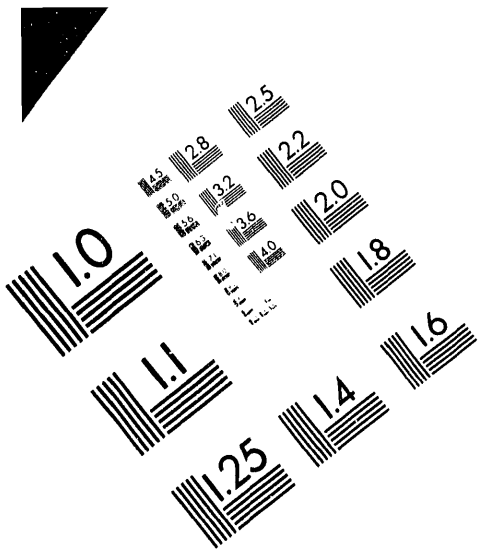

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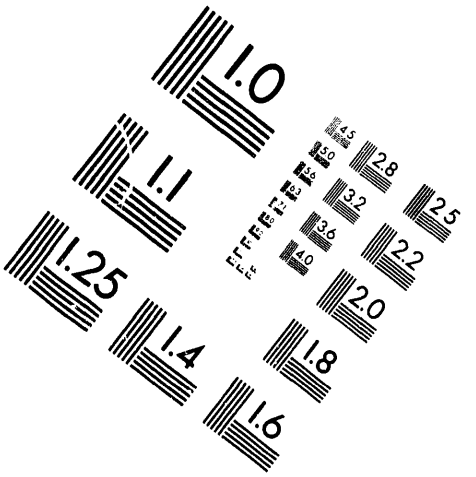

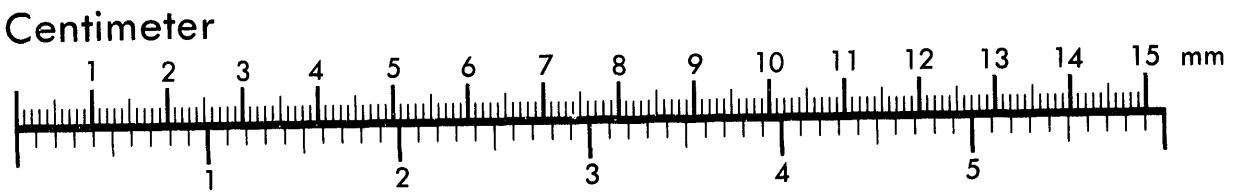

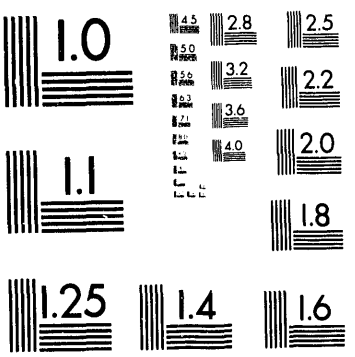

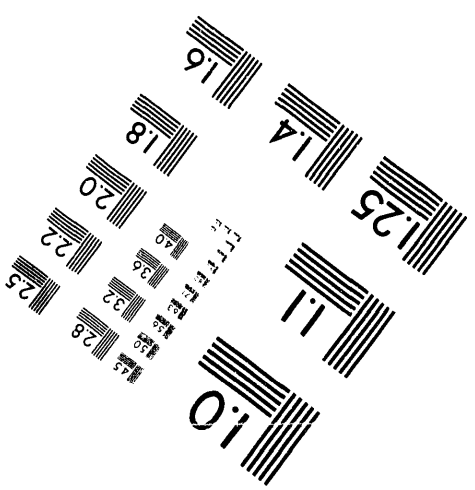

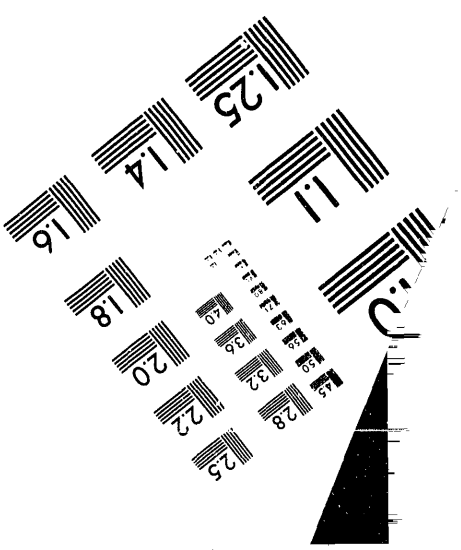

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WSRC-TR-92-346, Rev. 1

Keywords: glass, DWPF, durability standard, redox standard, reference material

CHARACTERIZATION OF THE DEFENSE WASTE PROCESSING FACILITY (DWPF) ENVIRONMENTAL ASSESSMENT (EA) GLASS STANDARD REFERENCE MATERIAL (U)

