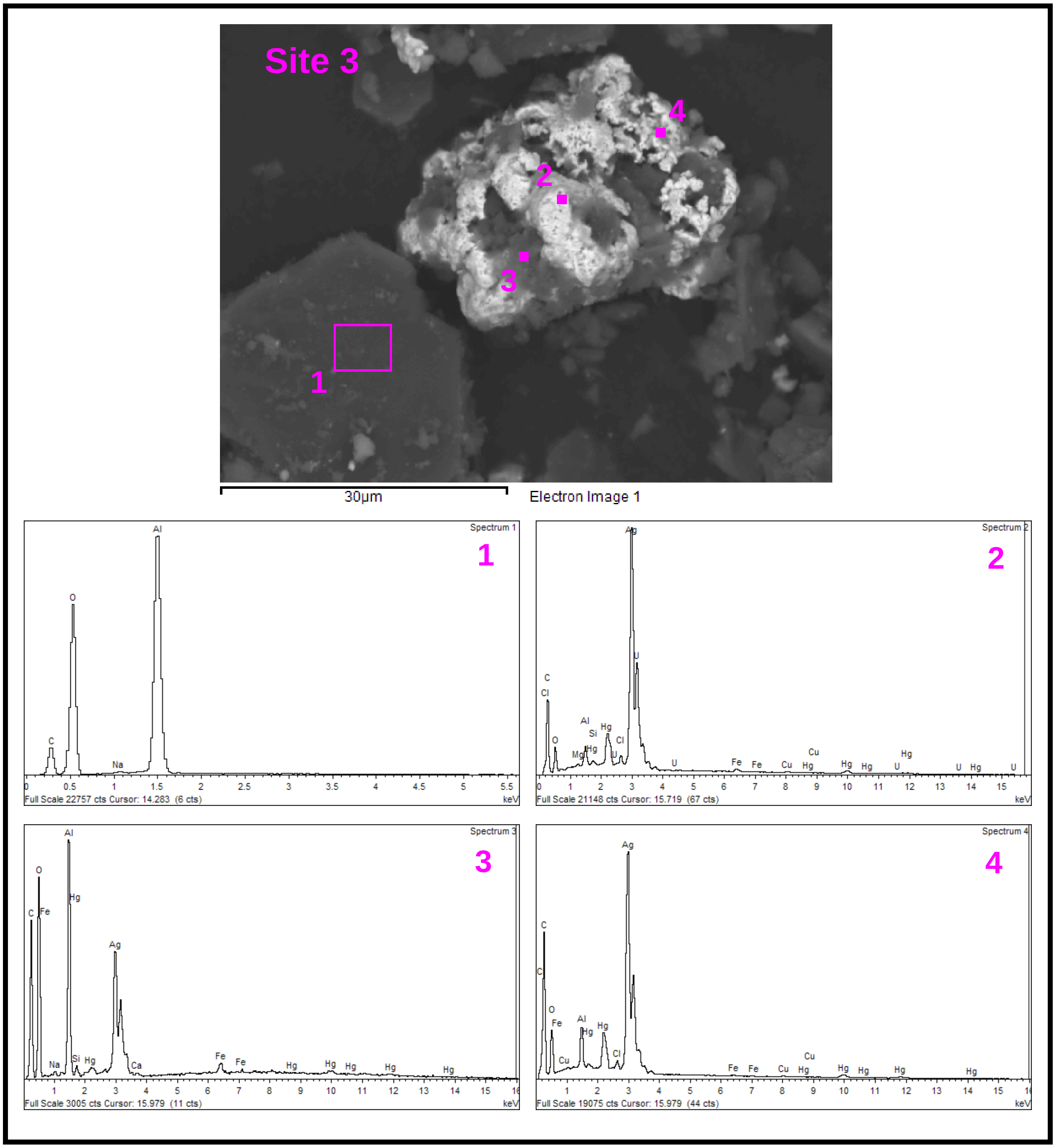

Figure B.57. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

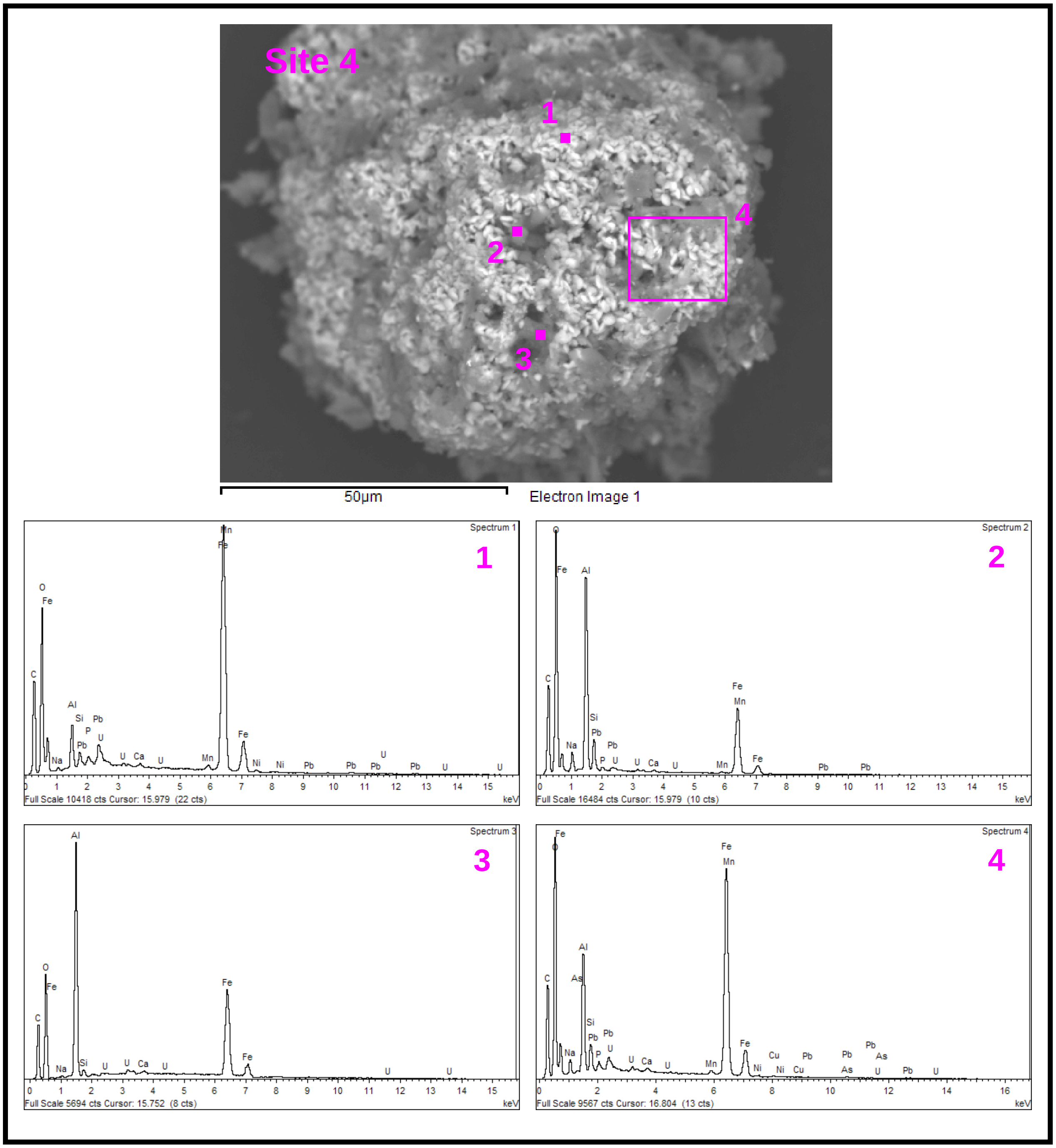

Figure B.58. EDS Spectra for Numbered Areas Marked in Pink in top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

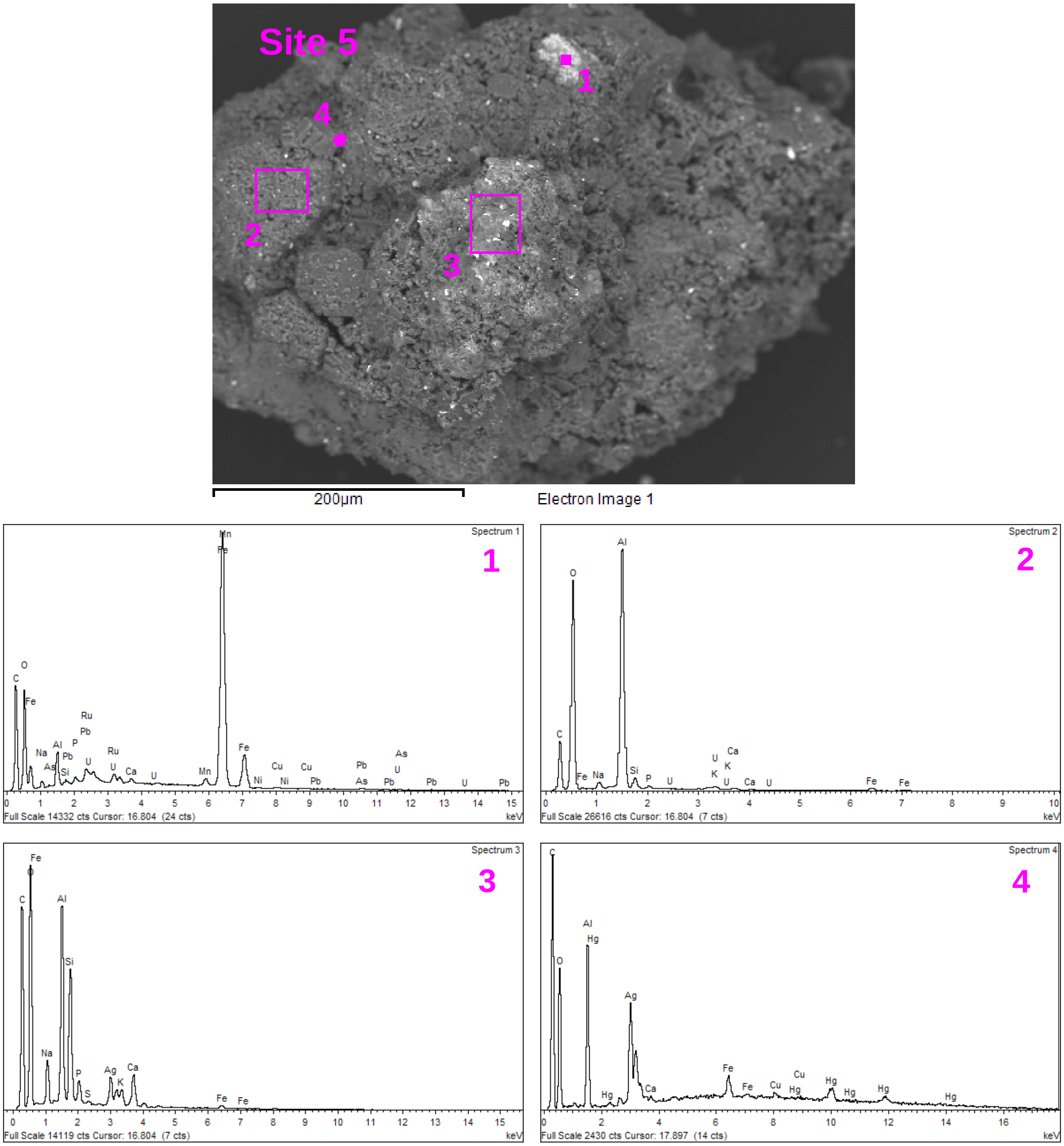

Figure B.59. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

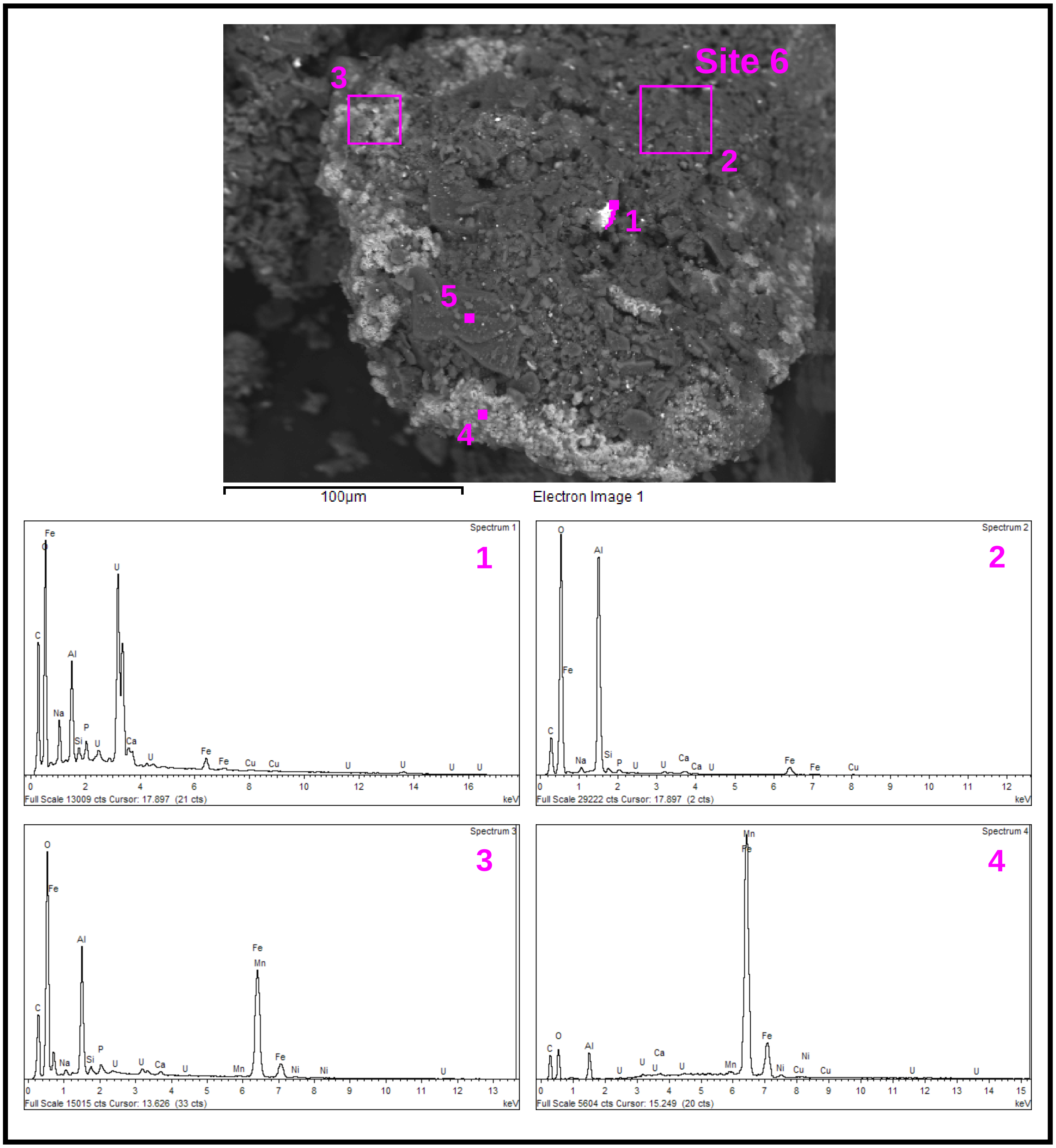

Figure B.60. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

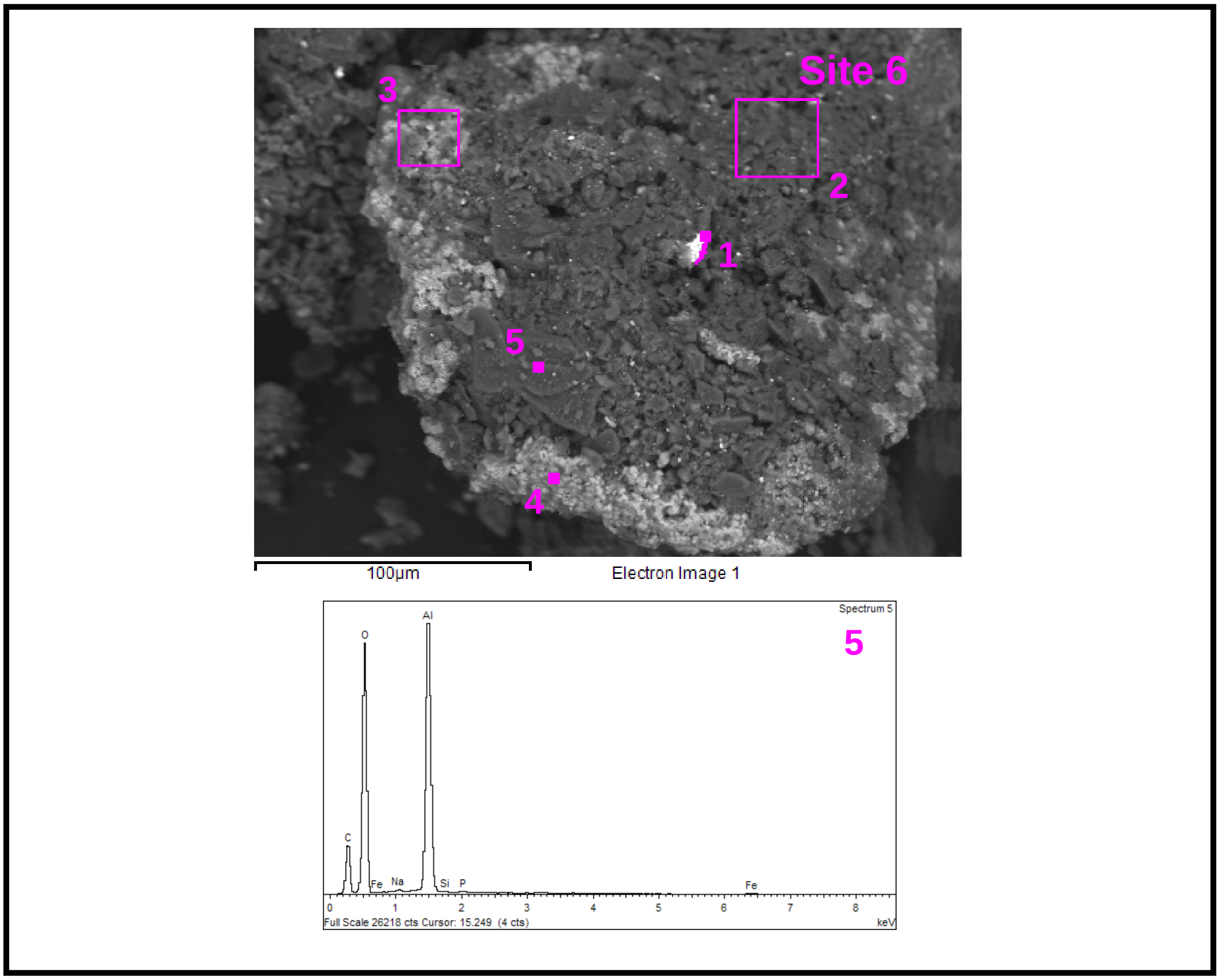

Figure B.61. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

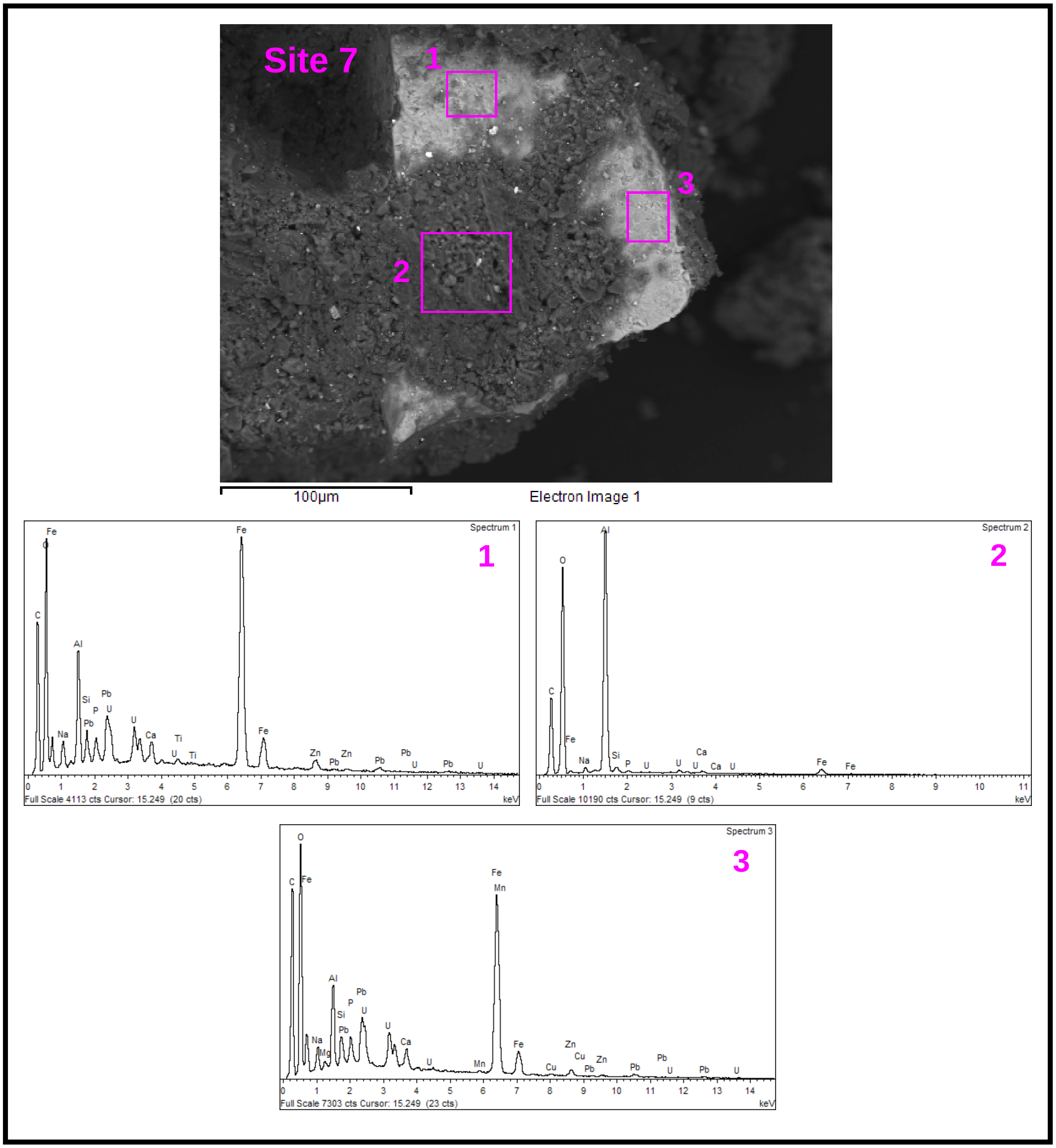

Figure B.62. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

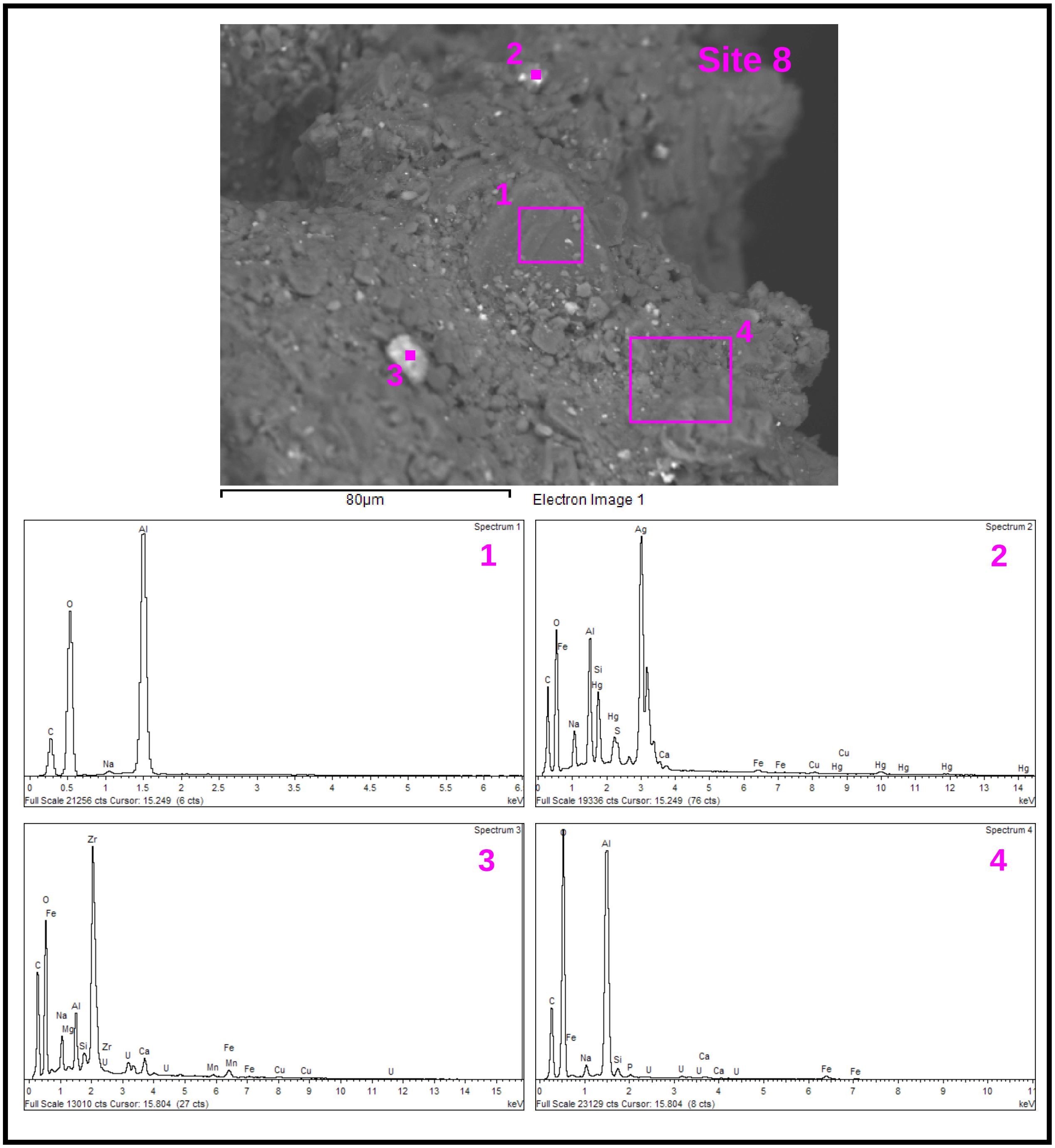

Figure B.63. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of Unleached Residual Waste from Tank C-103

Table B.6. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %(a)**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.54/1	1	14.9		2.5	3.8	28.9	0.3					49.0		Cu (0.6)
	2	15.7	2.1	7.2	0.5	17.1	0.8					55.6	0.5	Cu (0.5)
	3	32.2		1.1	1.5	1.4	0.5					63.1	0.2	
B.55 and B.56/2	1	8.6	1.5	5.4	0.6	33.1	1.3					47.9	1.1	Cu (0.5)
	2	37.5		0.3			0.2					62.0		
	3	9.2	0.9	2.5	0.3	4.8	25.7					51.6	1.0	Cu (0.3), Mn (0.8), Ni (0.3), Pb (2.5)
	4	5.4	0.7	1.2	0.2	0.8	43.6					40.9	0.6	Cu (0.6), Mn (1.5), Ni (0.4), Pb (4.0)
	5	21.6	0.8	0.9	0.2	1.0	13.5					59.7	0.4	Mn (0.5), Pb (1.5)
B.57/3	1	34.5		0.5								65.0		
	2	2.0	0.2			2.8	1.0			61.9	9.3	21.9		Cl (0.2), Cu (0.5), Mg (0.2)
	3	15.5	0.7	0.6	0.2		2.2			21.9	1.3	57.6		
	4	3.9					0.3			54.4	10.0	30.8		Cl (0.1), Cu (0.6)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table B.7. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.58/4	1	4.2	1.2	0.9	0.3	0.7	58.9					27.6	0.6	Mn (0.9), Ni (0.7), Pb (4.0)
	2	18.8	3.3	3.5	0.3	0.8	21.2					50.4	0.4	Mn (0.3), Pb (1.0)
	3	29.0	1.1	0.4	0.4	2.1	34.7					32.3		
	4	9.6	2.0	2.3	0.3	1.0	44.8					35.2	0.6	Ag (0.4), Cu (0.4), Mn (0.7), Ni (0.4), Pb (2.3)
B.59/5	1	3.5	0.4	1.5	0.4	2.9	63.3					19.7	0.5	Ag (0.1), Cu (0.5), Mn (1.5), Ni (0.4), Pb (3.2), Ru (2.1)
	2	28.4	1.8	1.4	0.3	1.1	1.1					65.1	0.5	K (0.3)
	3	12.8	9.6	5.0	3.1		0.8			5.8		59.6	1.9	K (1.0), S (0.3)
	4	14.2			0.4		6.0			23.3	0.7	53.0		Cu (2.5)
B.60 and B.61/6	1	6.2	0.7	4.2	0.8	41.7	2.1					42.8	1.1	Cu (0.3)
	2	25.8	0.7	1.1	0.4	1.1	3.3					66.7	0.5	Cu (0.3)
	3	14.1	0.8	1.3	0.4	2.1	34.1					45.4	0.9	Mn (0.3), Ni (0.6)
	4	4.3			0.2	0.9	84.7					7.5		Cu (0.2), Mn (0.8), Ni (1.5)
	5	30.4	0.2	0.4			0.4					68.5	0.2	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table B.8. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
B.62 / 7	1	6.5	1.6	2.0	1.3	7.4	36.4					32.8	1.2	Pb (6.5), Ti (0.4), Zn (3.9)
	2	29.3	0.8	1.1	0.3	1.8	2.3					64.0	0.3	
	3	5.4	1.7	2.2	1.4	7.7	33.0					35.4	1.5	Cu (0.6), Mg (0.5), Mn (0.3), Pb (7.4), Zn (2.8)
B.63 / 8	1	35.1		0.8								64.1		
	2	7.1	3.8	3.8	0.2		0.4			33.9	4.4	45.7		Cu (0.4), S (0.3)
	3	3.8	0.7	4.2	1.6	3.8	1.5					50.3		Cu (0.4), Mg (0.2), Mn (0.4), Zr (33.0)
	4	26.1	1.3	2.4	0.3	0.9	1.4					67.2	0.4	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Appendix C

SEM Micrographs and EDS Results for One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

Appendix C

SEM Micrographs and EDS Results for One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

This appendix includes the scanning electron microscope (SEM) micrographs and the energy-dispersive spectroscopy (EDS) spectra for samples 19845, 19849, and 19850 of one-month single-contact DDI water-leached residual waste from tank C-103. The operating conditions for the SEM and procedures used for mounting the SEM samples are described in Section 2.4 of the main report.

The identification number for the digital micrograph image file, descriptor for the type of sample, and a size scale bar are given at the bottom of each SEM micrograph. Micrographs labeled by “BSE” or “SE” to the immediate right of the digital image file number indicate that the micrograph was collected with backscattered electrons or secondary electrons, respectively. Sample areas or particles identified in a micrograph by a pink arrow or pink dotted-line square designate sample material that was imaged at higher magnification, which is typically shown in figure(s) that immediately follow in the series for that sample.

The SEM micrographs, EDS spectra, and corresponding calculated compositions (in weight percent) based on EDS analyses for material analyzed from samples 19845, 19849, and 19850 of one-month single-contact DDI water-leached C-103 residual waste are shown in the following figures and tables:

- Sample 19845
    - SEM micrographs – Figures C.1 through C.13
    - EDS spectra – Figures C.14 through C.26
    - Calculated compositions based on EDS analyses – Table C.1 through C.3

- Sample 19849
    - SEM micrographs – Figures C.27 through C.33
    - EDS spectra – Figures C.34 through C.46
    - Calculated compositions based on EDS analyses – Table C.4 through C.6

- Sample 19850
    - SEM micrographs – Figures C.47 through C.59
    - EDS spectra – Figures C.60 through C.68
    - Calculated compositions based on EDS analyses – Table C.7 through C.9

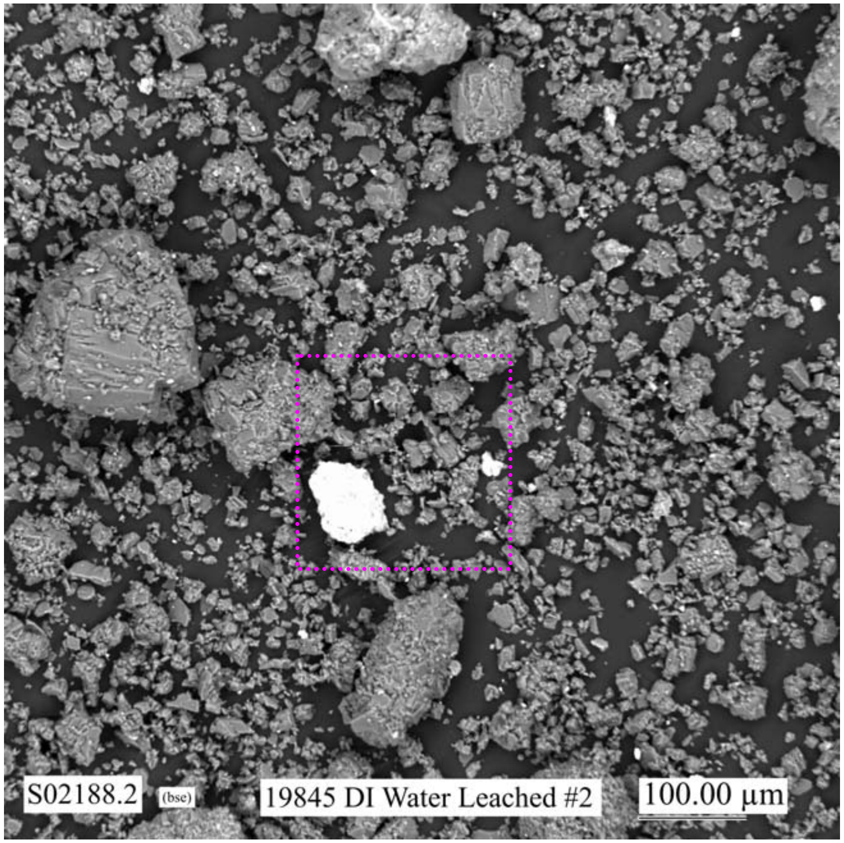

Figure C.1. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

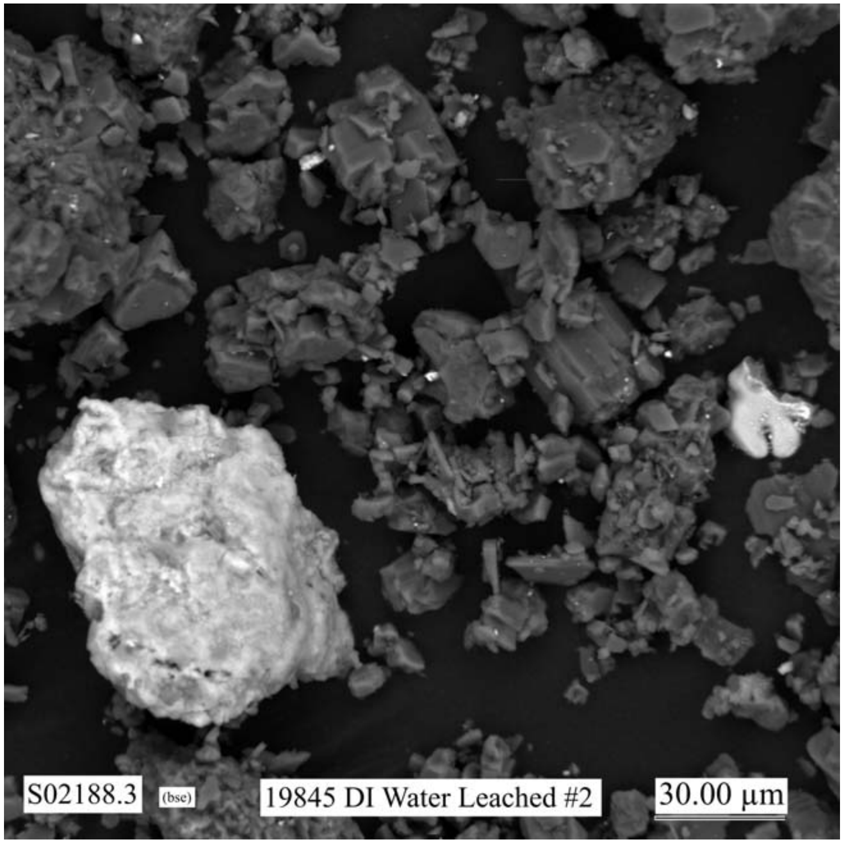

Figure C.2. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square in Figure C.1 (Areas where EDS analyses were made are shown in Figures C.14 and C.15.)

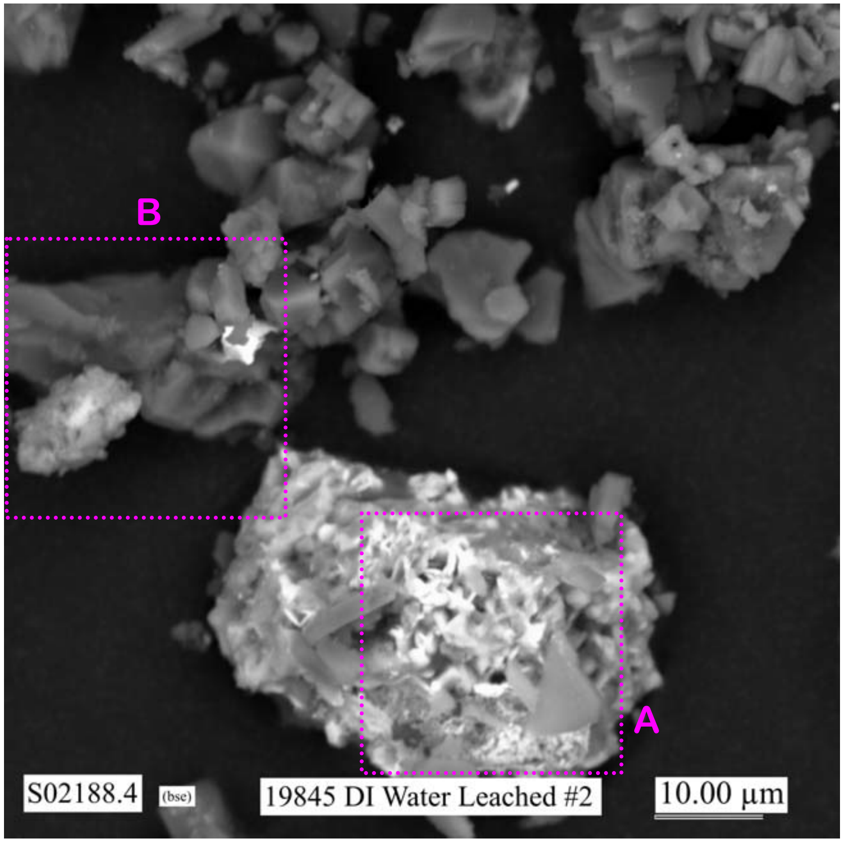

Figure C.3. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.16 and C.17.)

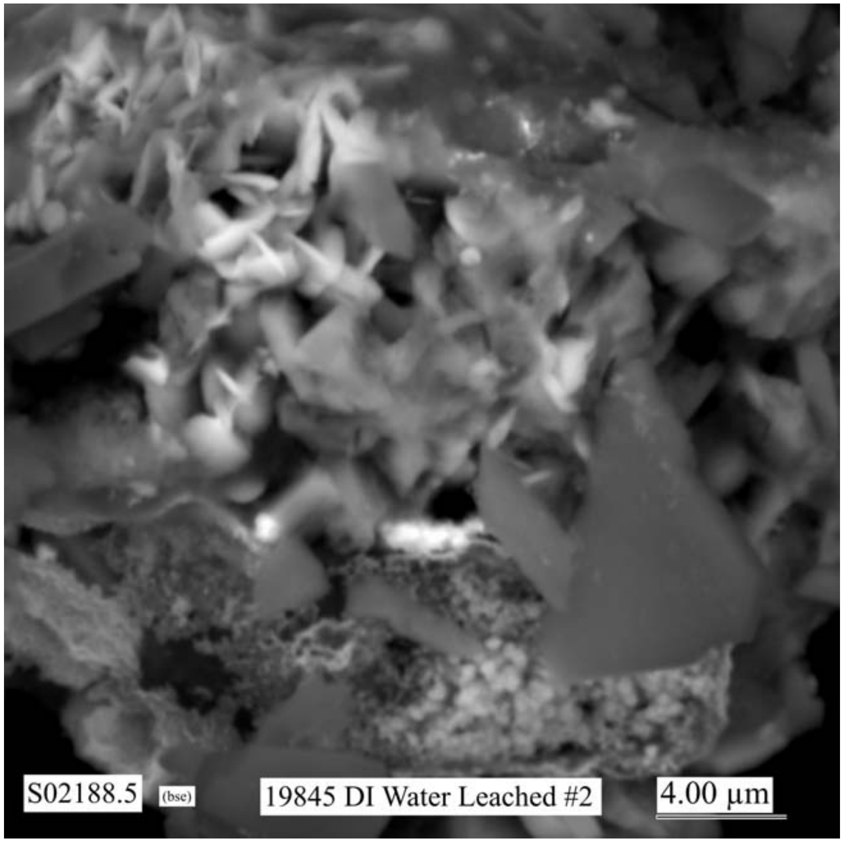

Figure C.4. Micrograph Showing at Higher Magnification the Particles Aggregate in the Area Indicated by the Pink Dotted-Line Square A in Figure C.3 (Areas where EDS analyses were made are shown in Figures C.16 and C.17.)

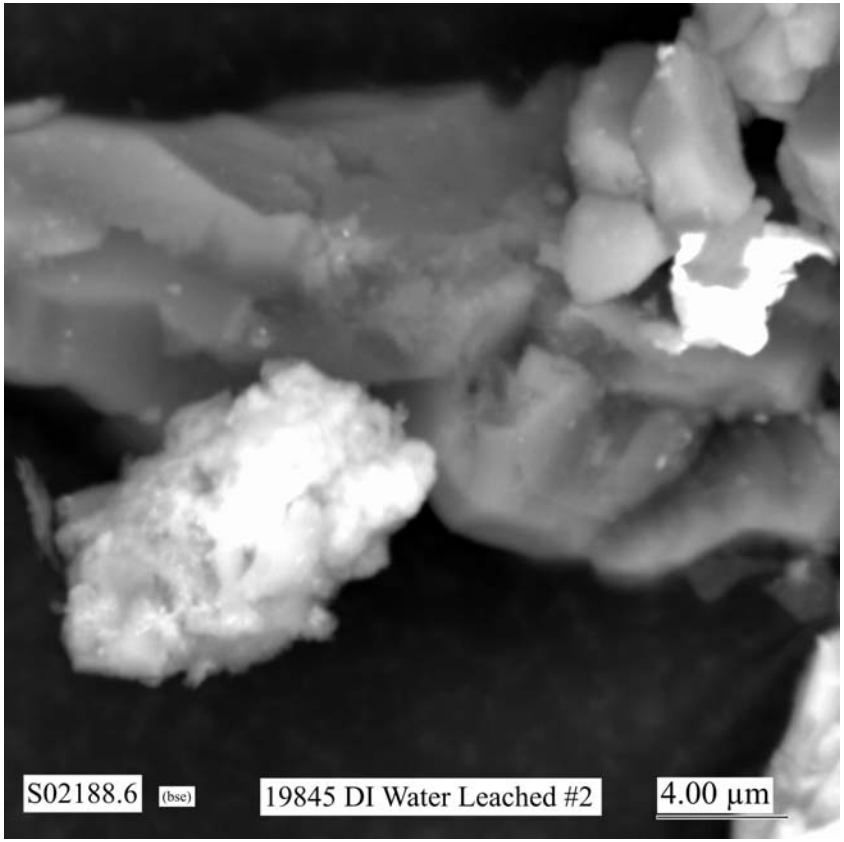

Figure C.5. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square B in Figure C.3 (Areas where EDS analyses were made are shown in Figures C.16 and C.17.)

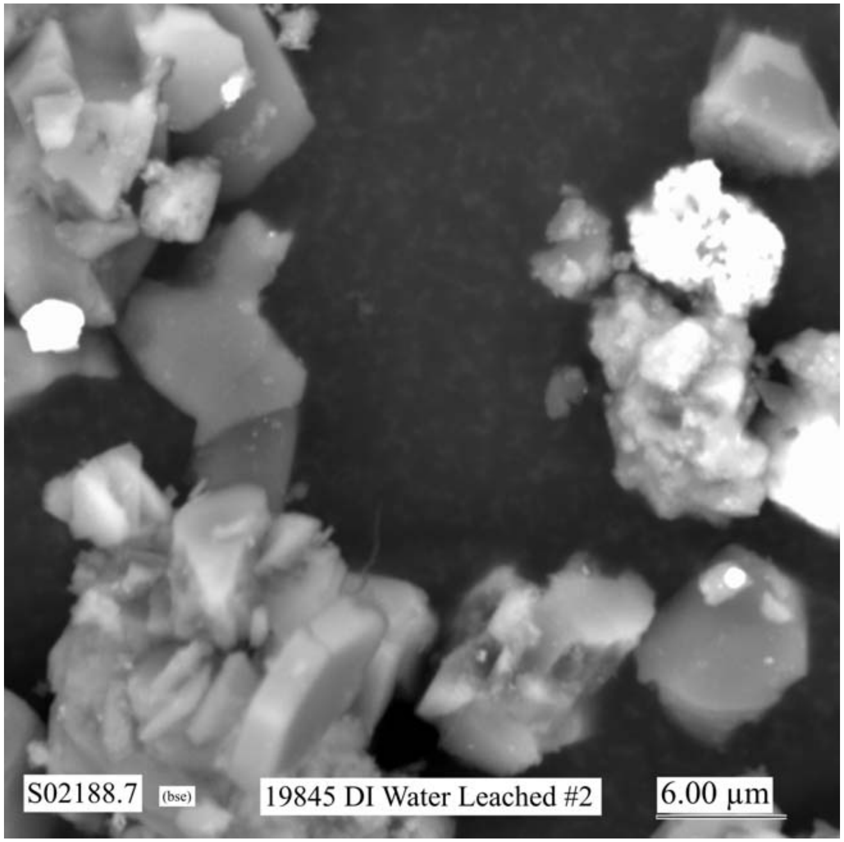

Figure C.6. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.18 and C.19.)

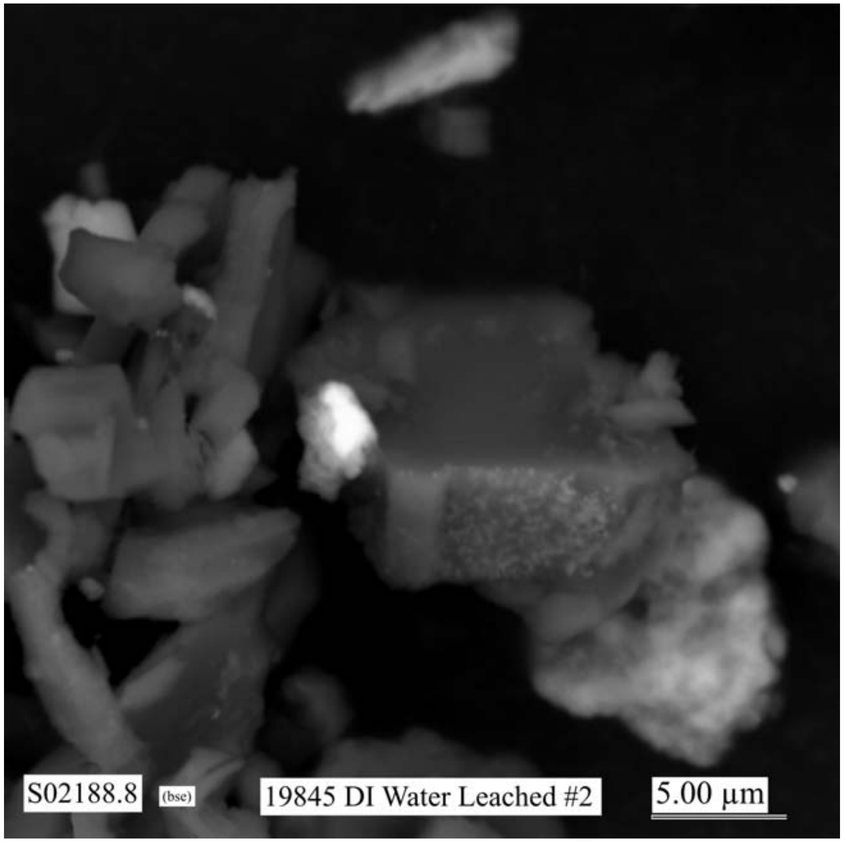

Figure C.7. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.20 and C.21.)

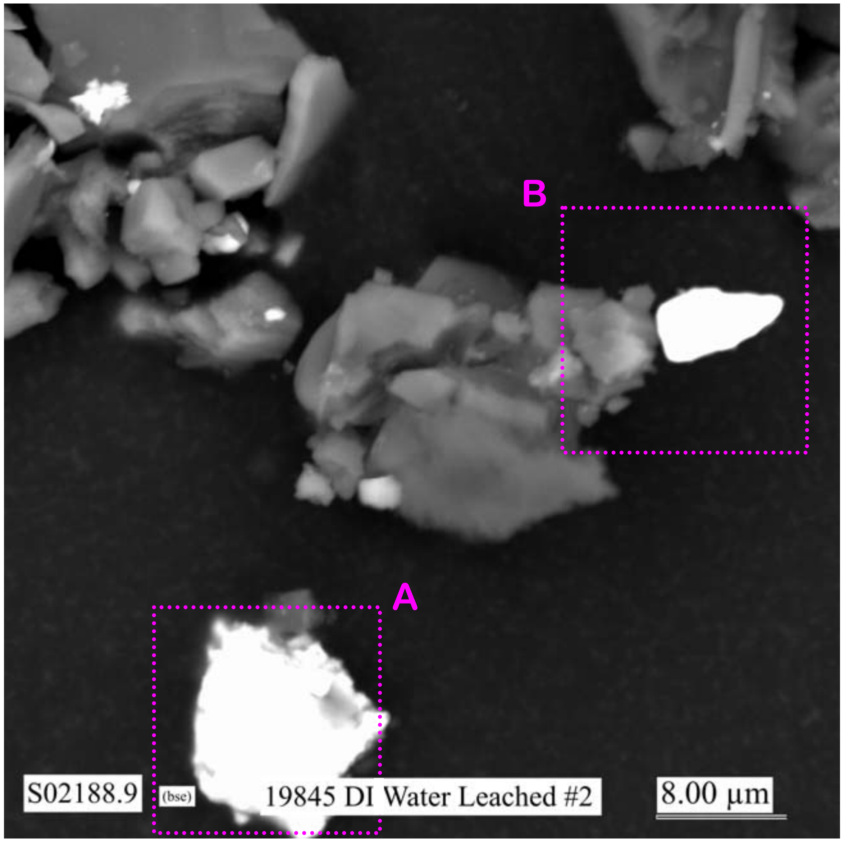

Figure C.8. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.22.)

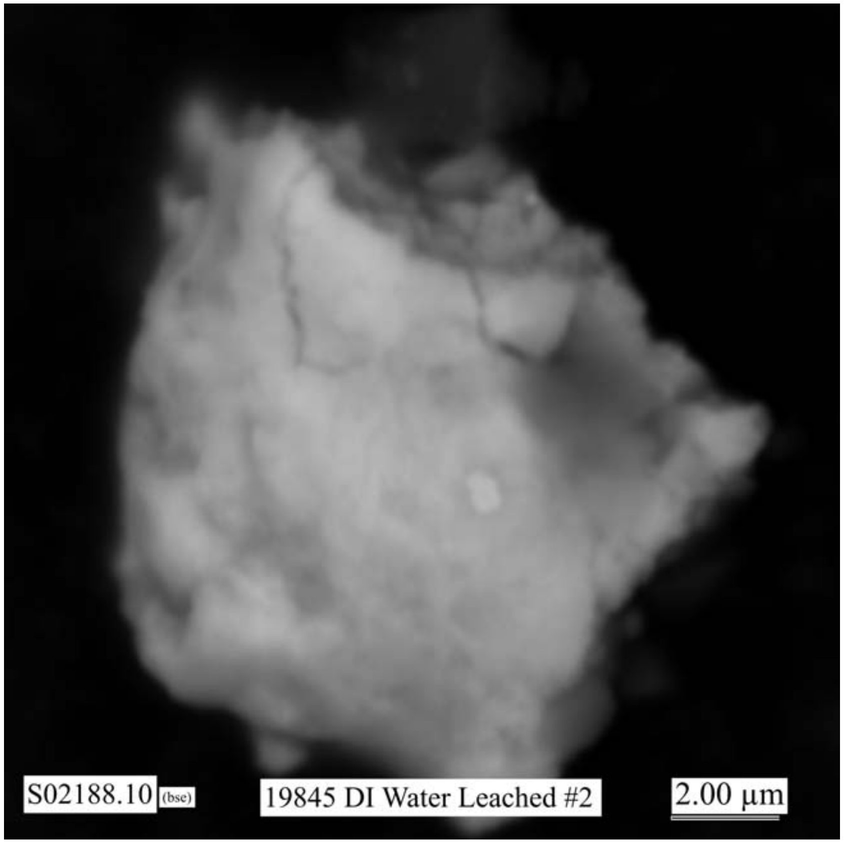

Figure C.9. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square A in Figure C.8

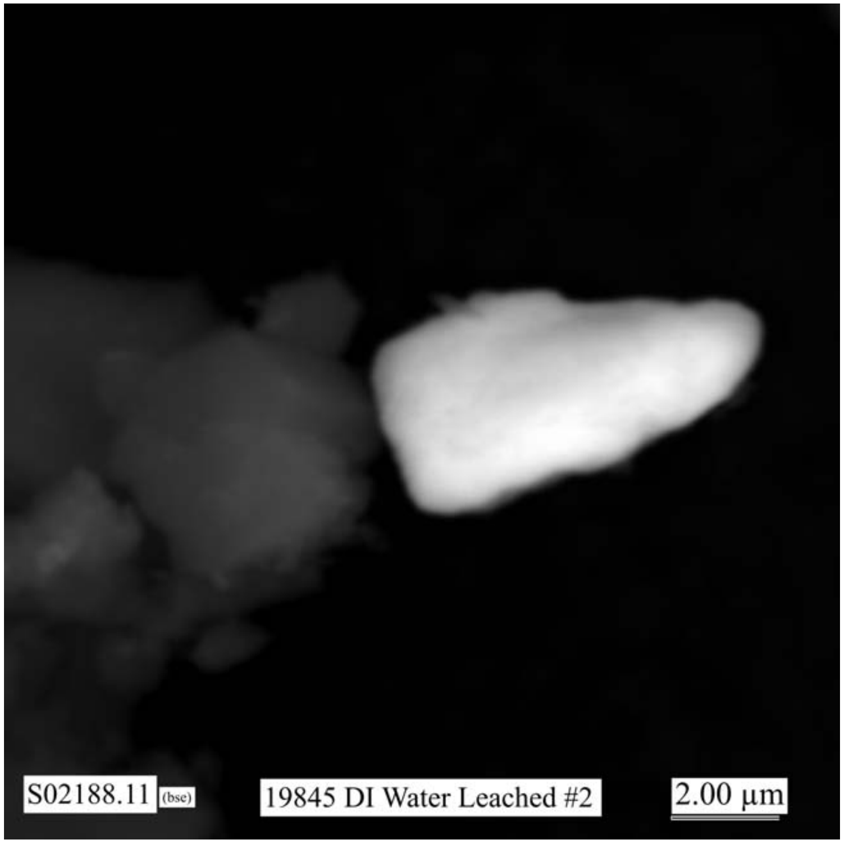

Figure C.10. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square B in Figure C.8

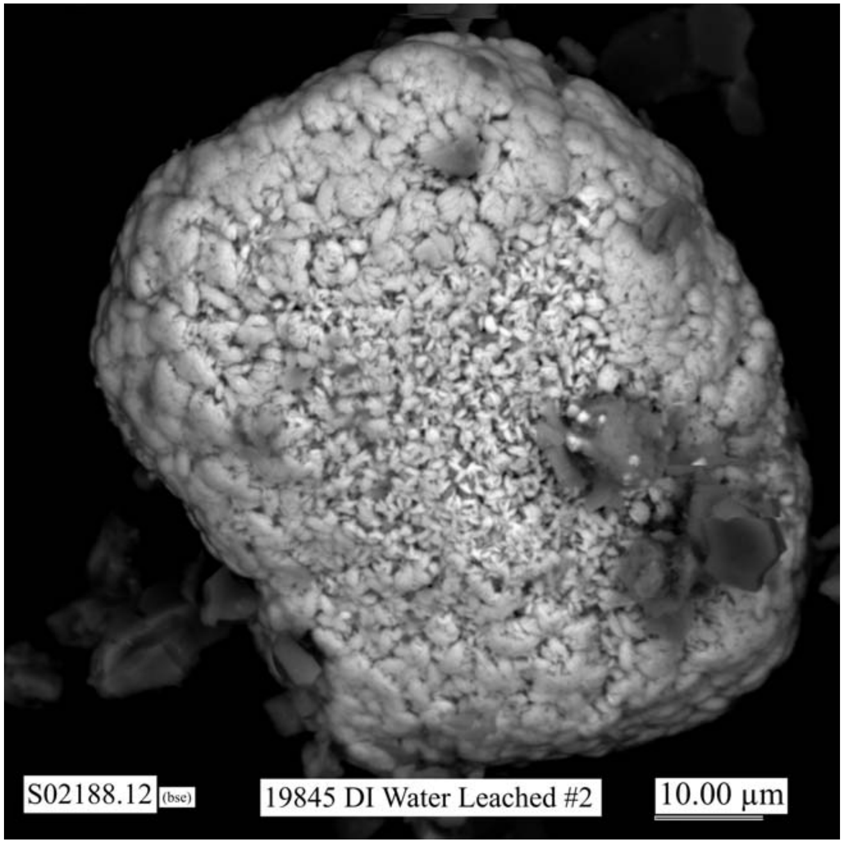

Figure C.11. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.23.)

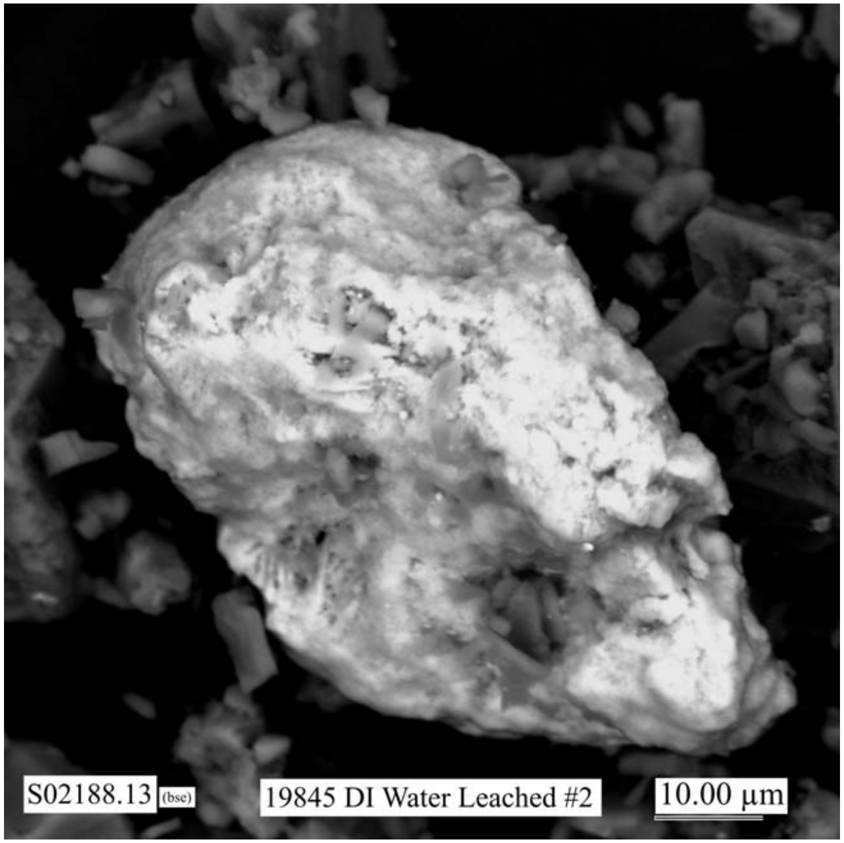

Figure C.12. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.24.)

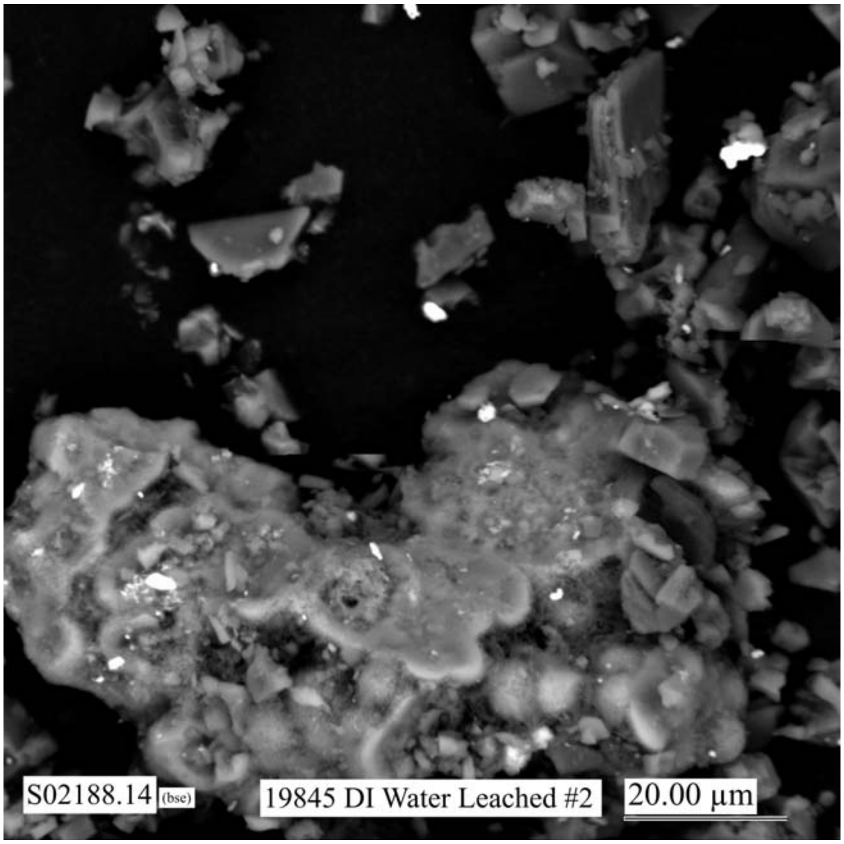

Figure C.13. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.25 and C.26.)

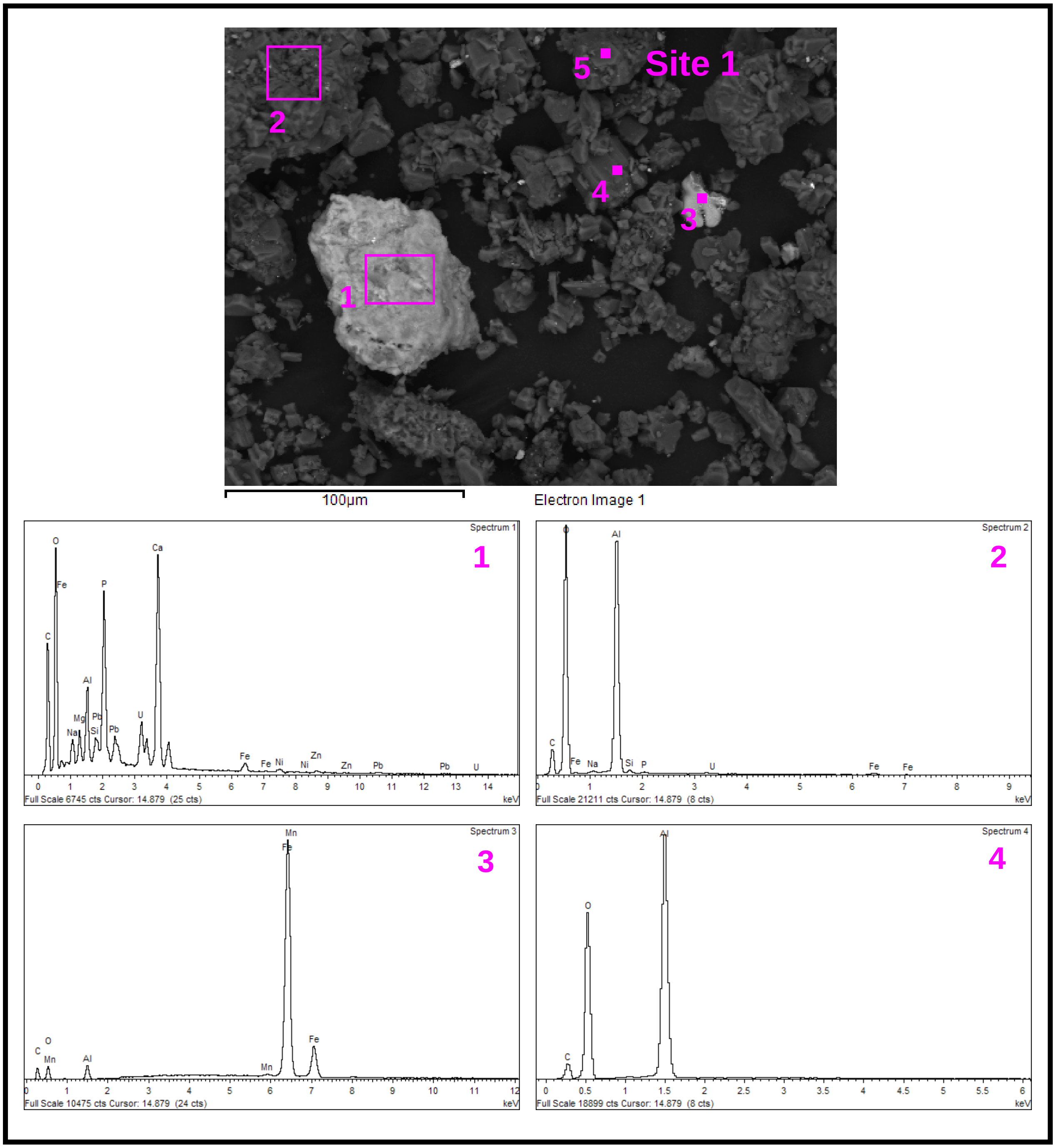

Figure C.14. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

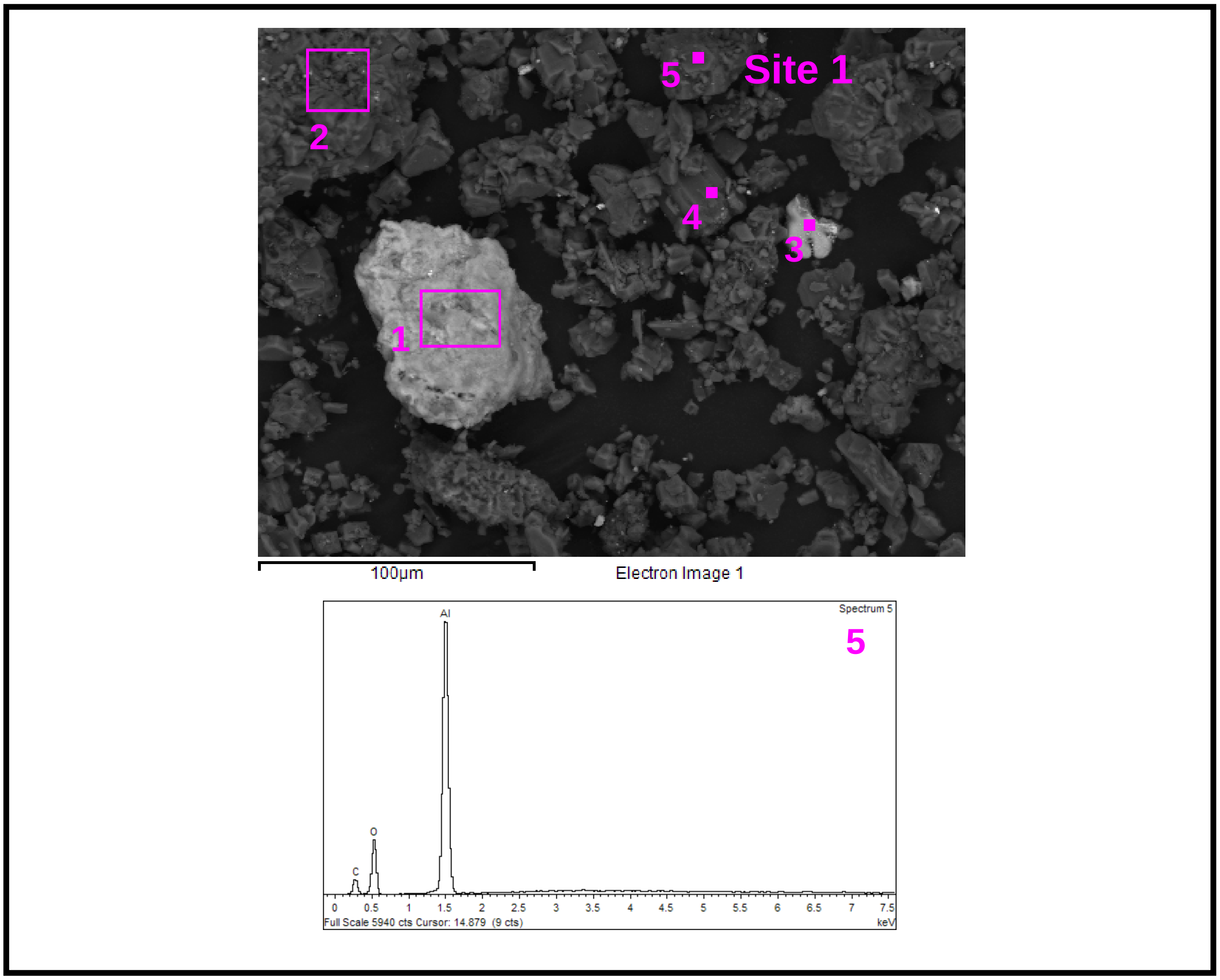

Figure C.15. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

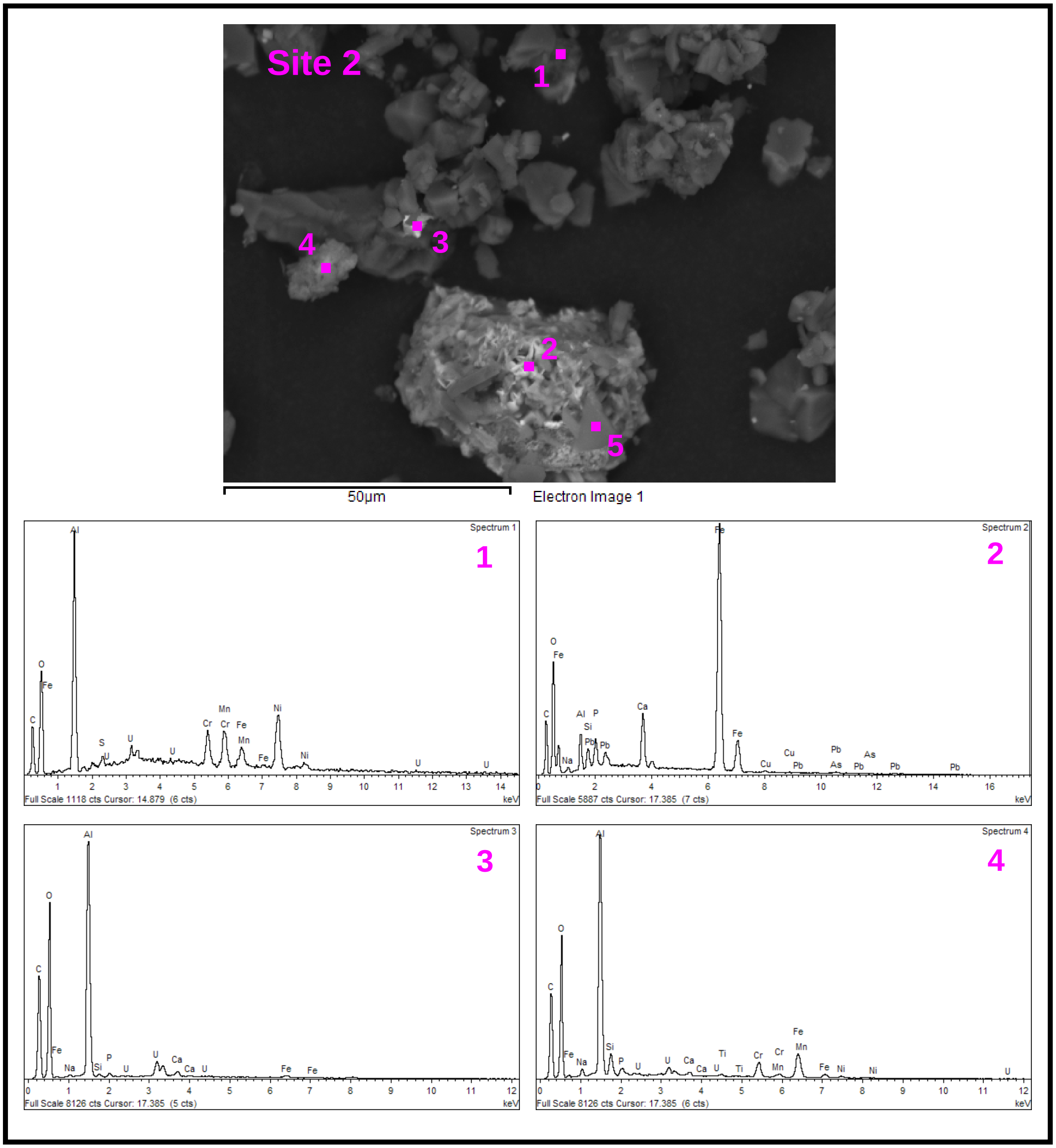

Figure C.16. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

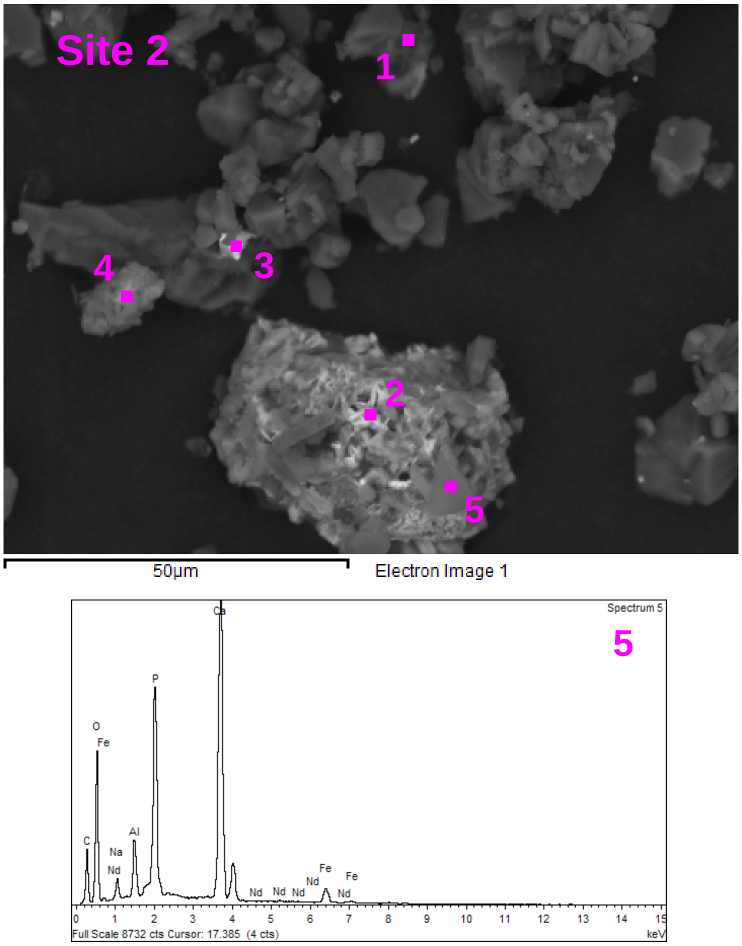

Figure C.17. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

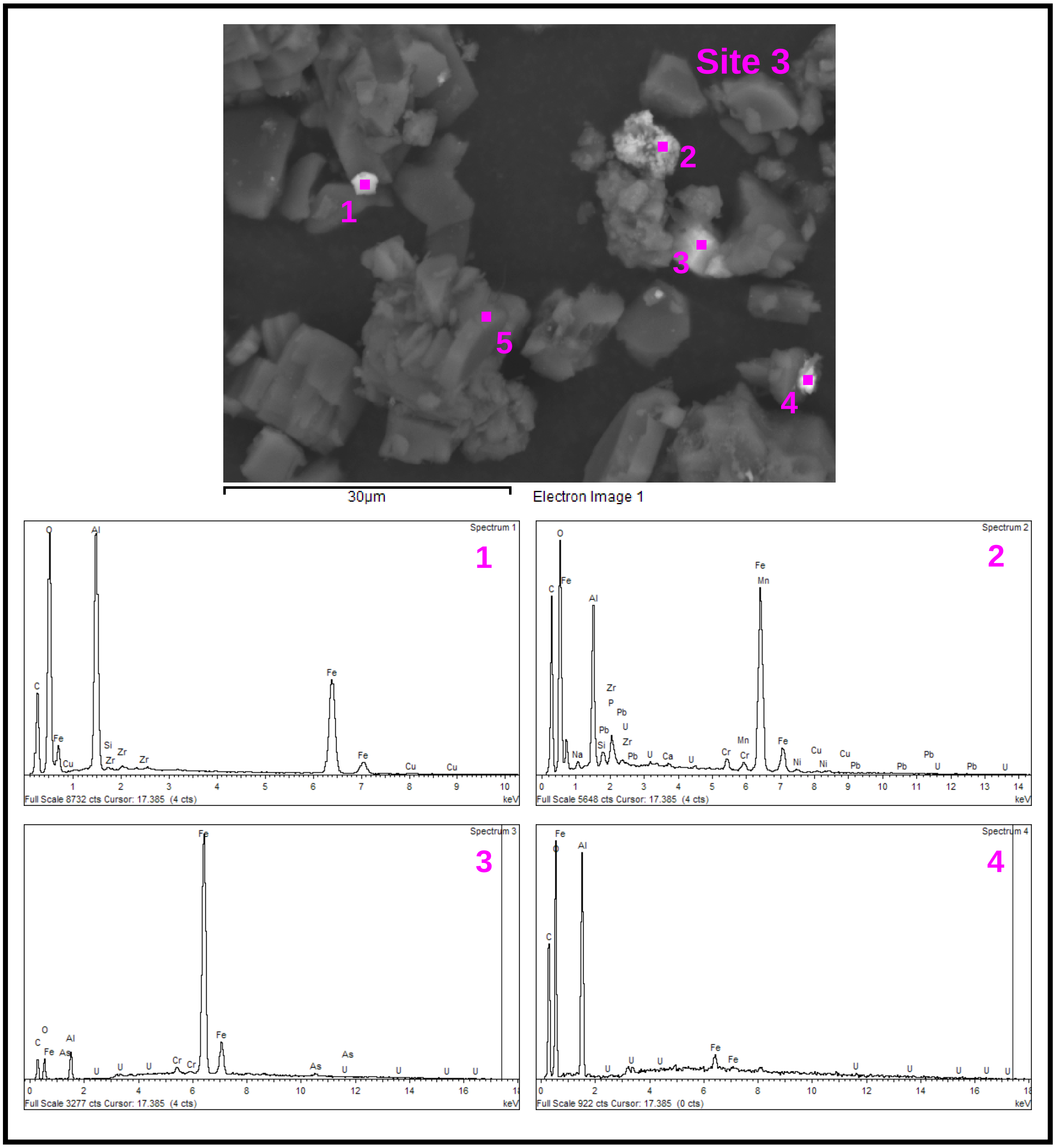

Figure C.18. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

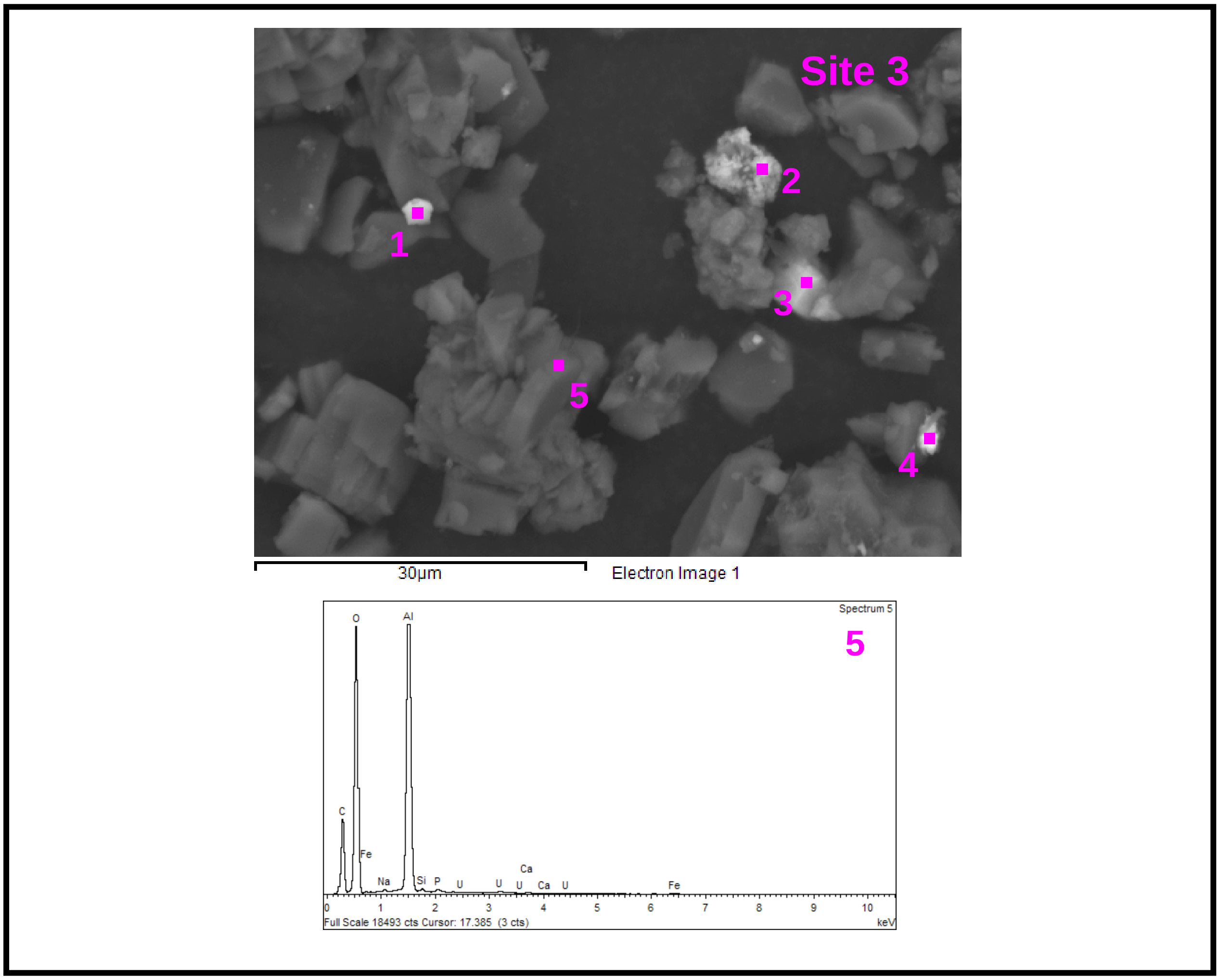

Figure C.19. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

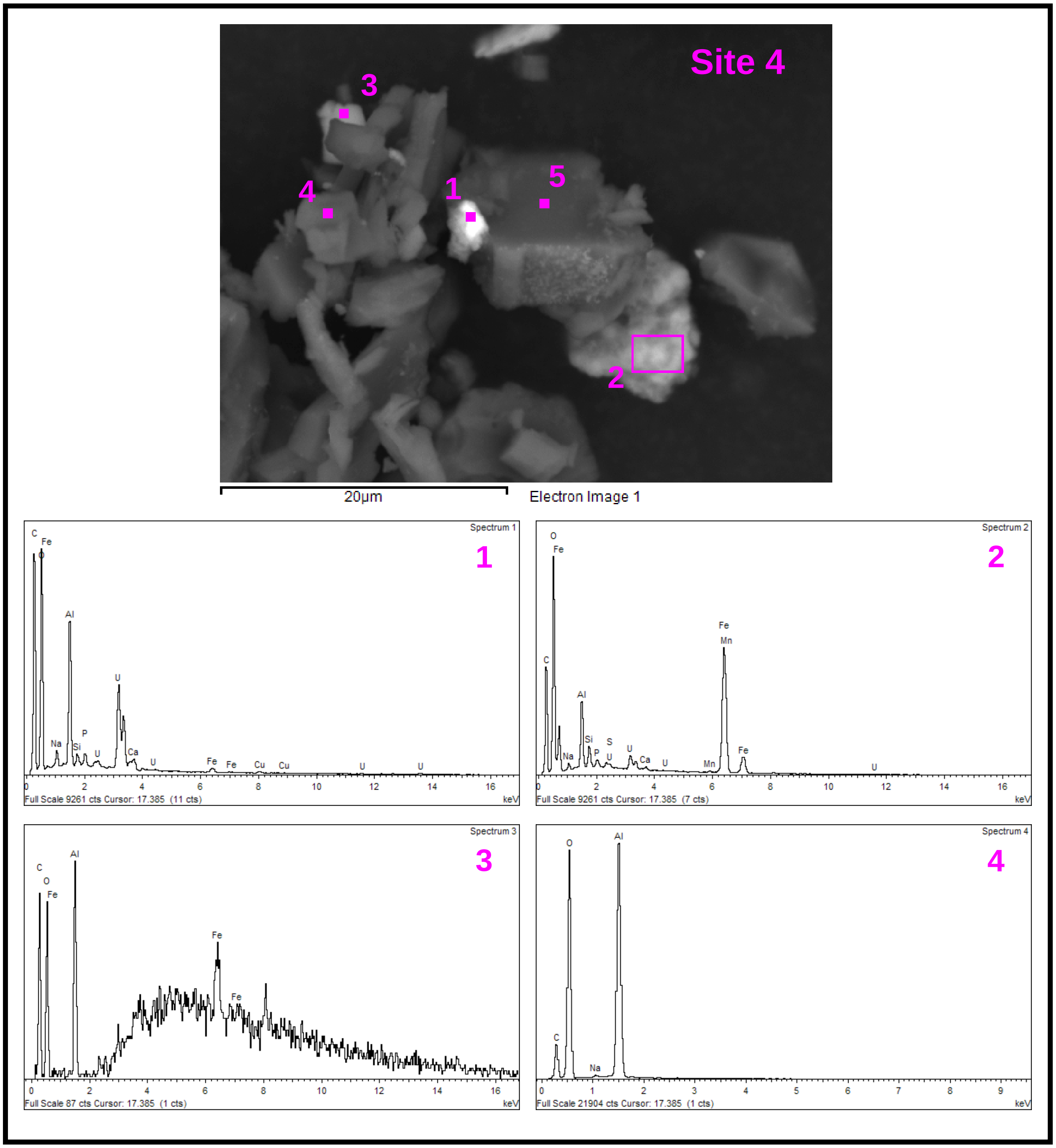

Figure C.20. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

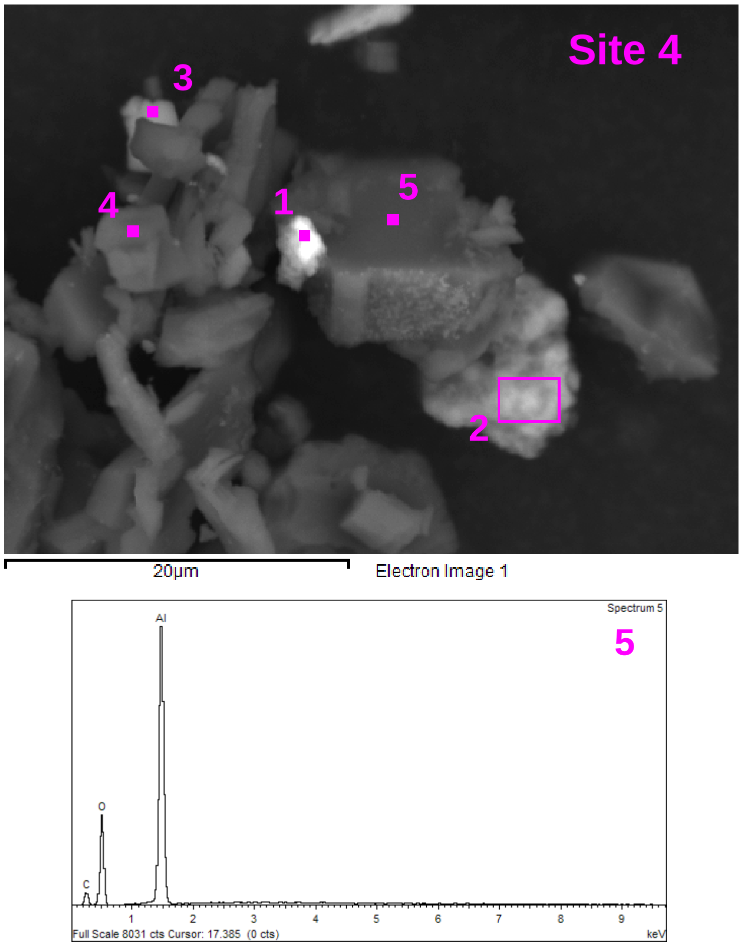

Figure C.21. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

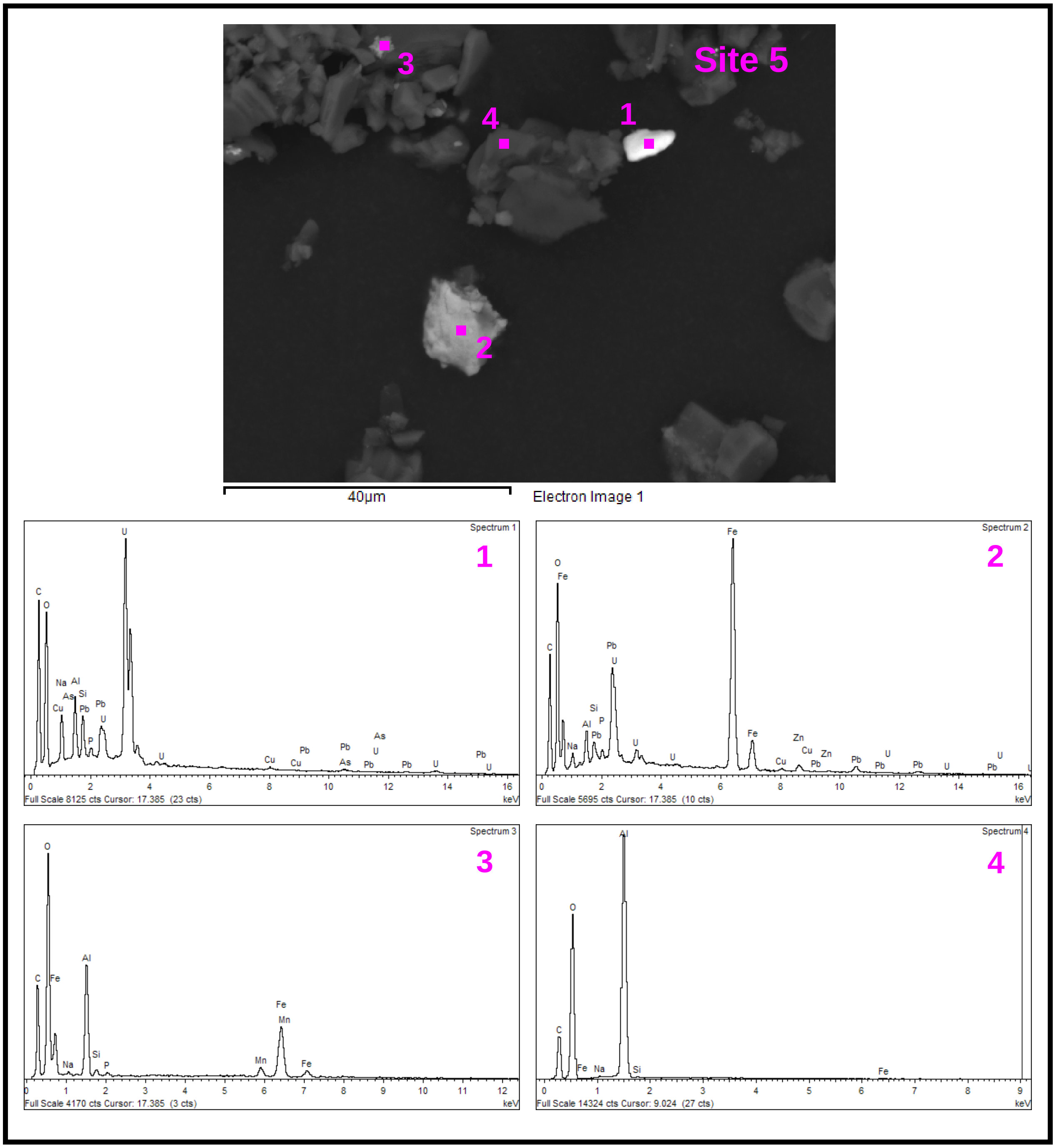

Figure C.22. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

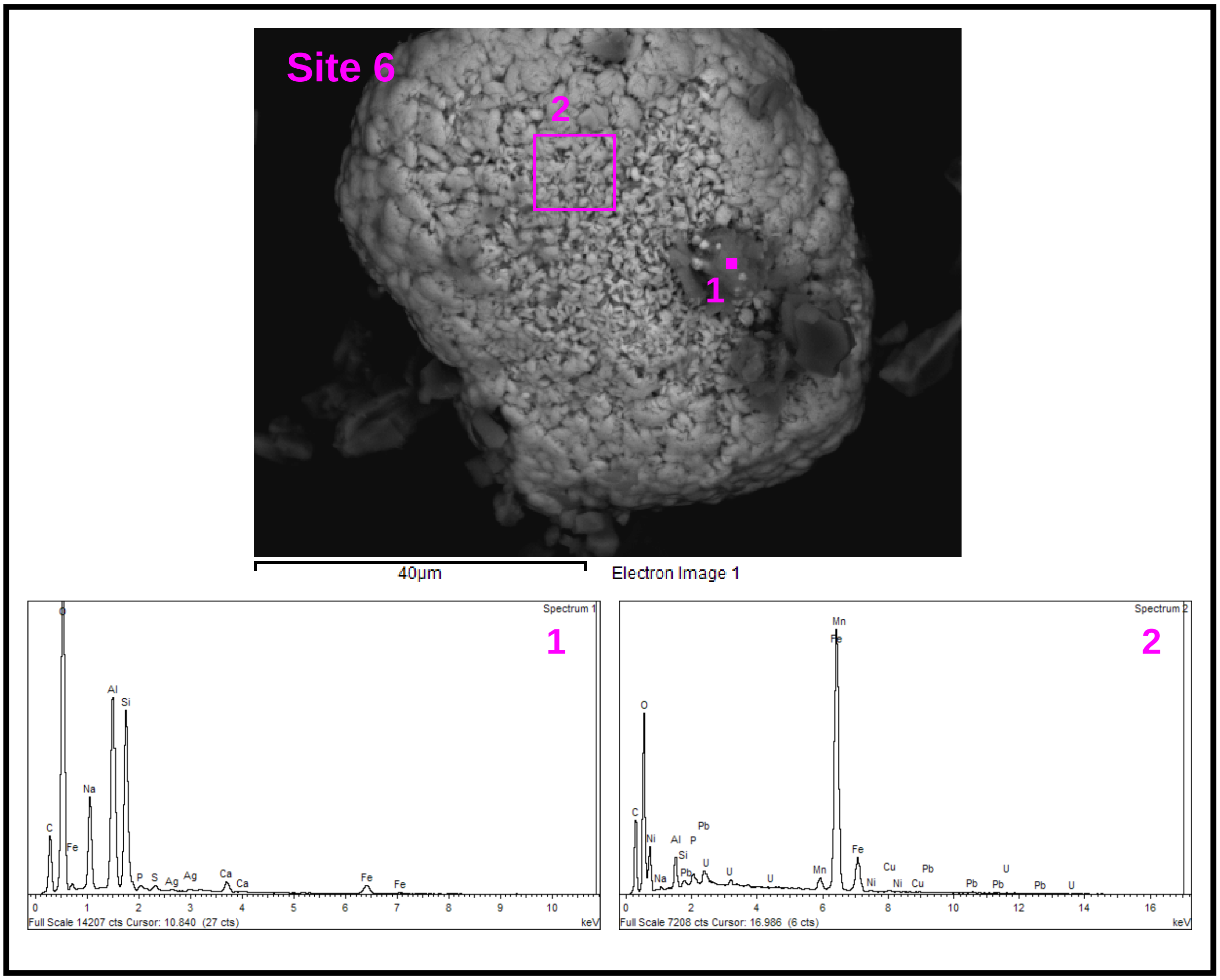

Figure C.23. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

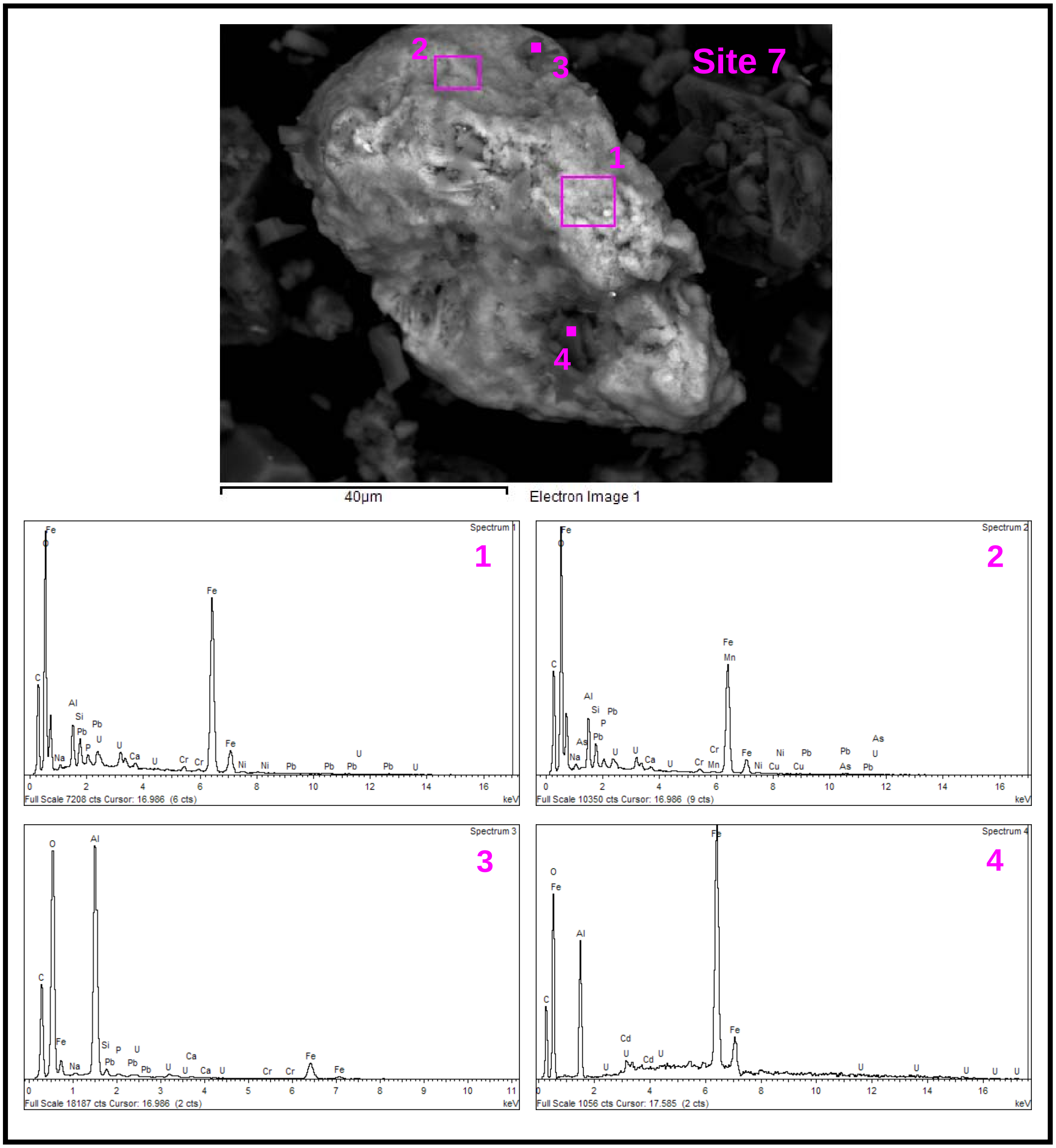

Figure C.24. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

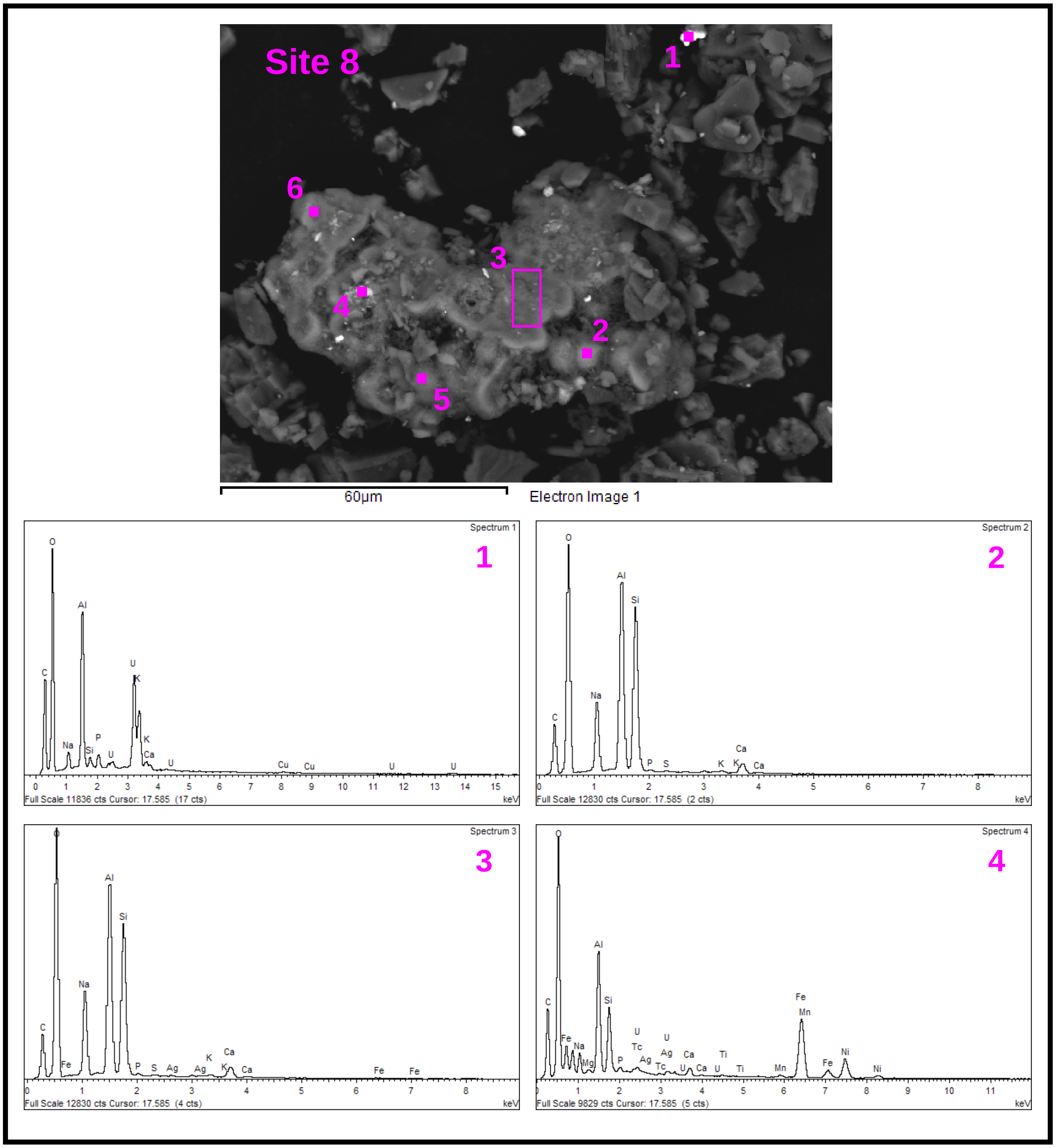

Figure C.25. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

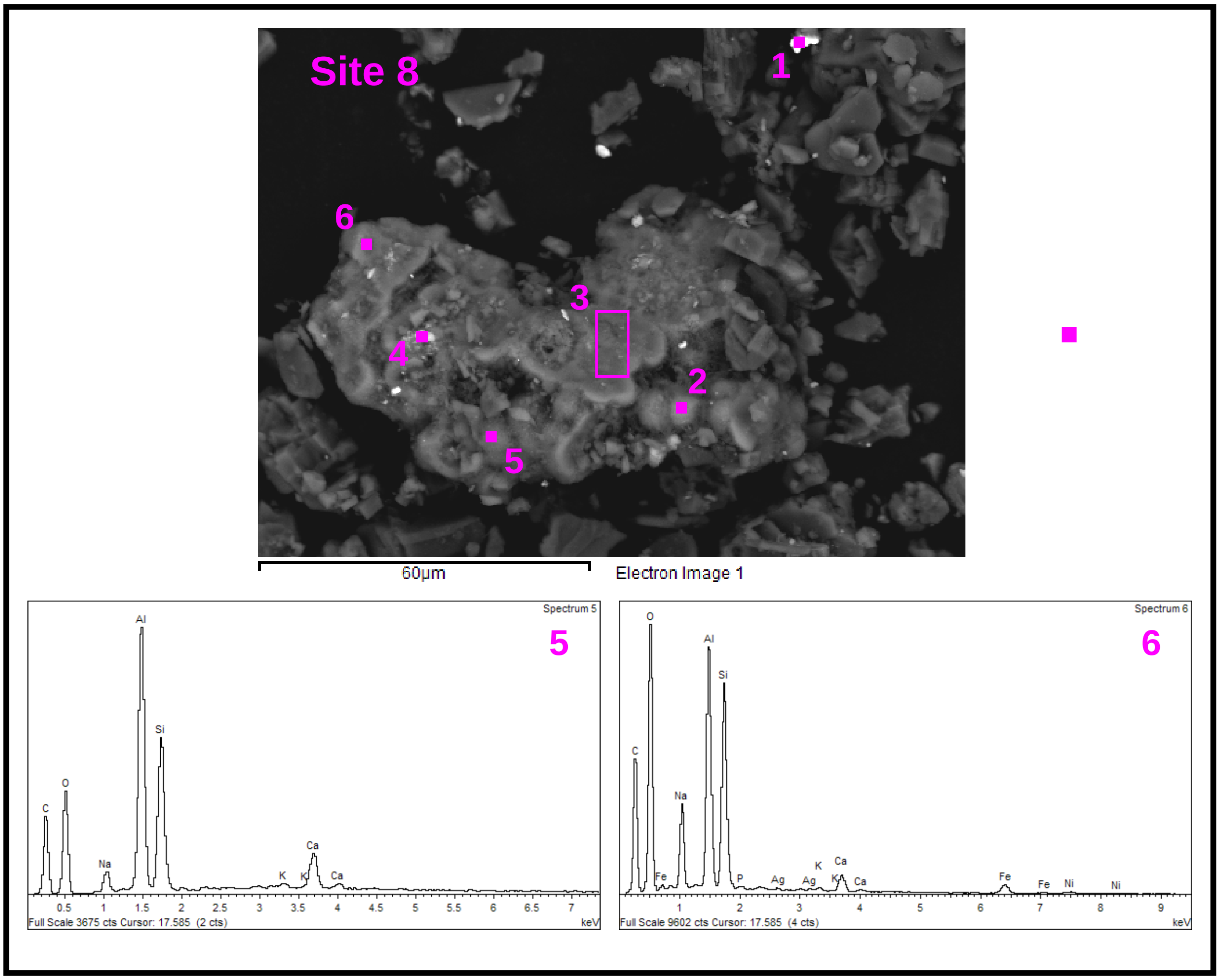

Figure C.26. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

Table C.1. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %(a)												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.14 and C.15/1	1	3.8	0.7	1.8	14.6	9.6	1.4					51.6	8.7	Mg (2.0), Ni (0.8), Pb (4.1), Zn (0.9)
	2	28.1	0.5	0.4		0.5	0.7					69.6	0.2	
	3	2.7					93.1					3.7		Mn (0.6)
	4	35.4										64.6		
	5	54.9										45.1		
C.16 and C.17/2	1	24.9				5.3	4.7	6.8				26.2		Mn (7.7), Ni (23.3), S (1.1)
	2	3.5	1.6	1.0	4.9		59.2					23.7	2.2	As (0.2), Cu (0.7), Pb (2.9)
	3	28.0	0.4	0.4	0.9	8.5	0.9					60.4	0.7	
	4	27.1	3.1	1.6	0.6	3.8	10.0	4.4				46.6	1.0	Mn (0.6), Ni (1.0), Ti (0.3)
	5	3.3		2.2	24.2		3.0					54.5	12.2	Nd (0.5)
C.18 and C.19/3	1	22.4	0.3				28.8					47.2		Cu (0.5), Zr (0.9)
	2	12.2	0.5	1.1	0.3	1.0	38.7	1.6				36.3	1.1	Cu (0.6), Mn (1.3), Ni (0.8), Pb (1.0), Zr (3.6)
	3	4.8				1.4	87.3	1.2				5.2		As (0.1)
	4	26.5				4.4	5.7					63.4		
	5	28.7	0.4	0.4	0.1	0.9	0.2					69.0	0.3	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.2. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %[(a)]**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.20 and C.21/4	1	12.2	0.9	2.3	1.1	27.6	1.2					52.9	1.2	Cu (0.6)
	2	7.4	2.2	1.5	0.3	5.3	38.8					43.3	0.8	Mn (0.3), S (0.2)
	3	27.3					26.4					46.3		
	4	30.2		0.4								69.4		
	5	47.0										53.0		
C.22/5	1	3.9	2.4	4.6		49.7						32.9	0.5	Cu (0.7), Pb (5.2)
	2	2.4	1.1	1.3		3.1	43.6					29.5	0.6	Cu (0.9), Pb (14.6), Zn (2.9)
	3	15.9	1.0	0.8			22.5					56.0	0.4	Mn (3.3)
	4	35.1	0.2	0.3			0.3					64.0		
C.23/6	1	13.6	14.0	10.4	1.0		2.2			0.5		57.6	0.3	S (0.4)
	2	3.0	0.4	0.8		1.4	59.9					27.4	0.7	Cu (0.6), Mn (2.3), Ni (0.5), Pb (2.9)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.3. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.24/7	1	3.8	2.2	0.9	0.5	4.4	42.7	0.7				40.5	0.7	Ni (0.5), Pb (3.1)
	2	5.3	2.4	1.2	0.4	4.6	33.1	0.6				47.6	0.8	As (0.2), Cu (0.4), Mn (0.2), Ni (0.5), Pb (2.6)
	3	26.4	0.9	0.5	0.1	1.4	7.0	0.2				62.3	0.3	Pb (0.8)
	4	12.3				2.3	55.7					28.9		Cd (0.7)
C.25 and C.26/8	1	12.6	0.8	2.2	0.4	29.4						52.6	1.2	Cu (0.5), K (0.3)
	2	15.8	16.0	9.0	1.3							57.5	0.2	K (0.2), S (0.1)
	3	15.5	14.0	10.5	1.3		0.2			0.3		57.6	0.3	K (0.2), S (0.1)
	4	11.3	6.2	3.8	0.8	1.0	16.7		0.8	0.4		49.3	0.5	Mg (0.3), Mn (0.5), Ni (8.2), Ti (0.2)
	5	24.1	19.4	3.4	5.6							46.9		K (0.6)
	6	15.8	15.4	9.1	1.6		2.2			0.4		54.3	0.3	K (0.2), Ni (0.6)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