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ABSTRACT

Liquid high-level nuclear waste at the Savannah River Site (SRS) will be immobilized by vitrification in borosilicate glass. The glass will be produced and poured into stainless steel canisters in the Defense Waste Processing Facility (DWPF). Other waste form producers, such as West Valley Nuclear Services (WVNS) and the Hanford Waste Vitrification Project (HWVP), will also immobilize high-level radioactive waste in borosilicate glass. The canistered waste will be stored temporarily at each facility for eventual permanent disposal in a geologic repository. The Department of Energy has defined a set of requirements for the canistered waste forms, the Waste Acceptance Product Specifications (WAPS). The current Waste Acceptance Preliminary Specification (WAPS) 1.3, the product consistency specification, requires the waste form producers to demonstrate control of the consistency of the final waste form using a crushed glass durability test, the Product Consistency Test (PCT). In order to be acceptable, a waste glass must be more durable during PCT analysis than the waste glass identified in the DWPF Environmental Assessment (EA). In order to supply all the waste form producers with the same standard benchmark glass, 1000 pounds of the EA glass was fabricated. The chemical analyses and characterization of the benchmark EA glass are reported. This material is now available to act as a durability and/or redox Standard Reference Material (SRM) for all waste form producers.

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CHARACTERIZATION OF THE DEFENSE WASTE PROCESSING FACILITY (DWPF) ENVIRONMENTAL ASSESSMENT (EA) GLASS STANDARD REFERENCE MATERIAL (U)

INTRODUCTION

Waste form producers at the Savannah River Site (SRS), West Valley Nuclear Services (WVNS), and Hanford Waste Vitrification Project (HWVP) will immobilize high-level radioactive waste in borosilicate glass. The glass will be poured into stainless steel canisters for eventual disposal in a geologic repository. The Department of Energy has defined a set of requirements for the canistered waste forms, the Waste Acceptance Product Specifications (WAPS).[1]

The current Waste Acceptance Product Specification (WAPS) 1.3, the product consistency specification, requires the waste form producers to demonstrate control of the consistency of the final waste form using the Product Consistency Test (PCT).[2-6] The PCT is a crushed glass durability test which is (1) sensitive to glass composition and homogeneity, and (2) may have the potential to be related to repository site-specific release tests. It is a glass dominated production test which can be used to test glasses during production, even in the shielded cell environments necessitated by highly radioactive glasses.[2-8] A standard glass is always measured simultaneously to an unknown during PCT analysis.

The WAPS 1.3 specification defines the acceptance criterion for a production glass: a waste glass being produced must be more durable during PCT analysis than the waste glass identified in the DWPF Environmental Assessment (EA).[9] During simultaneous PCT analysis of the production glass and the EA glass, the latter can be used as the standard glass required by the PCT protocol.

The WAPS 1.1.2 requires that the waste form producers report the measured chemical composition of the glass waste form in the Production Records. The Defense Waste Processing Facility (DWPF) process/product models relate important processing and product quality requirements to glass composition.[10] Routine chemical analyses of vitrified feed samples is required. In addition, control of the oxidation/reduction (redox) equilibrium in the glass melter is critical for processing of the nuclear waste.[11-16] As part of the DWPF process control strategy, the glass redox expected in the melter will be determined by measuring the ratio of $Fe^{2+}/\Sigma Fe$ in vitrified slurry.[17-18] Routine redox analyses of vitrified feed samples is required. A glass standard with a known redox and composition, such as the EA glass, will need to be run simultaneously with the production glass or vitrified feed in order to minimize error and long term instrumental bias.[19-20]

In order to supply the DWPF and all the waste form producers with the same standard benchmark glass, the Savannah River Technology Center (SRTC) had 1000 pounds of the EA glass fabricated by Corning Glass Works (AX-AA28362A). The chemical analyses and characterization of the benchmark EA glass, to be used as a durability, analytic, and/or redox Standard Reference Material, are reported in this study.