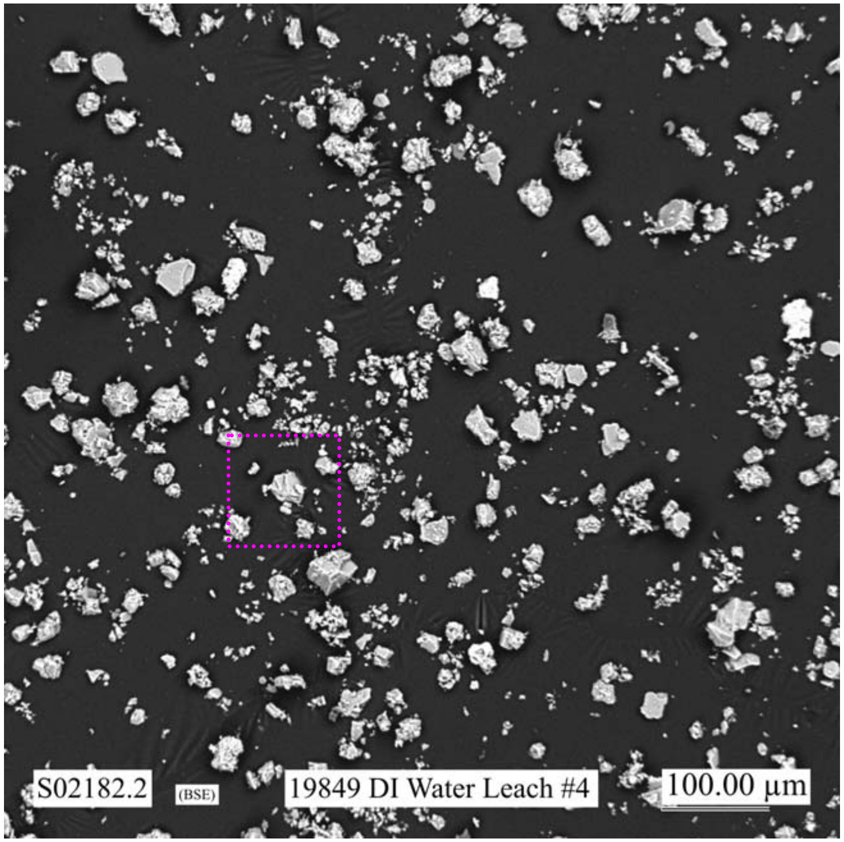

Figure C.27. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

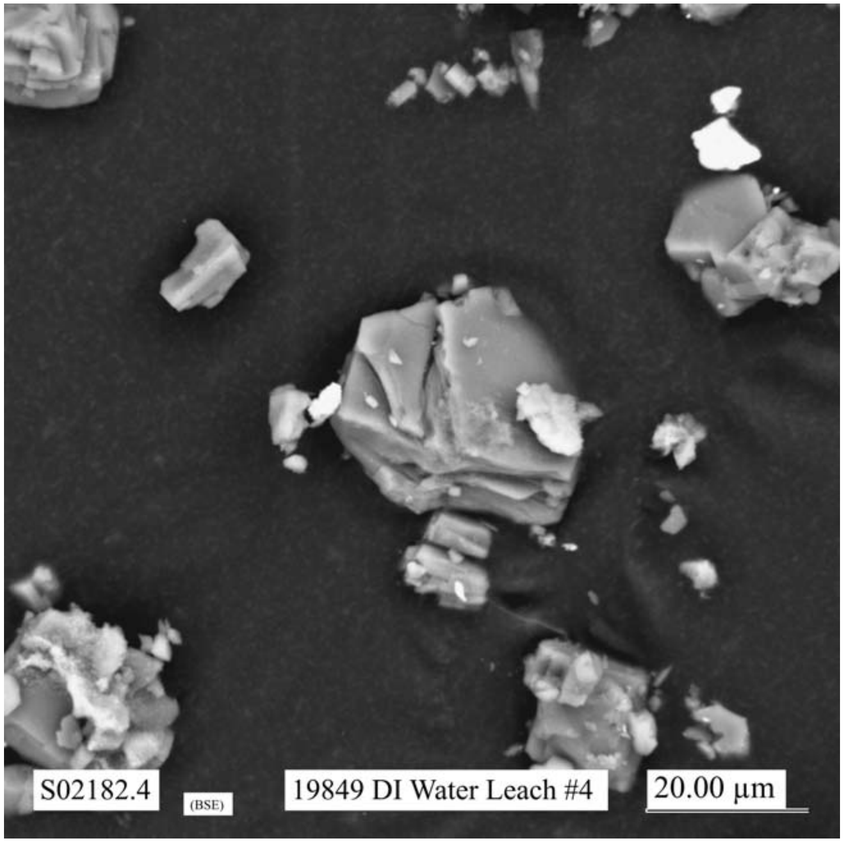

Figure C.28. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square in Figure C.27 (Areas where EDS analyses were made are shown in Figures C.34 and C.35.)

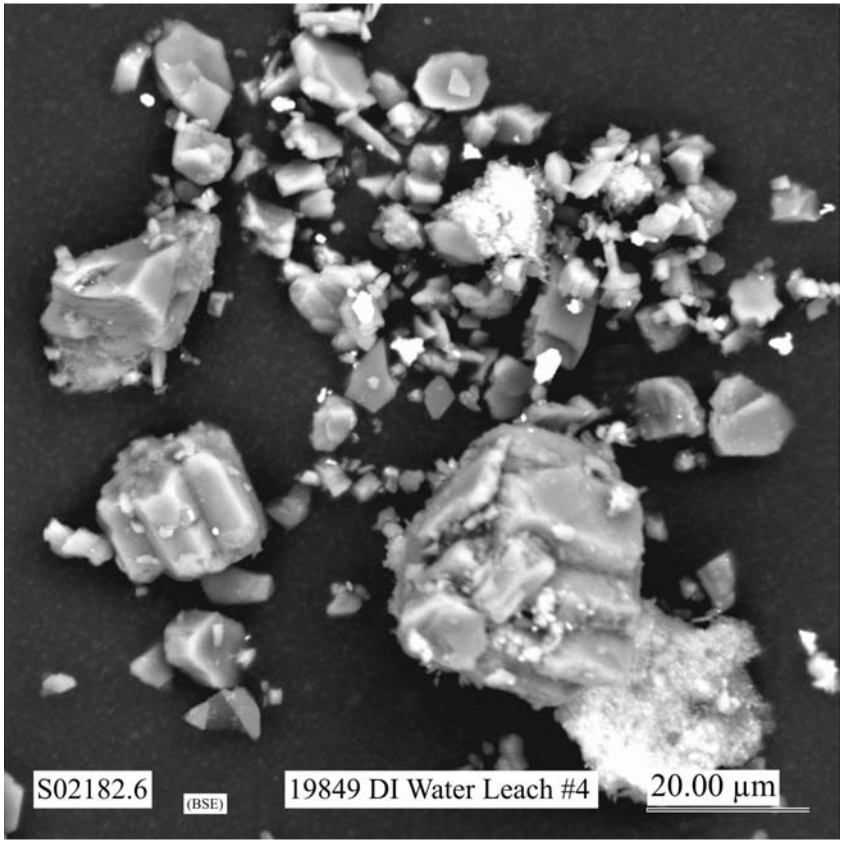

Figure C.29. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.36 and C.37.)

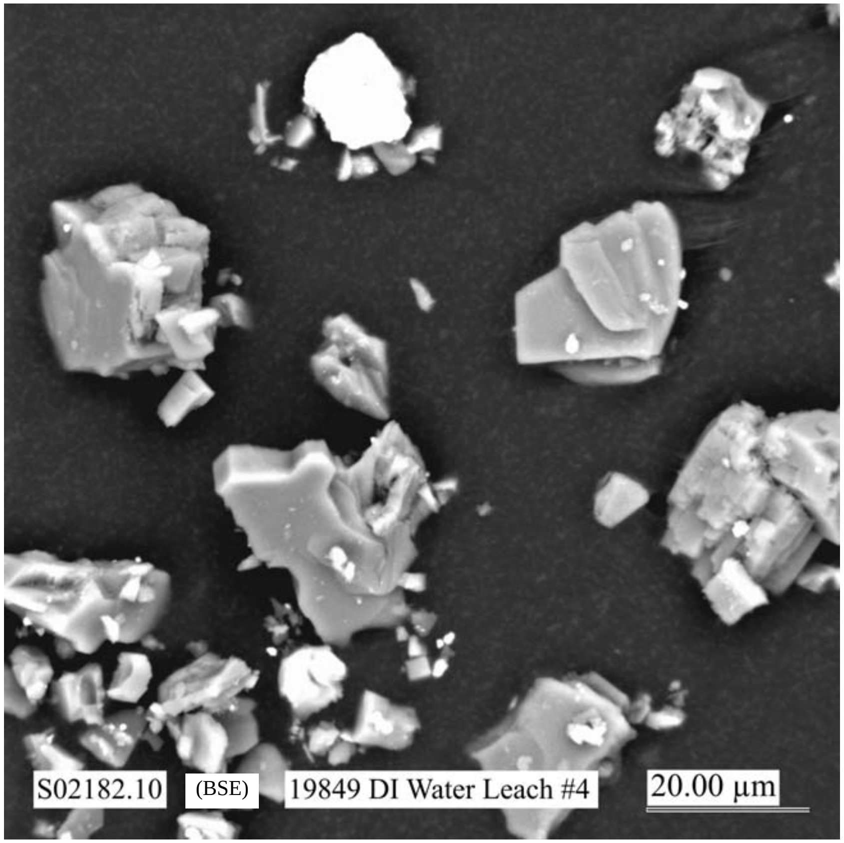

Figure C.30. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.40 and C.41.)

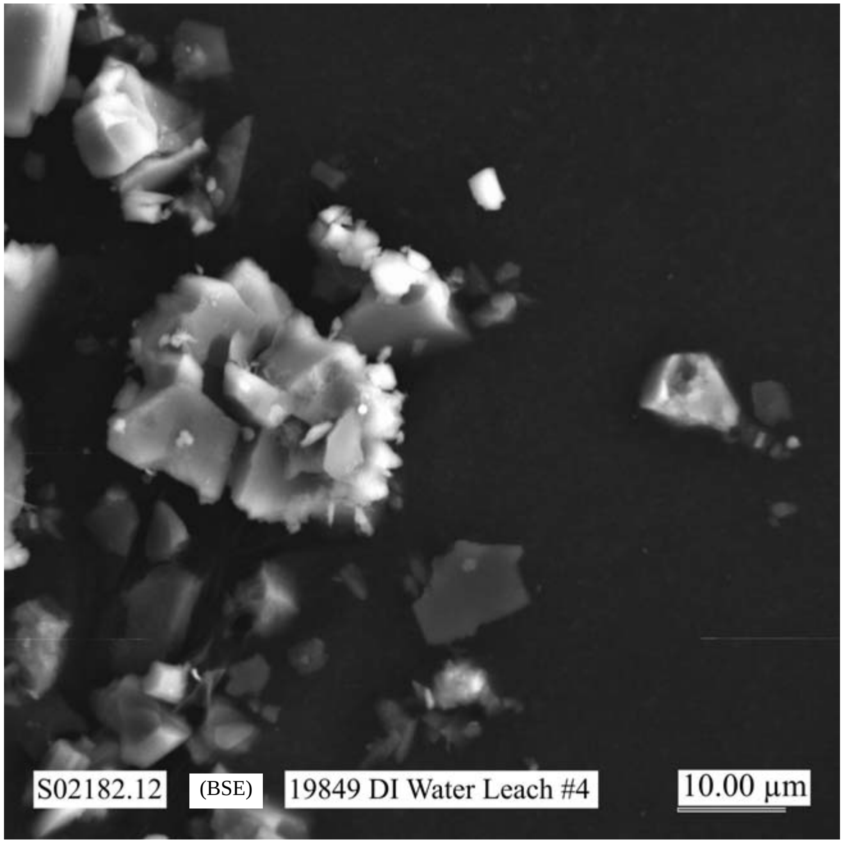

Figure C.31. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.42 and C.43.)

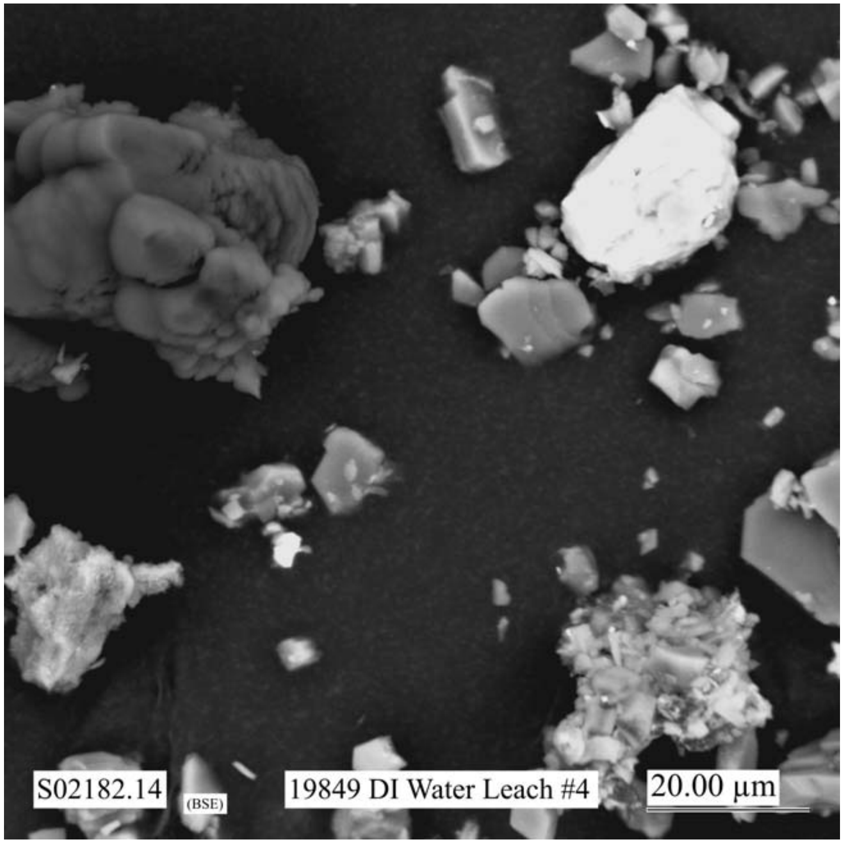

Figure C.32. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.44 and C.45.)

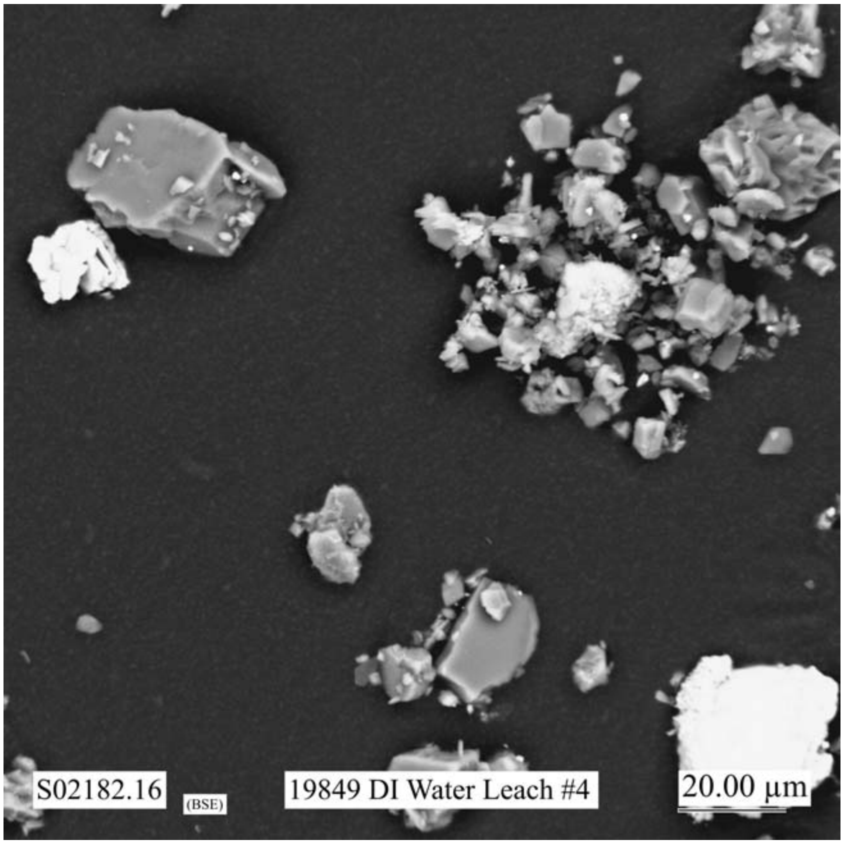

Figure C.33. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.46.)

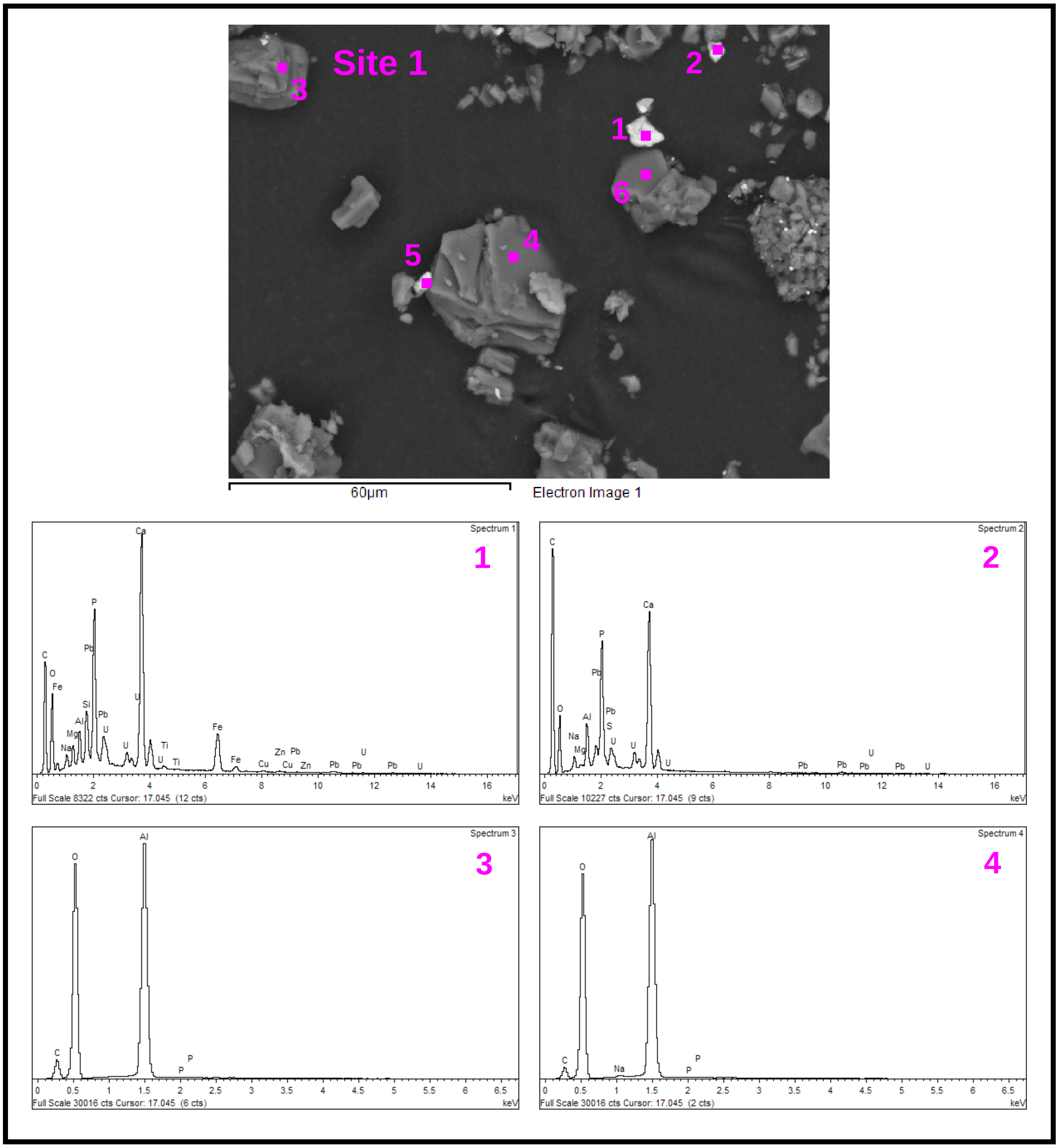

Figure C.34. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

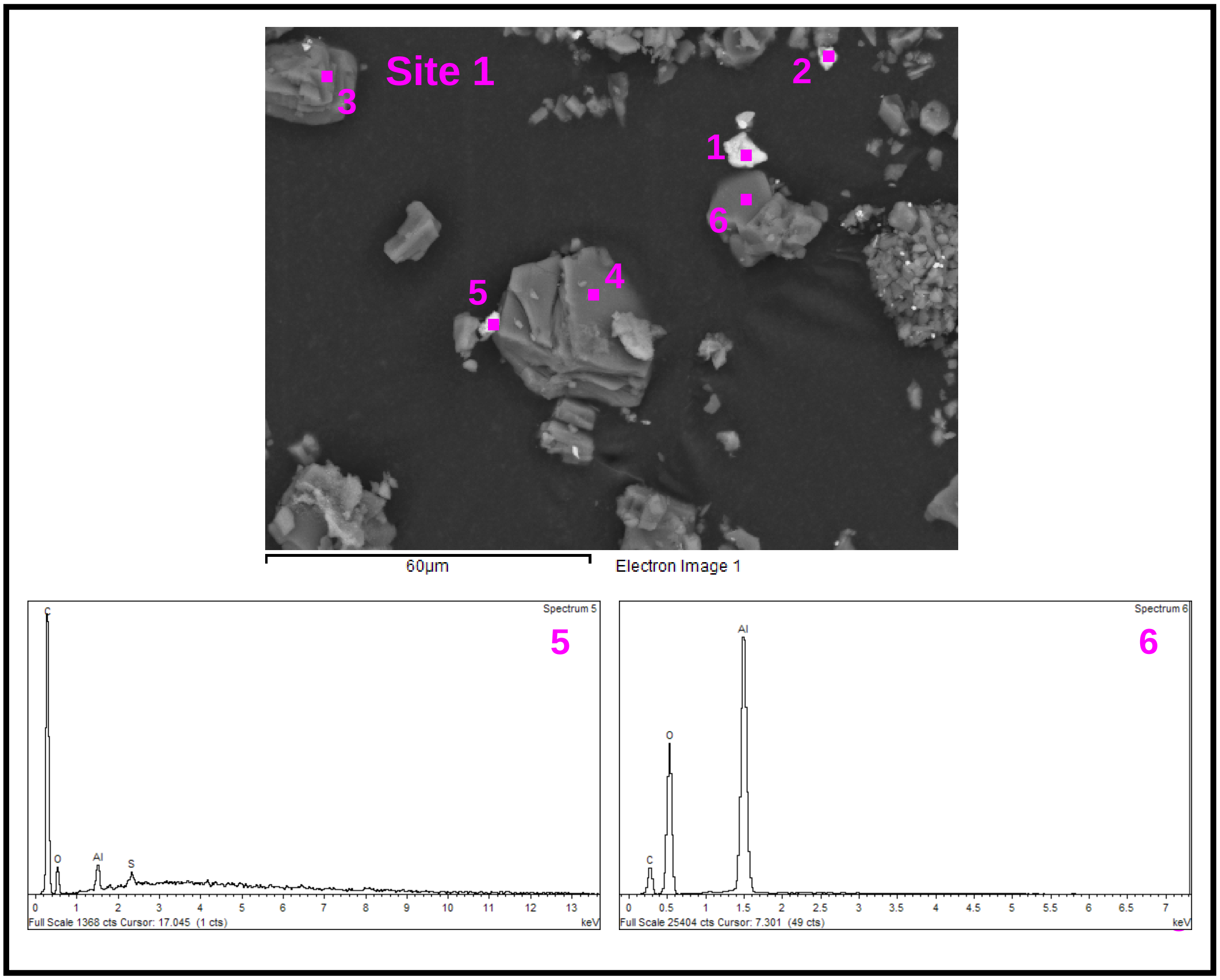

Figure C.35. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

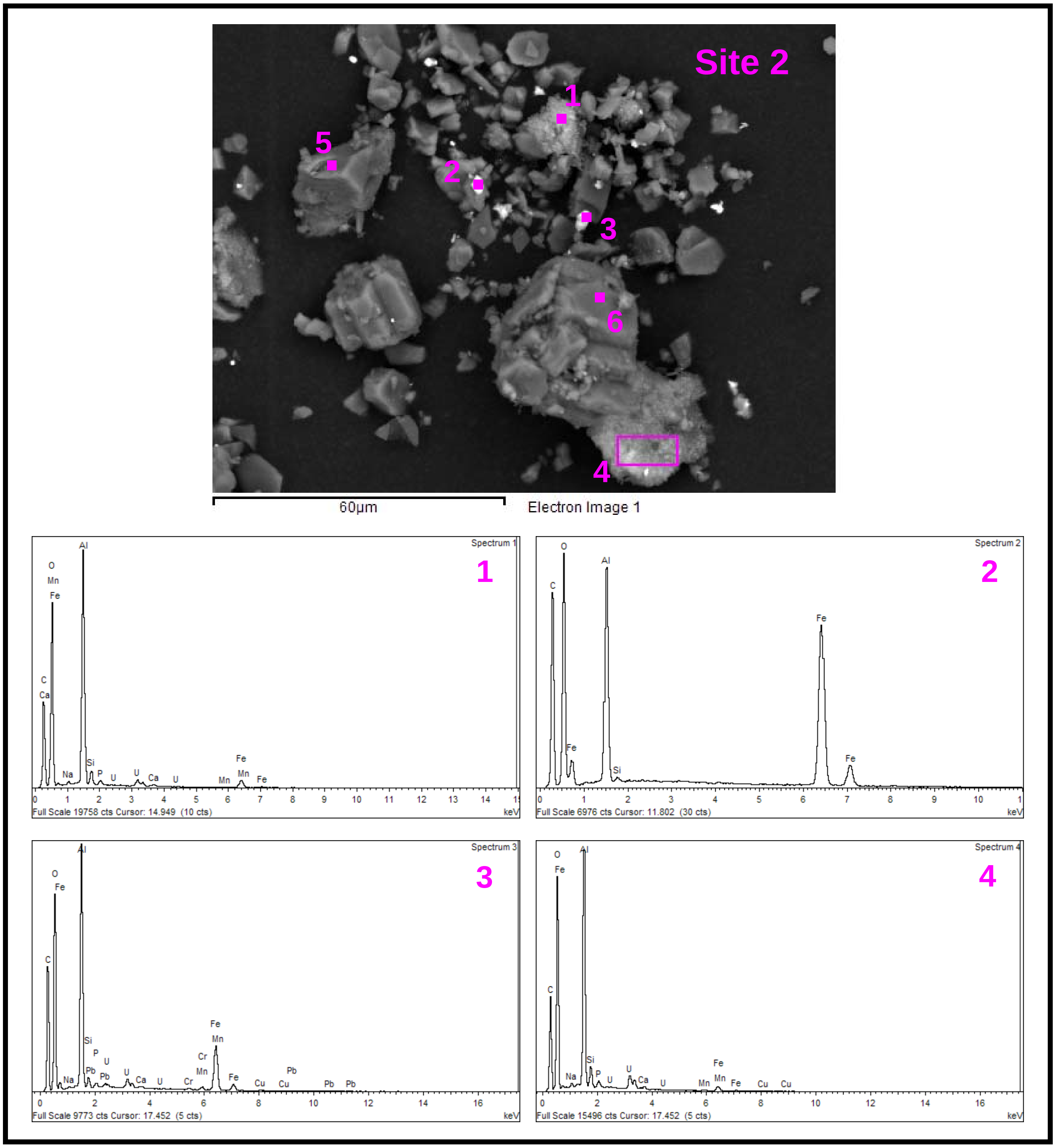

Figure C.36. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

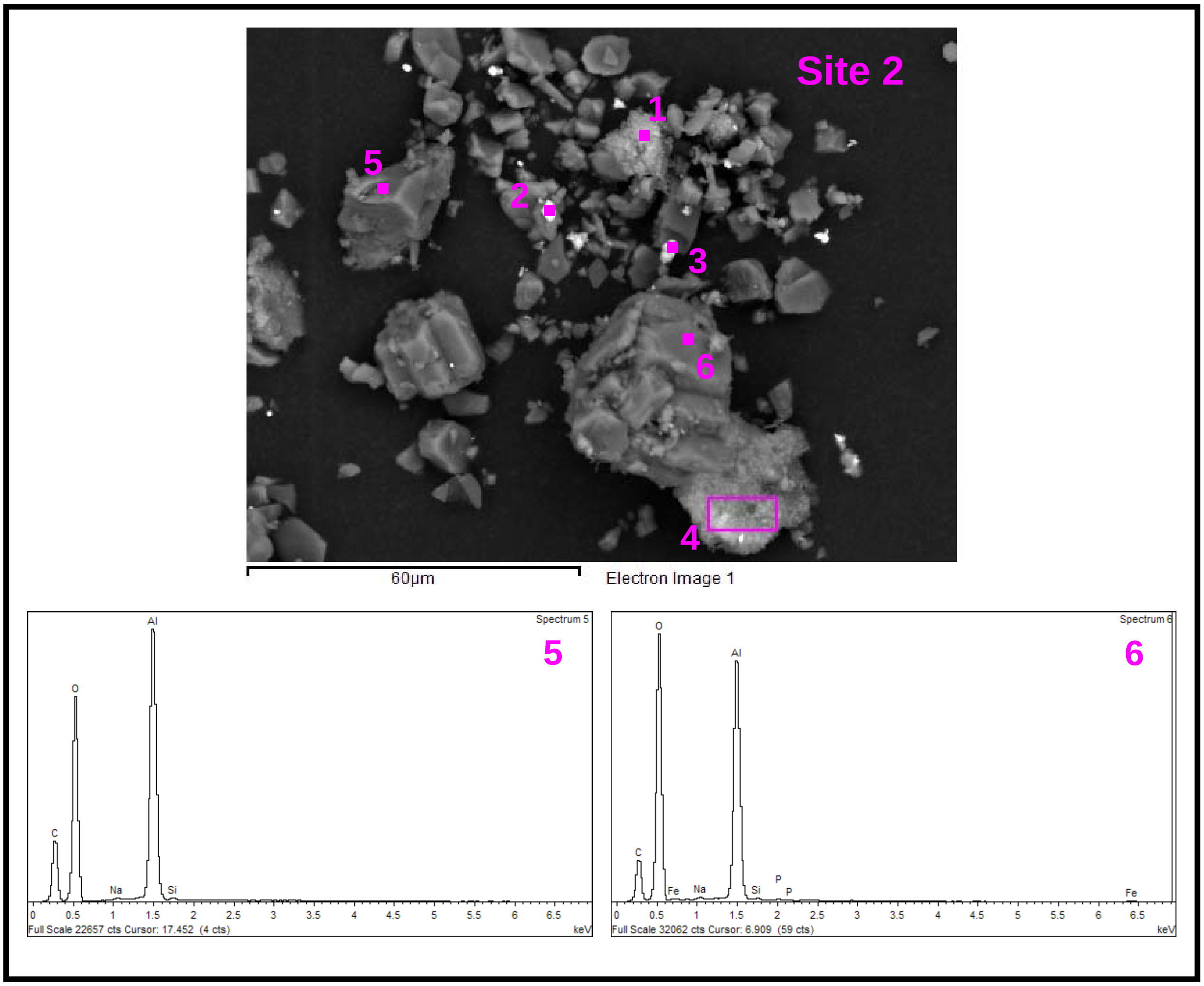

Figure C.37. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

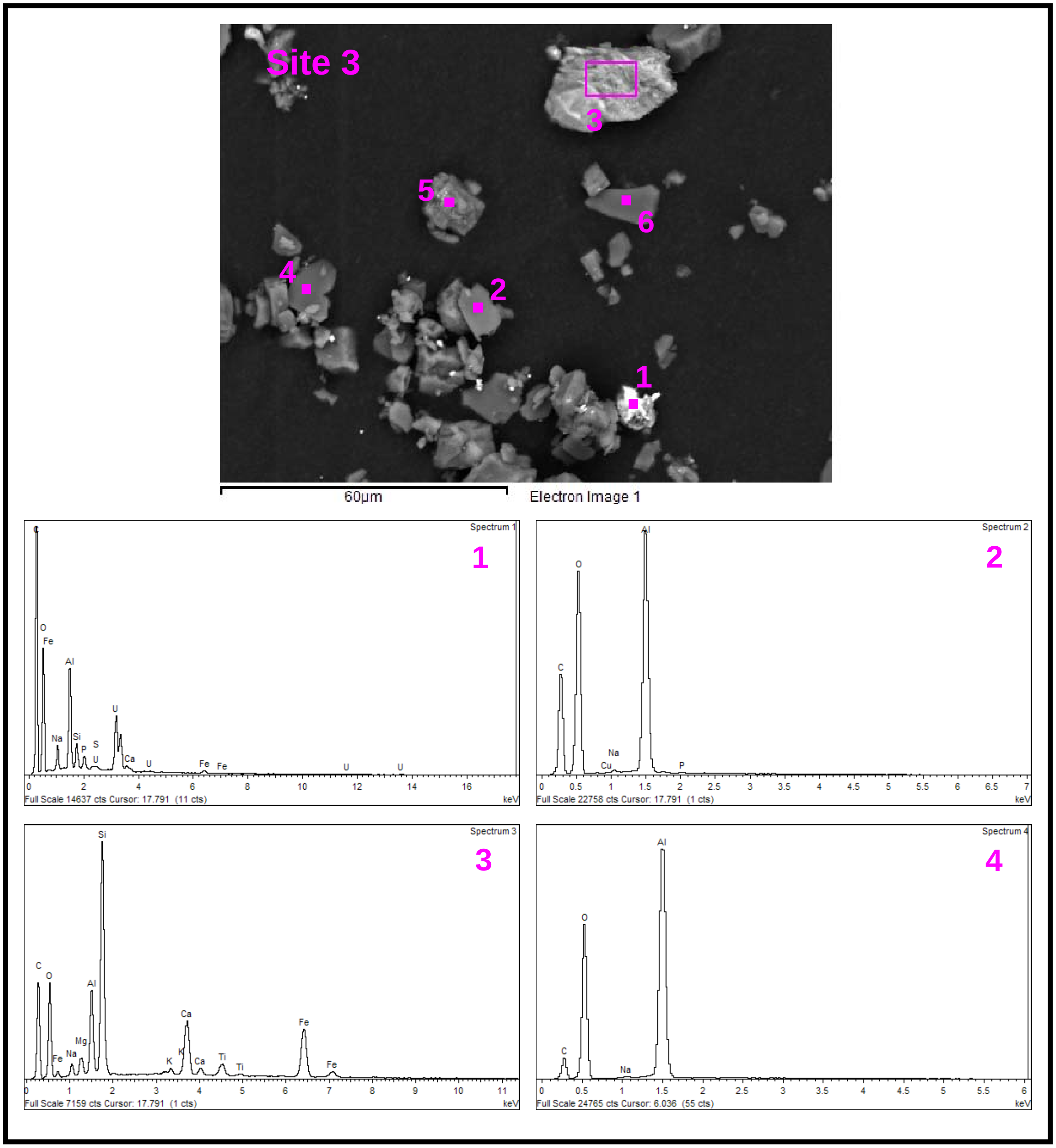

Figure C.38. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

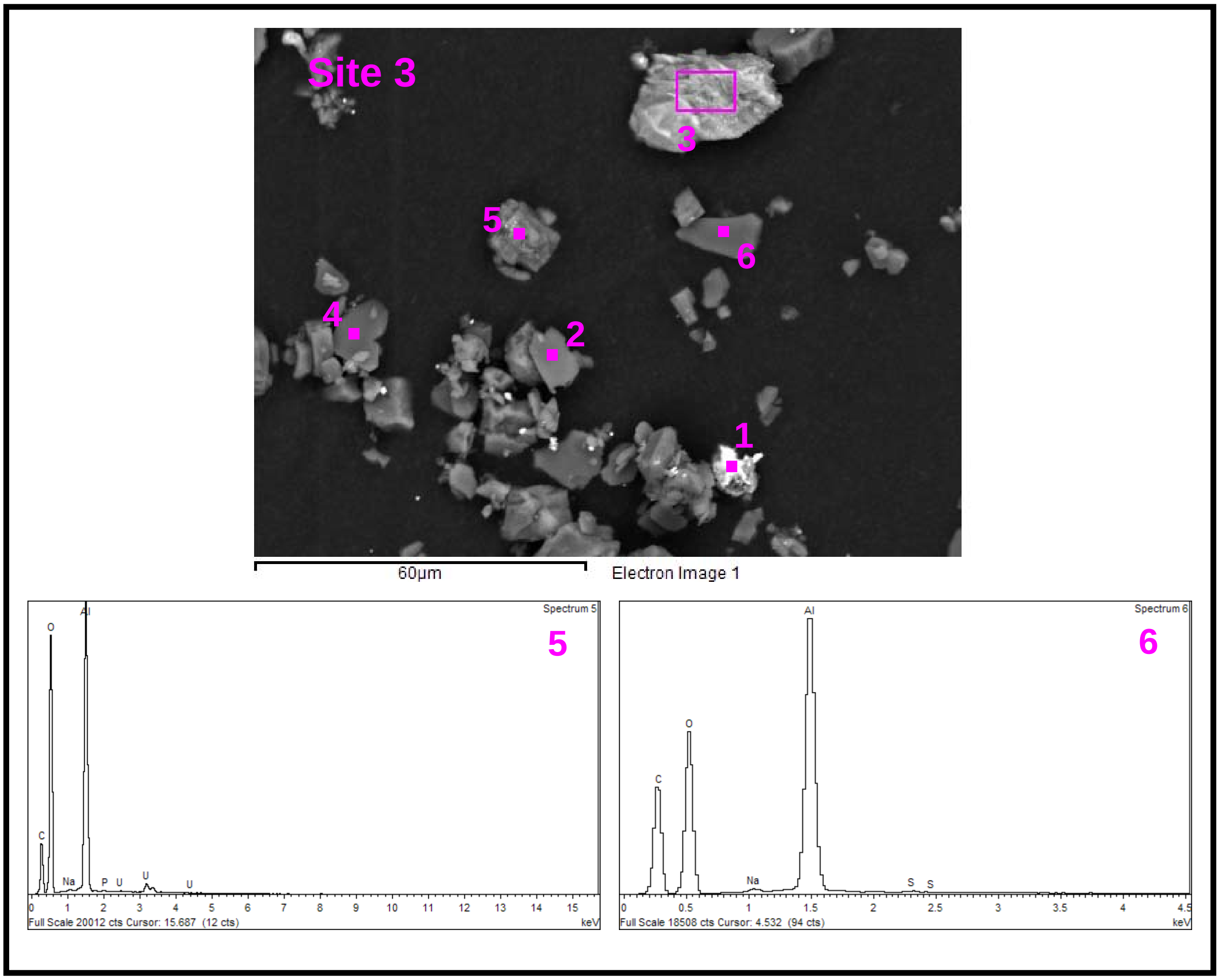

Figure C.39. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

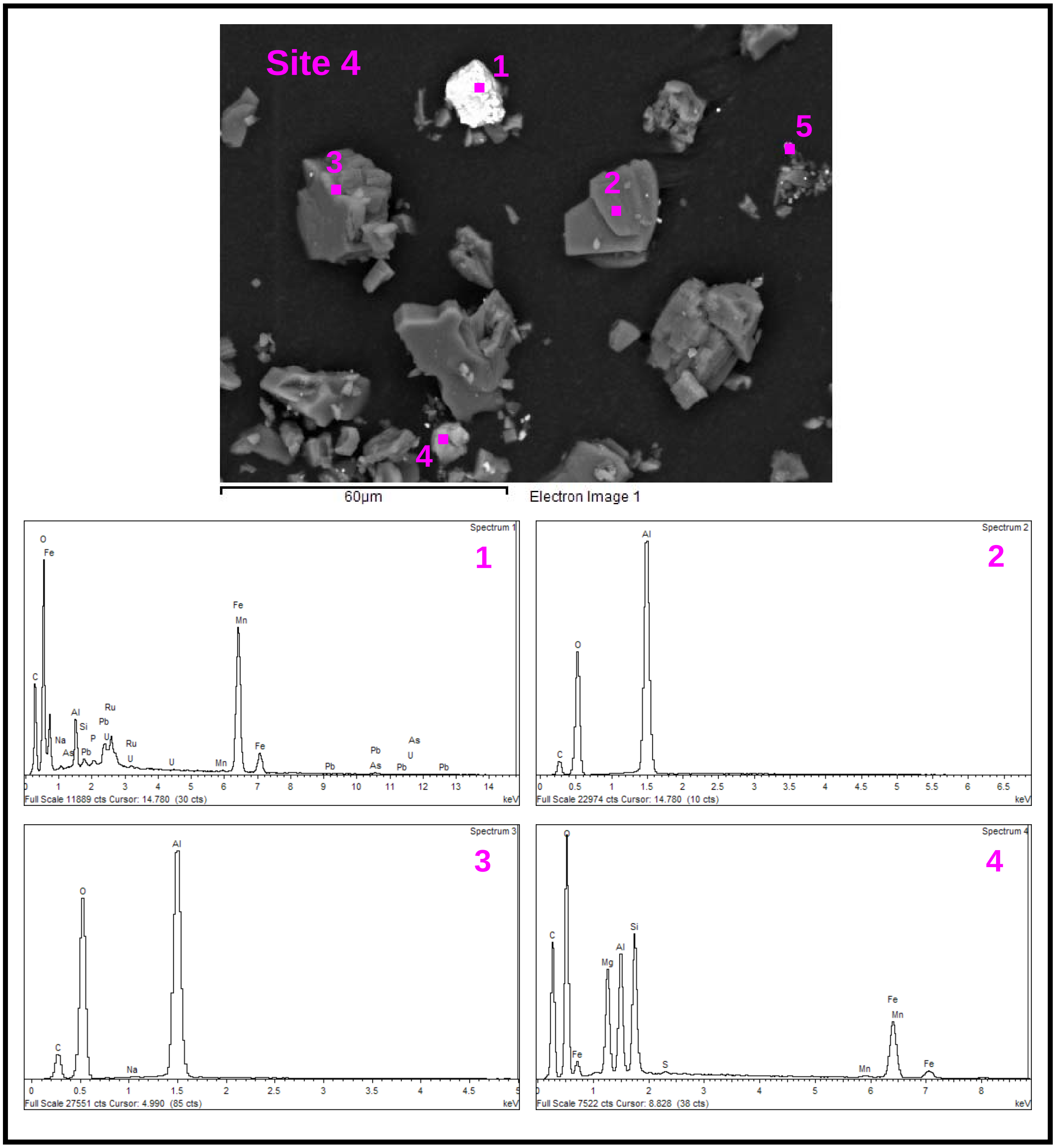

Figure C.40. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

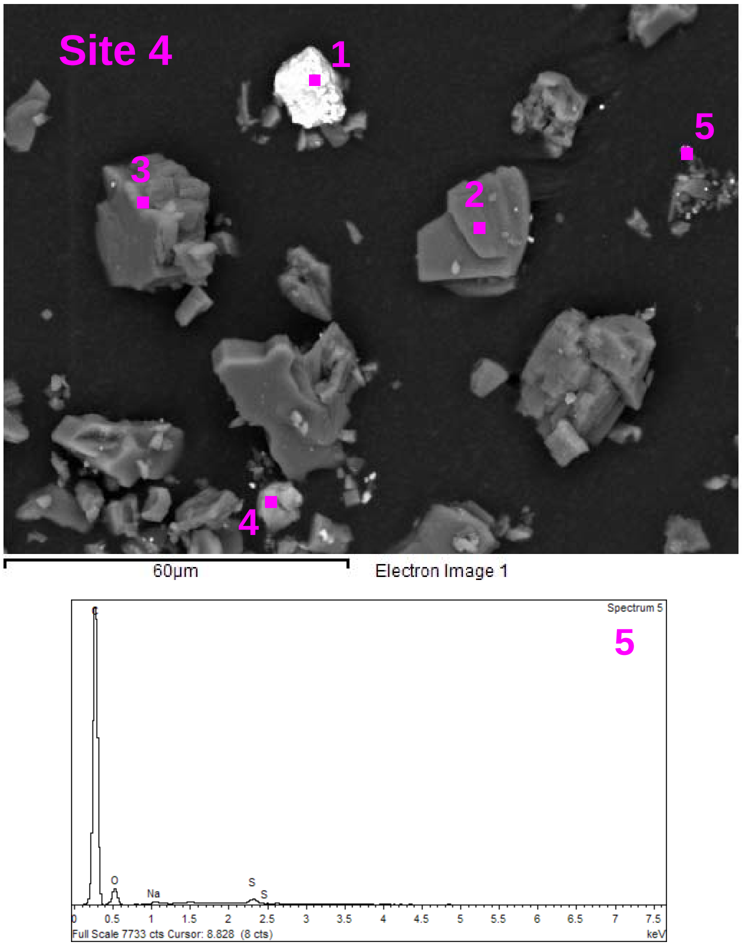

Figure C.41. SEDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

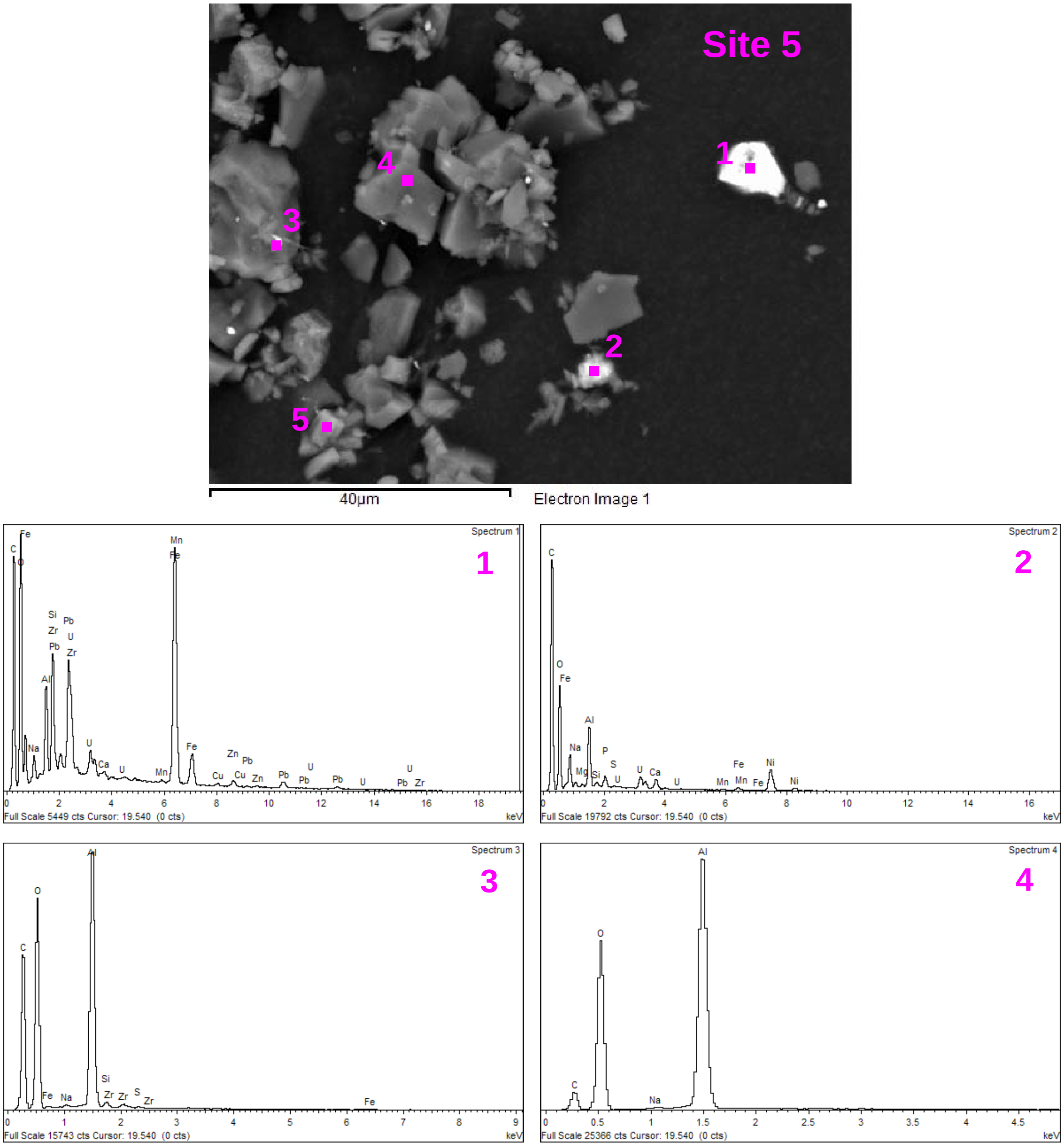

Figure C.42. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

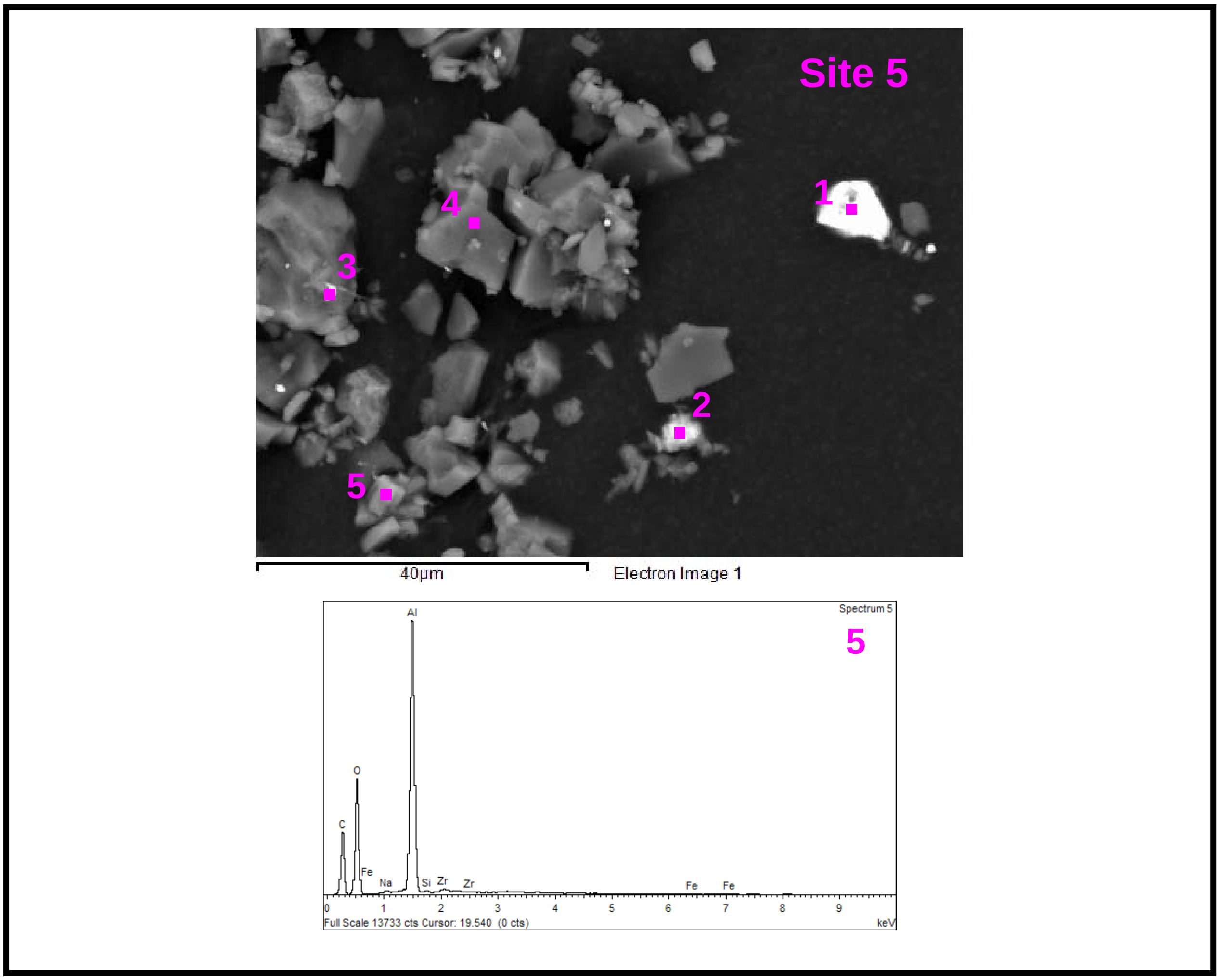

Figure C.43. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

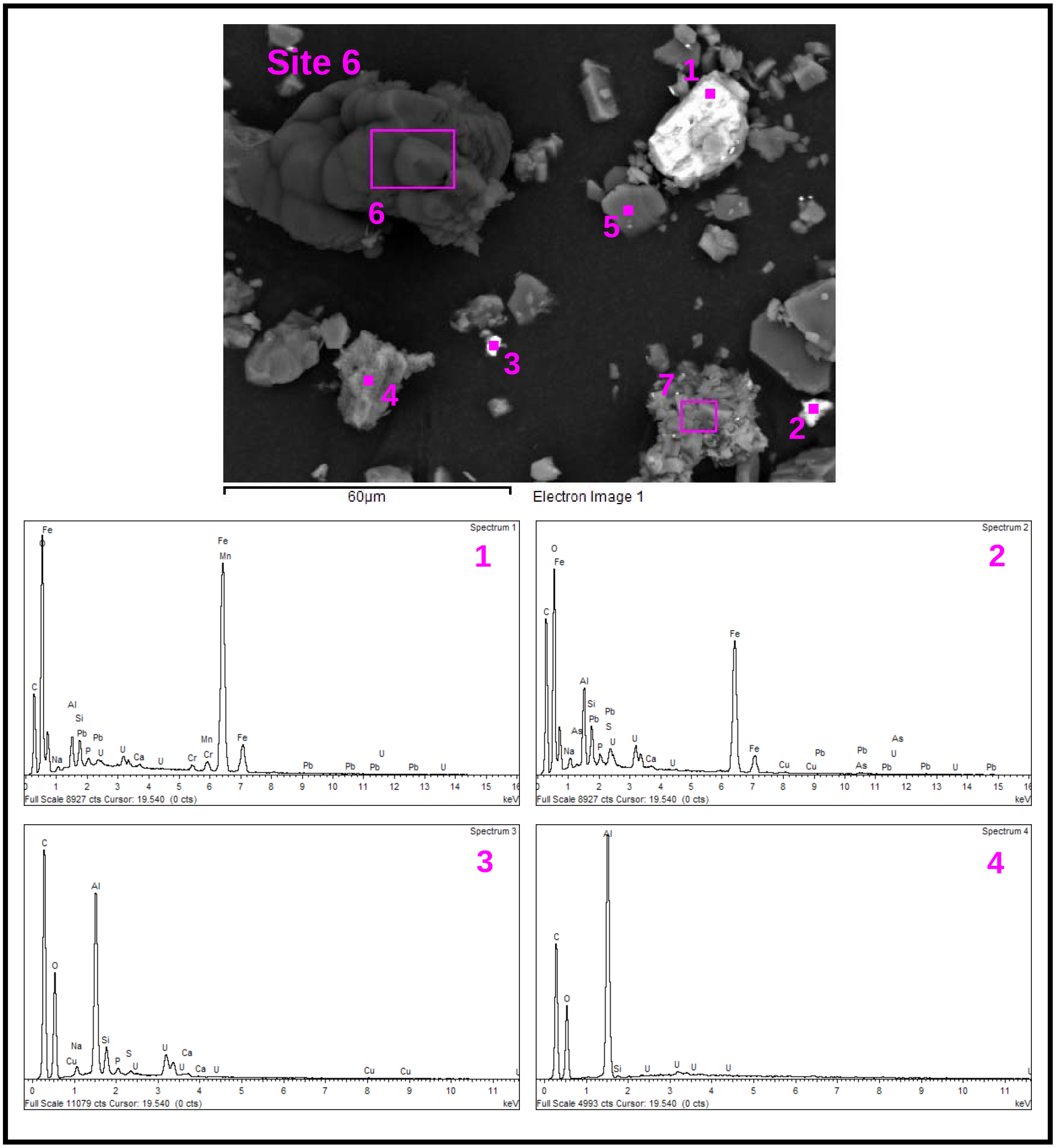

Figure C.44. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

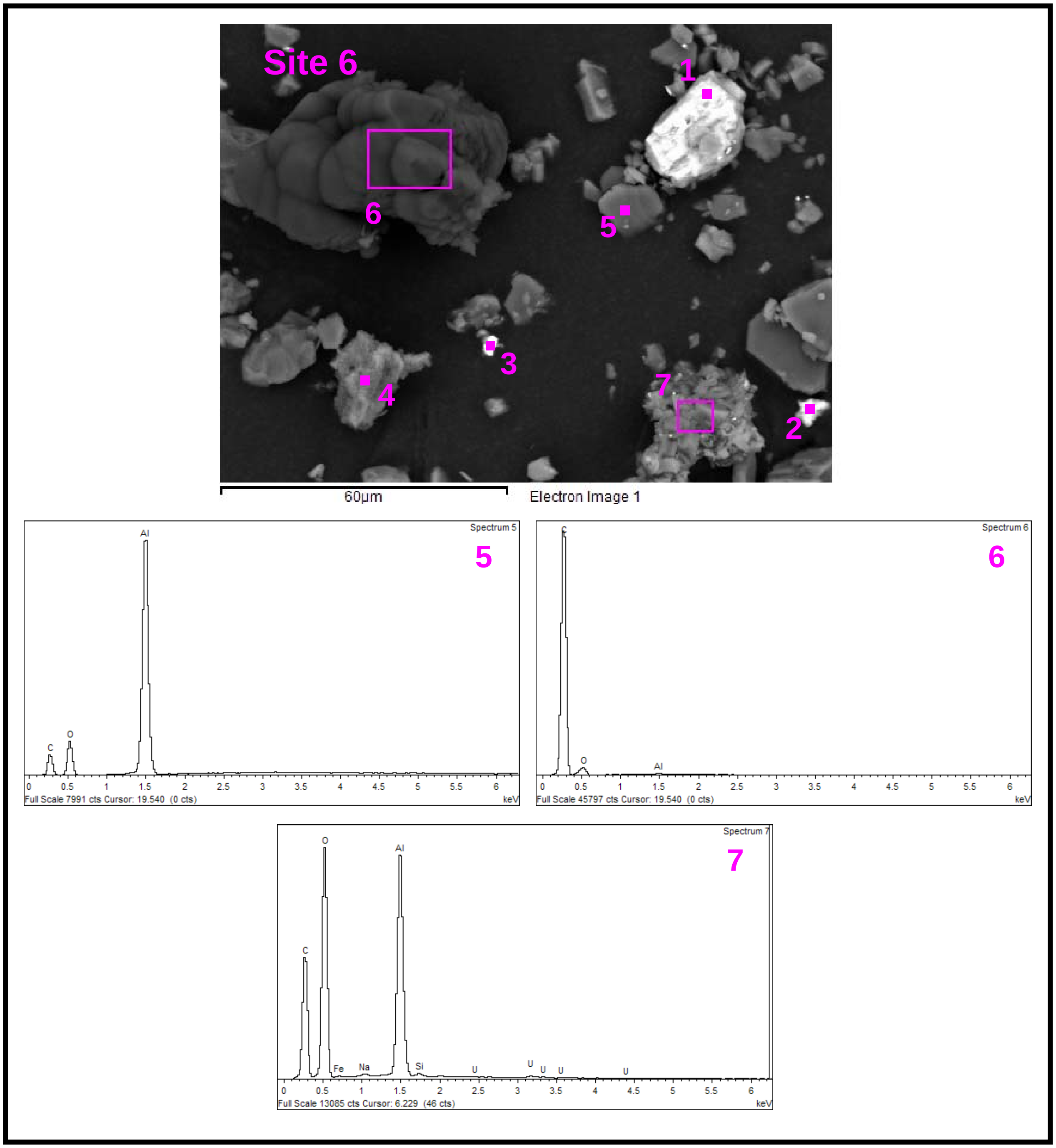

Figure C.45. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

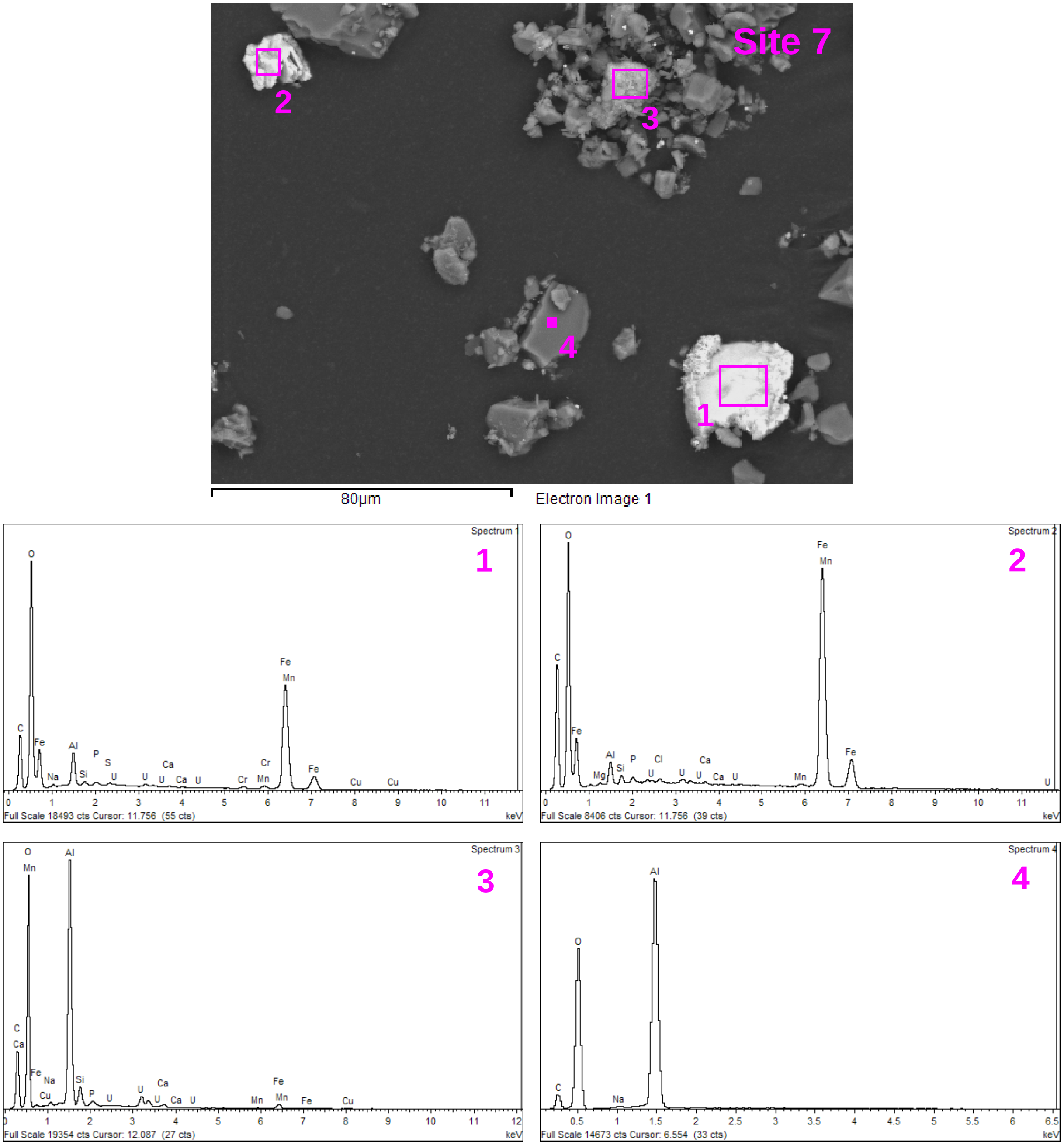

Figure C.46. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

Table C.4. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.34 and C.35/1	1	2.3	3.4	1.6	22.3	4.1	9.7					36.5	11.4	Cu (0.5), Mg (1.8), Pb (5.5), Ti (0.4), Zn (0.6)
	2	4.4		2.2	24.4	8.0						41.0	13.5	Mg (02), Pb (5.8), S (0.4)
	3	31.1										68.8	0.1	
	4	31.9		0.3								67.7	0.1	
	5	20.8										68.1		S (11.1)
	6	37.5										62.5		
C.36 and C.37/2	1	28.5	2.3	0.7	0.4	3.6	3.4					60.3	0.7	Mn (0.2)
	2	19.1	0.4				42.0					38.5		
	3	25.1	1.2	0.4	0.2	3.6	16.1	0.3				50.0	0.5	Cu (0.4), Mn (1.), Pb (1.1)
	4	25.0	2.7	0.9	0.4	7.0	1.9					60.7	0.9	Cu (0.3), Mn (0.2)
	5	33.5	0.3	0.3								65.9		
	6	27.8	0.2	0.4			0.5					70.9	0.2	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.5. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.38 and C.39/3	1	12.9	3.3	4.8	0.4	27.8	1.1					47.4	1.9	S (0.3)
	2	31.9		0.5								67.1	0.2	Cu (0.3)
	3	7.7	22.4	2.1	6.9		16.9					39.4		K (0.5), Mg (2.1), Ti (2.0)
	4	35.5		0.3								64.3		
	5	31.0		0.3		4.1						64.5	0.2	
	6	37.1		0.7								61.9		S (0.3)
C.40 and C.41/4	1	4.4	0.6	0.5		0.8	38.4					43.1	0.4	As (0.1), Mn (0.2), Pb (5.3), Ru (6.1)
	2	39.1										60.9		
	3	33.1		0.3								66.6		
	4	10.8	12.9				16.4					48.9		Mg (10.4), Mn (0.4), S (0.2)
	5			10.5								79.2		S (10.3)
C.42 and C.43/5	1	4.3	5.3	1.7	0.3	4.5	33.5					31.9		Cu (0.7), Mn (0.3), Pb (13.5), Zn (2.1), Zr (1.9)
	2	12.3	0.8	1.9	2.3	9.1	1.3					50.4	2.3	Mg (0.7), Mn (0.4), Ni (18.3), S (0.3)
	3	30.6	0.9	0.4			0.3					66.3		S (0.2), Zr (1.3)
	4	35.4		0.2								64.4		
	5	40.5	0.4	0.6			0.4					56.4		Zr (1.8)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.6. Estimated EDS Compositions (atomic%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %(a)												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.44 and C.45/6	1	2.8	2.1	0.8	0.3	3.0	50.5	0.8				36.1	0.6	Mn (1.9), Pb (1.1)
	2	7.2	3.4	2.0	0.3	7.3	34.9					39.7	0.9	As (0.2), Cu (0.5), Pb (3.4), S (0.4)
	3	25.7	4.7	2.2	0.6	14.4						50.0	1.2	Cu (0.6), S (0.6)
	4	45.8	0.6			3.4						50.2		
	5	59.8										40.2		
	6	10.2										89.8		
	7	28.3	0.5	0.5	0.5							69.1		Ni (1.1)
C.46/7	1	4.8	0.5	0.7	0.1	0.9	41.8	0.5				48.9	0.4	Cu (0.4), Mn (0.9), S (0.2)
	2	2.3	0.7		0.2	1.2	56.7					37.1	0.5	Cl (0.3), Mg (0.3), Mn (0.6)
	3	25.4	2.5	0.7	0.4	5.4	1.5					62.9	0.6	Cu (0.4), Mn (0.2)
	4	34.7		0.4								64.9		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

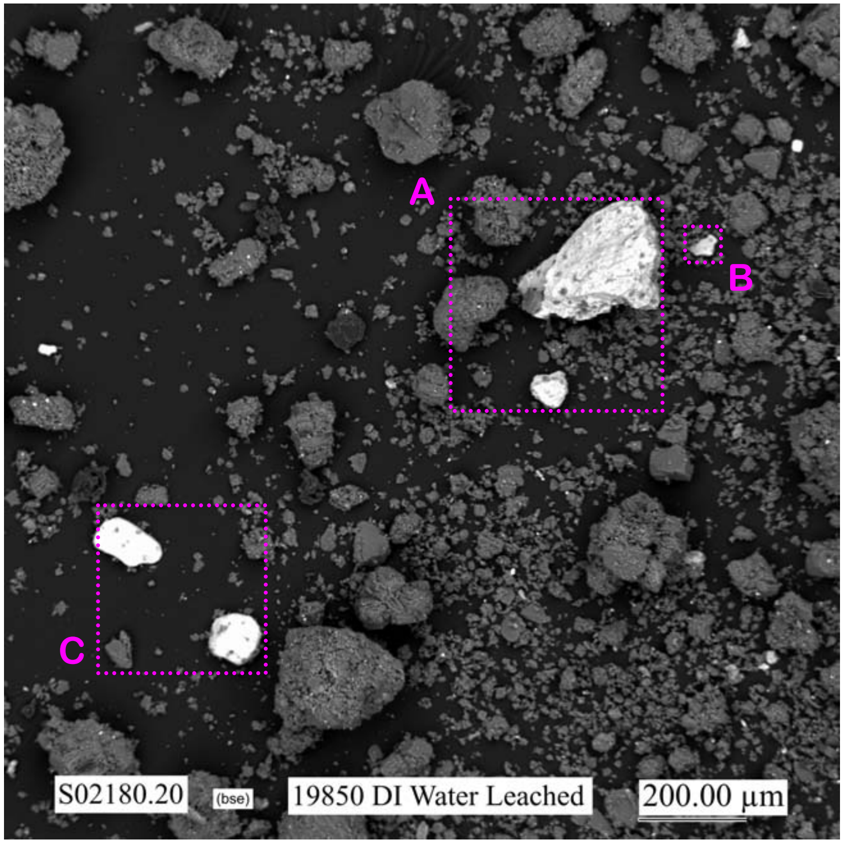

Figure C.47. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

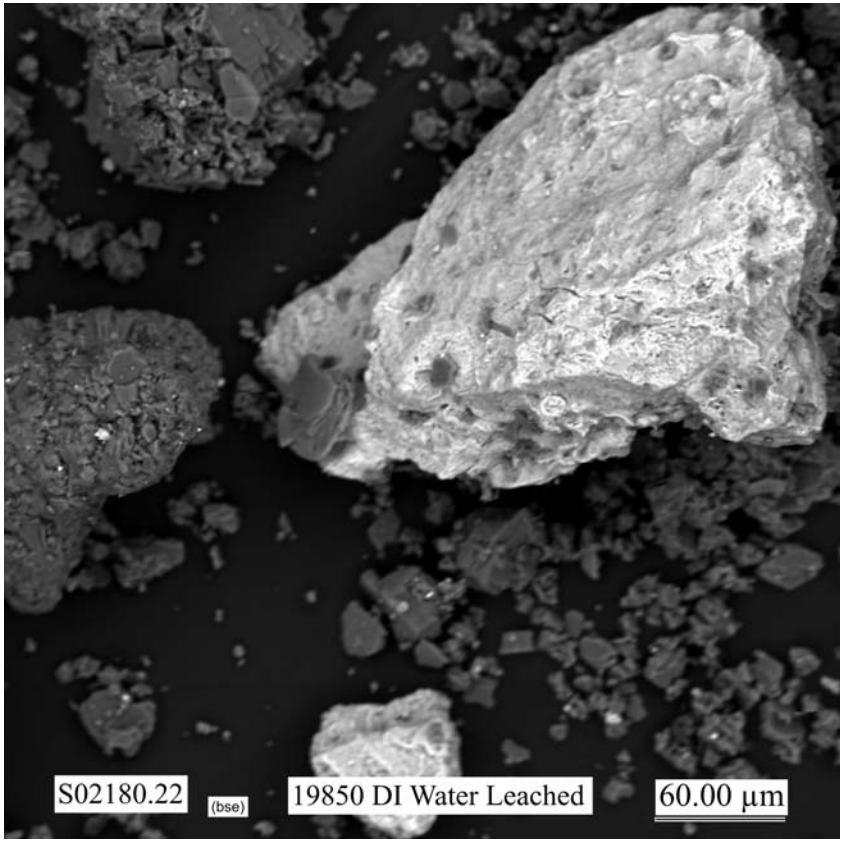

Figure C.48. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square A in Figure C.47 (Areas where EDS analyses were made are shown in Figure C.60.)

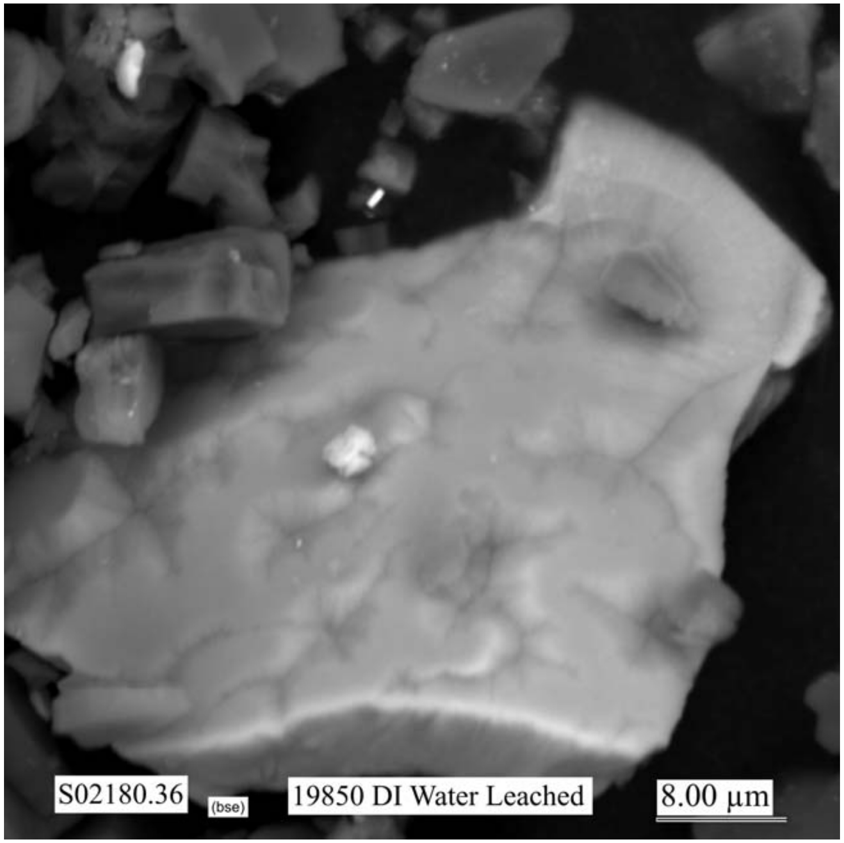

Figure C.49. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square B in Figure C.47 (Areas where EDS analyses were made are shown in Figure C.68.)

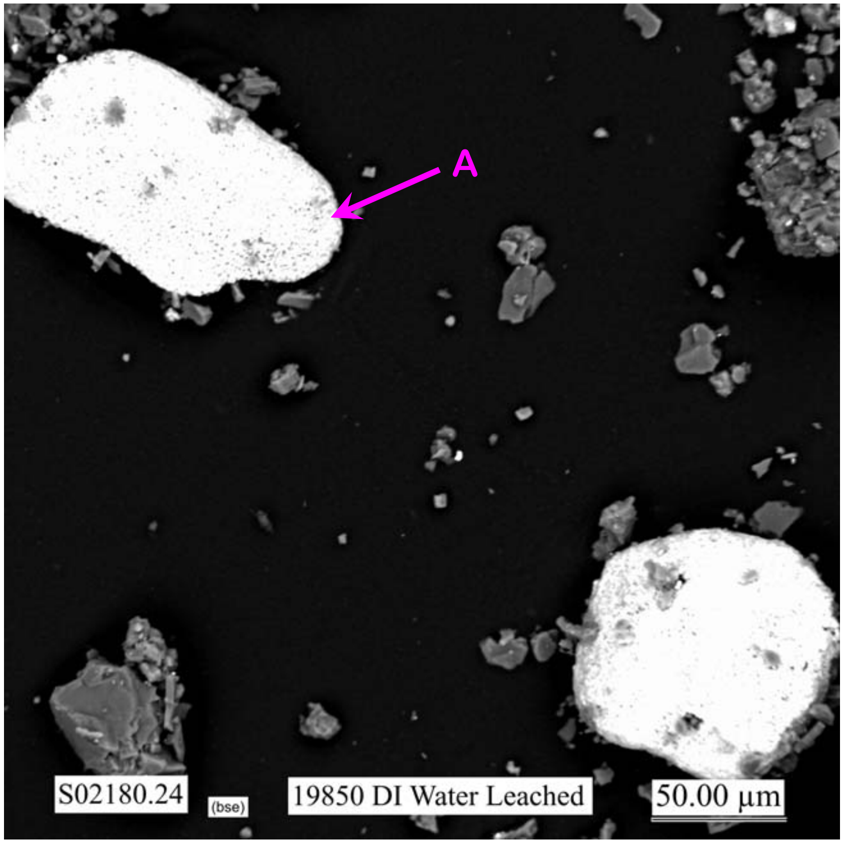

Figure C.50. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square C in Figure C.47 (Areas where EDS analyses were made are shown in Figure C.61.)

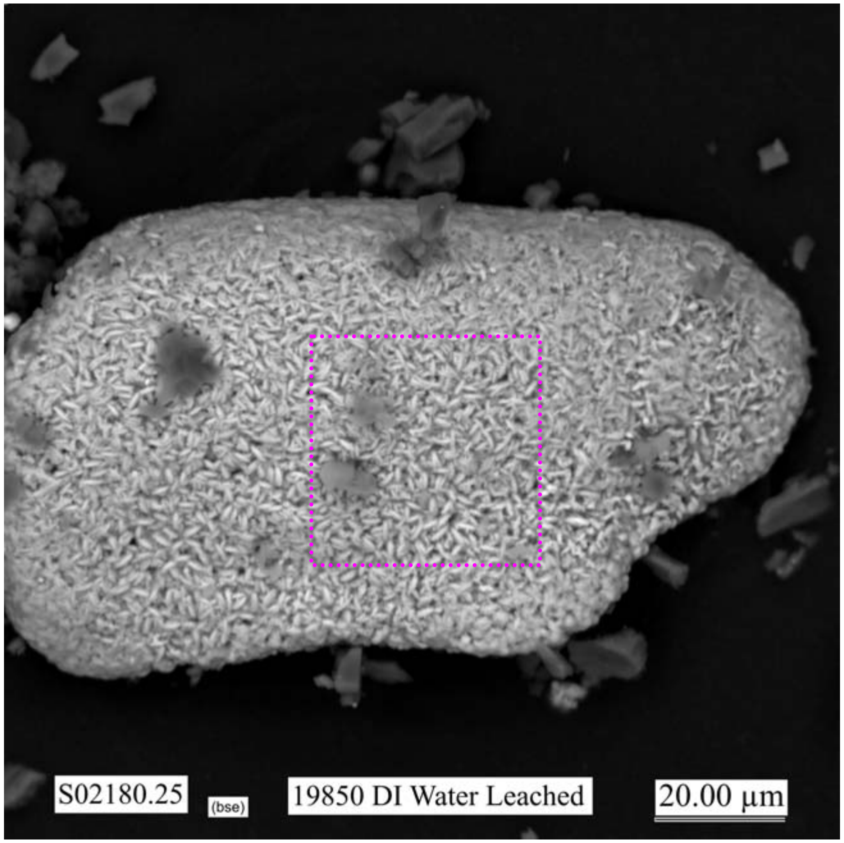

Figure C.51. Micrograph Showing at Higher Magnification the Particle Aggregate Labeled A in Figure C.50 (Areas where EDS analyses were made are shown in Figure C.61.)

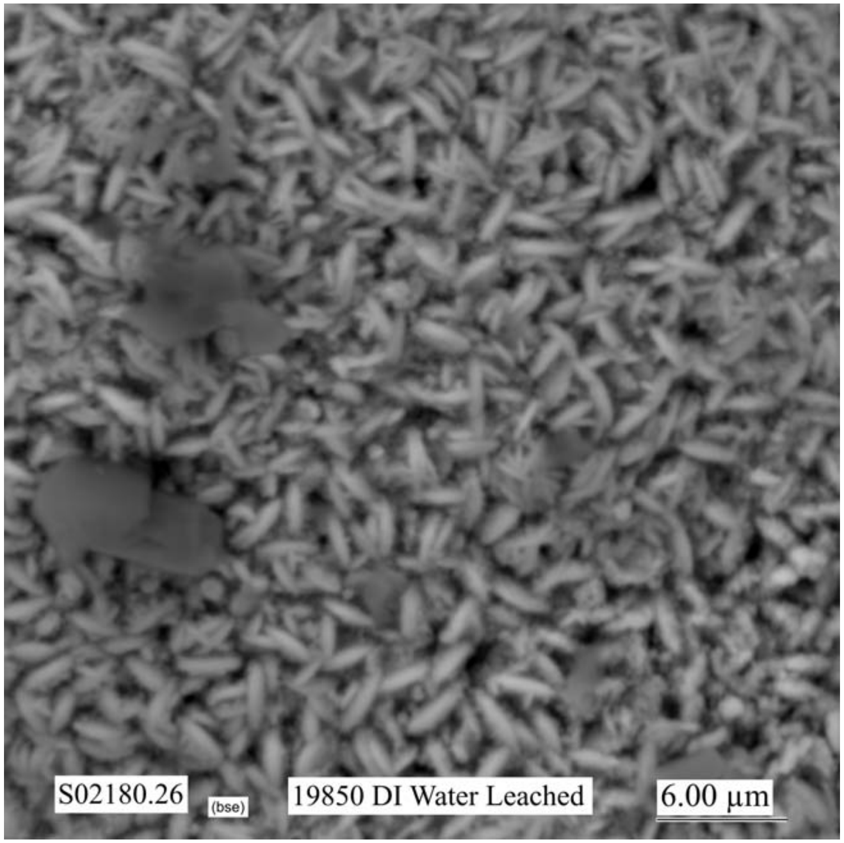

Figure C.52. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square in Figure C.51 (Areas where EDS analyses were made are shown in Figure C.61.)

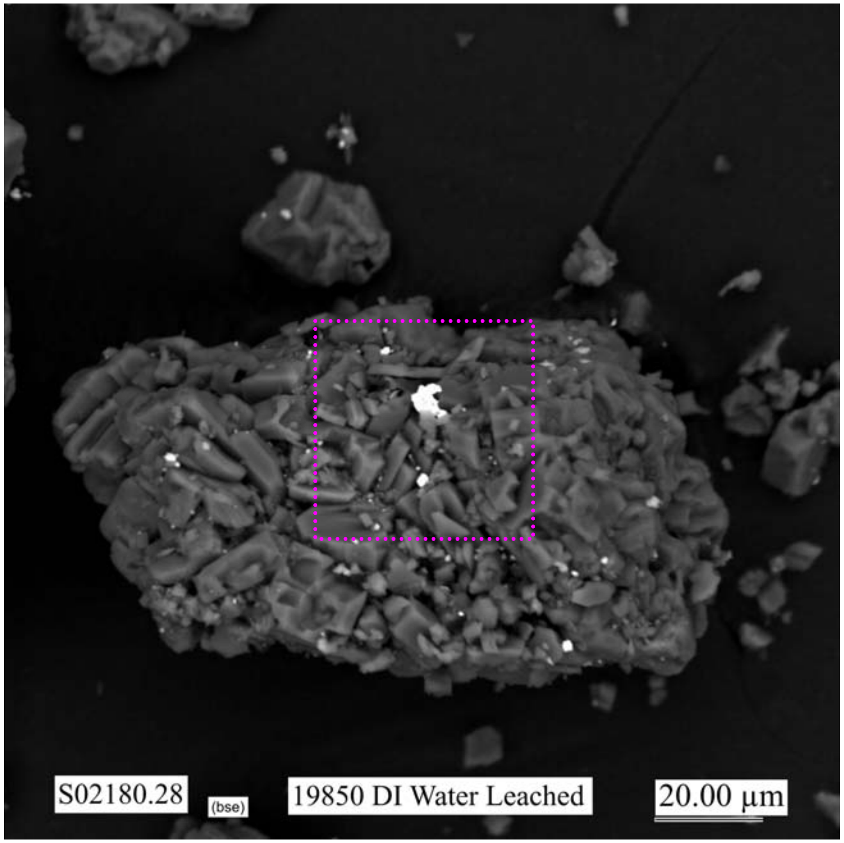

Figure C.53. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.62.)

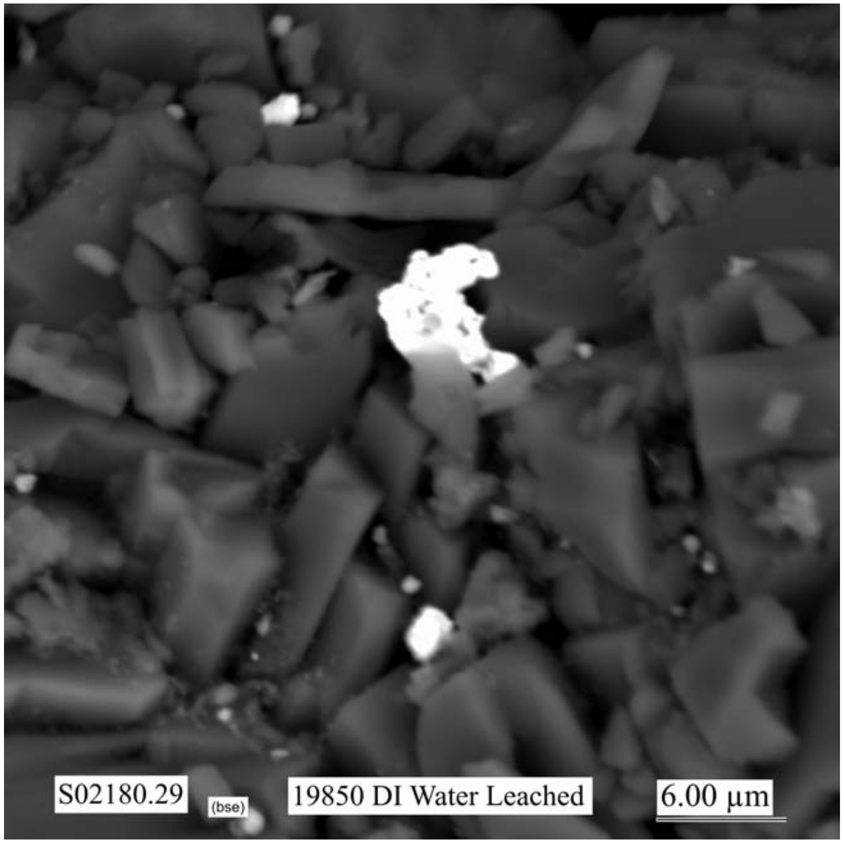

Figure C.54. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square in Figure C.53 (Areas where EDS analyses were made are shown in Figure C.62.)

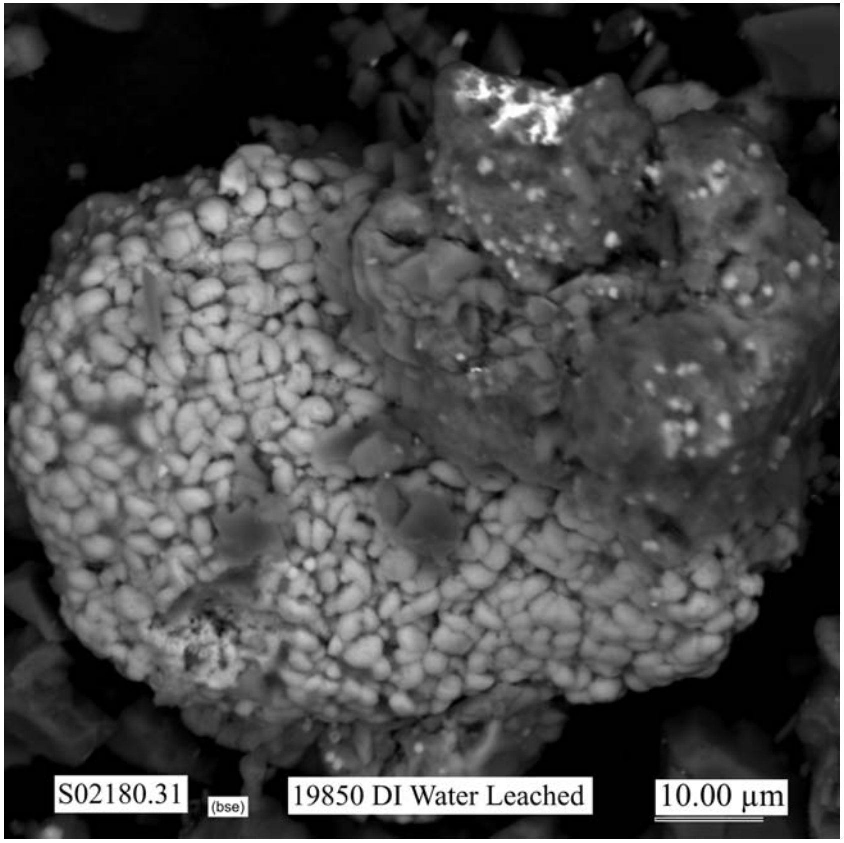

Figure C.55. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures C.63 and C.64.)