EXPERIMENTAL

Glass Fabrication

The composition of the glass as given in the DWPF Environmental Assessment[9] is shown in Table 1. The target composition of the glass to be fabricated is also given in Table 1. The target EA glass composition was derived from the composition given in the EA[9] by the following calculational procedure:

- recalculating the MnO_2 as MnO due to the reduced nature of this glass
- recalculating the Fe_3O_4 as Fe_2O_3 and FeO
- calculating "other solids" as primarily zeolite [21]
- deleting the U_3O_8 component due to the difficulty of handling and shipping uranium bearing glass as a Standard Reference Material
- normalizing to 100 wt%

Corning Engineering Laboratory Services (CELS) fabricated the glass in a gas fired atmospheric furnace with an oxygen:natural gas mixture of 2:1 to control the redox of the atmosphere. The iron was added as ferric iron oxide (Fe_2O_3) and ferrous iron oxalate dihydrate ($FeC_2O_4 \cdot 2H_2O$). Five pounds of carbocite carbon were added per master batch of 1203 pounds of glass to reduce the glass during melting and to be able to control the redox with the gas mixture more efficiently. The batch was melted at 1250°C and N_2 was bubbled through the batch to assist in homogenizing the glass. The glass was kept at 1100°C while it was being drained and water quenched to ensure that devitrification did not occur. The glass melt adsorbed water during quenching and was air dried in a Peterson Kelly (PK) blender to prevent particle agglomeration.

Glass Sampling

The glass was received in three large drums. A stainless steel tube of ~1/2 inch diameter was used under vacuum to sample glass from the bottom, middle, and top of each drum. A similar technique had been used at Corning Glass Works for glass sampling after fabrication.

Glass Composition Analyses

Corning Engineering Laboratory Services analyzed five samples of the EA glass after fabrication. Each sample was dissolved in triplicate. The fifteen dissolutions were analyzed in duplicate for Al, B, Ca, Fe, K, La, Li, Mg, Mn, Na, Ni, Si, Ti, Zr, and Fe^{2+}/Fe^{3+}. Analysis was performed on different days to include any short time instrumental bias in the measurement of the standard deviation. The Na, Li, and K analyses were achieved by dissolution of the glass in a fuming perchloric acid/hydroflouric acid ($HClO_4$ and HF) mixture. The Na, Li, and K were measured by Atomic Absorption analysis (AA). The B content was analyzed by dissolution in cold hydrochloric (HF) acid and subsequent measurement by Inducitively Coupled Plasma (ICP) spectroscopy. The Al, Ca, Fe_{Total}, La, Mg, Mn, Ni, Si, Ti and Zr were analyzed by fusing the

glass samples with sodium borate (NaB_4O_7) and sodium carbonate (Na_2CO_3), and subsequent dissolution in a mixture of water and hydrochloric acid (HCl). The dissolution was analyzed ICP spectroscopy. The ferrous iron (Fe^{2+}) analysis was performed by dissolving the sample in hydrofluoric acid (HF) under an inert atomsphere. The excess fluoride was complexed with boric acid. The Fe^{2+} content was measured by ceric sulfate titration using diphenylamine disulfonate as the indicator. The Fe^{2+}/Fe^{3+} ratio is calculated from $Fe^{2+}/(Fe_{Total} - Fe^{2+})$.

The Analytic Development Section of the Savannah River Technology Center analyzed ten samples of the EA glass and two Purex glass standards to determine the glass composition. Twelve samples of the EA glass were measured for redox. The EA glass samples were analyzed by the following techniques:

- Dissolution by Na_2O_2 with an HCl uptake
  - ICP for Al, Si, B
- Dissolution by HCl/HF microwave
  - ICP for Na, Zr, Ca, Fe, Mg, Mn, Li, Cr, Sr, Ti, P, Ba, Pb, Mo, Zn, Cu, Ni, La
  - AA for Na, K, Cs
- Dissolution by Na_2O_2 with a H_2O uptake
  - IC for SO_4, NO_3, and PO_4
  - ISE for Cl and F
- Dissolution by H_2SO_4/HF in the presence of NH_4VO_3[22]
  - Colorimetric for Fe^{2+} and total Fe (ΣFe)

where ICP is Inductively Coupled Plasma Spectroscopy, AA is Atomic Absorption analysis, IC is Ion Chromatography analysis, and ISE is Ion Selective Electrode analysis.