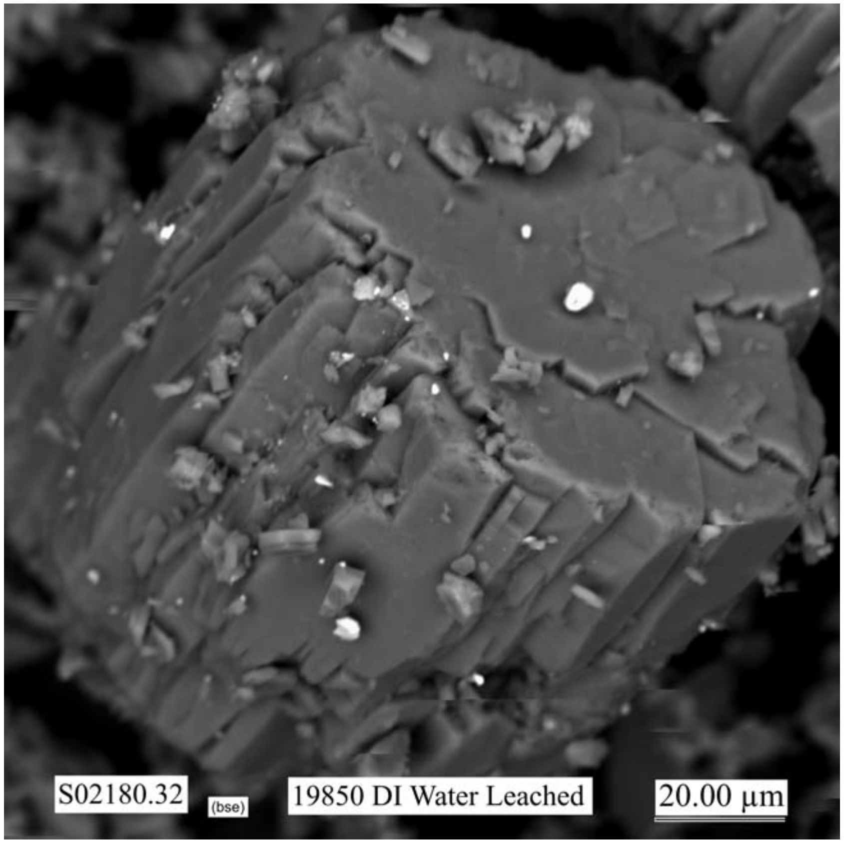

Figure C.56. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

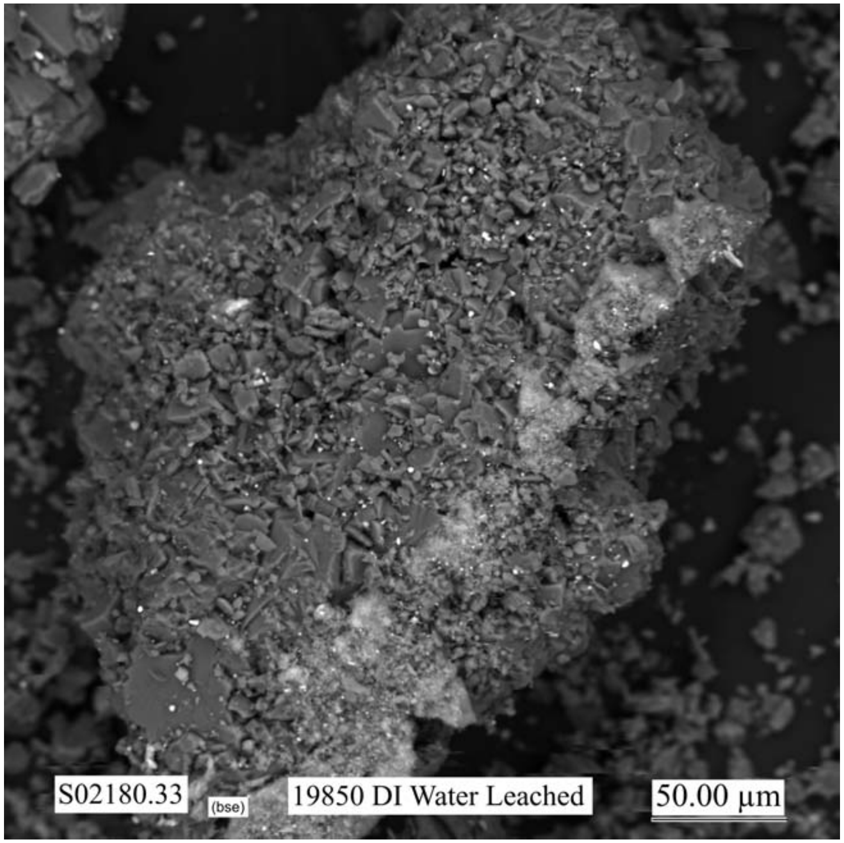

Figure C.57. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.65.)

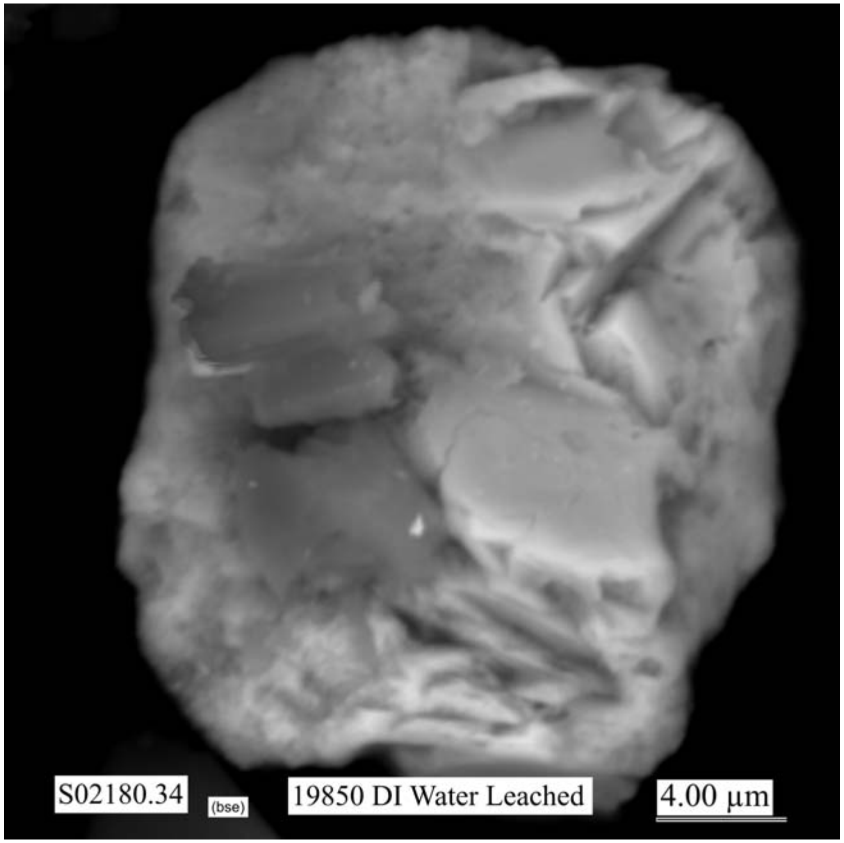

Figure C.58. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.66.)

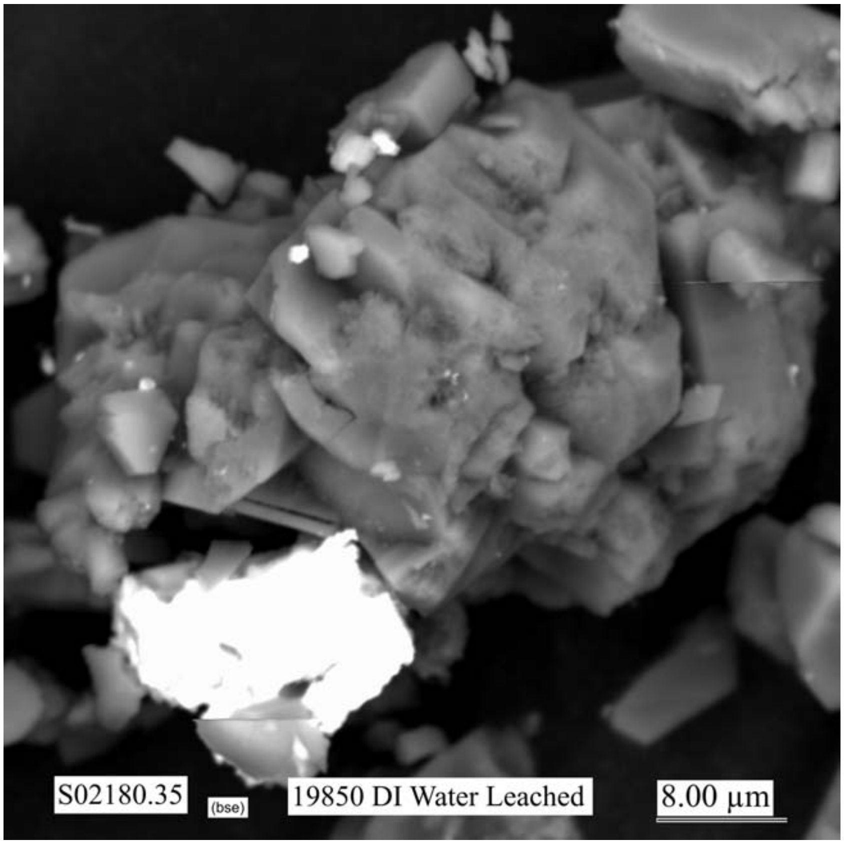

Figure C.59. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure C.67.)

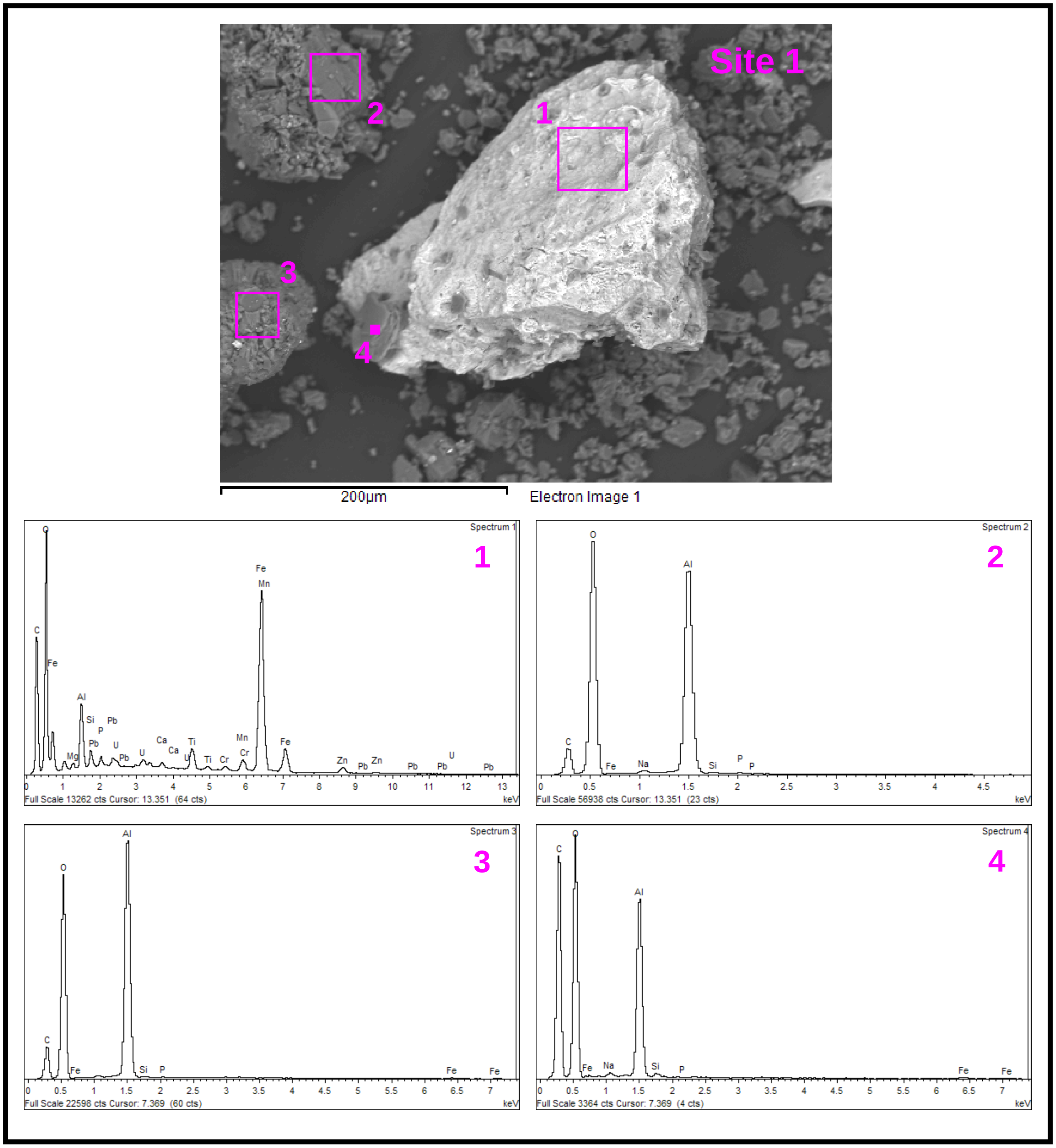

Figure C.60. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

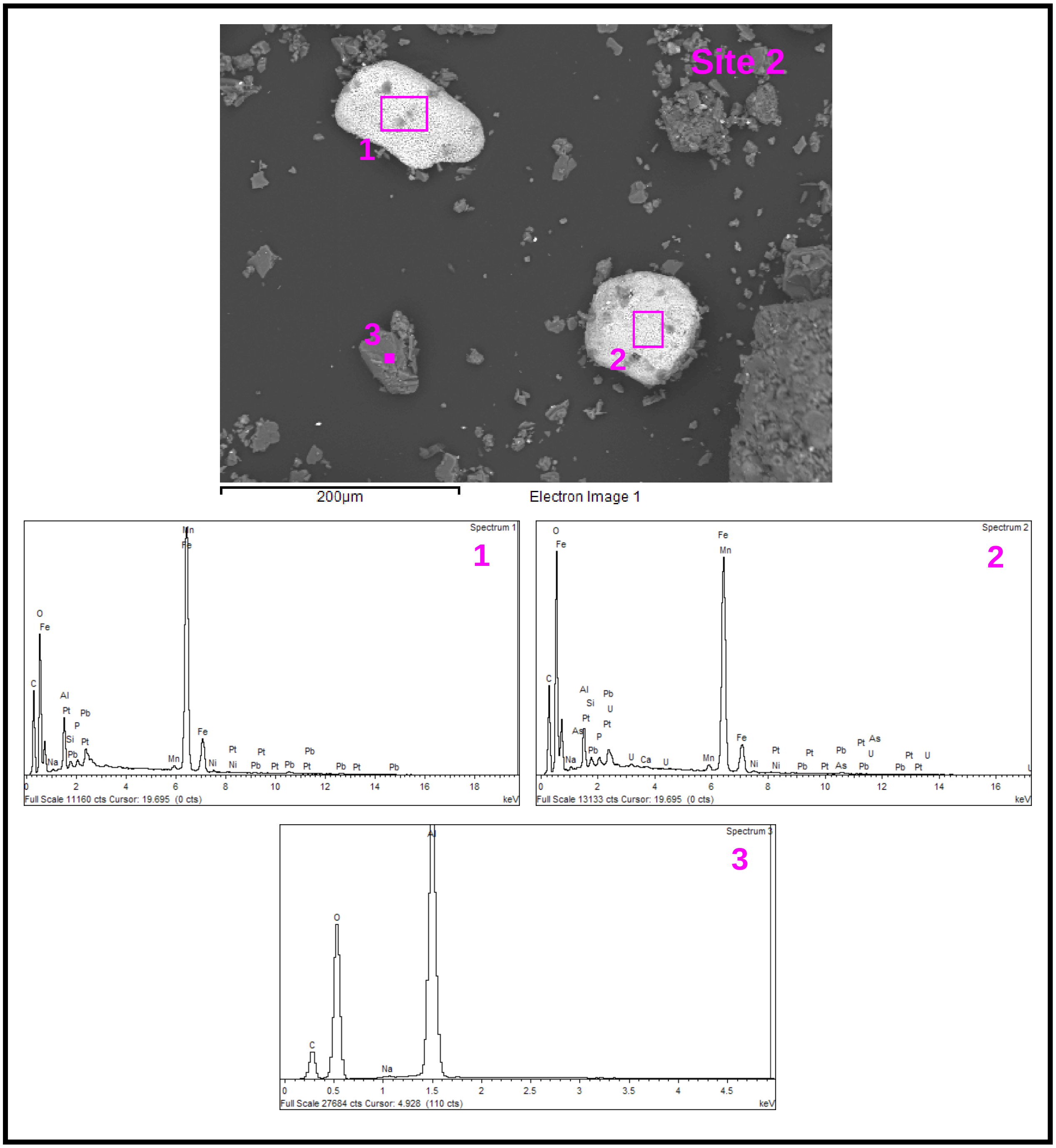

Figure C.61. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

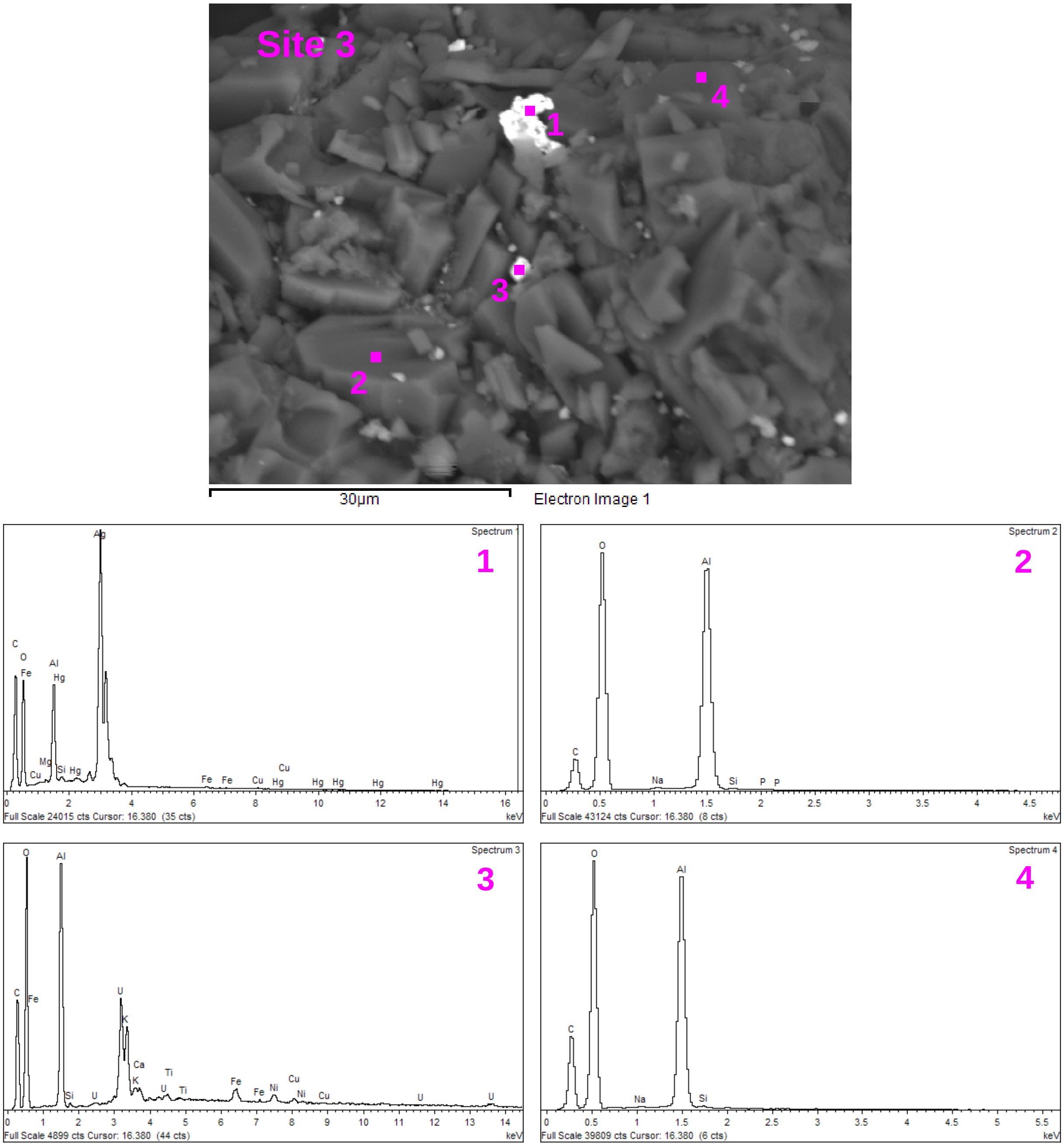

Figure C.62. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

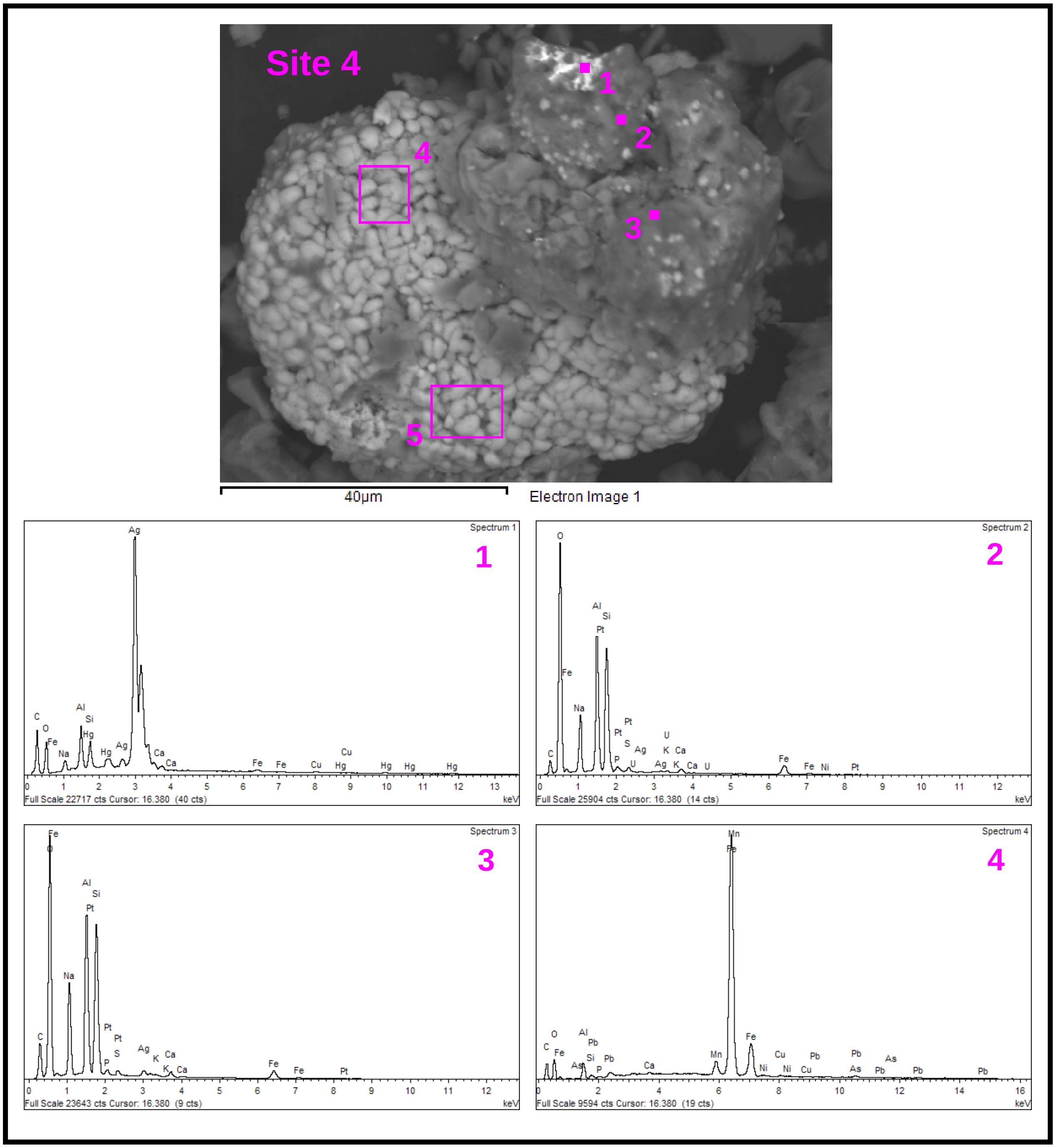

Figure C.63. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

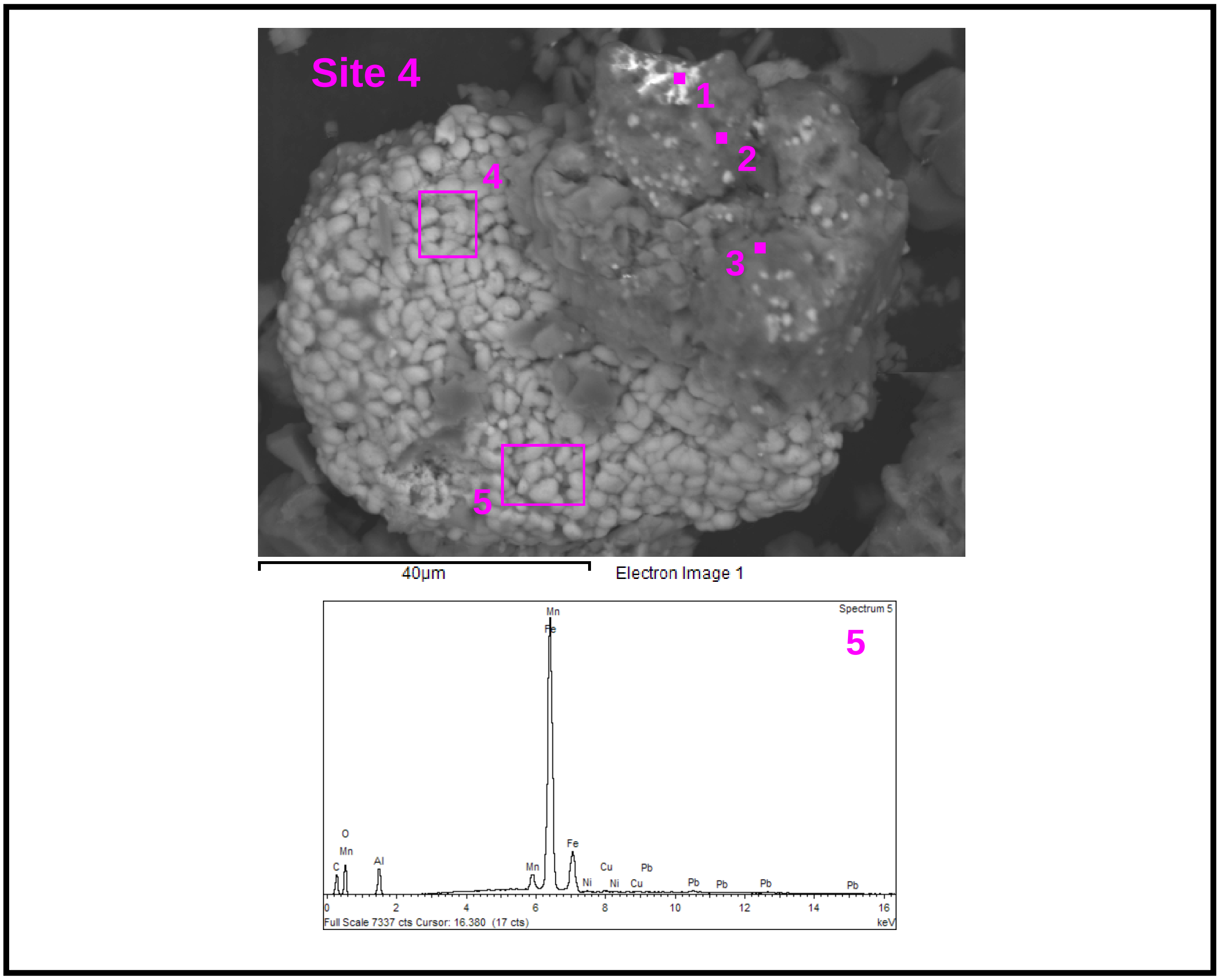

Figure C.64. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

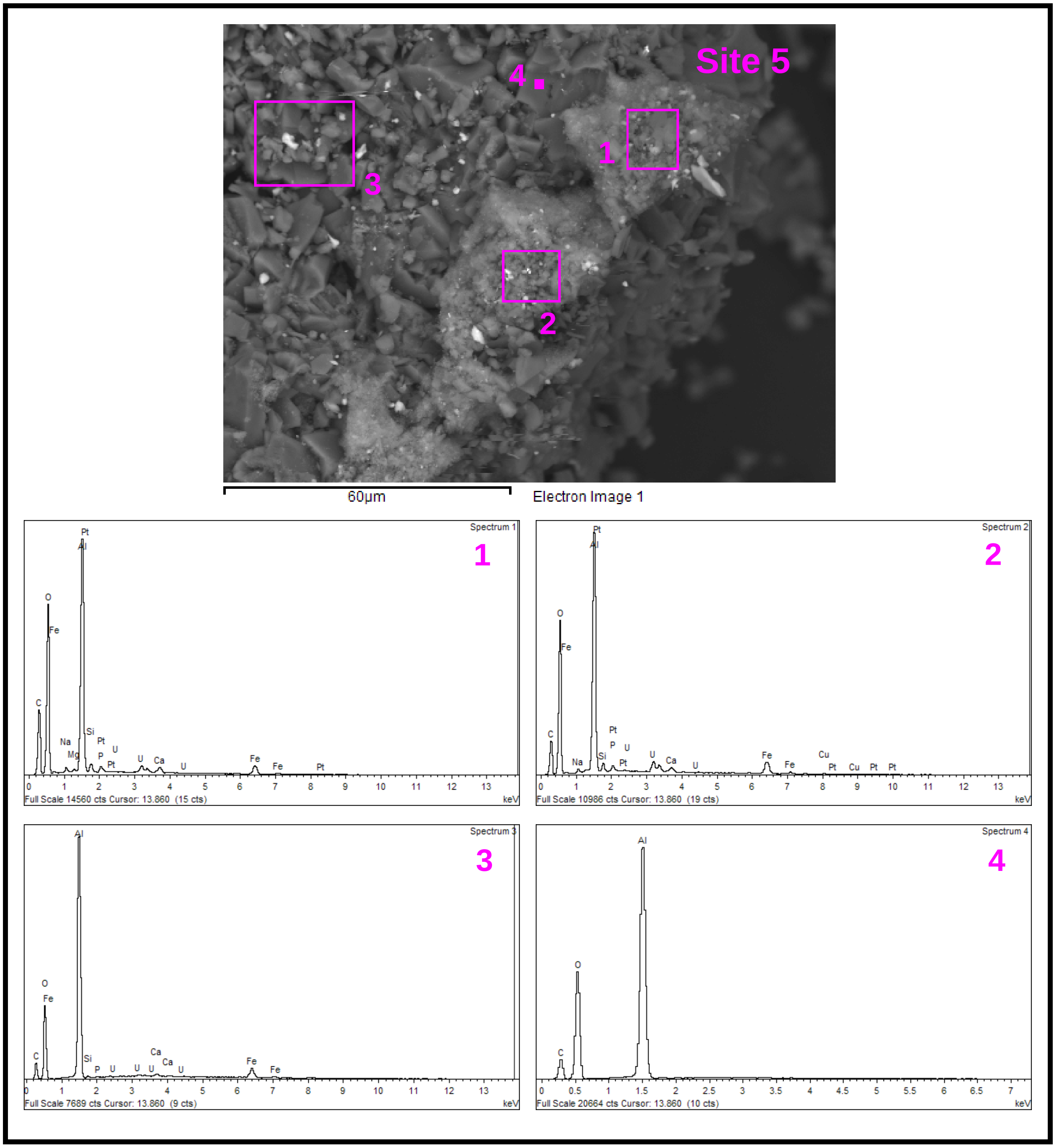

Figure C.65. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

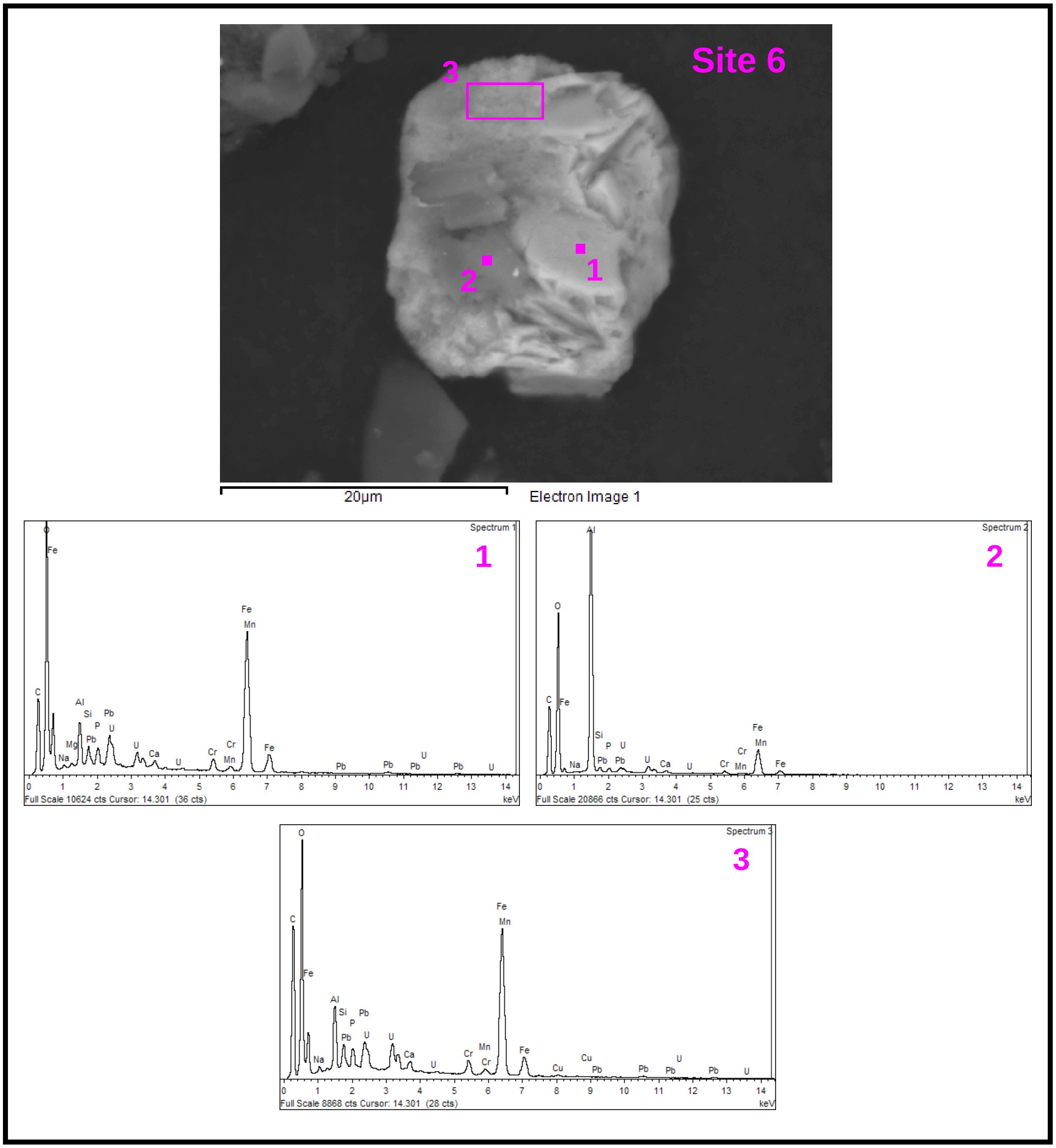

Figure C.66. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

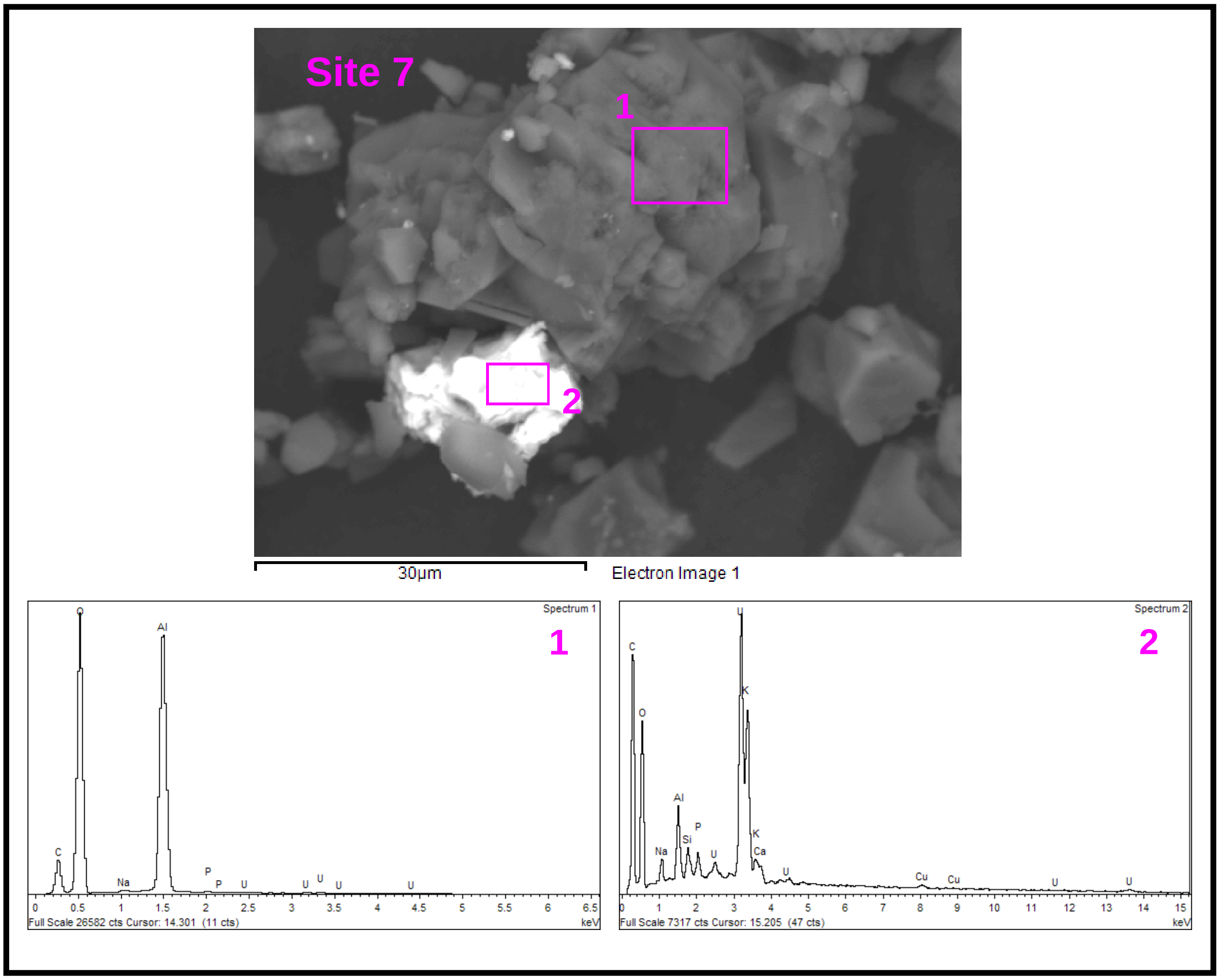

Figure C.67. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

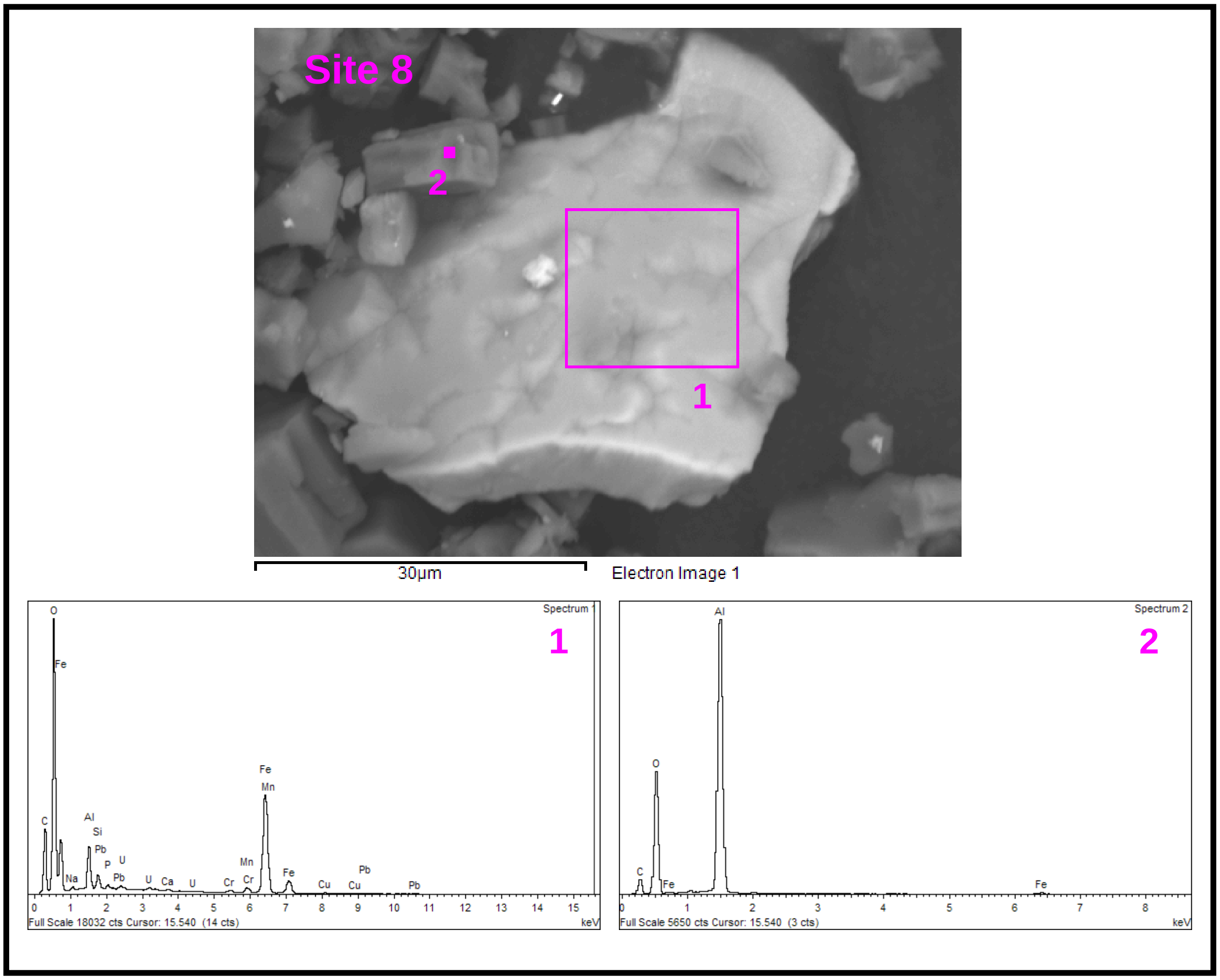

Figure C.68. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact DDI Water-Leached Residual Waste from Tank C-103

Table C.7. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.60/1	1	5.4	1.3		0.5	1.9	40.0	0.6				40.1	0.7	Mg (0.6), Mn (2.0), Pb (1.6), Ti (2.4), Zn (3.0)
	2	27.5	0.1	0.6			0.2					71.3	0.2	
	3	31.5	0.2				0.4					67.7	0.1	
	4	25.0	0.6	0.9			0.8					72.8		
C.61/2	1	5.5	0.6	0.5			63.0					24.4	0.5	Mn (0.9), Ni (0.5), Pb (3.2), Pt (0.9)
	2	3.8	0.7	0.7	0.1	0.8	52.2					34.7	0.5	As (0.2), Mn (1.2), Ni (0.7), Pb (3.4), Pt (1.0)
	3	37.0		0.4								62.7		
C.62/3	1	6.9	0.2				0.3			44.0	0.5	47.6		Cu (0.4), Mg (0.2)
	2	28.5	0.2	0.3								70.8	0.1	
	3	15.9	0.4		0.8	25.7	2.6					49.6		Cu (1.6), K (0.8), Ni (2.2), Ti (0.4)
	4	28.6	0.3	0.3								70.8		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.8. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.63 and C.64/4	1	4.6	2.6	2.1	0.2		0.6			60.2	2.3	26.9		Cu (0.4)
	2	13.0	13.0	8.9	0.5	0.5	3.1			0.3		58.6	0.6	K (0.2), Ni (0.3), Pt (0.6), S (0.5)
	3	13.1	13.5	11.7	0.6		2.3			1.4		55.8	0.6	K (0.1), Pt (0.4), S (0.5)
	4	2.5	0.4		0.2		84.4					5.0	0.2	Cu (1.0), Mn (4.1), Ni (0.7), Pb (1.4)
	5	3.9					84.2					6.4		Cu (0.8), Mn (4.0), Ni (0.7)
C.65/5	1	28.4	1.3	1.0	1.1	3.6	4.0					58.6	0.9	Mg (0.2), Pt (0.9)
	2	29.0	1.4	0.8	0.8	6.1	5.5					54.2	0.8	Cu (0.5), Pt (0.9)
	3	43.9	0.5		0.6	1.4	6.6					46.6	0.4	
	4	41.0										59.0		
C.66/6	1	3.6	1.4	0.6	0.7	4.5	34.4	1.9				44.7	1.3	Mg (0.3), Mn (0.7), Pb (5.9)
	2	29.1	0.7	0.2	0.3	3.1	11.3	0.9				51.8	0.6	Mn (0.3), Pb (1.8)
	3	5.1	1.7	1.0	0.8	7.3	34.0	2.1				39.9	1.5	Cu (0.6), Mn (0.8), Pb (5.2)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table C.9. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
C.67/7	1	28.1		0.4		0.5						70.8	0.2	
	2	4.4	1.4	2.3	1.0	53.3						34.7	1.4	Cu (0.9), K (0.6)
C.68/8	1	5.2	1.6	0.9	0.2	1.1	34.7	0.5				52.5	0.4	Cu (0.5), Mn (1.3), Pb (1.0)
	2	41.3					1.0					57.7		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Appendix D

SEM Micrographs and EDS Results for One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

Appendix D

SEM Micrographs and EDS Results for One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

This appendix includes the scanning electron microscope (SEM) micrographs and the energy-dispersive spectroscopy (EDS) spectra for samples 19845, 19849, and 19850 of one-month single-contact $Ca(OH)_2$-leached residual waste from tank C-103. The operating conditions for the SEM and procedures used for mounting the SEM samples are described in Section 2.4 of the main report.

The identification number for the digital micrograph image file, descriptor for the type of sample, and a size scale bar are given at the bottom of each SEM micrograph. Micrographs labeled by “BSE” or “SE” to the immediate right of the digital image file number indicate that the micrograph was collected with backscattered electrons or secondary electrons, respectively. Sample areas or particles identified in a micrograph by a pink arrow or pink dotted-line square designate sample material that was imaged at higher magnification, which is typically shown in figure(s) that immediately follow in the series for that sample.

The SEM micrographs, EDS spectra, and corresponding calculated compositions (in weight percent) based on EDS analyses for material analyzed from samples 19845, 19849, and 19850 of one-month single-contact $Ca(OH)_2$-leached C-103 residual waste are shown in the following figures and tables:

- Sample 19845
  - SEM micrographs – Figures D.1 through D.13
  - EDS spectra – Figures D.14 through D.26
  - Calculated compositions based on EDS analyses – Table D.1 through D.3

- Sample 19849
  - SEM micrographs – Figures D.27 through D.37
  - EDS spectra – Figures D.38 through D.49
  - Calculated compositions based on EDS analyses – Table D.4 through D.6

- Sample 19850
  - SEM micrographs – Figures D.50 through D.59
  - EDS spectra – Figures D.60 through D.72
  - Calculated compositions based on EDS analyses – Table D.7 through D.10

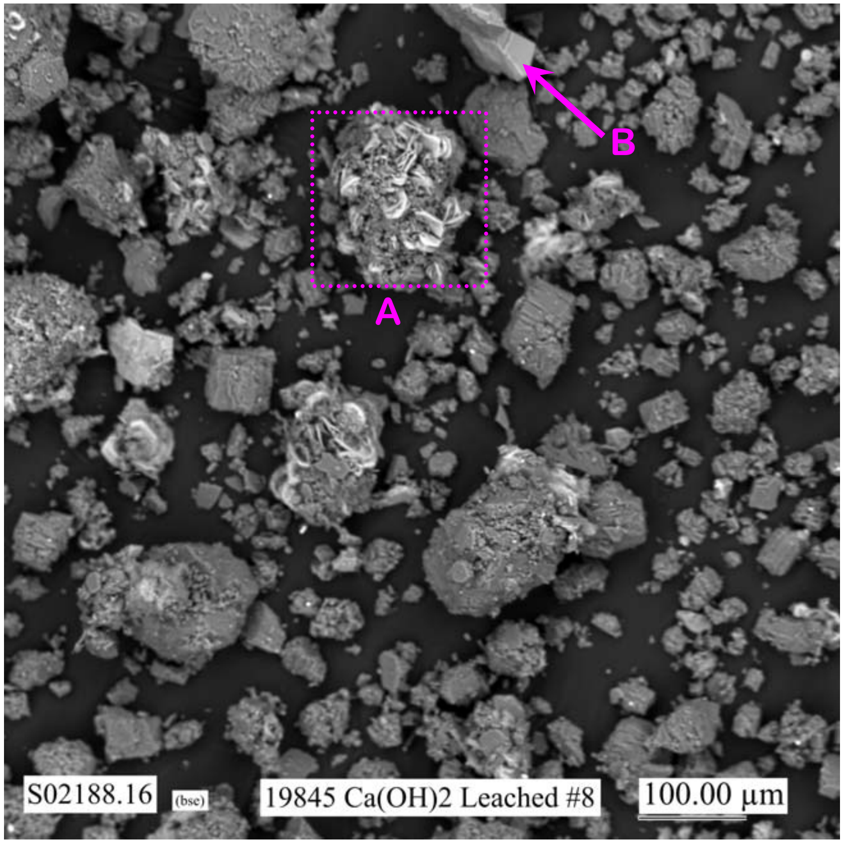

Figure D.1. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19845 of One-Month Single-Contact Ca$(OH)_2$-Leached Residual Waste from Tank C-103

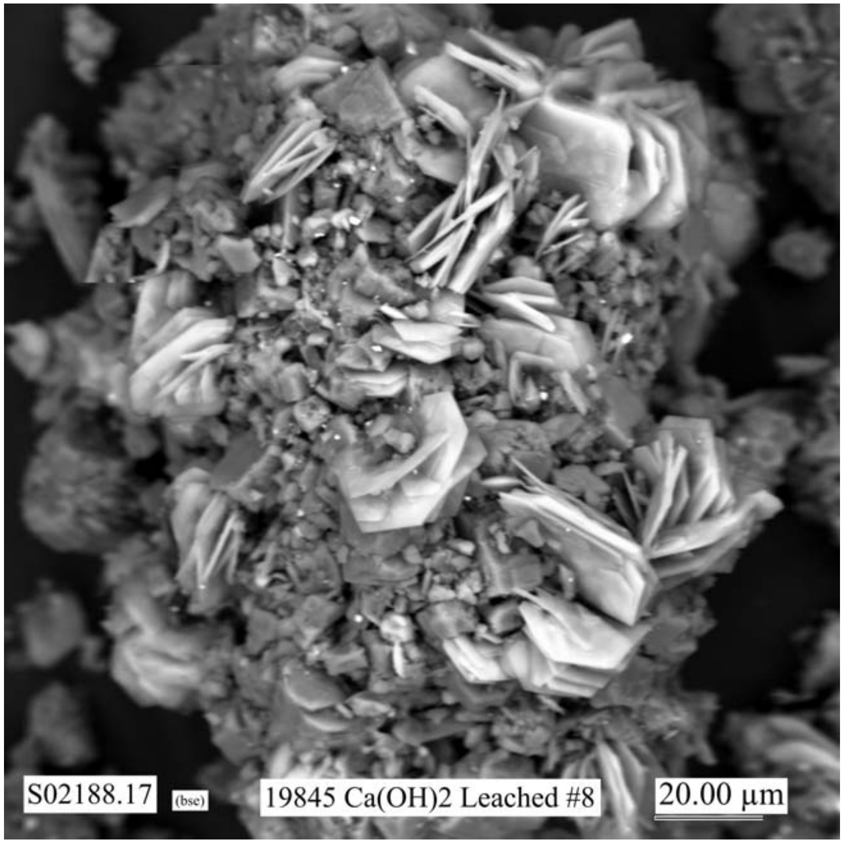

Figure D.2. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square A in Figure D.1 (Areas where EDS analyses were made are shown in Figures D.14 and D.15.)

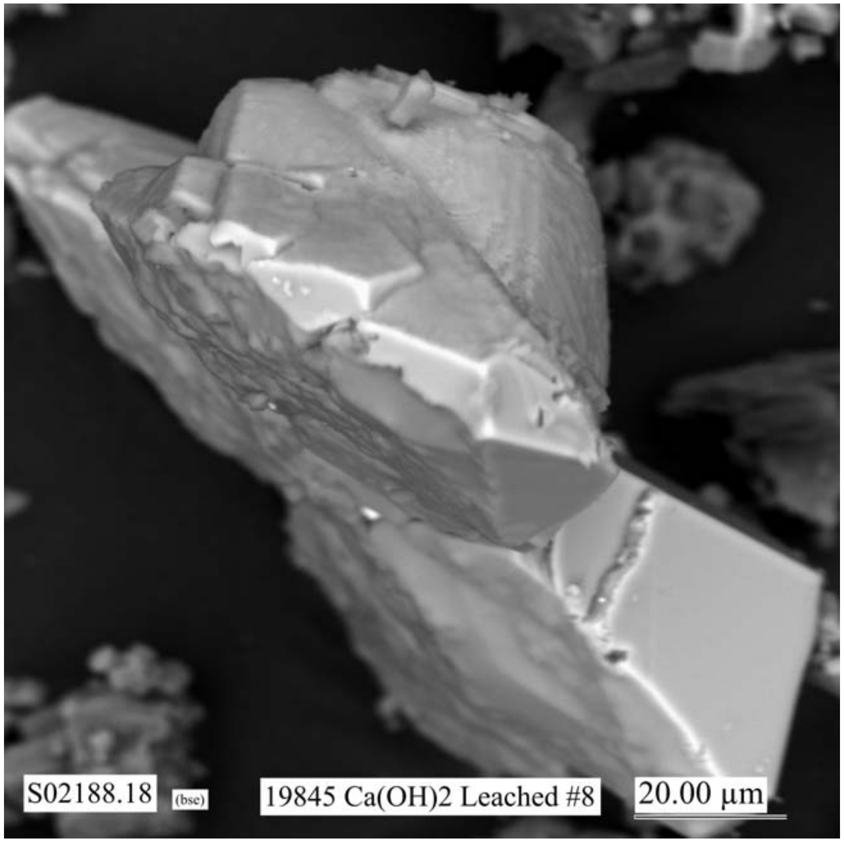

Figure D.3. Micrograph Showing at Higher Magnification the Particle Cluster Labeled B in Figure D.1 (Areas where EDS analyses were made are shown in Figure D.16.)

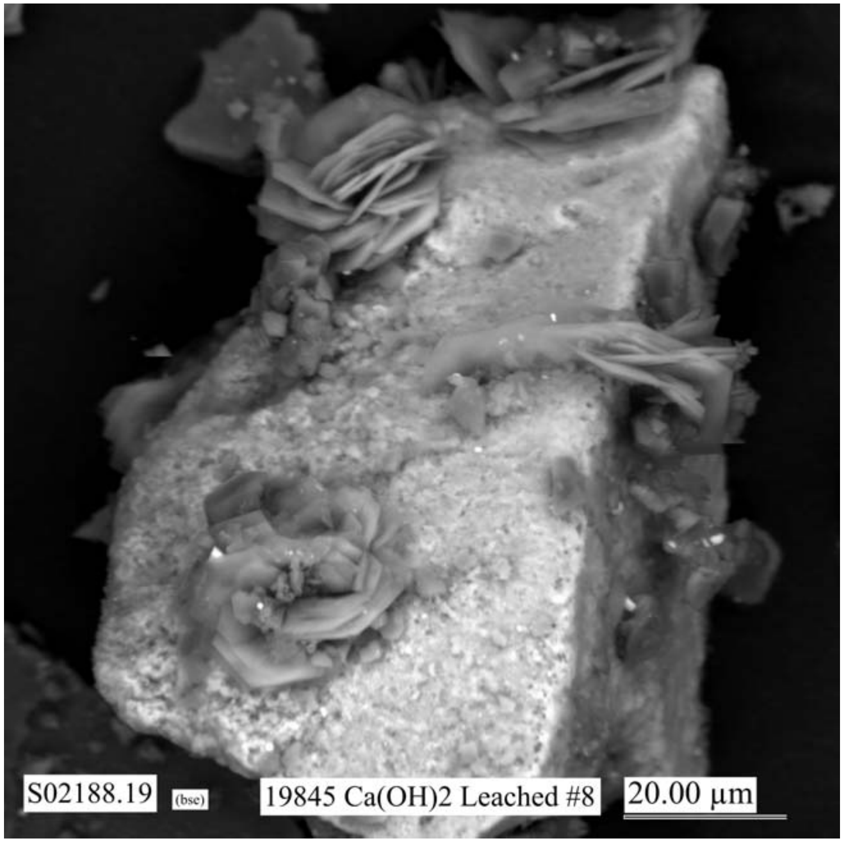

Figure D.4. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.17.)

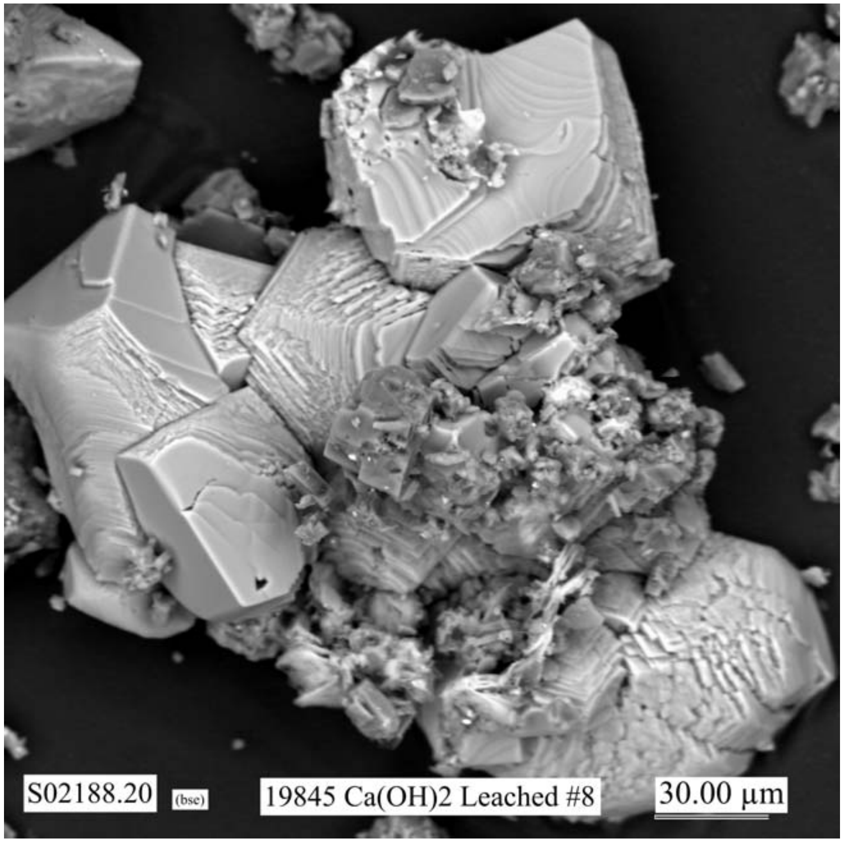

Figure D.5. Micrograph Showing Particle Cluster in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.18.)

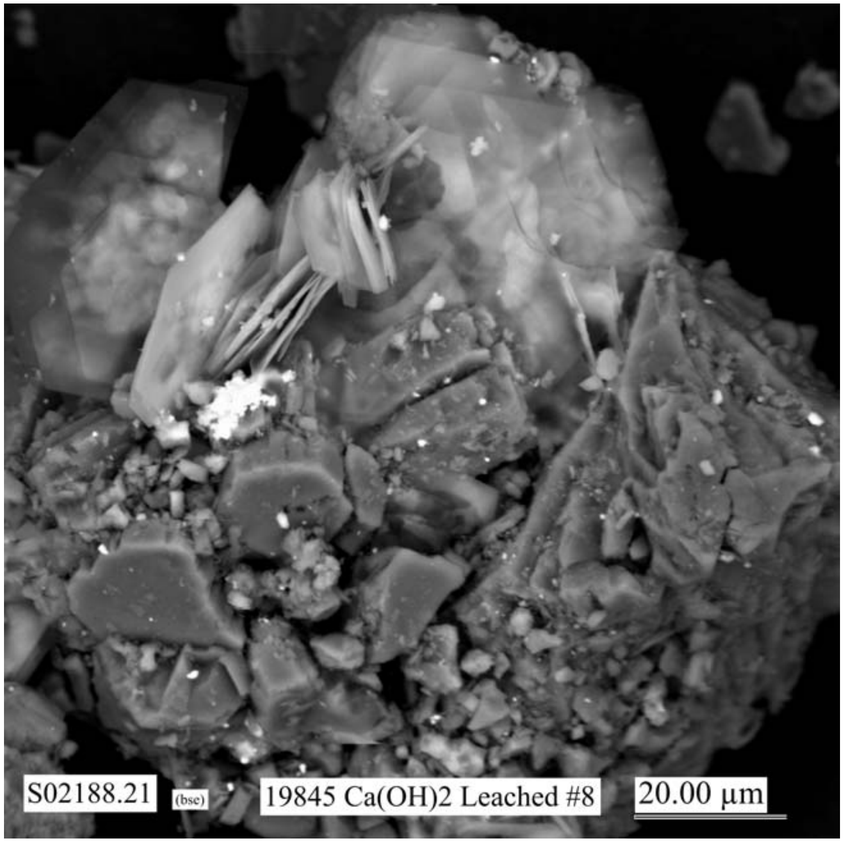

Figure D.6. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.19.)

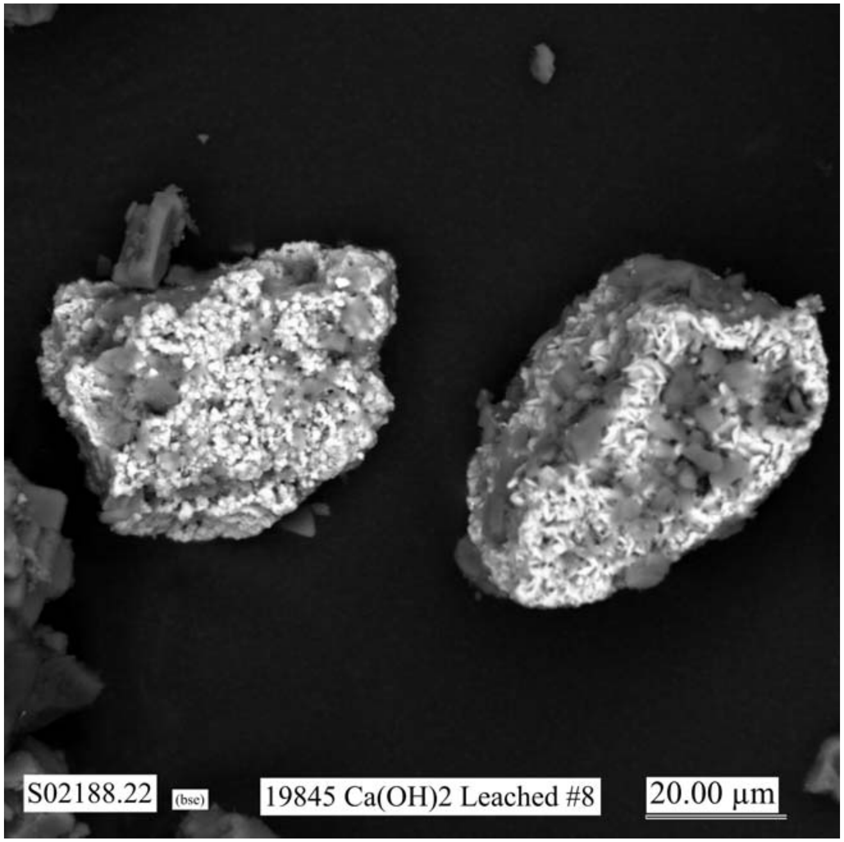

Figure D.7. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact Ca$(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.20 and D.21.)

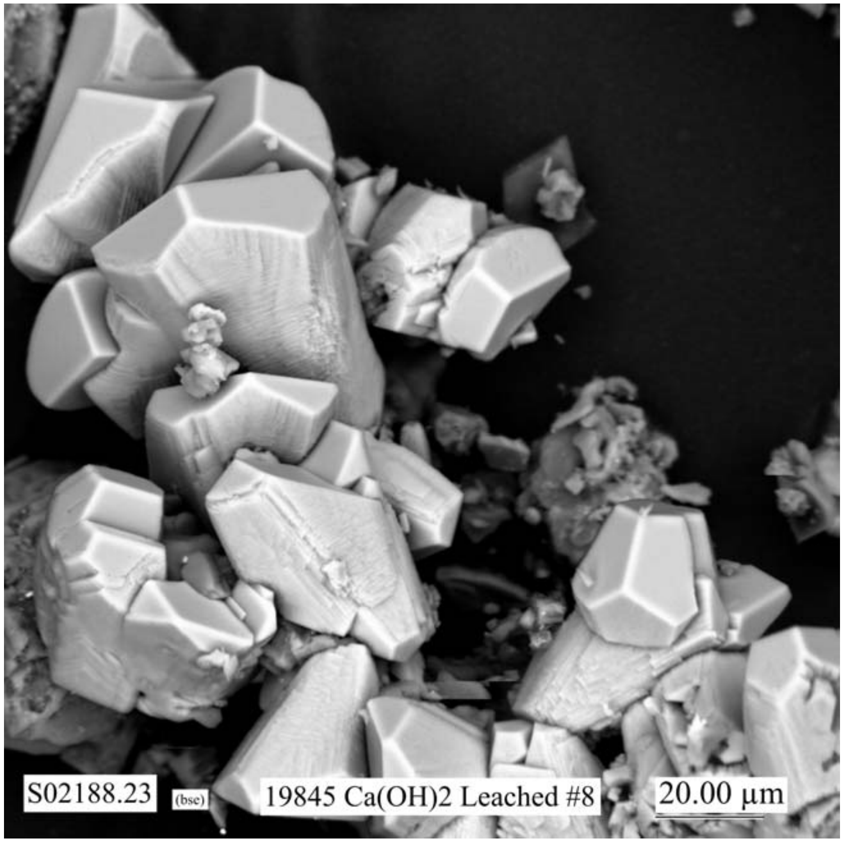

Figure D.8. Micrograph Showing Particle Clusters in Sample 19845 of One-Month Single-Contact Ca$(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.22.)

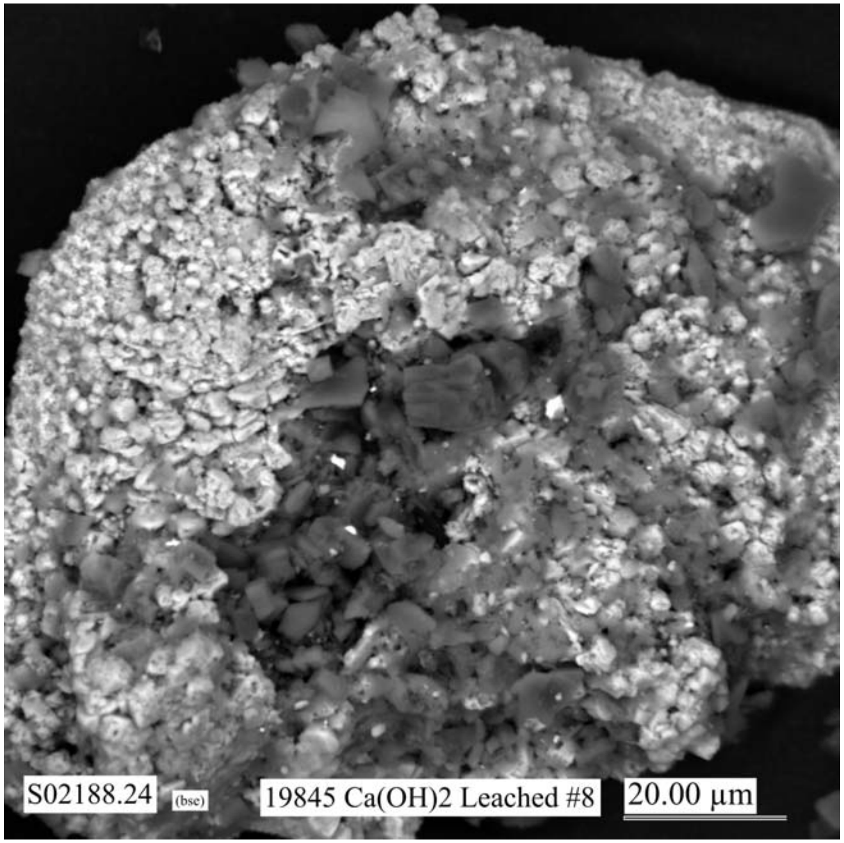

Figure D.9. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

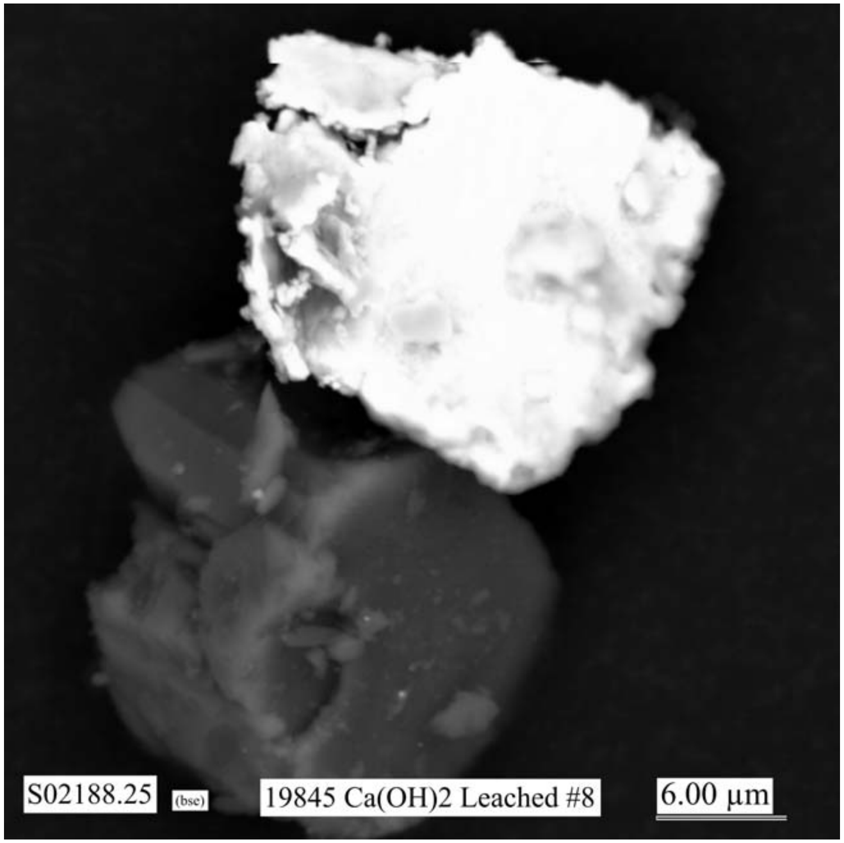

Figure D.10. Micrograph Showing Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.23.)

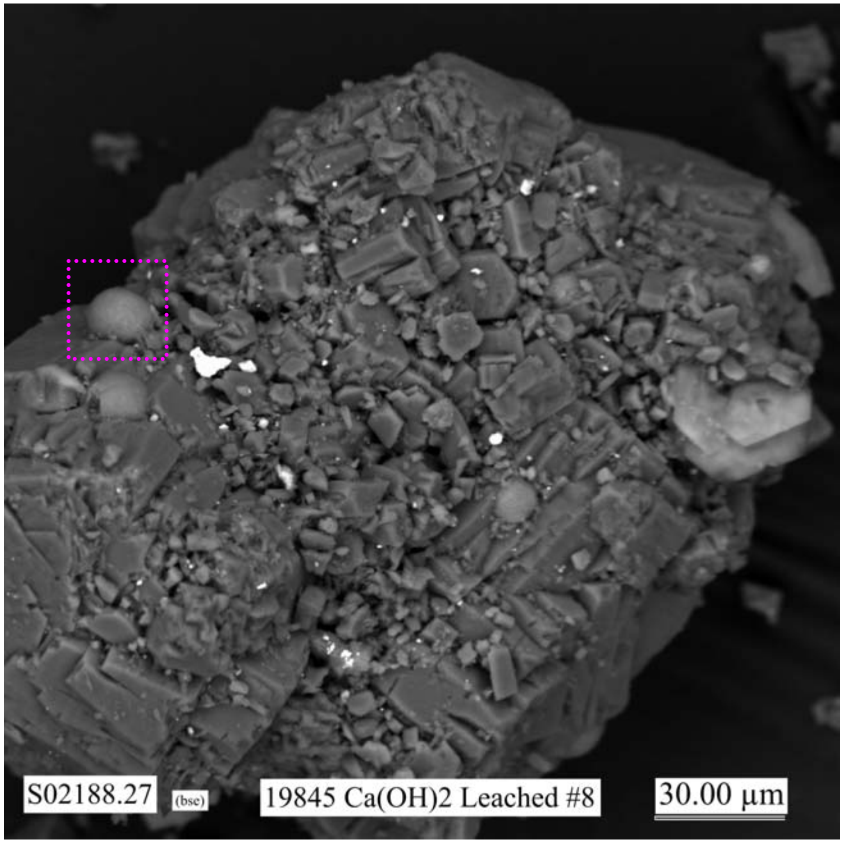

Figure D.11. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.25 and D.26.)

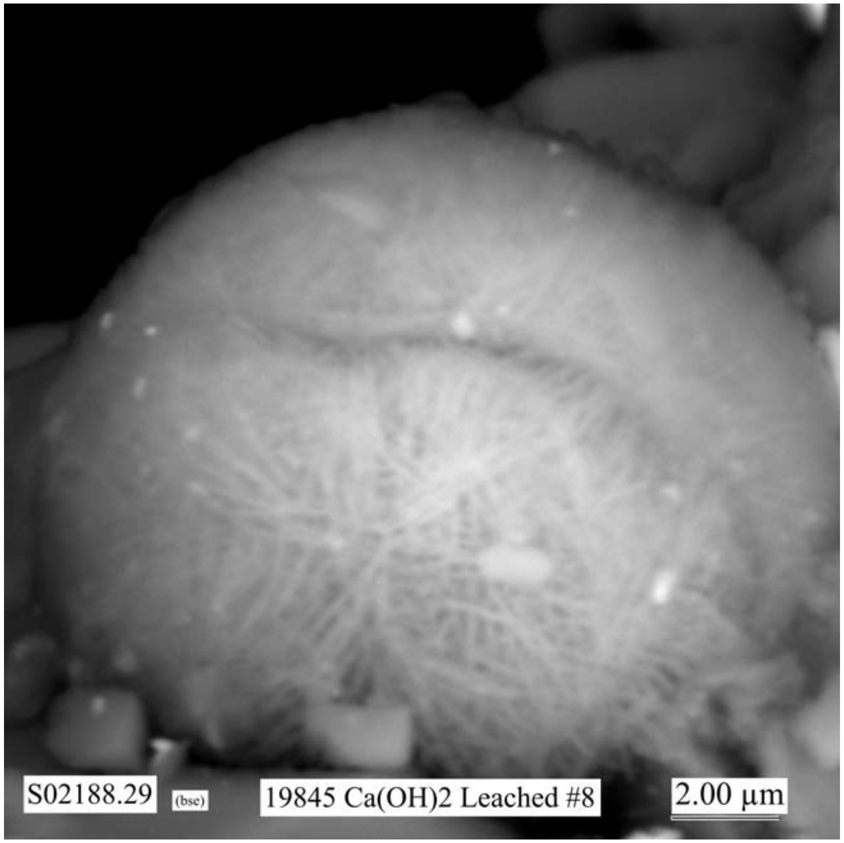

Figure D.12. Micrograph Showing Particle Aggregate Similar in Appearance to a Ball of Twine in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.25 and D.26.)

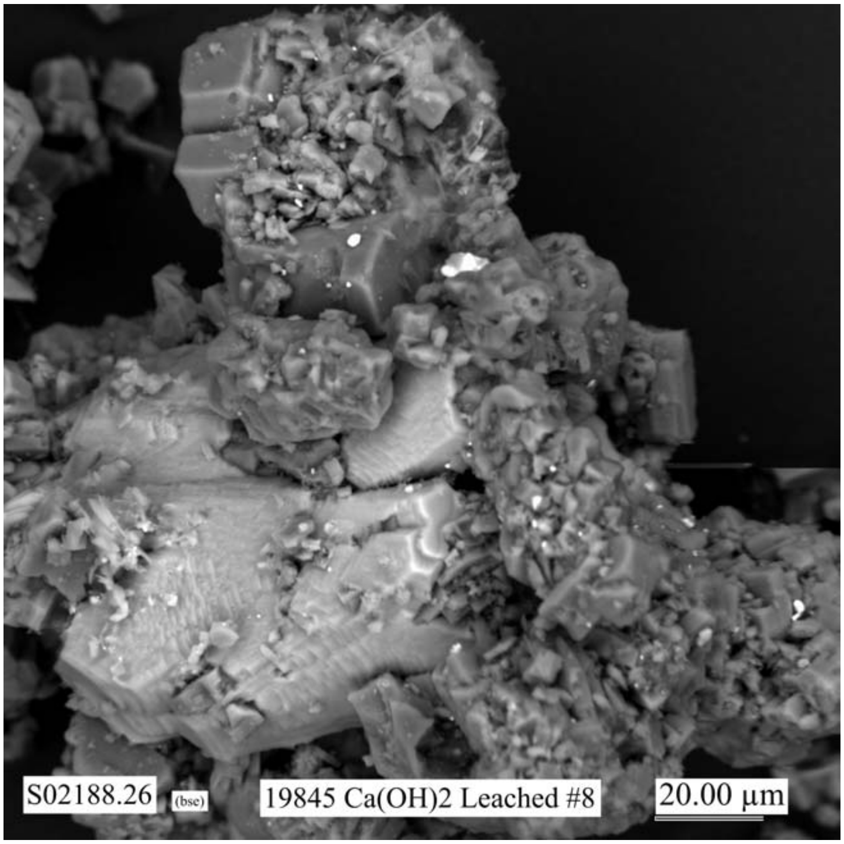

Figure D.13. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.24.)