Glass Viscosity Analyses

A five-point high temperature viscosity analysis was performed on a Brookfield Viscometer according to ASTM-C-965A by Sharp-Schurtz Analytical Division of Owens/Corning Fiberglas Corporation.

Glass Homogeneity Analyses

X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) analyses coupled with Energy Dispersive Analysis by X-ray (EDAX) were performed on the EA glass in order to determine the crystallinity and/or homogeneity of the glass.

Glass Durability Analyses

The durability of the EA glass was measured by four researchers using Versions 3.0 and 5.0 of the PCT.[3-4] In the PCT analysis, crushed glass of 100-200 mesh is immersed in ASTM Type I water for 7 days at 90°C. The surface area of the glass exposed in 100-200 mesh glass can be calculated using an assumed waste glass density (~2.76 g/cc for average SRS glasses) and by assuming a Gaussian distribution of particle sizes. Since the volume of leachant solution is maintained at 10 mL per gram of glass, the ratio of the glass surface area (SA) to the volume (V) of leachant is 19.55 cm^{-1}. PCT leachates were filtered to remove colloids and/or particulates. The leachates were analyzed for pH and the elemental concentration of the glass species of interest.

The four researchers completed PCT analysis of the EA glass using differnt types of vessels, different numbers of replicate analyses, and different versions of the PCT. However, Version 5.0 of the PCT is experimentally equivalent to Version 3.0 of the PCT.[4] Version 3.0 allowed the usage of either steel or Teflon® vessels and recommended the following nominal conditions: 100-200 mesh size glass particles, a ratio of leachate volume to mass of glass of 10 mL of solution to 1 gram of glass, a test temperature of 90°C to simulate the heat of radioactive decay, a leachant of ASTM-Type I water, and a 7 day test duration. Version 3.0 also allowed varying mesh sizes, leachate volume/mass of glass ratios, test temperatures, time durations, leachants. In Version 5.0 the PCT procedure was divided into a part A and part B. Testing using the PCT 5.0A protocol was limited to production testing of radioactive or simulated waste glass, where steel vessels were required for radioactive usage and/or closed system testing.[1] The mesh size, ratio of leachate volume to mass of glass, test temperature, leachant, and test duration were required to be the nominal values specified in Version 3.0. Testing using the PCT 5.0B protocol allows for the usage of either steel or Teflon® vessels so that open or closed system testing can be investigated. PCT 5.0B also allows for the usage of either nominal or variant conditions as in PCT Version 3.0.

All of the PCT testing carried out in this study used either PCT 3.0, 5.0A, or 5.0B using the nominal conditions. The data of all four researchers is, therefore, directly comparable. The first researcher completed triplicate PCT analyses of two EA glass samples in 60 mL 75 psi Teflon® vessels using Version 3.0 of the test protocol. The second researcher completed six replicate PCT analyses of one EA glass sample in the same type of Teflon® vessels using Version 3.0 of the test protocol. The third researcher completed quadruplicate PCT analyses of one EA glass sample in the same type of Teflon® vessels. The third researcher also ran two sets of quadruplicate PCT analyses of the EA glass in 22mL 304L stainless steel Parr bombs with a well polished surface interior finish. One set of tests in the steel vessels used 19 mL of ASTM-Type I water leaving 3 mL head space for air in the vessel. The second set of PCT analyses was performed on the EA glass in the 22mL Parr bombs with only 15mL of ASTM-Type I water leaving 7 mL head space for air in the vessel. The third researcher used Version 3.0 of the PCT test protocol. The fourth researcher used Version 5.0A of the PCT protocol. Three triplicate sets of EA glass durability tests were performed in 22mL 304L stainless steel Parr bombs with a well polished surface interior finish. One triplicate set of the EA glass leachates were analyzed as if they were seperate analyses.

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[1] closed system tests preclude the transport of matter, e.g. O_2 and CO_2 into or out of the vessels, closed system testing can only be achieved in steel vessels or in Teflon® vessels that are contained in an inert glove box, open system tests permit the transport of matter into or out of the system

These analytic sample pairs are identified with the letters A and B at the end. One triplicate set of analyses were performed in 150 mL 304L stainless steel cylinders with swage lock fitting from Georgia Valve and Fitting Co. The 150 mL vessels do not have a well polished surface interior finish. This triplicate set of EA glass leachates were analyzed as if they were seperate analyses. These analytic sample pairs are identified with the letters A and B at the end.

A standard glass, ARM-1 was used by all the researchers to ascertain if long term bias in the experimental analysis had occurred compared to previous glasses tested at SRS. Replicate PCT tests on the EA glass and on the glass standards were run simultaneously.

A multielement solution standard was used by all the researchers to ensure that instrumental drift in the Inductively Coupled Plasma (ICP) Spectroscopy and/or Atomic Absorption (AA) analyses did not bias the short term leachate analyses. Duplicate durability tests containing ASTM Type I water but no glass samples were run simultaneously with each set of samples as "blanks." All conditions, including the type of vessel and the head space in the vessel were kept the same for the blank tests and the EA glass tests. The use of blanks ensures that the test vessel preparation was adequate and that the sample leachates can be corrected for elemental variation occurring independently of the glass-solution interactions.

QUALITY ASSURANCE

All melting and glass analyses performed at Corning Engineering Laboratory Sercices (CELS), and all glass physical property measurements performed at Owens Corning Fiberglas were conducted in accordance with quality assurance requirements stipulated by the Savannah River Technology Center (SRTC) that met appropriate requirements of DOE/RW-0214 and ASME NQA-1. All glass analyses performed at the Savannah River Technology Center were conducted in accordance with their DOE/RW-0214 and ASME NQA-1 based quality assurance program.

The data for the chemical analyses performed at Corning Glass Works and at SRS are recorded in WSRC-NB-91-237 and WSRC-NB-92-129. The XRD, SEM, EDAX analyses performed at SRS and the viscosity analyses performed at Owens Corning Fiberglas are recorded in WSRC-NB-91-237. The glass durability data of the first and second researchers is recorded in WSRC-NB-91-199 and WSRC-NB-91-200, respectively. The data of the third researcher is recorded in DPSTN-4793. The durability data of the fourth researcher is recorded in WSRC-NB-92-232.

RESULTS AND DISCUSSION

Glass Composition Analyses

The average and pooled standard deviations of the 30 replicate EA glass analyses measured by Corning Engineering Laboratory Services (CELS) is given in Table 1. The CELS analyses are given in Appendix I. The mean of the means and the standard deviations were calculated in this study based on the raw data in Appendix I. Five replicate EA glass samples were each dissolved multiple (3) times and each dissolution was analyzed twice. Since each sample was dissolved and analyzed the same number of times the data set is considered balanced. However, in order to account for the total error associated with sampling, dissolution, and replicate solution analyses which were performed on different days, the Statistical Analysis System (SAS®) Variance

Components (VARCOMP) estimation model was employed (Appendix II). In this manner, the confounded sources of variation, e.g. replicate sampling (5 samples), replicate dissolutions (3 dissolutions per sample), and replicate analyses (2 per dissolution on different days) are combined to yield the total pooled standard deviations. The data, therefore, represents 30 distinct populations which account for the random effects which arise from the classification effects ("sample", "dissolution", and "read"-see Appendix II). A Type-I VARCOMP estimation Model was employed which computes the sum of the squares for each effect, equates each mean square involving only random effects to its expected value, and solves the resulting system of equations. Four variance components are obtained which include an evaluation of both the random and fixed effects in the data, in this case the "sample", "dissolution", and "read"variations, and the data error variation (Appendix II). The total standard deviation is equal to the square root of the sum of the four variance components. Negative values were set equal to zero. The standard deviations derived by this methodology are given in Table 1.