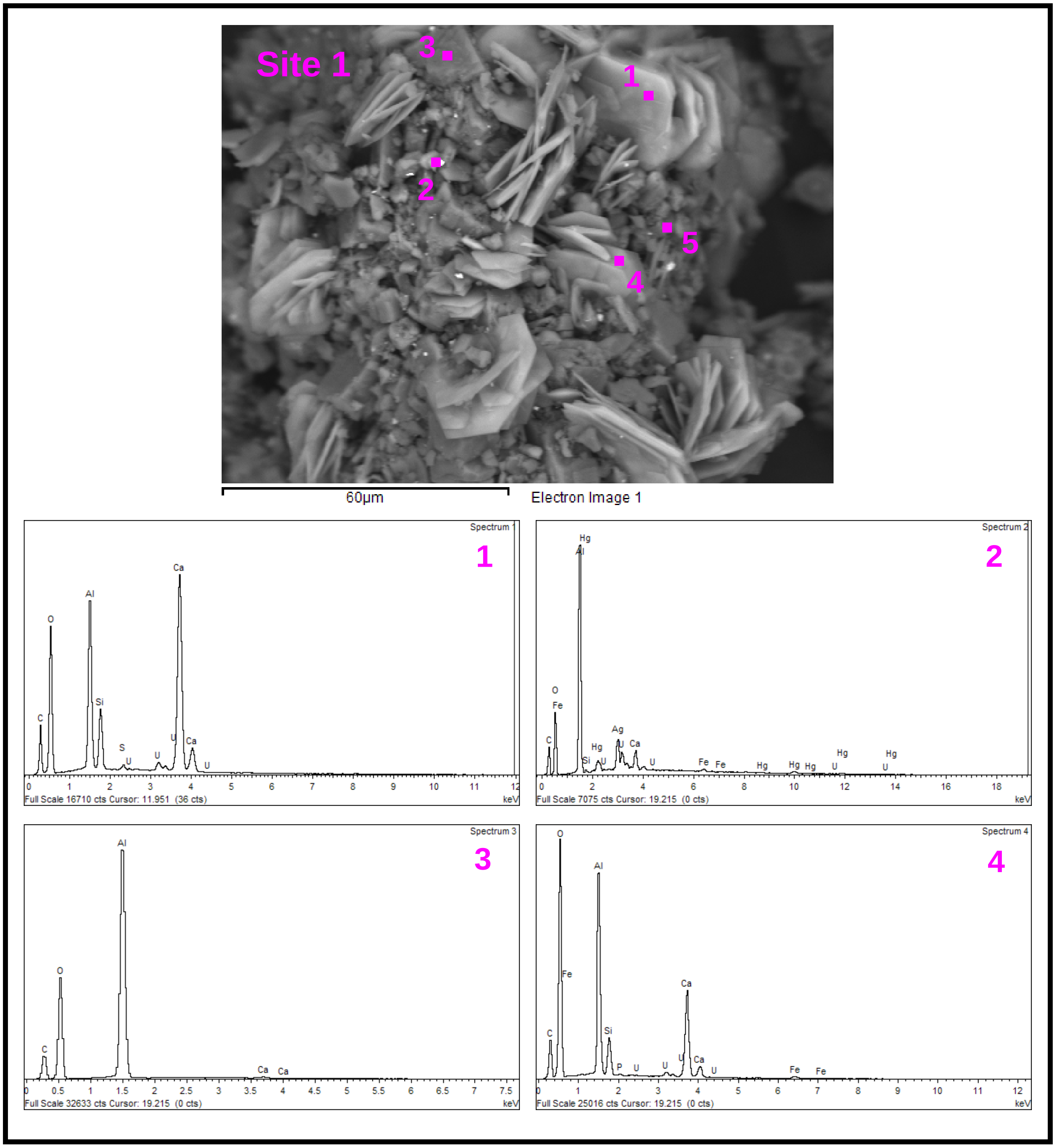

Figure D.14. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

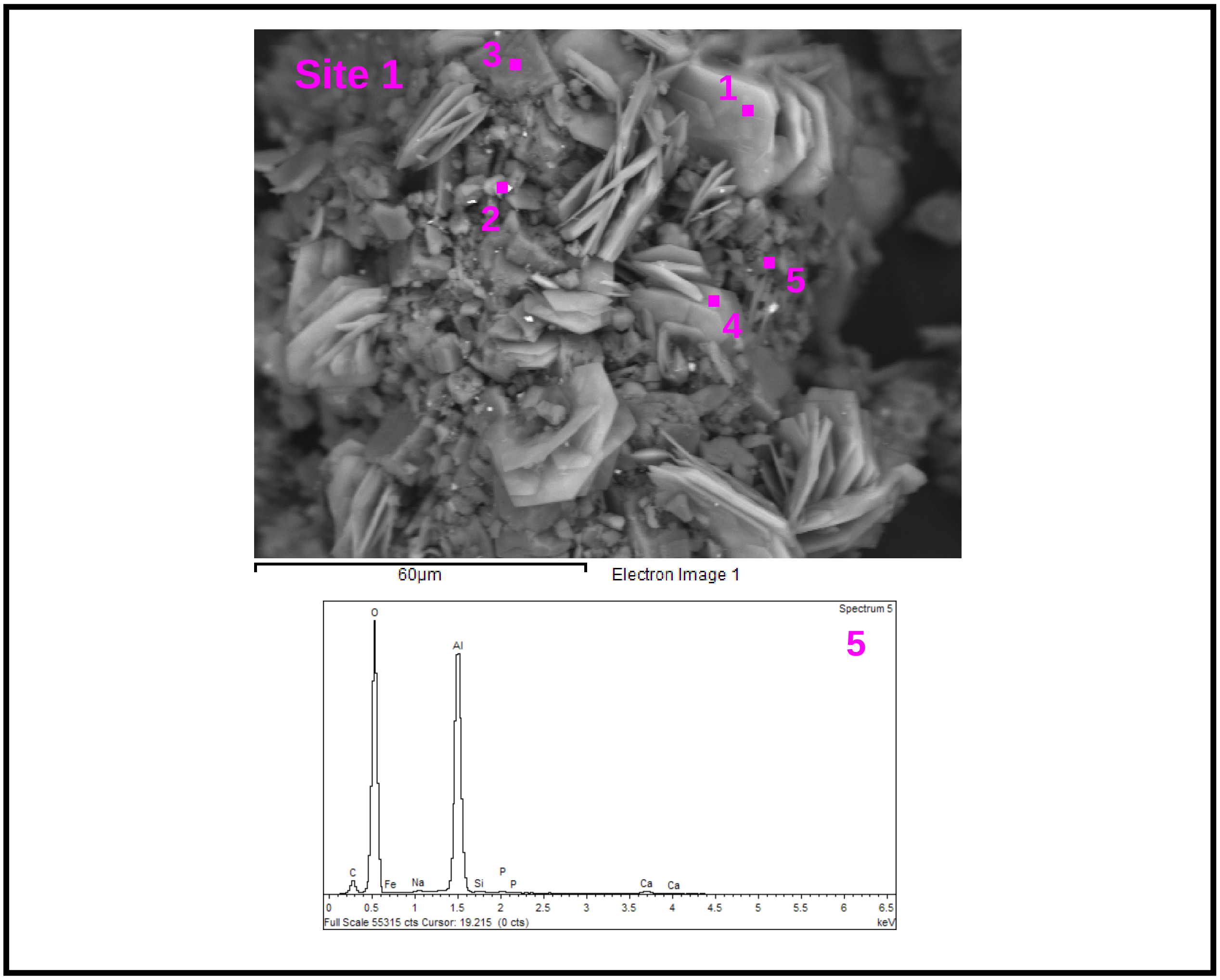

Figure D.15. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

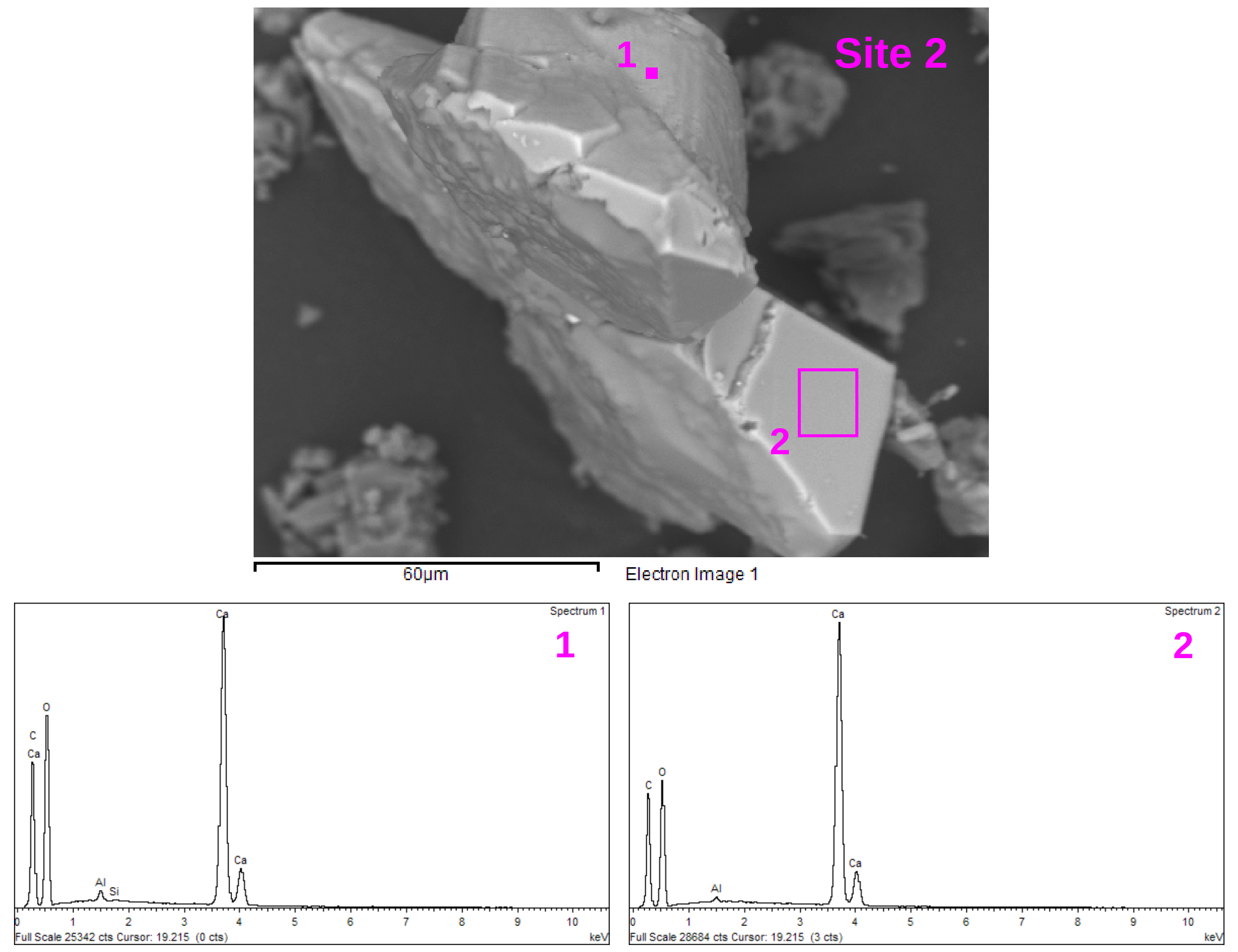

Figure D.16. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

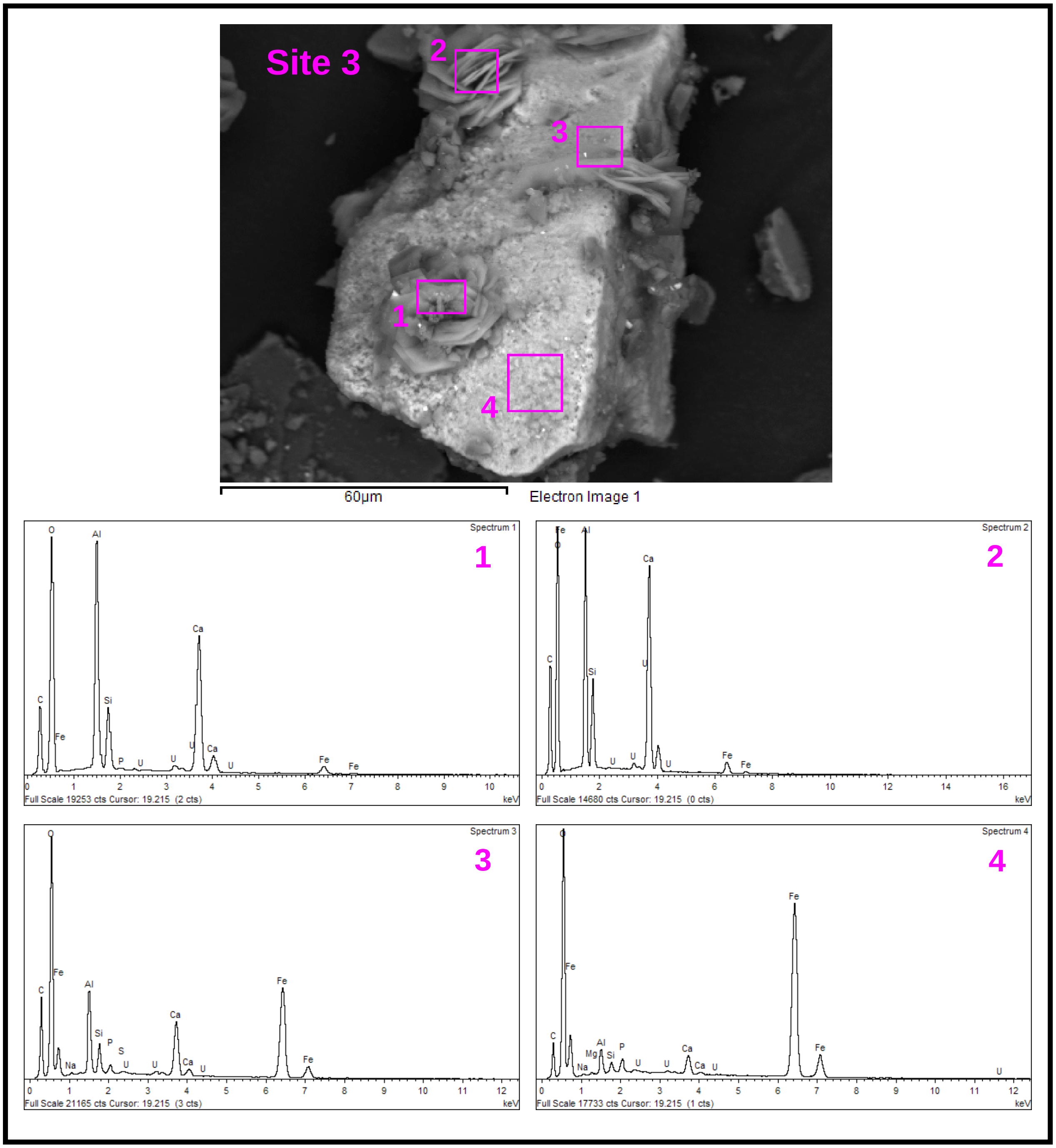

Figure D.17. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

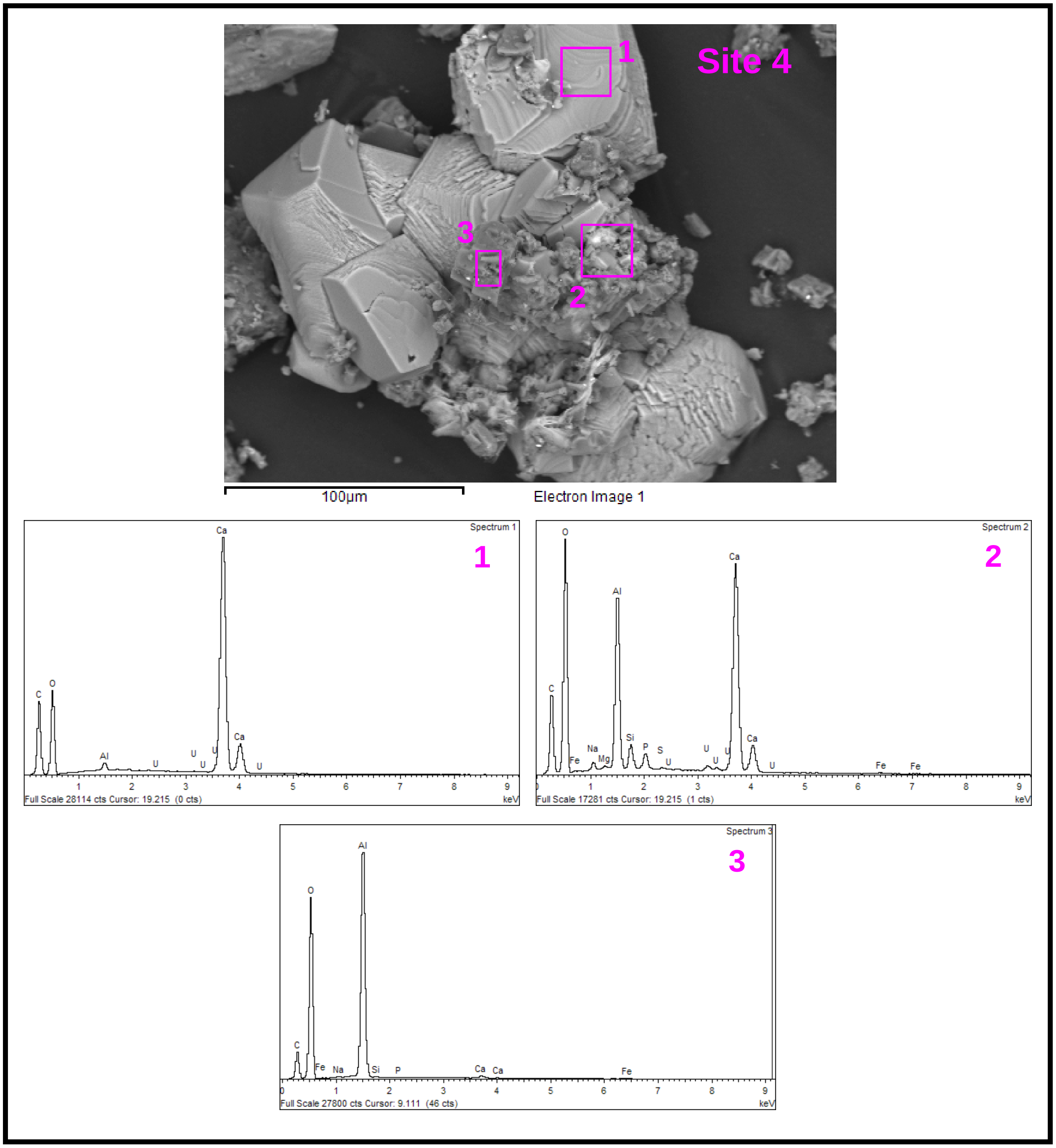

Figure D.18. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

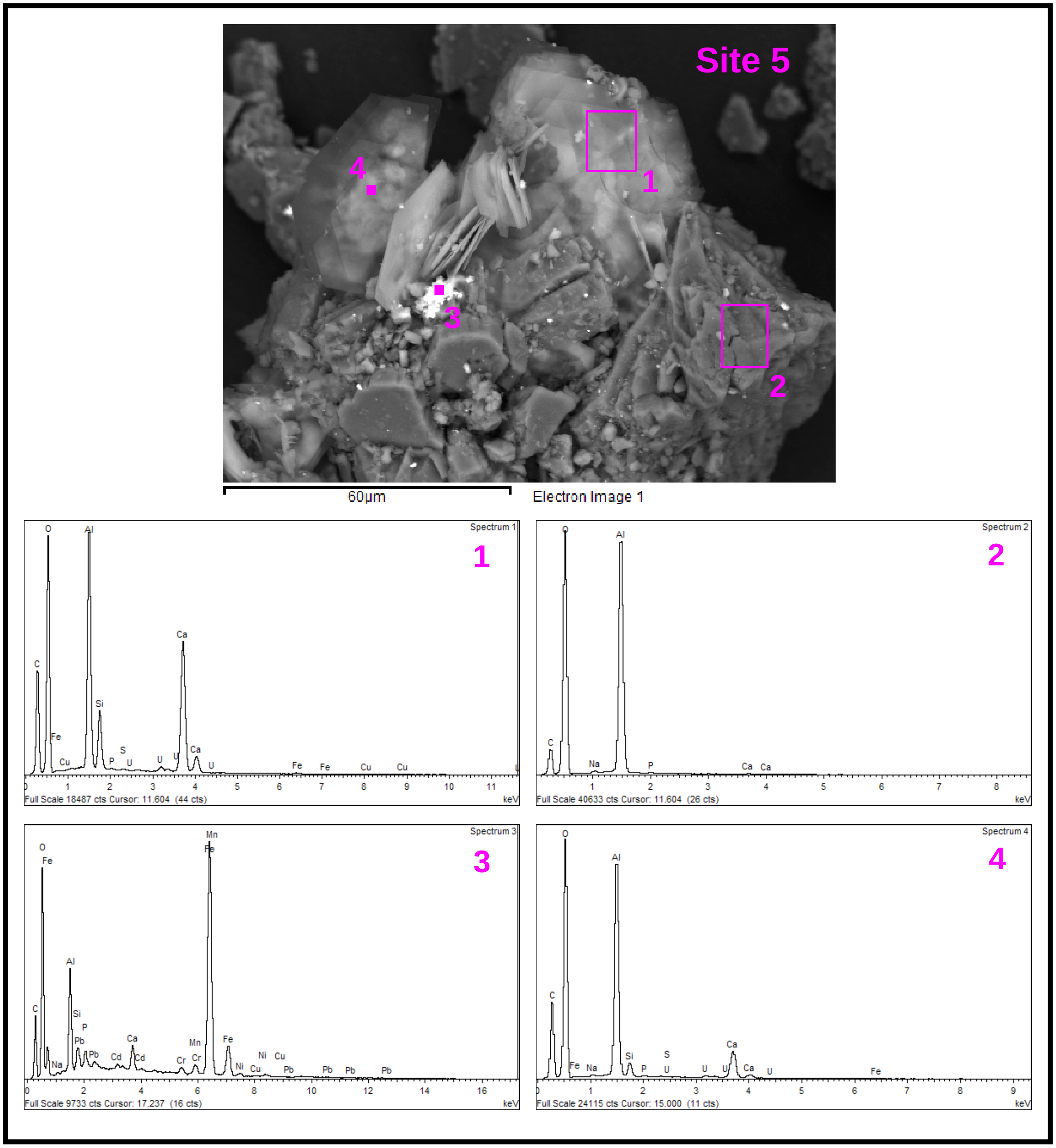

Figure D.19. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

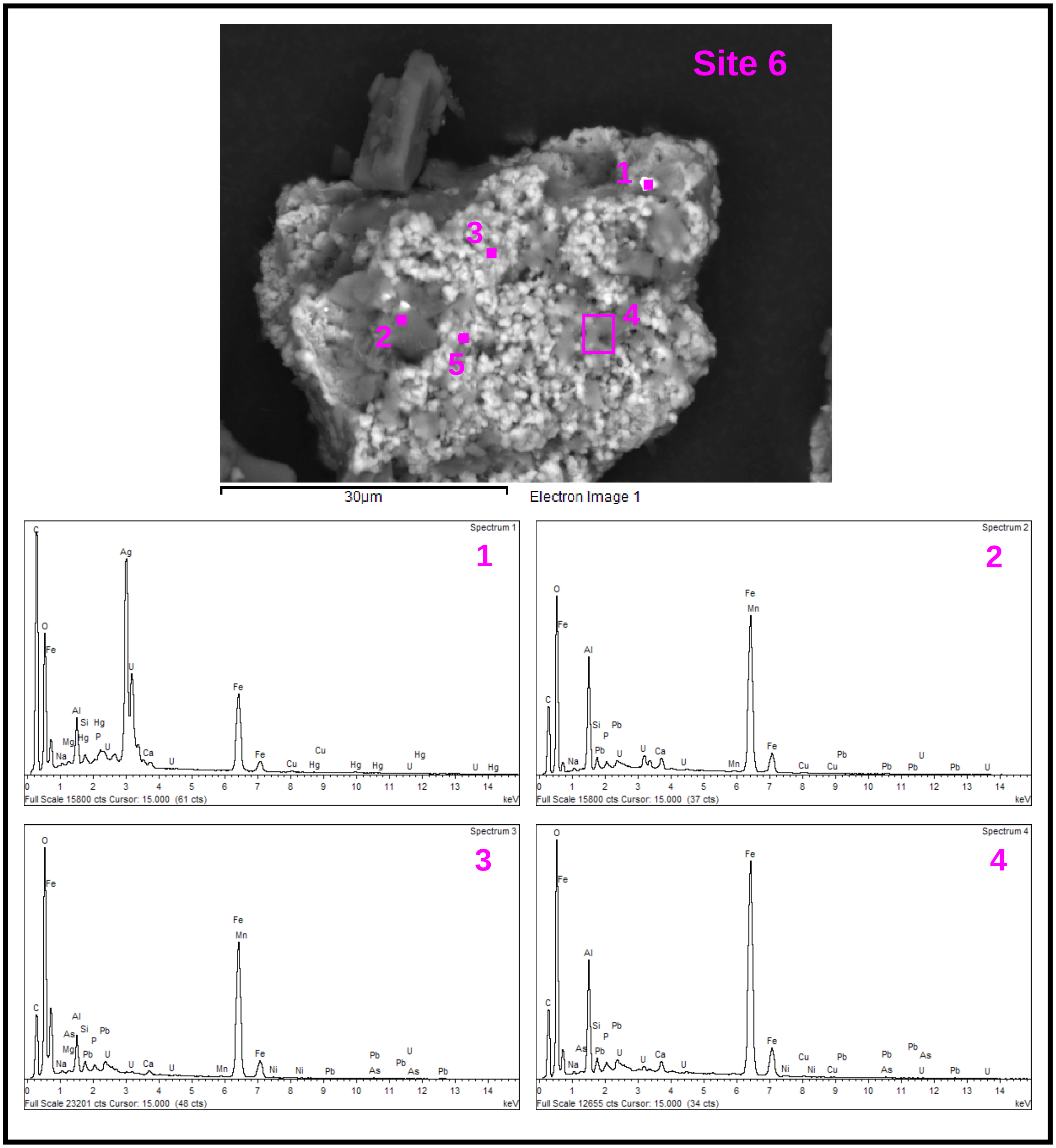

Figure D.20. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

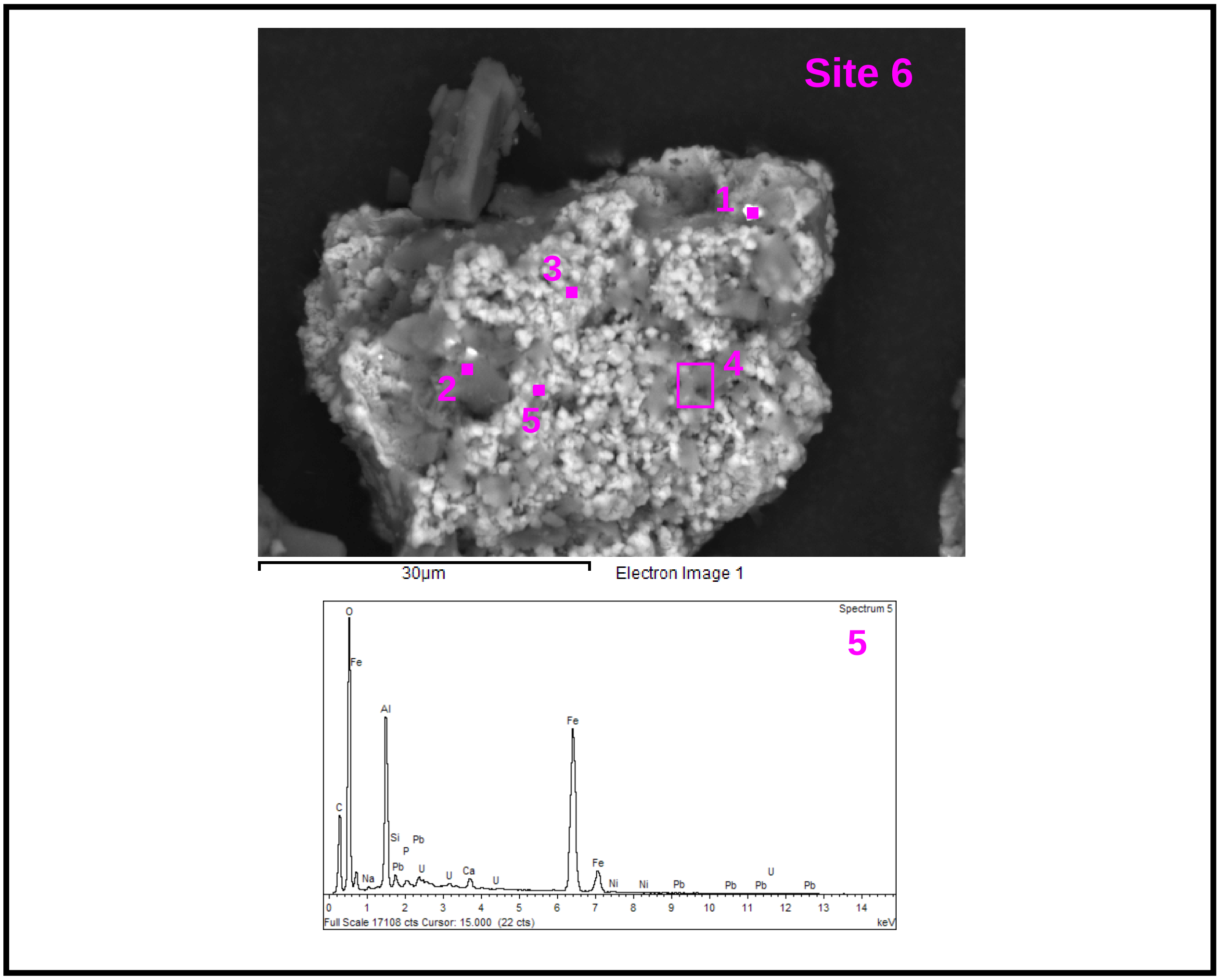

Figure D.21. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

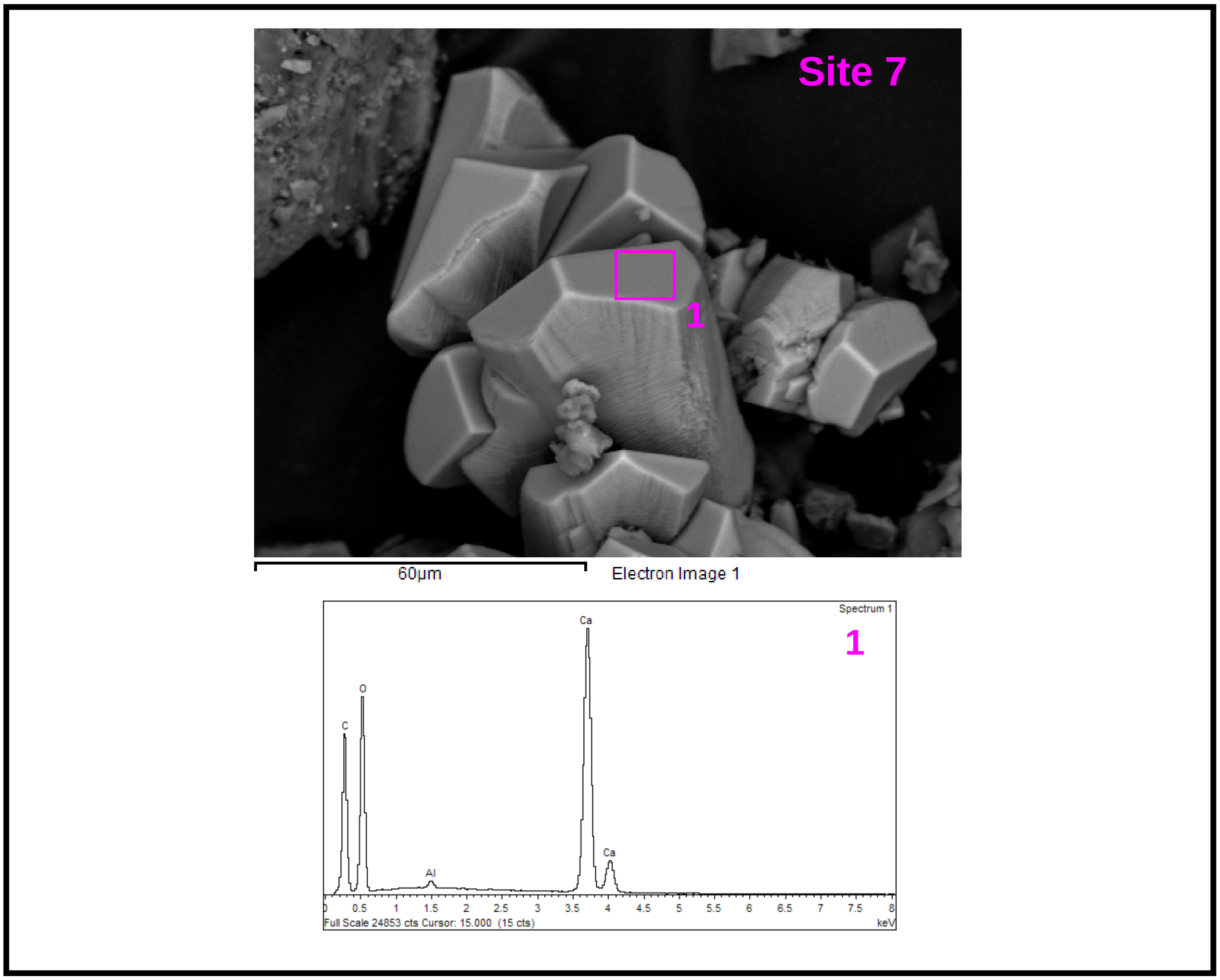

Figure D.22. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

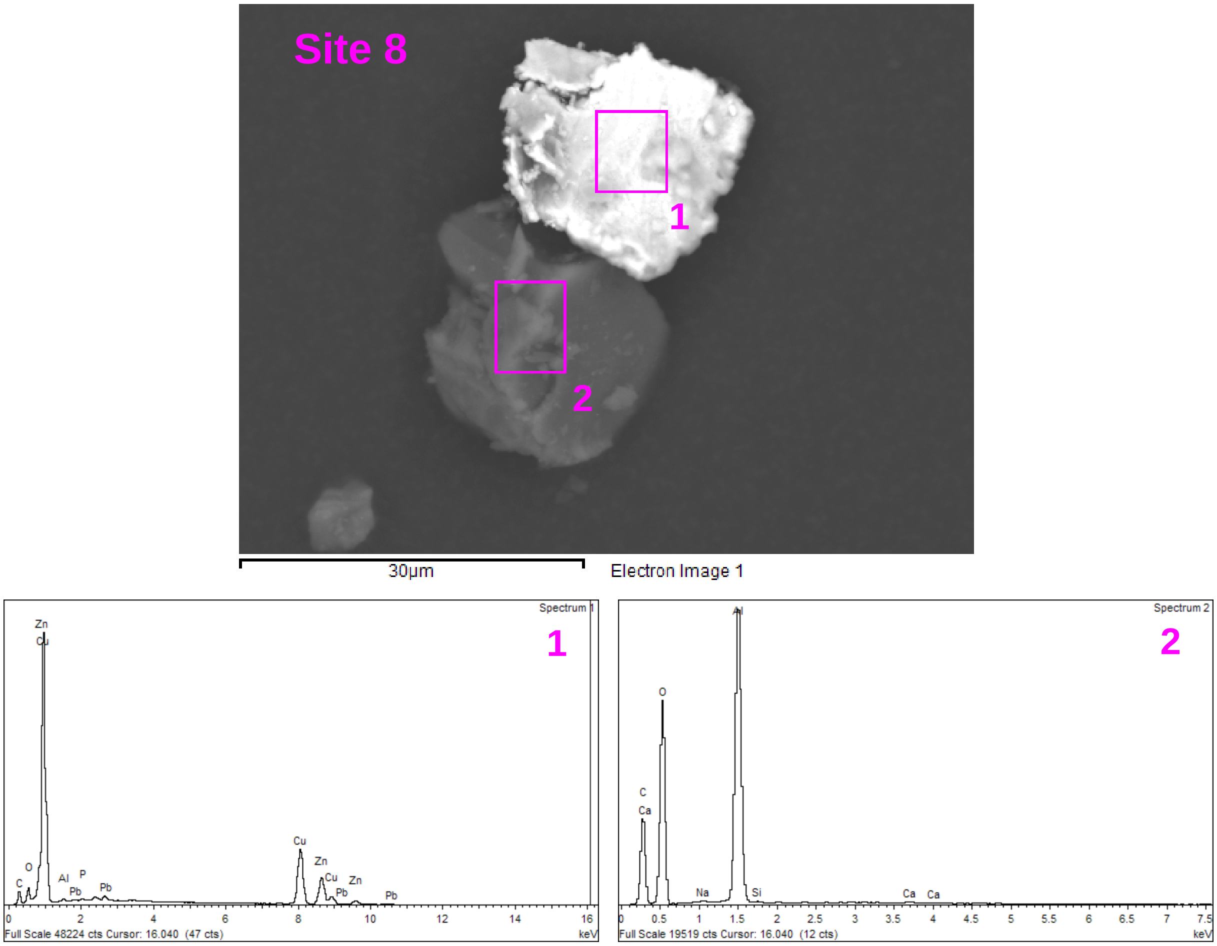

Figure D.23. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

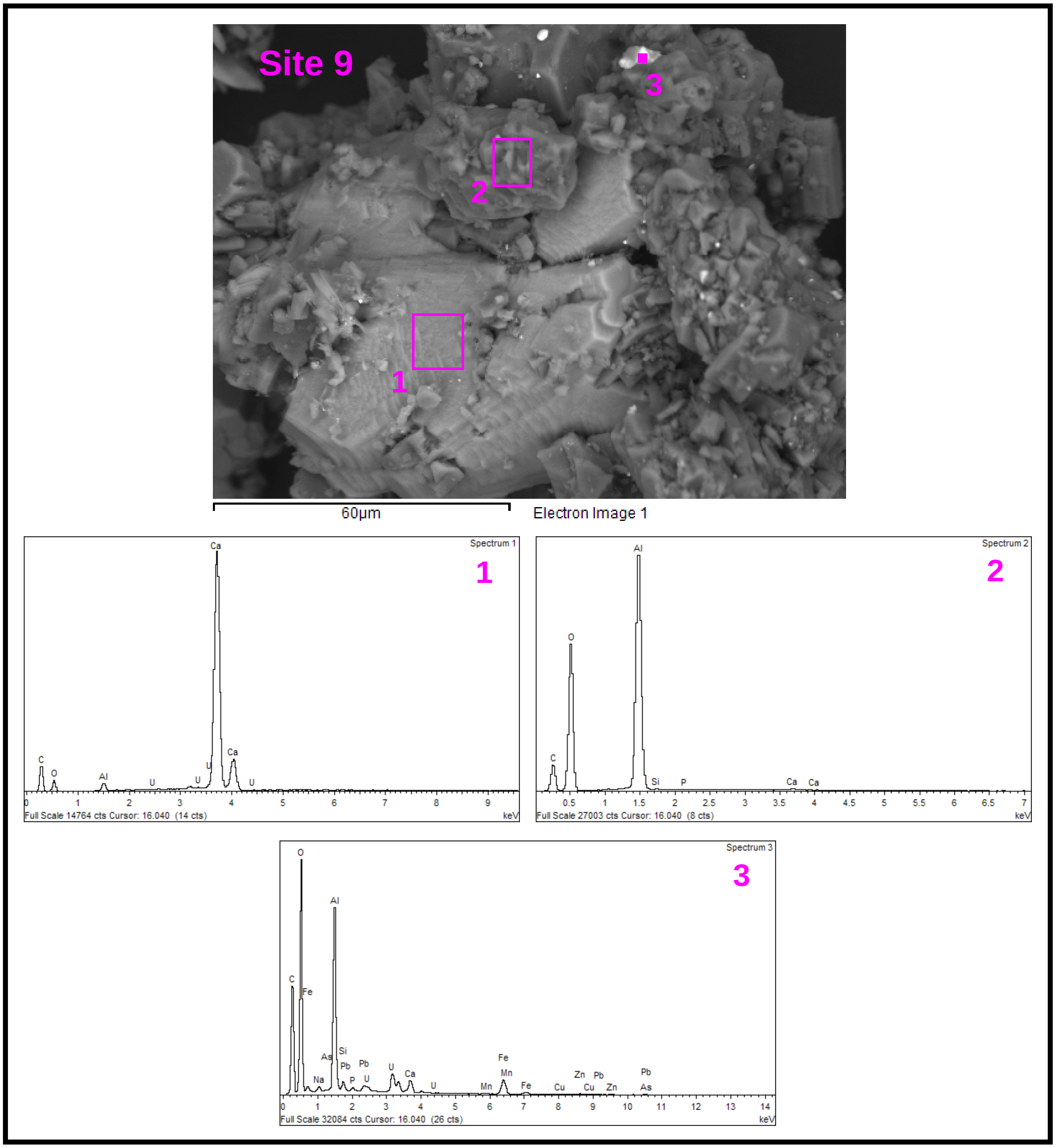

Figure D.24. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

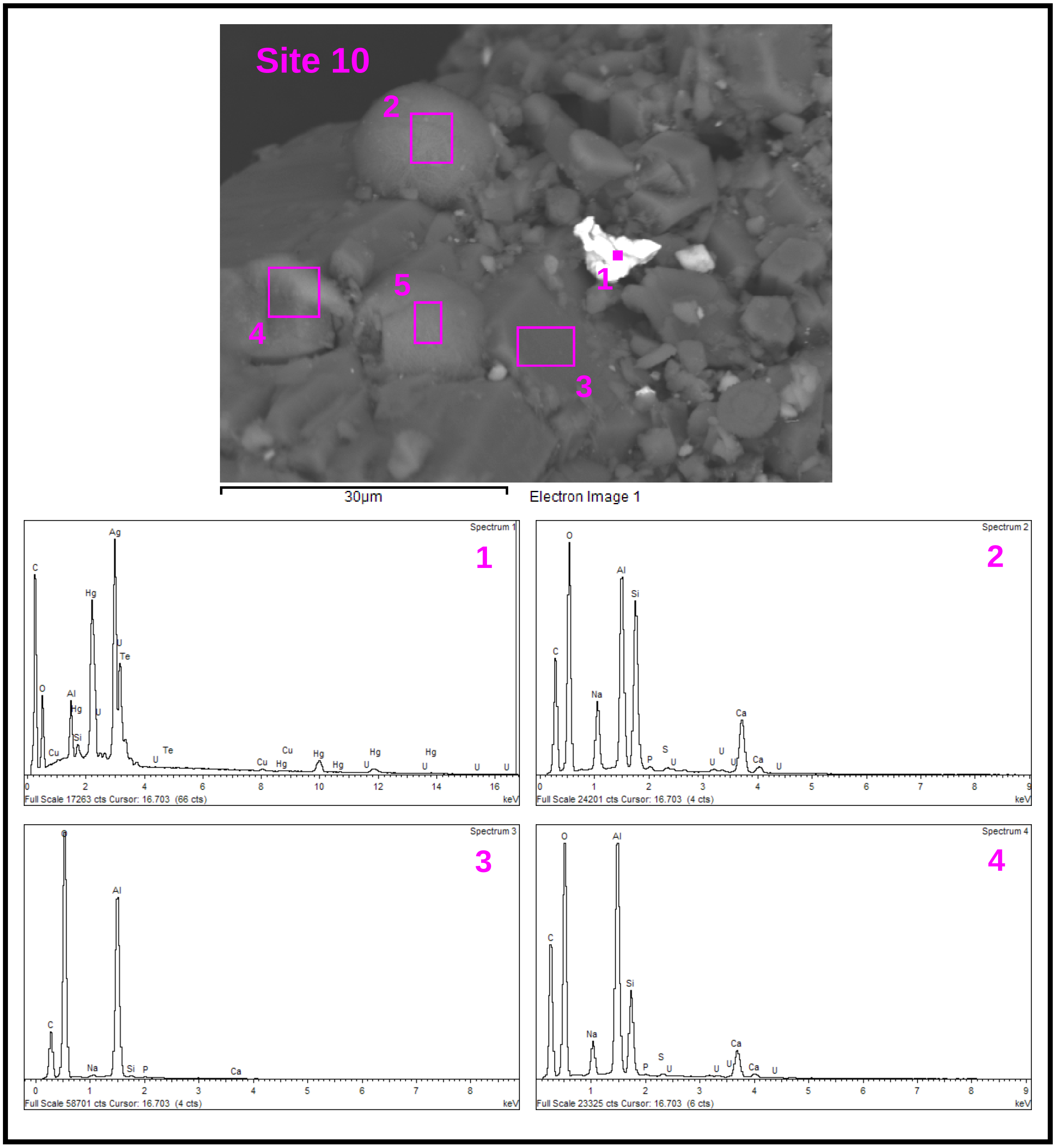

Figure D.25. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

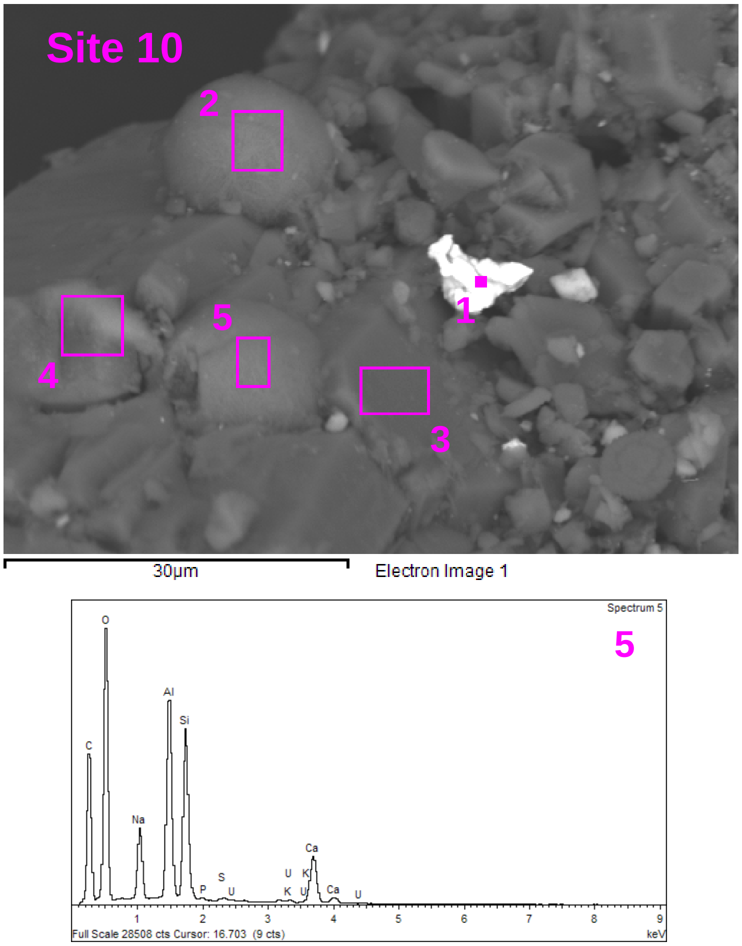

Figure D.26. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

Table D.1. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %**[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.14 and D.15/1	1	12.3	4.8		20.4	2.7						59.4		S (0.4)
	2	29.7	0.4		3.9	3.6	1.3			12.6	5.2	43.1		
	3	41.5			0.3							58.2		
	4	16.1	3.4		10.0	1.4	0.6					68.3	0.1	
	5	27.2	0.2	0.3	0.4		0.1					71.5	0.2	
D.16/2	1	0.7	0.1		26.6							72.6		
	2	0.4			31.4							68.3		
D.17/3	1	14.9	4.6		12.8	1.7	2.0					63.9	0.1	
	2	13.0	5.3		15.9	1.5	2.4					61.9		
	3	7.8	2.7	0.4	5.8	1.3	26.8					54.1	0.8	S (0.1)
	4	2.5	0.9	0.4	1.9	0.7	48.7					43.3	1.3	Mg (0.3)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.2. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.18/4	1	0.8			34.2	0.4						64.6		
	2	10.6	1.6	0.9	17.6	1.3	0.2					66.3	1.1	Mg (0.2), S (0.1)
	3	32.1	0.2	0.2	0.4		0.2					66.7	0.2	
D.19/5	1	15.7	4.5		12.5	1.4	0.3					65.1	0.1	Cu (0.2), S (0.1)
	2	28.8		0.4	0.1							70.5	0.2	
	3	8.2	1.1	0.5	1.9		49.0	0.9				32.3	1.1	Cd (0.7), Cu (0.5), Mn (1.5), Ni (1.0), Pb (1.3)
	4	22.2	1.8	0.3	4.2	0.9	0.2					70.1	0.1	S (0.1)
D.20 and D.21/6	1	3.2	0.5	0.4	0.3	1.2	16.4			32.5	1.2	43.5	0.2	Cu (0.4), Mg (0.2)
	2	11.4	1.2	0.6	1.2	4.5	43.2					35.5	0.5	Cu (0.4), Mn (0.2), Pb (1.3)
	3	4.4	1.1	0.7	0.5	0.6	44.6					44.4	0.6	As (0.1), Mg (0.2), Mn (0.2), Ni (0.3), Pb (2.3)
	4	9.4	1.1	0.6	0.9	1.1	47.9					35.7	0.5	As (0.2), Cu (0.4), Ni (0.4), Pb (1.8)
	5	13.8	1.0	0.5	0.8	1.0	38.4					42.2	0.4	Ni (0.3), Pb (1.5)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.3. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[a]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.22/7	1	0.6			25.2							74.3		
D.23/8	1	0.7										7.5	0.5	Cu (55.7), Pb (2.4), Zn (33.3)
	2	34.3	0.2	0.4	0.3							64.8		
D.24/9	1	1.5			66.3	1.9						30.3		
	2	36.0	0.2		0.3							63.3	0.2	
	3	18.7	1.0	0.6	1.7	8.3	5.3					61.1	0.4	As (0.2), Cu (0.2), Mn (0.1), Pb (1.7), Zn (0.6)
D.25 and D.26/10	1	3.3	0.2			2.5				38.8	26.7	27.6		Cu (0.5), Te (0.4)
	2	13.8	13.7	7.9	5.6	0.9						57.7	0.4	S (0.2)
	3	25.1	0.3	0.5	0.1							73.7	0.2	
	4	19.7	8.9	4.9	3.5	0.6						62.0	0.2	S (0.2)
	5	13.4	12.8	7.9	4.6	0.8						60.0	0.2	K (0.1), S (0.2)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

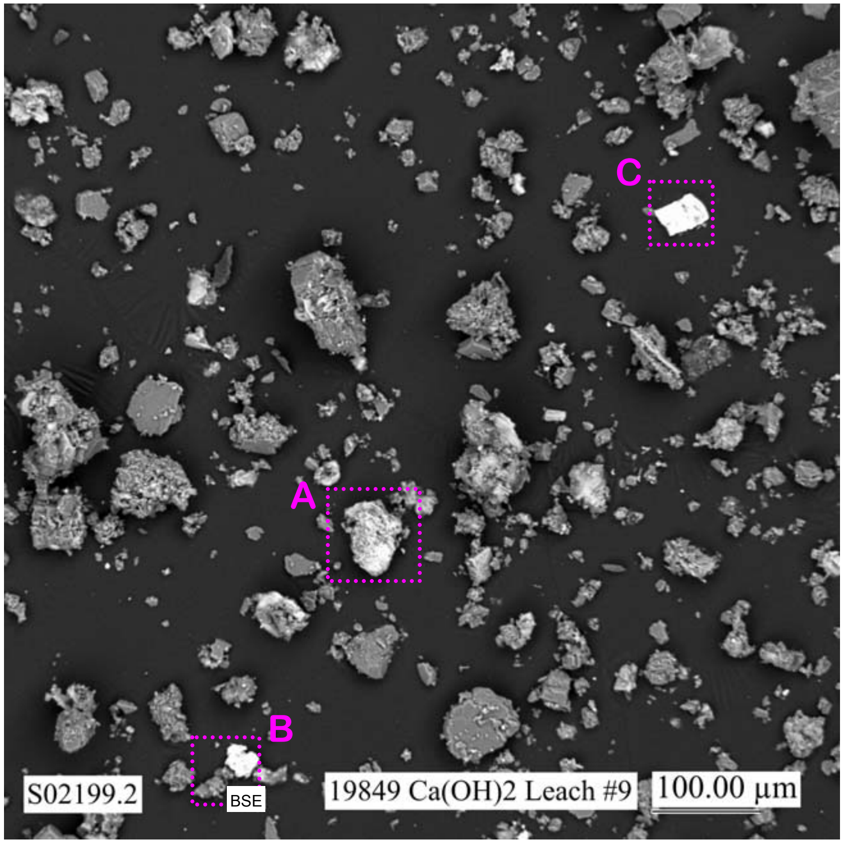

Figure D.27. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

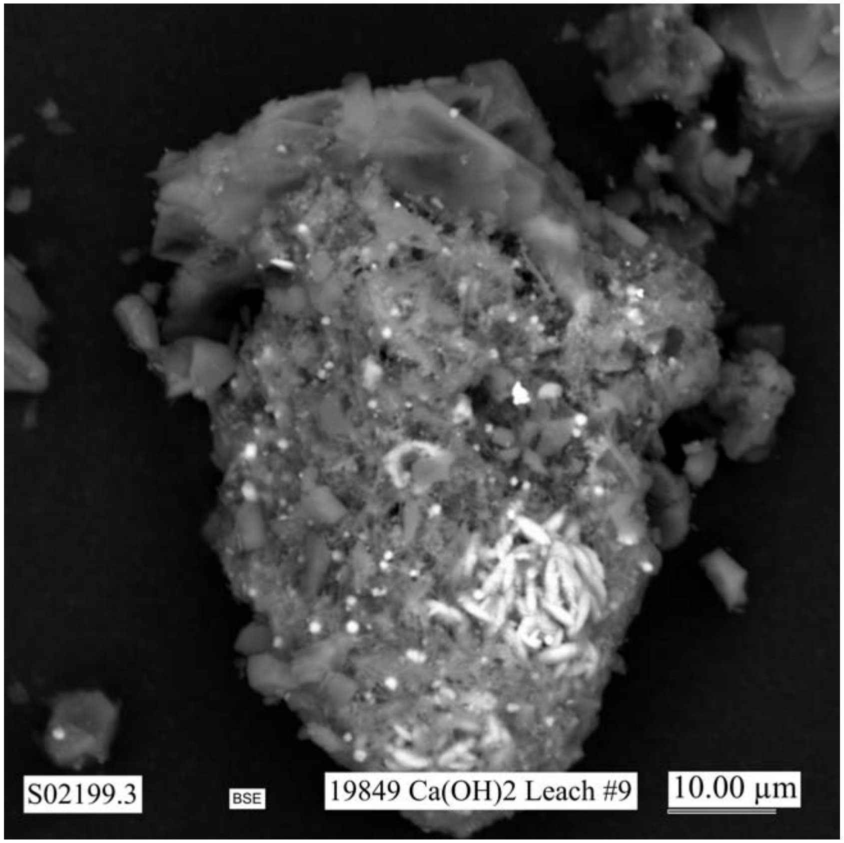

Figure D.28. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square A in Figure D.27 (Areas where EDS analyses were made are shown in Figure D.38.)

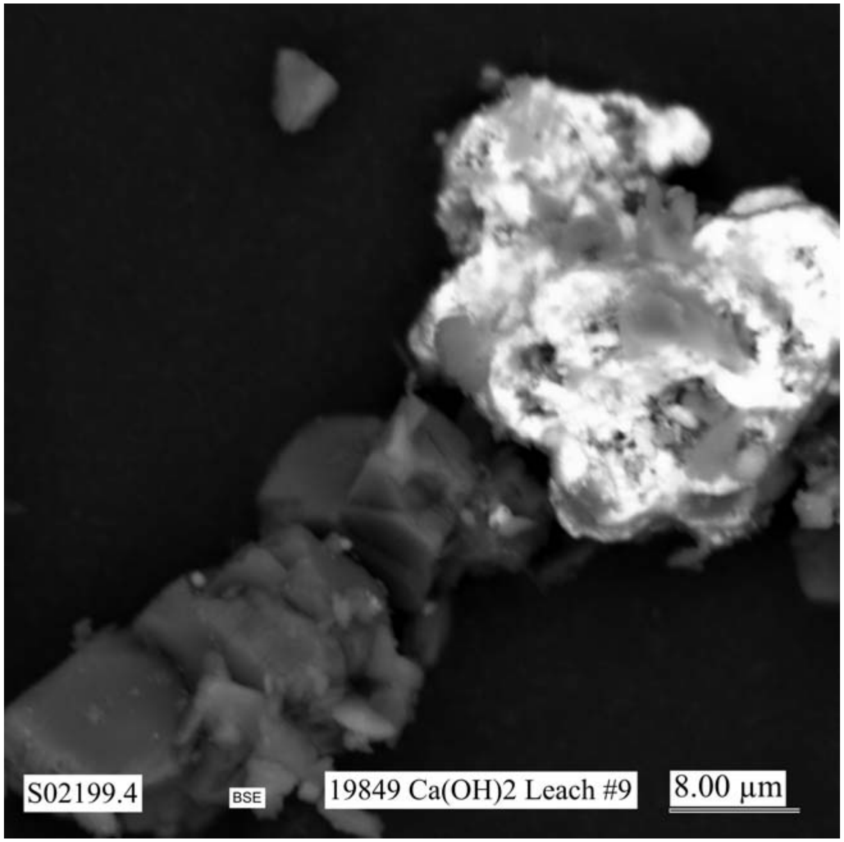

Figure D.29. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square B in Figure D.27 (Areas where EDS analyses were made are shown in Figures D.39 and D.40.)

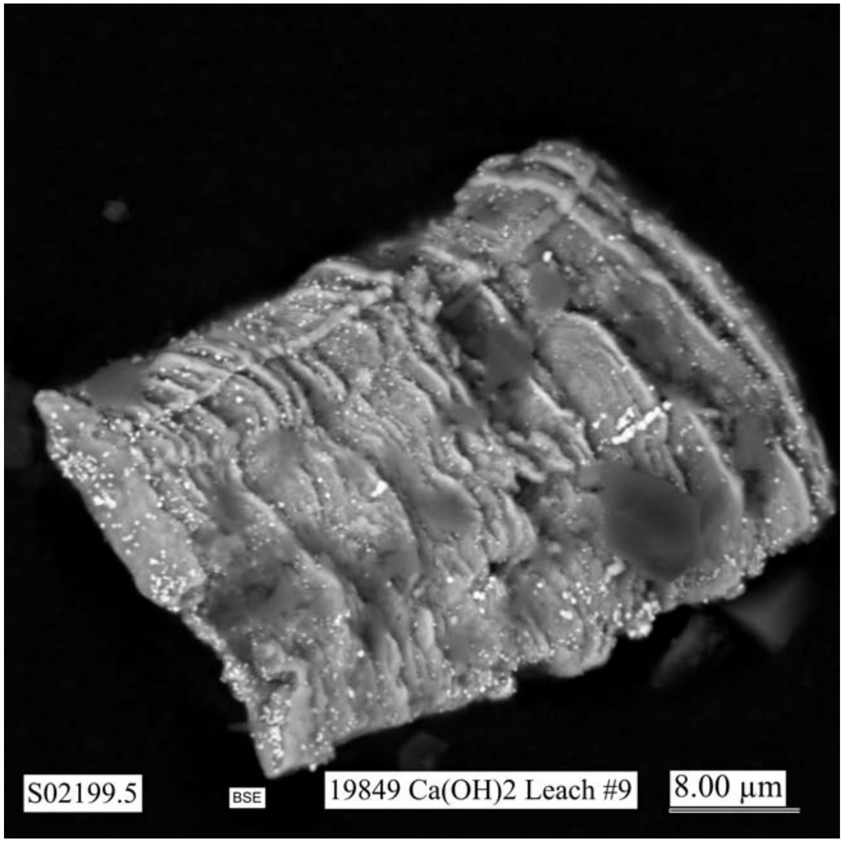

Figure D.30. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square C in Figure D.27 (Areas where EDS analyses were made are shown in Figure D.41.)

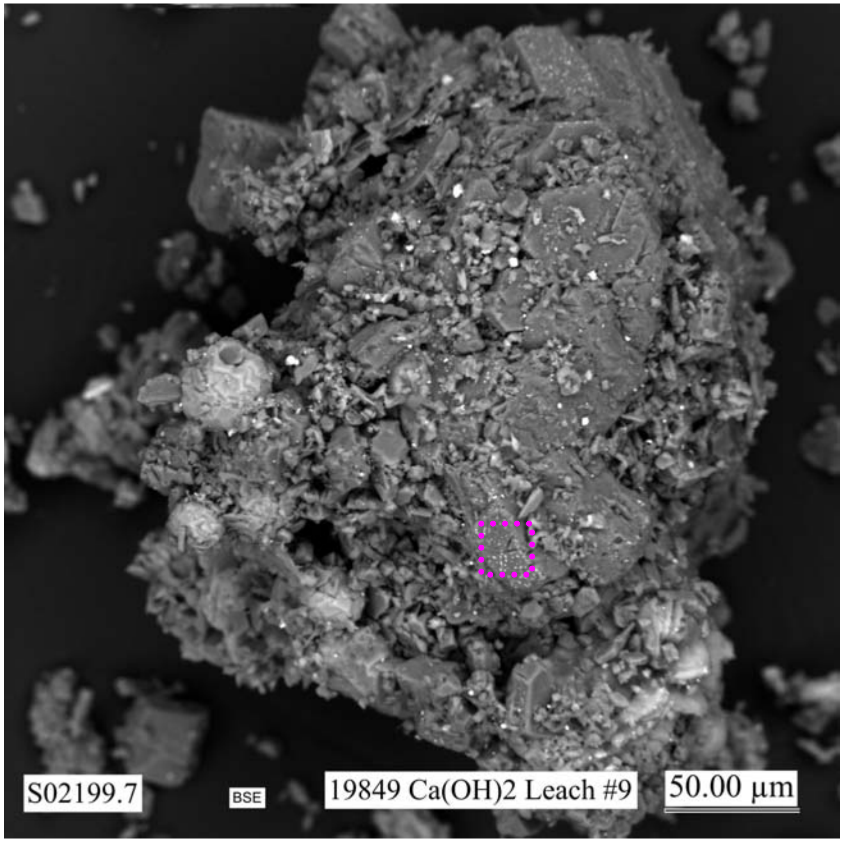

Figure D.31. Micrograph Showing Particle Aggregate in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

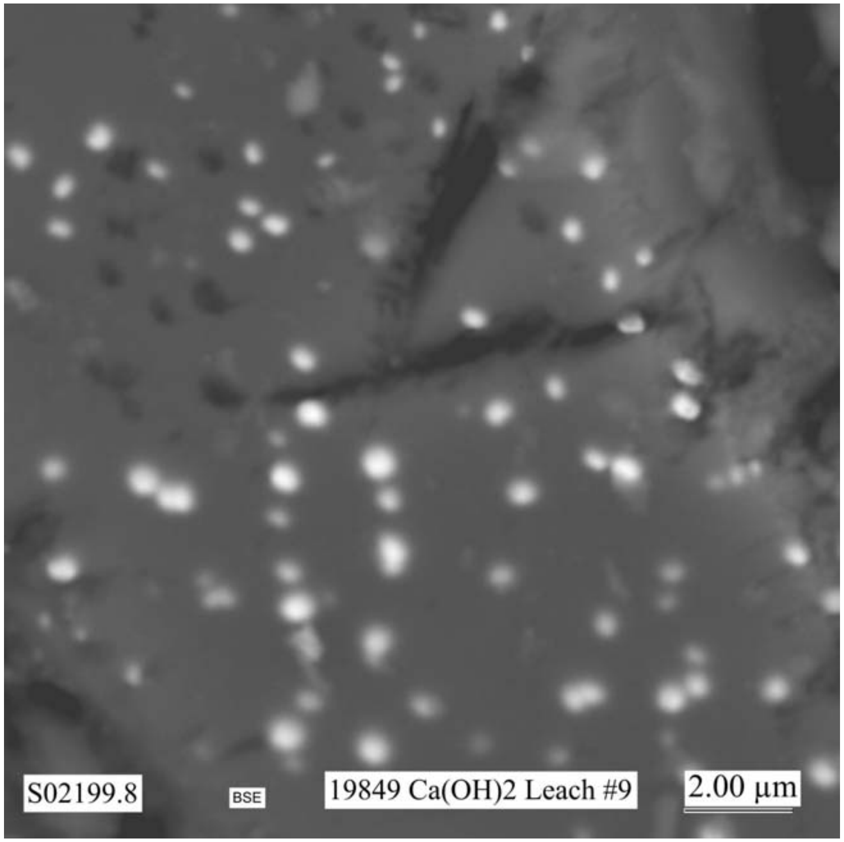

Figure D.32. Micrograph Showing at Higher Magnification the Material in the Area Indicated by the Pink Dotted-Line Square in Figure D.31 (Areas where EDS analyses were made are shown in Figure D.44.)

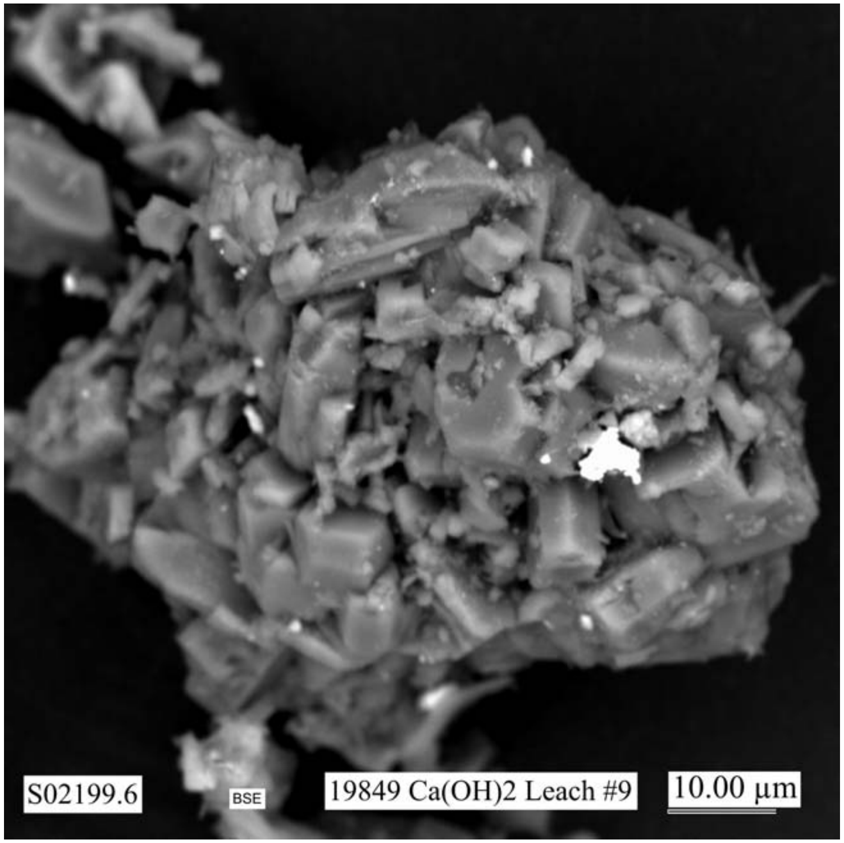

Figure D.33. Micrograph Showing Particle Aggregate in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.42.)

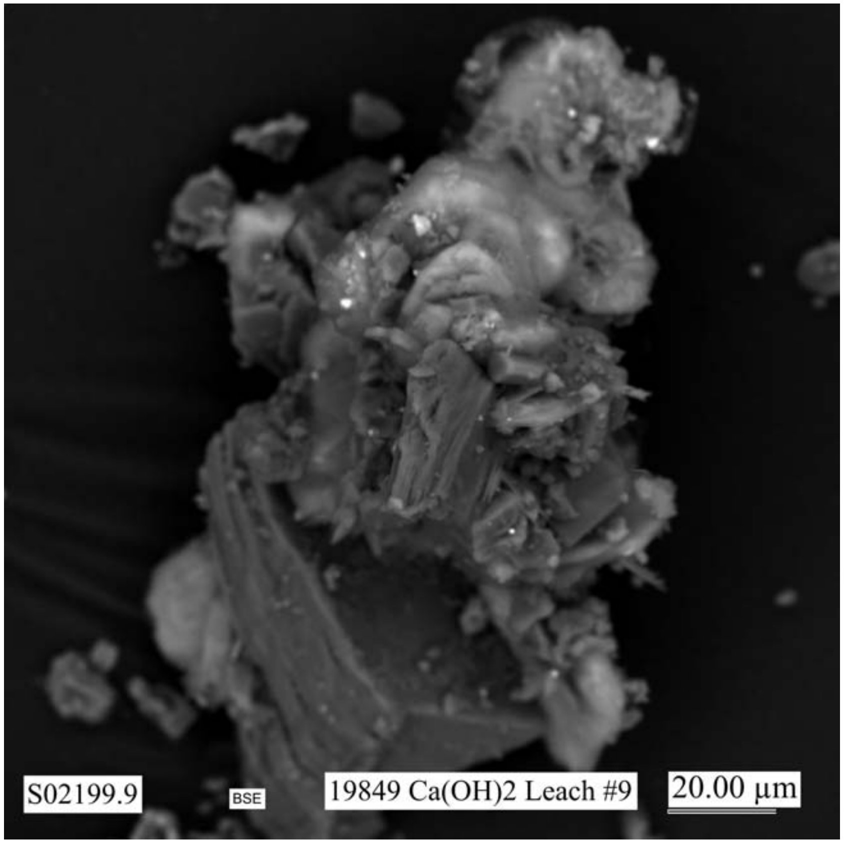

Figure D.34. Micrograph Showing Particle Aggregate in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.45.)

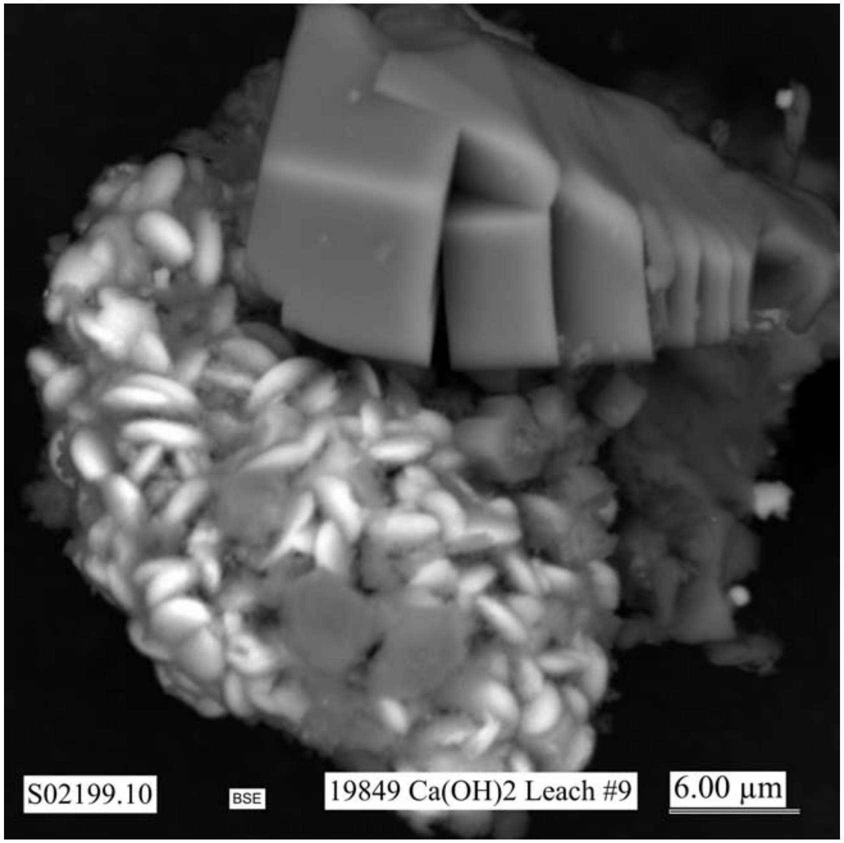

Figure D.35. Micrograph Showing Particle Cluster in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.46.)

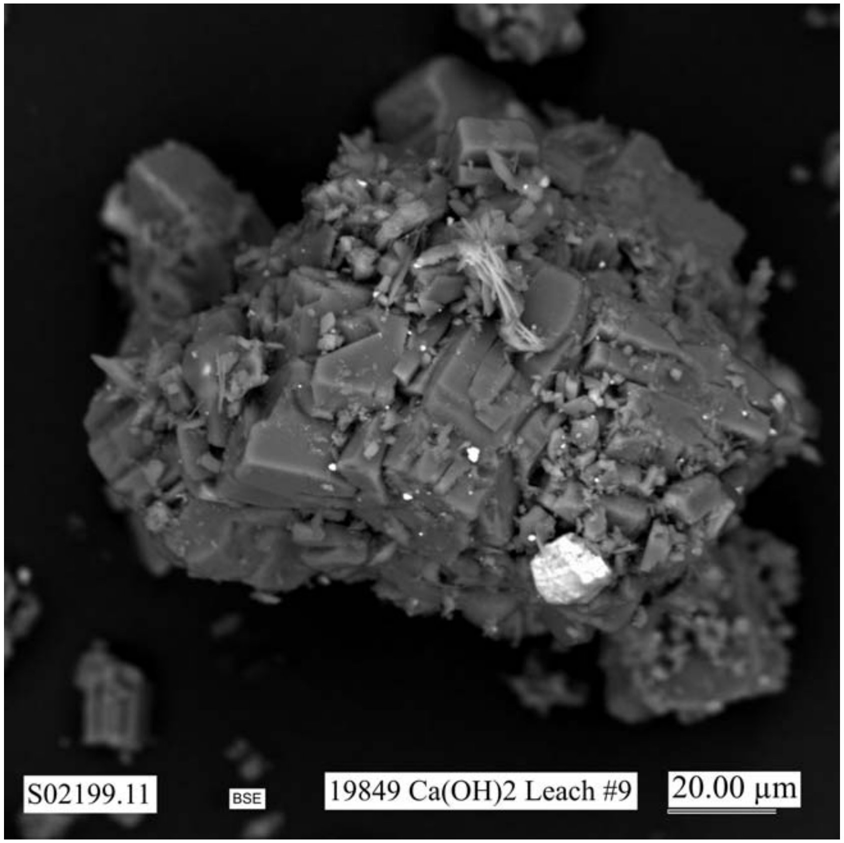

Figure D.36. Micrograph Showing Particle Aggregate in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.47.)

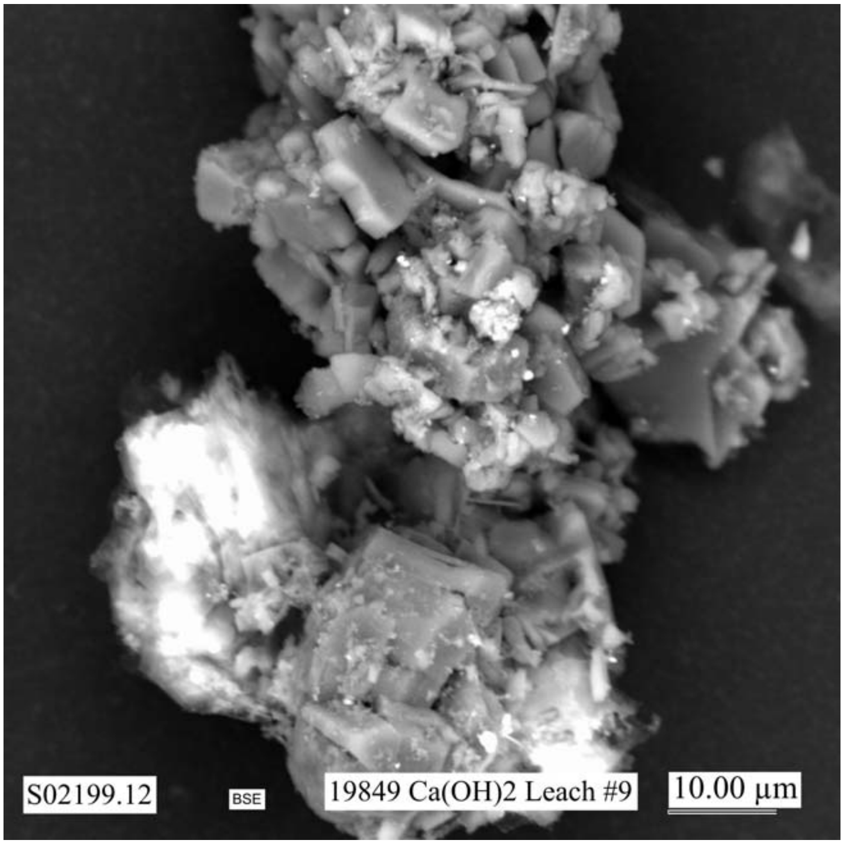

Figure D.37. Micrograph Showing Particle Aggregates in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.48 and D.49.)

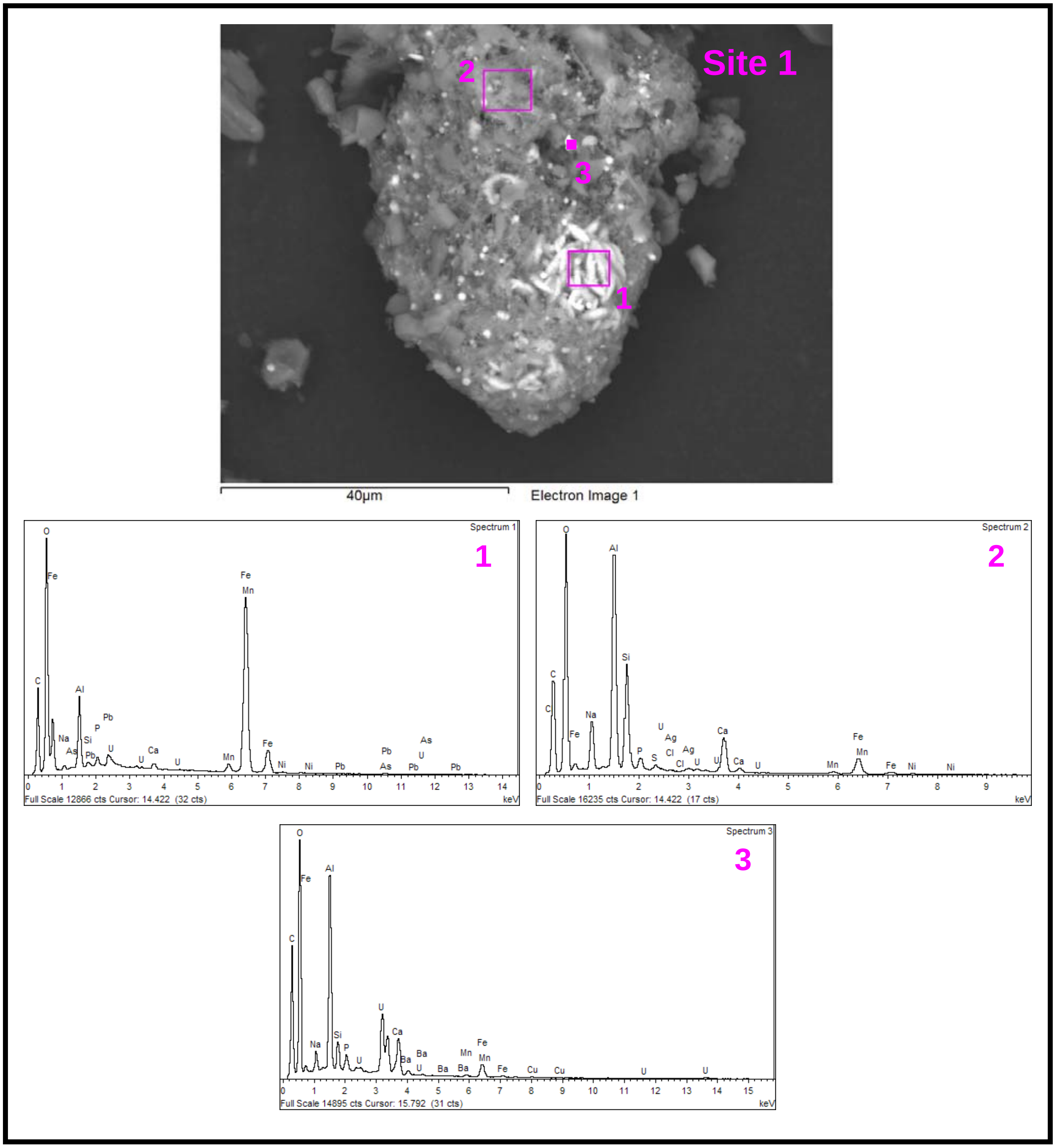

Figure D.38. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

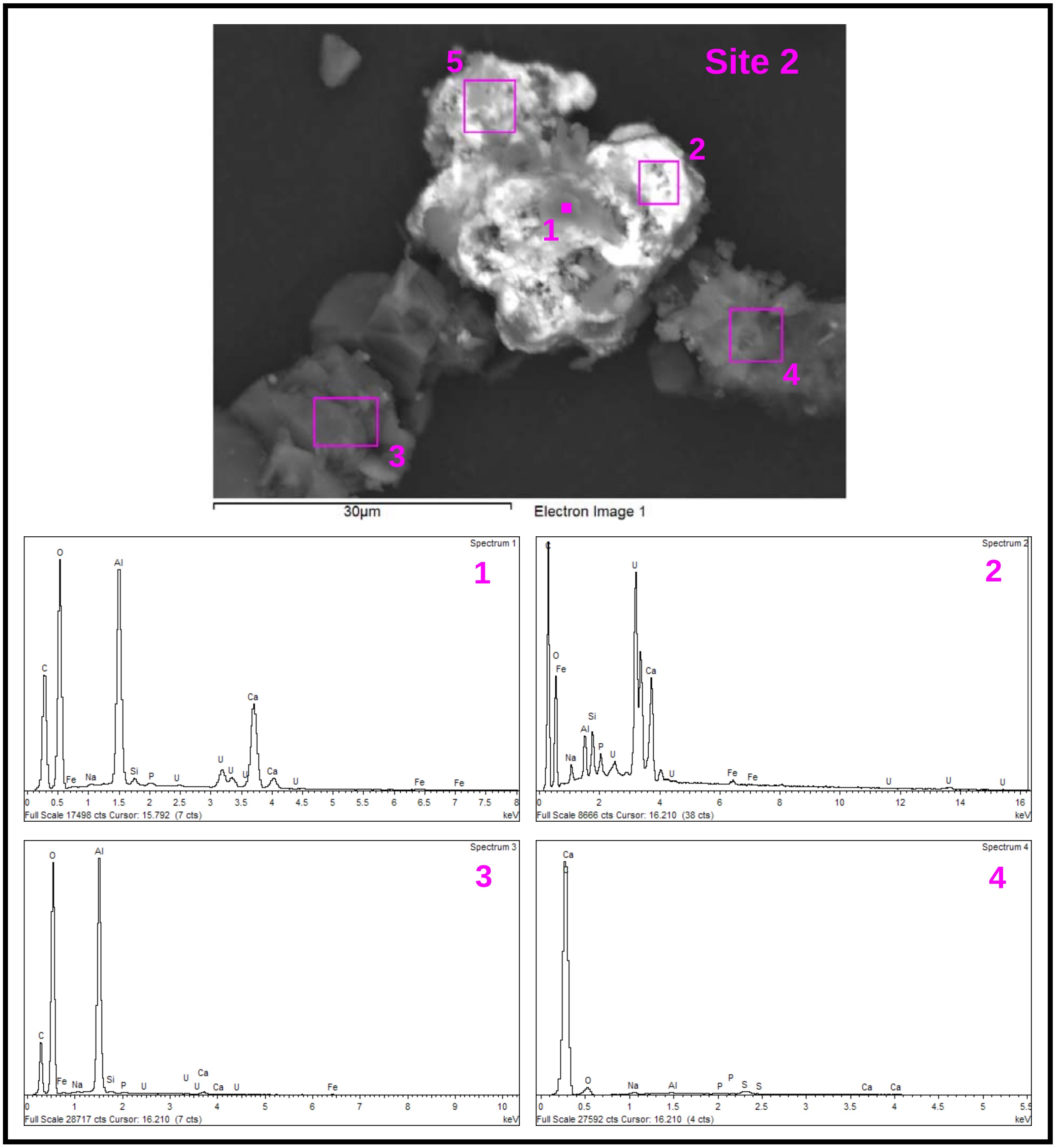

Figure D.39. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

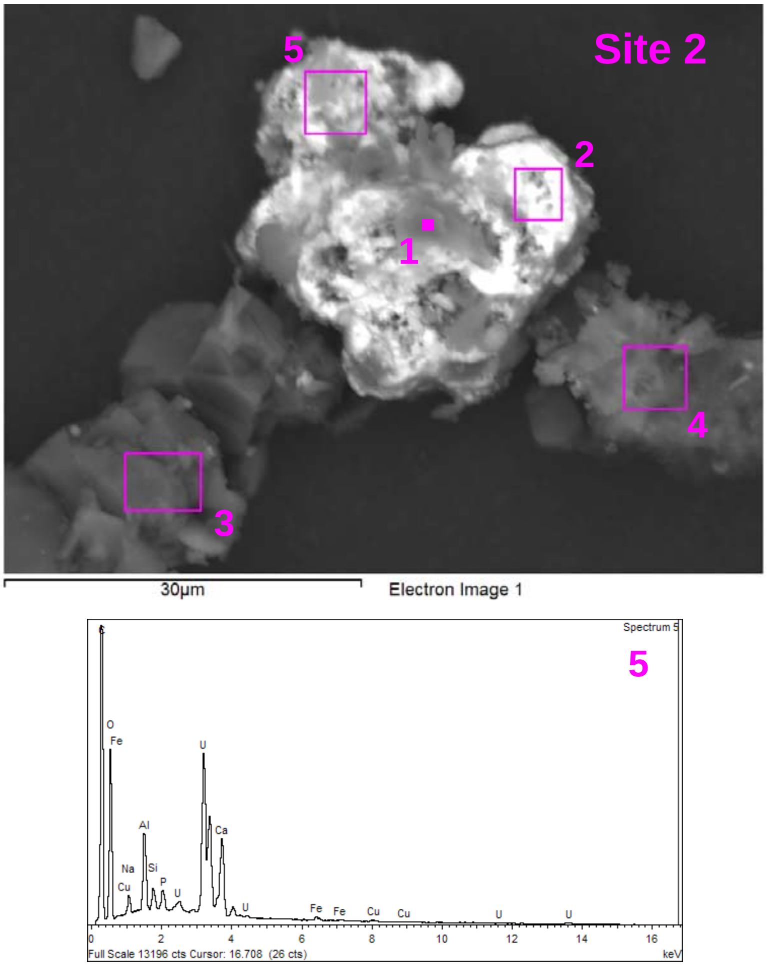

Figure D.40. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

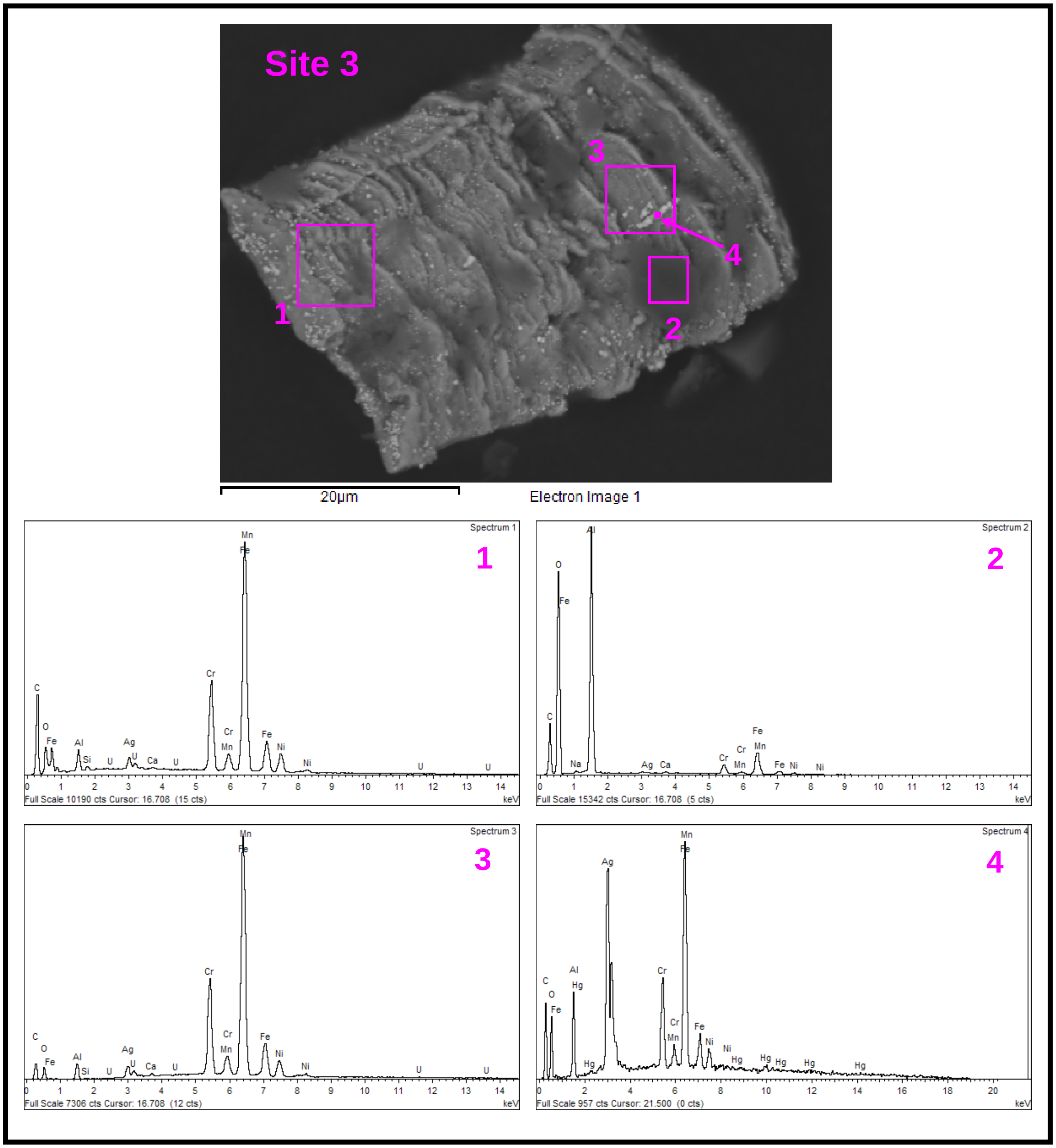

Figure D.41. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

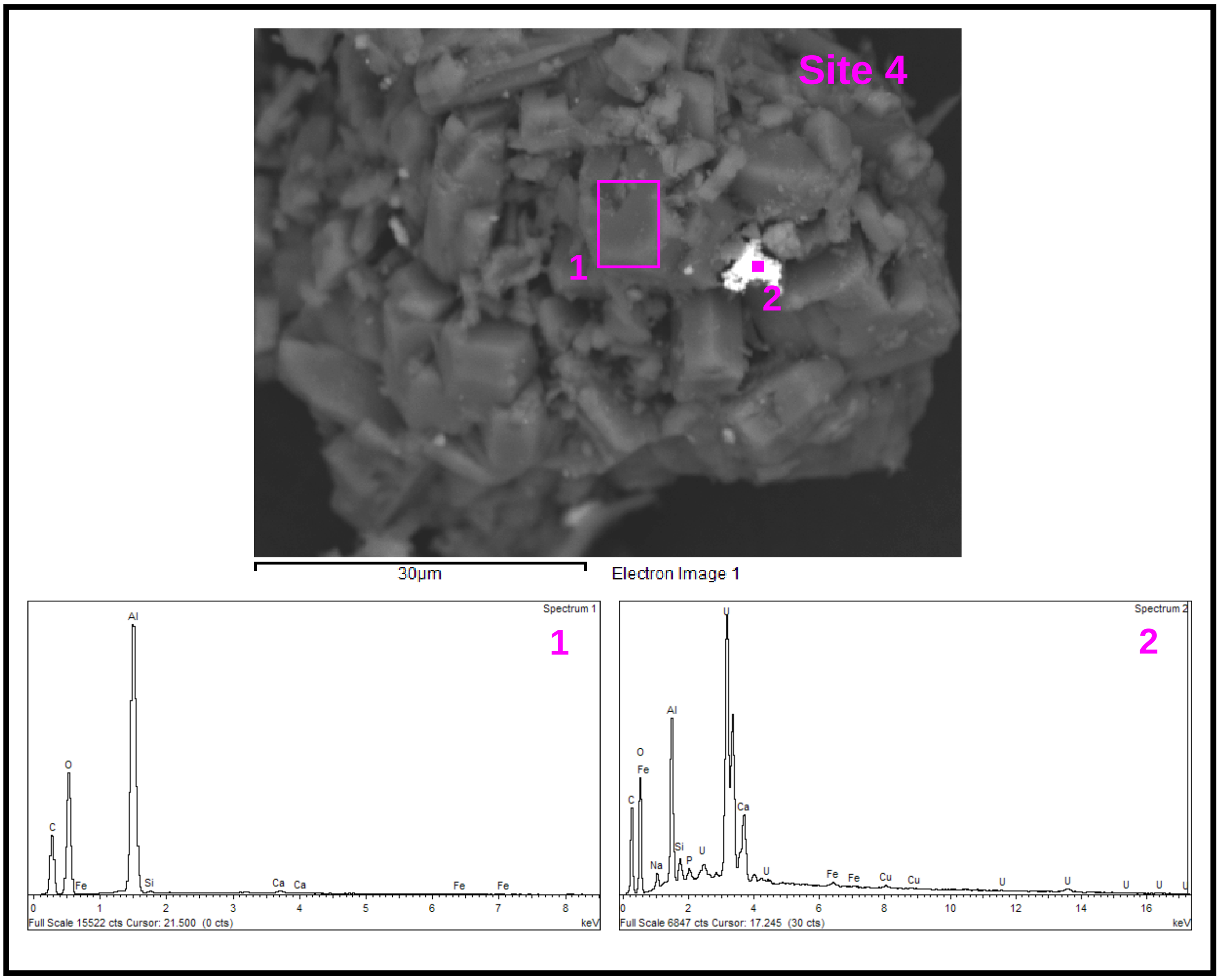

Figure D.42. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

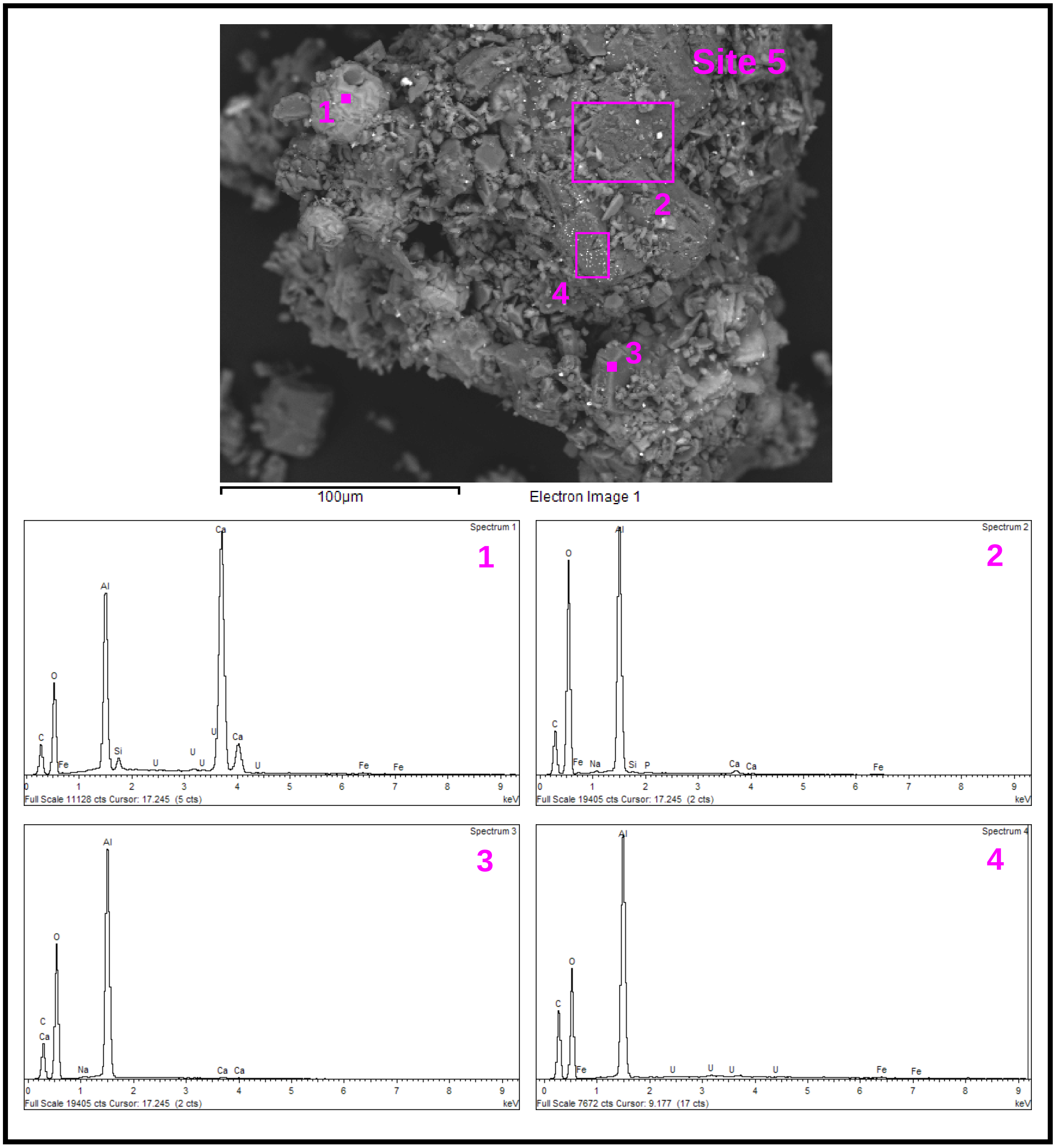

Figure D.43. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

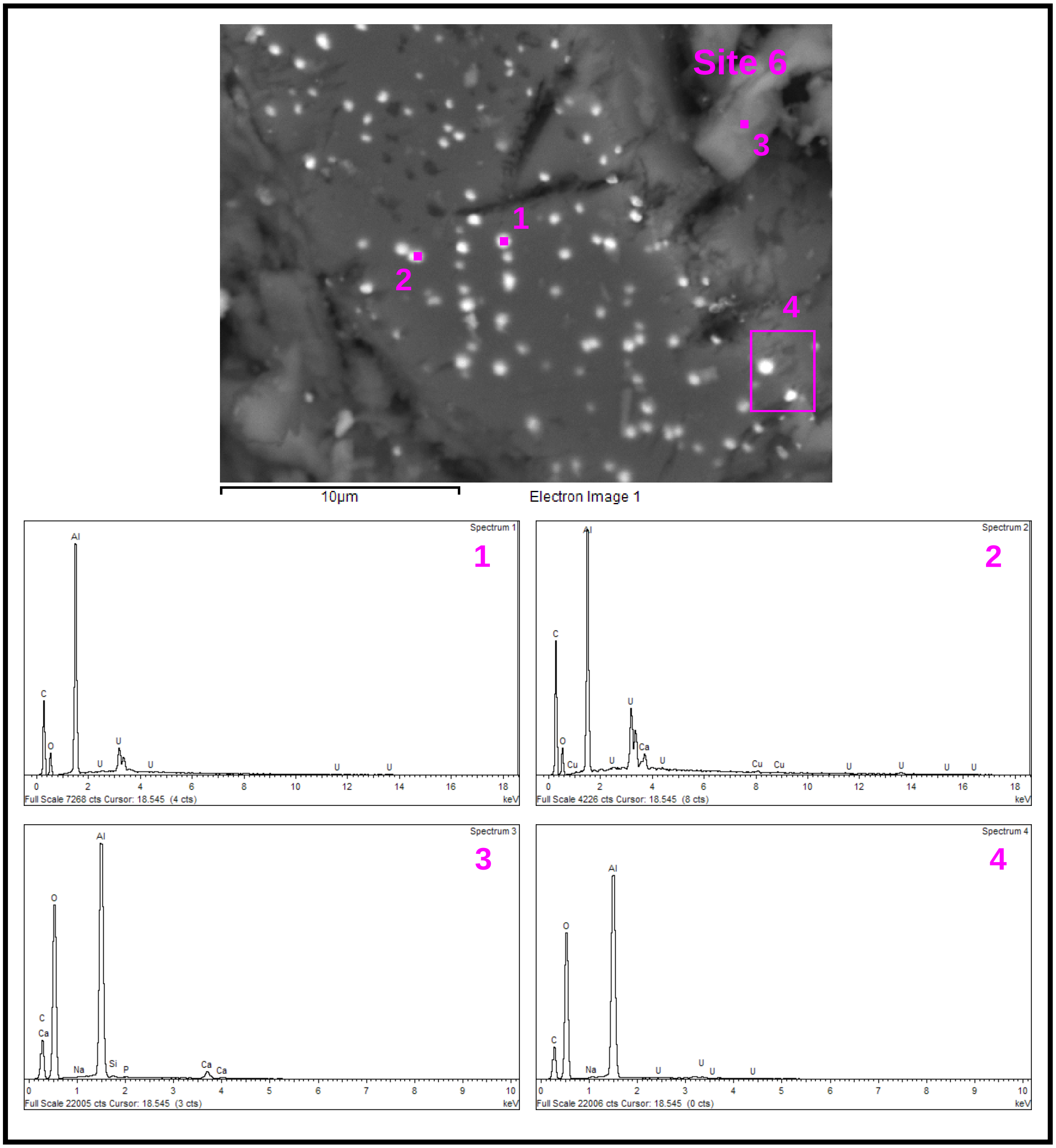

Figure D.44. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

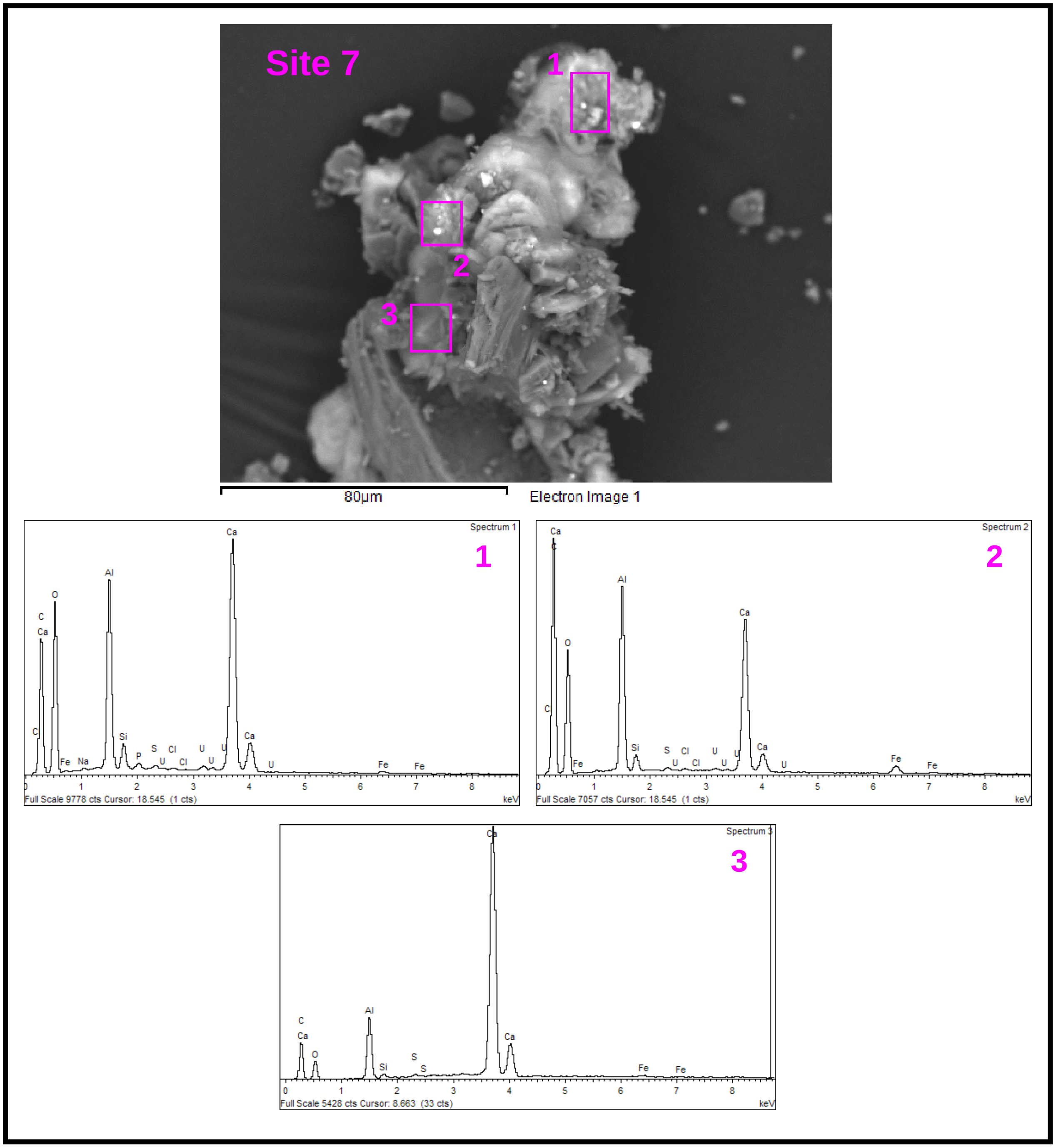

Figure D.45. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

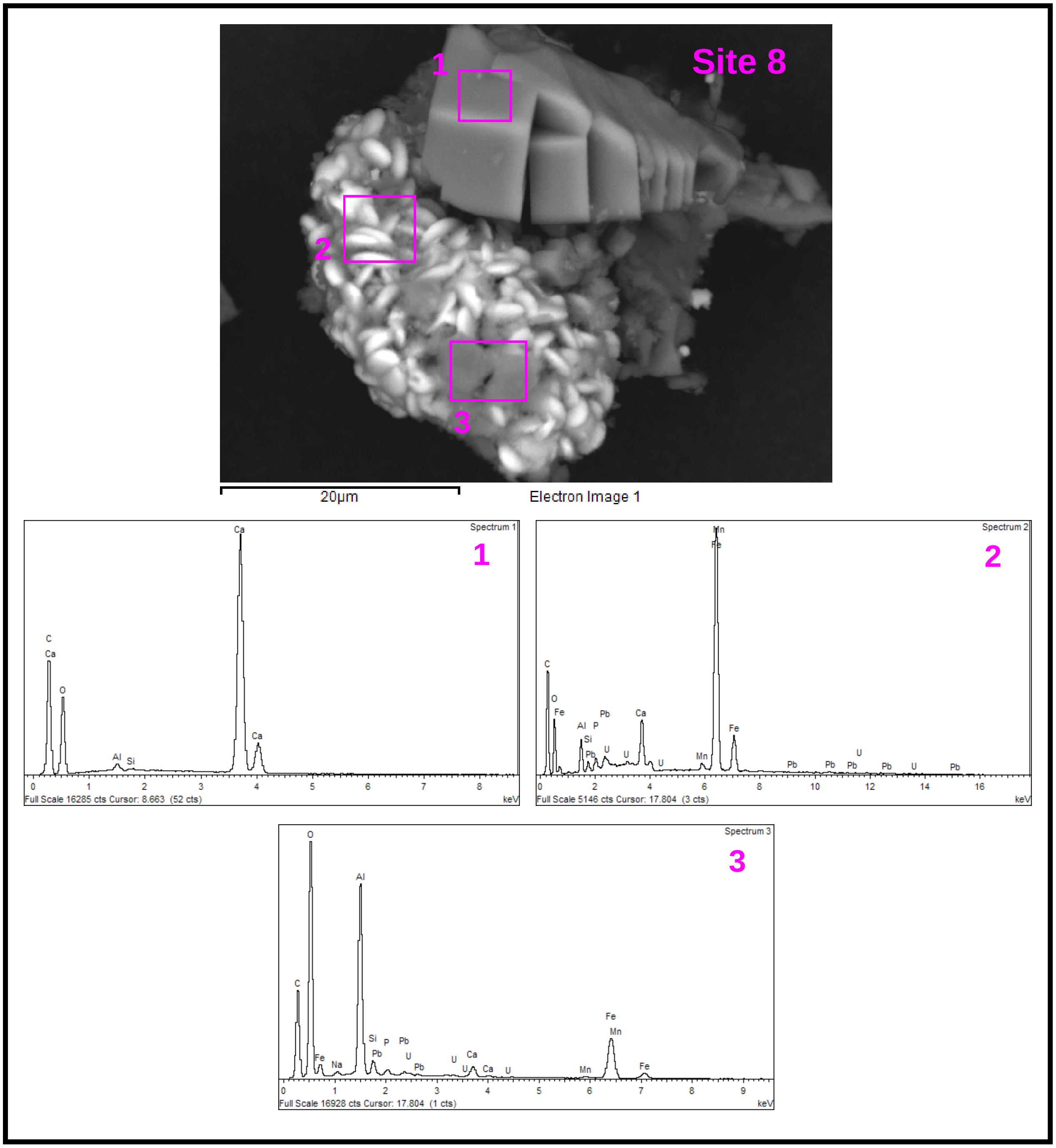

Figure D.46. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

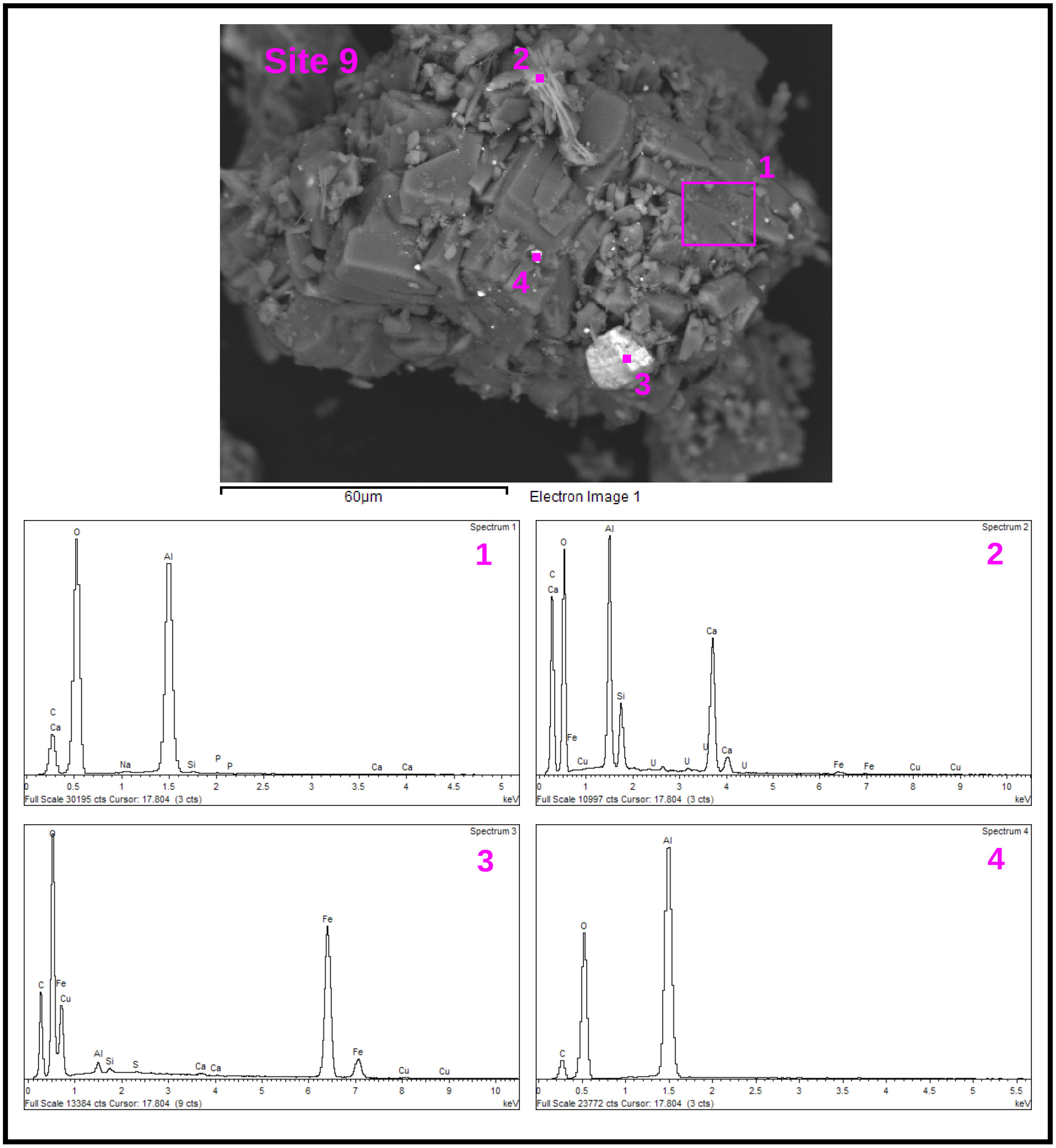

Figure D.47. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

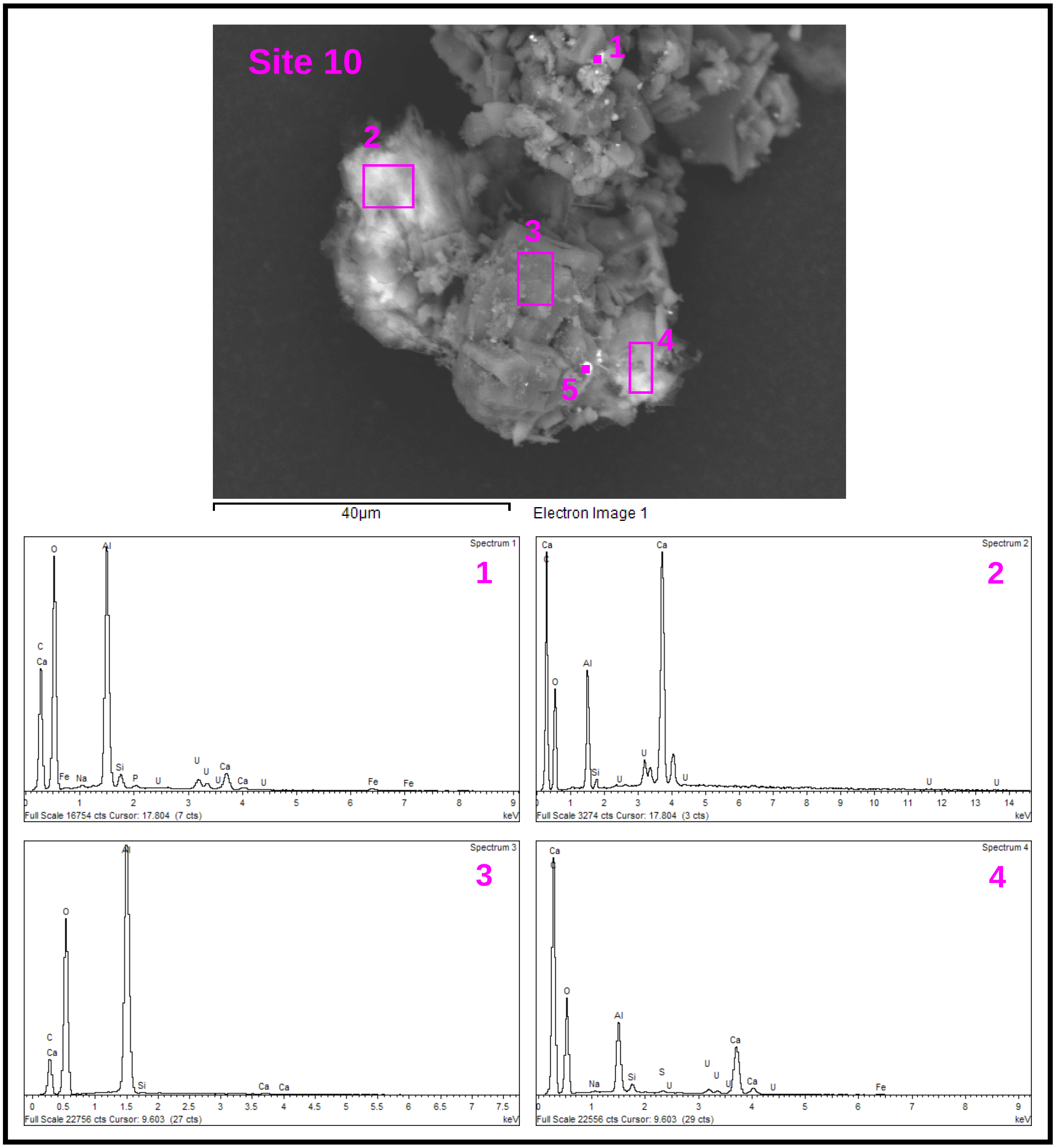

Figure D.48. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

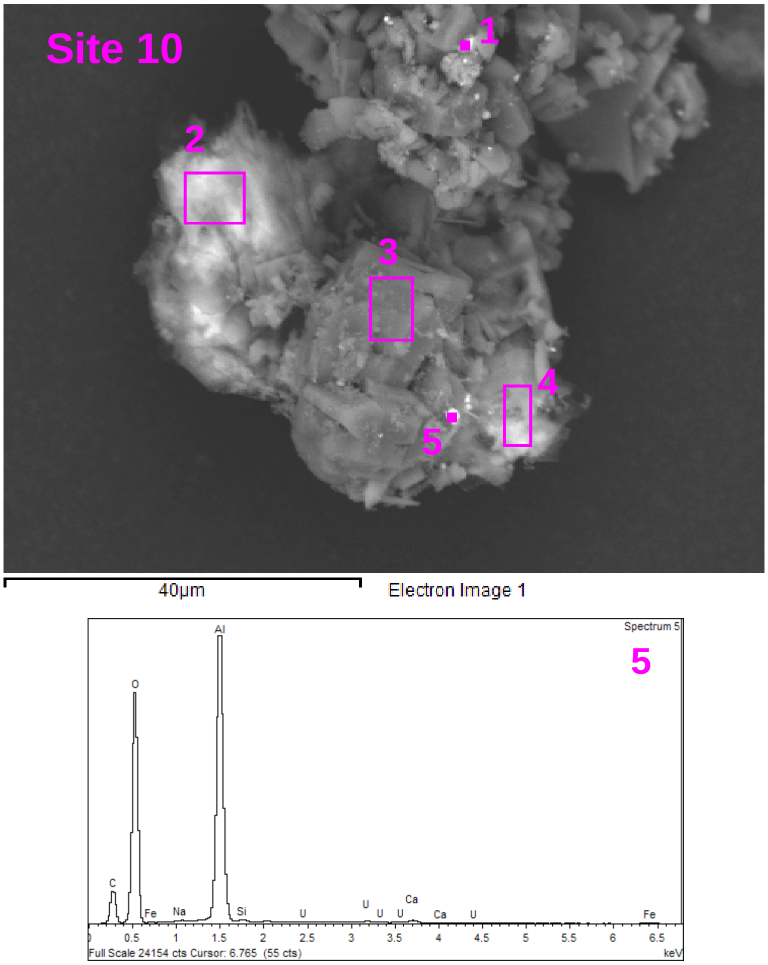

Figure D.49. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

Table D.4. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.38/1	1	7.0	0.4	0.9	0.5	0.7	46.1					38.9	0.9	As (0.1), Mn (1.6), Ni (0.4), Pb (2.4)
	2	16.4	9.1	6.3	3.8	0.5	4.5			0.7		56.1	1.2	Cl (0.1), Mn (0.6), Ni (0.4), S(0.4)
	3	14.7	2.2	2.5	3.5	18.2	3.3					53.0	1.4	Ba (0.3), Cu (0.3), Mn (0.5)
D.39 and D.40/2	1	17.4	0.6	0.3	9.6	6.1	0.2					65.5	0.3	
	2	2.9	2.8	1.9	8.8	49.5	0.7					31.9	1.4	
	3	29.0	0.2	0.2	0.4	0.4	0.2					69.4	0.2	
	4	3.1		12.7	2.3							68.2	2.7	S (11.0)
	5	5.3	1.4	2.1	6.7	39.6	0.6					42.5	1.4	Cu (0.5)
D.41/3	1	2.8	0.4		0.2	0.6	62.8	15.8		2.5		5.0		Mn (1.6), Ni (8.3)
	2	28.9		0.4	0.3		9.8	2.9		0.4		56.1		Mn (0.3), Ni (1.0)
	3	2.0	0.1		0.2	0.6	66.4	16.6		2.5		2.5		Mn (1.8), Ni (7.3)
	4	5.4					36.6	10.3		26.6	0.4	14.6		Mn (1.3), Ni (4.8)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.5. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.42/4	1	40.6	0.5		0.4		0.4					58.0		
	2	9.8	1.3	1.4	4.7	54.0	0.5					27.0	0.6	Cu (0.6)
D.43/5	1	15.2	1.0		28.5	0.8	0.2					54.4		
	2	30.7	0.2	0.4	0.6		0.4					67.5	0.2	
	3	37.1		0.3	0.2							62.3		
	4	40.5				1.6	0.7					57.1		
D.44/6	1	51.1				25.9						23.0		
	2	37.7			2.9	39.6						18.4		Cu (1.4)
	3	31.8	0.3	0.3	1.5							66.0	0.1	
	4	33.6		0.3		1.5						64.5		
D.45/7	1	12.5	1.8	0.3	21.4	1.4	0.5					61.4	0.5	Cl (0.1), S (0.2)
	2	16.8	1.7		19.0	1.2	2.9					57.9		Cl (0.1), S (0.3)
	3	9.6	0.7		54.2		0.8					34.4		S (0.3)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.6. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.46/8	1	0.7	0.2		35.6							63.5		
	2	4.0	1.0		4.9	1.4	69.3					14.1	1.1	Mn (1.4), Pb (2.8)
	3	20.3	1.7	1.0	1.4	0.5	15.3					57.6	0.7	Mn (0.4), Pb (1.2)
D.47/9	1	27.9	0.3	0.3	0.1							71.3	0.2	
	2	15.6	5.1		13.2	0.9	0.6					64.3		Cu (0.3)
	3	1.4	0.5		0.2		52.6					44.7		Cu (0.4), S (0.2)
	4	36.5										63.5		
D.48 and D.49/10	1	24.0	1.8	0.5	2.4	4.6	0.7					65.6	0.4	
	2	9.8	0.8		27.0	9.0						53.3		
	3	34.3	0.2		0.2							65.4		
	4	13.2	1.5	0.6	12.5	3.4	0.4					67.9		S (0.5)
	5	31.7	0.3	0.2	0.4	0.6	0.6					66.2		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

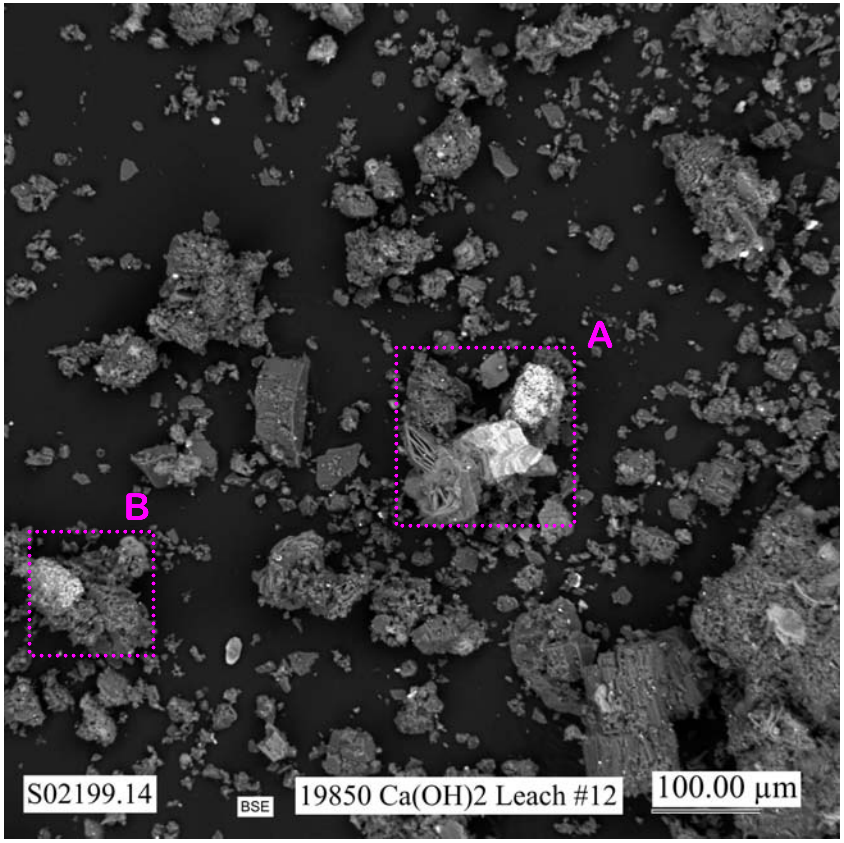

Figure D.50. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Long fiber on right side of micrograph is impurity introduced during preparation of the sample mount.)