Ten samples of the EA glass were analyzed chemically at the Savannah River Technology Center. Replicate dissolutions and replicate analyses per dissolution were not performed. Detailed results of each analysis are given in Appendix II. Duplicate analyses of a glass standard from the Waste Compliance Plan (WCP),[23] the Purex glass, were performed simultaneously. The analysis included a redox measurement so that the amount of Fe present could be speciated as Fe_2O_3 and FeO. The analytic values for Al_2O_3, SiO_2, and Na_2O were biased low compared to the standard Purex glass analysis. An average bias correction for these oxides was calculated from the duplicate Purex glass analyses and applied to the analyses of the ten replicate EA glass samples (Appendix III). The average oxide wt% bias for Al_2O_3 ranged from 4 to 6.7, while the average bias for SiO_2 and Na_2O ranged from 1.5 to 2.9 and 4.3 to 4.4, respectively. The average oxide wt% bias corrections used were 5, 2, and 4 for Al_2O_3, SiO_2, and Na_2O, respectively. The bias corrected analyses for the ten replicate EA glass samples is given in Table 2 with the Fe speciated as Fe_2O_3 and FeO based on the measured redox. The composition of the 1000 pounds of EA glass, including the redox, appears to be homogeneous: there are no chemical differences between the glass samples from the three drums, nor from the glass sampled from the top, middle, or bottom of each drum.

The average composition and the standard deviations of the EA glass composition measurement at SRTC are also given in Table 2. These values are compared to the target glass analyses and to the Corning Engineering Laboratory Services composition in Table 1. One sample from drum two (2-MISC) appears to be significantly different than the other analyses in terms of its Fe_2O_3, B_2O_3, and SiO_2 content. Although this analysis is considered deviate, the average and standard deviations given in Table 2 are based on all ten replicate analyses.

The replicate analyses of both laboratories verify that the 1000 pounds of EA glass is within the target glass composition specified. The redox analyses measured by SRTC agree to within 0.01 of the values measured by CELS. The SRTC analyses agree closely with the Corning Glass Works CELS analyses except for minor component and anion analysis, e.g. La_2O_3, ZnO, Cl, and F. The SRTC values for La_2O_3 are lower than the values reported by Corning Glass Works by ~33%. In addition SRTC determined the presence of ZnO and trace amounts of Cl (~0.10±0.05 wt%) and F (~0.008±0.005 wt%). The presence of the ZnO impurity was ascertained from glasses that were dissolved in microwave Teflon® bombs. Therefore, the presence of the trace ZnO is not due to

Table 1. Comparison of the Target and Analyzed Environmental Assessment (EA) Glass Compositions

	EA Reference Composition	Target Glass Composition	Corning Engineering Laboratory Services Glass Composition**	Savannah River Technology Center Glass Composition*
Al_2O_3	3.2	3.67 ± 0.18[t]	3.70 ± 0.025	3.60±0.12
B_2O_3	10.9	11.12 ± 0.556[t]	11.28 ± 0.108	11.16± 0.17
CaO	1.0	1.13 ± 0.06[t]	1.12 ± 0.007	1.23± 0.09
Fe_2O_3	5.9	8.08 ± (see redox)[‡]	7.38 ± 0.083	7.58 ± 0.41
FeO		0.89 ± (see redox)[‡]	1.45 ± 0.043	1.59 ± 0.06
Fe_3O_4	2.8			
K_2O		0.04 ± 0.004	0.04 ± 0.000	0.04 ±0.01
La_2O_3	0.4	0.41 ± 0.04	0.42 ± 0.005	0.28 ±0.02
Li_2O	4.2	4.28 ± 0.21[t]	4.26 ± 0.018	4.21 ± 0.15
MgO	1.6	1.66 ± 0.08[t]	1.72 ± 0.012	1.79 ± 0.07
MnO		1.34 ± 0.07[t]	1.34 ± 0.011	1.36 ± 0.05
MnO_2	1.6			
Na_2O	16.3	16.71 ± 0.84[t]	16.81 ± 0.070	16.88 ± 0.32
NiO	0.6	0.61 ± 0.06	0.57 ± 0.005	0.53 ± 0.03
SiO_2	46.3	48.95 ± 4.90	48.73 ± 0.339	48.76 ± 0.82
TiO_2	0.7	0.71 ± 0.07	0.70 ± 0.006	0.65 ± 0.03
U_3O_8	1.2			
ZnO				0.26 ± 0.04
ZrO_2	0.4	0.41 ± 0.04	0.46 ± 0.013	0.48 ± 0.08
Other Solids[tt]	2.9			
SUM	100.00	100.01	99.99	100.41
Fe^{2+}/Fe^{3+}	0.123	0.1 to 0.3	0.22±0.01	0.23 ± 0.01

** details of the 30 replicate analyses are given in Appendix I; standard deviations shown are the standard deviations representing each source of variation (see Appendix II)

* details of the 10 replicate analyses are given in Appendix III

tt where other solids include zeolite, undissolved salts, and radionuclides (<0.1% of the waste)[8]

t corresponds to 5 relative wt%, all others are 10 relative wt%

‡ values based on Fe^{2+}/Fe^{3+}=0.123; actual values vary on exact ratio of Fe^{2+}/Fe^{3+} achieved between the specified range of 0.1 to 0.3

Table 2. Replicate Analyses of the Environmental Assessment Glass

OXIDE WT%	SAMPLE AND ANALYTIC IDENTIFICATIONS 1-TOP-A	2-TOP-A	3-TOP-A	1-MISC-A	2-MISC	3-MISC-A
	#200074772 #200074760 #200080110 #200080126	#200074773 #200074761 #200080111 #200080128	#200074774 #200074762 #200080112 #200080129	#200074770 #200074763 #200080113 #200080130	#200074777 #200074764 #200080114 #200080131	#200074771 #200074765 #200080115 #200080132
Al_2O_3	3.58	3.67	3.77	3.54	3.80	3.46
B_2O_3	11.12	11.32	11.22	11.32	10.76	11.12
CaO	1.20	1.22	1.22	1.23	1.15	1.20
Fe_2O_3	7.47	7.49	7.48	7.43	8.30	7.33
FeO	1.59	1.57	1.69	1.60	1.61	1.50
K_2O	0.04	0.06	0.04	0.04	0.04	0.04
La_2O_3	0.27	0.28	0.28	0.27	0.26	0.26
Li_2O	4.19	4.24	4.28	4.19	4.02	4.13
MgO	1.77	1.79	1.81	1.78	1.72	1.76
MnO	1.35	1.37	1.38	1.36	1.32	1.33
Na_2O	16.86	17.03	17.33	16.90	16.37	16.75
NiO	0.52	0.52	0.54	0.54	0.50	0.50
SiO_2	49.03	49.18	48.36	49.34	48.37	47.81
TiO_2	0.64	0.65	0.66	0.64	0.62	0.63
ZnO	0.25	0.24	0.24	0.25	0.25	0.24
ZrO_2	0.48	0.48	0.46	0.44	0.70	0.42
OXIDE SUMS	100.38	101.11	100.77	100.87	99.8	98.48
Fe^{2+}/Fe^{3+}	0.24	0.23	0.25	0.24	0.22	0.23
ANION WT%						
Cl	0.086	0.095	0.094	0.114	0.142	0.090
F	0.006	0.005	0.013	0.003	0.005	0.004

Table 2. Replicate Analyses of the Environmental Assessment Glass (Cont'd)

OXIDE WT%	SAMPLE AND ANALYTIC IDENTIFICATIONS 1-B-3 #200074778-80 #200074766 #200080116 #200080133	2-B-A #200074781 #200074767 #200080117 #200080134	2-M-1 #200074775 #200074768 #200080118 #200080135	2-M-3 #200074776 #200074769 #200080119 #200080136	SRS MEAN ANALYSIS	SRS STD DEV	CELS** MEAN ANALYSIS
Al_2O_3	3.43	3.55	3.55	3.64	3.60	0.12	3.70
B_2O_3	11.08	11.16	11.18	11.33	11.16	0.17	11.30
CaO	1.25	1.15	1.24	1.48	1.23	0.09	1.12
Fe_2O_3	7.29	7.02	7.76	8.26	7.58	0.41	7.38
FeO	1.63	1.61	1.51	1.60	1.59	0.06	1.45
K_2O	0.04	0.04	0.03	0.04	0.04	0.01	0.04
La_2O_3	0.30	0.28	0.28	0.33	0.28	0.02	0.42
Li_2O	4.17	4.03	4.25	4.57	4.21	0.15	4.26
MgO	1.76	1.71	1.80	1.97	1.79	0.07	1.72
MnO	1.34	1.30	1.38	1.48	1.36	0.05	1.34
Na_2O	16.93	16.45	17.37	16.85*	16.88	0.32	16.80
NiO	0.52	0.51	0.54	0.60	0.53	0.03	0.57
SiO_2	47.41	50.19	48.57	49.31	48.76	0.82	48.73
TiO_2	0.66	0.63	0.67	0.72	0.65	0.03	0.70
ZnO	0.37	0.24	0.27	0.26	0.26	0.04	
ZrO_2	0.44	0.42	0.46	0.48	0.48	0.08	0.46
OXIDE SUMS	98.61	100.31	100.85	102.94	100.41		100.00
Fe^{2+}/Fe^{3+}	0.25	0.26	0.22	0.22	0.23	0.01	0.22
ANION WT%							
Cl	0.063	0.212	0.055	0.059	0.101	0.047	
F	0.005	0.010	0.017	0.010	0.008	0.005	