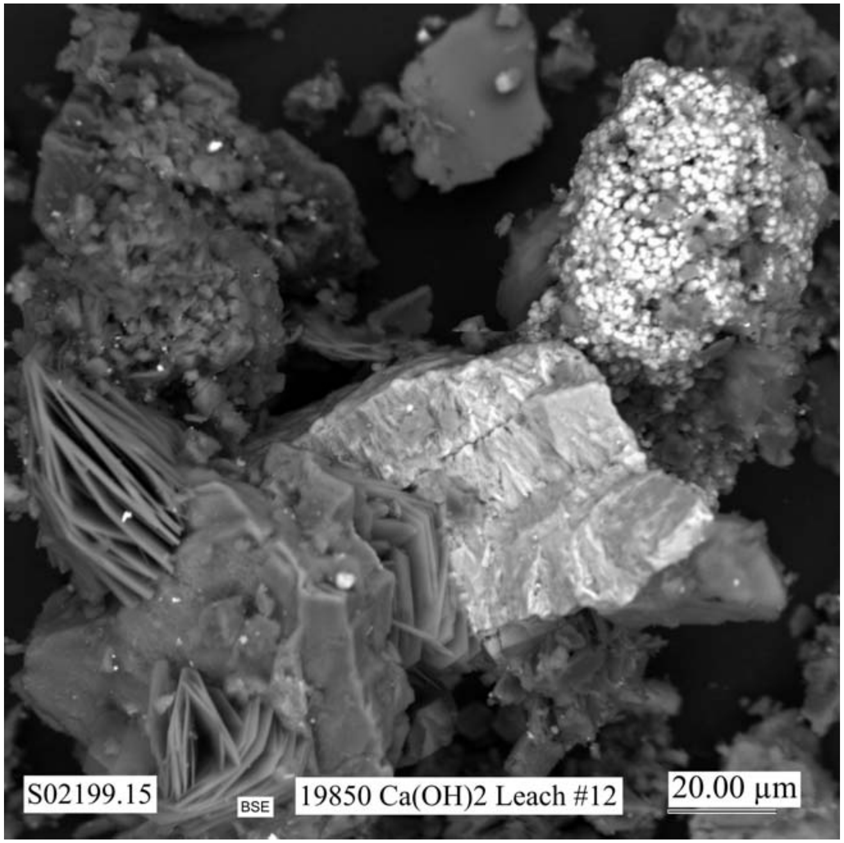

Figure D.51. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square A in Figure D.50 (Areas where EDS analyses were made are shown in Figures D.60 and D.61.)

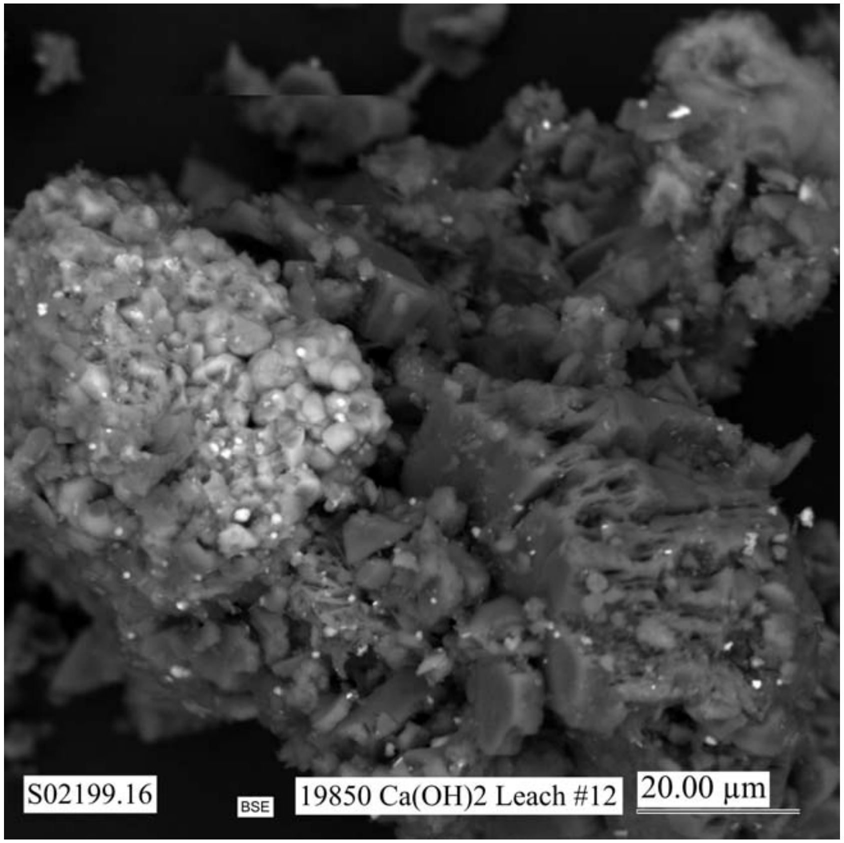

Figure D.52. Micrograph Showing at Higher Magnification the Particle Aggregates in the Area Indicated by the Pink Dotted-Line Square B in Figure D.50 (Areas where EDS analyses were made are shown in Figure D.62.)

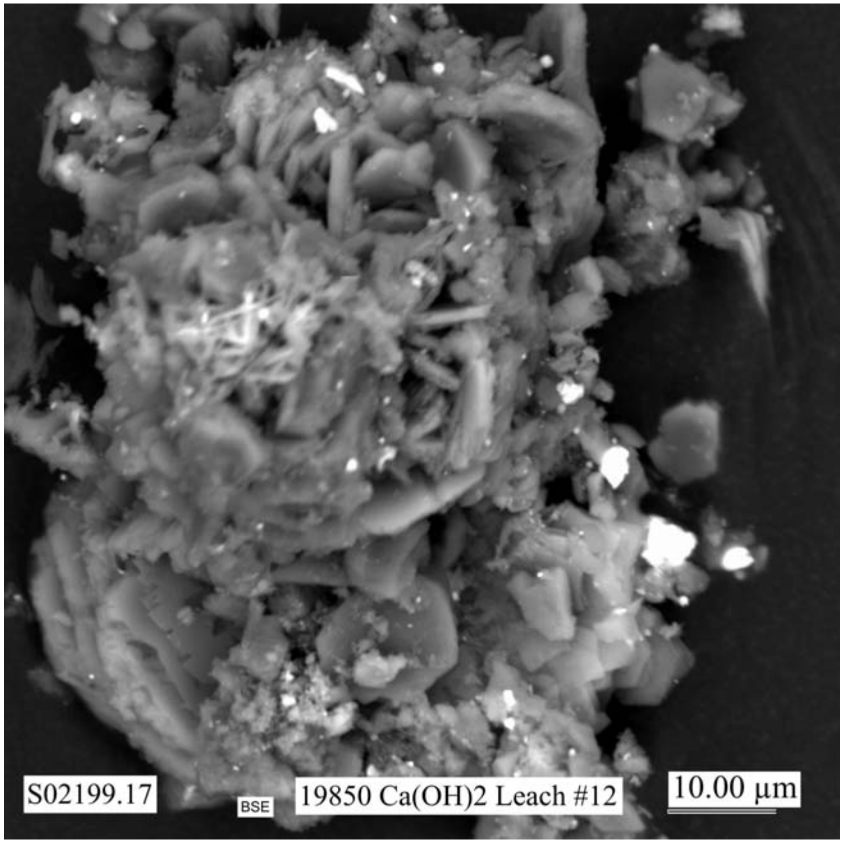

Figure D.53. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.63.)

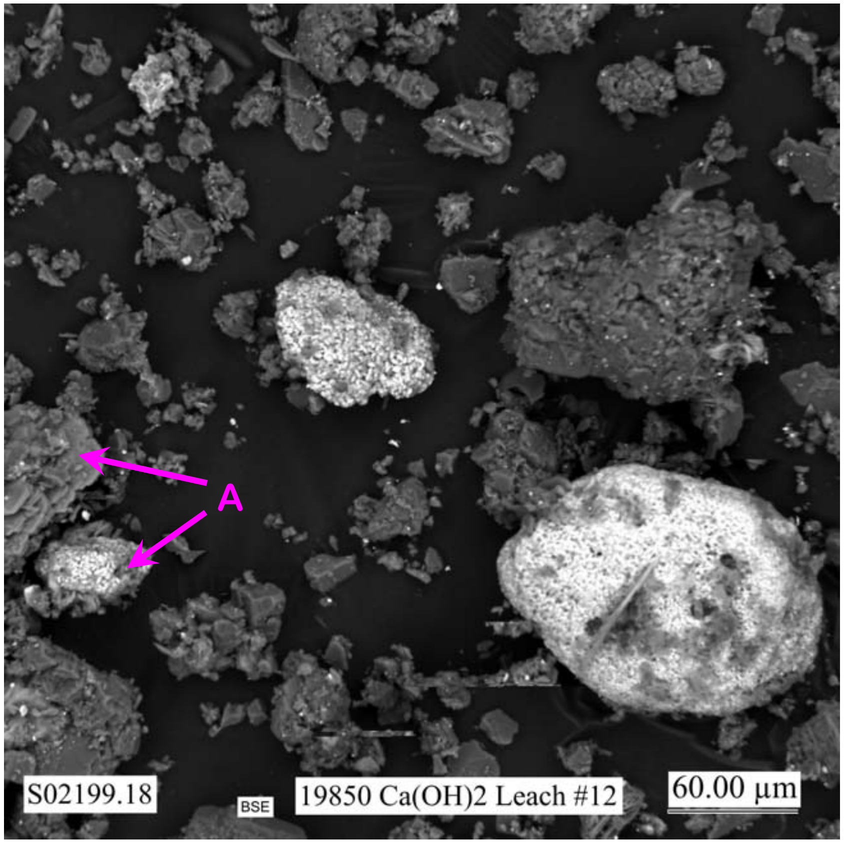

Figure D.54. Micrograph Showing Particle Aggregates in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.64 and D.65.)

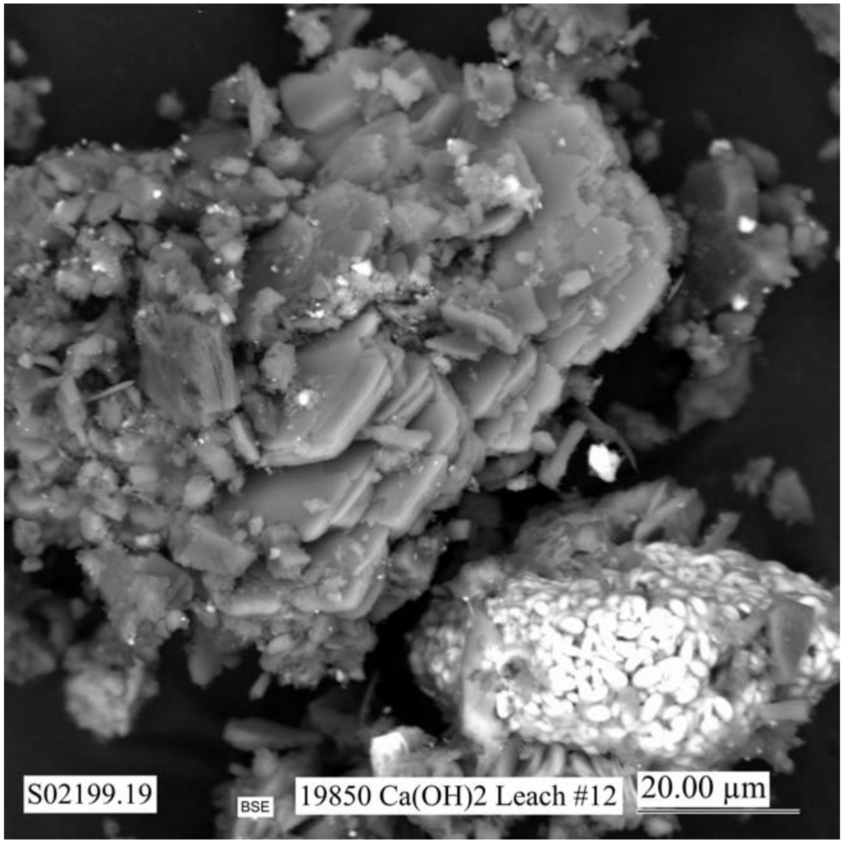

Figure D.55. Micrograph Showing at Higher Magnification the Particle Aggregates Labeled A in Figure D.54 (Areas where EDS analyses were made are shown in Figure D.66.)

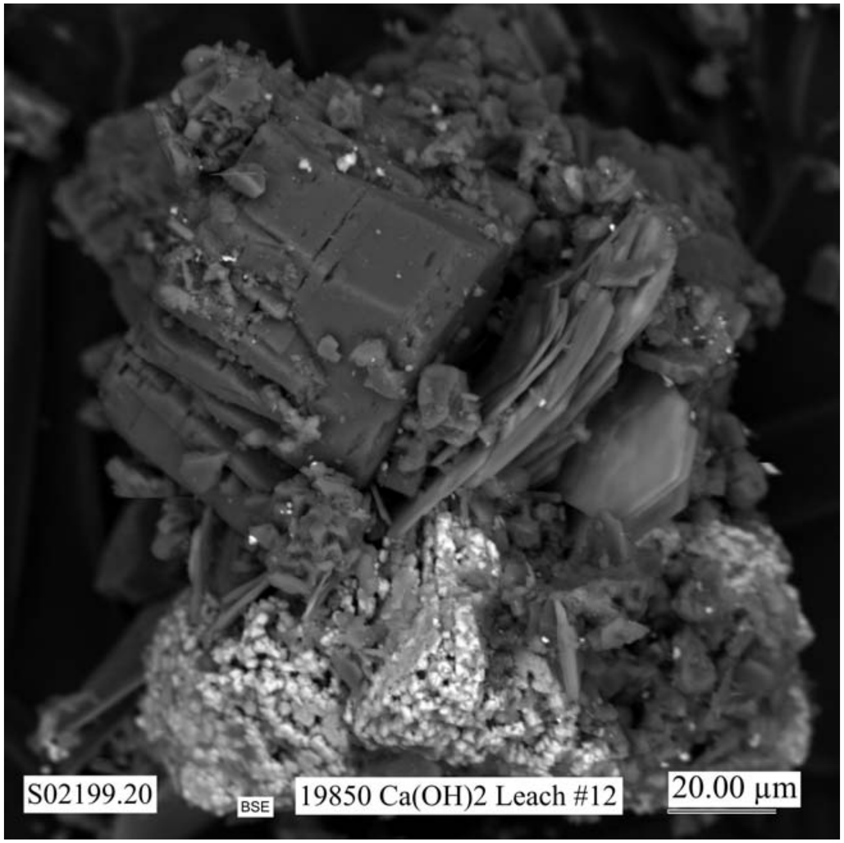

Figure D.56. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.67.)

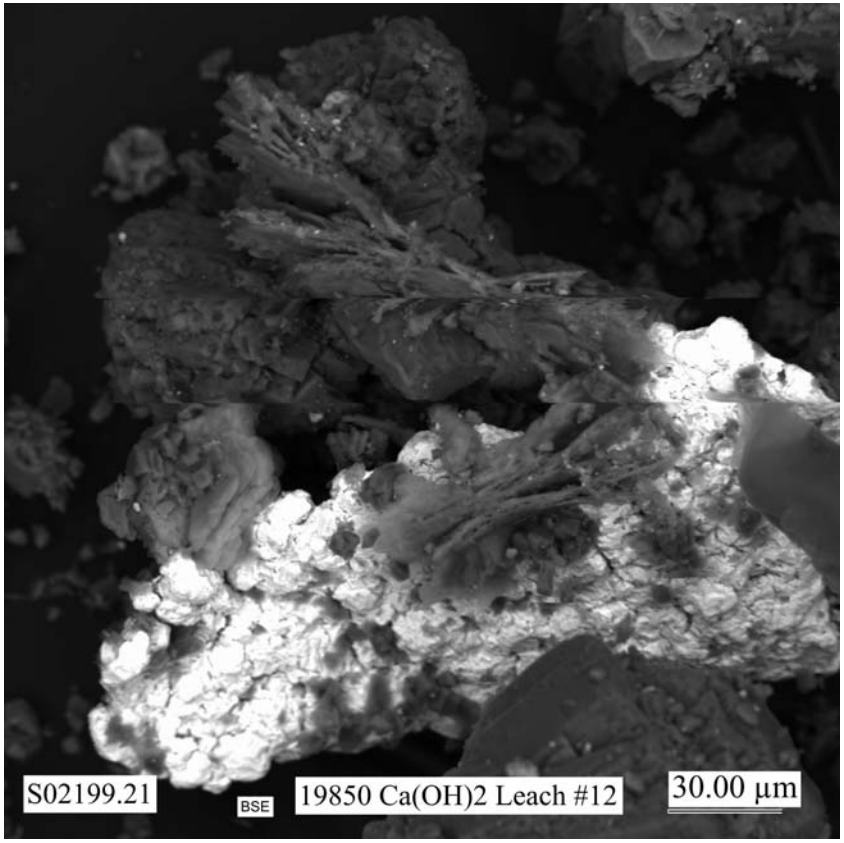

Figure D.57. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures D.68 and D.69.)

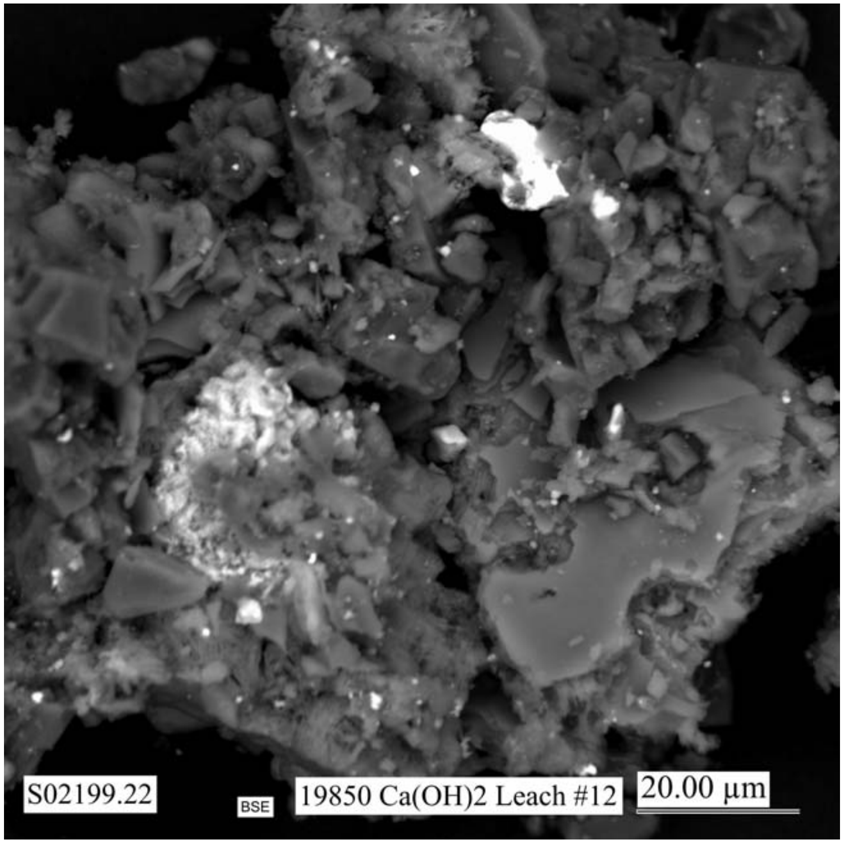

Figure D.58. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.70.)

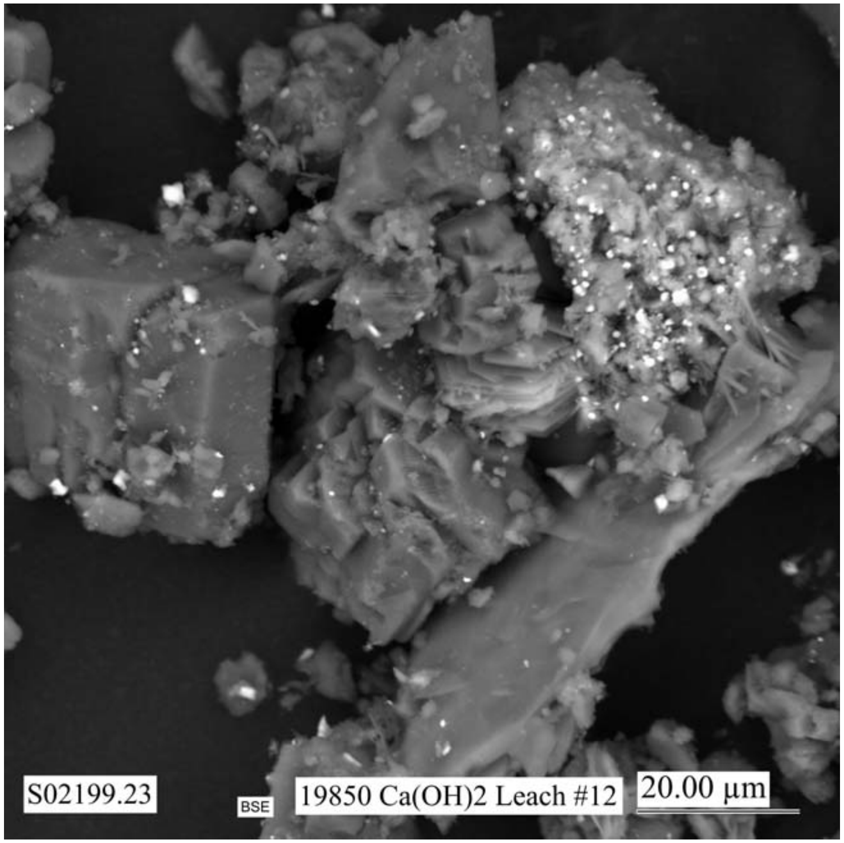

Figure D.59. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure D.71.)

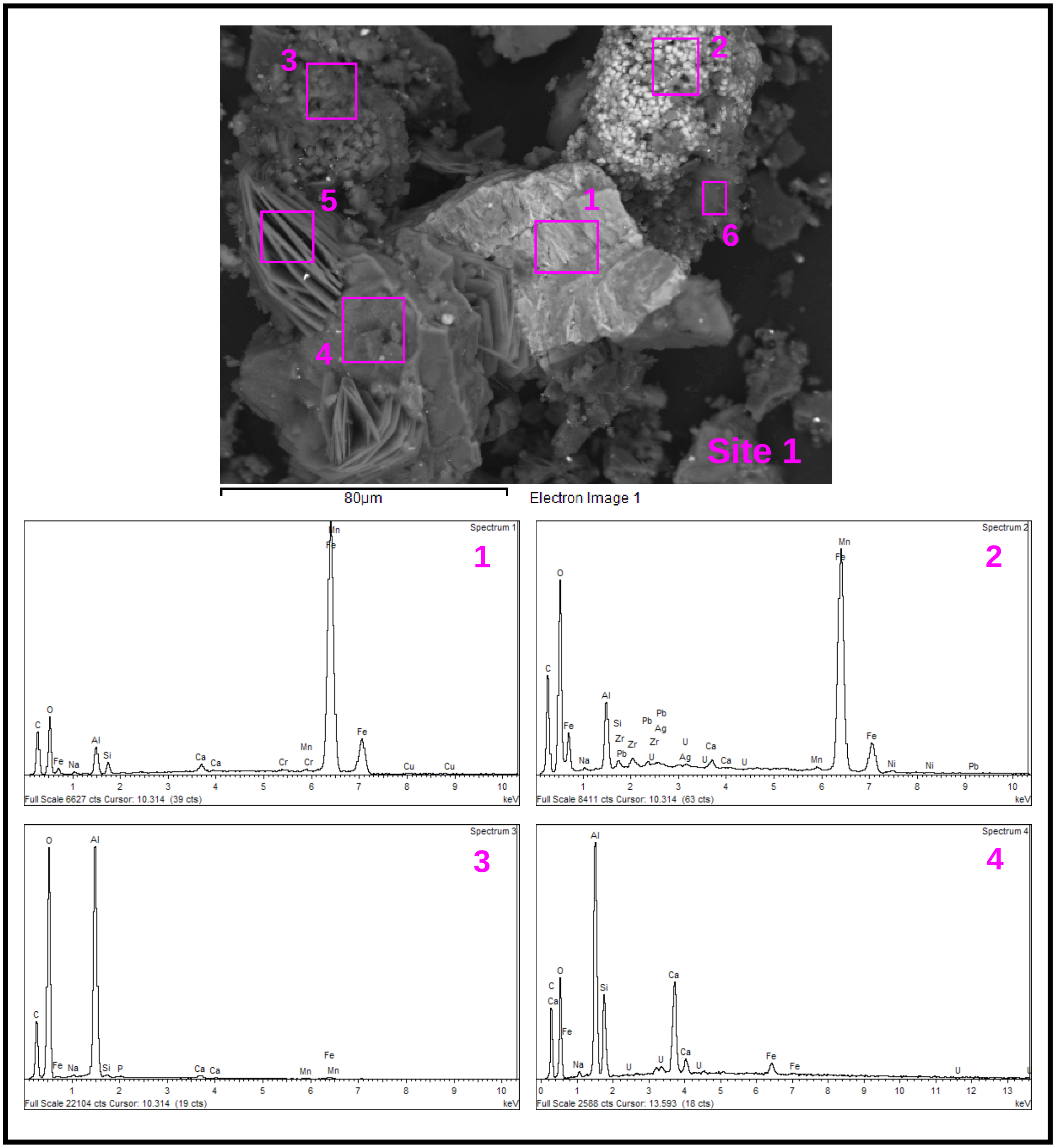

Figure D.60. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

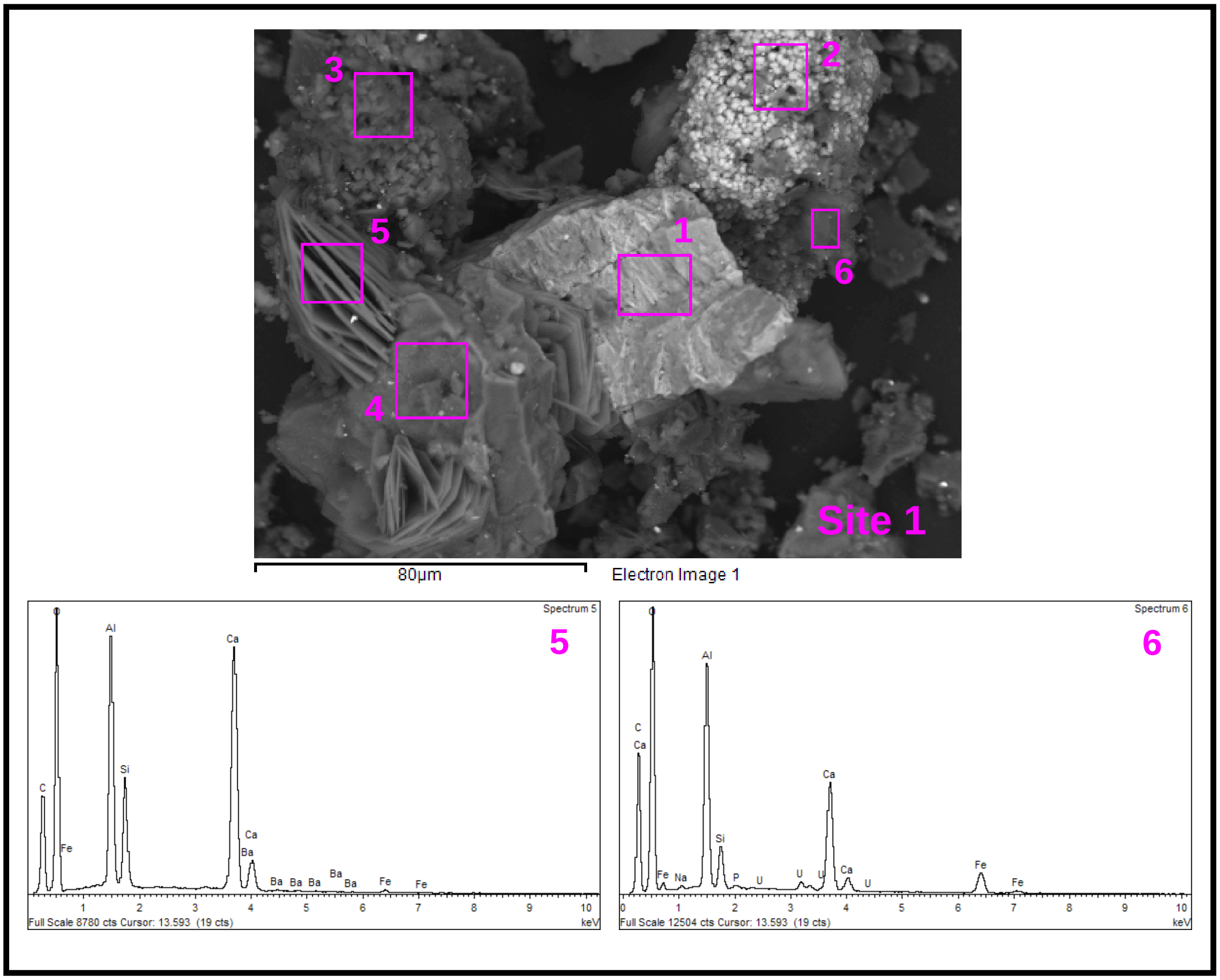

Figure D.61. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

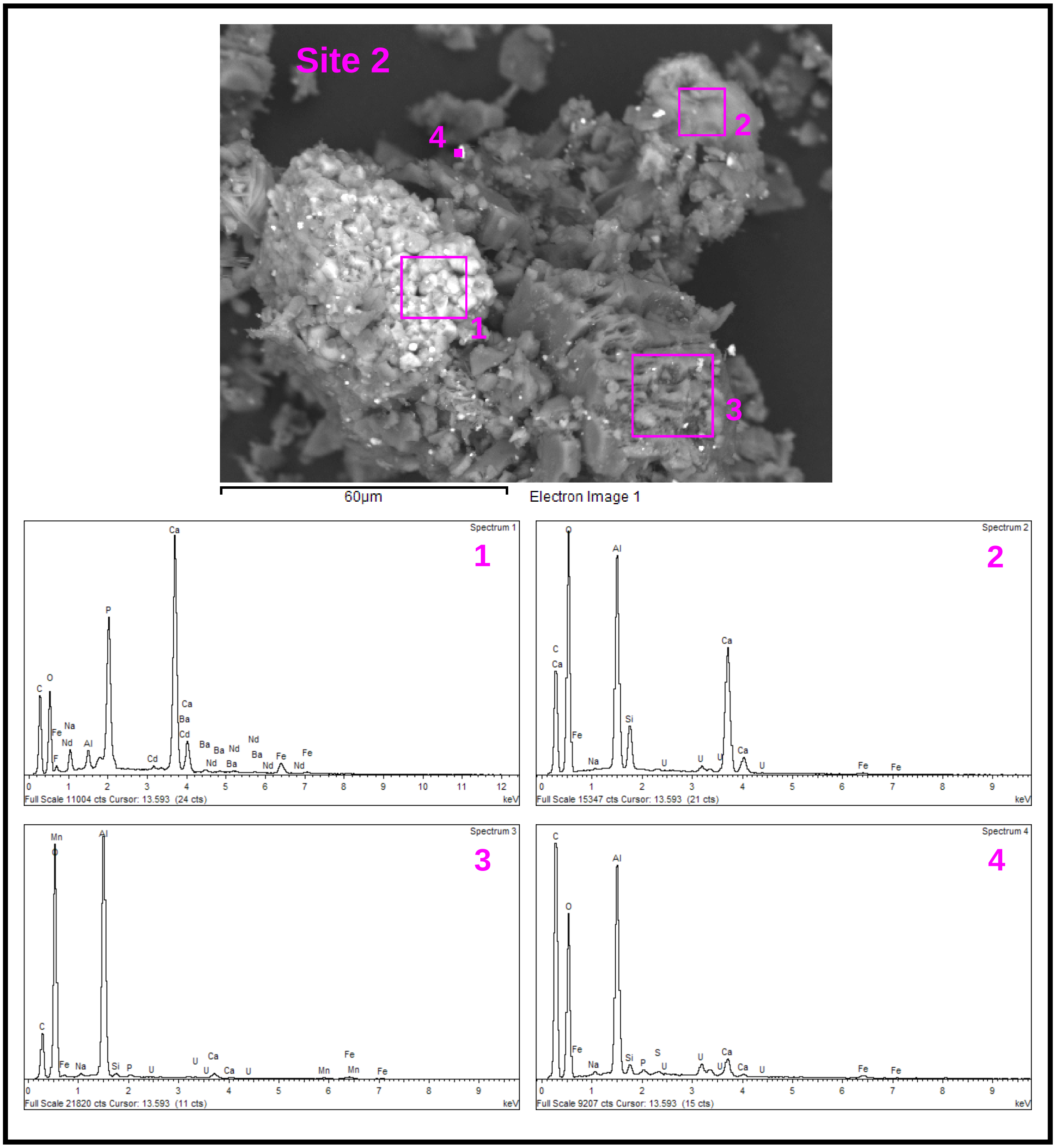

Figure D.62. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

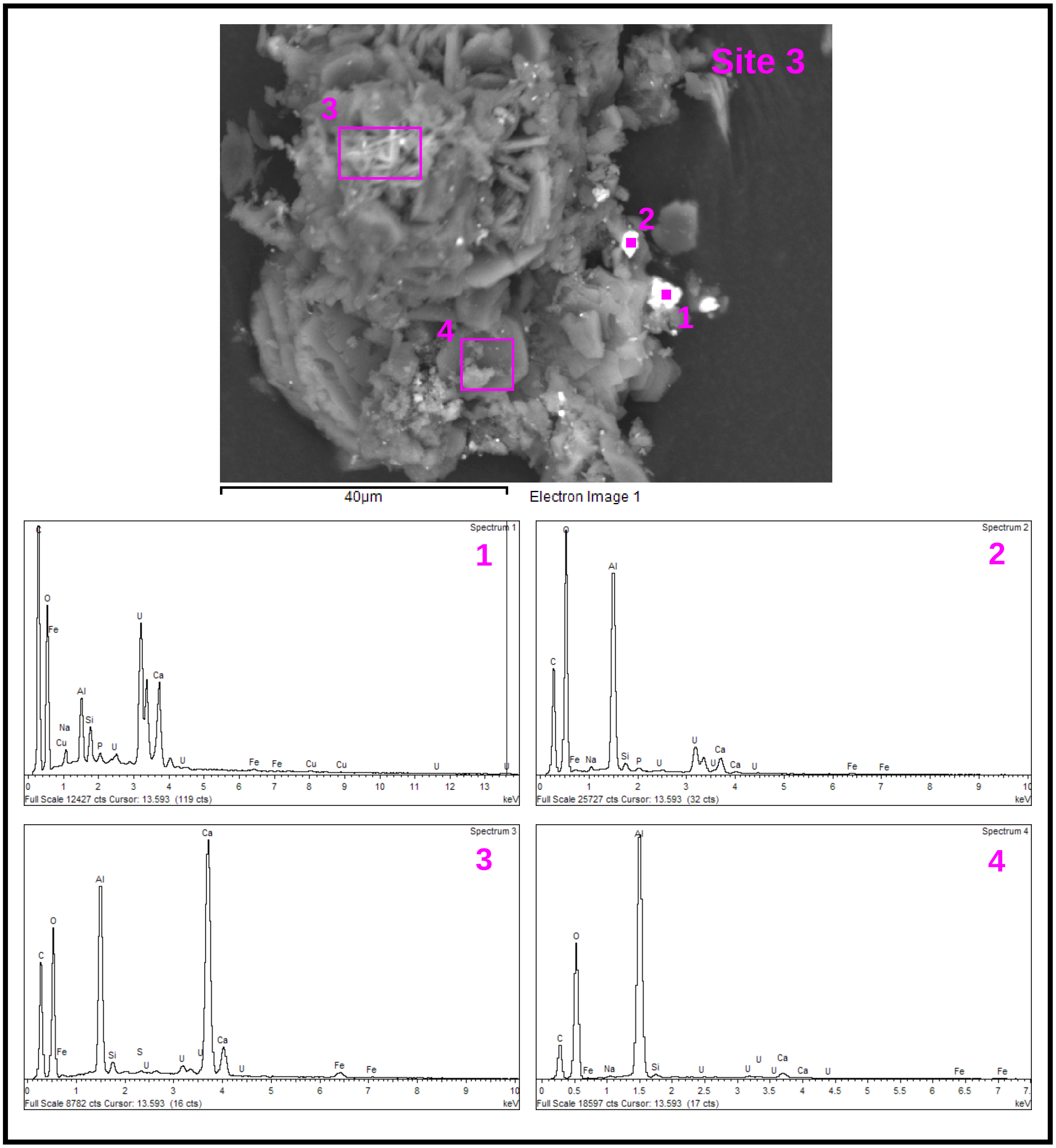

Figure D.63. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

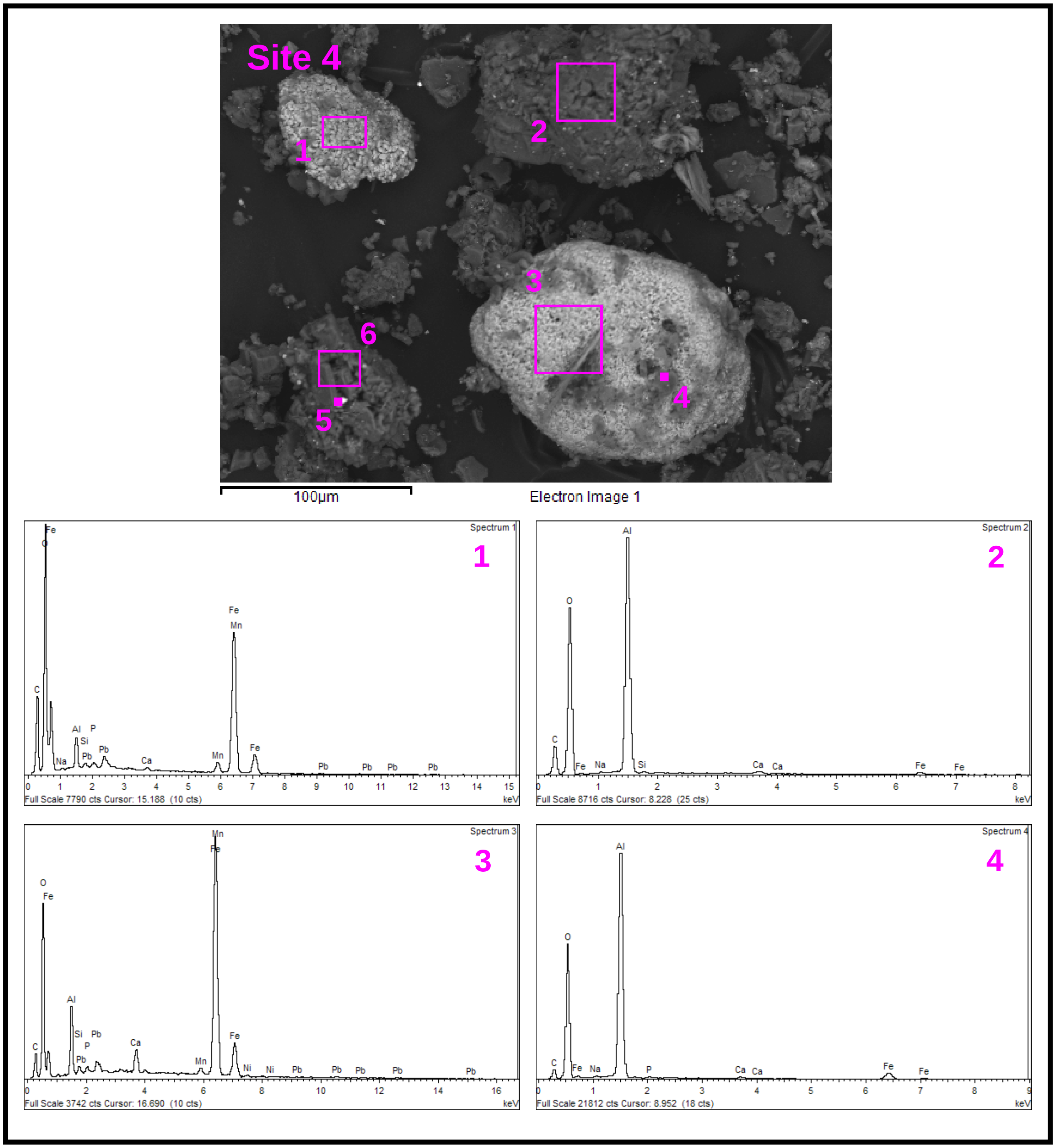

Figure D.64. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

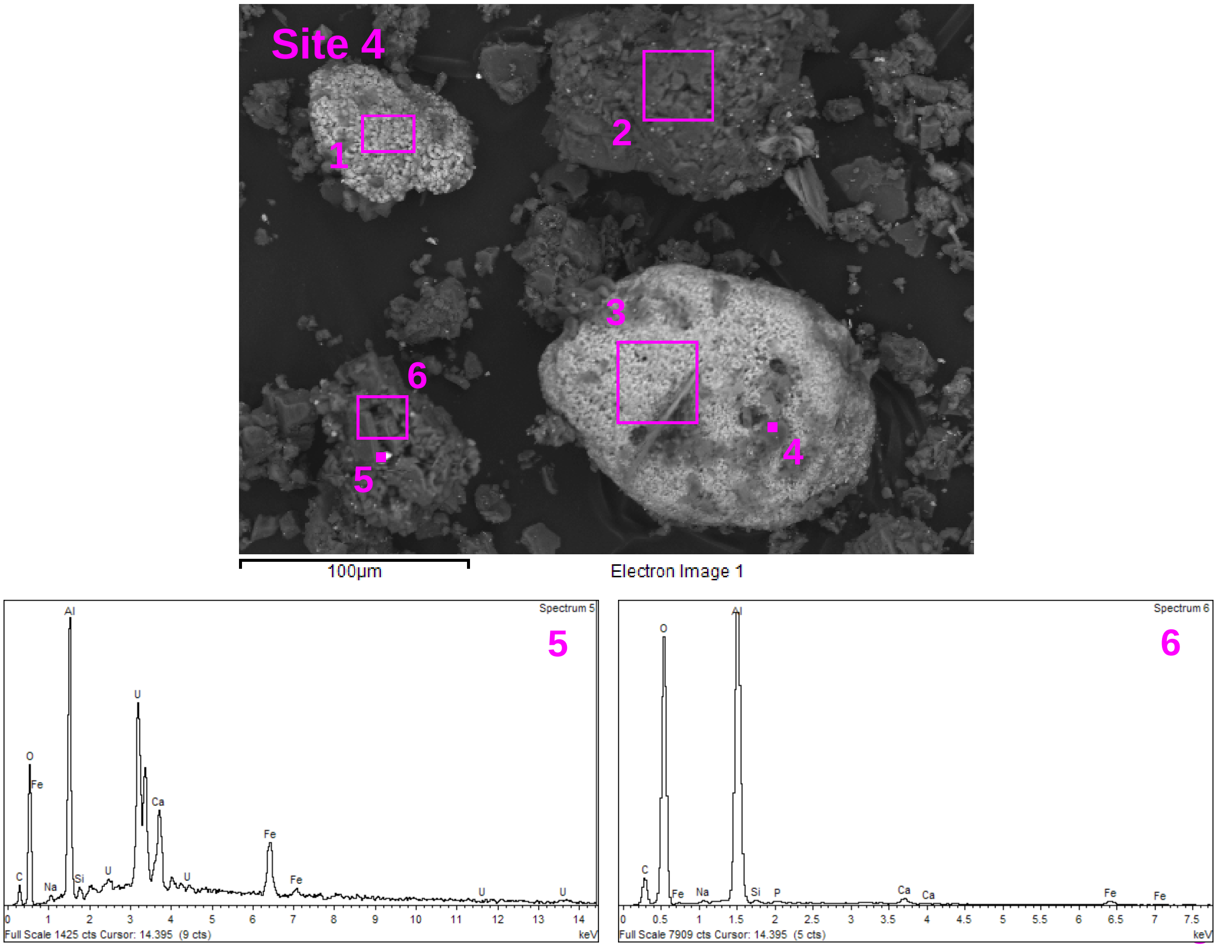

Figure D.65. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

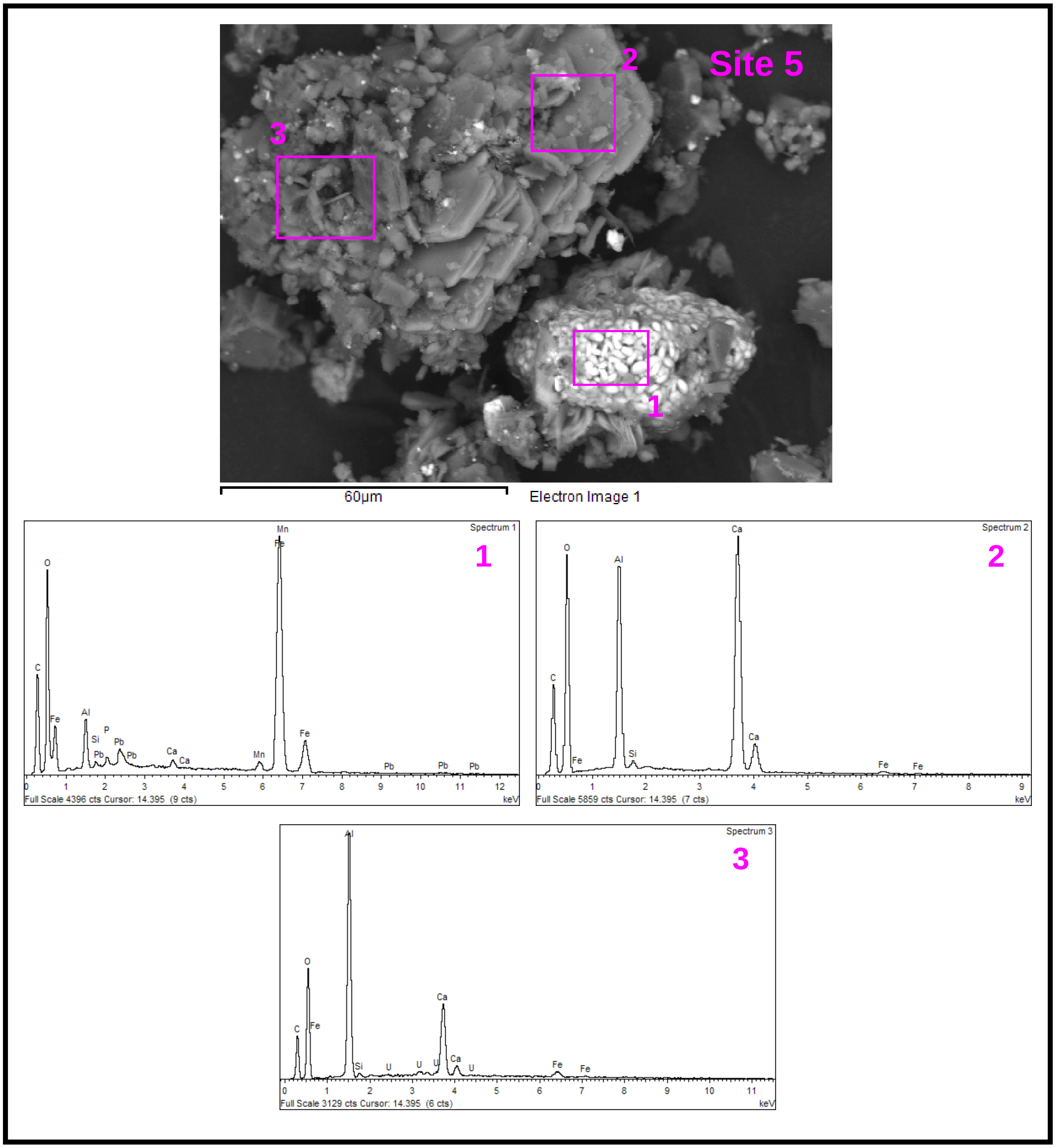

Figure D.66. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

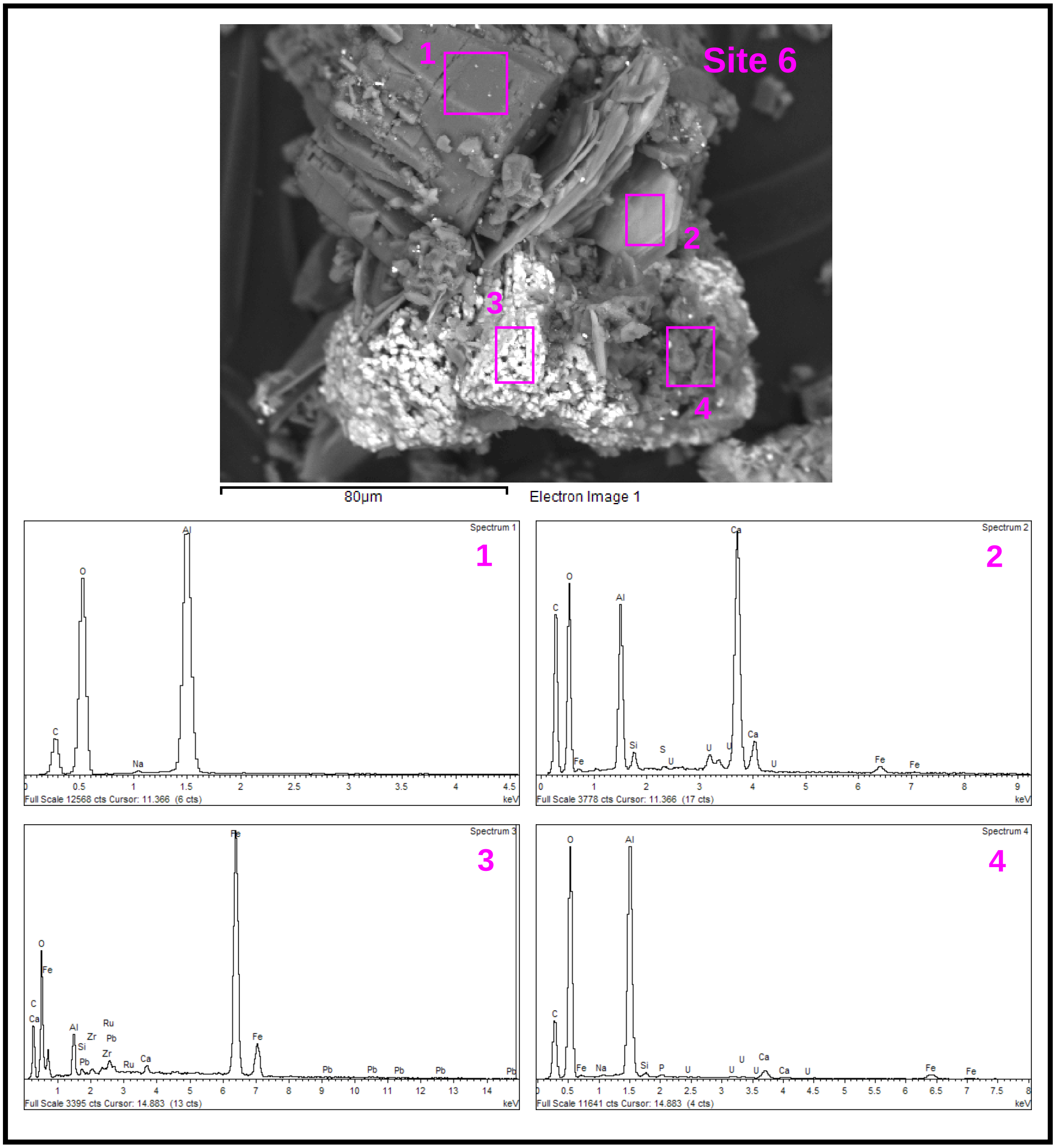

Figure D.67. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

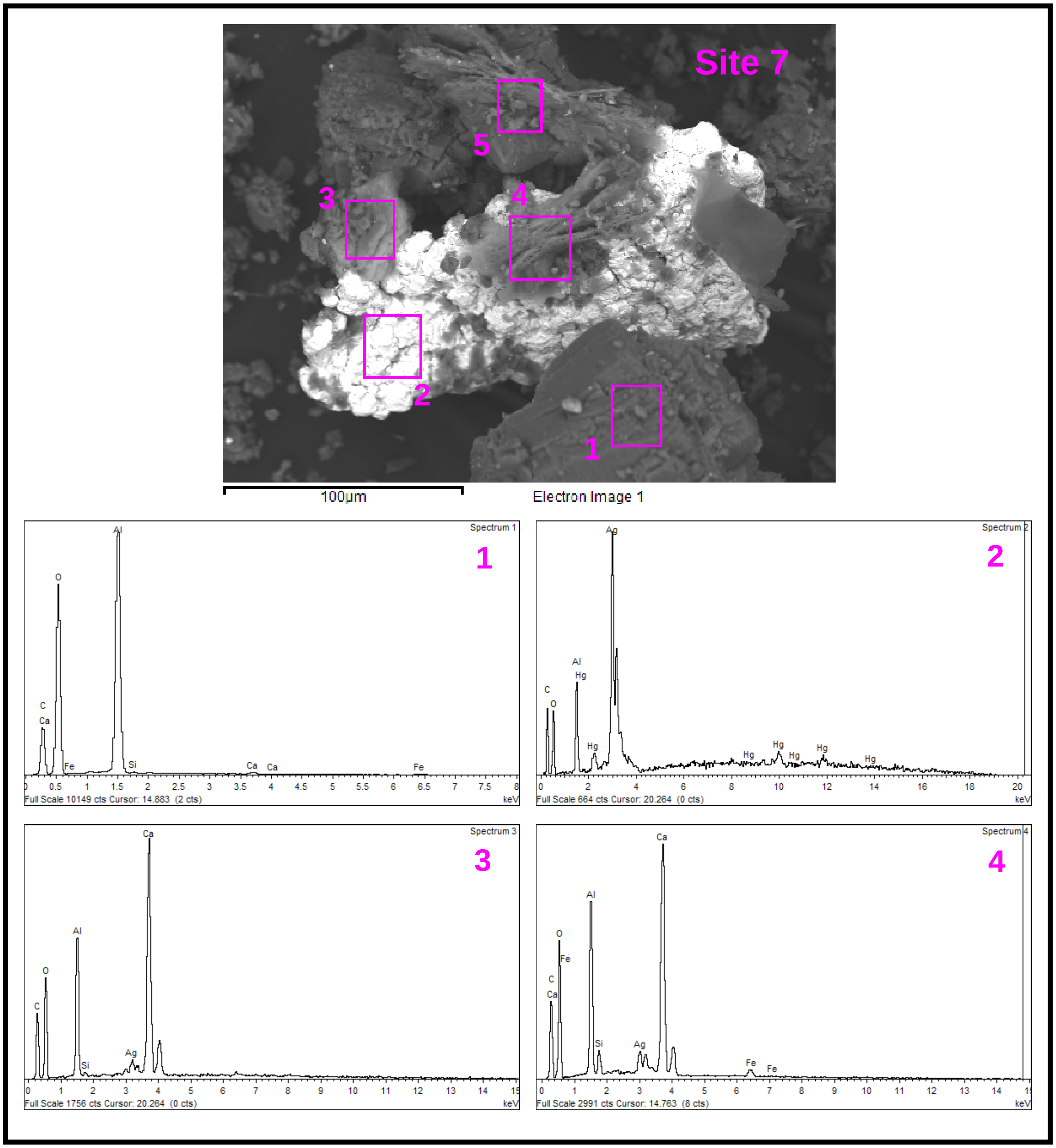

Figure D.68. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

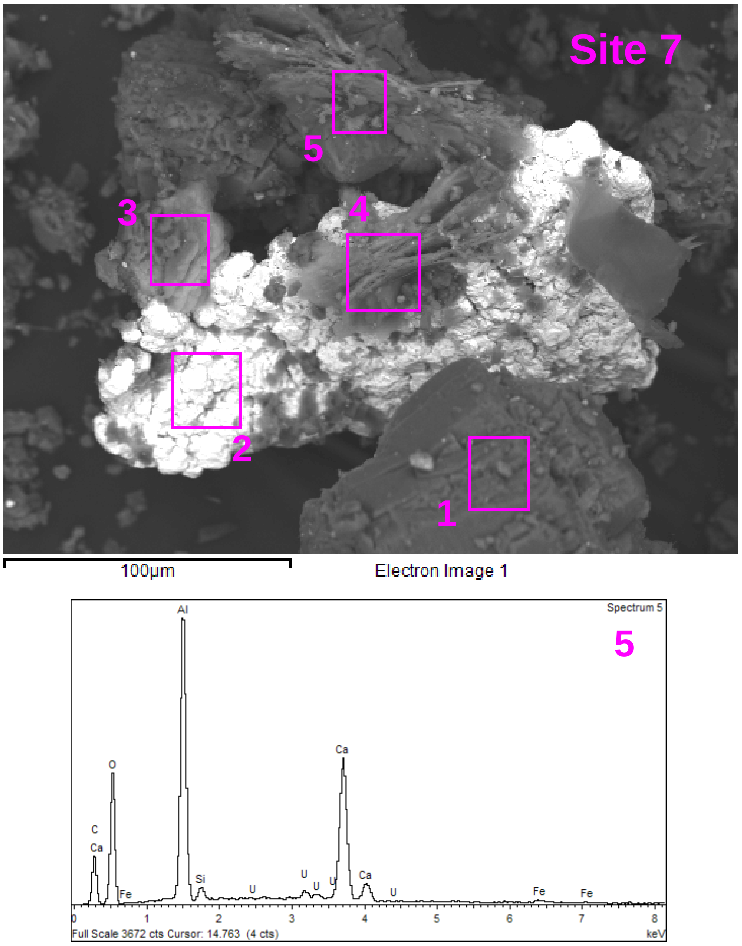

Figure D.69. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

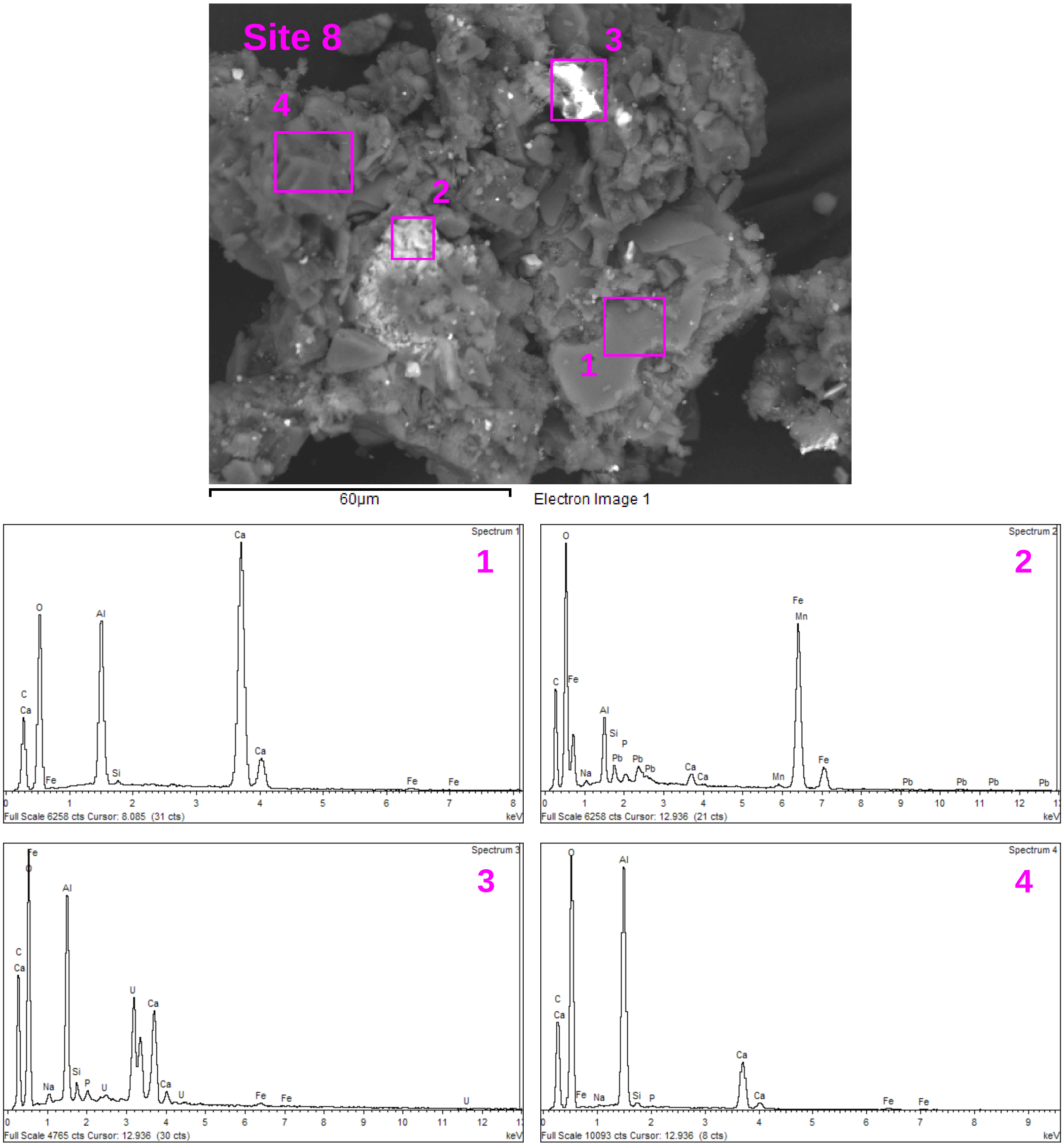

Figure D.70. SEDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

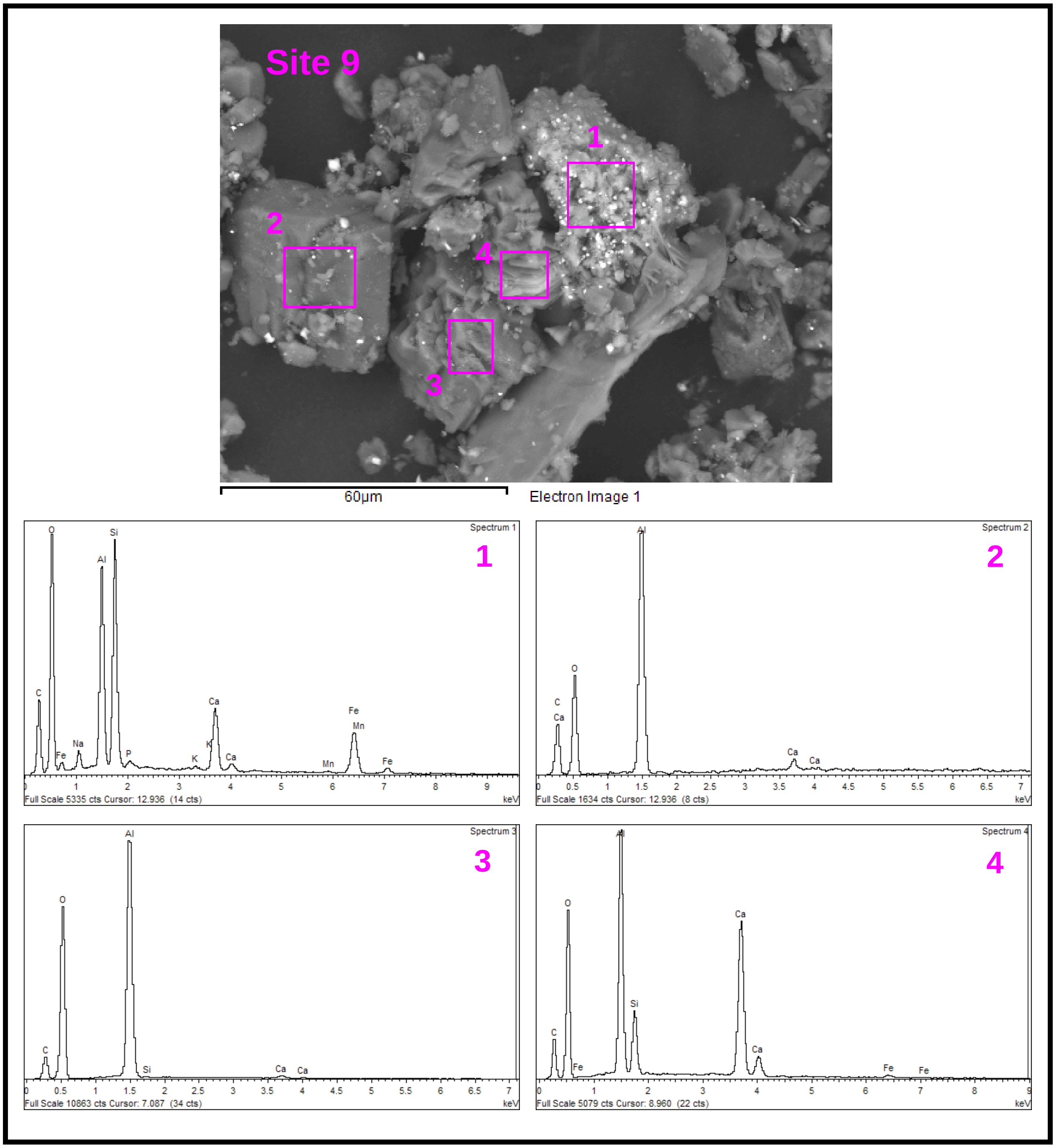

Figure D.71. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

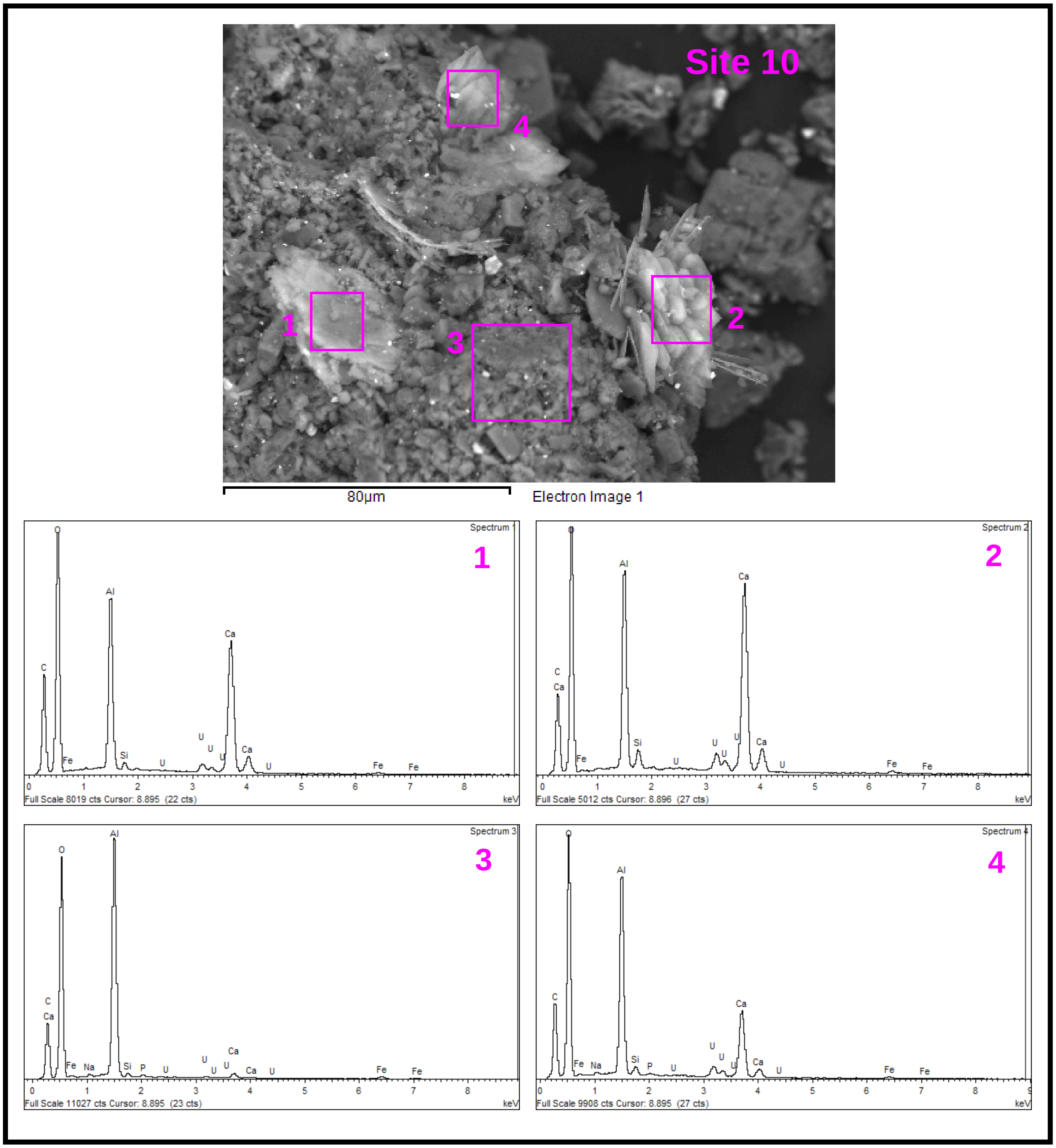

Figure D.72. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $Ca(OH)_2$-Leached Residual Waste from Tank C-103

Table D.7. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	Si	Na	Ca	U	Fe	Cr	Tc	Ag	Hg	O	P	Others
D.60 and D.61/1	1	3.9	1.5	0.7	0.8		78.8	0.3				13.2		Cu (0.5), Mn (0.4)
	2	6.4	0.6	0.5	0.7	0.6	54.2			0.5		32.4		Mn (0.5), Ni (0.8), Pb (0.7), Zr (1.9)
	3	28.7	0.4	0.4	0.5		0.7					68.9	0.2	Mn (0.2)
	4	21.8	9.4	1.1	13.2	2.4	4.0					48.0		
	5	12.1	5.7		16.8		0.4					64.6		Ba (0.4)
	6	14.7	2.9	0.4	9.9	2.5	4.9					64.5	0.2	
D.62/2	1	1.6		3.4	27.6		3.1					48.6	13.0	Ba (1.3), Cd (0.8), Nd (0.5)
	2	14.8	3.5	0.2	12.4	1.8	0.2					67.1		
	3	28.2	0.4	0.7	0.8	0.6	0.9					67.6	0.4	Mn (0.3)
	4	25.1	1.5	0.8	3.1	6.5	1.1					60.8	0.8	S (0.4)
D.63/3	1	4.7	2.4	1.7	7.8	37.4	0.4					44.6	0.7	Cu (0.4)
	2	19.7	0.9	0.8	2.0	11.0	0.4					64.9	0.4	
	3	13.3	0.9		22.7	2.6	1.3					59.2		S (0.2)
	4	35.9	0.7	0.4	1.1	0.9	0.3					60.7		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.8. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.64 and D.65/4	1	3.6	0.4	0.6	0.3		44.7					44.3	0.4	Mn (2.8), Pb (2.9)
	2	33.9	0.3	0.3	0.5		1.0					63.9		
	3	6.3	0.6		2.0		56.9					29.2	0.5	Mn (1.2), Ni (0.6), Pb (2.6)
	4	35.7		0.4	0.3		4.1					59.1	0.3	
	5	15.3	0.7	0.6	5.4	39.0	9.5					29.5		
	6	29.5	0.4	0.4	0.7		1.4					67.3	0.3	
D.66/5	1	4.7	0.4		0.7		57.1					31.4	0.7	Mn (1.8), Pb (3.2)
	2	12.5	0.5		19.9		0.5					66.5		
	3	26.7	0.7		12.0	2.1	2.4					56.2		
D.67/6	1	32.6		0.4								67.0		
	2	10.7	1.2		20.7	3.9	1.6					61.8		S (0.2)
	3	4.5	0.5		0.8		64.4					24.7		Pb (1.6), Ru (2.5), Zr (1.1)
	4	26.9	0.6	0.4	1.3	0.6	2.1					67.7	0.4	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.9. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %**$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.68 and D.69/7	1	32.4	0.2		0.4		0.4					66.6		
	2	7.4								49.6	4.6	38.4		
	3	11.7	0.4		27.7					1.7		58.6		
	4	12.0	1.8		22.4		1.9			4.3		57.6		
	5	22.8	1.4		16.9	3.0	0.9					55.0		
D.70/8	1	11.2	0.3		23.1		0.5					65.0		
	2	6.4	1.6	1.1	1.1		44.0					41.5	0.7	Mn (0.7), Pb (3.0)
	3	12.1	1.1	1.0	7.3	23.9	0.6					53.5	0.6	
	4	21.8	0.5	0.3	6.4		0.5					70.4	0.2	
D.71/9	1	12.6	15.9	2.2	5.7		10.0					52.7	0.5	K (0.3), Mn (0.3)
	2	40.2			2.7							57.1		
	3	33.6	0.2		0.5							65.7		
	4	17.3	5.3		16.5		0.7					60.2		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table D.10. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
D.72/10	1	12.8	0.6		13.7	2.7	0.3					69.9		
	2	12.2	1.2		15.9	4.3	0.5					65.8		
	3	28.8	0.5	0.5	0.8	0.6	1.0					67.4	0.4	
	4	17.2	0.8	0.4	8.3	4.0	0.6					68.6	0.2	

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Appendix E

SEM Micrographs and EDS Results for One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

Appendix E

SEM Micrographs and EDS Results for One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

This appendix includes the scanning electron microscope (SEM) micrographs and the energy-dispersive spectroscopy (EDS) spectra for samples 19845, 19849, and 19850 of one-month single-contact $CaCO_3$-leached residual waste from tank C-103. The operating conditions for the SEM and procedures used for mounting the SEM samples are described in Section 2.4 of the main report.

The identification number for the digital micrograph image file, descriptor for the type of sample, and a size scale bar are given at the bottom of each SEM micrograph. Micrographs labeled by “BSE” or “SE” to the immediate right of the digital image file number indicate that the micrograph was collected with backscattered electrons or secondary electrons, respectively. Sample areas or particles identified in a micrograph by a pink arrow or pink dotted-line square designate sample material that was imaged at higher magnification, which is typically shown in figure(s) that immediately follow in the series for that sample.

The SEM micrographs, EDS spectra, and corresponding calculated compositions (in weight percent) based on EDS analyses for material analyzed from samples 19845, 19849, and 19850 of one-month single-contact $CaCO_3$-leached C-103 residual waste are shown in the following figures and tables:

- Sample 19845
  - SEM micrographs – Figures E.1 through E.9
  - EDS spectra – Figures E.10 through E.18
  - Calculated compositions based on EDS analyses – Table E.1 through E.3

- Sample 19849
  - SEM micrographs – Figures E.19 through E.28
  - EDS spectra – Figures E.29 through E.38
  - Calculated compositions based on EDS analyses – Table E.4 through E.6

- Sample 19850
  - SEM micrographs – Figures E.39 through E.49
  - EDS spectra – Figures E.50 through E.64
  - Calculated compositions based on EDS analyses – Table E.7 through E.10

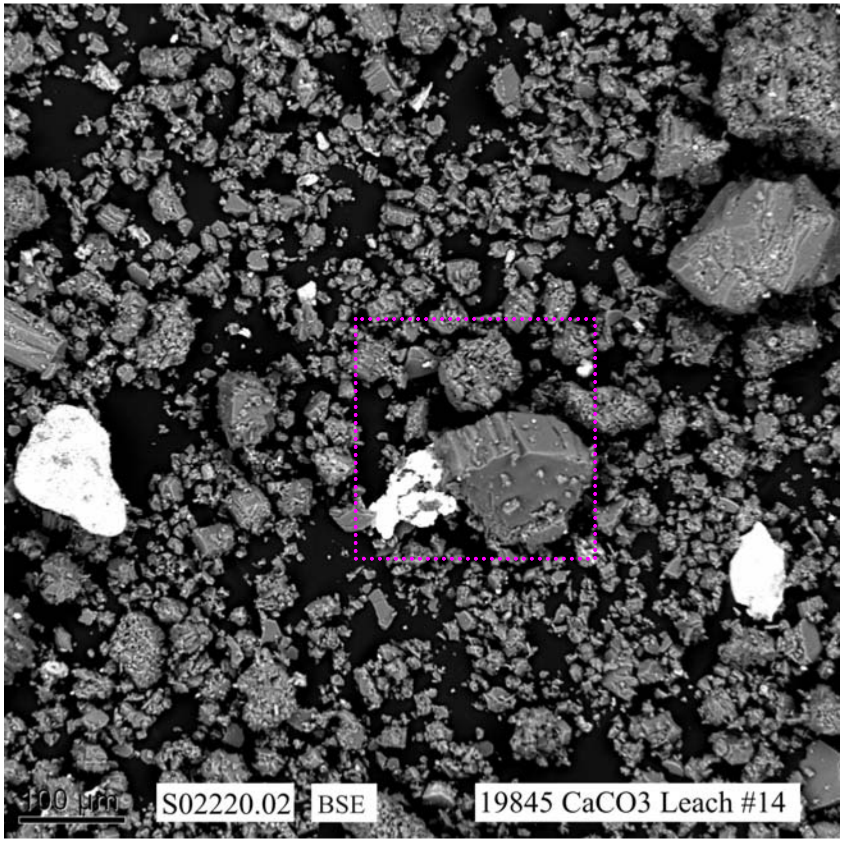

Figure E.1. Low Magnification SEM Micrograph Showing General Morphologies of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

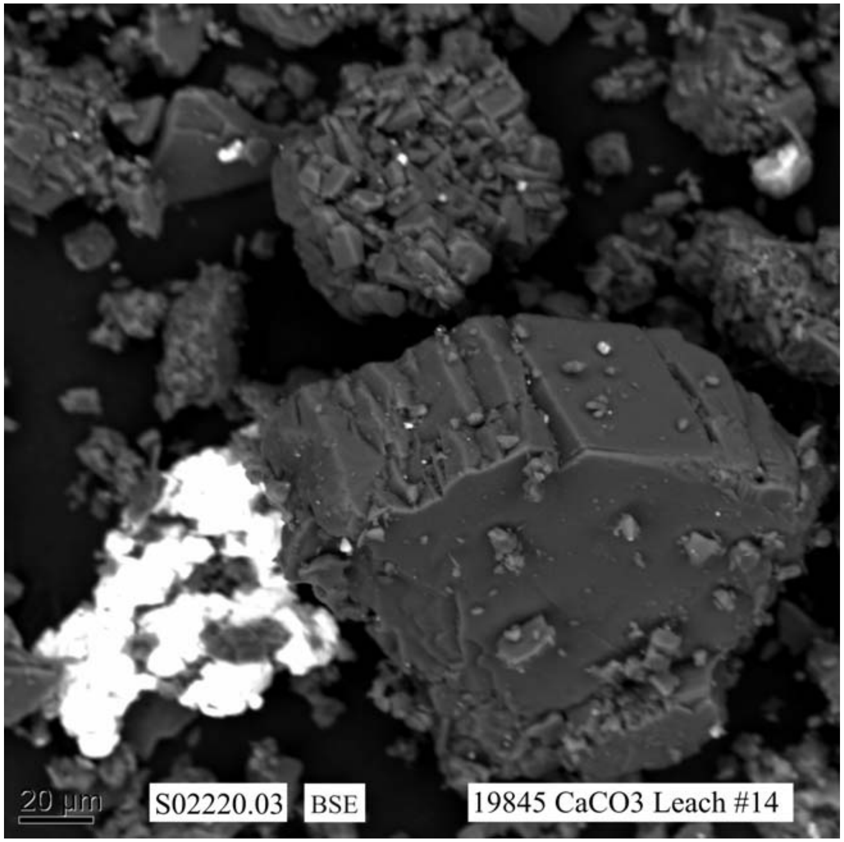

Figure E.2. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square in Figure E.1 (Areas where EDS analyses were made are shown in Figure E.10.)

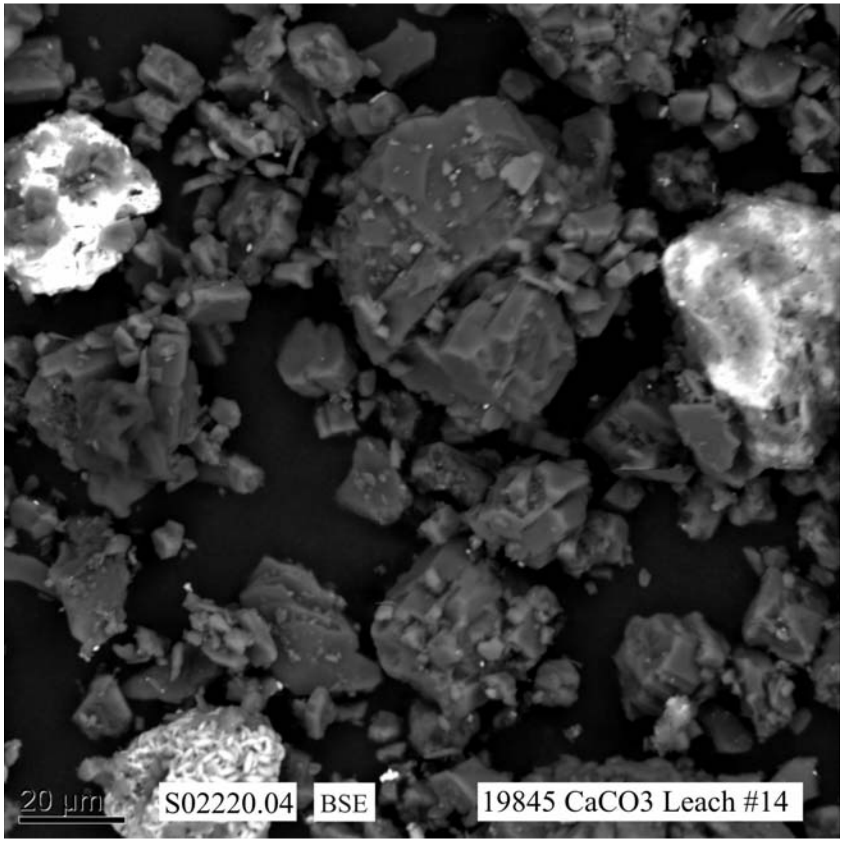

Figure E.3. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.11 and E.12.)

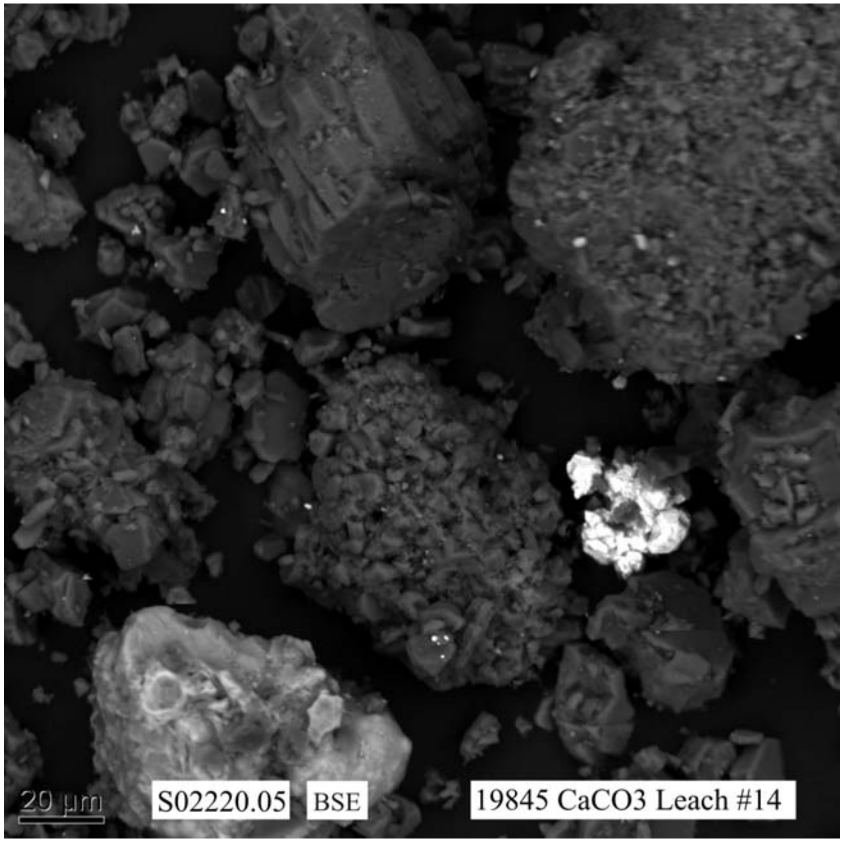

Figure E.4. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.13.)

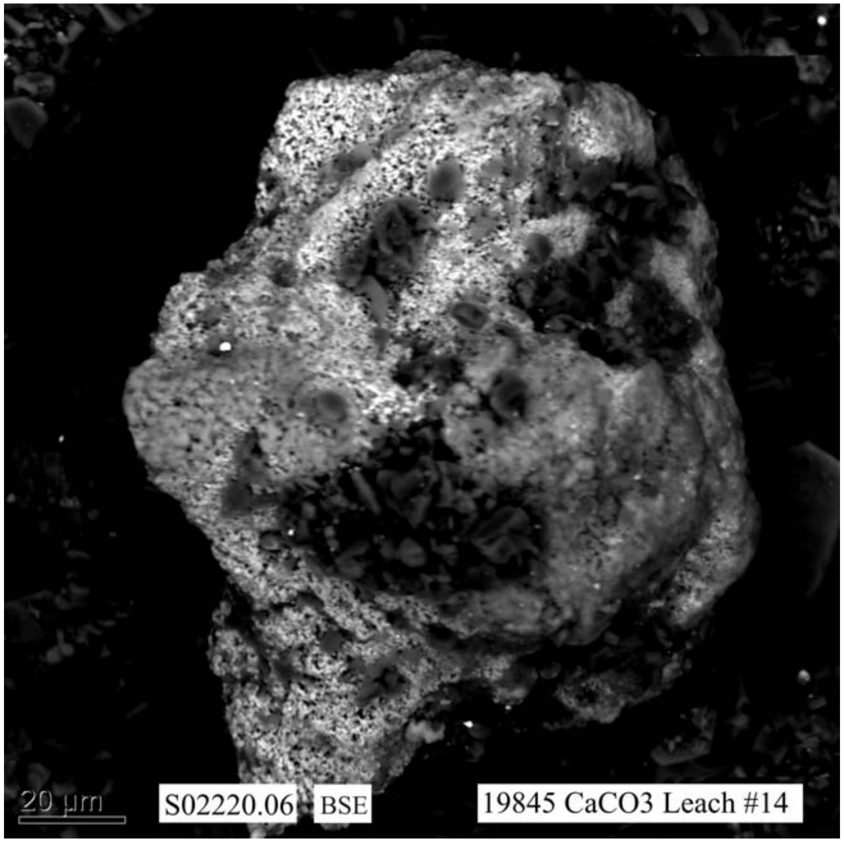

Figure E.5. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.14.)

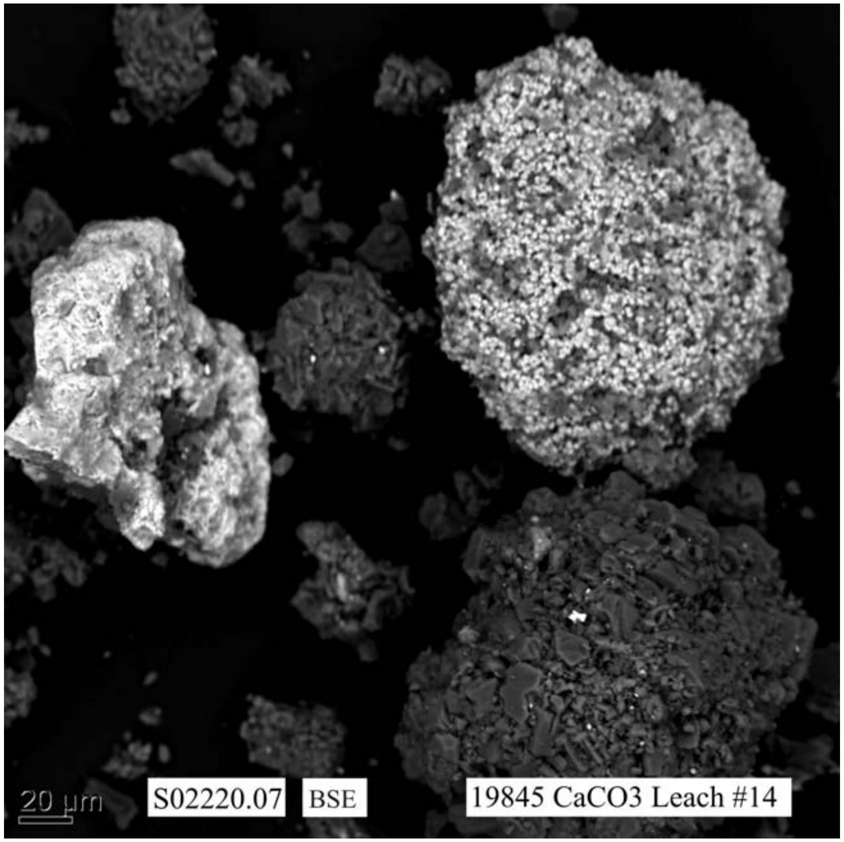

Figure E.6. Micrograph Showing Particle Aggregates in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.15.)

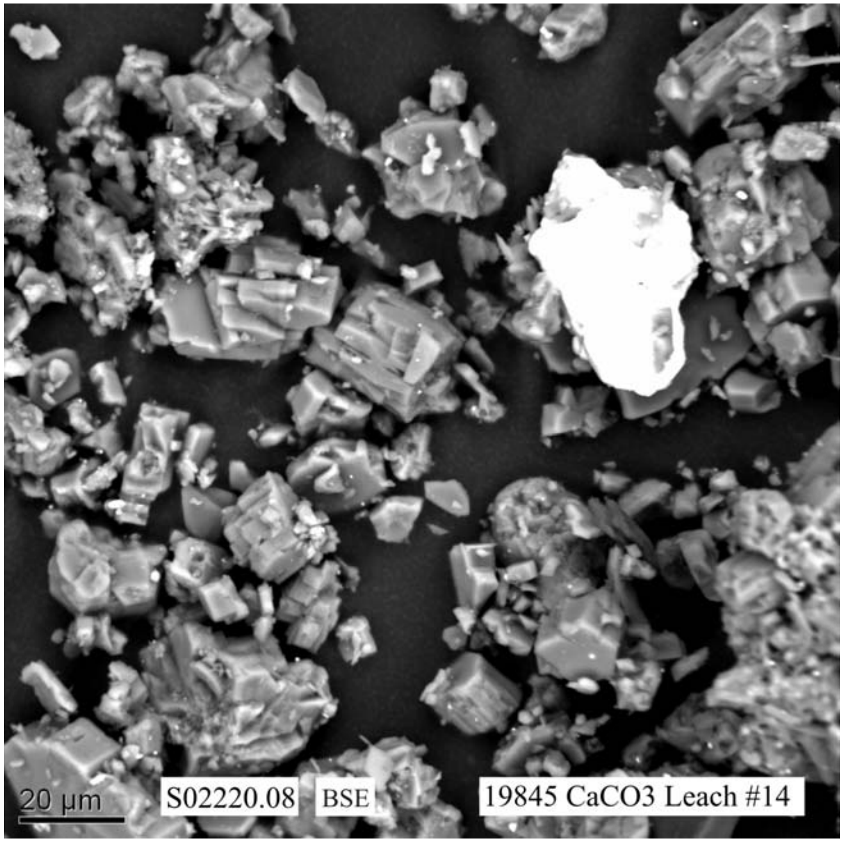

Figure E.7. Micrograph Showing Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.16.)

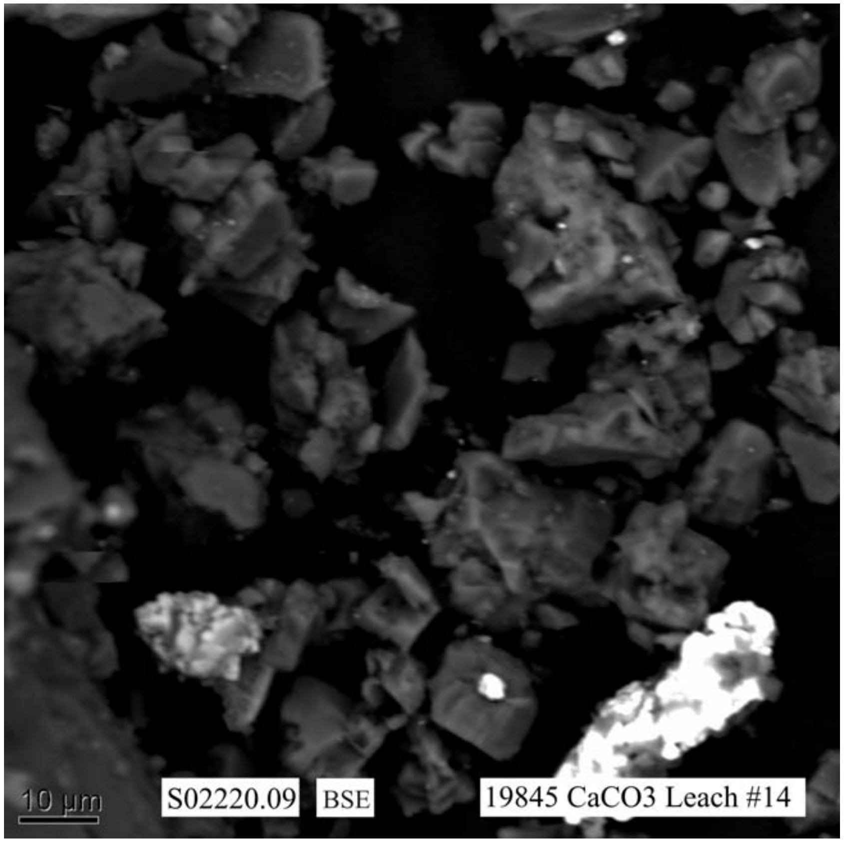

Figure E.8. Micrograph Showing Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.17.)

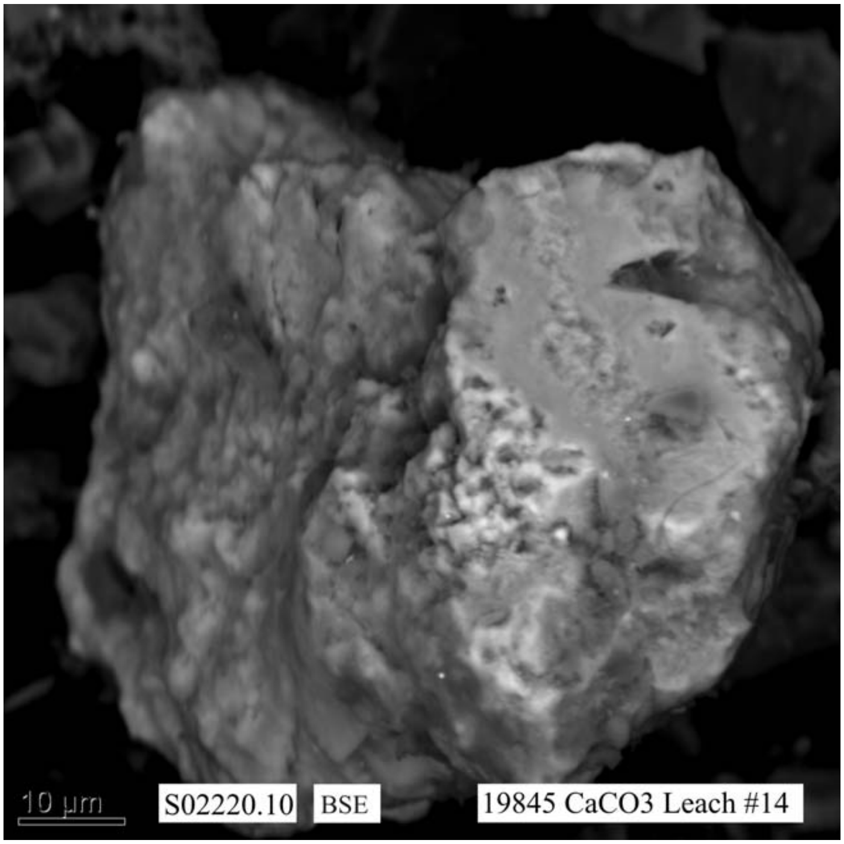

Figure E.9. Micrograph Showing Particle Aggregate in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.18.)

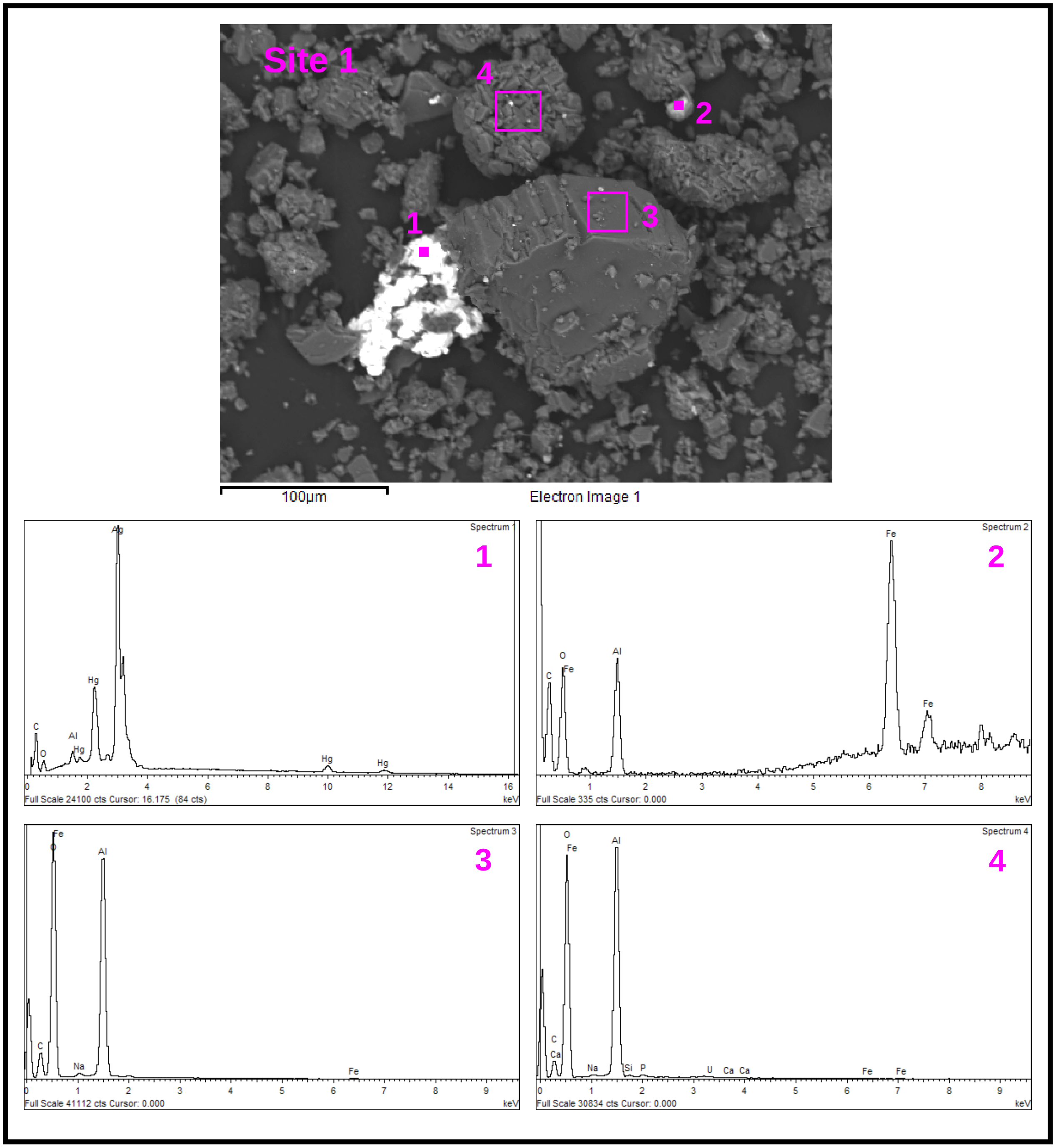

Figure E.10. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

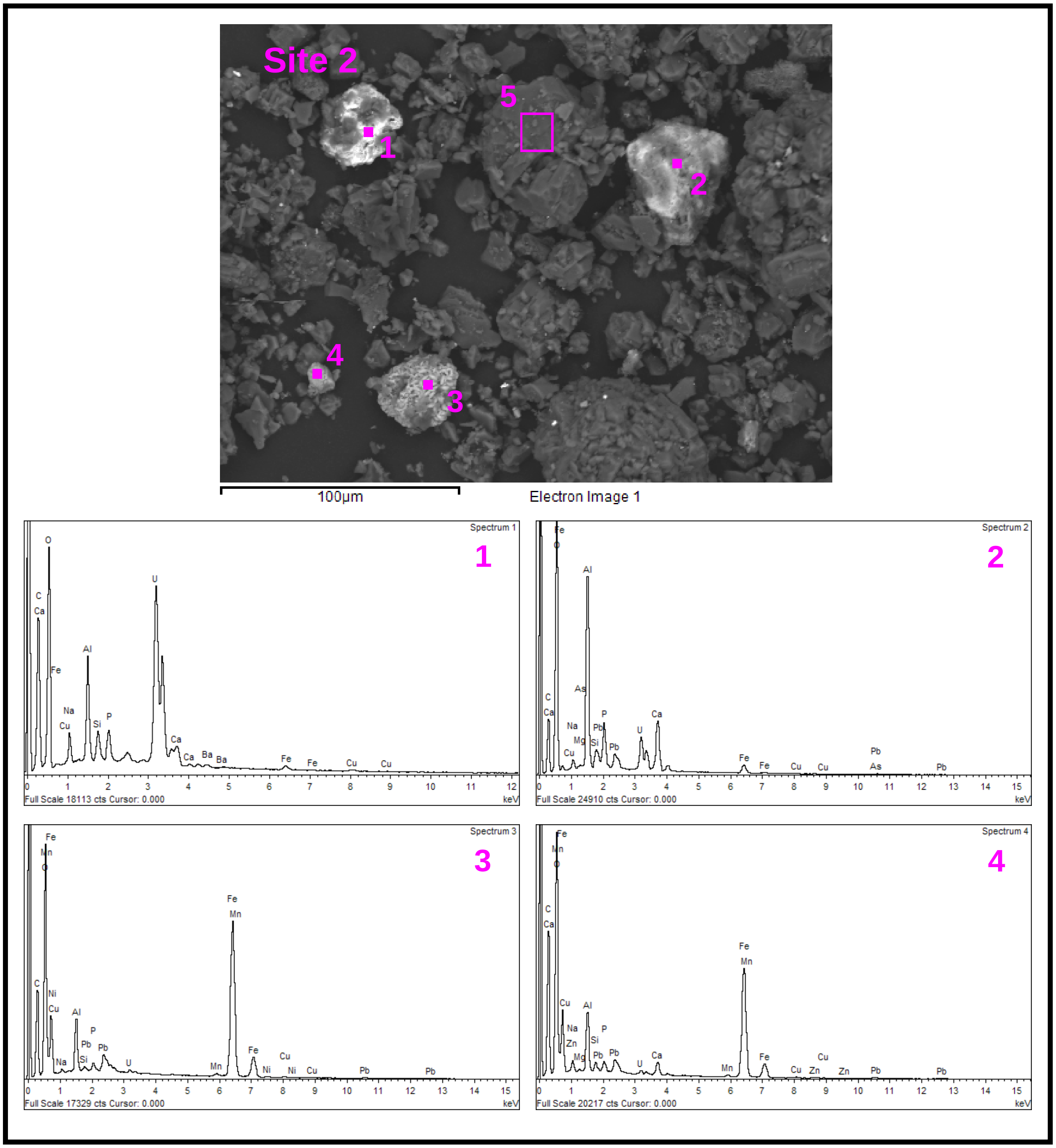

Figure E.11. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

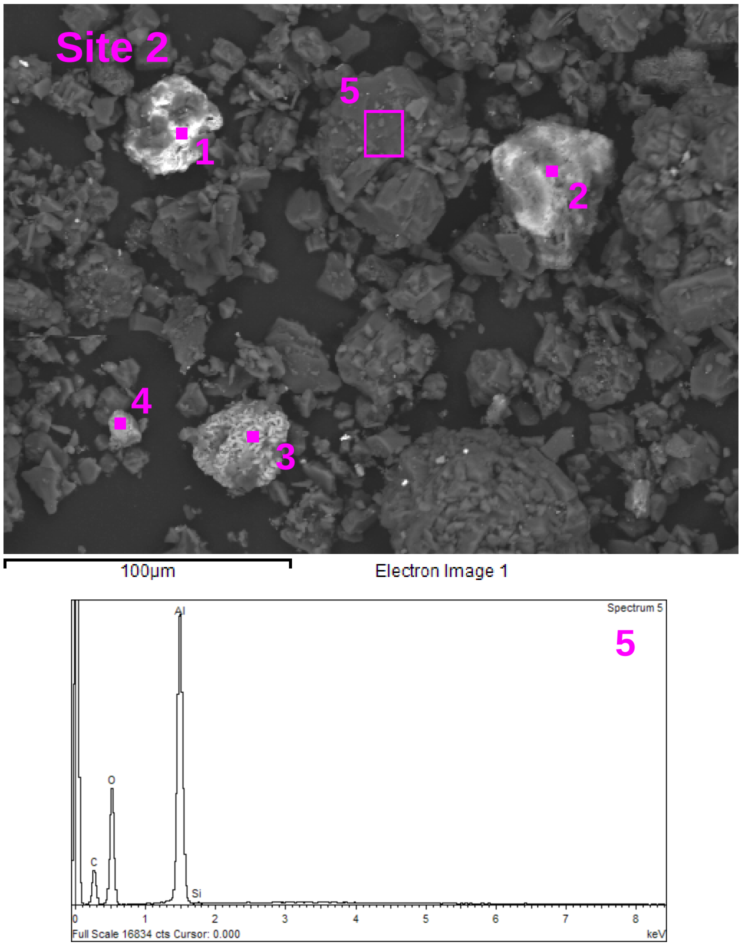

Figure E.12. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

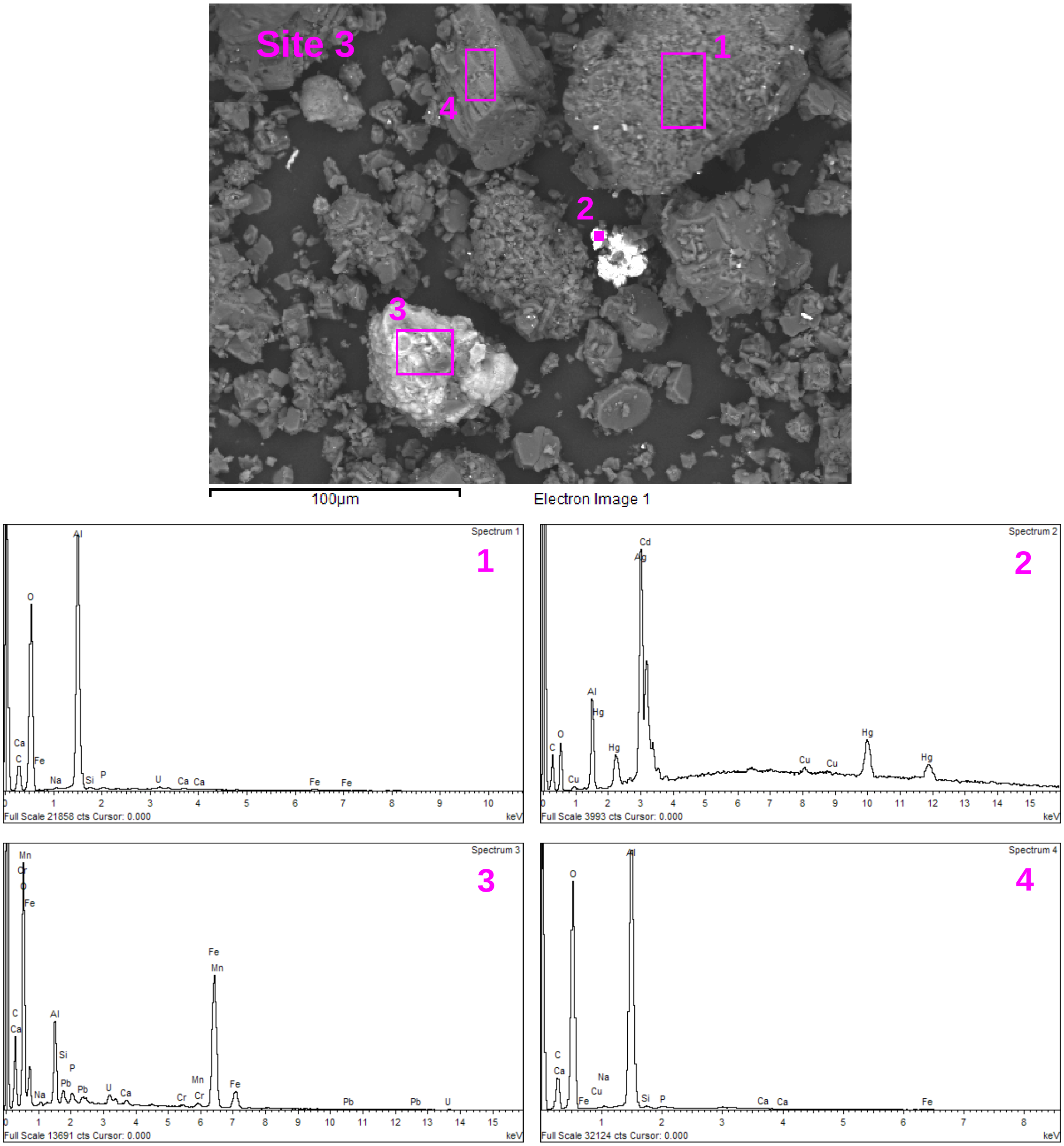

Figure E.13. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

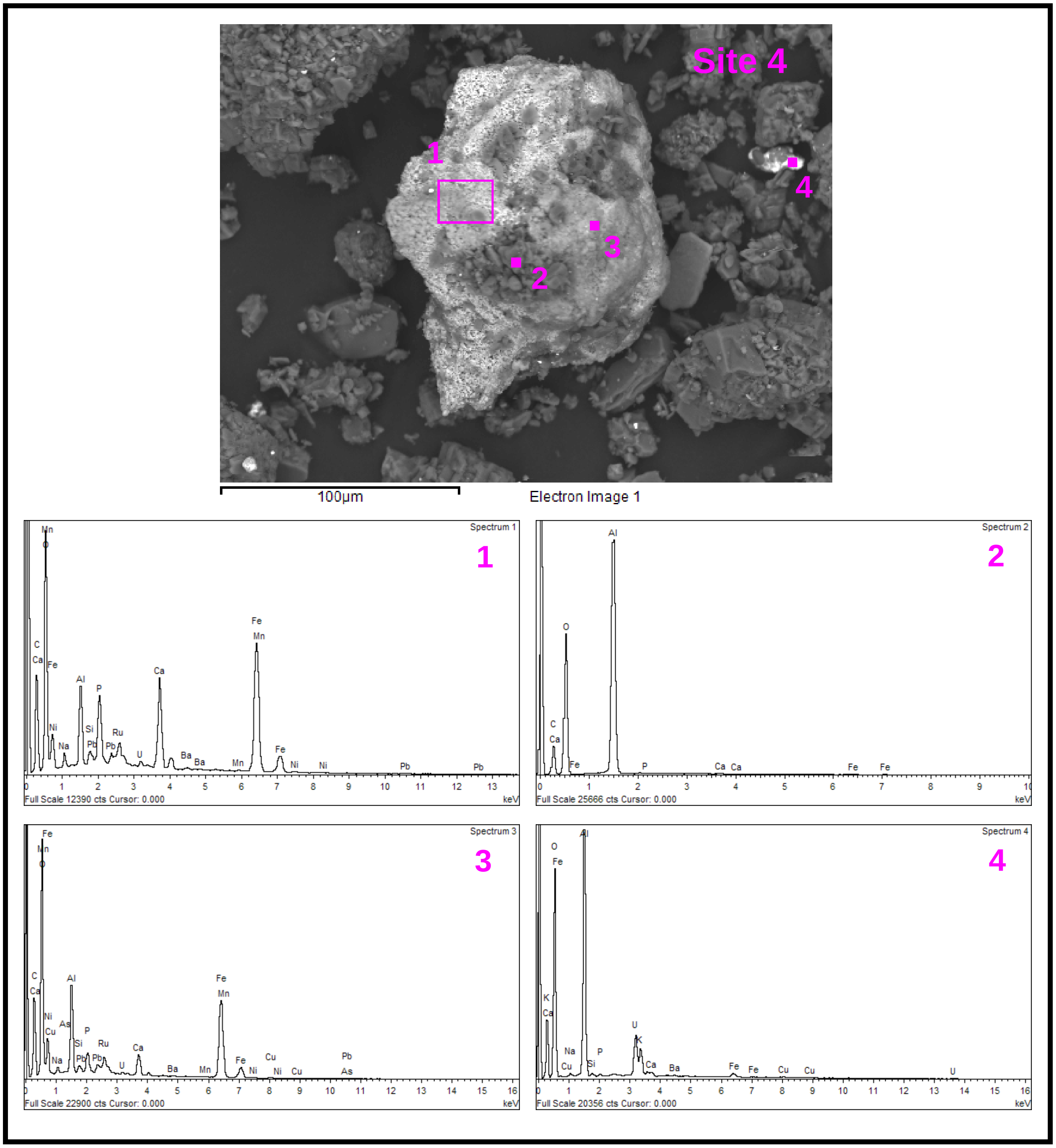

Figure E.14. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

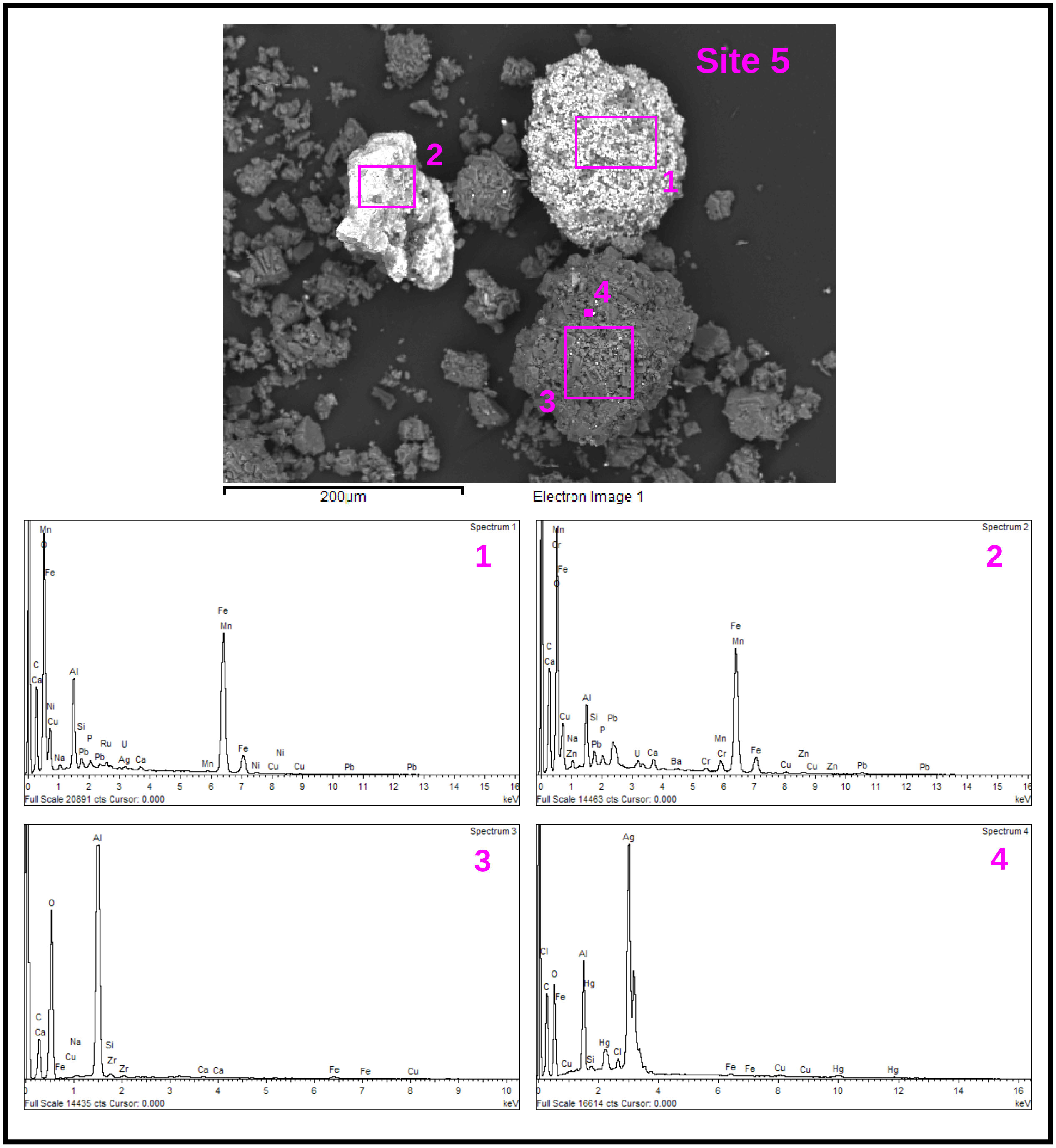

Figure E.15. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

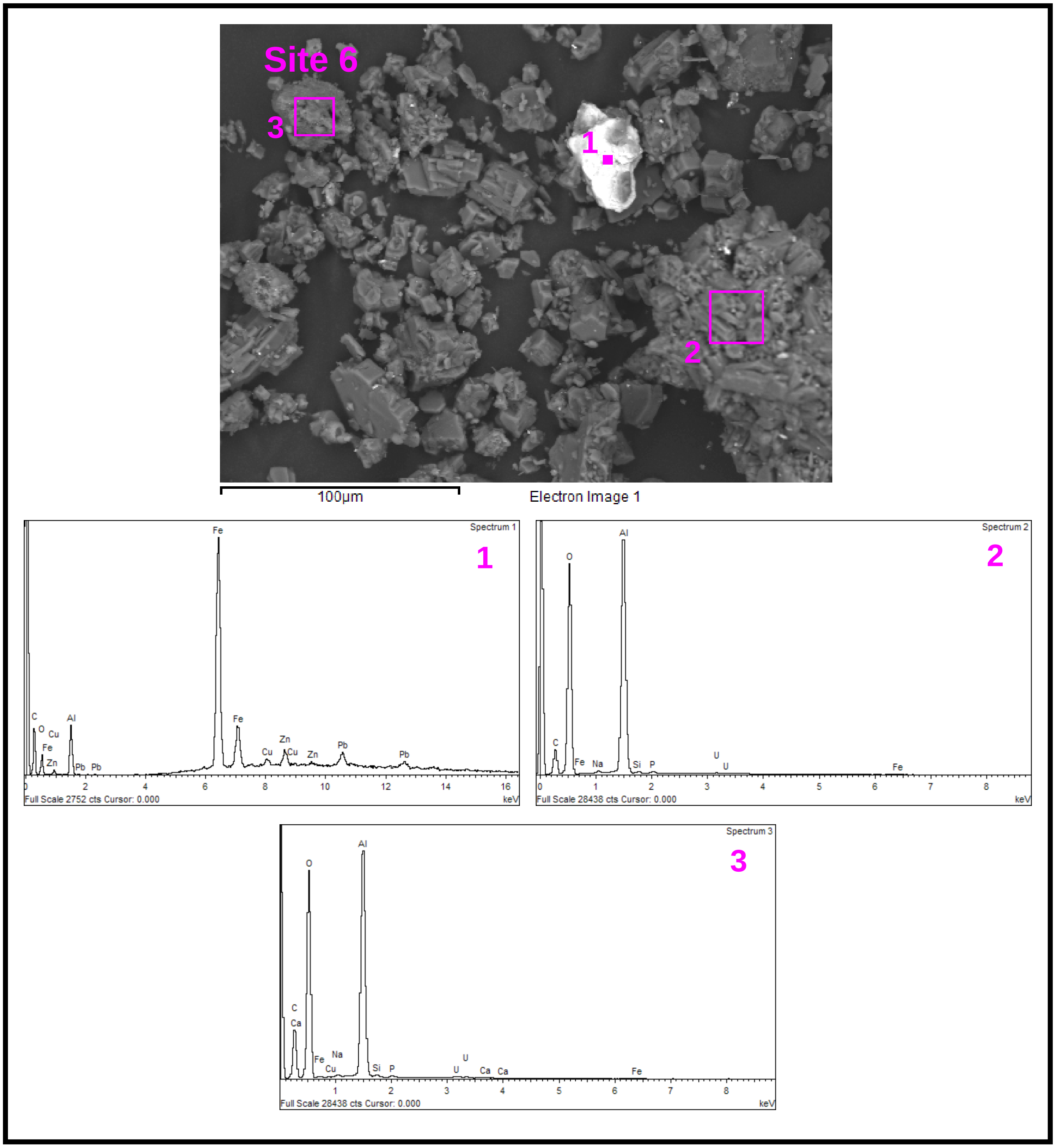

Figure E.16. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

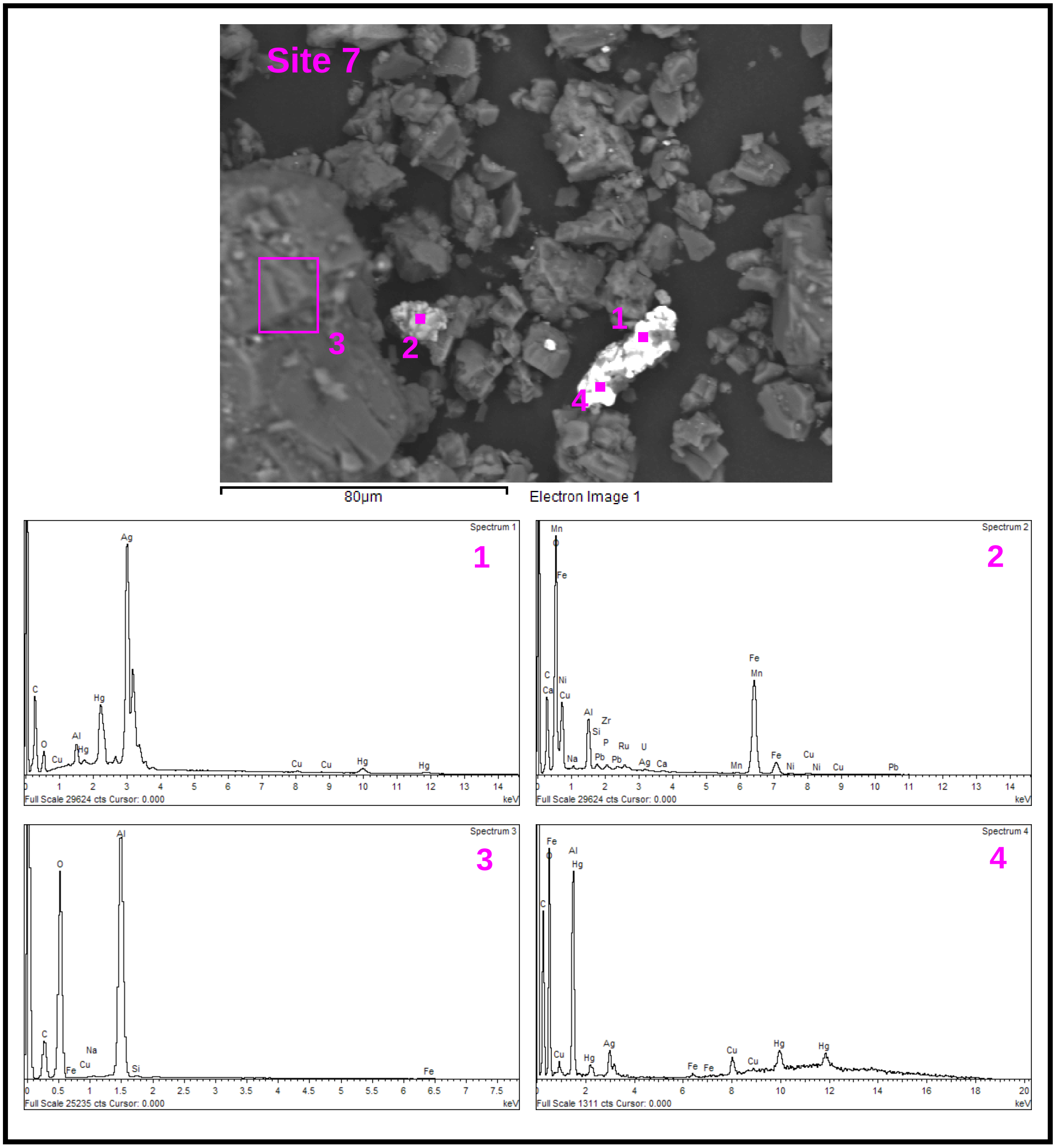

Figure E.17. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

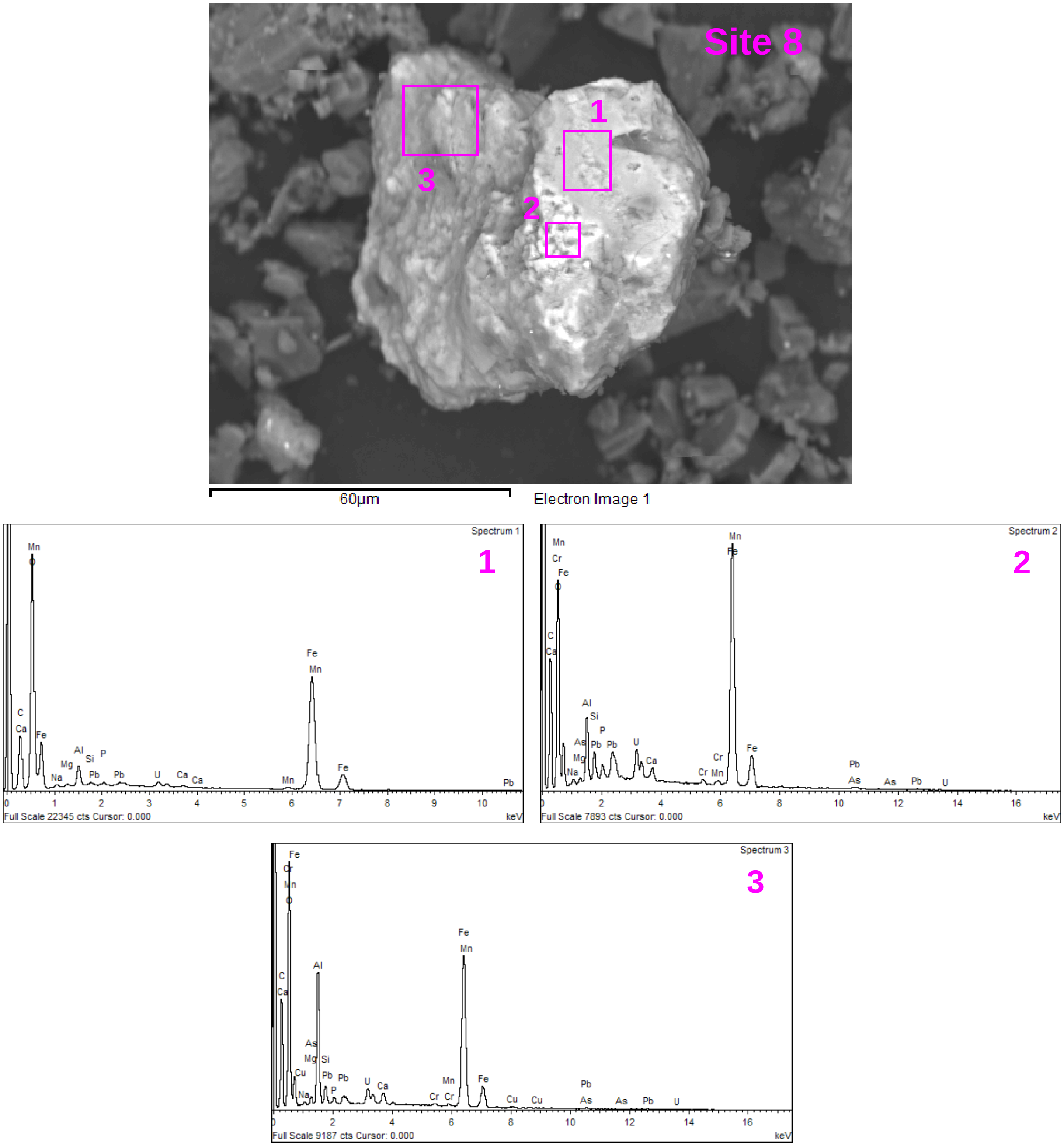

Figure E.18. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19845 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

Table E.1. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.10/1	1	1.4				3.3				65.0	20.2	9.7		Cu (0.4)
	2	14.2					61.6					24.2		
	3	26.9		0.6			0.2					72.3		
	4	28.1	0.3	0.4	0.1	0.6	0.3					69.9	0.3	
E.11 and E.12/2	1	6.6	1.7	3.1	1.4	39.8	0.7					43.6	2.0	Ba (0.6), Cu (0.5)
	2	13.9	0.8	1.2	5.1	10.1	2.1					59.2	3.7	As (0.2), Cu (0.3), Mg (0.2), Pb (3.2)
	3	5.7	0.4	0.9		1.1	45.2					41.3	0.8	Cu (0.4), Mn (0.6), Ni (0.3), Pb (3.3)
	4	6.3	0.9	1.6	1.4	1.6	33.8					48.1	1.1	Cu (0.4), Mg (0.2), Mn (0.6), Pb (3.3), Zn (0.7)
	5	43.4	0.3									56.4		
E.13/3	1	32.6	0.3	0.3	0.3	1.4	0.7					64.1	0.3	
	2	7.5								48.6	7.5	28.9		Cd (4.9), Cu (2.6)
	3	8.3	1.2	0.8	0.5	3.3	37.8	0.3				44.3	0.9	Mn (0.9), Pb (1.7)
	4	30.8	0.3	0.4	0.1		0.3					67.5	0.3	Cu (0.2)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.2. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.14/4	1	5.3	0.6	2.0	7.0	1.2	26.2					46.7	4.3	Ba (0.5), Mn (0.2), Ni (0.3), Pb (2.3), Ru (3.4)
	2	36.7			0.1		0.6					62.4	0.2	
	3	8.4	0.6	1.2	2.4	1.0	23.5					53.8	1.8	As (0.2), Ba (0.4), Cu (0.3), Mn (0.1), Ni (0.2), Pb (2.3), Ru (3.8)
	4	23.2	0.3	0.5	0.4	16.9	1.2					55.9	0.3	Ba (0.5), Cu (0.4), K (0.2)
E.15/5	1	9.1	0.9	1.0	0.4	0.9	39.4			0.3		43.9	0.5	Cu (0.4), Mn (0.2), Ni (0.4), Pb (1.1), Ru (1.5)
	2	5.8	1.3	1.2	1.0	2.4	33.0	0.6				44.0	0.9	Ba (0.6), Cu (0.5), Mn (2.5), Pb (5.5), Zn (0.7)
	3	32.7	0.7	0.4	0.2		1.0					63.9		Cu (0.5), Zr (0.6)
	4	8.0	0.2				0.4			42.7	4.5	43.3		Cl (0.2), Cu (0.6)
E.16/6	1	7.6					72.5					4.9		Cu (3.7), Zn (11.5)
	2	30.5	0.3	0.5		0.5	0.3					67.8	0.3	
	3	29.6	0.4	0.4	0.1	1.0	0.4					67.5	0.3	Cu (0.3)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.3. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.17/7	1	2.1								62.2	17.2	17.9		Cu (0.6)
	2	6.4	0.6	0.8	0.2	0.7	34.2			0.3		51.9	0.2	Cu (0.5), Mn (0.2), Ni (0.4), Pb (1.3), Ru (1.6)
	3	31.5	0.3	0.2			0.3					67.3		Cu (0.3)
	4	19.0					0.9			6.7	3.5	59.4		Cu (10.4)
E.18/8	1	2.9	0.3	0.7	0.2	2.2	43.0					48.6	0.4	Mg (0.3), Mn (0.5), Pb (0.8)
	2	4.7	1.8	0.8	0.8	6.9	47.0	0.6				30.9	0.9	Mg (0.5), Mn (0.7), Pb (4.4)
	3	11.0	1.4	0.7	1.0	4.3	36.2	0.4				41.2	0.4	As (0.2), Mg (0.7), Mn (0.3), Pb (1.7)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

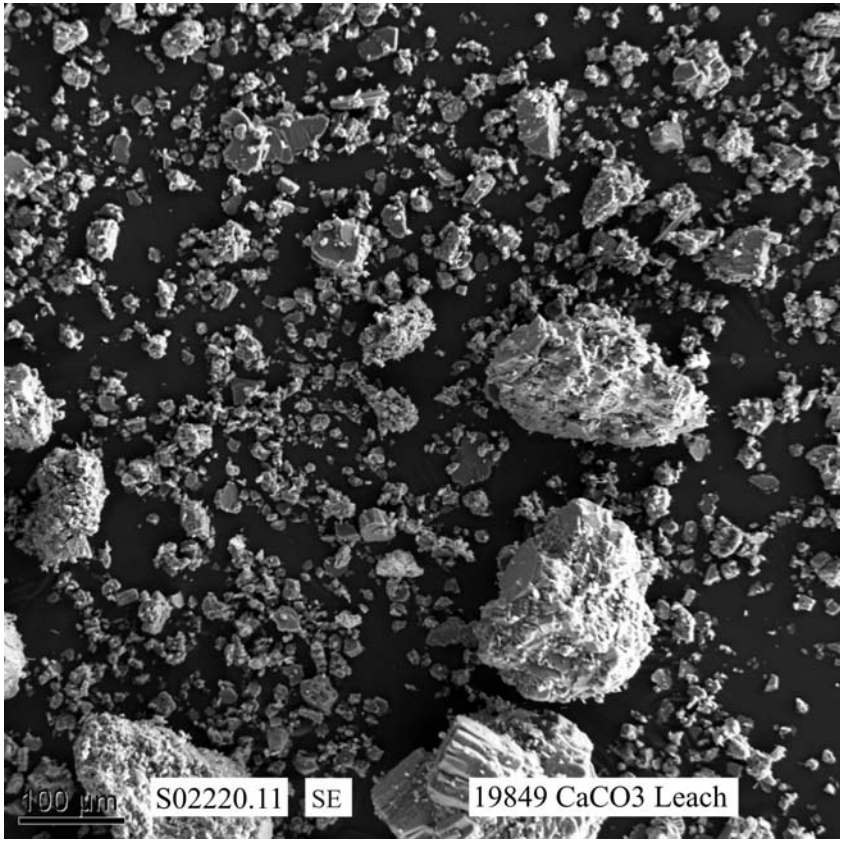

Figure E.19. Low Magnification Secondary-Electron SEM Micrograph Showing General Morphologies of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

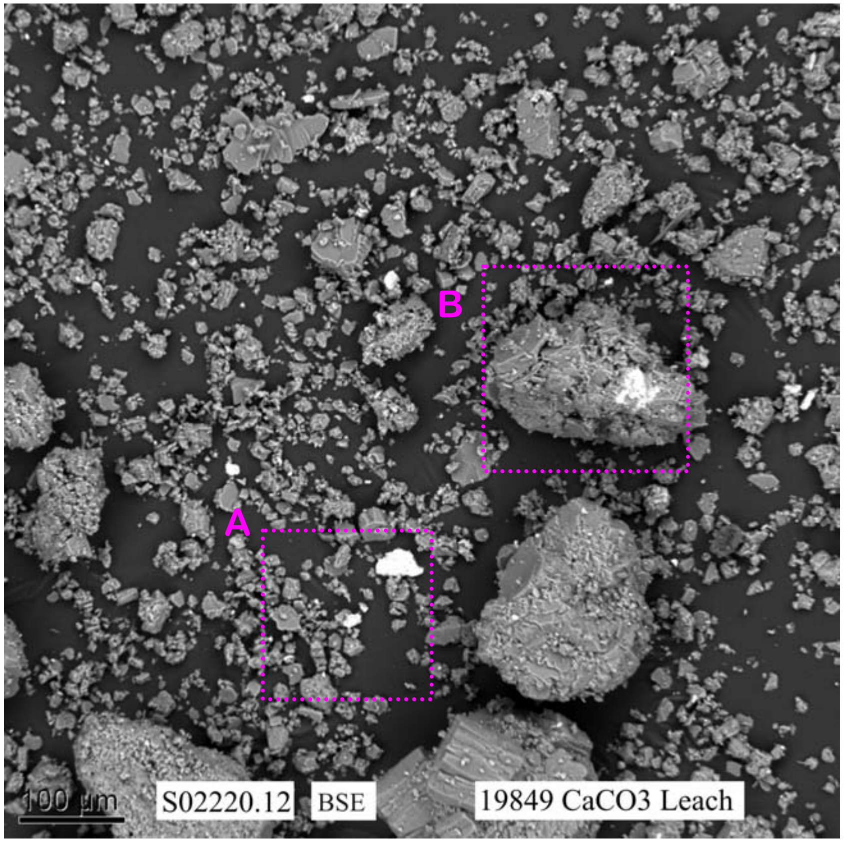

Figure E.20. Low Magnification Backscattered-Electron SEM Micrograph Showing Same Particles as in Figure E.19

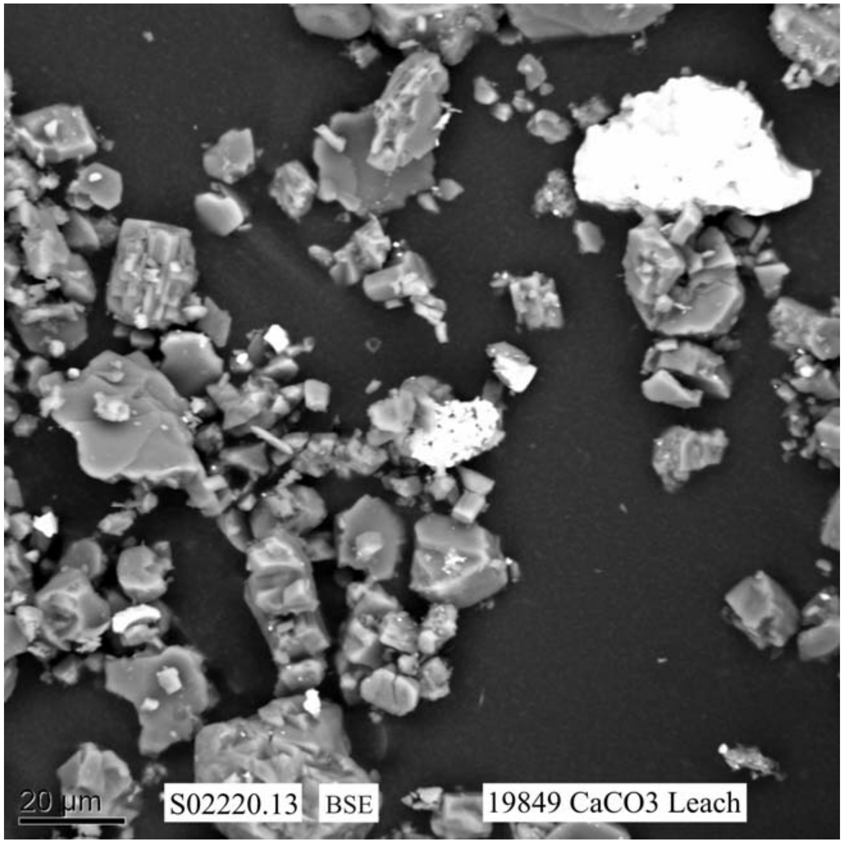

Figure E.21. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square A in Figure E.20 (Areas where EDS analyses were made are shown in Figure E.29.)

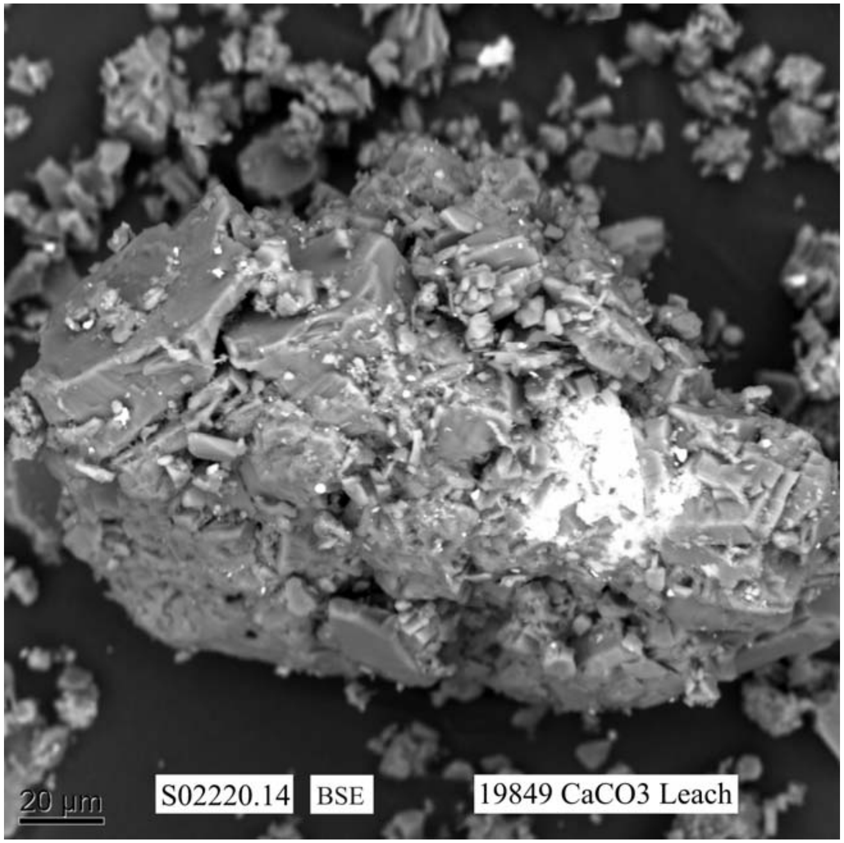

Figure E.22. Micrograph Showing at Higher Magnification the Particle Aggregate in the Area Indicated by the Pink Dotted-Line Square B in Figure E.20 (Areas where EDS analyses were made are shown in Figure E.30.)

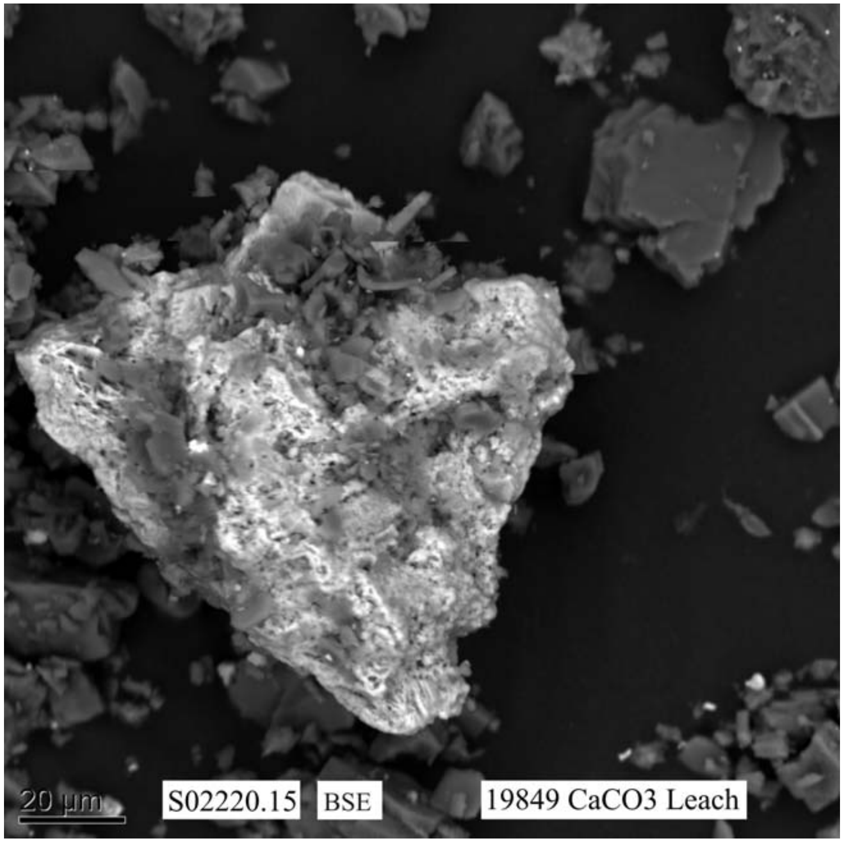

Figure E.23. Micrograph Showing Particle Aggregate in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.31.)

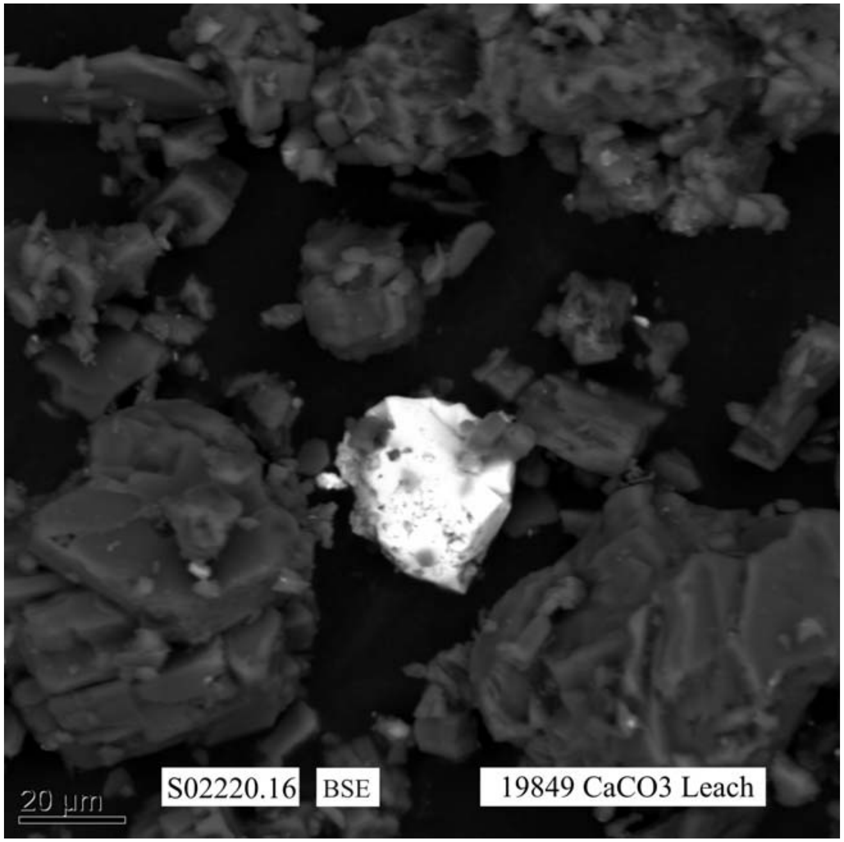

Figure E.24. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.32.)

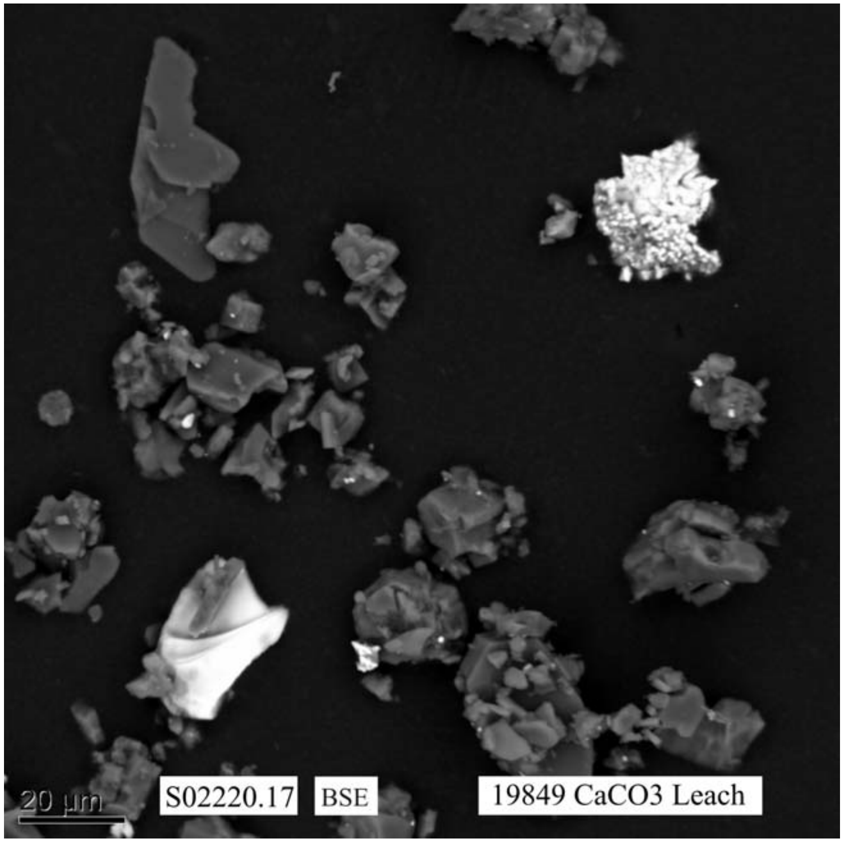

Figure E.25. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.33.)

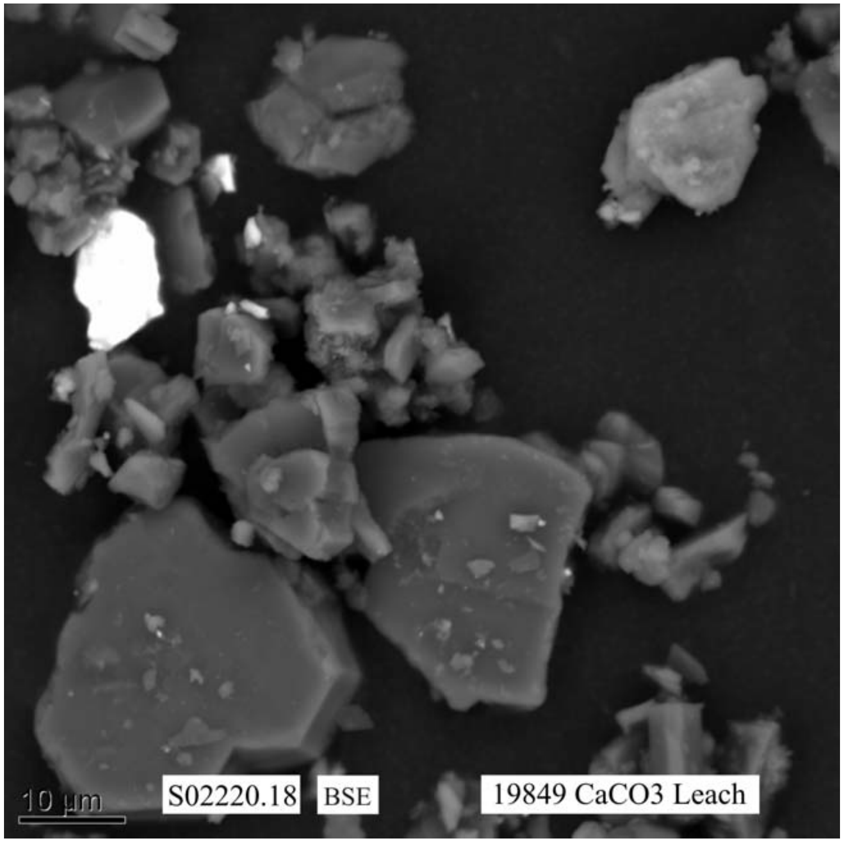

Figure E.26. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.34.)

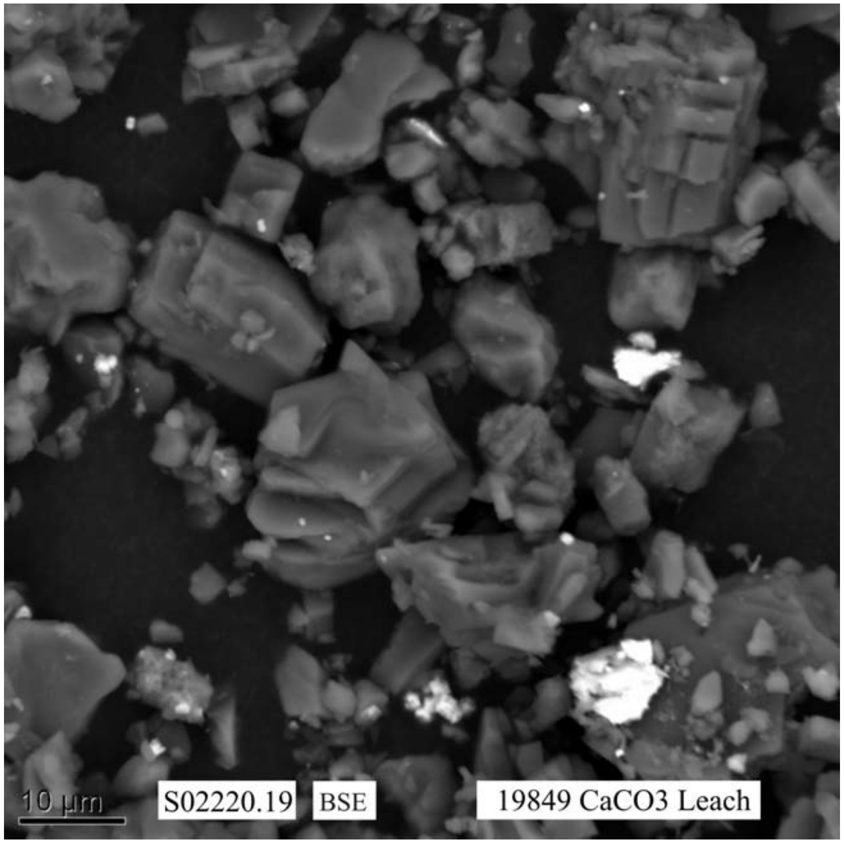

Figure E.27. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.35 and E.36.)

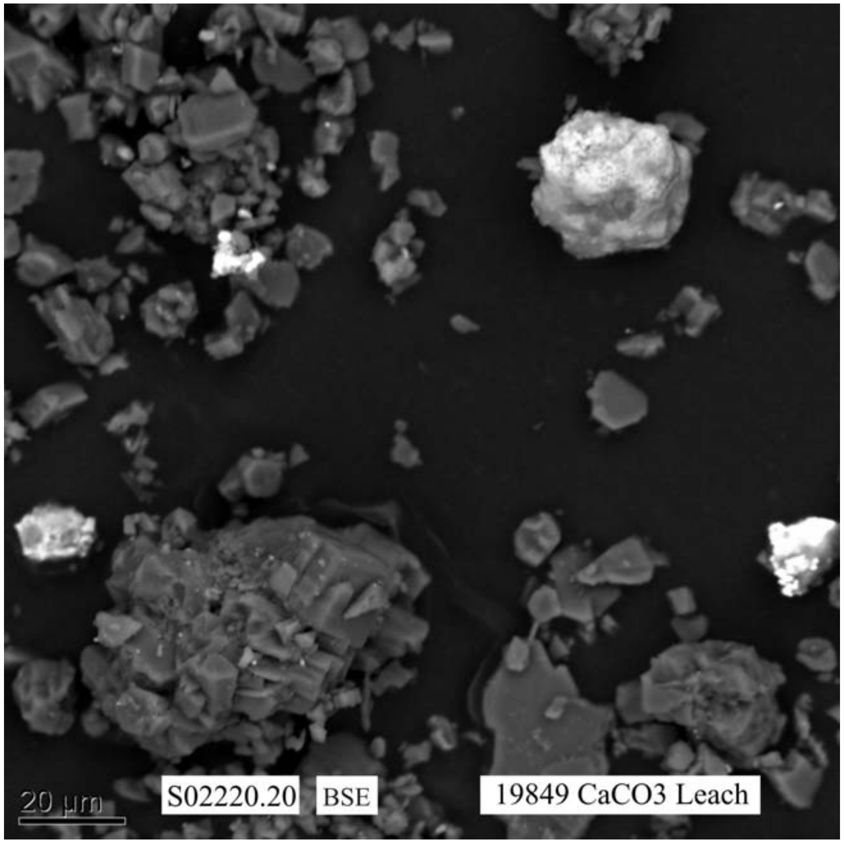

Figure E.28. Micrograph Showing Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.37 and E.38.)

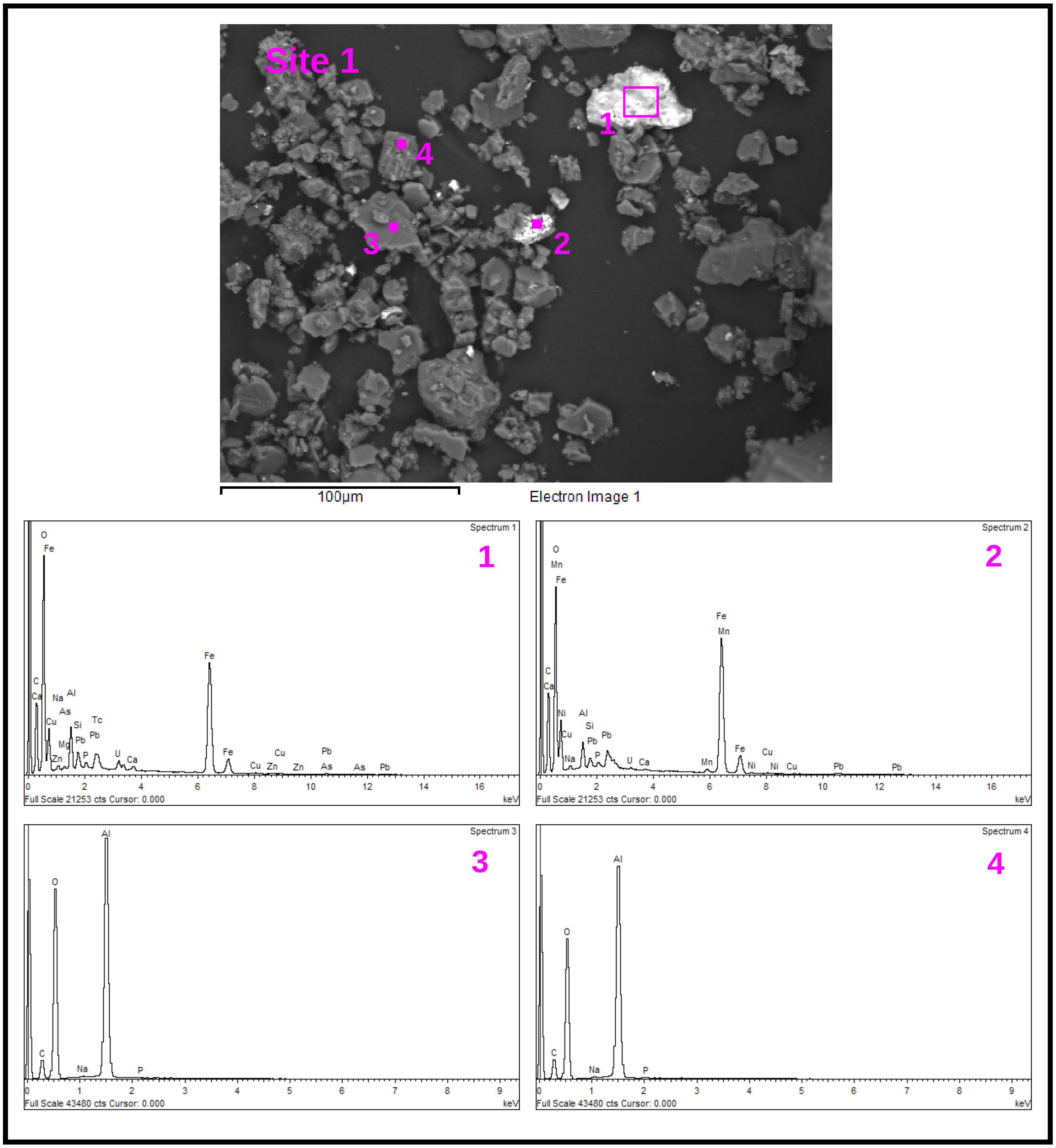

Figure E.29. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

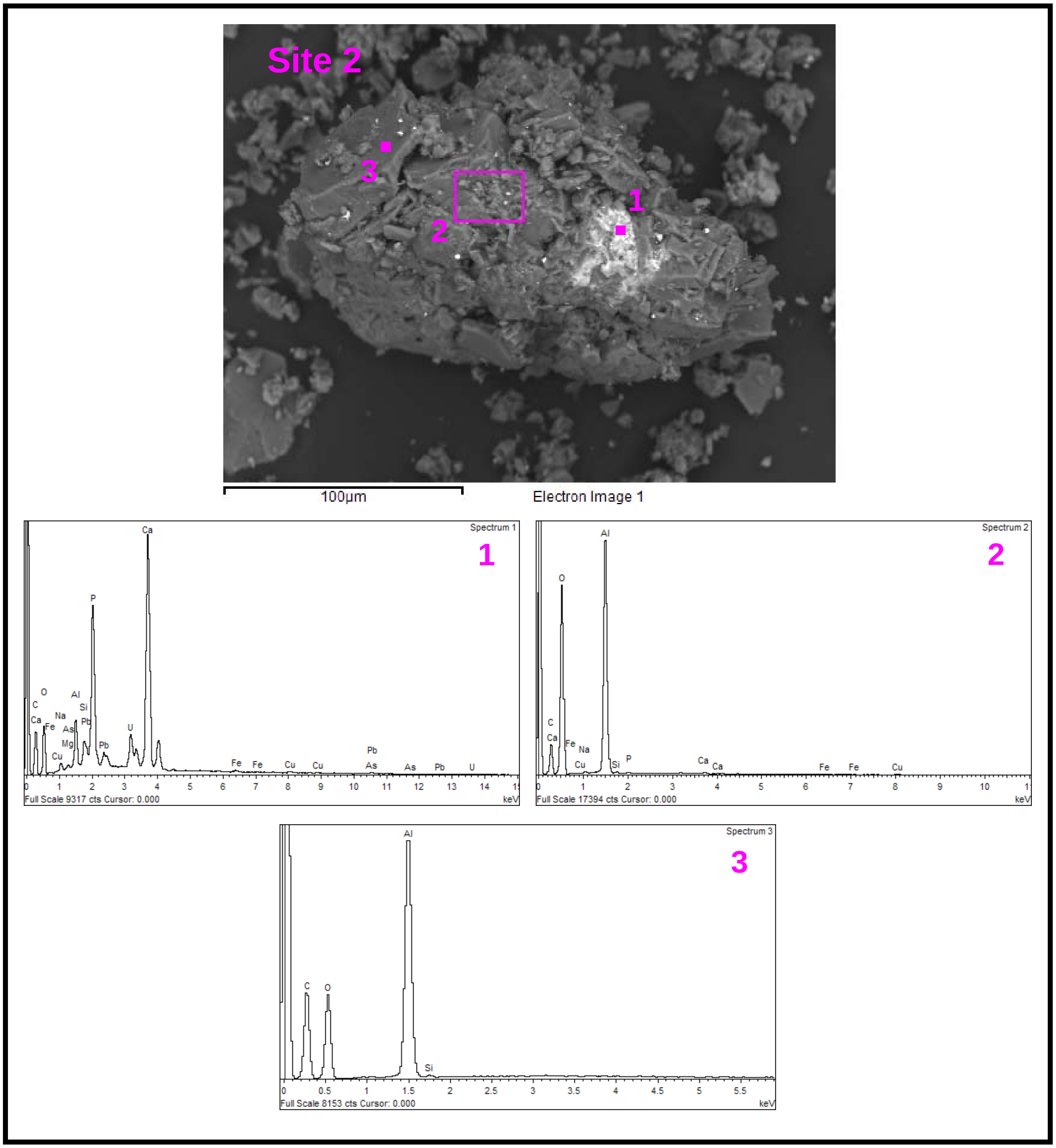

Figure E.30. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

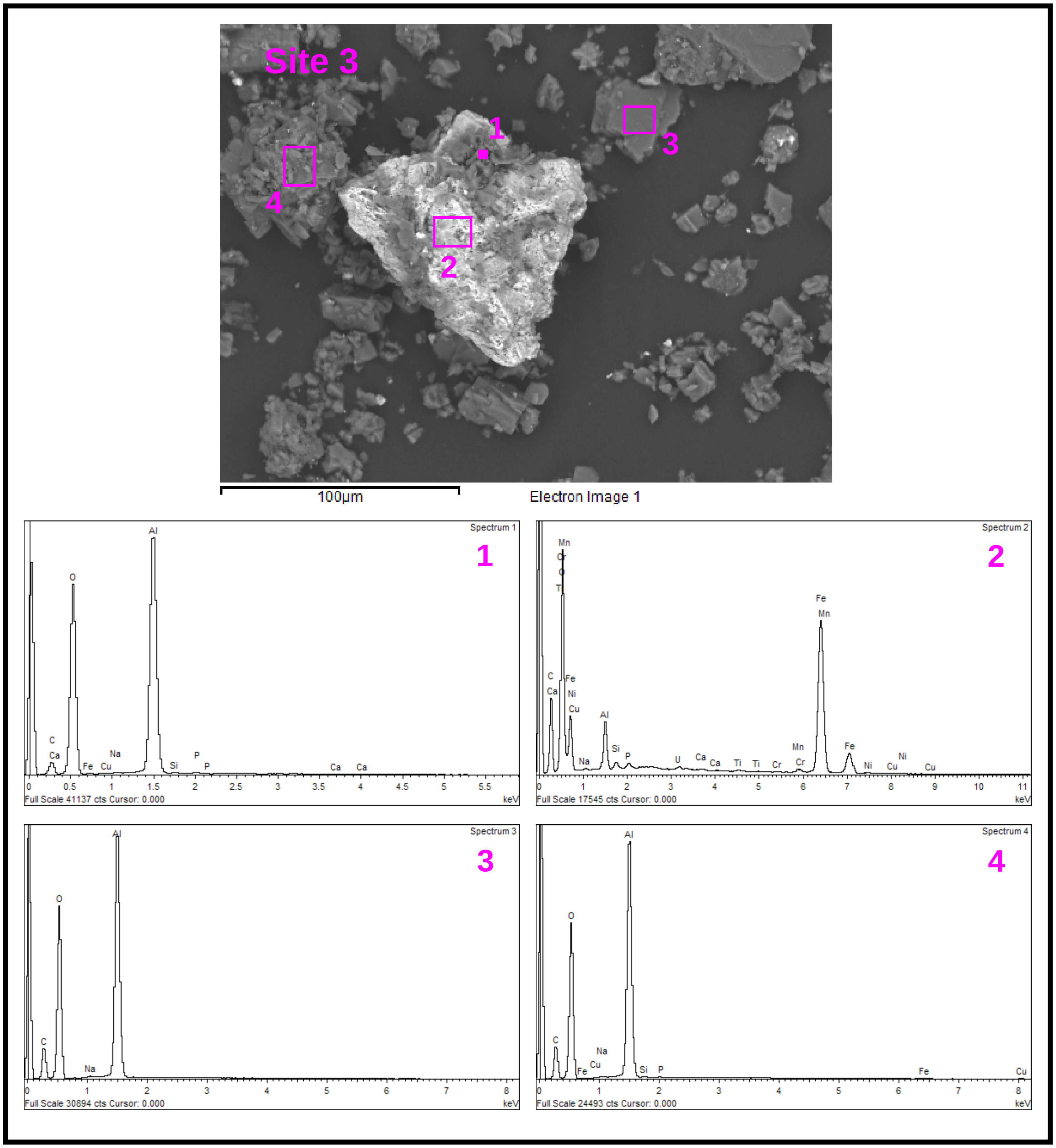

Figure E.31. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

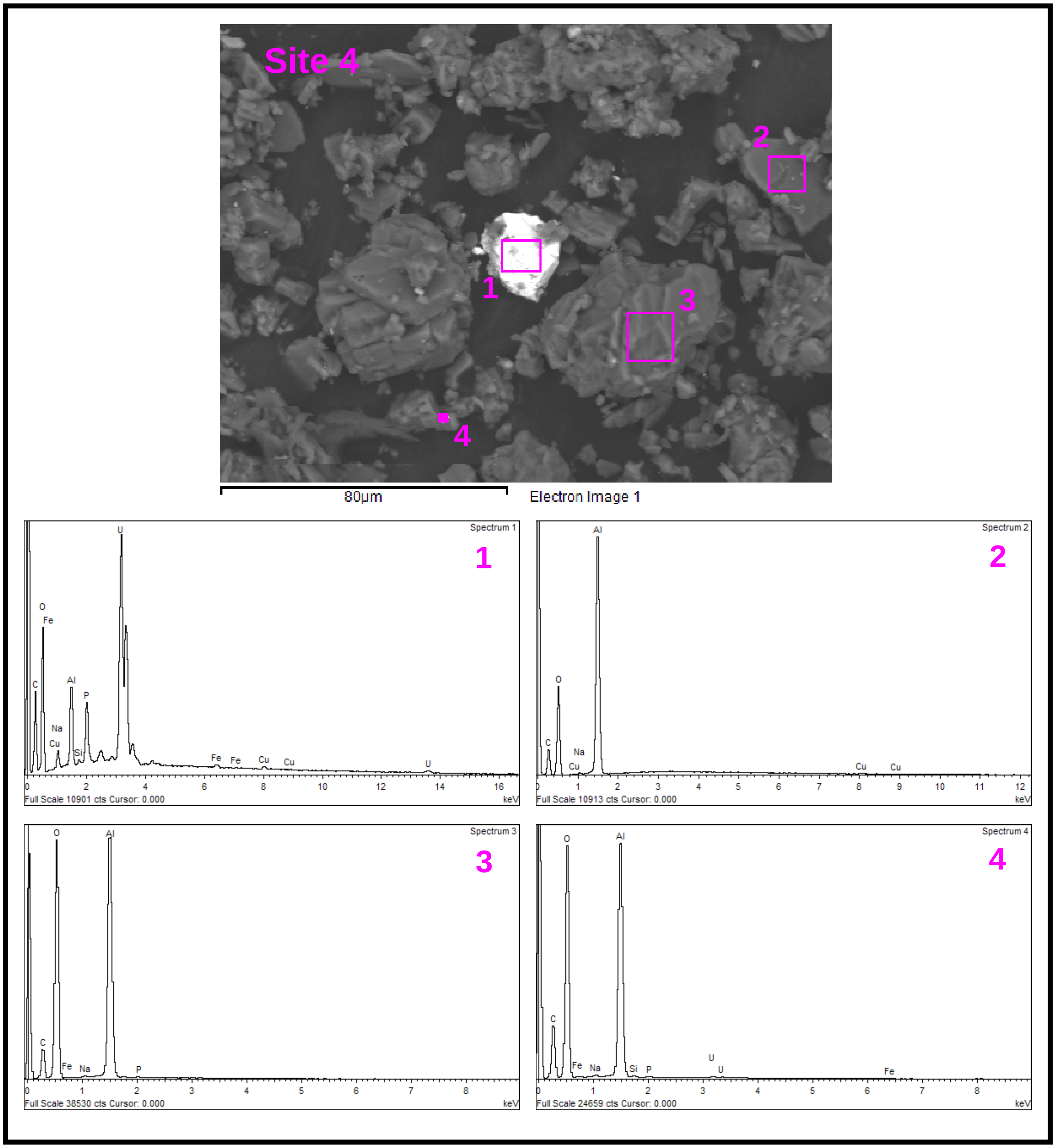

Figure E.32. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

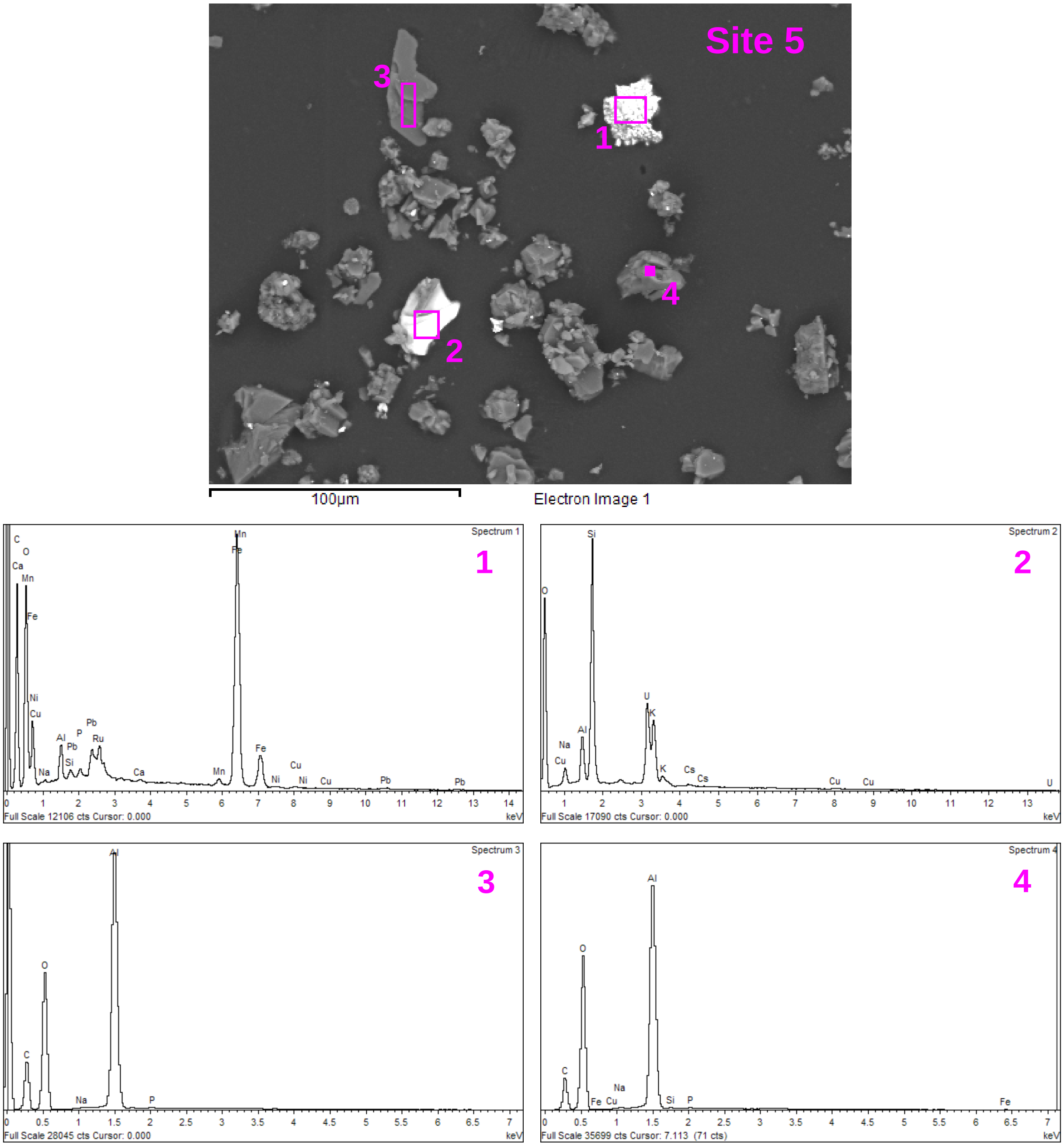

Figure E.33. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

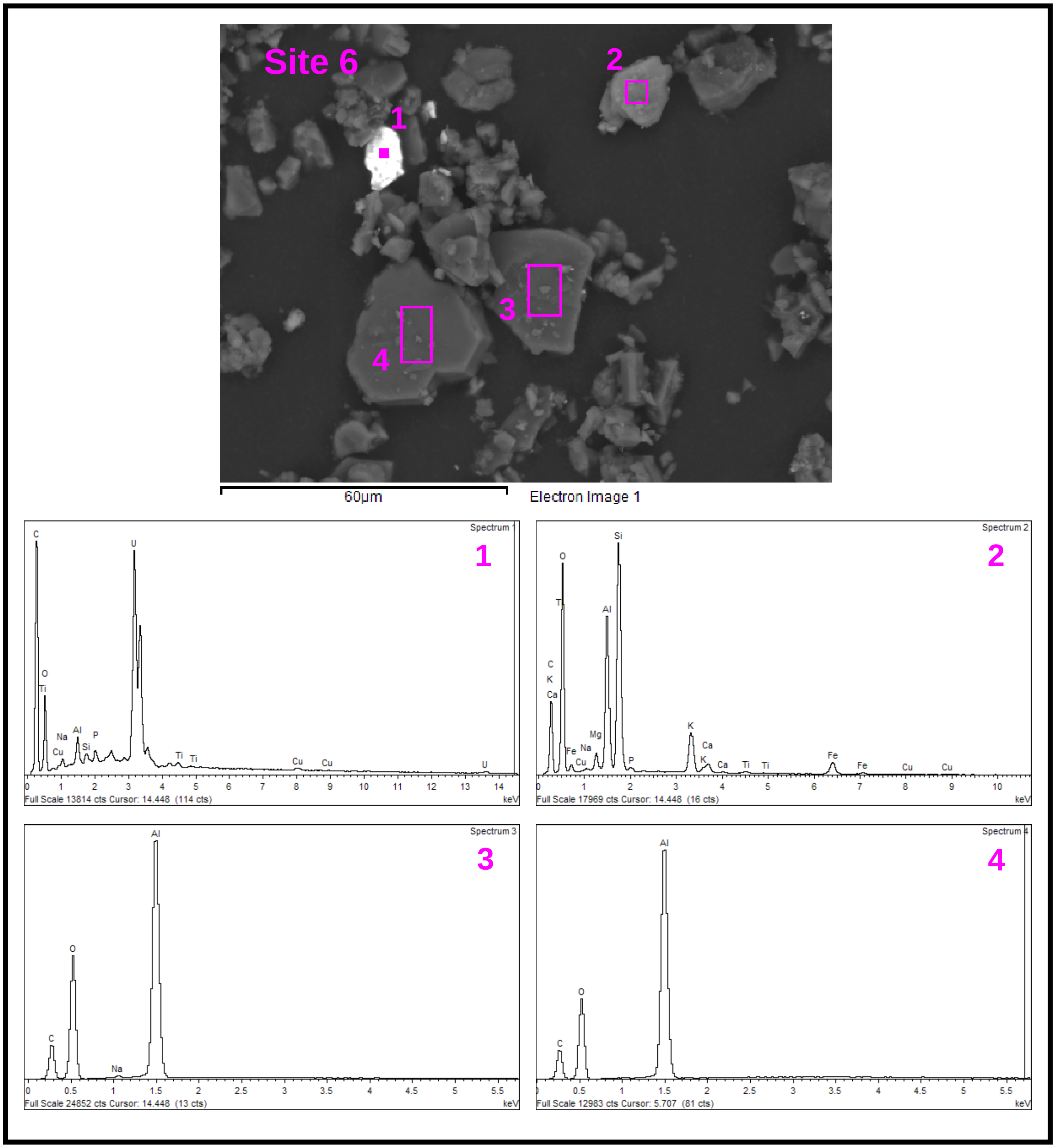

Figure E.34. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

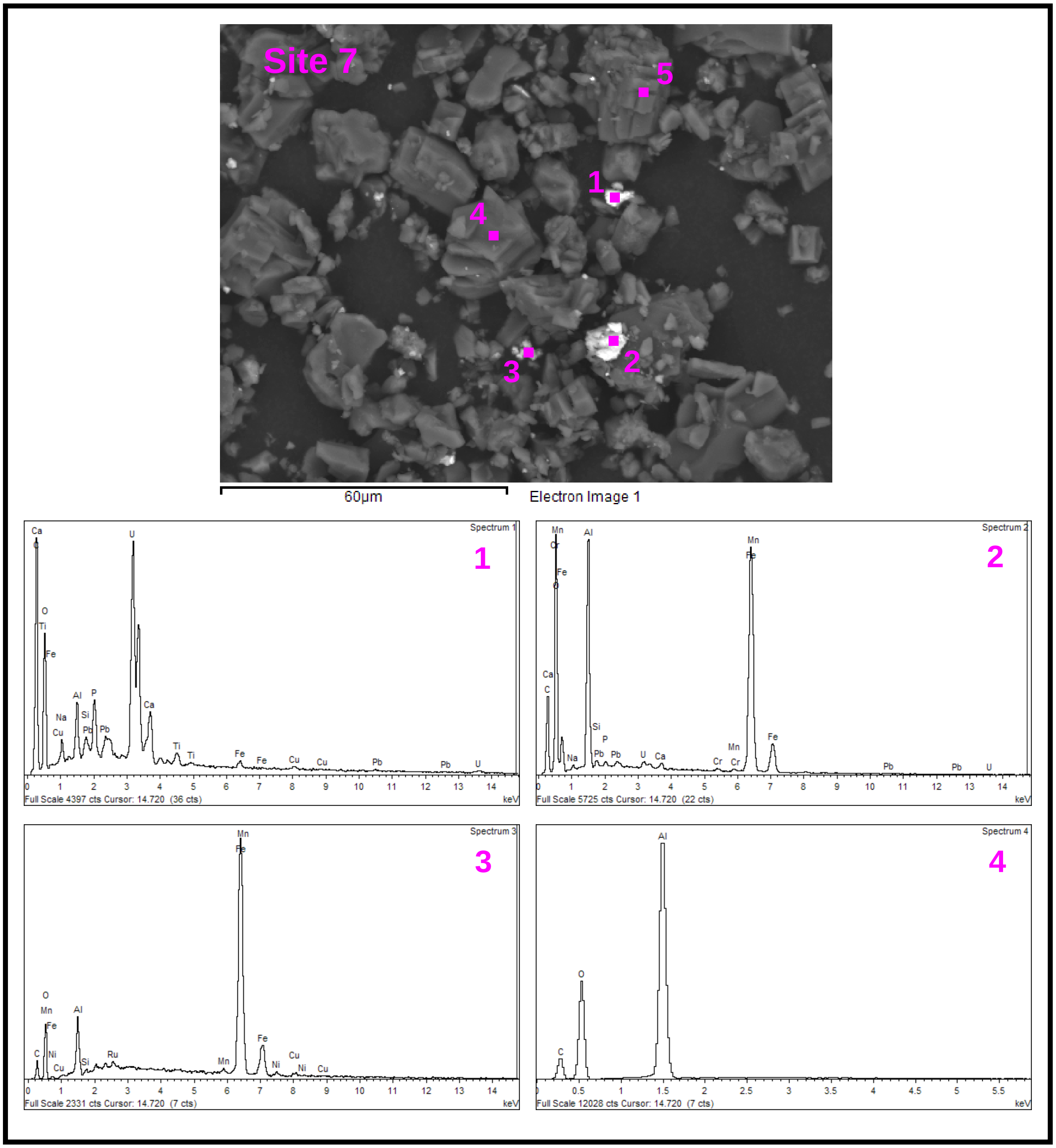

Figure E.35. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

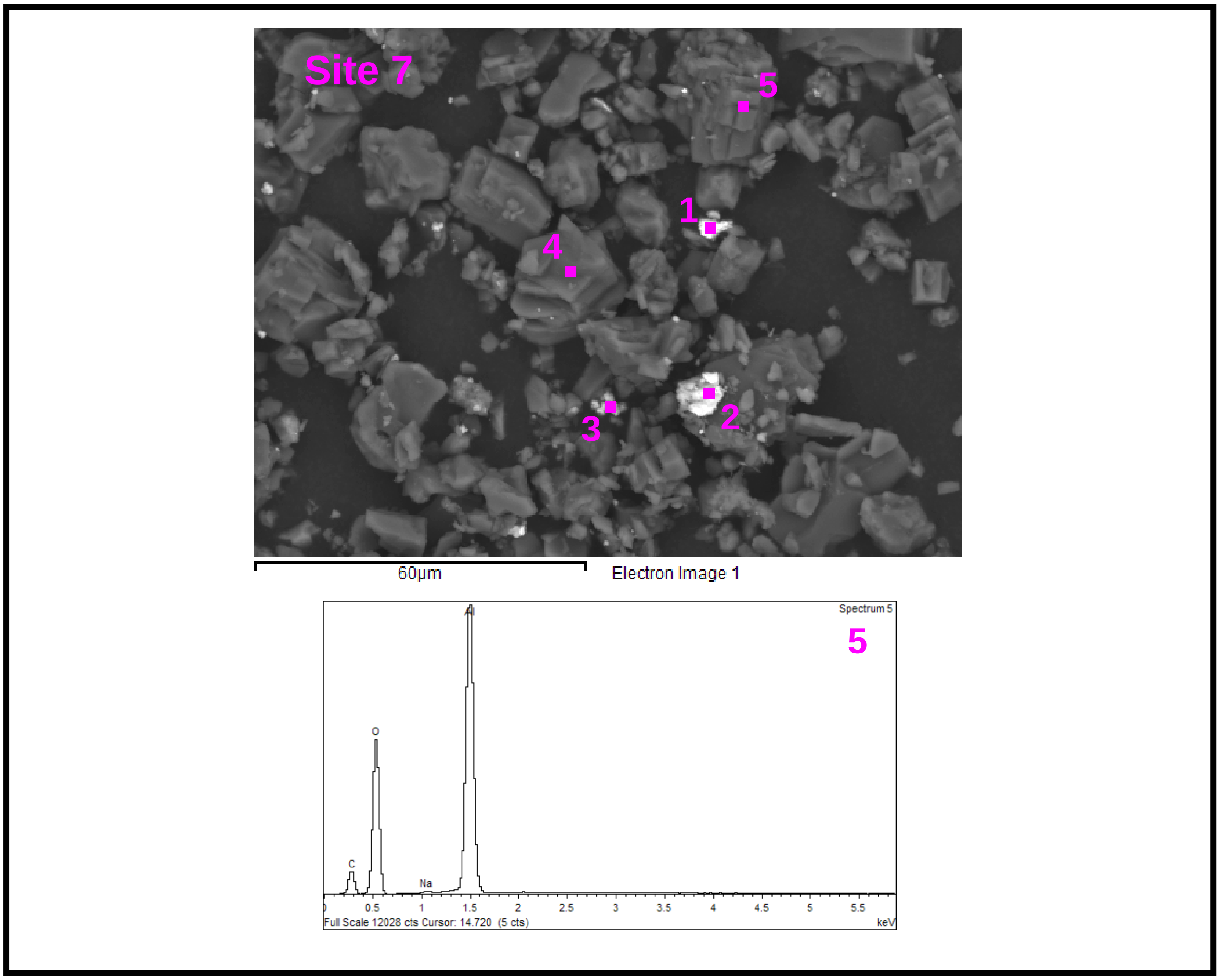

Figure E.36. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

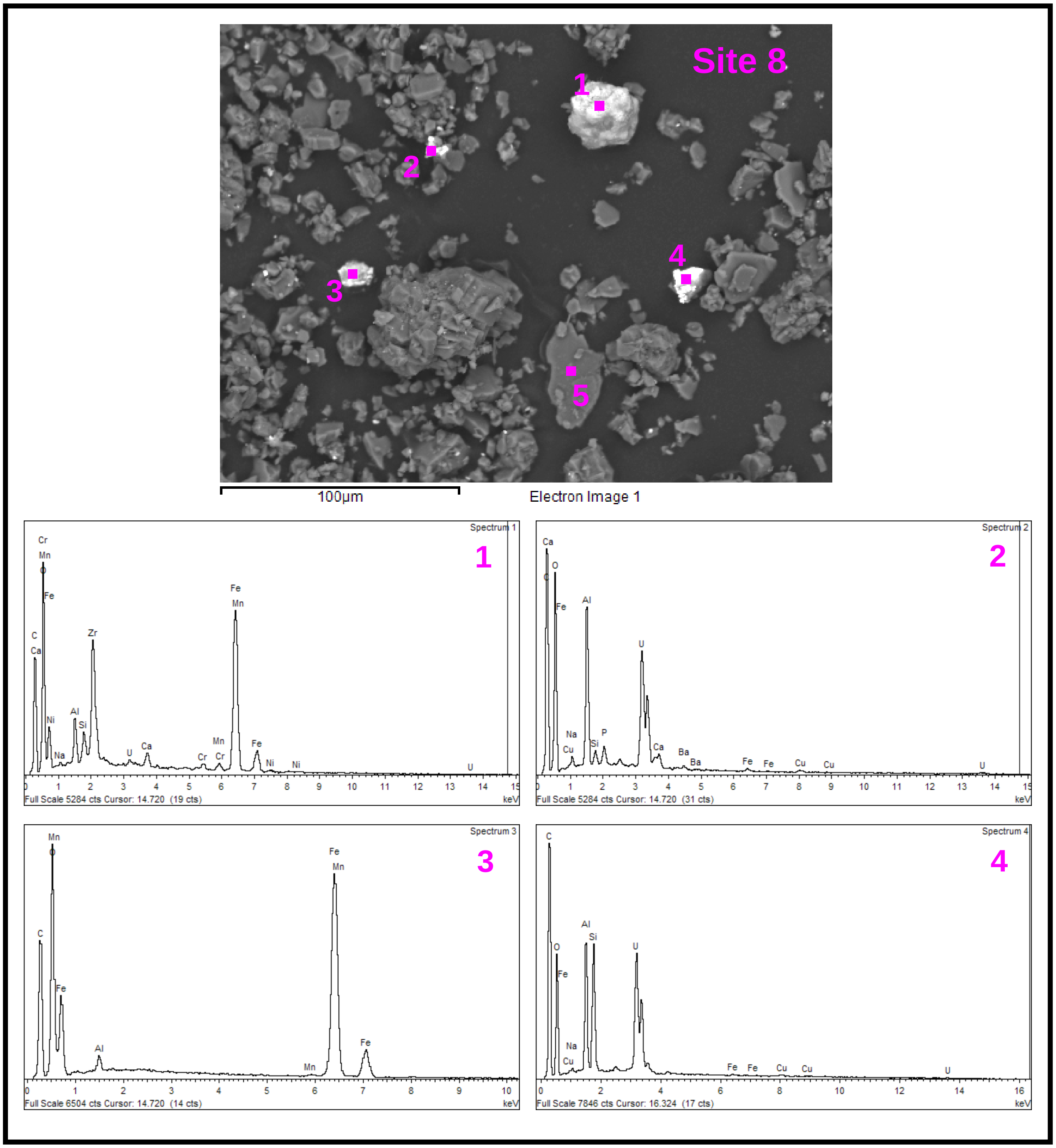

Figure E.37. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

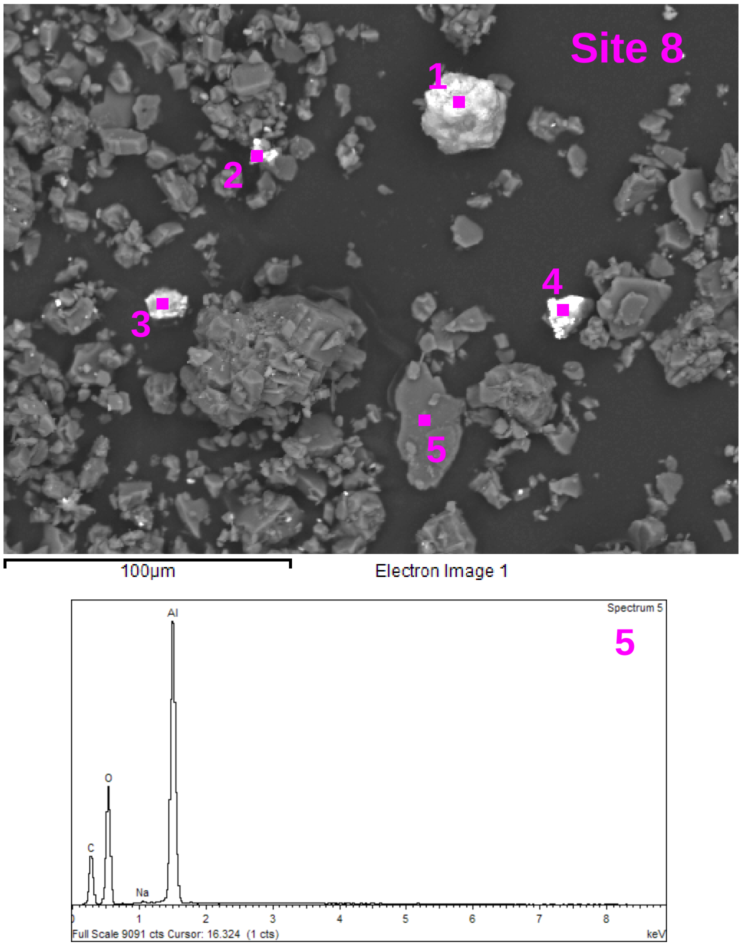

Figure E.38. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19849 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

Table E.4. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[a]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.29/1	1	4.8	1.7	1.0	0.5	3.5	35.5		1.0			46.4	0.6	Cu (0.5), Mg (0.4), Pb (3.6), Zn (0.5)
	2	3.5	1.1	1.1	0.1	0.6	47.0					40.4	0.5	Cu (0.5), Mn (0.8), Ni (0.3), Pb (4.1)
	3	33.0		0.3								66.6	0.2	
	4	35.6		0.3								64.0	0.2	
E.30/2	1	4.0	1.4	1.2	28.9	12.3	0.4					32.5	14.1	Cu (0.8), Mg (0.4), Pb (3.9)
	2	31.8	0.3	0.4	0.2		0.2					66.2	0.2	Cu (0.6)
	3	44.7	0.7									54.6		
E.31/3	1	32.2	0.2	0.2	0.1		0.9					66.1	0.2	Cu (0.2)
	2	5.7	0.7	0.5	0.2	0.9	47.8	0.1				41.6	0.5	Cu (0.3), Mn (0.9), Ni (0.5), Ti (0.2)
	3	34.5		0.3								65.2		
	4	35.1	0.3	0.3			0.4					63.4	0.2	Cu (0.4)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.5. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %(a)												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.32/4	1	5.5	0.3	2.0		53.2	0.6					33.5	3.9	Cu (1.0)
	2	44.6		0.5								53.9		Cu (1.0)
	3	29.8		0.3			0.1					69.6	0.2	
	4	29.0	0.2	0.4		0.8	0.3					69.0	0.2	
E.33/5	1	2.7	0.6	0.5	0.2		50.8					32.2	0.5	Cu (0.7), Mn (1.1), Ni (0.4), Pb (5.3), Ru (5.0)
	2	3.3	17.7	2.0		25.6						48.9		Cs (0.4), Cu (0.4), K (1.6)
	3	38.7		0.2								60.9	0.2	
	4	34.7	0.2	0.3			0.2					64.2	0.2	Cu (0.3)
E.34/6	1	2.7	0.7	1.3		66.0						26.7	1.1	Cu (1.0), Ti (0.5)
	2	11.5	18.7	0.3	1.0		3.6					58.4	0.4	Cu (0.2), K (4.3), Mg (1.4), Ti (0.3)
	3	39.3		0.5								60.3		
	4	45.2										54.8		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.6. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %(a)												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.35 and E.36/7	1	3.3	0.7	2.2	3.7	47.5	1.2					33.2	3.2	Cu (0.9), Pb (2.7), Ti (1.4)
	2	16.4	0.4	0.7	0.5	1.4	45.4	0.3				33.3	0.3	Mn (0.5), Pb (0.9)
	3	7.7	0.5				72.2					13.0		Cu (2.1), Mn (1.1), Ni (1.6), Ru (1.8)
	4	42.7										57.3		
	5	38.6		0.3								61.1		
E.37 and E.38/8	1	3.0	1.3	0.6	1.1	1.3	32.3	0.7				40.9		Mn (1.1), Ni (0.5)
	2	12.2	1.1	1.3	1.2	33.7	0.6					46.5	1.5	Ba (1.0), Cu (0.9)
	3	1.8					60.5					37.3		Mn (0.4)
	4	10.9	11.1	0.6		39.6	0.4					36.8		Cu (0.6)
	5	42.6		0.5								56.9		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

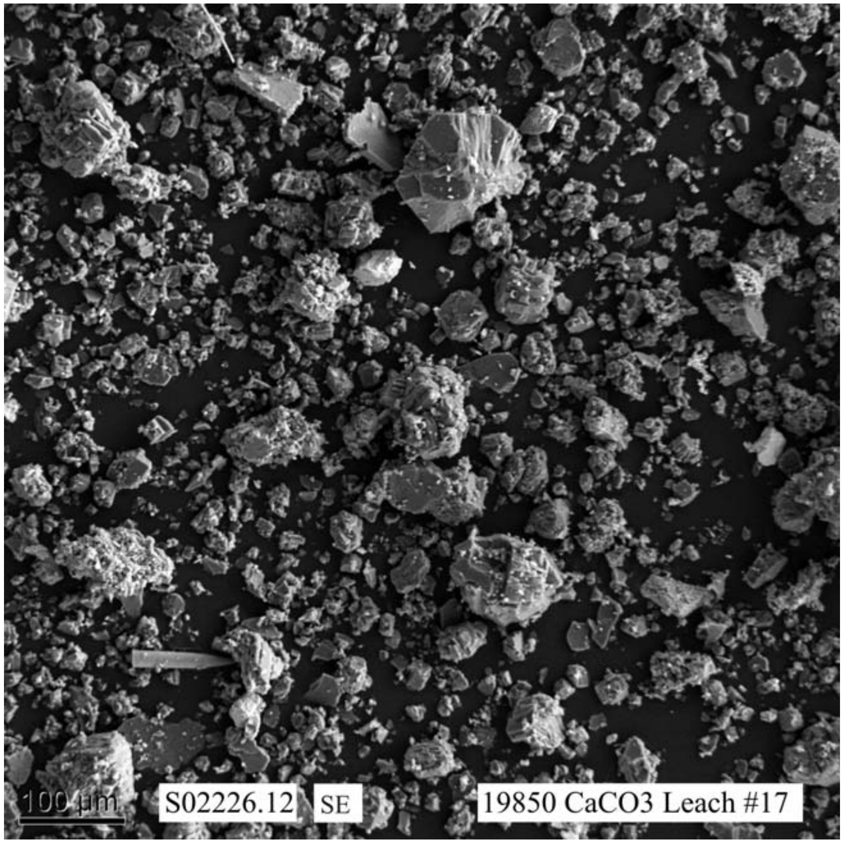

Figure E.39. Low Magnification Secondary-Electron SEM Micrograph Showing General Morphologies of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

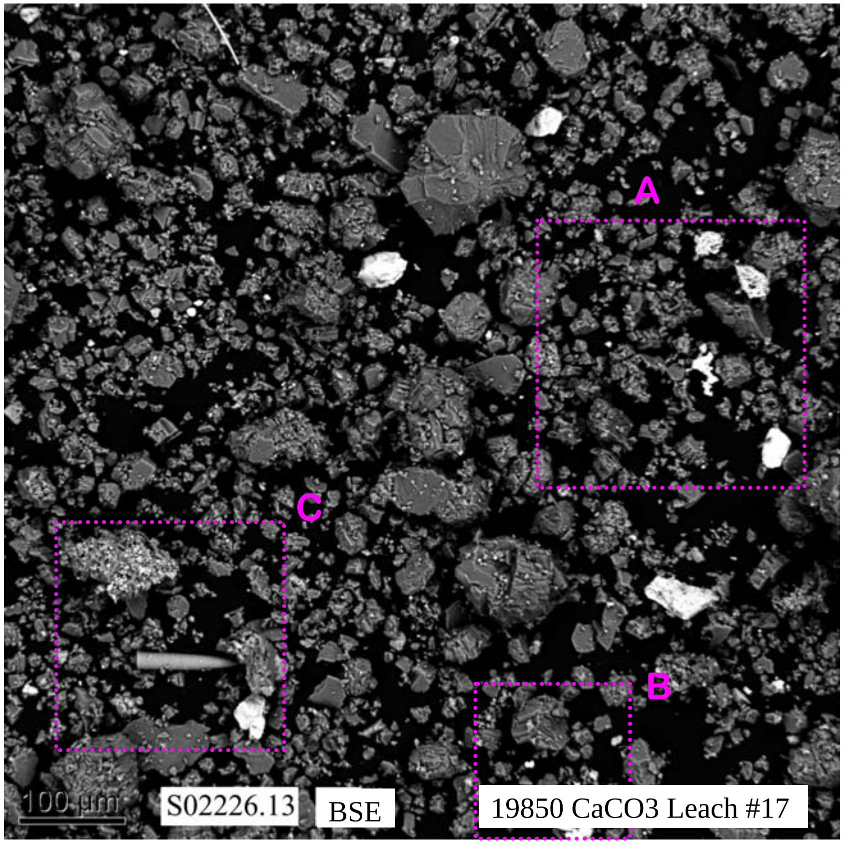

Figure E.40. Low Magnification Backscattered-Electron SEM Micrograph Showing Same Particles as in Figure E.39

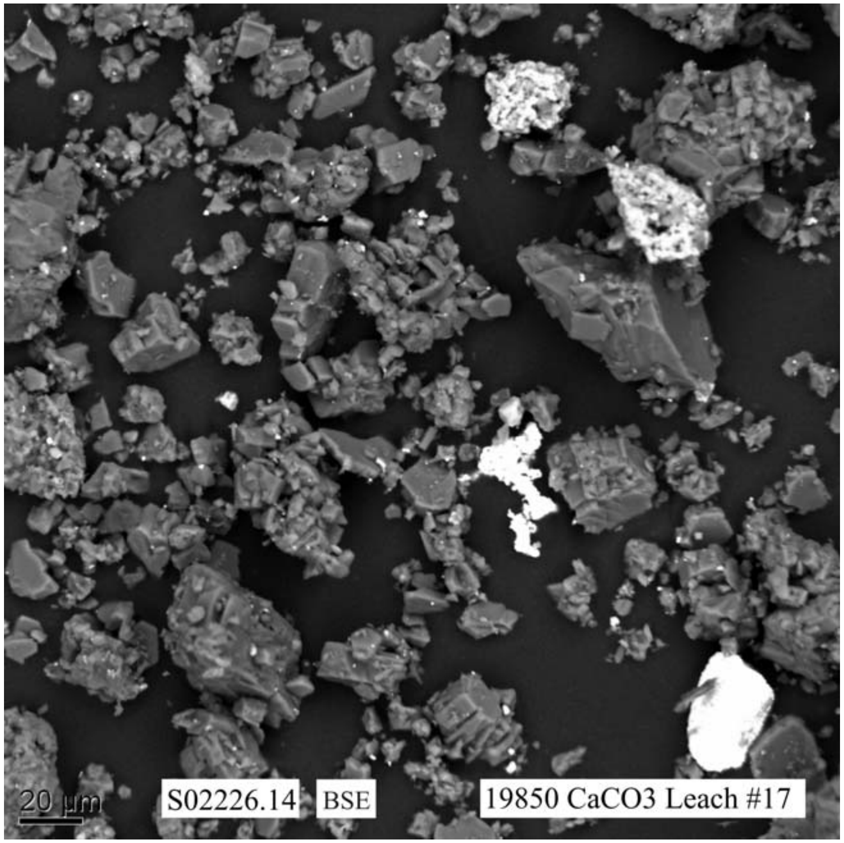

Figure E.41. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square A in Figure E.40 (Areas where EDS analyses were made are shown in Figures E.50 and E.51.)

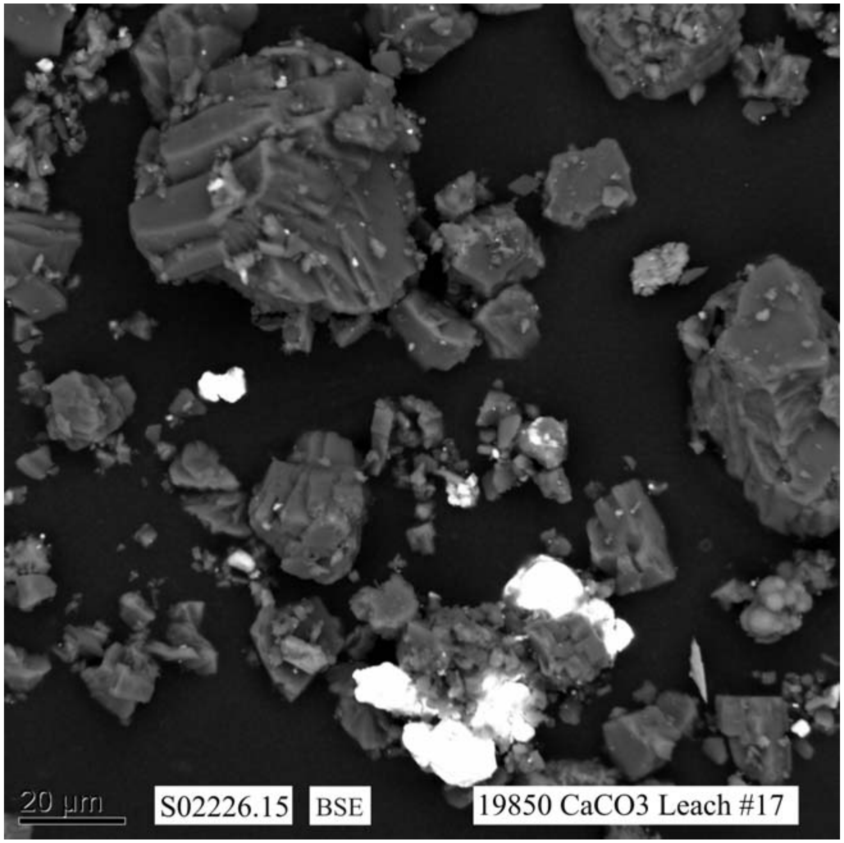

Figure E.42. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square B in Figure E.40 (Areas where EDS analyses were made are shown in Figures E.52 and E.53.)

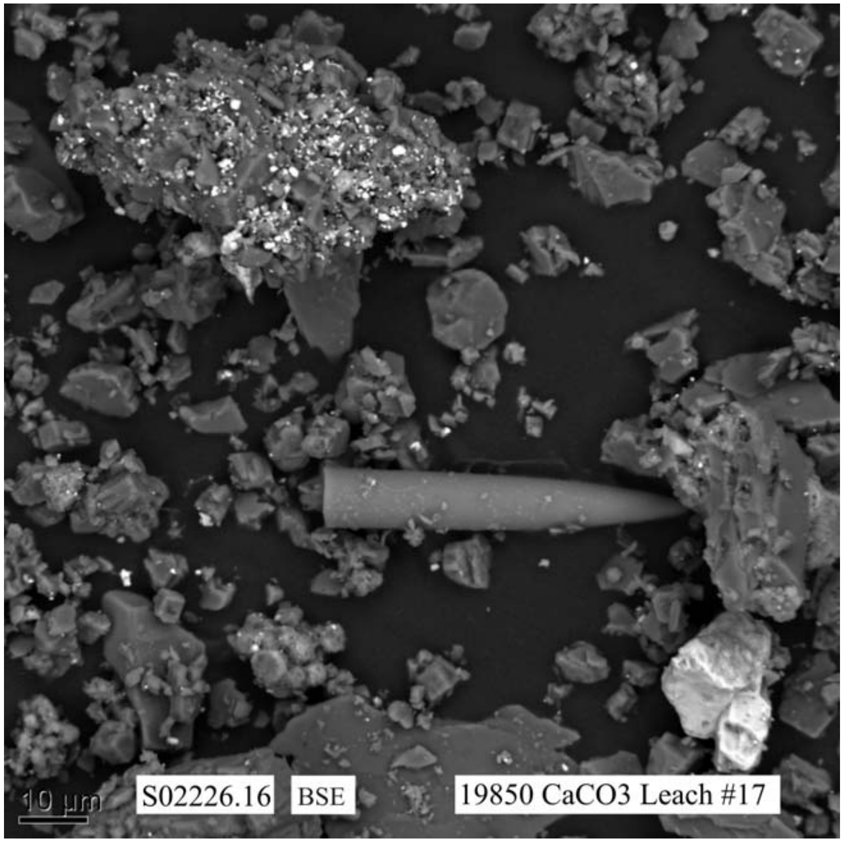

Figure E.43. Micrograph Showing at Higher Magnification the Particles in the Area Indicated by the Pink Dotted-Line Square C in Figure E.40 (Areas where EDS analyses were made are shown in Figure E.54. The bullet-shaped particle near center is part of a fiber from filter material used to minimize dispersion of the dried residual waste.)

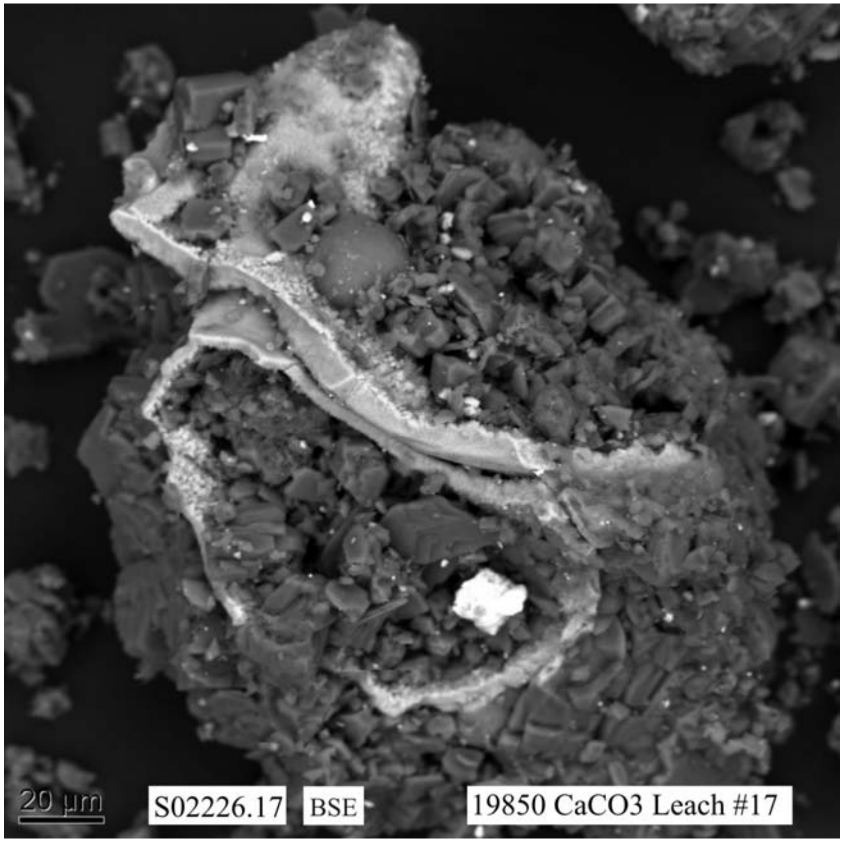

Figure E.44. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.55 and E.56.)

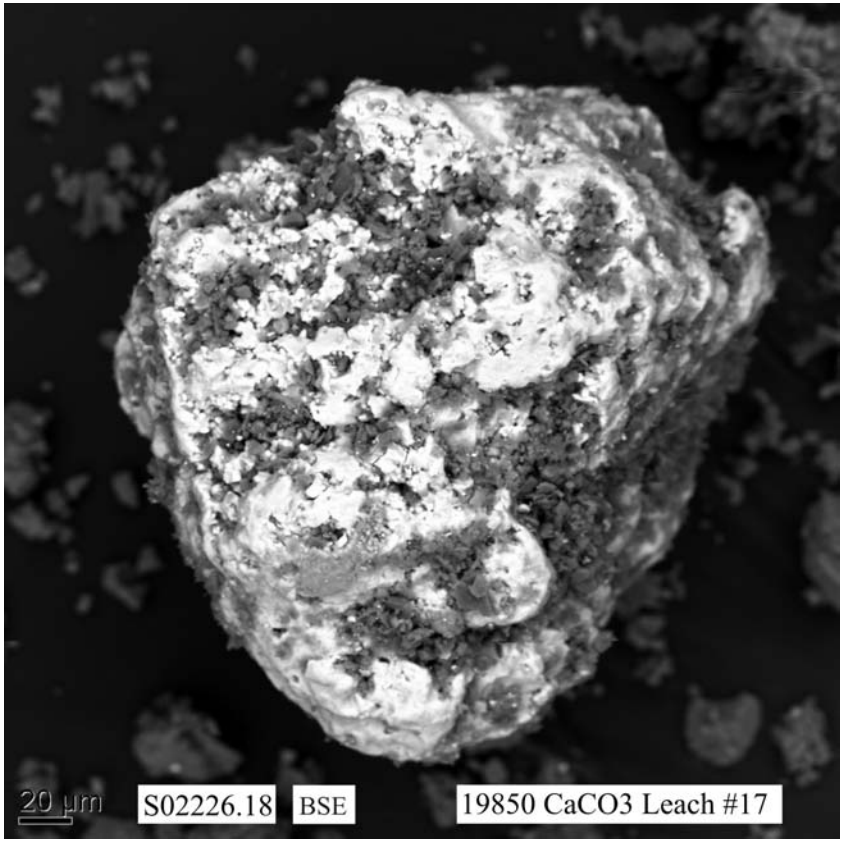

Figure E.45. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.57.)

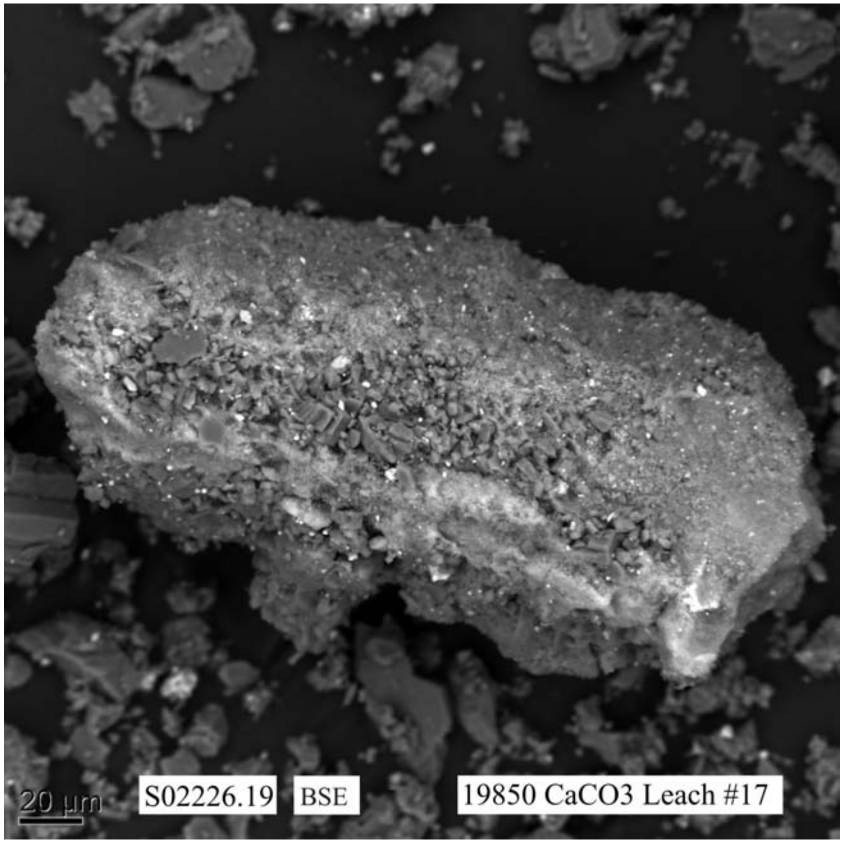

Figure E.46. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.58.)

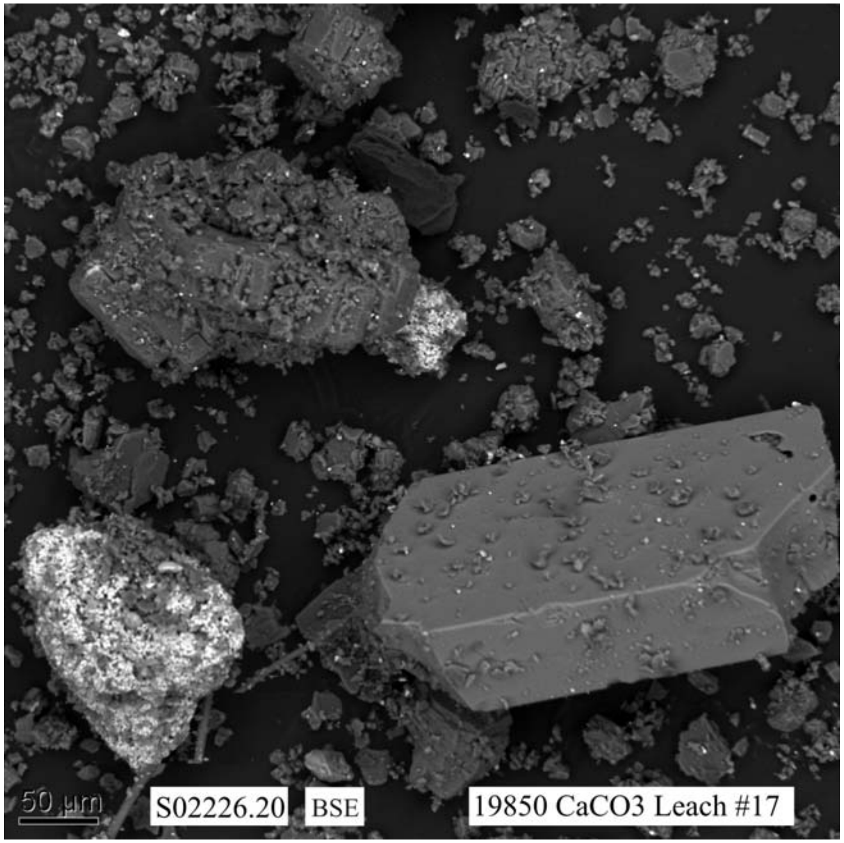

Figure E.47. Micrograph Showing Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figure E.60.)

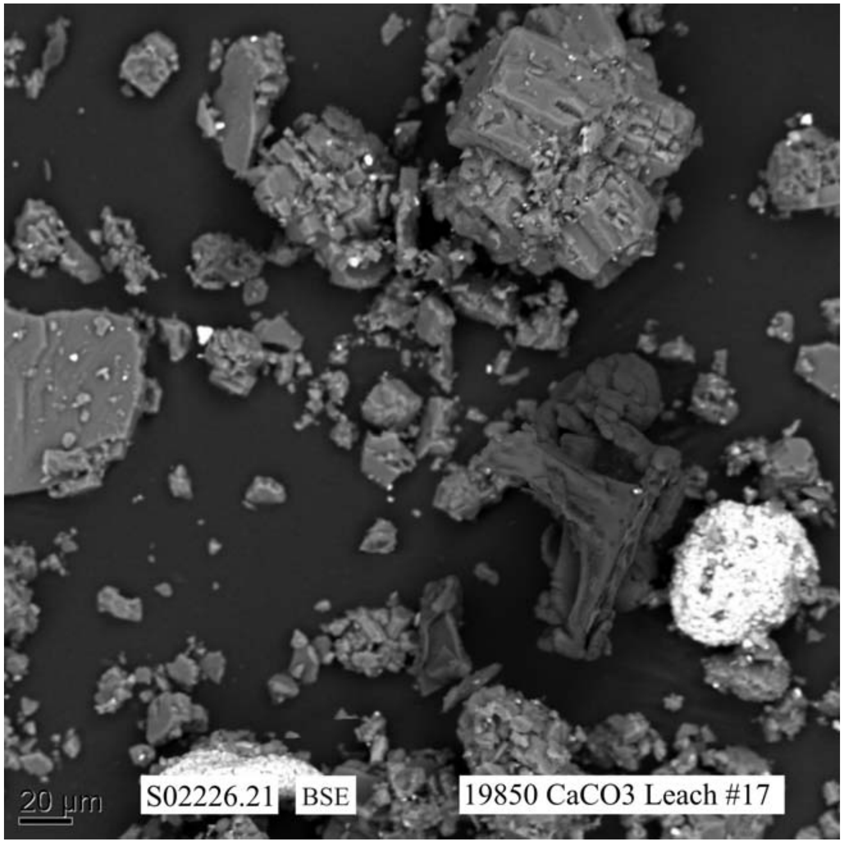

Figure E.48. Micrograph Showing Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.61 and E.62.)

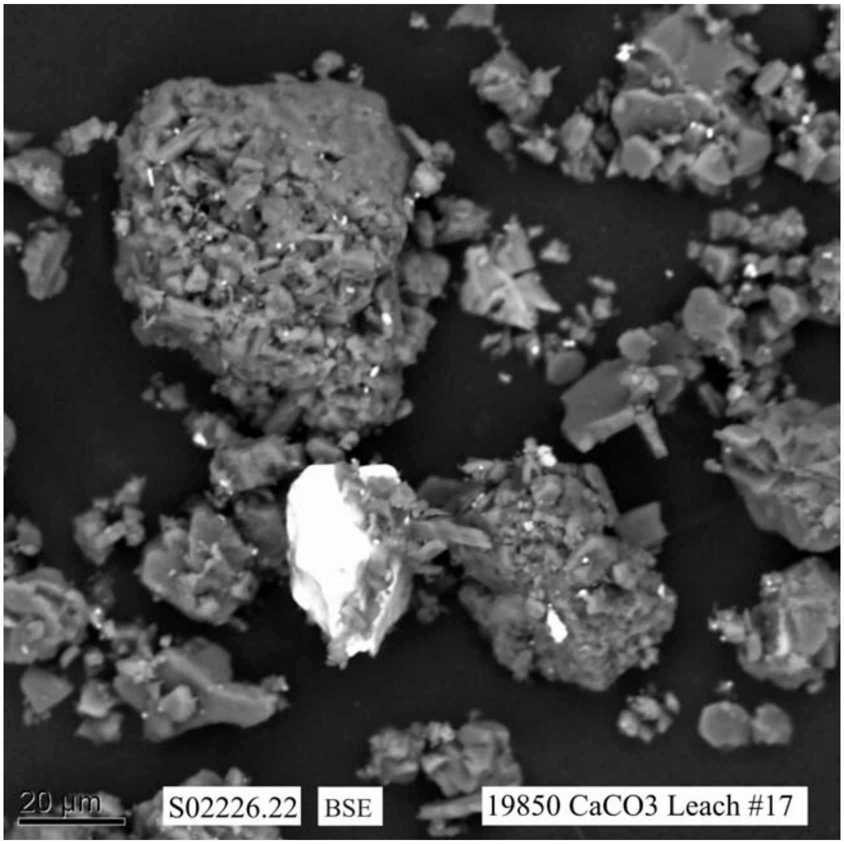

Figure E.49. Micrograph Showing Particle Aggregate in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103 (Areas where EDS analyses were made are shown in Figures E.63 and E.64.)

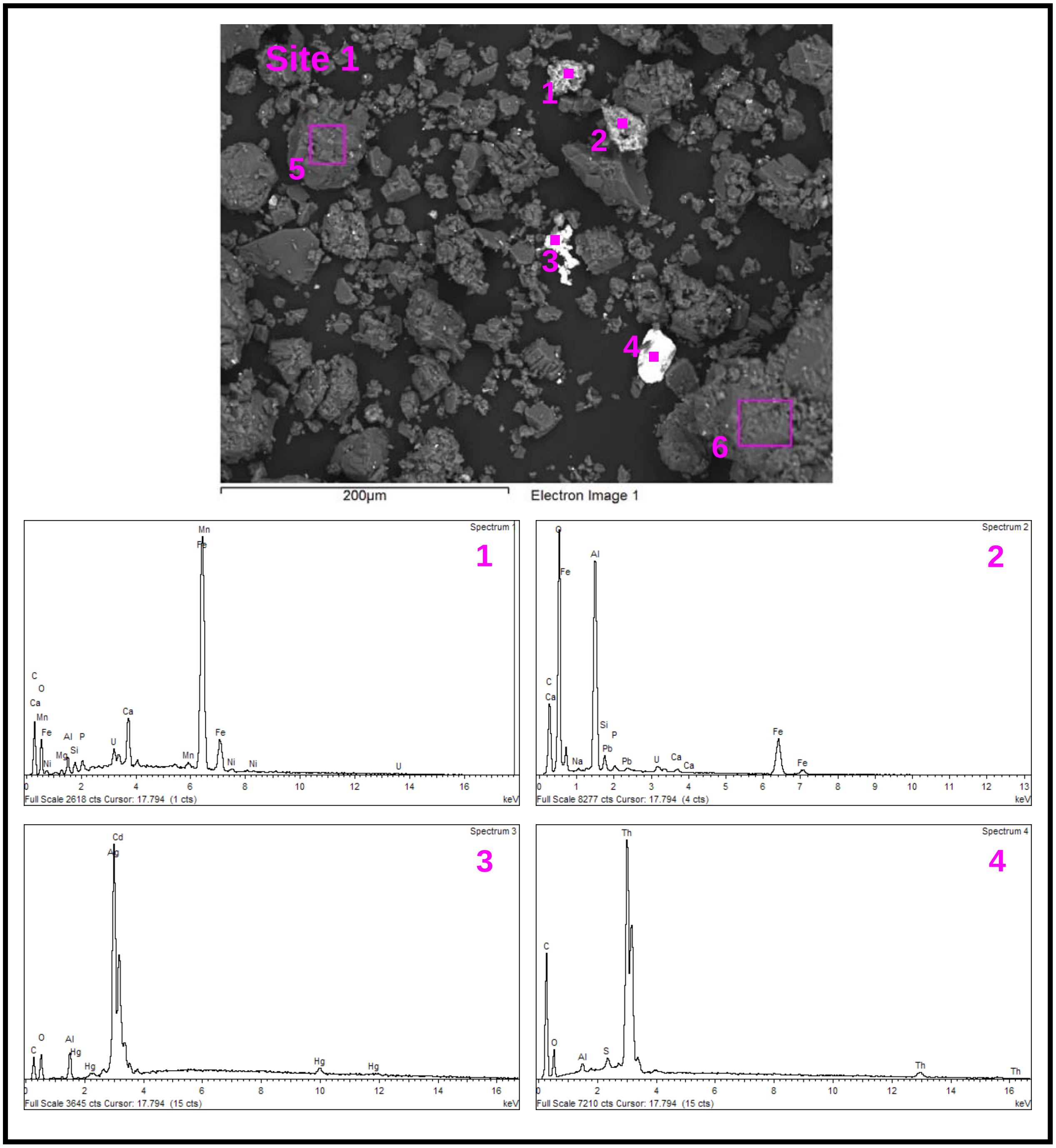

Figure E.50. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

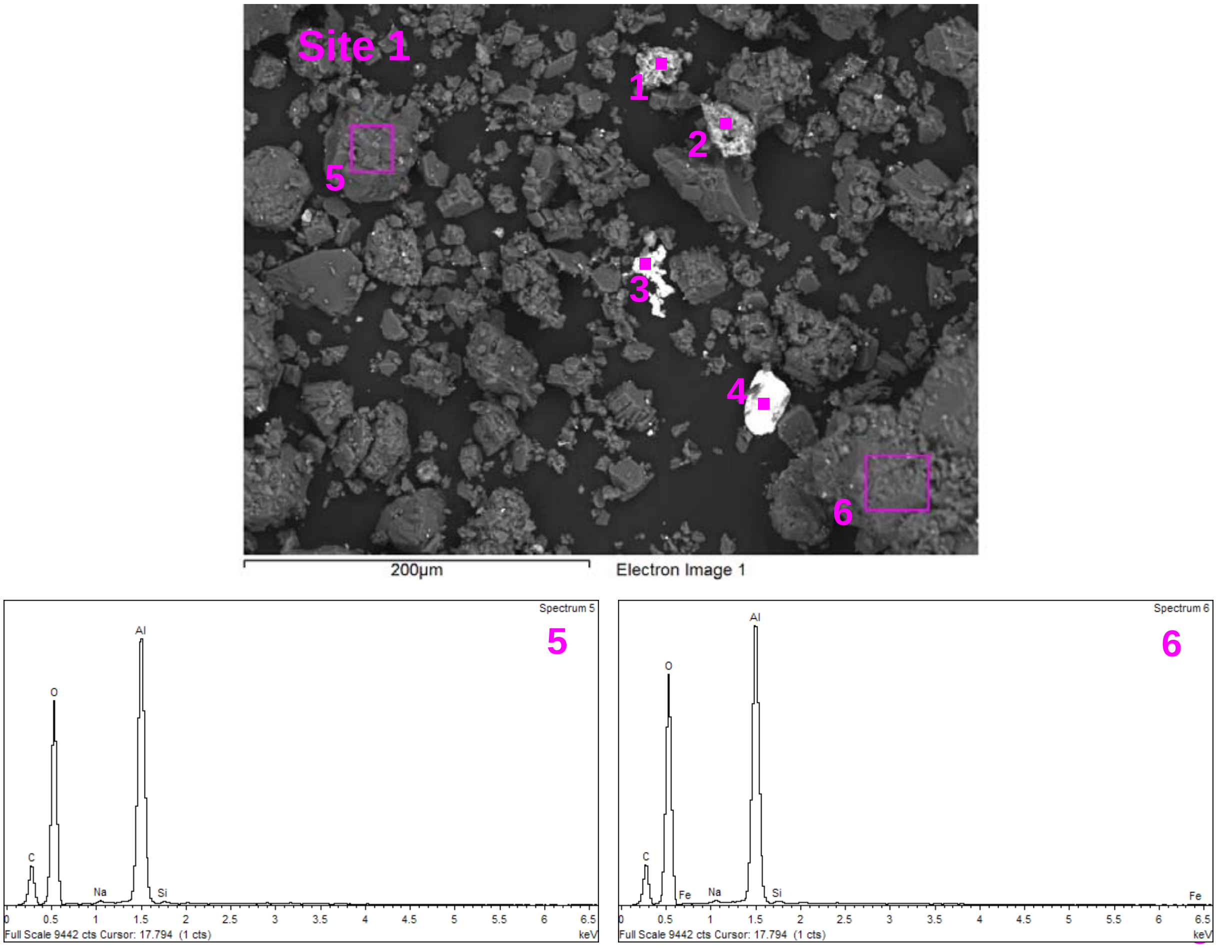

Figure E.51. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

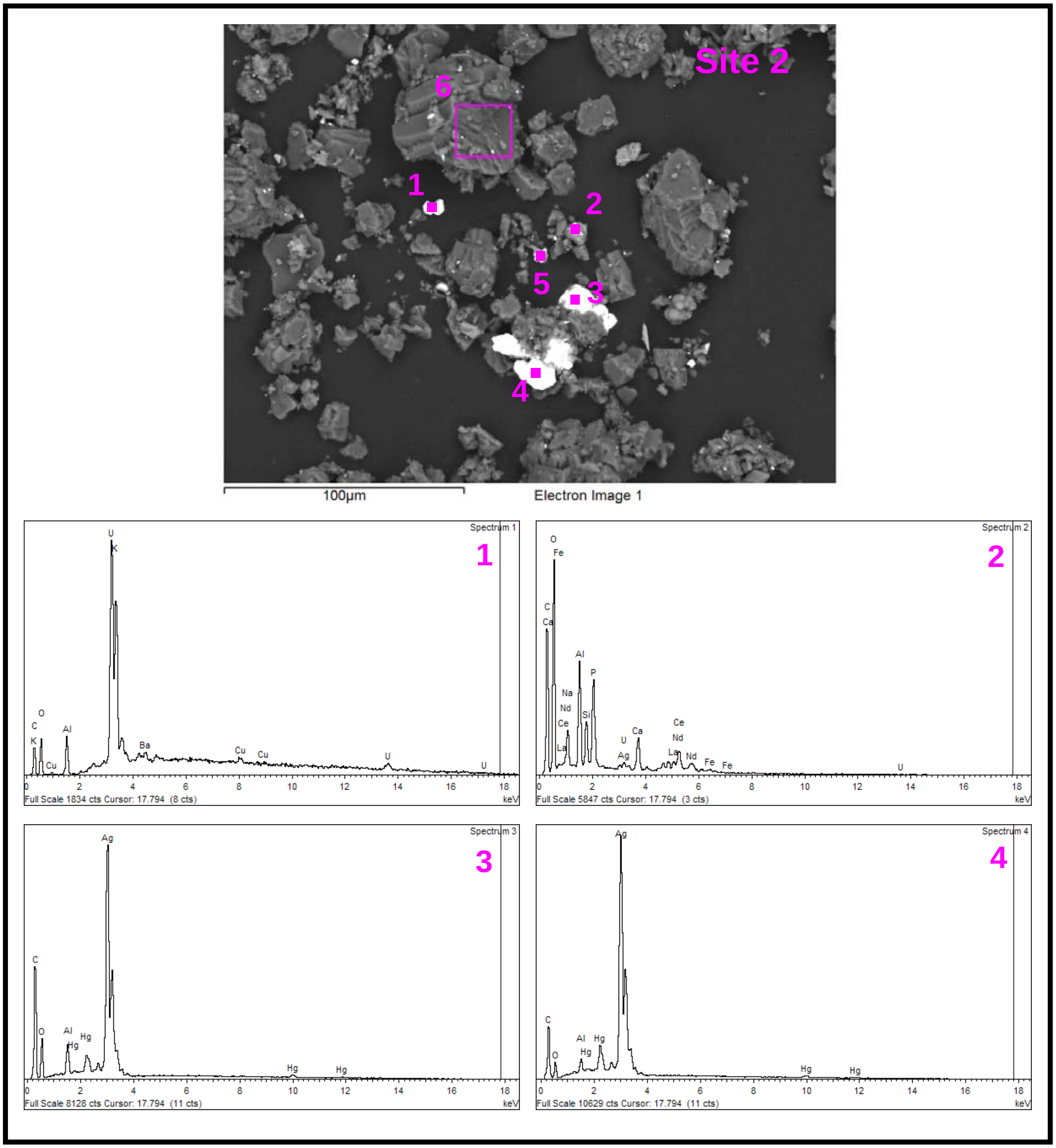

Figure E.52. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

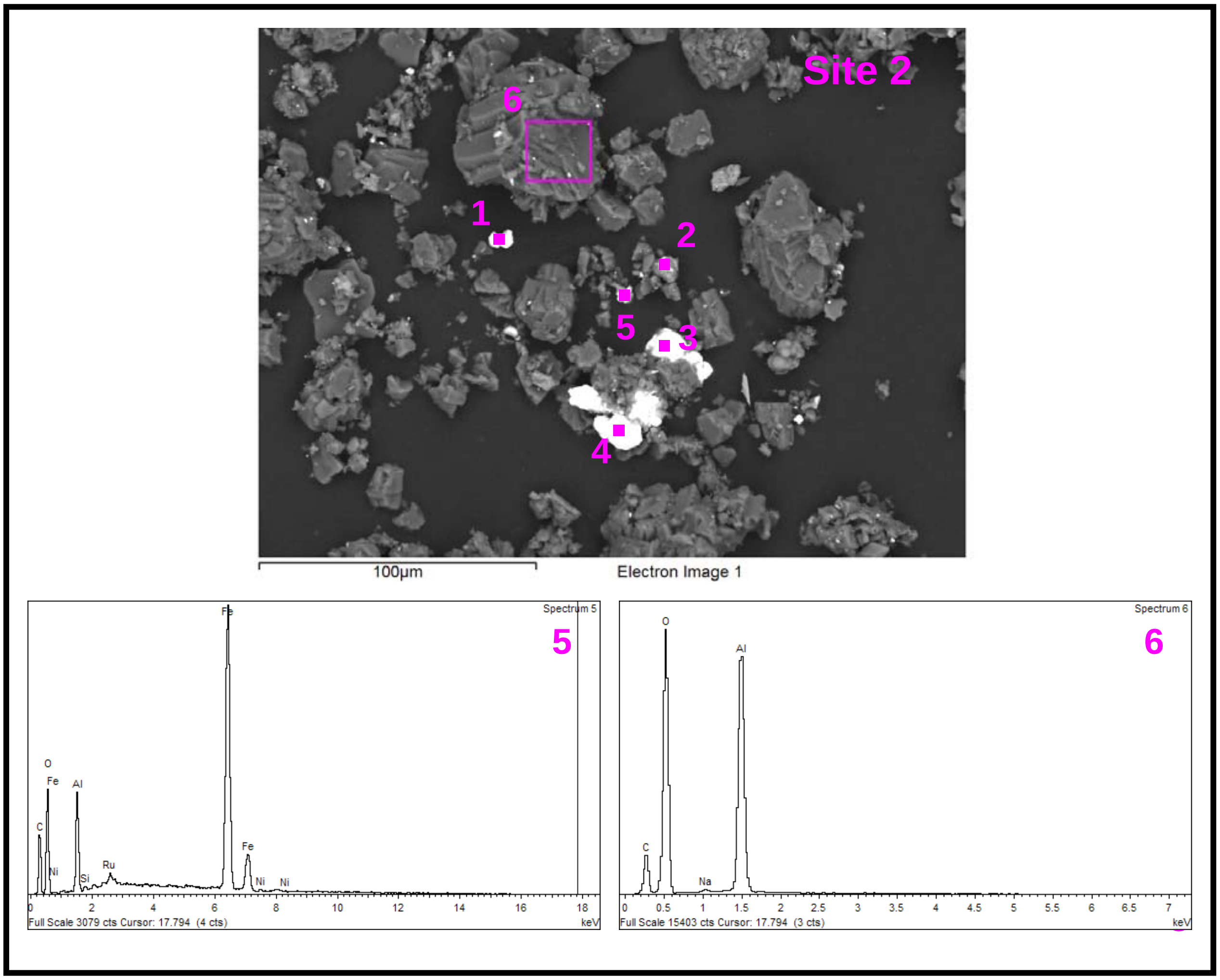

Figure E.53. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

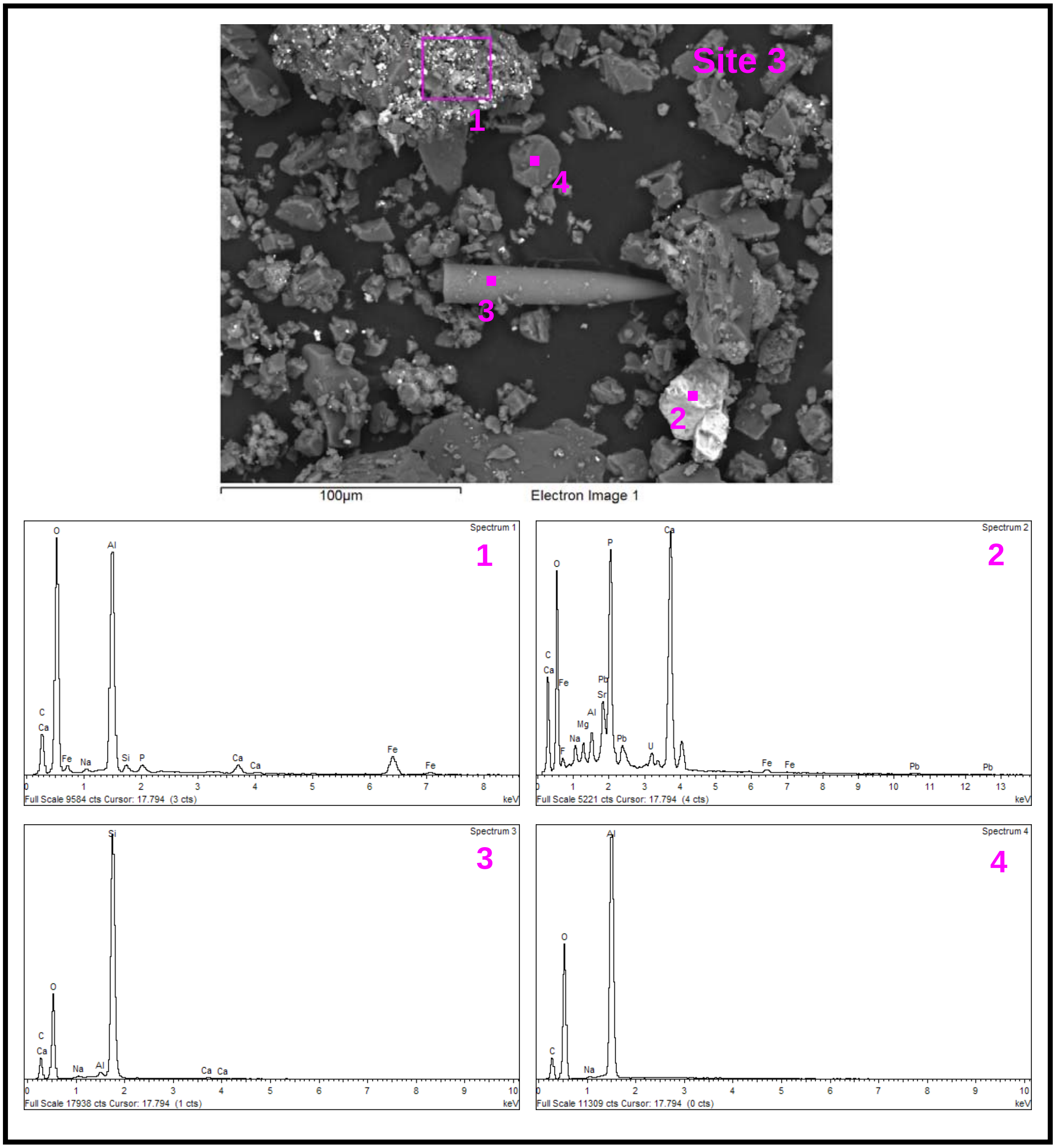

Figure E.54. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

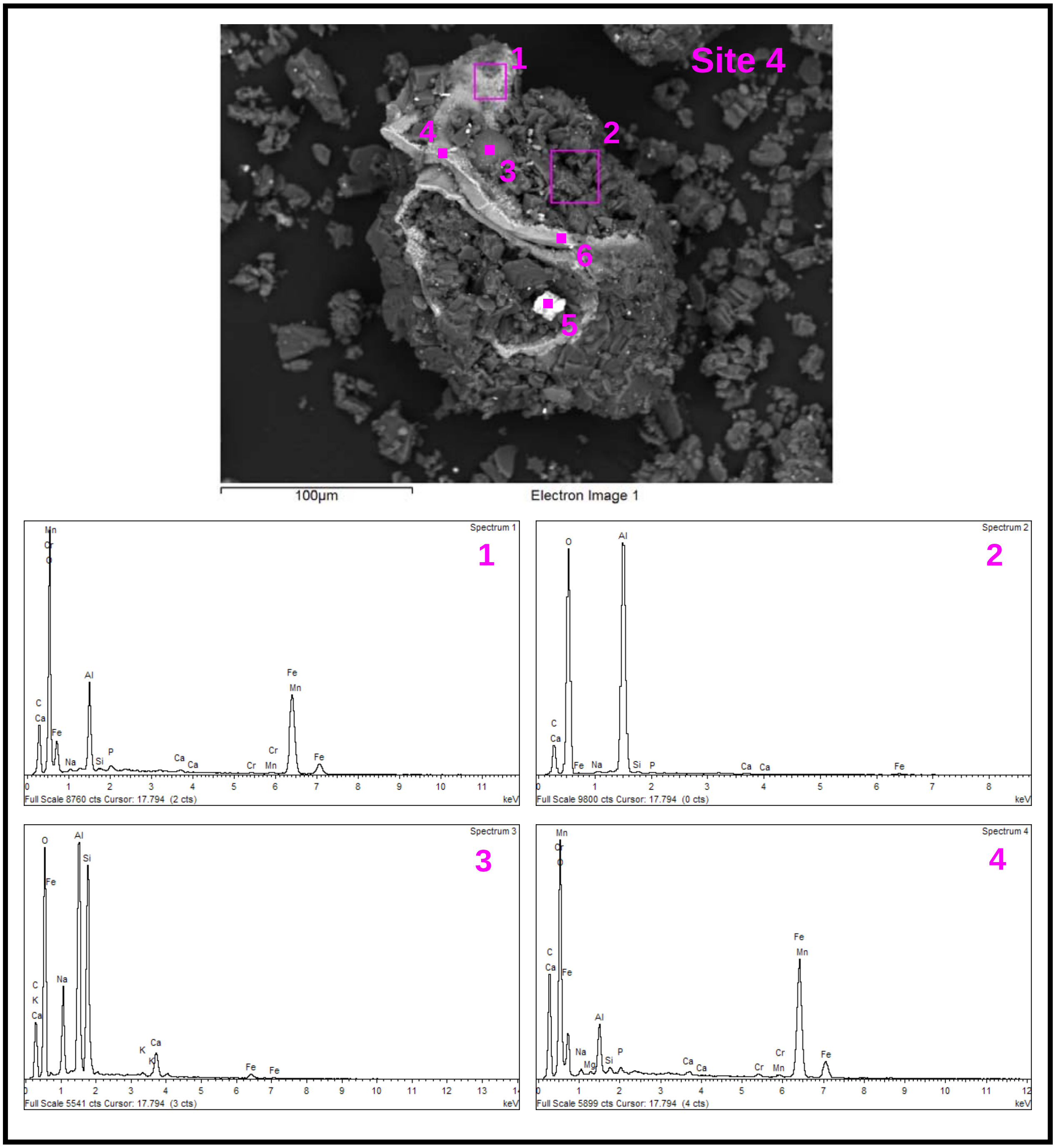

Figure E.55. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

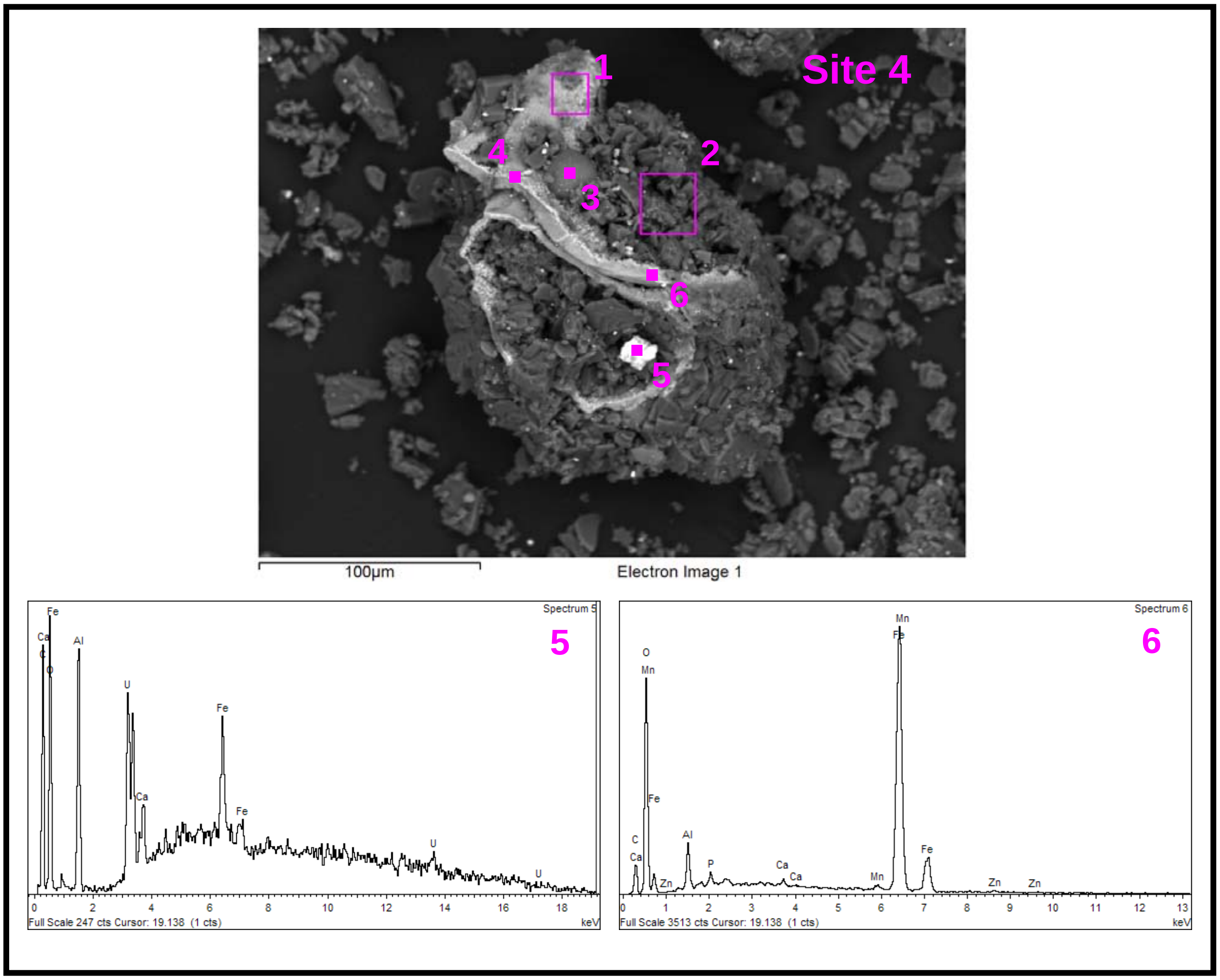

Figure E.56. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

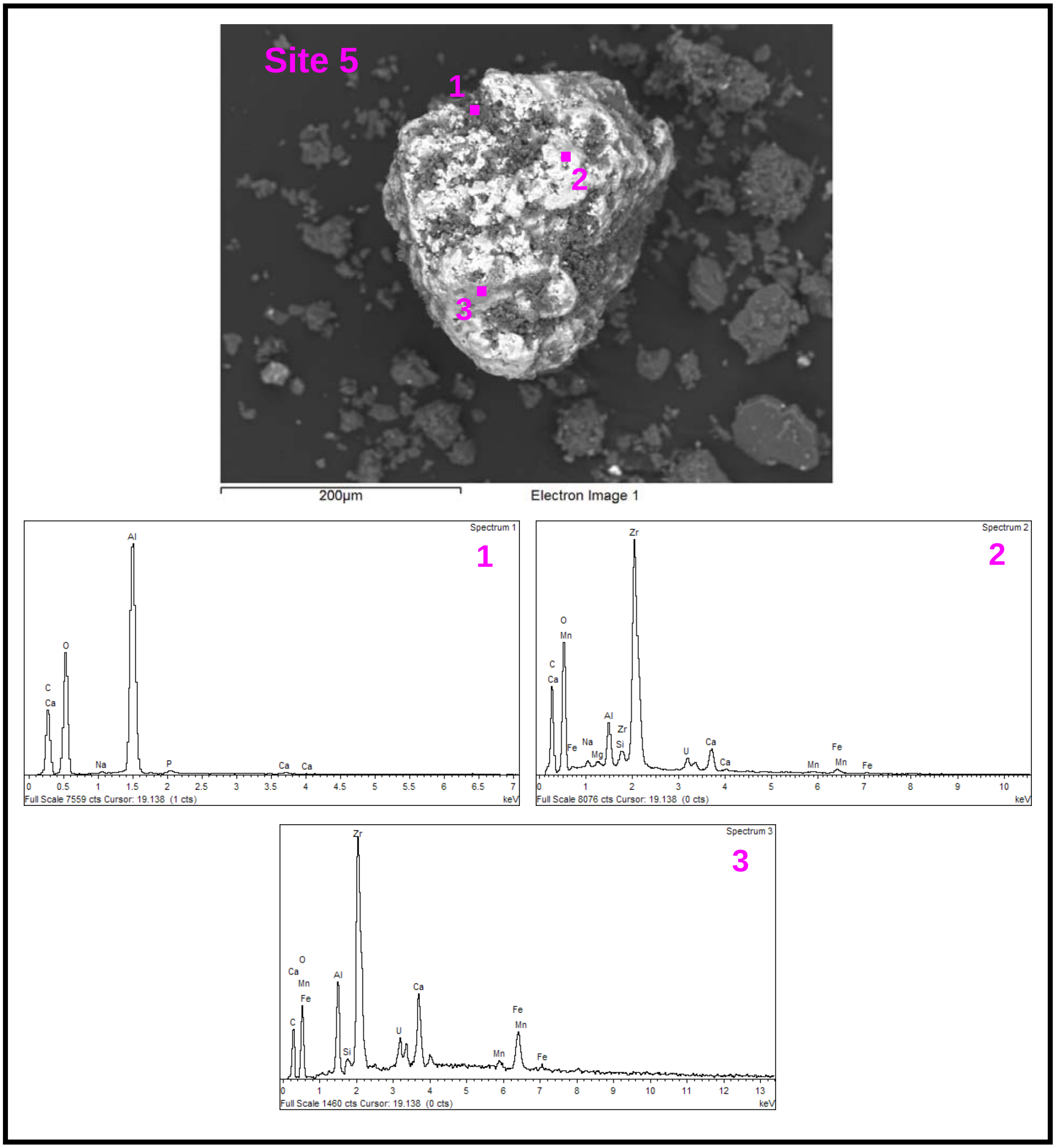

Figure E.57. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

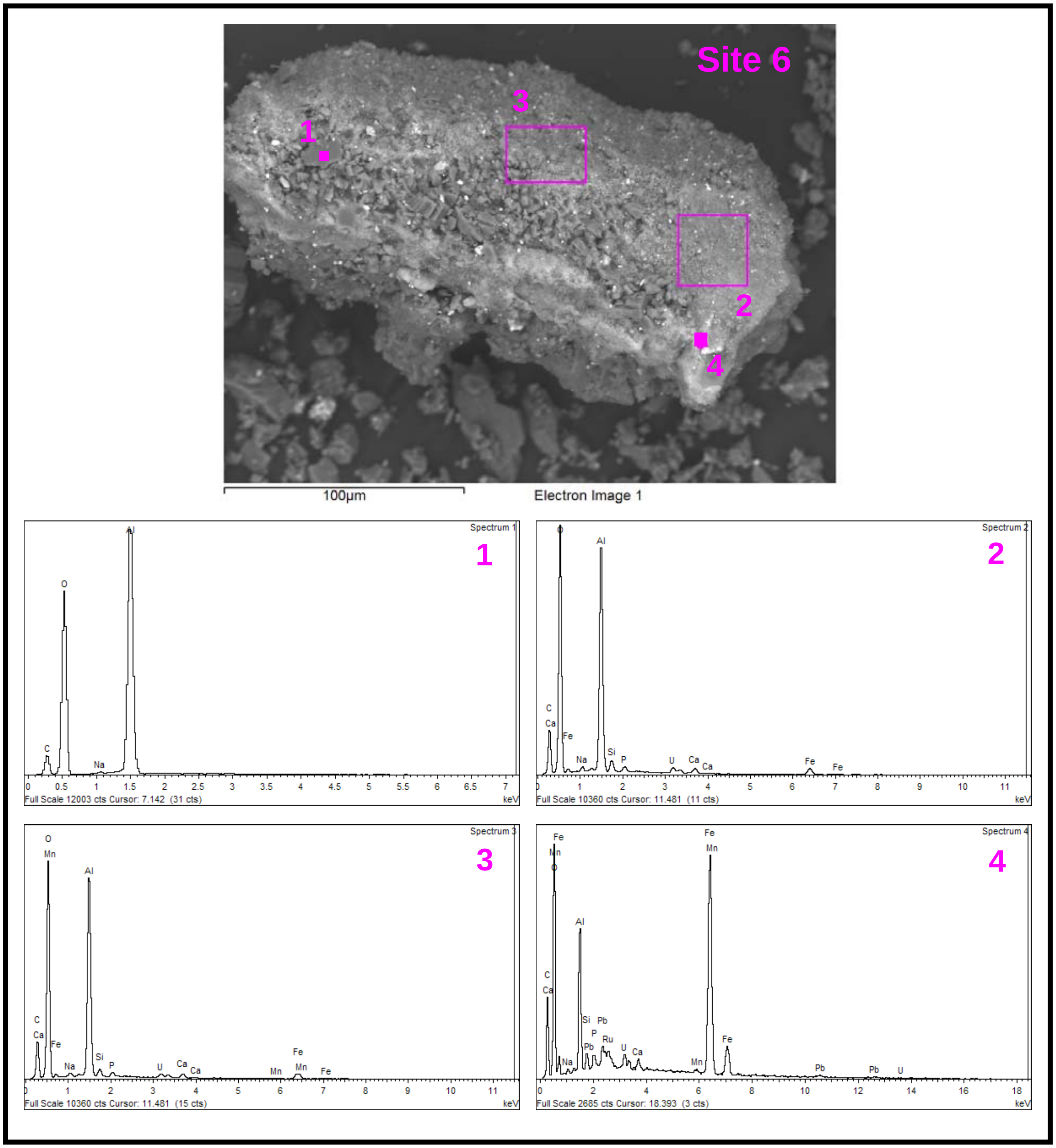

Figure E.58. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

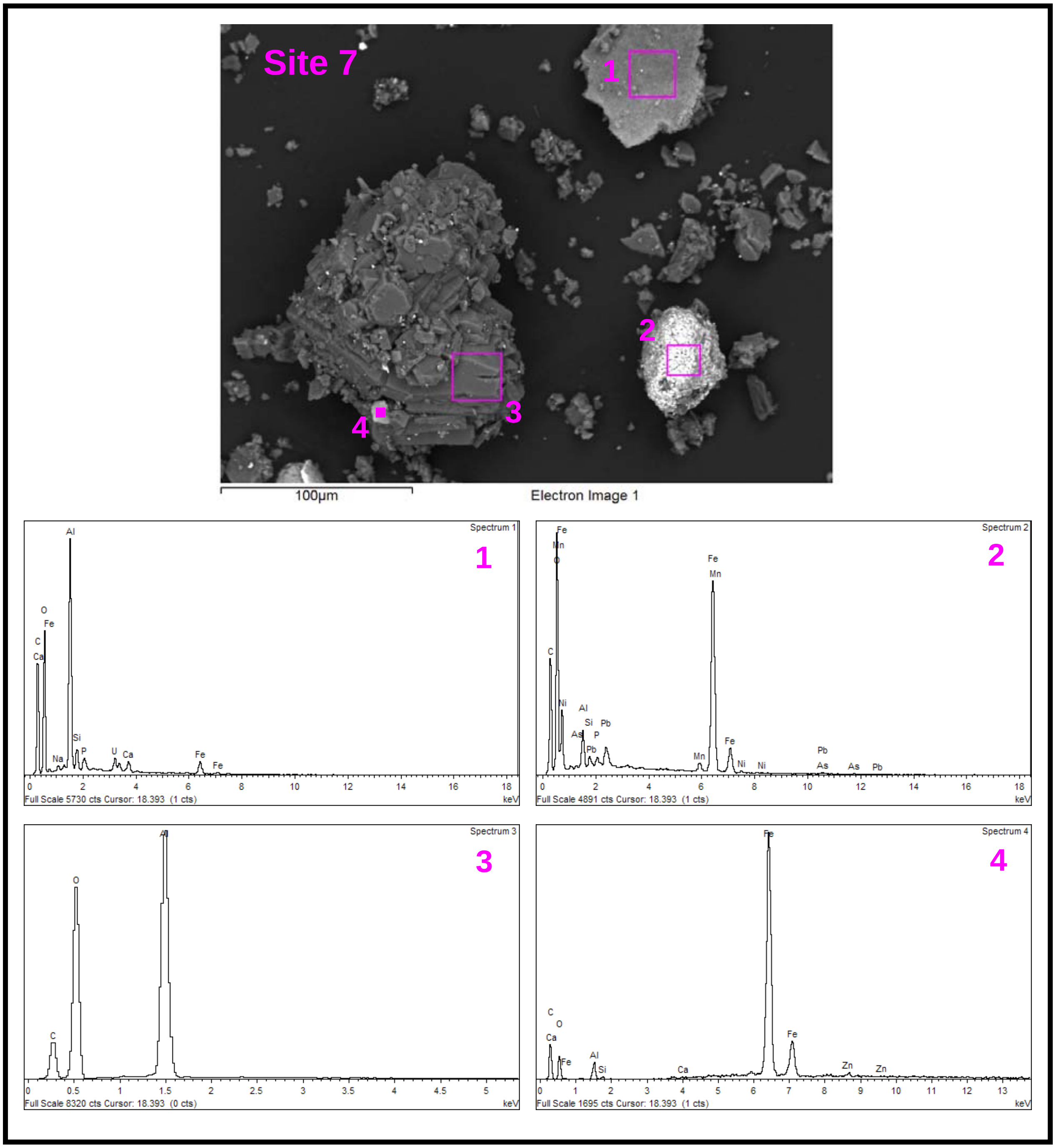

Figure E.59. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

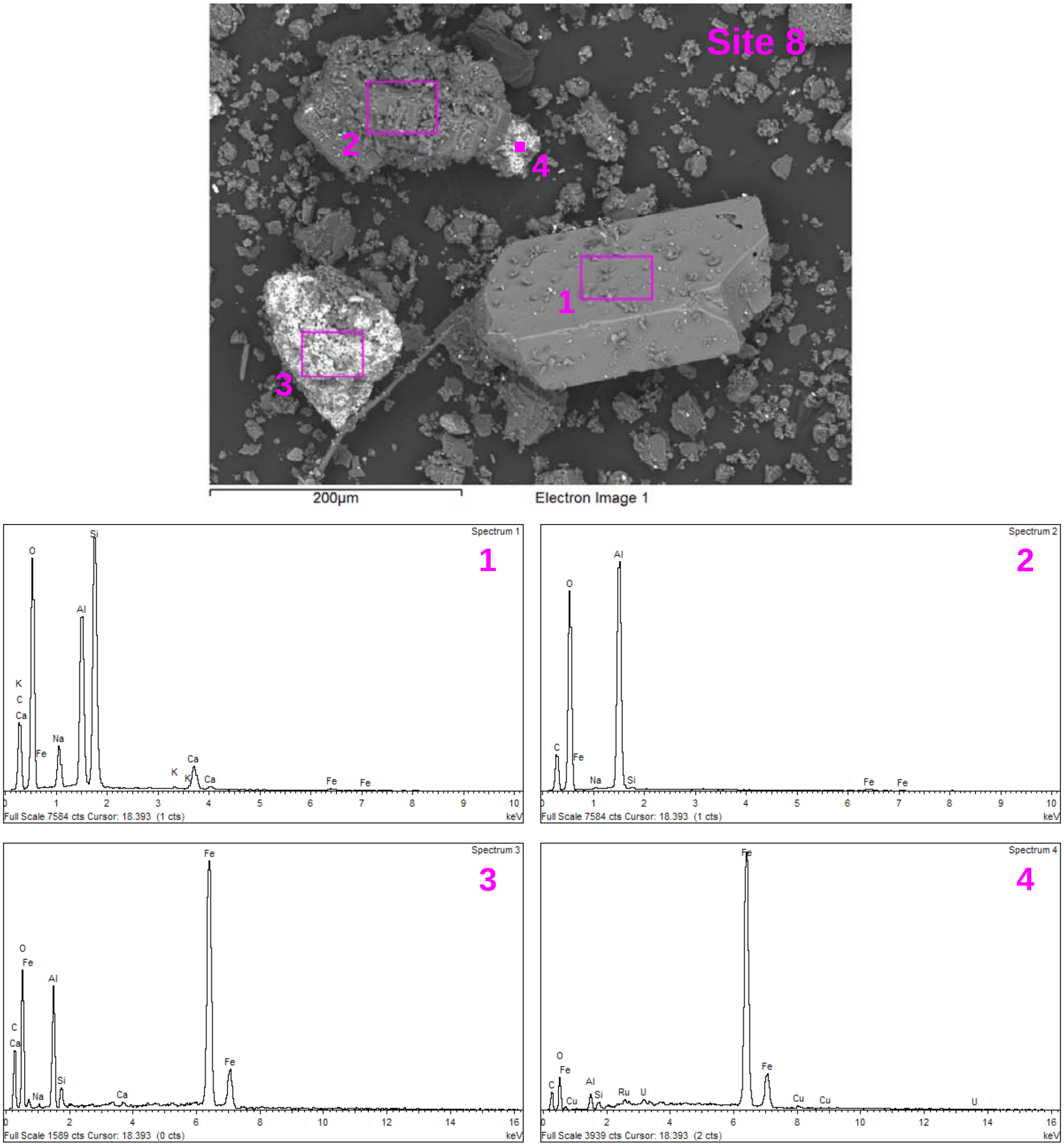

Figure E.60. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

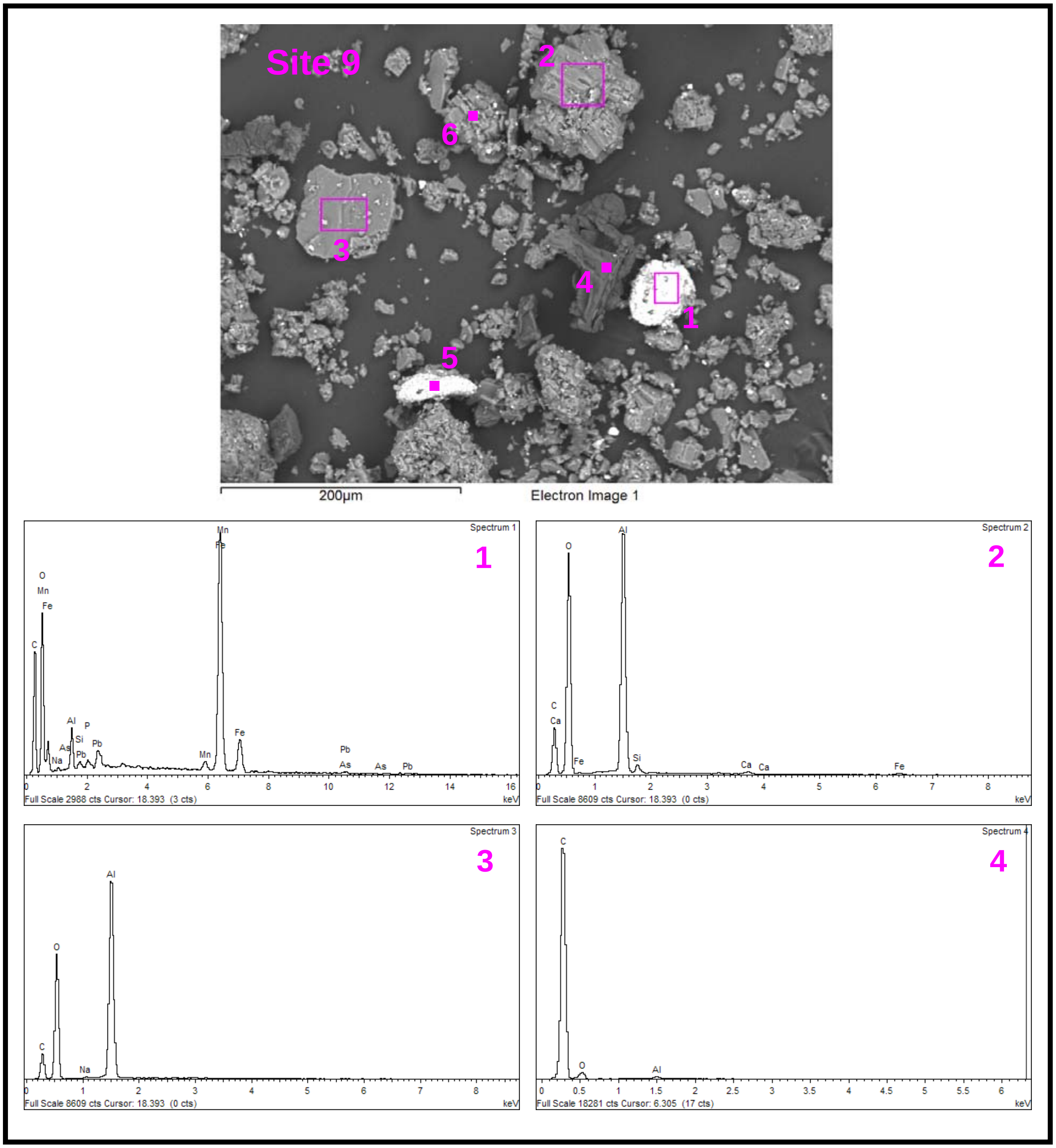

Figure E.61. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

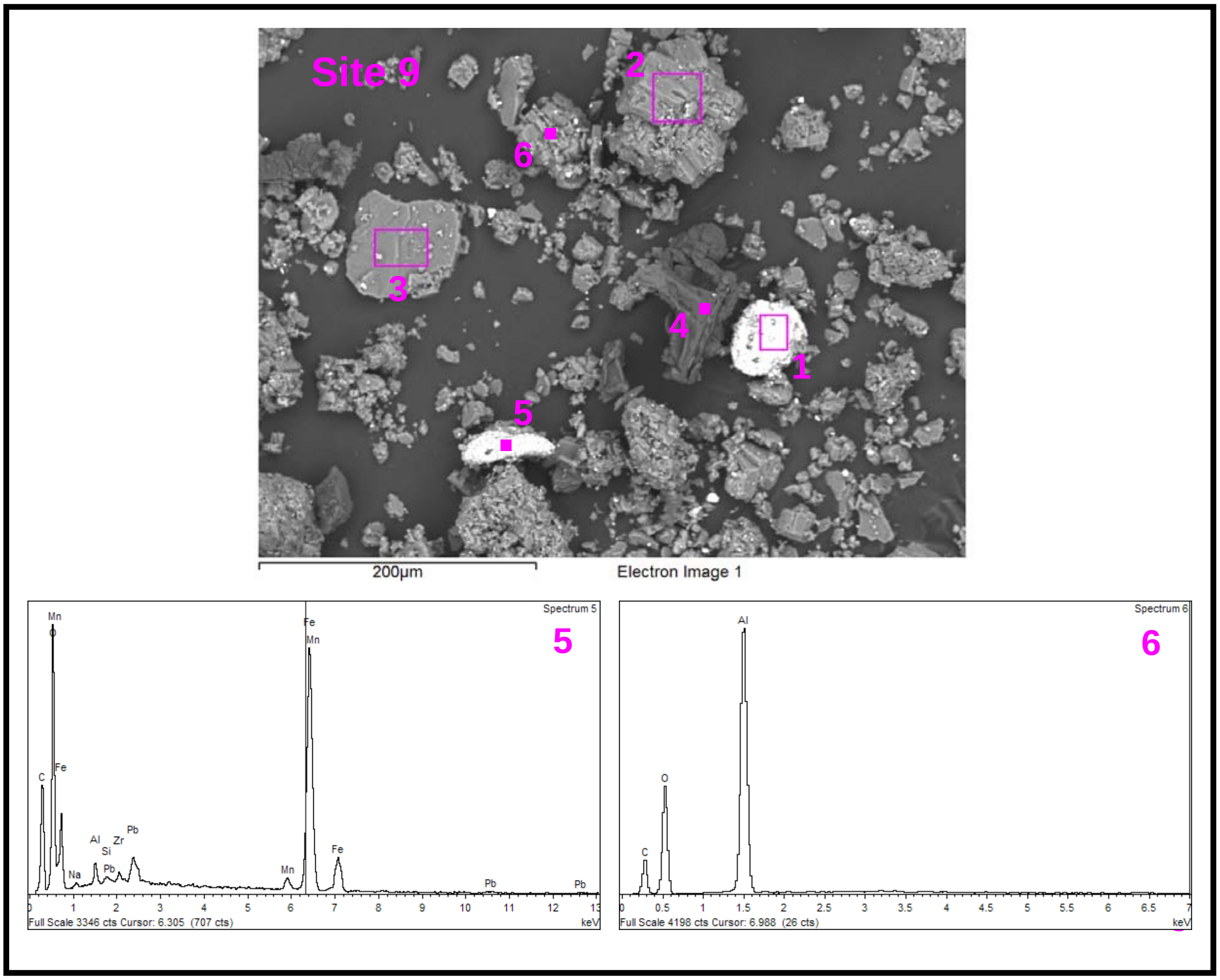

Figure E.62. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

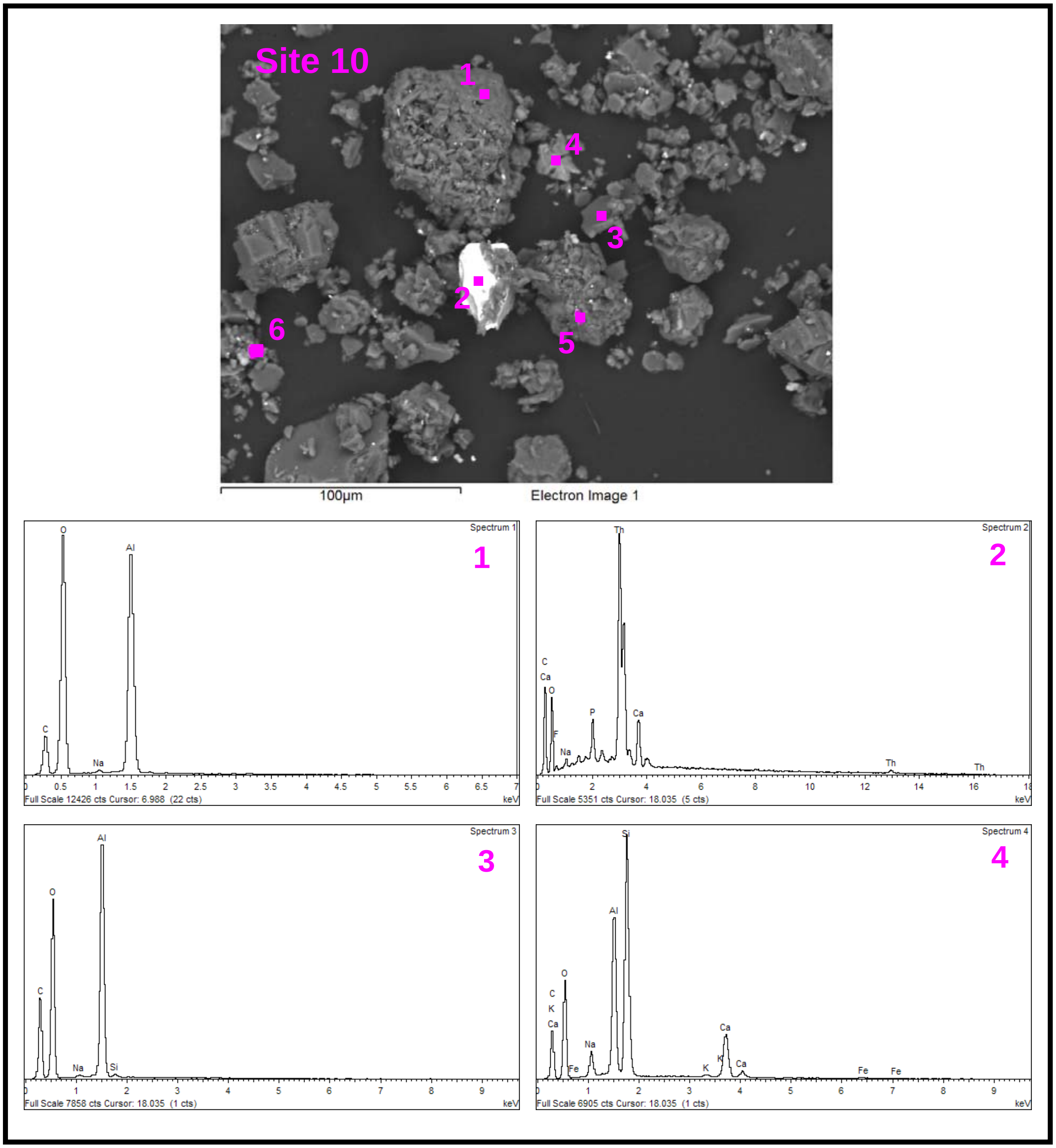

Figure E.63. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

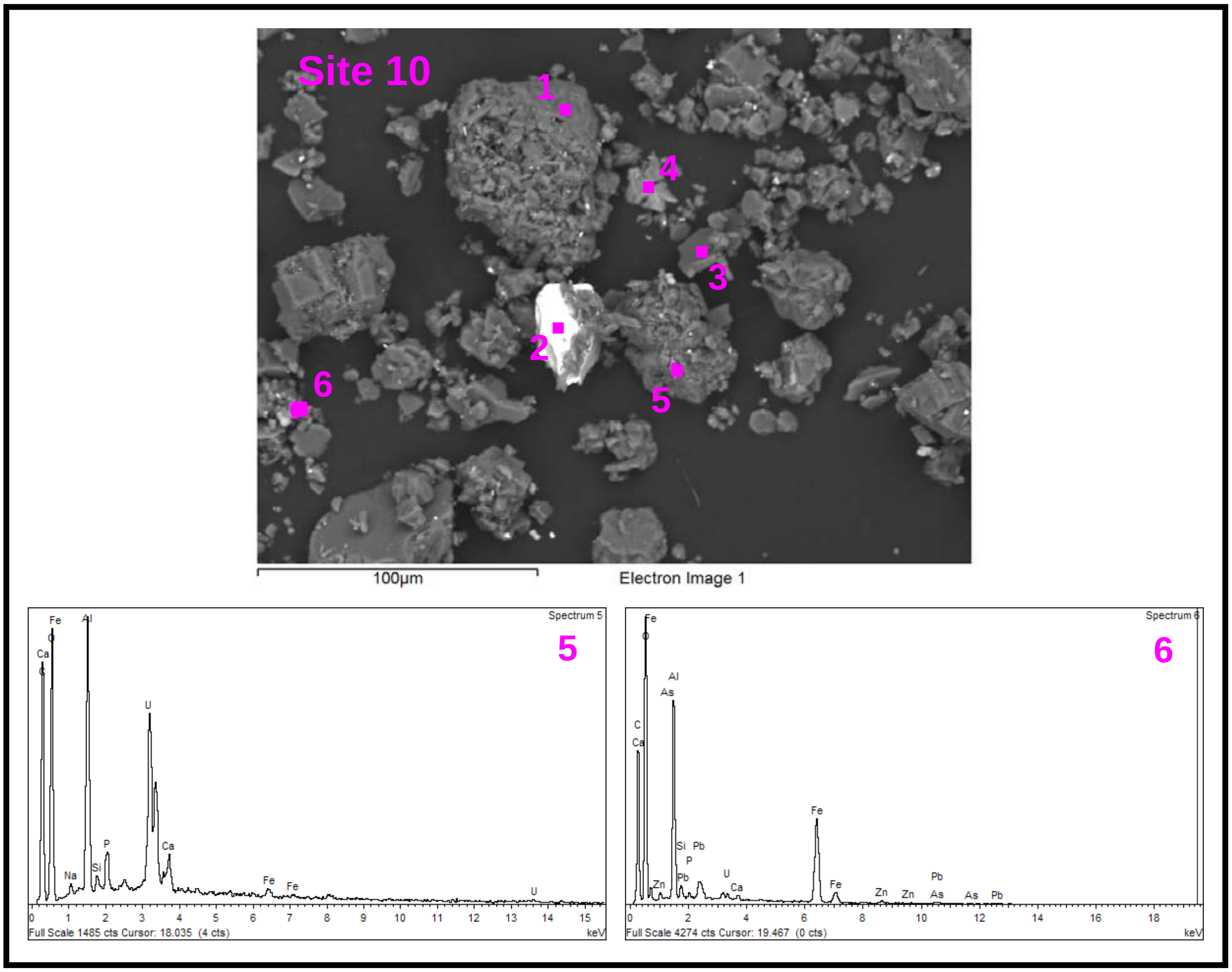

Figure E.64. EDS Spectra for Numbered Areas Marked in Pink in Top SEM Micrograph of Particles in Sample 19850 of One-Month Single-Contact $CaCO_3$-Leached Residual Waste from Tank C-103

Table E.7. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	**Spectrum**	**Weight %[(a)]**												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.50 and E.51/1	1	2.1	1.2		5.4	6.4	70.8					9.8	1.0	Mg (0.8), Mn (1.2), Ni (1.4)
	2	21.6	1.9	0.5	0.4	2.6	13.3					58.1	0.6	Pb (1.0)
	3	3.1								64.9	1.0	24.9		Cd (6.0)
	4	1.0										15.0		S (0.1), Th (83.9)
	5	33.1	0.3	0.6								66.0		
	6	32.0	0.4	0.5	0.5							66.6		
E.52 and E.53/2	1	4.1				73.8						14.8		Ba (3.1), Cu (2.3), K (1.8)
	2	9.7	4.0	4.9	3.5	1.9	0.5			0.8		51.6	8.6	Ce (4.2), La (3.1), Nd (7.1)
	3	3.2								59.9	5.1	31.8		
	4	1.6								73.2	8.2	16.9		
	5	10.1	0.5				68.2					18.6		Ni (0.8), Ru (1.8)
	6	28.1		0.6								71.3		
E.54/3	1	24.8	0.9	0.7	1.3		7.4					63.9	1.0	
	2	1.5		1.6	16.3	3.2	0.6					51.9	11.5	F (3.5), Mg (1.2), Pb (2.9), Sr (5.7)
	3	0.6	40.9	0.4	0.4							57.7		
	4	38.3		0.4								61.2		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.8. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.55 and E.56/4	1	12.0	0.3	0.6	0.3		32.0	0.3				53.3	0.7	Mn (0.5)
	2	29.3	0.3	0.3	0.2		0.7					69.0	0.2	
	3	16.1	17.1	9.7	2.5		1.2					53.1		K (0.3)
	4	6.3	0.7	1.5	0.5		42.5	0.6				46.3	0.7	Mg (0.5), Mn (0.5)
	5	11.4			3.1	32.9	15.2					37.5		
	6	4.5			0.5		61.3					30.8	1.1	Mn (0.8), Zn (1.0)
E.57/5	1	38.0		0.5	0.4							60.4	0.7	
	2	3.1	0.7	0.8	2.4	4.6	1.0					50.2		Mg (0.4), Mn (0.3), Zr (36.6)
	3	6.0	0.7		7.2	9.9	8.7					30.3		Mn (1.5), Zr (35.6)
	4	13.7	0.5	0.5	1.0	2.3	0.7					63.3		Mn (0.2), Zr (17.9)
E.58/6	1	33.6		0.3								66.0		
	2	24.3	1.6	1.0	0.8	2.8	2.5					66.3	0.7	
	3	25.0	1.2	0.9	0.7	2.3	2.7					66.2	0.7	Mn (0.3)
	4	9.8	1.2	0.7	0.7	3.6	42.4					34.6	0.8	Mn (0.5), Pb (3.4), Ru (2.2)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.9. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %[(a)]												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.59/7	1	27.3	3.1	1.1	1.8	6.9	5.4					52.6	1.8	Mn (1.9), Ni (0.6), Pb (4.3)
	2	3.5	0.8				50.1					38.2	0.6	
	3	33.3										66.7		
	4	3.0	0.4		0.3		87.1					6.2		
E.60/8	1	12.5	20.6	5.2	2.6		0.5					58.4		K (0.1)
	2	30.9	0.4	0.4			0.9					67.4		
	3	11.8	1.9	0.8	0.3		62.1					23.1		
	4	2.4	0.8			2.6	84.0					7.8		Cu (1.1), Ru (1.3)
E.61 and E.62/9	1	4.2	0.5	0.8			61.5					26.4	0.4	Mn (2.0), Pb (4.2)
	2	29.6	1.3		0.3		0.7					68.1		
	3	36.2		0.5								63.3		
	4	16.2										83.8		
	5	1.7	0.4	0.8			52.6					36.4		Mn (2.0), Pb (4.5), Zr (1.5)
	6	43.3										56.7		

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Table E.10. Estimated EDS Compositions (wt%) Corresponding to the EDS Spectra Shown in Previous Figures

Figure No./ Area of Interest	Spectrum	Weight %$^{(a)}$												
		Al	**Si**	**Na**	**Ca**	**U**	**Fe**	**Cr**	**Tc**	**Ag**	**Hg**	**O**	**P**	**Others**
E.63 and E.64/10	1	28.5		0.7								70.8		
	2			1.1	5.8							26.7	3.1	F (2.8), Th (60.5)
	3	33.1	0.6	0.5								65.9		
	4	14.6	26.7	3.8	6.9		0.5					47.2		K (0.3)
	5	13.7	0.8	0.9	2.1	33.5	1.4					45.2	2.3	
	6	16.5	1.1		0.5	2.5	22.2					51.7	0.5	As (0.1), Pb (3.6), Zn (1.3)

(a) The listed concentrations are based on compositions (wt%) normalized to 100%. Because carbon was used to coat the SEM mounts, the concentrations of carbon determined by EDS were therefore suspect and not included in the calculated compositions for analyzed area. Empty cells indicate that the corresponding element was not detected by EDS. EDS cannot detect hydrogen (H) or other elements with atomic numbers less than that of boron.

Appendix F

Solution Concentrations in the DDI, $Ca(OH)_2$, and $CaCO_3$ Leachants from Tanks C-103 Residual Waste

Table F.1. DDI Water Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19845

Tank C-103 (19845) DDI Water Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	9.04	6.71	8.00	8.04	9.04	6.71	5.34	6.81	6.73	6.73	5.07	5.09	5.03	6.00	8.02	8.06
Alkalinity	mg/L as $CaCO_3$	2.43E+01	1.67E+01	4.03E+01	4.26E+01	2.43E+01	1.67E+01	1.52E+01	1.98E+01	1.90E+01	1.37E+01	8.36E+00	8.36E+00	8.36E+00	8.36E+00	2.81E+01	3.12E+01
Radionuclides																	
^{90}Sr	µCi/L	6.61E+02	6.99E+02	8.02E+02	8.26E+02	6.61E+02	6.99E+02			6.58E+02	6.83E+02			6.77E+02	6.93E+02	6.91E+02	6.87E+02
^{99}Tc	mg/L	1.21E-04	1.20E-04	2.31E-04	1.60E-04	1.21E-04	1.20E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(1.00E-05)	(1.70E-05)
^{238}U	mg/L	6.52E-01	6.94E-01	2.06E+00	2.12E+00	6.52E-01	6.94E-01	(4.30E-02)	1.13E-01	8.03E-02	7.20E-02	7.42E-02	8.60E-02	5.16E-02	5.70E-02	4.79E-01	5.33E-01
^{239}Pu	µCi/L	3.94E-02	(6.01E-03)	4.41E-02	4.29E-02	3.94E-02	(6.01E-03)	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	(2.60E-03)	(5.83E-03)
^{237} Np	µCi/L	1.31E-04	9.73E-05	1.73E-04	1.70E-04	1.31E-04	9.73E-05	6.32E-05	4.26E-05	6.53E-05	6.32E-05	5.89E-05	5.82E-05	3.34E-05	3.27E-05	6.67E-05	5.75E-05
^{241}Am	µCi/L	(3.40E-02)	<1.70E-01	(3.74E-02)	(2.72E-02)	(3.40E-02)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	8.36E-03	1.73E-03	6.43E-03	6.67E-03	8.36E-03	1.73E-03	(2.69E-04)	(1.46E-04)	(1.91E-04)	(7.45E-05)	(8.00E-05)	(4.50E-05)	(3.95E-05)	(6.45E-05)	6.84E-04	1.06E-03
Al	mg/L	1.72E+00	5.98E-01	6.69E+00	6.36E+00	1.72E+00	5.98E-01	9.03E-02	1.17E-01	9.66E-02	9.08E-02	4.54E-02	4.73E-02	4.95E-02	4.15E-02	4.10E+00	5.05E+00
As	mg/L	<3.00E-01	<3.00E-01	(6.76E-02)	(3.32E-02)	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	<1.50E-01	<1.50E-01	(1.14E-02)	(1.10E-02)	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Ba	mg/L	<3.75E-02	<3.75E-02	(1.05E-02)	(1.15E-02)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Be	mg/L	<1.50E-02	<1.50E-02	(1.16E-03)	(8.71E-04)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Bi	mg/L	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00
Ca	mg/L	1.51E-01	1.26E-01	1.38E-01	1.33E-01	1.51E-01	1.26E-01	(4.78E-02)	(4.01E-02)	(4.93E-02)	(4.72E-02)	9.76E-02	8.52E-02	(5.21E-02)	8.09E-02	(3.71E-02)	(6.16E-02)
Cd ICP-MS	mg/L	<1.50E-02	<1.50E-02	2.80E-03	2.86E-03	5.04E-03	7.89E-04	(1.03E-04)	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	(1.90E-04)	(3.67E-04)
Cd ICP-OES	mg/L	5.04E-03	7.89E-04	(3.08E-03)	(1.98E-03)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Co	mg/L	<3.75E-02	<3.75E-02	(3.34E-03)	(1.10E-03)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Cr ICP-MS	mg/L	2.38E-02	(4.17E-03)	(1.74E-02)	(1.63E-02)	2.38E-02	(4.17E-03)	(3.71E-04)	(4.83E-04)	(4.62E-04)	(2.08E-04)	(2.00E-04)	(1.46E-04)	(2.10E-05)	(1.20E-04)	8.95E-04	1.86E-03
Cr ICP-OES	mg/L	(1.50E-02)	(7.34E-03)	1.36E-02	1.36E-02	(1.50E-02)	(7.34E-03)	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02	<1.88E-02
Cu ICP-MS	mg/L	7.62E-03	(2.11E-03)	6.22E-03	6.51E-03	7.62E-03	(2.11E-03)	(2.03E-04)	(2.03E-04)	(1.73E-04)	(1.10E-04)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	(7.22E-04)	(1.01E-03)
Cu ICP-OES	mg/L	(1.56E-02)	(1.21E-02)	(1.13E-02)	(1.09E-02)	(1.56E-02)	(1.21E-02)	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02
Fe	mg/L	2.55E-01	7.70E-02	2.31E-01	2.11E-01	2.55E-01	7.70E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	(1.54E-02)	3.04E-02
K	mg/L	(2.33E-01)	(3.15E-01)	(4.48E-01)	(4.29E-01)	(2.33E-01)	(3.15E-01)	(2.09E-01)	(8.84E-02)	(9.86E-02)	(2.53E-01)	(1.29E-01)	(1.02E-01)	<3.75E+00	(3.53E-02)	(1.33E-01)	(3.24E-02)
Li	mg/L	(1.20E-02)	(1.13E-02)	(6.11E-03)	(3.79E-03)	(1.20E-02)	(1.13E-02)	(1.05E-02)	(9.12E-03)	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02
Mg	mg/L	(3.22E-02)	(2.18E-02)	(3.08E-02)	(2.94E-02)	(3.22E-02)	(2.18E-02)	(9.22E-03)	(9.84E-03)	(1.05E-02)	(1.08E-02)	(2.22E-02)	(2.10E-02)	(1.08E-02)	(1.43E-02)	(1.11E-02)	(1.15E-02)
Mn	mg/L	2.64E-02	9.00E-03	2.63E-02	2.48E-02	2.64E-02	9.00E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	(2.32E-03)	(3.89E-03)
Mo	mg/L	<1.50E-02	<1.50E-02	(8.06E-04)	(4.30E-04)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	(4.69E-03)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Mo 95	mg/L	1.48E-03	1.45E-03	1.74E-03	1.81E-03	1.48E-03	1.45E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Mo 97	mg/L	1.38E-03	1.52E-03	1.89E-03	1.86E-03	1.38E-03	1.52E-03	2.20E-04	<1.00E-04	<1.00E-04	1.17E-04	<1.00E-04	<1.00E-04	<1.00E-04	1.01E-04	<1.00E-04	<1.00E-04
Mo 98	mg/L	1.14E-03	1.17E-03	1.39E-03	1.40E-03	1.14E-03	1.17E-03	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04
Na	mg/L	5.54E+00	5.51E+00	1.56E+01	1.55E+01	5.54E+00	5.51E+00	3.62E+00	5.24E+00	5.12E+00	4.21E+00	1.30E+00	1.41E+00	1.20E+00	1.07E+00	8.66E+00	9.45E+00
Ni	mg/L	5.14E-02	(2.57E-02)	4.86E-02	4.22E-02	5.14E-02	(2.57E-02)	(1.45E-02)	(1.10E-02)	(1.36E-02)	(1.30E-02)	(1.15E-02)	(1.32E-02)	(9.07E-03)	(1.10E-02)	(1.10E-02)	(1.25E-02)
P	mg/L	(2.21E-01)	(9.95E-02)	5.35E-01	5.30E-01	(2.21E-01)	(9.95E-02)	<3.75E-01	<3.75E-01	<3.75E-01	<3.75E-01	<3.75E-01	<3.75E-01	<3.75E-01	<3.75E-01	(1.53E-01)	(2.13E-01)
Pb ICP-MS	mg/L	6.85E-02	9.47E-03	4.09E-02	3.90E-02	6.85E-02	9.47E-03	(7.81E-04)	(3.38E-04)	(4.07E-04)	(1.38E-04)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	(2.11E-03)	5.11E-03
Pb ICP-OES	mg/L	4.17E-02	(1.50E-02)	4.00E-02	4.49E-02	4.17E-02	(1.50E-02)	(2.40E-03)	<3.00E-02	<3.00E-02	<3.00E-02	(8.53E-04)	(1.01E-02)	<3.00E-02	(1.38E-03)	<3.00E-02	(6.45E-03)
Ru 101	mg/L	1.17E-02	2.04E-03	7.41E-03	6.75E-03	1.17E-02	2.04E-03	(3.22E-04)	(2.25E-04)	(2.56E-04)	(1.18E-04)	(6.70E-05)	(4.80E-05)	(6.30E-05)	(4.60E-05)	(4.14E-04)	(7.32E-04)
Ru 102	mg/L	5.31E-03	1.04E-03	3.34E-03	3.17E-03	5.31E-03	1.04E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
S	mg/L	(1.20E-01)	(8.55E-02)	(1.13E-01)	(1.26E-01)	(1.20E-01)	(8.55E-02)	(9.34E-02)	(1.70E-01)	(2.87E-02)	(9.01E-02)	(1.46E-02)	(5.59E-02)	(6.19E-02)	(4.03E-02)	(1.77E-01)	(1.73E-01)
Sb 121	mg/L	<1.00E-03	<1.00E-03	(2.11E-04)	(1.87E-04)	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Se	mg/L	<3.00E+00	<3.00E+00	(4.57E-02)	(3.31E-02)	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00
Se 82	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Si	mg/L	(6.57E-01)	(5.72E-01)	7.04E+00	7.00E+00	(6.57E-01)	(5.72E-01)	1.54E+00	2.31E+00	2.67E+00	2.22E+00	(6.44E-01)	(7.34E-01)	(5.96E-01)	(5.04E-01)	6.31E+00	7.11E+00
Sr	mg/L	(1.24E-02)	(5.83E-03)	(1.48E-02)	(1.40E-02)	(1.24E-02)	(5.83E-03)	(2.10E-03)	(2.79E-03)	(1.43E-03)	(1.36E-03)	(4.13E-03)	(3.80E-03)	(2.80E-03)	(4.04E-03)	(4.41E-03)	(4.51E-03)
Ti	mg/L	(2.32E-03)	(6.34E-04)	(2.48E-03)	(2.09E-03)	(2.32E-03)	(6.34E-04)	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	(7.76E-04)	(7.51E-04)
Tl	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
V	mg/L	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Zn	mg/L	(3.72E-02)	(3.19E-02)	(3.37E-02)	(3.12E-02)	(3.72E-02)	(3.19E-02)	(3.62E-02)	(2.88E-02)	(2.39E-02)	(2.84E-02)	(2.96E-02)	(3.26E-02)	(2.91E-02)	(2.70E-02)	(2.68E-02)	(2.52E-02)
Zr	mg/L	1.30E-01	4.19E-02	1.32E-01	1.23E-01	1.30E-01	4.19E-02	(3.65E-05)	(3.36E-04)	(8.54E-05)	(9.74E-05)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	(5.70E-03)	(1.35E-02)
Anions																	
NO_2^- as NO_2^-	mg/L	4.05E-01	3.40E-01	6.35E-01	6.22E-01	4.05E-01	3.40E-01	3.15E-02	5.28E-02	7.71E-02	6.16E-02	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.70E-01	1.77E-01
NO_3^- as NO_3^-	mg/L	3.46E-01	2.82E-01	1.71E+00	1.65E+00	3.46E-01	2.82E-01	2.82E-01	4.31E-01	6.29E-01	4.89E-01	1.01E-01	1.25E-01	9.77E-02	8.34E-02	1.30E+00	1.30E+00
CO_3^{2-}	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
SO_4^{2-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	<1.50E-01	<1.50E-01	9.88E-01	1.13E+00	<1.50E-01	<1.50E-01	<1.50E-01	4.42E-01	9.80E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	1.10E-01	1.28E-01
Cl^-	mg/L	<5.00E-02	<5.00E-02	4.52E-02	4.95E-02	<5.00E-02	<5.00E-02	4.02E-02	<5.00E-02	3.19E-02	5.46E-02	<5.00E-02	<5.00E-02	<5.00E-02	2.77E-02	4.90E-02	7.90E-02
F^-	mg/L	8.87E-02	9.01E-02	3.41E-01	3.46E-01	8.87E-02	9.01E-02	5.43E-02	7.14E-02	6.97E-02	7.13E-02	<2.00E-02	<2.00E-02	<2.00E-02	<2.00E-02	1.66E-01	1.90E-01

Table F.2. DDI Water Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19849

		Tank C-103 (19849) DDI Water Leach Result															
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	7.10	6.05	7.82	7.96	7.10	6.05	6.63	6.56	6.92	6.90	6.81	6.14	6.00	6.30	8.23	7.41
Alkalinity	mg/L as $CaCO_3$	2.28E+01	1.98E+01	4.26E+01	3.80E+01	2.28E+01	1.98E+01	1.60E+01	1.37E+01	1.82E+01	1.82E+01	8.36E+00	1.22E+01	8.36E+00	8.36E+00	2.89E+01	1.60E+01
Radionuclides																	
^{90}Sr	µCi/L	8.26E+02	8.14E+02	8.61E+02	8.92E+02	8.26E+02	8.14E+02			8.28E+02	8.16E+02			8.43E+02	8.50E+02	8.76E+02	8.51E+02
^{99}Tc	mg/L	1.03E-04	(8.10E-05)	1.44E-04	1.18E-04	1.03E-04	(8.10E-05)	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(1.50E-05)	(2.00E-06)
^{238}U	mg/L	1.50E-01	1.54E-01	2.70E+00	2.03E+00	1.50E-01	1.54E-01	9.96E-02	8.07E-02	7.46E-02	1.12E-01	6.57E-02	7.26E-02	1.22E-01	7.92E-02	1.22E+00	2.03E-01
^{239}Pu	µCi/L	<1.55E-02	<1.55E-02	5.33E-02	7.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	(3.04E-03)	<1.55E-02	<1.55E-02	6.54E-02	(1.24E-03)
^{237} Np	µCi/L	8.45E-05	8.31E-05	2.57E-04	2.08E-04	8.45E-05	8.31E-05	1.15E-04	8.59E-05	5.82E-05	6.25E-05	6.25E-05	9.02E-05	3.76E-05	4.12E-05	1.14E-04	6.39E-05
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	(3.06E-02)	(6.12E-02)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	(4.42E-02)	<1.70E-01
Metals																	
Ag	mg/L	(1.91E-04)	(1.44E-04)	5.89E-03	6.74E-03	(1.91E-04)	(1.44E-04)	(4.25E-05)	(3.25E-05)	(4.50E-05)	(3.05E-05)	(3.95E-05)	(3.10E-05)	(2.30E-05)	(3.40E-05)	4.79E-03	(2.37E-04)
Al	mg/L	1.88E-01	1.47E-01	4.08E+00	6.14E+00	1.88E-01	1.47E-01	6.78E-02	7.59E-02	1.08E-01	9.00E-02	6.05E-02	4.76E-02	(2.75E-02)	(2.80E-02)	7.16E+00	1.46E+00
As	mg/L	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Ba	mg/L	<3.75E-02	<3.75E-02	(1.28E-02)	(1.80E-02)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Be	mg/L	<1.50E-02	<1.50E-02	(4.14E-04)	(3.51E-04)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Bi	mg/L	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00
Ca	mg/L	(4.97E-02)	(5.06E-02)	1.16E-01	1.52E-01	(4.97E-02)	(5.06E-02)	(4.46E-02)	(6.87E-02)	(4.68E-02)	(4.25E-02)	(3.24E-02)	(6.39E-02)	9.96E-02	9.35E-02	2.50E-01	7.51E-02
Cd ICP-MS	mg/L	<5.00E-04	<5.00E-04	2.23E-03	3.06E-03	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	5.02E-03	<5.00E-04
Cd ICP-OES	mg/L	<1.50E-02	<1.50E-02	(1.58E-03)	(1.89E-03)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Co	mg/L	<3.75E-02	<3.75E-02	(2.21E-03)	(1.99E-03)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Cr ICP-MS	mg/L	(1.57E-03)	(1.18E-03)	(1.44E-02)	(1.60E-02)	(1.57E-03)	(1.18E-03)	(1.19E-04)	(1.44E-04)	(3.03E-04)	(4.60E-04)	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	1.43E-02	5.76E-04
Cr ICP-OES	mg/L	(2.75E-03)	(2.04E-03)	1.09E-02	1.34E-02	(2.75E-03)	(2.04E-03)	(8.96E-04)	(5.38E-04)	(9.78E-04)	(2.16E-03)	(1.59E-03)	(7.05E-04)	(1.83E-03)	(1.29E-03)	(1.64E-02)	(3.08E-03)
Cu ICP-MS	mg/L	(1.05E-03)	<2.50E-03	4.57E-03	5.02E-03	(1.05E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	3.44E-03	<2.50E-03
Cu ICP-OES	mg/L	(4.03E-03)	(3.53E-03)	(5.75E-03)	(6.51E-03)	(4.03E-03)	(3.53E-03)	(2.21E-03)	(3.04E-03)	(2.11E-03)	(3.90E-03)	(3.14E-03)	(2.73E-03)	(2.18E-03)	(1.20E-03)	(4.67E-03)	(1.43E-03)
Fe	mg/L	(2.75E-03)	(3.70E-03)	1.92E-01	2.74E-01	(2.75E-03)	(3.70E-03)	(2.70E-03)	(2.23E-03)	(2.28E-03)	(5.32E-03)	(3.69E-03)	(3.20E-03)	(2.77E-03)	(2.11E-03)	2.86E-01	(1.18E-02)
K	mg/L	(2.62E-01)	(9.44E-02)	(4.56E-01)	(4.47E-01)	(2.62E-01)	(9.44E-02)	<3.75E+00	(3.23E-02)	(2.65E-01)	(8.82E-02)	(6.14E-02)	<3.75E+00	<3.75E+00	<3.75E+00	(1.97E-01)	(1.67E-01)
Li	mg/L	(3.40E-03)	(5.93E-03)	(3.66E-03)	(2.87E-03)	(3.40E-03)	(5.93E-03)	(6.52E-03)	(3.21E-03)	(2.31E-03)	(5.61E-03)	(3.58E-03)	(3.20E-03)	(1.07E-03)	<3.00E-02	(2.39E-03)	<3.00E-02
Mg	mg/L	(8.09E-03)	(9.02E-03)	(2.75E-02)	(2.94E-02)	(8.09E-03)	(9.02E-03)	(1.64E-02)	(1.19E-02)	(8.38E-03)	(1.10E-02)	(8.60E-03)	(1.76E-02)	(1.75E-02)	(1.68E-02)	(3.92E-02)	(1.41E-02)
Mn	mg/L	(3.63E-04)	(4.90E-04)	2.50E-02	3.51E-02	(3.63E-04)	(4.90E-04)	(4.24E-04)	(9.52E-05)	<7.50E-03	(1.36E-03)	(7.34E-04)	(6.40E-04)	(1.15E-03)	(1.34E-03)	3.55E-02	(1.25E-03)
Mo	mg/L	(3.03E-03)	(3.43E-03)	<1.50E-02	<1.50E-02	(3.03E-03)	(3.43E-03)	<1.50E-02	(4.47E-03)	<1.50E-02	<1.50E-02	<1.50E-02	(1.03E-03)	(4.21E-03)	<1.50E-02	(3.12E-03)	<1.50E-02
Mo 95	mg/L	1.40E-03	1.16E-03	1.77E-03	1.66E-03	1.40E-03	1.16E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Mo 97	mg/L	1.40E-03	1.30E-03	1.87E-03	1.67E-03	1.40E-03	1.30E-03	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	1.26E-04	<1.00E-04
Mo 98	mg/L	1.20E-03	9.20E-04	1.31E-03	1.25E-03	1.20E-03	9.20E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04
Na	mg/L	7.33E+00	5.81E+00	1.60E+01	1.54E+01	7.33E+00	5.81E+00	2.63E+00	2.49E+00	4.86E+00	4.10E+00	2.07E+00	1.57E+00	7.84E-01	7.30E-01	9.36E+00	4.79E+00
Ni	mg/L	(7.34E-03)	(8.89E-03)	(2.92E-02)	4.25E-02	(7.34E-03)	(8.89E-03)	(5.95E-03)	(9.17E-03)	(4.07E-03)	(9.29E-03)	(8.35E-03)	(4.32E-03)	(5.84E-03)	(8.84E-03)	4.40E-02	(5.15E-03)
P	mg/L	(4.61E-02)	(4.86E-02)	4.52E-01	5.78E-01	(4.61E-02)	(4.86E-02)	(1.67E-02)	(3.93E-02)	(3.62E-02)	(2.97E-02)	(2.08E-02)	(4.74E-02)	(3.91E-02)	<3.75E-01	(2.96E-01)	(7.69E-02)
Pb ICP-MS	mg/L	(1.21E-04)	(6.85E-05)	3.19E-02	4.18E-02	(1.21E-04)	(6.85E-05)	(1.45E-05)	(2.20E-05)	(1.30E-05)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	7.13E-02	(5.92E-04)
Pb ICP-OES	mg/L	<3.00E-02	<3.00E-02	4.35E-02	3.99E-02	<3.00E-02	<3.00E-02	(1.19E-03)	<3.00E-02	(4.97E-03)	(9.59E-03)	<3.00E-02	(5.81E-03)	(2.29E-03)	(1.69E-03)	6.48E-02	(3.19E-03)
Ru 101	mg/L	(3.96E-04)	(3.14E-04)	6.72E-03	9.23E-03	(3.96E-04)	(3.14E-04)	<1.00E-03	(3.60E-05)	(4.40E-05)	(2.90E-05)	(6.20E-05)	(4.60E-05)	(5.00E-06)	(1.40E-05)	7.21E-03	(1.01E-04)
Ru 102	mg/L	(1.64E-04)	(1.29E-04)	3.33E-03	4.27E-03	(1.64E-04)	(1.29E-04)	<1.00E-03	(2.50E-05)	<1.00E-03	(5.00E-06)	(1.10E-05)	(1.90E-05)	(1.40E-05)	<1.00E-03	3.26E-03	(3.30E-05)
S	mg/L	(1.13E-01)	(1.56E-01)	(1.20E-01)	(8.28E-02)	(1.13E-01)	(1.56E-01)	(2.61E-02)	(1.24E-01)	(9.25E-02)	(9.04E-02)	(8.51E-02)	(4.18E-02)	(9.87E-02)	(1.72E-01)	(1.67E-01)	(4.34E-02)
Sb 121	mg/L	<1.00E-03	<1.00E-03	(2.01E-04)	(2.47E-04)	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Se	mg/L	<3.00E+00	<3.00E+00	(2.52E-02)	(3.24E-02)	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00
Se 82	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	(1.34E-03)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Si	mg/L	(9.46E-01)	(9.06E-01)	5.96E+00	6.42E+00	(9.46E-01)	(9.06E-01)	(1.24E+00)	(1.24E+00)	2.57E+00	2.26E+00	(1.03E+00)	(7.92E-01)	(3.16E-01)	(3.20E-01)	6.59E+00	3.34E+00
Sr	mg/L	(2.40E-03)	(3.13E-03)	(1.49E-02)	1.75E-02	(2.40E-03)	(3.13E-03)	(3.34E-03)	(2.68E-03)	(1.70E-03)	(4.89E-03)	(3.30E-03)	(4.37E-03)	(6.91E-03)	(7.84E-03)	2.34E-02	(3.02E-03)
Ti	mg/L	<7.50E-03	<7.50E-03	(1.78E-03)	(2.30E-03)	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	<7.50E-03	(8.05E-04)	(3.14E-04)	(1.63E-04)	<7.50E-03	<7.50E-03	(2.80E-03)	<7.50E-03
Tl	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
V	mg/L	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Zn	mg/L	(2.72E-02)	(2.69E-02)	(3.27E-02)	(2.95E-02)	(2.72E-02)	(2.69E-02)	(2.46E-02)	(2.37E-02)	(2.85E-02)	(2.35E-02)	(2.79E-02)	(2.83E-02)	(2.91E-02)	(2.57E-02)	(3.61E-02)	(2.49E-02)
Zr	mg/L	(9.53E-04)	(1.22E-04)	8.64E-02	1.23E-01	(9.53E-04)	(1.22E-04)	<1.50E-02	<1.50E-02	(2.71E-04)	(1.04E-03)	(3.87E-04)	(2.85E-04)	(5.55E-05)	(1.49E-04)	1.07E-01	(4.29E-03)
Anions																	
NO_2^- as NO_2^-	mg/L	2.64E-01	3.14E-01	5.35E-01	4.73E-01	2.64E-01	3.14E-01	<1.00E-01	<1.00E-01	7.14E-02	8.03E-02	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.98E-01	<1.00E-01
NO_3^- as NO_3^-	mg/L	3.17E-01	3.21E-01	2.09E+00	1.83E+00	3.17E-01	3.21E-01	2.55E-01	2.66E-01	7.37E-01	4.22E-01	2.40E-01	1.39E-01	<1.00E-01	1.68E-01	2.11E+00	<1.00E-01
CO_3^{2-}	mg/L	<5.00E+00	<5.00E+00	<5.00E+01	<5.00E+01	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO_4^{2-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	1.67E-01	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	4.48E-02	1.64E-01	6.03E-01	9.09E-01	4.48E-02	1.64E-01	<1.50E-01	<1.50E-01	<1.50E-01	3.92E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl^-	mg/L	3.40E-02	4.76E-02	<5.00E-02	1.43E-01	3.40E-02	4.76E-02	<5.00E-02	1.02E-01	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
F^-	mg/L	1.09E-01	7.37E-02	2.93E-01	3.01E-01	1.09E-01	7.37E-02	3.33E-02	3.53E-02	6.72E-02	6.13E-02	<2.00E-02	<2.00E-02	<2.00E-02	<2.00E-02	1.68E-01	1.28E-01

Table F.3. DDI Water Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19850

Tank C-103 (19850) DDI Water Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	7.39	7.44	7.90	7.85	7.39	7.44	6.50	6.70	6.74	6.68	6.18	6.39	6.10	6.26	7.22	7.66
Alkalinity	mg/L as $CaCO_3$	2.13E+01	2.43E+01	3.57E+01	4.41E+01	2.13E+01	2.43E+01	1.44E+01	1.60E+01	1.60E+01	1.52E+01	8.36E+00	1.06E+01	1.06E+01	1.06E+01	1.98E+01	2.36E+01
Radionuclides																	
^{90}Sr	µCi/L	8.86E+02	9.24E+02	9.57E+02	9.40E+02	8.86E+02	9.24E+02			7.91E+02	8.31E+02			8.12E+02	8.45E+02	8.23E+02	8.39E+02
^{99}Tc	mg/L	(9.50E-05)	1.01E-04	1.36E-04	1.20E-04	(9.50E-05)	1.01E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(2.00E-06)	(1.00E-06)
^{238}U	mg/L	1.81E+00	2.00E+00	2.22E+00	2.69E+00	1.81E+00	2.00E+00	(2.79E-02)	(2.64E-02)	7.16E-02	(4.67E-02)	7.98E-02	7.39E-02	5.38E-02	1.34E-01	4.31E-01	5.45E-01
^{239}Pu	µCi/L	9.00E+01	1.57E-01	2.07E-01	1.46E-01	9.00E+01	1.57E-01	(1.12E-03)	(9.30E-04)	(1.86E-03)	(1.61E-03)	(2.48E-03)	(2.11E-03)	(1.80E-03)	(1.61E-03)	(8.80E-03)	(8.49E-03)
^{237} Np	µCi/L	2.36E-04	3.10E-04	4.15E-04	3.80E-04	2.36E-04	3.10E-04	1.03E-04	1.07E-04	1.26E-04	1.21E-04	1.18E-04	1.19E-04	7.38E-05	9.23E-05	7.17E-05	8.17E-05
^{241}Am	µCi/L	(7.14E-02)	(1.02E-01)	(1.60E-01)	(9.52E-02)	(7.14E-02)	(1.02E-01)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	8.02E-03	1.21E-02	1.75E-02	1.36E-02	8.02E-03	1.21E-02	(3.55E-05)	(4.00E-05)	(3.15E-05)	(3.00E-05)	(1.70E-05)	(2.65E-05)	(2.15E-05)	(1.30E-05)	7.17E-04	8.92E-04
Al	mg/L	1.63E+00	2.26E+00	5.81E+00	4.97E+00	1.63E+00	2.26E+00	9.51E-02	9.20E-02	1.13E-01	1.03E-01	5.71E-02	5.99E-02	4.26E-02	4.76E-02	3.47E+00	2.70E+00
As	mg/L	<3.00E-01	<3.00E-01	(3.74E-02)	(2.44E-02)	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01	<3.00E-01
As 75	mg/L	<2.28E-04	<3.60E-04	<5.00E-03	<5.00E-03	<2.28E-04	<3.60E-04	<3.08E-04	<2.08E-04	<1.03E-04	<2.85E-04	<5.00E-03	<2.39E-04	<1.53E-04	<2.68E-04	<4.30E-04	<5.00E-03
B	mg/L	<1.50E-01	<1.50E-01	(9.68E-03)	(5.87E-03)	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Ba	mg/L	<3.75E-02	<3.75E-02	4.62E-02	(2.92E-02)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Be	mg/L	<1.50E-02	<1.50E-02	(1.21E-03)	(1.10E-03)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Bi	mg/L	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00	<1.50E+00
Ca	mg/L	3.03E-01	4.26E-01	5.38E-01	3.84E-01	3.03E-01	4.26E-01	1.33E-01	1.53E-01	1.67E-01	1.79E-01	1.93E-01	2.91E-01	1.42E-01	1.89E-01	7.63E-02	9.89E-02
Cd ICP-MS	mg/L	3.89E-03	6.11E-03	8.25E-03	5.54E-03	3.89E-03	6.11E-03	(1.40E-05)	(4.05E-05)	(4.05E-05)	(2.20E-05)	(1.04E-04)	(1.77E-04)	(4.00E-05)	(3.50E-05)	(1.99E-04)	(2.35E-04)
Cd ICP-OES	mg/L	<1.50E-02	<1.50E-02	(8.03E-03)	(4.51E-03)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Co	mg/L	<3.75E-02	<3.75E-02	(8.73E-04)	(1.17E-03)	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02	<3.75E-02
Cr ICP-MS	mg/L	1.61E-02	2.43E-02	3.75E-02	2.88E-02	1.61E-02	2.43E-02	<5.00E-04	9.09E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	1.12E-03	1.45E-03
Cr ICP-OES	mg/L	1.95E-02	2.69E-02	3.35E-02	2.44E-02	1.95E-02	2.69E-02	(1.07E-03)	(1.74E-03)	(1.11E-03)	(1.59E-03)	(1.02E-03)	(1.77E-03)	(8.12E-04)	(1.06E-03)	(2.42E-03)	(2.69E-03)
Cu ICP-MS	mg/L	9.66E-03	1.10E-02	1.44E-02	1.18E-02	9.66E-03	1.10E-02	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	3.44E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Cu ICP-OES	mg/L	(1.17E-02)	(1.53E-02)	(1.62E-02)	(1.35E-02)	(1.17E-02)	(1.53E-02)	(3.38E-03)	(2.88E-03)	(1.85E-03)	(5.18E-02)	(3.49E-04)	(1.81E-03)	(4.28E-05)	(5.81E-04)	(4.32E-03)	(2.29E-03)
Fe	mg/L	4.88E-01	7.08E-01	9.24E-01	6.32E-01	4.88E-01	7.08E-01	(7.32E-03)	(6.05E-03)	(2.79E-02)	(6.38E-03)	(4.36E-03)	(1.16E-02)	(2.92E-03)	(2.43E-03)	5.13E-02	3.26E-02
K	mg/L	(5.53E-02)	(2.92E-01)	(3.13E-01)	(3.73E-01)	(5.53E-02)	(2.92E-01)	(1.56E-01)	(4.47E-02)	<3.75E+00	(3.50E-02)	(1.34E-01)	<3.75E+00	(1.86E-02)	(7.92E-02)	(8.49E-02)	<3.75E+00
Li	mg/L	(3.06E-03)	(7.70E-03)	(1.12E-02)	(1.02E-02)	(3.06E-03)	(7.70E-03)	(4.58E-03)	(4.51E-03)	(2.42E-03)	(1.96E-03)	(4.51E-03)	(1.88E-03)	(4.76E-04)	(1.33E-03)	(8.13E-03)	(3.77E-03)
Mg	mg/L	(7.07E-02)	(1.01E-01)	1.21E-01	8.59E-02	(7.07E-02)	(1.01E-01)	(2.80E-02)	(2.67E-02)	(3.63E-02)	(3.55E-02)	(4.77E-02)	(5.17E-02)	(3.06E-02)	(4.34E-02)	(1.71E-02)	(1.81E-02)
Mn	mg/L	4.91E-02	7.39E-02	9.66E-02	6.48E-02	4.91E-02	7.39E-02	(1.51E-03)	(1.06E-03)	(9.04E-04)	(5.33E-04)	(6.67E-04)	(3.96E-04)	(4.06E-04)	(2.18E-04)	(4.67E-03)	(3.65E-03)
Mo	mg/L	(5.07E-03)	(2.52E-03)	(1.24E-03)	(8.46E-03)	(5.07E-03)	(2.52E-03)	<1.50E-02	(1.54E-03)	<1.50E-02	(2.56E-04)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	(2.36E-03)	(5.32E-03)
Mo 95	mg/L	2.18E-03	2.39E-03	2.61E-03	2.57E-03	2.18E-03	2.39E-03	(8.60E-05)	(1.13E-04)	(5.70E-05)	(5.80E-05)	(1.00E-04)	(4.97E-04)	(3.40E-05)	(3.10E-05)	(7.10E-05)	(6.70E-05)
Mo 97	mg/L	2.20E-03	2.41E-03	2.39E-03	2.55E-03	2.20E-03	2.41E-03	1.37E-04	1.57E-04	(6.80E-05)	(2.10E-05)	(6.60E-05)	5.60E-04	<1.00E-04	(1.80E-05)	(8.50E-05)	(4.70E-05)
Mo 98	mg/L	1.79E-03	1.97E-03	2.05E-03	2.06E-03	1.79E-03	1.97E-03	(5.50E-05)	(1.35E-04)	(6.90E-05)	(4.10E-05)	(3.60E-05)	4.38E-04	(2.00E-06)	(1.00E-05)	(5.70E-05)	(2.30E-05)
Na	mg/L	6.50E+00	7.14E+00	1.47E+01	1.75E+01	6.50E+00	7.14E+00	3.23E+00	3.37E+00	4.30E+00	4.21E+00	1.65E+00	1.93E+00	1.23E+00	1.27E+00	7.07E+00	7.29E+00
Ni	mg/L	6.04E-02	8.94E-02	1.16E-01	7.69E-02	6.04E-02	8.94E-02	(6.46E-03)	(7.30E-03)	(5.05E-03)	(3.31E-03)	(3.67E-03)	(4.67E-03)	(5.81E-03)	(3.15E-03)	(1.36E-02)	(9.66E-03)
P	mg/L	(3.42E-01)	4.67E-01	8.57E-01	8.43E-01	(3.42E-01)	4.67E-01	(3.59E-02)	(6.05E-02)	(4.01E-02)	(3.04E-02)	(2.61E-02)	(3.49E-02)	(3.72E-02)	(1.06E-02)	(1.60E-01)	(1.54E-01)
Pb ICP-MS	mg/L	6.66E-02	9.81E-02	1.37E-01	9.74E-02	6.66E-02	9.81E-02	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	(1.26E-03)	<5.00E-03	<5.00E-03	(3.48E-03)	(4.66E-03)
Pb ICP-OES	mg/L	6.57E-02	1.02E-01	1.39E-01	9.61E-02	6.57E-02	1.02E-01	(7.54E-03)	<3.00E-02	(5.66E-03)	(7.77E-03)	<3.00E-02	<3.00E-02	<3.00E-02	<3.00E-02	(6.25E-03)	(1.09E-02)
Ru 101	mg/L	1.72E-02	2.28E-02	3.03E-02	2.41E-02	1.72E-02	2.28E-02	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	1.09E-03	1.37E-03
Ru 102	mg/L	7.97E-03	1.09E-02	1.43E-02	1.11E-02	7.97E-03	1.09E-02	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
S	mg/L	(8.42E-02)	(9.53E-02)	(1.68E-01)	(1.82E-01)	(8.42E-02)	(9.53E-02)	(9.65E-02)	(6.61E-02)	(8.90E-02)	<3.00E+00	(4.42E-03)	(4.93E-02)	(1.04E-01)	<3.00E+00	(2.40E-02)	(7.88E-02)
Sb 121	mg/L	(1.19E-04)	(1.57E-04)	(3.34E-04)	(3.59E-04)	(1.19E-04)	(1.57E-04)	(1.29E-04)	(9.60E-05)	(4.20E-05)	(3.60E-05)	(8.00E-06)	(7.20E-05)	(1.30E-05)	(4.00E-06)	(5.00E-05)	(3.70E-05)
Se	mg/L	<3.00E+00	<3.00E+00	(6.37E-02)	(7.98E-02)	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00	<3.00E+00
Se 82	mg/L	<5.65E-04	<4.15E-04	<5.00E-03	<5.00E-03	<5.65E-04	<4.15E-04	<9.82E-04	<2.24E-04	<7.00E-05	<1.09E-03	<2.81E-04	<1.50E-03	<8.54E-04	<5.95E-04	<5.48E-04	<1.00E-04
Si	mg/L	(3.92E-01)	(5.60E-01)	4.48E+00	4.58E+00	(3.92E-01)	(5.60E-01)	(1.10E+00)	(1.18E+00)	2.02E+00	1.97E+00	(8.02E-01)	(9.32E-01)	(5.42E-01)	(5.89E-01)	4.99E+00	4.61E+00
Sr	mg/L	1.94E-02	2.81E-02	4.13E-02	2.85E-02	1.94E-02	2.81E-02	(5.77E-03)	(4.95E-03)	(4.21E-03)	(3.87E-03)	(5.56E-03)	(5.36E-03)	(4.22E-03)	(7.20E-03)	(6.06E-03)	(5.41E-03)
Ti	mg/L	(3.05E-03)	(5.64E-03)	(6.61E-03)	(4.87E-03)	(3.05E-03)	(5.64E-03)	(4.45E-04)	<7.50E-03	(4.40E-04)	<7.50E-03	<7.50E-03	(3.45E-04)	<7.50E-03	<7.50E-03	(1.21E-03)	(5.72E-04)
Tl	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
V	mg/L	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02
Zn	mg/L	(3.55E-02)	4.94E-02	6.03E-02	4.56E-02	(3.55E-02)	4.94E-02	3.87E-02	3.82E-02	5.06E-02	4.28E-02	(3.53E-02)	7.19E-02	(2.97E-02)	(2.46E-02)	(3.20E-02)	(2.62E-02)
Zr	mg/L	1.87E-01	2.74E-01	3.58E-01	2.44E-01	1.87E-01	2.74E-01	(1.32E-03)	(5.98E-04)	(3.71E-04)	(6.82E-04)	<1.50E-02	<1.50E-02	<1.50E-02	<1.50E-02	(1.12E-02)	(1.06E-02)
Anions																	
NO_2^- as NO_2^-	mg/L	3.99E-01	4.02E-01	5.75E-01	6.68E-01	3.99E-01	4.02E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.67E-01	2.00E-01
NO_3^- as NO_3^-	mg/L	2.28E-01	2.47E-01	1.43E+00	1.91E+00	2.28E-01	2.47E-01	2.13E-01	2.66E-01	5.87E-01	5.68E-01	1.70E-01	1.83E-01	1.23E-01	1.46E-01	1.48E+00	1.46E+00
CO_3^{2-}	mg/L	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO_4^{2-}	mg/L	<1.50E-01	<1.50E-01	1.80E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	3.11E-01	4.33E-01	1.80E+00	1.16E+00	3.11E-01	4.33E-01	<1.50E-01	2.83E-01	9.94E-01	1.10E+00	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	1.70E-01	2.45E-01
Cl^-	mg/L	<5.00E-02	<5.00E-02	8.15E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
F^-	mg/L	6.70E-02	7.51E-02	2.28E-01	2.47E-01	6.70E-02	7.51E-02	<2.00E-02	<2.00E-02	5.69E-02	5.68E-02	<2.00E-02	<2.00E-02	<2.00E-02	<2.00E-02	1.41E-01	1.44E-01

Table F.4. Ca(OH)$_2$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19845

Tank C-103 (19845) Ca(OH)$_2$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	11.94	11.98	11.14	11.23	11.94	11.98	12.07	12.07	12.08	12.09	12.09	12.12	12.11	12.14	10.97	11.02
Alkalinity	mg/L as CaCO$_3$	2.51E+03	2.47E+03	1.98E+03	2.66E+03	2.51E+03	2.47E+03	2.66E+03	2.58E+03	2.58E+03	2.55E+03	2.70E+03	2.70E+03	2.74E+03	2.74E+03	2.39E+03	1.94E+03
Radionuclides																	
^{90}Sr	µCi/L	1.07E+03	1.14E+03	1.389E+03	1.051E+03	1.07E+03	1.14E+03			9.48E+02	9.60E+02			8.64E+02	9.10E+02	1.11E+03	1.21E+03
^{99}Tc	mg/L	1.13E-04	1.23E-04	1.80E-04	1.46E-04	1.13E-04	1.23E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(7.00E-05)	(7.10E-05)
^{238}U	mg/L	(7.05E-04)	(8.20E-05)	(2.00E-05)	(1.78E-04)	(7.05E-04)	(8.20E-05)	(2.90E-05)	(8.00E-05)	(1.60E-05)	(1.27E-04)	(2.43E-04)	(1.43E-04)	(1.42E-04)	(1.10E-05)	(2.36E-04)	(5.00E-06)
^{239}Pu	µCi/L	<1.55E-02	<1.55E-02	(1.55E-02)	(1.55E-02)	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02
^{237}Np	µCi/L	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	(1.14E-04)	(1.39E-04)	3.78E-03	1.39E-03	(1.14E-04)	(1.39E-04)	(4.75E-05)	(7.80E-05)	(3.60E-05)	(2.90E-05)	(2.50E-05)	(1.85E-05)	(2.35E-05)	(1.35E-05)	1.20E-03	(2.46E-04)
Al	mg/L	3.65E-01	3.69E-01	1.03E+00	1.94E-01	3.65E-01	3.69E-01	3.25E-01	2.92E-01	3.93E-01	3.59E-01	2.69E-01	2.75E-01	2.71E-01	2.36E-01	6.01E-01	8.59E-01
As	mg/L	(1.38E-01)	(1.49E-01)	(2.20E-01)	(1.35E-01)	(1.38E-01)	(1.49E-01)	(1.50E-01)	(1.29E-01)	(2.29E-01)	(2.91E-01)	(2.32E-01)	(2.17E-01)	(2.12E-01)	(2.14E-01)	(1.96E-01)	(1.79E-01)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Ba	mg/L	(1.18E-01)	1.27E-01	2.28E-01	(1.01E-01)	(1.18E-01)	1.27E-01	(6.11E-02)	(8.18E-02)	(7.30E-02)	(1.23E-01)	(3.81E-02)	(4.90E-02)	(3.30E-02)	(4.38E-02)	1.96E-01	3.63E-01
Be	mg/L	(1.52E-03)	(1.15E-03)	(1.98E-03)	(1.65E-03)	(1.52E-03)	(1.15E-03)	(1.07E-03)	(9.14E-04)	(9.77E-04)	(9.47E-04)	(9.52E-04)	(9.19E-04)	(9.33E-04)	(9.61E-04)	(3.49E-03)	(2.49E-03)
Bi	mg/L	(8.48E-02)	(3.76E-02)	(6.74E-02)	(5.46E-02)	(8.48E-02)	(3.76E-02)	(6.46E-02)	(7.21E-02)	(5.08E-02)	(4.86E-02)	(3.06E-02)	(7.95E-02)	(6.20E-02)	(7.78E-02)	(6.15E-02)	(7.01E-02)
Ca	mg/L	7.97E+02	7.92E+02	6.27E+02	7.84E+02	7.97E+02	7.92E+02	8.52E+02	8.57E+02	8.26E+02	8.09E+02	8.69E+02	8.78E+02	8.81E+02	8.64E+02	6.69E+02	6.39E+02
Cd ICP-MS	mg/L	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	1.49E-02	1.40E-02	(1.51E-04)	1.14E-02	1.49E-02	1.40E-02	1.19E-02	1.45E-02	1.09E-02	1.17E-02	1.60E-02	1.64E-02	1.69E-02	1.72E-02	(2.28E-03)	(1.52E-04)
Cr ICP-OES	mg/L	1.44E-02	1.38E-02	<1.25E-02	(1.08E-02)	1.44E-02	1.38E-02	(1.17E-02)	1.41E-02	(9.31E-03)	(1.21E-02)	1.59E-02	1.57E-02	1.43E-02	1.47E-02	<1.25E-02	<1.25E-02
Cu ICP-MS	mg/L	(1.29E-03)	(1.40E-03)	(9.06E-04)	(7.09E-04)	(1.29E-03)	(1.40E-03)	(3.91E-04)	(5.77E-04)	(3.29E-04)	(4.32E-04)	(2.37E-04)	(3.23E-04)	(2.18E-04)	(1.88E-04)	(3.51E-04)	(3.14E-04)
Cu ICP-OES	mg/L	(1.61E-02)	(1.52E-02)	(4.97E-03)	(2.72E-03)	(1.61E-02)	(1.52E-02)	(1.21E-02)	(1.13E-02)	(1.00E-02)	(9.49E-03)	(6.86E-03)	(7.87E-03)	(6.50E-03)	(6.68E-03)	(3.59E-03)	(4.03E-03)
Fe	mg/L	(1.27E-02)	(1.09E-02)	(6.34E-03)	(6.34E-03)	(1.27E-02)	(1.09E-02)	(9.53E-03)	(1.06E-02)	(8.44E-03)	(8.51E-03)	(7.40E-03)	(7.56E-03)	(8.52E-03)	(6.38E-03)	(9.44E-03)	(7.61E-03)
K	mg/L	(3.95E-01)	(3.99E-01)	(6.68E-01)	(4.55E-01)	(3.95E-01)	(3.99E-01)	<6.25E+00	<6.25E+00	(6.79E-02)	(1.28E-01)	<6.25E+00	<6.25E+00	<6.25E+00	<6.25E+00	(3.53E-01)	(2.62E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(1.95E-02)	(1.80E-02)	(1.43E-02)	(1.46E-02)	(1.95E-02)	(1.80E-02)	(1.77E-02)	(1.81E-02)	(1.59E-02)	(1.64E-02)	(1.75E-02)	(1.71E-02)	(1.89E-02)	(1.71E-02)	(2.00E-02)	(1.50E-02)
Mn	mg/L	(1.63E-03)	(1.32E-03)	(4.94E-04)	(3.98E-04)	(1.63E-03)	(1.32E-03)	(1.30E-03)	(1.15E-03)	(1.14E-03)	(9.76E-04)	(8.20E-04)	(6.73E-04)	(7.48E-04)	(3.84E-04)	(1.70E-03)	(1.09E-03)
Mo	mg/L	7.49E-02	7.58E-02	6.47E-02	8.19E-02	7.49E-02	7.58E-02	8.54E-02	9.72E-02	7.96E-02	7.32E-02	8.35E-02	7.84E-02	5.87E-02	8.47E-02	8.28E-02	6.86E-02
Mo 95	mg/L	1.47E-03	1.67E-03	(8.90E-05)	1.42E-03	1.47E-03	1.67E-03	(3.32E-04)	(4.52E-04)	(3.07E-04)	(3.98E-04)	(3.82E-04)	(3.03E-04)	(2.83E-04)	(2.13E-04)	(8.40E-05)	(2.90E-05)
Mo 97	mg/L	1.46E-03	1.81E-03	(5.50E-05)	1.47E-03	1.46E-03	1.81E-03	2.42E-04	5.03E-04	2.46E-04	4.03E-04	2.32E-04	2.03E-04	2.31E-04	2.87E-04	<1.00E-04	<1.00E-04
Mo 98	mg/L	1.24E-03	1.40E-03	(4.40E-05)	1.10E-03	1.24E-03	1.40E-03	2.77E-04	3.69E-04	(2.49E-04)	3.33E-04	3.13E-04	(2.27E-04)	2.52E-04	(2.32E-04)	(6.40E-05)	(1.00E-06)
Na	mg/L	1.10E+01	1.35E+01	3.02E+01	1.47E+01	1.10E+01	1.35E+01	3.49E+00	3.61E+00	5.83E+00	6.86E+00	1.77E+00	1.65E+00	1.54E+00	1.29E+00	1.17E+01	1.32E+01
Ni	mg/L	(1.73E-02)	(1.24E-02)	(2.80E-03)	(1.10E-02)	(1.73E-02)	(1.24E-02)	(1.10E-02)	(1.23E-02)	(1.32E-02)	(1.41E-02)	(9.32E-03)	(1.12E-02)	(1.46E-02)	(8.63E-03)	(1.01E-03)	(5.85E-03)
P	mg/L	(5.49E-01)	(5.70E-01)	(4.80E-01)	(4.78E-01)	(5.49E-01)	(5.70E-01)	(5.22E-01)	(4.89E-01)	(5.41E-01)	(5.22E-01)	(5.62E-01)	(5.22E-01)	(5.15E-01)	(5.42E-01)	(4.79E-01)	(4.63E-01)
Pb ICP-MS	mg/L	6.03E-02	7.47E-02	7.68E-02	5.37E-02	6.03E-02	7.47E-02	5.65E-02	7.16E-02	4.65E-02	6.27E-02	2.79E-02	3.49E-02	2.07E-02	2.24E-02	4.52E-02	7.48E-02
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(4.61E-04)	(4.59E-04)	(7.39E-04)	(3.47E-04)	(4.61E-04)	(4.59E-04)	(2.53E-04)	(2.19E-04)	(1.96E-04)	(2.38E-04)	(7.10E-05)	(4.50E-05)	(4.40E-05)	(3.20E-05)	(4.09E-04)	(4.85E-04)
Ru 102	mg/L	(6.54E-04)	(5.98E-04)	(6.07E-04)	(5.35E-04)	(6.54E-04)	(5.98E-04)	(4.77E-04)	(6.13E-04)	(4.63E-04)	(4.86E-04)	(4.25E-04)	(4.47E-04)	(4.29E-04)	(4.27E-04)	(5.73E-04)	(5.45E-04)
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	(7.20E-05)	(4.20E-05)	<1.00E-03	<1.00E-03	(7.20E-05)	(4.20E-05)	(3.30E-05)	(5.90E-05)	(1.20E-05)	(1.50E-05)	(5.00E-06)	(1.30E-05)	(1.50E-05)	(2.00E-05)	(2.30E-05)	(2.80E-05)
Se	mg/L	(2.89E+00)	(2.65E+00)	(2.69E+00)	(2.84E+00)	(2.89E+00)	(2.65E+00)	(2.82E+00)	(2.73E+00)	(2.82E+00)	(2.97E+00)	(2.82E+00)	(3.02E+00)	(3.03E+00)	(2.76E+00)	(2.89E+00)	(2.53E+00)
Se 82	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Si	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Sr	mg/L	7.63E-01	7.93E-01	9.36E-01	7.60E-01	7.63E-01	7.93E-01	6.98E-01	7.00E-01	7.06E-01	7.11E-01	6.61E-01	6.65E-01	6.27E-01	6.17E-01	7.08E-01	7.40E-01
Ti	mg/L	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(6.00E-02)	(5.78E-02)	(6.58E-02)	(4.97E-02)	(6.00E-02)	(5.78E-02)	(6.44E-02)	(4.48E-02)	(5.78E-02)	(5.84E-02)	(5.25E-02)	(4.99E-02)	(5.02E-02)	(5.26E-02)	(5.51E-02)	(5.68E-02)
Zr	mg/L	(1.60E-03)	(1.26E-03)	(1.65E-03)	(1.20E-03)	(1.60E-03)	(1.26E-03)	(1.02E-04)	(1.66E-03)	(4.71E-04)	(6.09E-04)	(4.81E-04)	(1.47E-03)	(6.27E-04)	(4.16E-04)	(2.79E-03)	(2.64E-03)
Anions																	
NO$_2^-$ as NO$_2^-$	mg/L	3.52E-01	4.41E-01	6.06E-01	4.92E-01	3.52E-01	4.41E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.39E-01	1.46E-01
NO$_3^-$ as NO$_3^-$	mg/L	5.97E-01	7.48E-01	4.32E+00	1.45E+00	5.97E-01	7.48E-01	3.59E-01	3.65E-01	1.01E+00	1.23E+00	1.91E-01	2.34E-01	1.81E-01	1.20E-01	2.04E+00	2.43E+00
CO$_3^{2-}$	mg/L	<5.00E+01	1.42E+02	<5.00E+01	<5.00E+01	<5.00E+01	1.42E+02	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO$_4^{2-}$	mg/L	7.38E-01	8.50E-01	<1.50E-01	<1.50E-01	7.38E-01	8.50E-01	6.65E-01	7.72E-01	4.28E-01	3.92E-01	9.01E-01	1.02E+00	9.26E-01	8.98E-01	2.09E-01	<1.50E-01
PO$_4^{3-}$ as PO$_4^{3-}$	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl$^-$	mg/L	1.69E-01	3.85E-01	1.22E-01	2.09E-01	1.69E-01	3.85E-01	1.42E-01	1.41E-01	1.44E-01	1.46E-01	1.48E-01	1.57E-01	1.39E-01	1.22E-01	1.49E-01	8.82E-02
F$^-$	mg/L	1.06E-01	1.30E-01	2.27E-01	1.58E-01	1.06E-01	1.30E-01	7.82E-02	8.80E-02	1.06E-01	1.27E-01	6.02E-02	5.27E-02	4.24E-02	4.81E-02	1.62E-01	2.22E-01

Table F.5. $Ca(OH)_2$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19849

Tank C-103 (19849) $Ca(OH)_2$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	11.41	11.56	11.80	11.83	11.41	11.56	11.66	11.73	10.65	10.80	11.32	11.44	11.54	11.62	11.73	11.79
Alkalinity	mg/L as $CaCO_3$	2.62E+03	2.55E+03	2.01E+03	2.13E+03	2.62E+03	2.55E+03	2.66E+03	2.74E+03	2.70E+03	2.58E+03	2.74E+03	2.74E+03	2.74E+03	2.51E+03	2.24E+03	2.13E+03
Radionuclides																	
^{90}Sr	µCi/L	1.13E+03	1.18E+03	1.546E+03	1.683E+03	1.13E+03	1.18E+03			9.28E+02	9.50E+02			8.47E+02	8.48E+02	1.23E+03	1.15E+03
^{99}Tc	mg/L	(9.80E-05)	1.09E-04	1.42E-04	1.55E-04	(9.80E-05)	1.09E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(4.90E-05)	(6.00E-05)
^{238}U	mg/L	1.26E-03	(1.98E-03)	(1.36E-04)	(1.62E-04)	1.26E-03	(1.98E-03)	(1.40E-04)	(1.04E-04)	(1.10E-05)	(1.96E-04)	(1.29E-04)	(2.10E-05)	(2.00E-06)	(1.00E-06)	(3.21E-04)	(2.14E-04)
^{239}Pu	µCi/L	<1.55E-02	<1.55E-02	(1.55E-02)	(1.55E-02)	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02
^{237} Np	µCi/L	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	(6.35E-05)	(7.40E-05)	4.57E-03	4.80E-03	(6.35E-05)	(7.40E-05)	(3.05E-05)	(2.45E-05)	(1.95E-05)	(1.50E-05)	(3.50E-05)	(3.30E-05)	(2.65E-05)	(1.20E-05)	(3.33E-04)	1.31E-03
Al	mg/L	3.23E-01	3.61E-01	6.67E-01	3.49E-01	3.23E-01	3.61E-01	2.61E-01	2.69E-01	3.64E-01	4.05E-01	2.43E-01	2.49E-01	2.72E-01	2.57E-01	6.54E-01	5.99E-01
As	mg/L	(1.58E-01)	(1.81E-01)	(2.76E-01)	(1.24E-01)	(1.58E-01)	(1.81E-01)	(2.66E-01)	(1.84E-01)	(1.80E-01)	(2.89E-01)	(1.62E-01)	(2.01E-01)	(2.05E-01)	(1.46E-01)	(1.83E-01)	(1.19E-01)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Ba	mg/L	1.61E-01	1.89E-01	3.20E-01	4.54E-01	1.61E-01	1.89E-01	(6.55E-02)	(6.96E-02)	(1.06E-01)	(1.23E-01)	(3.96E-02)	(3.84E-02)	(3.26E-02)	(3.45E-02)	2.08E-01	1.96E-01
Be	mg/L	(1.69E-03)	(1.54E-03)	(1.34E-03)	(1.31E-03)	(1.69E-03)	(1.54E-03)	(1.56E-03)	(1.46E-03)	(1.47E-03)	(3.95E-03)	(2.87E-03)	(2.54E-03)	(2.07E-03)	(1.82E-03)	(1.66E-03)	(1.49E-03)
Bi	mg/L	(2.49E-02)	(3.45E-02)	(5.66E-02)	(3.10E-02)	(2.49E-02)	(3.45E-02)	(3.94E-02)	(2.69E-02)	(4.65E-02)	(4.61E-02)	(6.58E-02)	(1.83E-02)	(1.88E-02)	(5.38E-02)	(8.22E-03)	(3.90E-02)
Ca	mg/L	8.27E+02	8.04E+02	6.08E+02	6.17E+02	8.27E+02	8.04E+02	8.73E+02	8.56E+02	8.23E+02	8.40E+02	8.67E+02	8.53E+02	8.60E+02	8.71E+02	6.80E+02	6.26E+02
Cd ICP-MS	mg/L	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	1.39E-02	1.35E-02	(2.17E-04)	(4.06E-04)	1.39E-02	1.35E-02	1.40E-02	1.35E-02	1.09E-02	(8.35E-03)	1.59E-02	1.58E-02	1.69E-02	1.69E-02	(1.70E-03)	(5.26E-04)
Cr ICP-OES	mg/L	1.28E-02	1.26E-02	<1.25E-02	<1.25E-02	1.28E-02	1.26E-02	(1.13E-02)	1.39E-02	(9.27E-03)	(7.67E-03)	1.52E-02	1.39E-02	1.51E-02	1.71E-02	<1.25E-02	<1.25E-02
Cu ICP-MS	mg/L	(1.78E-03)	(1.82E-03)	(1.71E-03)	(1.90E-03)	(1.78E-03)	(1.82E-03)	(5.06E-04)	(6.16E-04)	(5.85E-04)	(7.52E-04)	(3.12E-04)	(3.85E-04)	(2.32E-04)	(2.53E-04)	(5.42E-04)	(5.71E-04)
Cu ICP-OES	mg/L	<5.00E-02	<5.00E-02	(1.59E-03)	(1.15E-03)	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
Fe	mg/L	(5.66E-03)	(5.34E-03)	(4.36E-03)	(4.62E-03)	(5.66E-03)	(5.34E-03)	(5.55E-03)	(4.63E-03)	(4.82E-03)	(8.92E-03)	(6.84E-03)	(5.89E-03)	(6.30E-03)	(6.22E-03)	(5.55E-03)	(4.66E-03)
K	mg/L	(4.93E-01)	(5.40E-01)	(7.58E-01)	(8.13E-01)	(4.93E-01)	(5.40E-01)	(8.62E-02)	(3.01E-02)	(1.84E-01)	<6.25E+00	(2.89E-02)	(2.43E-01)	(3.62E-02)	(7.57E-02)	(3.03E-01)	(1.37E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(2.01E-02)	(1.99E-02)	(1.33E-02)	(1.30E-02)	(2.01E-02)	(1.99E-02)	(1.98E-02)	(1.83E-02)	(1.75E-02)	(2.15E-02)	(2.15E-02)	(2.07E-02)	(1.91E-02)	(1.93E-02)	(1.72E-02)	(1.34E-02)
Mn	mg/L	(4.61E-04)	(5.17E-04)	(2.64E-04)	(1.83E-04)	(4.61E-04)	(5.17E-04)	(1.84E-04)	(2.67E-04)	(3.31E-04)	(2.09E-03)	(1.24E-03)	(7.57E-04)	(8.60E-04)	(5.14E-04)	(2.07E-04)	(1.86E-04)
Mo	mg/L	6.87E-02	7.43E-02	6.53E-02	8.11E-02	6.87E-02	7.43E-02	7.47E-02	7.66E-02	6.77E-02	7.61E-02	8.02E-02	6.27E-02	9.42E-02	7.59E-02	7.33E-02	6.70E-02
Mo 95	mg/L	1.21E-03	1.31E-03	(8.20E-05)	(1.10E-04)	1.21E-03	1.31E-03	(3.41E-04)	(2.05E-04)	(2.56E-04)	(2.93E-04)	(3.13E-04)	(2.91E-04)	(2.47E-04)	(2.88E-04)	(3.90E-05)	(4.50E-05)
Mo 97	mg/L	1.37E-03	1.32E-03	1.24E-04	(3.60E-05)	1.37E-03	1.32E-03	3.68E-04	3.10E-04	2.08E-04	2.96E-04	3.61E-04	3.00E-04	2.21E-04	3.87E-04	(6.30E-05)	(7.70E-05)
Mo 98	mg/L	1.14E-03	1.18E-03	(5.50E-05)	(9.30E-05)	1.14E-03	1.18E-03	2.71E-04	(2.16E-04)	(2.00E-04)	(2.22E-04)	(2.39E-04)	(2.32E-04)	(2.27E-04)	(2.32E-04)	(8.40E-05)	(2.40E-05)
Na	mg/L	1.04E+01	1.16E+01	2.49E+01	2.55E+01	1.04E+01	1.16E+01	2.51E+00	2.63E+00	4.53E+00	5.41E+00	1.36E+00	1.58E+00	1.25E+00	1.41E+00	9.37E+00	1.08E+01
Ni	mg/L	(8.69E-03)	(5.85E-03)	(1.17E-03)	(3.77E-03)	(8.69E-03)	(5.85E-03)	(3.26E-04)	(6.14E-03)	(4.58E-03)	(9.70E-03)	(6.52E-03)	(4.58E-03)	(2.01E-03)	(4.15E-03)	(7.11E-03)	(7.35E-03)
P	mg/L	(5.56E-01)	(5.60E-01)	(5.42E-01)	(5.60E-01)	(5.56E-01)	(5.60E-01)	(5.29E-01)	(5.19E-01)	(4.94E-01)	(5.31E-01)	(5.59E-01)	(5.42E-01)	(5.02E-01)	(5.20E-01)	(5.12E-01)	(4.33E-01)
Pb ICP-MS	mg/L	5.94E-02	7.15E-02	5.71E-02	5.74E-02	5.94E-02	7.15E-02	3.63E-02	4.12E-02	4.35E-02	5.52E-02	2.73E-02	3.17E-02	2.08E-02	2.77E-02	5.13E-02	6.13E-02
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(4.76E-04)	(5.02E-04)	(6.68E-04)	(7.30E-04)	(4.76E-04)	(5.02E-04)	(2.14E-04)	(1.77E-04)	(2.44E-04)	(3.30E-04)	(1.05E-04)	(1.36E-04)	(8.30E-05)	(7.10E-05)	(5.13E-04)	(5.30E-04)
Ru 102	mg/L	(5.86E-04)	(6.54E-04)	(5.63E-04)	(6.40E-04)	(5.86E-04)	(6.54E-04)	(4.14E-04)	(4.48E-04)	(5.09E-04)	(5.80E-04)	(4.01E-04)	(4.59E-04)	(4.15E-04)	(4.27E-04)	(6.15E-04)	(5.44E-04)
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	(6.00E-06)	(5.00E-06)	<1.00E-03	<1.00E-03	(6.00E-06)	(5.00E-06)	(1.50E-05)	(2.10E-05)	(1.30E-05)	(1.00E-06)	(6.50E-05)	(6.40E-05)	(3.00E-05)	(1.60E-05)	(2.10E-05)	(5.00E-06)
Se	mg/L	(3.11E+00)	(2.73E+00)	(2.56E+00)	(2.59E+00)	(3.11E+00)	(2.73E+00)	(2.90E+00)	(2.72E+00)	(2.80E+00)	(2.93E+00)	(3.38E+00)	(3.10E+00)	(3.05E+00)	(2.93E+00)	(2.80E+00)	(2.49E+00)
Se 82	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Si	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Sr	mg/L	8.44E-01	8.81E-01	1.01E+00	1.02E+00	8.44E-01	8.81E-01	7.02E-01	7.09E-01	7.31E-01	7.52E-01	6.18E-01	6.29E-01	6.29E-01	6.33E-01	7.57E-01	7.62E-01
Ti	mg/L	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(5.42E-02)	(5.05E-02)	(6.49E-02)	(4.23E-02)	(5.42E-02)	(5.05E-02)	(4.79E-02)	(4.79E-02)	(5.38E-02)	(4.93E-02)	(5.59E-02)	(4.64E-02)	(4.95E-02)	(5.50E-02)	(4.90E-02)	(4.64E-02)
Zr	mg/L	(1.48E-03)	(1.40E-03)	(1.24E-03)	(3.15E-04)	(1.48E-03)	(1.40E-03)	(1.85E-03)	(6.97E-04)	(3.01E-04)	(2.52E-03)	(2.54E-03)	(2.00E-03)	(1.80E-03)	(1.65E-03)	(1.08E-03)	(1.05E-03)
Anions																	
NO_2^- as NO_2^-	mg/L	3.01E-01	4.36E-01	5.13E-01	5.77E-01	3.01E-01	4.36E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.09E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.23E-01	1.53E-01
NO_3^- as NO_3^-	mg/L	4.81E-01	6.81E-01	3.56E+00	3.71E+00	4.81E-01	6.81E-01	2.58E-01	3.29E-01	6.43E-01	9.00E-01	1.30E-01	1.69E-01	1.22E-01	1.70E-01	1.55E+00	1.86E+00
CO_3^{2-}	mg/L	<5.00E+01	<5.00E+01	1.46E+02	1.56E+02	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	5.04E+01	5.73E+01	5.81E+01	<5.00E+01	7.82E+01	8.97E+01
SO_4^{2-}	mg/L	7.18E-01	6.19E-01	<1.50E-01	<1.50E-01	7.18E-01	6.19E-01	9.54E-01	9.68E-01	4.84E-01	4.47E-01	9.90E-01	1.03E+00	1.14E+00	1.07E+00	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl^-	mg/L	1.45E-01	1.69E-01	1.42E-01	1.09E-01	1.45E-01	1.69E-01	1.88E-01	2.00E-01	1.40E-01	2.44E-01	1.15E-01	1.39E-01	1.38E-01	1.22E-01	9.60E-02	9.74E-02
F^-	mg/L	1.05E-01	1.13E-01	1.46E-01	1.73E-01	1.05E-01	1.13E-01	5.47E-02	6.33E-02	9.97E-02	1.38E-01	5.34E-02	5.83E-02	5.29E-02	5.42E-02	1.76E-01	2.17E-01

Table F.6. $Ca(OH)_2$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19850

Tank C-103 (19850) $Ca(OH)_2$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	11.50	11.53	11.32	11.38	11.50	11.53	11.56	11.61	11.62	11.63	11.68	11.72	11.73	11.74	11.36	11.36
Alkalinity	mg/L as $CaCO_3$	2.43E+03	2.55E+03	1.98E+03	2.17E+03	2.43E+03	2.55E+03	2.43E+03	2.55E+03	2.47E+03	2.43E+03	2.62E+03	2.62E+03	2.55E+03	2.58E+03	2.24E+03	2.09E+03
Radionuclides																	
^{90}Sr	µCi/L	7.88E+02	8.49E+02	1.481E+03	1.336E+03	7.88E+02	8.49E+02			6.37E+02	6.80E+02			5.42E+02	5.53E+02	8.92E+02	1.04E+03
^{99}Tc	mg/L	(7.30E-05)	(9.90E-05)	1.86E-04	1.48E-04	(7.30E-05)	(9.90E-05)	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	(5.90E-05)	(6.80E-05)
^{238}U	mg/L	(1.09E-03)	(1.78E-03)	(5.20E-04)	3.85E-04	(1.09E-03)	(1.78E-03)	(1.36E-04)	(6.40E-05)	(1.16E-04)	(1.56E-04)	(2.63E-04)	(2.80E-04)	(4.00E-05)	(4.00E-06)	(4.23E-04)	(3.10E-05)
^{239}Pu	µCi/L	<1.55E-02	<1.55E-02	(1.55E-02)	(1.55E-02)	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02
^{237}Np	µCi/L	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06
^{241}Am	µCi/L	<5.00E-02	<5.00E-02	<1.70E-01	<1.70E-01	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
Metals																	
Ag	mg/L	(4.85E-05)	(6.75E-05)	5.42E-03	6.21E-04	(4.85E-05)	(6.75E-05)	(6.75E-05)	(2.55E-05)	(2.20E-05)	(2.20E-05)	(1.25E-05)	(1.85E-05)	(1.05E-05)	(2.25E-05)	2.94E-03	3.08E-03
Al	mg/L	3.84E-01	3.81E-01	4.62E-01	1.34E+00	3.84E-01	3.81E-01	3.44E-01	3.27E-01	3.22E-01	3.81E-01	2.95E-01	3.29E-01	2.44E-01	2.59E-01	4.65E-01	5.31E-01
As	mg/L	(2.23E-01)	(2.02E-01)	(1.36E-01)	(2.41E-01)	(2.23E-01)	(2.02E-01)	(2.76E-01)	(1.41E-01)	(1.90E-01)	(2.23E-01)	(2.93E-01)	(1.88E-01)	(2.22E-01)	(2.55E-01)	(1.57E-01)	(2.26E-01)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Ba	mg/L	1.80E-01	2.31E-01	4.64E-01	3.73E-01	1.80E-01	2.31E-01	1.36E-01	1.44E-01	(1.16E-01)	1.70E-01	(6.10E-02)	(7.96E-02)	(4.37E-02)	(5.20E-02)	2.60E-01	4.07E-01
Be	mg/L	(1.30E-03)	(4.09E-03)	(2.20E-03)	(2.26E-03)	(1.30E-03)	(4.09E-03)	(2.86E-03)	(2.24E-03)	(1.82E-03)	(1.81E-03)	(1.67E-03)	(1.59E-03)	(1.53E-03)	(1.52E-03)	(4.31E-03)	(2.69E-03)
Bi	mg/L	(3.52E-02)	(4.94E-02)	(7.29E-02)	(6.05E-02)	(3.52E-02)	(4.94E-02)	(6.32E-02)	(4.54E-02)	(3.50E-02)	(7.62E-02)	(4.53E-02)	(8.61E-02)	(2.65E-02)	(2.74E-02)	(5.52E-02)	(3.36E-02)
Ca	mg/L	8.23E+02	8.14E+02	6.08E+02	6.57E+02	8.23E+02	8.14E+02	8.53E+02	8.25E+02	8.28E+02	8.21E+02	8.50E+02	8.58E+02	8.53E+02	8.48E+02	6.98E+02	6.61E+02
Cd ICP-MS	mg/L	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	1.41E-02	1.46E-02	(2.47E-03)	(2.00E-03)	1.41E-02	1.46E-02	1.37E-02	1.39E-02	1.43E-02	1.23E-02	1.64E-02	1.48E-02	1.84E-02	1.82E-02	(3.47E-03)	(1.10E-03)
Cr ICP-OES	mg/L	1.40E-02	1.56E-02	(3.81E-03)	(2.42E-03)	1.40E-02	1.56E-02	1.40E-02	1.31E-02	1.47E-02	(1.20E-02)	1.61E-02	1.49E-02	1.87E-02	1.88E-02	(4.50E-03)	(3.34E-04)
Cu ICP-MS	mg/L	2.77E-03	3.58E-03	5.14E-03	5.67E-03	2.77E-03	3.58E-03	(1.25E-03)	(1.50E-03)	(1.65E-03)	(2.05E-03)	(6.44E-04)	(8.83E-04)	(5.05E-04)	(5.98E-04)	(1.26E-03)	(1.30E-03)
Cu ICP-OES	mg/L	<5.00E-02	<5.00E-02	(2.74E-03)	(3.81E-03)	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
Fe	mg/L	(4.77E-03)	(8.82E-03)	(5.95E-03)	(6.03E-03)	(4.77E-03)	(8.82E-03)	(8.10E-03)	(6.72E-03)	(5.98E-03)	(6.11E-03)	(5.60E-03)	(5.63E-03)	(4.08E-03)	(5.29E-03)	(1.00E-02)	(7.86E-03)
K	mg/L	(4.86E-01)	(6.52E-01)	(1.49E+00)	(1.15E+00)	(4.86E-01)	(6.52E-01)	(3.36E-02)	(1.31E-01)	<6.25E+00	(2.57E-01)	(1.29E-01)	(2.09E-01)	(1.45E-01)	(3.07E-02)	(5.42E-01)	(4.83E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(2.09E-02)	(2.45E-02)	(1.91E-02)	(1.78E-02)	(2.09E-02)	(2.45E-02)	(2.11E-02)	(2.08E-02)	(1.99E-02)	(1.97E-02)	(2.08E-02)	(2.02E-02)	(2.07E-02)	(2.07E-02)	(2.15E-02)	(1.56E-02)
Mn	mg/L	(1.96E-04)	(2.08E-03)	(7.75E-04)	(8.51E-04)	(1.96E-04)	(2.08E-03)	(1.38E-03)	(7.11E-04)	(6.98E-04)	(4.03E-04)	(3.04E-04)	(3.26E-04)	(3.74E-04)	(4.92E-04)	(2.09E-03)	(1.12E-03)
Mo	mg/L	5.38E-02	8.39E-02	6.30E-02	6.61E-02	5.38E-02	8.39E-02	6.84E-02	6.96E-02	7.26E-02	7.78E-02	6.03E-02	7.69E-02	8.64E-02	8.21E-02	7.33E-02	7.54E-02
Mo 95	mg/L	1.95E-03	2.42E-03	(6.10E-04)	(5.51E-04)	1.95E-03	2.42E-03	(4.12E-04)	(4.61E-04)	(3.09E-04)	(4.60E-04)	(3.45E-04)	(2.55E-04)	(3.22E-04)	(3.08E-04)	(2.08E-04)	(1.20E-04)
Mo 97	mg/L	2.11E-03	2.50E-03	6.03E-04	6.18E-04	2.11E-03	2.50E-03	3.91E-04	4.14E-04	3.05E-04	3.42E-04	2.65E-04	2.61E-04	2.83E-04	2.92E-04	2.07E-04	(7.10E-05)
Mo 98	mg/L	1.75E-03	1.99E-03	5.02E-04	4.62E-04	1.75E-03	1.99E-03	3.37E-04	3.59E-04	3.49E-04	2.96E-04	(2.38E-04)	2.74E-04	2.54E-04	(2.03E-04)	(1.33E-04)	(4.50E-05)
Na	mg/L	9.53E+00	1.17E+01	3.29E+01	2.73E+01	9.53E+00	1.17E+01	3.45E+00	3.66E+00	4.94E+00	5.56E+00	2.10E+00	2.27E+00	1.64E+00	1.80E+00	1.20E+01	1.33E+01
Ni	mg/L	(4.93E-03)	(1.07E-02)	(6.88E-03)	(7.12E-03)	(4.93E-03)	(1.07E-02)	(6.06E-03)	(7.10E-03)	(1.10E-03)	(4.43E-03)	(2.45E-03)	(1.06E-02)	<2.50E-02	(6.20E-03)	(8.28E-03)	(6.57E-03)
P	mg/L	(5.95E-01)	(7.03E-01)	(5.53E-01)	(5.86E-01)	(5.95E-01)	(7.03E-01)	(5.31E-01)	(5.42E-01)	(4.54E-01)	(5.43E-01)	(5.34E-01)	(5.42E-01)	(5.60E-01)	(5.35E-01)	(4.79E-01)	(4.83E-01)
Pb ICP-MS	mg/L	7.08E-02	8.36E-02	6.90E-02	7.86E-02	7.08E-02	8.36E-02	7.33E-02	7.60E-02	5.39E-02	6.79E-02	4.95E-02	5.85E-02	3.40E-02	4.10E-02	6.01E-02	7.28E-02
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(5.82E-04)	(6.23E-04)	1.50E-03	1.30E-03	(5.82E-04)	(6.23E-04)	(4.20E-04)	(3.61E-04)	(3.25E-04)	(4.73E-04)	(1.69E-04)	(2.62E-04)	(1.05E-04)	(1.79E-04)	(7.73E-04)	(8.85E-04)
Ru 102	mg/L	(6.29E-04)	(7.12E-04)	1.05E-03	(9.58E-04)	(6.29E-04)	(7.12E-04)	(6.17E-04)	(6.39E-04)	(5.40E-04)	(5.18E-04)	(4.67E-04)	(4.58E-04)	(4.13E-04)	(3.90E-04)	(6.78E-04)	(6.64E-04)
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Se	mg/L	(3.05E+00)	(3.18E+00)	(2.57E+00)	(2.69E+00)	(3.05E+00)	(3.18E+00)	(2.98E+00)	(3.01E+00)	(2.96E+00)	(3.06E+00)	(3.10E+00)	(3.06E+00)	(2.92E+00)	(2.67E+00)	(2.72E+00)	(2.61E+00)
Se 82	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Si	mg/L	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00	<2.50E+00
Sr	mg/L	8.09E-01	8.56E-01	1.14E+00	1.03E+00	8.09E-01	8.56E-01	7.54E-01	7.42E-01	7.35E-01	7.40E-01	6.66E-01	6.70E-01	6.33E-01	6.31E-01	8.05E-01	8.21E-01
Ti	mg/L	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(5.37E-02)	(5.04E-02)	(7.92E-02)	(6.41E-02)	(5.37E-02)	(5.04E-02)	(4.83E-02)	(4.98E-02)	(7.18E-02)	(6.75E-02)	(7.47E-02)	(7.39E-02)	(8.53E-02)	(7.31E-02)	(7.34E-02)	(8.03E-02)
Zr	mg/L	(9.43E-04)	(2.50E-03)	(2.41E-03)	(1.84E-03)	(9.43E-04)	(2.50E-03)	(2.55E-03)	(2.32E-03)	(1.17E-03)	(1.03E-03)	(8.73E-04)	(1.55E-03)	(2.47E-04)	(1.07E-03)	(3.78E-03)	(1.98E-03)
Anions																	
NO_2^- as NO_2^-	mg/L	3.78E-01	4.65E-01	7.03E-01	5.68E-01	3.78E-01	4.65E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.50E-01	1.93E-01
NO_3^- as NO_3^-	mg/L	4.06E-01	4.80E-01	4.89E+00	3.92E+00	4.06E-01	4.80E-01	2.88E-01	3.33E-01	7.49E-01	8.51E-01	2.26E-01	2.98E-01	1.75E-01	2.11E-01	2.01E+00	2.40E+00
CO_3^{2-}	mg/L	6.05E+01	6.92E+01	<5.00E+01	<5.00E+01	6.05E+01	6.92E+01	5.75E+01	6.95E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO_4^{2-}	mg/L	1.13E+00	1.05E+00	<1.50E-01	<1.50E-01	1.13E+00	1.05E+00	1.03E+00	1.05E+00	8.38E-01	8.26E-01	1.24E+00	1.36E+00	1.48E+00	1.26E+00	4.40E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl^-	mg/L	2.11E-01	2.05E-01	1.26E-01	1.19E-01	2.11E-01	2.05E-01	1.59E-01	1.37E-01	1.45E-01	1.73E-01	1.76E-01	3.92E-01	1.31E-01	1.40E-01	1.08E-01	8.28E-02
F^-	mg/L	9.59E-02	1.03E-01	3.59E-01	2.59E-01	9.59E-02	1.03E-01	7.65E-02	7.70E-02	8.99E-02	1.02E-01	5.55E-02	7.51E-02	4.63E-02	5.54E-02	1.73E-01	1.69E-01

Table F.7. CaCO$_3$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19845

Tank C-103 (19845) CaCO$_3$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	8.81	7.41	7.26	7.42	8.81	7.41	NA	6.28	6.52	6.80	6.71	6.90	6.95	6.95	7.20	6.73
Alkalinity	mg/L as CaCO$_3$	4.94E+01	2.89E+01	3.80E+01	4.10E+01	4.94E+01	2.89E+01	NA	2.20E+01	2.36E+01	2.36E+01	1.98E+01	2.20E+01	2.13E+01	1.90E+01	2.74E+01	2.74E+01
Radionuclides																	
^{90}Sr	µCi/L	5.53E+02	5.37E+02	7.531E+02	7.688E+02	5.53E+02	5.37E+02			5.51E+02	5.72E+02			7.62E+02	7.63E+02	7.90E+02	7.76E+02
^{99}Tc	mg/L	1.19E-04	(9.50E-05)	1.19E-04	1.21E-04	1.19E-04	(9.50E-05)	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04
^{238}U	mg/L	2.17E+00	9.82E-01	1.88E+00	2.15E+00	2.17E+00	9.82E-01	3.72E-01	4.37E-01	4.26E-01	5.26E-01	5.23E-01	7.18E-01	4.37E-01	6.29E-01	6.26E-01	7.98E-01
^{239}Pu	µCi/L	(1.23E-02)	<1.55E-02	(7.56E-03)	2.93E-02	(1.23E-02)	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	(3.10E-03)	(2.79E-03)
^{237} Np	µCi/L	1.18E-04	1.41E-04	1.69E-04	2.01E-04	1.18E-04	1.41E-04	7.95E-05	8.66E-05	7.88E-05	8.24E-05	6.11E-05	6.46E-05	3.91E-05	4.05E-05	1.28E-04	1.68E-04
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	(6.80E-03)	(1.70E-02)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	1.90E-03	<1.00E-03	3.05E-03	3.23E-03	1.90E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Al	mg/L	6.78E-01	3.27E-01	3.86E+00	3.58E+00	6.78E-01	3.27E-01	1.79E-01	2.07E-01	2.07E-01	2.08E-01	1.96E-01	2.08E-01	2.46E-01	2.55E-01	8.11E-01	4.11E-01
As	mg/L	(7.27E-02)	(6.76E-02)	(7.08E-02)	(9.86E-02)	(7.27E-02)	(6.76E-02)	(5.78E-02)	(7.33E-02)	(3.44E-02)	(9.69E-02)	(6.11E-02)	(8.70E-02)	(2.77E-02)	(4.33E-02)	(1.80E-02)	(1.29E-01)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	(2.56E-01)	(2.36E-01)	(2.53E-01)	(2.52E-01)	(2.56E-01)	(2.36E-01)	(2.28E-01)	(2.26E-01)	(2.33E-01)	(2.31E-01)	(2.31E-01)	(2.51E-01)	(2.29E-01)	(2.38E-01)	(2.77E-01)	(2.75E-01)
Ba	mg/L	(6.14E-03)	(4.37E-03)	(1.24E-02)	(1.17E-02)	(6.14E-03)	(4.37E-03)	(4.57E-03)	(2.52E-03)	(5.28E-03)	(5.28E-03)	(7.45E-03)	(5.55E-03)	(9.12E-03)	(7.29E-03)	(8.37E-03)	(8.20E-03)
Be	mg/L	(4.10E-03)	(2.90E-03)	(1.85E-03)	(1.47E-03)	(4.10E-03)	(2.90E-03)	(2.37E-03)	(2.19E-03)	(2.07E-03)	(1.78E-03)	(1.56E-03)	(1.34E-03)	(1.11E-03)	(1.00E-03)	(4.73E-03)	(2.86E-03)
Bi	mg/L	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01
Ca	mg/L	1.67E+00	(2.44E-01)	3.85E-01	2.51E-01	1.67E+00	(2.44E-01)	2.32E+00	2.50E+00	2.90E+00	3.40E+00	4.55E+00	4.56E+00	4.80E+00	4.68E+00	3.10E+00	3.41E+00
Cd ICP-MS	mg/L	9.58E-04	(8.70E-05)	1.52E-03	2.05E-03	9.58E-04	(8.70E-05)	(1.08E-04)	(1.11E-04)	(9.00E-06)	(1.76E-04)	(2.20E-05)	(5.90E-05)	(1.08E-04)	(4.80E-05)	(1.81E-04)	(1.50E-04)
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	(5.53E-03)	(2.82E-03)	(9.02E-03)	1.07E-02	(5.53E-03)	(2.82E-03)	(5.49E-04)	(4.68E-04)	(6.07E-04)	(7.04E-04)	(3.20E-04)	(3.42E-04)	(2.12E-04)	(2.79E-04)	(1.56E-03)	(1.56E-03)
Cr ICP-OES	mg/L	(8.82E-03)	(4.16E-03)	(1.50E-02)	(1.17E-02)	(8.82E-03)	(4.16E-03)	(2.62E-03)	(1.67E-03)	(2.53E-03)	(1.86E-03)	(3.05E-03)	(5.39E-04)	(1.29E-03)	(2.26E-03)	(4.23E-03)	(4.59E-03)
Cu ICP-MS	mg/L	(3.05E-03)	(1.86E-03)	(3.88E-03)	(4.44E-03)	(3.05E-03)	(1.86E-03)	(5.76E-04)	(4.71E-04)	(3.86E-04)	(4.23E-04)	(4.58E-04)	(4.08E-04)	(3.09E-04)	(3.28E-04)	(7.90E-04)	(6.81E-04)
Cu ICP-OES	mg/L	(8.82E-03)	(5.09E-03)	(6.50E-03)	(6.53E-03)	(8.82E-03)	(5.09E-03)	(4.47E-03)	(3.46E-03)	(9.39E-04)	(1.96E-03)	(4.44E-04)	(2.28E-04)	(1.33E-03)	(1.87E-03)	(7.57E-03)	(3.65E-03)
Fe	mg/L	6.42E-02	(5.94E-03)	1.65E-01	1.37E-01	6.42E-02	(5.94E-03)	(5.13E-03)	(5.40E-03)	(5.85E-03)	(4.59E-03)	(3.77E-03)	(2.76E-03)	(3.51E-03)	(3.04E-03)	(1.75E-02)	(6.84E-03)
K	mg/L	(6.10E-02)	(4.40E-01)	(4.30E-01)	(4.53E-01)	(6.10E-02)	(4.40E-01)	(1.82E-01)	(6.18E-01)	(5.78E-01)	(6.80E-01)	(4.28E-01)	(5.73E-01)	(3.73E-01)	(3.75E-01)	(1.01E-01)	(3.38E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(7.69E-02)	(3.17E-02)	(4.85E-02)	(4.02E-02)	(7.69E-02)	(3.17E-02)	(9.20E-02)	(1.03E-01)	(1.14E-01)	(1.20E-01)	(1.23E-01)	(1.20E-01)	(8.00E-02)	(8.24E-02)	(9.51E-02)	(9.45E-02)
Mn	mg/L	(8.10E-03)	(1.55E-03)	1.80E-02	1.62E-02	(8.10E-03)	(1.55E-03)	(1.16E-03)	(9.30E-04)	(8.87E-04)	(3.46E-04)	(4.14E-04)	(3.39E-04)	(1.81E-04)	(2.46E-04)	(3.56E-03)	(1.44E-03)
Mo	mg/L	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
Mo 95	mg/L	(1.60E-03)	(1.88E-03)	(1.75E-03)	(1.42E-03)	(1.60E-03)	(1.88E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 97	mg/L	(1.88E-03)	(1.92E-03)	(1.61E-03)	(1.61E-03)	(1.88E-03)	(1.92E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 98	mg/L	1.54E-03	1.63E-03	1.38E-03	1.21E-03	1.54E-03	1.63E-03	(1.80E-04)	(1.82E-04)	(1.19E-04)	(2.43E-04)	(7.80E-05)	(1.08E-04)	(2.50E-05)	(1.00E-05)	(1.37E-04)	(1.26E-04)
Na	mg/L	8.07E+00	1.12E+01	1.44E+01	1.58E+01	8.07E+00	1.12E+01	3.76E+00	3.68E+00	3.98E+00	3.39E+00	1.28E+00	1.30E+00	8.48E-01	8.85E-01	5.41E+00	5.58E+00
Ni	mg/L	(1.64E-02)	(1.09E-02)	3.39E-02	3.68E-02	(1.64E-02)	(1.09E-02)	(4.01E-03)	(6.38E-03)	(1.34E-02)	(7.31E-03)	(1.03E-02)	(2.62E-03)	(7.52E-03)	(3.26E-03)	(1.48E-02)	(1.18E-02)
P	mg/L	(1.12E-01)	(6.12E-02)	(3.31E-01)	(2.91E-01)	(1.12E-01)	(6.12E-02)	(6.59E-02)	(6.65E-02)	(1.67E-02)	(3.12E-02)	(5.96E-02)	(8.16E-02)	(3.13E-02)	(4.07E-02)	(6.41E-02)	(6.19E-02)
Pb ICP-MS	mg/L	1.02E-02	(1.93E-04)	1.91E-02	2.28E-02	1.02E-02	(1.93E-04)	(1.95E-04)	(1.71E-04)	(1.58E-04)	(2.21E-04)	(1.51E-04)	(1.24E-04)	(9.55E-05)	(8.55E-05)	2.73E-03	2.36E-03
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(2.43E-03)	<5.00E-03	(3.99E-03)	(4.32E-03)	(2.43E-03)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Ru 102	mg/L	(1.22E-03)	<2.50E-03	(1.95E-03)	(2.02E-03)	(1.22E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	(4.67E-04)	(3.28E-04)	(2.86E-04)	(3.43E-04)	(4.67E-04)	(3.28E-04)	(3.66E-04)	(2.32E-04)	(2.40E-04)	(3.42E-04)	(2.32E-04)	(1.93E-04)	(2.68E-04)	(2.08E-04)	(3.40E-04)	(3.48E-04)
Se	mg/L	(3.55E-01)	(2.81E-01)	(2.41E-01)	(2.91E-01)	(3.55E-01)	(2.81E-01)	(2.54E-01)	(3.18E-01)	(4.63E-01)	(3.86E-01)	(3.47E-01)	(2.48E-01)	(3.17E-01)	(2.20E-01)	(2.45E-01)	(3.40E-01)
Se 82	mg/L	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02
Si	mg/L	(1.87E-01)	(3.34E-01)	3.27E+00	3.80E+00	(1.87E-01)	(3.34E-01)	(3.92E-01)	(3.30E-01)	(8.17E-01)	(7.02E-01)	(2.79E-01)	(2.42E-01)	(1.32E-01)	(8.25E-02)	(1.84E+00)	(1.63E+00)
Sr	mg/L	(1.73E-02)	(5.78E-03)	(1.07E-02)	(9.55E-03)	(1.73E-02)	(5.78E-03)	(1.43E-02)	(2.16E-02)	(1.65E-02)	2.71E-02	(1.94E-02)	2.70E-02	(1.56E-02)	(2.11E-02)	(2.16E-02)	4.36E-02
Ti	mg/L	(3.21E-03)	(1.76E-03)	(2.83E-03)	(2.26E-03)	(3.21E-03)	(1.76E-03)	(1.08E-03)	(7.91E-04)	(5.77E-04)	(3.78E-04)	(4.00E-04)	(2.24E-04)	(1.80E-04)	(1.02E-04)	(3.42E-03)	(1.55E-03)
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(3.85E-02)	(4.10E-02)	(4.62E-02)	(4.32E-02)	(3.85E-02)	(4.10E-02)	(3.82E-02)	(4.42E-02)	(4.74E-02)	(4.77E-02)	(4.52E-02)	(4.48E-02)	(3.65E-02)	(4.23E-02)	(3.37E-02)	(3.07E-02)
Zr	mg/L	3.02E-02	(1.25E-03)	8.53E-02	7.52E-02	3.02E-02	(1.25E-03)	(1.45E-03)	(1.08E-03)	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	(5.69E-03)	(2.12E-03)
Anions																	
NO$_2^-$ as NO$_2^-$	mg/L	4.39E-01	3.34E-01	4.42E-01	4.81E-01	4.39E-01	3.34E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01
NO$_3^-$ as NO$_3^-$	mg/L	5.97E-01	6.00E-01	1.43E+00	1.64E+00	5.97E-01	6.00E-01	3.77E-01	3.83E-01	5.25E-01	5.06E-01	3.37E-01	4.42E-01	3.19E-01	3.00E-01	9.13E-01	8.44E-01
CO$_3^{2-}$	mg/L	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO$_4^{2-}$	mg/L	3.31E-01	3.33E-01	2.54E-01	2.88E-01	3.31E-01	3.33E-01	2.33E-01	2.19E-01	1.89E-01	1.72E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	1.82E-01	<1.50E-01
PO$_4^{3-}$ as PO$_4^{3-}$	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	2.52E-01	<1.50E-01	<1.50E-01	1.60E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl$^-$	mg/L	1.12E-01	9.44E-02	1.11E-01	1.04E-01	1.12E-01	9.44E-02	9.77E-02	8.81E-02	6.48E-02	8.09E-02	7.39E-02	8.79E-02	6.27E-02	7.12E-02	7.62E-02	7.64E-02
F$^-$	mg/L	7.14E-02	9.07E-02	2.18E-01	2.29E-01	7.14E-02	9.07E-02	<2.00E-02	<2.00E-02	3.64E-02	3.45E-02	<2.00E-02	<2.00E-02	<2.00E-02	<2.00E-02	7.46E-02	6.98E-02

Table F.8. $CaCO_3$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19849

Tank C-103 (19849) $CaCO_3$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	7.11	7.16	7.44	7.26	7.11	7.16	6.88	7.04	7.02	7.04	7.09	7.01	6.92	6.97	7.27	7.31
Alkalinity	mg/L as $CaCO_3$	2.66E+01	3.12E+01	4.10E+01	3.65E+01	2.66E+01	3.12E+01	2.20E+01	2.28E+01	2.36E+01	2.28E+01	2.36E+01	2.28E+01	1.82E+01	1.98E+01	2.58E+01	2.66E+01
Radionuclides																	
^{90}Sr	µCi/L	7.87E+02	7.73E+02	8.994E+02	9.193E+02	7.87E+02	7.73E+02			8.14E+02	7.73E+02			7.71E+02	7.78E+02	7.95E+02	8.00E+02
^{99}Tc	mg/L	(8.70E-05)	1.21E-04	1.55E-04	1.21E-04	(8.70E-05)	1.21E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04
^{238}U	mg/L	1.86E+00	2.77E+00	1.86E+00	1.66E+00	1.86E+00	2.77E+00	5.77E-01	6.51E-01	4.55E-01	4.10E-01	7.95E-01	8.54E-01	3.40E-01	3.26E-01	4.08E-01	1.52E+00
^{239}Pu	µCi/L	1.92E-02	2.03E-02	3.86E-02	3.16E-02	1.92E-02	2.03E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02
^{237} Np	µCi/L	1.66E-04	1.81E-04	2.28E-04	2.29E-04	1.66E-04	1.81E-04	7.81E-05	7.81E-05	8.02E-05	9.16E-05	8.09E-05	8.95E-05	3.20E-05	2.70E-05	8.66E-05	1.60E-04
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	(3.06E-02)	(2.38E-02)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	2.38E-03	2.33E-03	3.27E-03	2.88E-03	2.38E-03	2.33E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03
Al	mg/L	9.06E-01	8.03E-01	2.85E+00	1.17E+00	9.06E-01	8.03E-01	1.78E-01	2.17E-01	1.98E-01	2.04E-01	2.32E-01	2.46E-01	1.22E-01	1.21E-01	6.10E-01	9.51E-01
As	mg/L	(5.78E-02)	(9.09E-02)	(6.60E-02)	(7.96E-02)	(5.78E-02)	(9.09E-02)	(7.81E-02)	(4.47E-02)	(7.57E-02)	(7.18E-02)	(6.82E-02)	(7.80E-02)	(5.52E-02)	(1.07E-01)	(5.92E-02)	(7.68E-02)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	(2.41E-01)	(2.40E-01)	(2.84E-01)	(2.77E-01)	(2.41E-01)	(2.40E-01)	(2.42E-01)	(2.56E-01)	(2.54E-01)	(2.92E-01)	(2.94E-01)	(2.82E-01)	(2.82E-01)	(2.91E-01)	(2.89E-01)	(2.79E-01)
Ba	mg/L	(9.06E-03)	(6.82E-03)	(1.19E-02)	(5.40E-03)	(9.06E-03)	(6.82E-03)	(5.29E-03)	(4.68E-03)	(6.34E-03)	(6.54E-03)	(7.99E-03)	(7.20E-03)	(7.42E-03)	(6.72E-03)	(7.21E-03)	(1.13E-02)
Be	mg/L	(1.31E-03)	(1.18E-03)	(1.06E-03)	(1.02E-03)	(1.31E-03)	(1.18E-03)	(1.24E-03)	(1.23E-03)	(1.15E-03)	(4.82E-03)	(2.88E-03)	(2.21E-03)	(1.72E-03)	(1.50E-03)	(1.28E-03)	(1.13E-03)
Bi	mg/L	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01
Ca	mg/L	8.79E-01	1.29E+00	5.41E-01	6.69E-01	8.79E-01	1.29E+00	3.92E+00	3.57E+00	3.47E+00	2.57E+00	4.81E+00	4.70E+00	4.37E+00	4.54E+00	3.55E+00	3.54E+00
Cd ICP-MS	mg/L	1.16E-03	7.84E-04	1.67E-03	1.85E-03	1.16E-03	7.84E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	(5.91E-03)	(4.80E-03)	(8.87E-03)	(8.89E-03)	(5.91E-03)	(4.80E-03)	(4.74E-04)	(4.14E-04)	(4.79E-04)	(4.97E-04)	(3.48E-04)	(1.86E-04)	(2.32E-04)	(2.38E-04)	(1.50E-03)	(1.21E-03)
Cr ICP-OES	mg/L	(7.19E-03)	(6.57E-03)	1.27E-02	(6.37E-03)	(7.19E-03)	(6.57E-03)	(1.36E-03)	(2.85E-03)	(1.98E-03)	(3.11E-03)	(8.46E-04)	(1.37E-03)	(1.18E-03)	(2.30E-03)	(2.07E-03)	(3.43E-03)
Cu ICP-MS	mg/L	(2.94E-03)	(3.40E-03)	(4.44E-03)	(4.87E-03)	(2.94E-03)	(3.40E-03)	(4.68E-04)	(5.17E-04)	(4.56E-04)	(3.94E-04)	(4.31E-04)	(4.74E-04)	(3.57E-04)	(3.12E-04)	(6.73E-04)	(1.55E-03)
Cu ICP-OES	mg/L	(3.85E-03)	(4.53E-03)	(3.74E-03)	(2.04E-03)	(3.85E-03)	(4.53E-03)	(1.13E-03)	(1.45E-04)	(7.87E-04)	(7.24E-03)	(4.09E-03)	(9.95E-04)	(1.89E-03)	(9.51E-04)	(5.19E-05)	(7.96E-04)
Fe	mg/L	9.67E-02	7.33E-02	1.46E-01	6.79E-02	9.67E-02	7.33E-02	(4.11E-03)	(3.37E-03)	(4.09E-03)	(1.06E-02)	(7.64E-03)	(4.76E-03)	(5.56E-03)	(4.53E-03)	(1.10E-02)	(2.50E-02)
K	mg/L	(5.15E-01)	(7.53E-01)	(5.25E-01)	(7.16E-01)	(5.15E-01)	(7.53E-01)	(4.34E-01)	(5.21E-01)	(5.47E-01)	(3.22E-01)	(1.04E-01)	(4.75E-01)	<6.25E+00	(2.42E-01)	(6.32E-01)	(5.91E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(6.64E-02)	(7.43E-02)	(5.22E-02)	(6.46E-02)	(6.64E-02)	(7.43E-02)	(1.10E-01)	(1.04E-01)	(1.15E-01)	(1.05E-01)	1.27E-01	1.30E-01	(4.84E-02)	(4.47E-02)	(6.88E-02)	(9.87E-02)
Mn	mg/L	(1.19E-02)	(8.94E-03)	1.86E-02	(8.76E-03)	(1.19E-02)	(8.94E-03)	(2.54E-04)	(5.42E-04)	(1.78E-04)	(3.08E-03)	(1.70E-03)	(1.27E-03)	(8.50E-04)	(5.45E-04)	(1.10E-03)	(3.41E-03)
Mo	mg/L	<5.00E-02	(4.27E-03)	<5.00E-02	<5.00E-02	<5.00E-02	(4.27E-03)	(9.68E-03)	<5.00E-02	(4.77E-03)	(6.20E-03)	(4.56E-03)	(3.80E-03)	(1.13E-02)	<5.00E-02	(9.82E-03)	<5.00E-02
Mo 95	mg/L	(1.26E-03)	(1.85E-03)	(1.84E-03)	(1.44E-03)	(1.26E-03)	(1.85E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 97	mg/L	(1.14E-03)	(1.77E-03)	(1.81E-03)	(1.31E-03)	(1.14E-03)	(1.77E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 98	mg/L	1.11E-03	1.45E-03	1.55E-03	1.07E-03	1.11E-03	1.45E-03	(5.80E-05)	(7.90E-05)	(8.40E-05)	(4.40E-05)	(4.80E-05)	(5.30E-05)	(6.20E-05)	(4.60E-05)	(6.40E-05)	(1.08E-04)
Na	mg/L	9.00E+00	9.53E+00	1.55E+01	1.29E+01	9.00E+00	9.53E+00	1.92E+00	2.33E+00	3.34E+00	4.56E+00	1.37E+00	1.48E+00	8.15E-01	7.58E-01	4.28E+00	5.67E+00
Ni	mg/L	(1.85E-02)	(1.53E-02)	2.83E-02	(1.58E-02)	(1.85E-02)	(1.53E-02)	(3.32E-03)	(2.51E-03)	(4.95E-03)	(1.14E-02)	(1.24E-02)	(1.18E-02)	(6.57E-03)	(3.65E-03)	(8.63E-03)	(9.09E-03)
P	mg/L	(1.32E-01)	(1.30E-01)	(3.20E-01)	(1.34E-01)	(1.32E-01)	(1.30E-01)	(7.90E-02)	(8.18E-02)	(6.21E-02)	(6.36E-02)	(8.10E-02)	(1.26E-02)	(2.91E-02)	(3.67E-02)	(7.65E-02)	(1.24E-01)
Pb ICP-MS	mg/L	1.54E-02	1.03E-02	1.97E-02	2.19E-02	1.54E-02	1.03E-02	(2.30E-04)	(1.39E-04)	(1.15E-04)	(1.26E-04)	(1.37E-04)	(1.21E-04)	(1.30E-04)	(1.14E-04)	1.42E-03	7.29E-04
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(3.11E-03)	(2.41E-03)	(4.63E-03)	(4.82E-03)	(3.11E-03)	(2.41E-03)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
Ru 102	mg/L	(1.51E-03)	(1.18E-03)	(2.16E-03)	(2.19E-03)	(1.51E-03)	(1.18E-03)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	(2.49E-04)	(2.32E-04)	(3.57E-04)	(2.85E-04)	(2.49E-04)	(2.32E-04)	(1.96E-04)	(1.64E-04)	(2.05E-04)	(2.09E-04)	(2.69E-04)	(1.87E-04)	(2.53E-04)	(2.29E-04)	(3.32E-04)	(2.72E-04)
Se	mg/L	(1.67E-01)	(2.13E-01)	(3.55E-01)	(1.50E-01)	(1.67E-01)	(2.13E-01)	(1.12E-01)	(3.82E-01)	(4.47E-01)	(2.97E-01)	(2.28E-01)	(4.01E-01)	(3.40E-01)	(3.13E-01)	(1.82E-01)	(3.19E-01)
Se 82	mg/L	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02
Si	mg/L	(3.94E-01)	(2.81E-01)	2.93E+00	(2.20E+00)	(3.94E-01)	(2.81E-01)	(2.43E-01)	(2.61E-01)	(7.88E-01)	(8.96E-01)	(3.35E-01)	(3.64E-01)	(1.44E-01)	(1.31E-01)	(1.40E+00)	(2.13E+00)
Sr	mg/L	(1.48E-02)	(1.79E-02)	(1.35E-02)	(1.13E-02)	(1.48E-02)	(1.79E-02)	2.96E-02	2.63E-02	2.75E-02	2.66E-02	3.73E-02	3.39E-02	2.71E-02	(2.45E-02)	3.28E-02	3.41E-02
Ti	mg/L	(1.69E-03)	(1.84E-03)	(1.86E-03)	(1.20E-03)	(1.69E-03)	(1.84E-03)	(1.55E-04)	(4.09E-04)	(2.35E-04)	(3.07E-03)	(1.77E-03)	(1.24E-03)	(7.08E-04)	(5.73E-04)	(3.92E-04)	(7.34E-04)
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(4.12E-02)	(3.95E-02)	(3.28E-02)	(3.65E-02)	(4.12E-02)	(3.95E-02)	(5.02E-02)	(4.36E-02)	(4.00E-02)	(4.23E-02)	(4.54E-02)	(3.80E-02)	(5.24E-02)	(4.63E-02)	(3.36E-02)	(4.99E-02)
Zr	mg/L	3.73E-02	2.69E-02	5.68E-02	2.62E-02	3.73E-02	2.69E-02	(7.19E-04)	(9.30E-04)	(2.49E-04)	(3.09E-03)	(1.43E-03)	(6.48E-04)	(1.83E-03)	(1.11E-03)	(2.74E-03)	(7.81E-03)
Anions																	
NO_2^- as NO_2^-	mg/L	3.34E-01	4.54E-01	5.59E-01	4.53E-01	3.34E-01	4.54E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	1.24E-01
NO_3^- as NO_3^-	mg/L	5.68E-01	6.32E-01	1.47E+00	1.25E+00	5.68E-01	6.32E-01	3.43E-01	3.59E-01	5.14E-01	5.15E-01	3.32E-01	3.51E-01	3.54E-01	3.51E-01	7.79E-01	9.51E-01
CO_3^{2-}	mg/L	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO_4^{2-}	mg/L	2.44E-01	2.53E-01	2.29E-01	<1.50E-01	2.44E-01	2.53E-01	<1.50E-01	<1.50E-01	<1.50E-01	1.05E+00	1.51E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl^-	mg/L	9.50E-02	1.14E-01	1.17E-01	1.02E-01	9.50E-02	1.14E-01	7.97E-02	8.15E-02	9.84E-02	1.25E-01	9.43E-02	7.78E-02	8.22E-02	8.29E-02	8.70E-02	7.08E-02
F^-	mg/L	7.85E-02	9.71E-02	2.44E-01	1.80E-01	7.85E-02	9.71E-02	<2.00E-02	<2.00E-02	3.84E-02	4.24E-02	<2.00E-02	<2.00E-02	<2.00E-02	<2.00E-02	6.80E-02	7.15E-02

Table F.9. $CaCO_3$ Leachant Concentration Results for Tank C-103 Residual Waste, Sample 19850

Tank C-103 (19850) $CaCO_3$ Leach Result																	
		Single Contact				Periodic Replenishment Tests											
Parameter	Units	1 day	1 day (dup)	1 month	1 month (dup)	Stage 1	Stage 1 (dup)	Stage 2	Stage 2 (dup)	Stage 3	Stage 3 (dup)	Stage 4	Stage 4 (dup)	Stage 5	Stage 5 (dup)	Stage 6	Stage 6 (dup)
pH	std units	11.90	11.67	7.53	7.73	11.90	11.67	10.72	8.08	8.20	7.81	7.50	7.50	7.15	7.27	7.62	7.61
Alkalinity	mg/L as $CaCO_3$	2.55E+03	1.33E+03	4.64E+01	3.65E+01	2.55E+03	1.33E+03	1.75E+02	5.40E+01	4.86E+01	4.26E+01	3.27E+01	3.12E+01	2.81E+01	2.81E+01	3.19E+01	3.34E+01
Radionuclides																	
^{90}Sr	µCi/L	1.33E+03	1.19E+03	9.716E+02	9.576E+02	1.33E+03	1.19E+03			9.14E+02	9.17E+02			9.21E+02	9.08E+02	9.32E+02	9.35E+02
^{99}Tc	mg/L	1.06E-04	1.09E-04	1.04E-04	1.01E-04	1.06E-04	1.09E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04
^{238}U	mg/L	(5.95E-03)	(6.65E-03)	4.05E+00	2.09E+00	(5.95E-03)	(6.65E-03)	1.05E-01	1.43E-01	2.20E-01	2.32E+00	1.95E+00	1.92E+00	1.66E+00	1.33E+00	1.69E+00	1.89E+00
^{239}Pu	µCi/L	<1.55E-02	<1.55E-02	4.53E-02	7.99E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	<1.55E-02	(3.22E-03)	(1.55E-03)	<1.55E-02	<1.55E-02	<1.55E-02	(6.01E-03)	(4.65E-03)
^{237} Np	µCi/L	<7.10E-06	<7.10E-06	4.69E-04	2.45E-04	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	<7.10E-06	3.34E-05	4.47E-05	4.97E-05	5.25E-05	4.76E-05	5.18E-05	5.54E-05
^{241}Am	µCi/L	<1.70E-01	<1.70E-01	(3.74E-02)	(5.44E-02)	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01	<1.70E-01
Metals																	
Ag	mg/L	<1.00E-03	<1.00E-03	2.87E-03	6.23E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	<1.00E-03	(7.12E-04)	(4.62E-04)
Al	mg/L	4.81E-01	4.14E+00	1.11E+00	3.06E+00	4.81E-01	4.14E+00	1.20E+01	1.09E+00	4.44E+00	1.42E+00	4.11E-01	4.29E-01	3.77E-01	3.53E-01	1.23E+00	1.13E+00
As	mg/L	(1.95E-01)	(1.41E-01)	(5.16E-02)	(1.33E-02)	(1.95E-01)	(1.41E-01)	(2.15E-01)	(7.77E-02)	(9.94E-02)	(6.23E-02)	(5.74E-02)	(9.53E-02)	(8.73E-02)	(1.08E-01)	(6.83E-02)	(6.16E-02)
As 75	mg/L	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03
B	mg/L	(4.53E-02)	(1.40E-01)	(3.11E-01)	(3.44E-01)	(4.53E-02)	(1.40E-01)	(2.80E-01)	(2.94E-01)	(2.91E-01)	(2.76E-01)	(2.89E-01)	(2.80E-01)	(2.93E-01)	(2.87E-01)	(3.26E-01)	(3.02E-01)
Ba	mg/L	2.99E-01	1.26E-01	(1.79E-02)	(1.83E-02)	2.99E-01	1.26E-01	(1.42E-02)	(8.24E-03)	(6.75E-03)	(7.13E-03)	(4.78E-03)	(1.06E-02)	(9.92E-03)	(9.59E-03)	(9.96E-03)	(1.05E-02)
Be	mg/L	(1.11E-03)	(4.40E-03)	(2.10E-03)	(2.22E-03)	(1.11E-03)	(4.40E-03)	(2.59E-03)	(1.93E-03)	(1.62E-03)	(1.37E-03)	(1.25E-03)	(1.13E-03)	(1.05E-03)	(9.22E-04)	(4.51E-03)	(2.78E-03)
Bi	mg/L	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01	<5.00E-01
Ca	mg/L	7.98E+02	3.54E+02	1.45E+00	1.01E+00	7.98E+02	3.54E+02	2.99E+01	1.58E+01	1.28E+01	1.09E+01	9.27E+00	8.99E+00	7.90E+00	7.61E+00	6.16E+00	6.23E+00
Cd ICP-MS	mg/L	<5.00E-04	<5.00E-04	1.67E-03	3.08E-03	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	<5.00E-04	(3.14E-04)	(2.70E-04)
Cd ICP-OES	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Co	mg/L	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02	<6.25E-02
Cr ICP-MS	mg/L	1.21E-02	(9.89E-03)	(7.37E-03)	1.44E-02	1.21E-02	(9.89E-03)	(7.09E-03)	(3.54E-03)	(6.67E-03)	(1.69E-03)	(1.25E-03)	(6.57E-04)	(7.47E-04)	(5.71E-04)	(4.53E-03)	(3.55E-03)
Cr ICP-OES	mg/L	1.32E-02	(1.04E-02)	(1.13E-02)	1.76E-02	1.32E-02	(1.04E-02)	(6.83E-03)	(2.03E-03)	(9.09E-03)	(5.85E-03)	(3.69E-03)	(1.81E-03)	(3.85E-03)	(2.15E-03)	(5.86E-03)	(5.03E-03)
Cu ICP-MS	mg/L	(4.30E-03)	(5.67E-03)	(5.89E-03)	(8.29E-03)	(4.30E-03)	(5.67E-03)	(4.20E-03)	(1.25E-03)	(1.56E-03)	(1.39E-03)	(7.33E-04)	(5.55E-04)	(5.91E-04)	(5.68E-04)	(1.40E-03)	(1.31E-03)
Cu ICP-OES	mg/L	<5.00E-02	<5.00E-02	(6.89E-03)	(9.21E-03)	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02	<5.00E-02
Fe	mg/L	(5.34E-03)	(1.03E-02)	1.98E-01	3.47E-01	(5.34E-03)	(1.03E-02)	(6.70E-03)	(5.08E-03)	(4.59E-03)	(7.46E-03)	(2.48E-03)	(4.00E-03)	(5.32E-03)	(4.99E-03)	(4.34E-02)	(3.99E-02)
K	mg/L	(1.06E+00)	(9.93E-01)	(1.01E+00)	(9.05E-01)	(1.06E+00)	(9.93E-01)	(5.01E-01)	(5.59E-01)	(4.83E-01)	(5.43E-01)	(4.12E-01)	(2.21E-01)	(2.91E-01)	(3.75E-01)	(6.35E-01)	(5.23E-01)
Li	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Mg	mg/L	(2.01E-02)	(1.78E-02)	2.16E-01	1.29E-01	(2.01E-02)	(1.78E-02)	(2.85E-02)	(4.18E-02)	(4.58E-02)	(9.37E-02)	(8.96E-02)	(1.23E-01)	(8.90E-02)	(1.12E-01)	(9.82E-02)	(1.15E-01)
Mn	mg/L	(3.56E-04)	(2.23E-03)	2.22E-02	3.62E-02	(3.56E-04)	(2.23E-03)	(8.41E-04)	(5.34E-04)	(5.43E-04)	(8.65E-04)	(4.52E-04)	(4.88E-04)	(6.77E-04)	(1.72E-04)	(6.41E-03)	(4.99E-03)
Mo	mg/L	6.56E-02	(4.90E-02)	<5.00E-02	<5.00E-02	6.56E-02	(4.90E-02)	(2.26E-02)	(3.93E-03)	(5.39E-03)	<5.00E-02	<5.00E-02	(3.26E-03)	(6.43E-03)	(9.82E-03)	(1.14E-02)	(8.12E-03)
Mo 95	mg/L	(2.00E-03)	3.12E-03	2.59E-03	(2.09E-03)	(2.00E-03)	3.12E-03	(6.55E-04)	(2.23E-04)	(5.64E-04)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 97	mg/L	(2.04E-03)	2.71E-03	(2.47E-03)	(2.24E-03)	(2.04E-03)	2.71E-03	(6.66E-04)	<2.50E-03	(4.60E-04)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03
Mo 98	mg/L	1.75E-03	2.56E-03	2.06E-03	1.88E-03	1.75E-03	2.56E-03	(5.08E-04)	(1.65E-04)	(4.20E-04)	(1.12E-04)	(5.10E-05)	(3.90E-05)	(1.01E-04)	(2.10E-05)	(7.60E-05)	(6.80E-05)
Na	mg/L	1.25E+01	1.16E+01	1.71E+01	1.38E+01	1.25E+01	1.16E+01	2.77E+00	3.35E+00	2.90E+00	3.46E+00	1.04E+00	1.60E+00	8.79E-01	9.52E-01	4.46E+00	4.94E+00
Ni	mg/L	(7.89E-03)	(7.30E-03)	3.14E-02	4.99E-02	(7.89E-03)	(7.30E-03)	(8.36E-03)	(6.19E-03)	(6.98E-03)	(1.01E-02)	(1.70E-03)	(6.20E-03)	(1.44E-03)	(3.77E-03)	(1.65E-02)	(1.74E-02)
P	mg/L	(6.21E-01)	(4.70E-01)	(2.14E-01)	(4.92E-01)	(6.21E-01)	(4.70E-01)	(9.97E-02)	(7.36E-02)	(1.11E-01)	(5.28E-02)	(4.68E-02)	(3.24E-02)	(8.96E-02)	(2.94E-02)	(1.03E-01)	(9.91E-02)
Pb ICP-MS	mg/L	1.05E-01	3.23E-02	2.39E-02	4.05E-02	1.05E-01	3.23E-02	(1.93E-04)	(1.17E-04)	(1.01E-04)	6.46E-04	(1.38E-04)	(1.10E-04)	(1.69E-04)	(3.19E-04)	5.00E-03	4.85E-03
Pb ICP-OES	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
Ru 101	mg/L	(6.31E-04)	(4.24E-04)	7.01E-03	1.30E-02	(6.31E-04)	(4.24E-04)	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	<5.00E-03	(1.29E-03)	(9.96E-04)
Ru 102	mg/L	(6.13E-04)	(2.60E-04)	3.20E-03	6.01E-03	(6.13E-04)	(2.60E-04)	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	<2.50E-03	(4.75E-04)	(3.92E-04)
S	mg/L	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00	<5.00E+00
Sb 121	mg/L	<5.00E-04	<5.00E-04	(3.80E-04)	(3.24E-04)	<5.00E-04	<5.00E-04	(1.24E-04)	(1.57E-04)	(2.48E-04)	(2.94E-04)	(2.31E-04)	(2.01E-04)	(3.04E-04)	(2.23E-04)	(3.50E-04)	(3.54E-04)
Se	mg/L	(3.02E+00)	(1.89E+00)	(2.97E-01)	(3.46E-01)	(3.02E+00)	(1.89E+00)	(5.84E-01)	(3.17E-01)	(3.66E-01)	(4.60E-01)	(3.59E-01)	(3.48E-01)	(4.66E-01)	(2.59E-01)	(3.41E-01)	(3.58E-01)
Se 82	mg/L	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	<1.00E-02
Si	mg/L	<2.50E+00	<2.50E+00	3.06E+00	(2.31E+00)	<2.50E+00	<2.50E+00	(7.83E-01)	<2.50E+00	(2.01E-01)	(1.13E+00)	(4.60E-01)	(5.97E-01)	(4.91E-01)	(3.94E-01)	(1.61E+00)	(1.56E+00)
Sr	mg/L	9.13E-01	4.87E-01	3.93E-02	2.46E-02	9.13E-01	4.87E-01	5.13E-02	4.41E-02	(2.43E-02)	2.98E-02	(1.56E-02)	2.51E-02	(1.63E-02)	(2.03E-02)	3.18E-02	2.67E-02
Ti	mg/L	<2.50E-02	<2.50E-02	(3.30E-03)	(3.72E-03)	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02
Tl	mg/L	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01	<2.50E-01
V	mg/L	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01	<1.25E-01
Zn	mg/L	(7.46E-02)	(7.89E-02)	(4.67E-02)	(4.78E-02)	(7.46E-02)	(7.89E-02)	(5.42E-02)	(2.23E-02)	(2.38E-02)	(2.46E-02)	(4.13E-02)	(3.36E-02)	(4.24E-02)	(4.34E-02)	(3.01E-02)	(3.05E-02)
Zr	mg/L	<2.50E-02	<2.50E-02	6.98E-02	1.26E-01	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	<2.50E-02	(1.51E-02)	(1.24E-02)
Anions																	
NO_2^- as NO_2^-	mg/L	4.62E-01	4.77E-01	5.29E-01	4.18E-01	4.62E-01	4.77E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01
NO_3^- as NO_3^-	mg/L	6.38E-01	5.44E-01	1.49E+00	1.08E+00	6.38E-01	5.44E-01	3.91E-01	4.24E-01	4.26E-01	4.95E-01	2.84E-01	3.39E-01	2.87E-01	3.26E-01	7.41E-01	7.87E-01
CO_3^{2-}	mg/L	<5.00E+01	2.25E+02	<5.00E+01	<5.00E+01	<5.00E+01	2.25E+02	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01	<5.00E+01
SO_4^{2-}	mg/L	6.38E-01	8.05E-01	2.71E-01	2.33E-01	6.38E-01	8.05E-01	6.77E-01	3.27E-01	3.33E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
PO_4^{3-} as PO_4^{3-}	mg/L	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01	<1.50E-01
Cl^-	mg/L	1.56E-01	1.49E-01	9.72E-02	1.10E-01	1.56E-01	1.49E-01	9.56E-02	7.88E-02	7.81E-02	8.41E-02	1.40E-01	8.38E-02	9.00E-02	6.11E-02	7.82E-02	7.62E-02
F^-	mg/L	1.04E-01	1.08E-01	1.70E-01	1.61E-01	1.04E-01	1.08E-01	3.71E-02	4.08E-02	3.85E-02	4.30E-02	2.67E-02	<2.00E-02	<2.00E-02	<2.00E-02	5.27E-02	6.38E-02

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