* this analysis had a significantly higher Na_2O content than the remaining nine samples by ICP analysis and the Na concentration measured by AA was substituted and not bias corrected

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impurities in the dissolution vessel as observed when samples are dissolved in nickel or zirconia crucibles.[24] The Cl and F analyses have large standard deviations since the values measured are close to the detection limits of the measurement technique. Sulfate (SO_4^{-2}), nitrate (NO_3^-, and phosphate (PO_4^{-3}) values were below the detection limits of the ion chromatography technique.

The EA glass is homogeneous and suitable as a redox and/or durability Standard Reference Material despite the minor differences between the SRTC and CELS analyses for La_2O_3 and ZnO. The presence of trace amounts of anions is not considered significant because the analytic determinations were so close to the detection limits of the instrumentation.

Glass Viscosity Analyses

The EA glass viscosity as a function of inverse temperature is given in Figure 1. The Fulcher equation of best fit to the measured data is

$$\log \eta \text{ (poise)} = -1.4913 + 2414.447/(T(℃)-235.99) \qquad (1)$$

The EA glass viscosity calculated from Equation 1 at the DWPF melt temperature of 1150℃ is 14.1 poise. The EA glass viscosity calculated from the DWPF processing algorithms[10] and the CELS chemical analysis of the glass is 19.98 poise. The viscosity calculated using the SRS chemical analysis of the EA glass is 19.8 poise. The deviation of the glass viscosity predicted from the glass composition at 1150℃ to that measured is only ~6 poise. A six poise difference in glass viscosity is well within measurement error and is not considered significant since this glass viscosity is at the lower limit tested with the DWPF processing algorithms.

Glass Homogeneity Analyses

X-ray Diffraction analysis indicated that the glass was x-ray amorphous and contained no crystalline species. During optical microscopy, individual glass grains were determined to be green while others were amber in color. The different colored grain were hand separated and examined by SEM/EDAX. The light element EDAX detector indicated that the green grains appeared to have more carbon than the amber colored grains indicating that the green color was associated with more reduced glass. The green grains were evenly distributed throughout the glass indicating that the bulk redox was homogeneous as confirmed by the chemical analyses in Table 2.

Glass Durability Analyses

Multielement Standard Analysis

During PCT analysis, a multielement solution standard was used by each researcher to ensure that the solution analyses were accurate. Researcher one ran the multielement solution standard before leachate analysis began and after every 5 leachate samples in order to asses any short term bias in the leachate analyses due to instrumental drift (Appendix IV). Analysis of the solution standard data indicated that there was less than 0.8 ppm bias in the ICP analyses for Na, Li, Al, Fe, and B, over 5 ppm bias in the ICP analyses for Si, and less than 0.4 ppm bias in the Atomic Absorption

(AA) analyses for K The data also indicated that there was ~0.15 ppm low bias in the Na determinations made by AA compared to the Na determinations by ICP analysis. Similar results were obtained by the other researchers. Bias of <1 ppm is well within normal instrumental error. Therefore, the instrumental drift was considered insignificant.

Standard Glass Analysis

Historical control charting using PNL's Approved Reference Material (ARM-1) as the standard glass as the PCT standard glass did not indicate any significant bias in the elemental releases (in ppm) for all elements whether the test was performed in Teflon® or Parr 304L steel vessels (Table 3). All the standard glass elemental releases used in this study fell within one-sigma of the average elemental release for ARM-1 glass since May, 1989. Hence, no long term bias corrections were made to the EA glass solution data set. Varying dilution factors were used by each researcher but the solution data sets between researchers was in agreement. The ARM-1 measured pH values were slightly lower for researcher 2 (Table 3) as were the EA glass measured pH values.

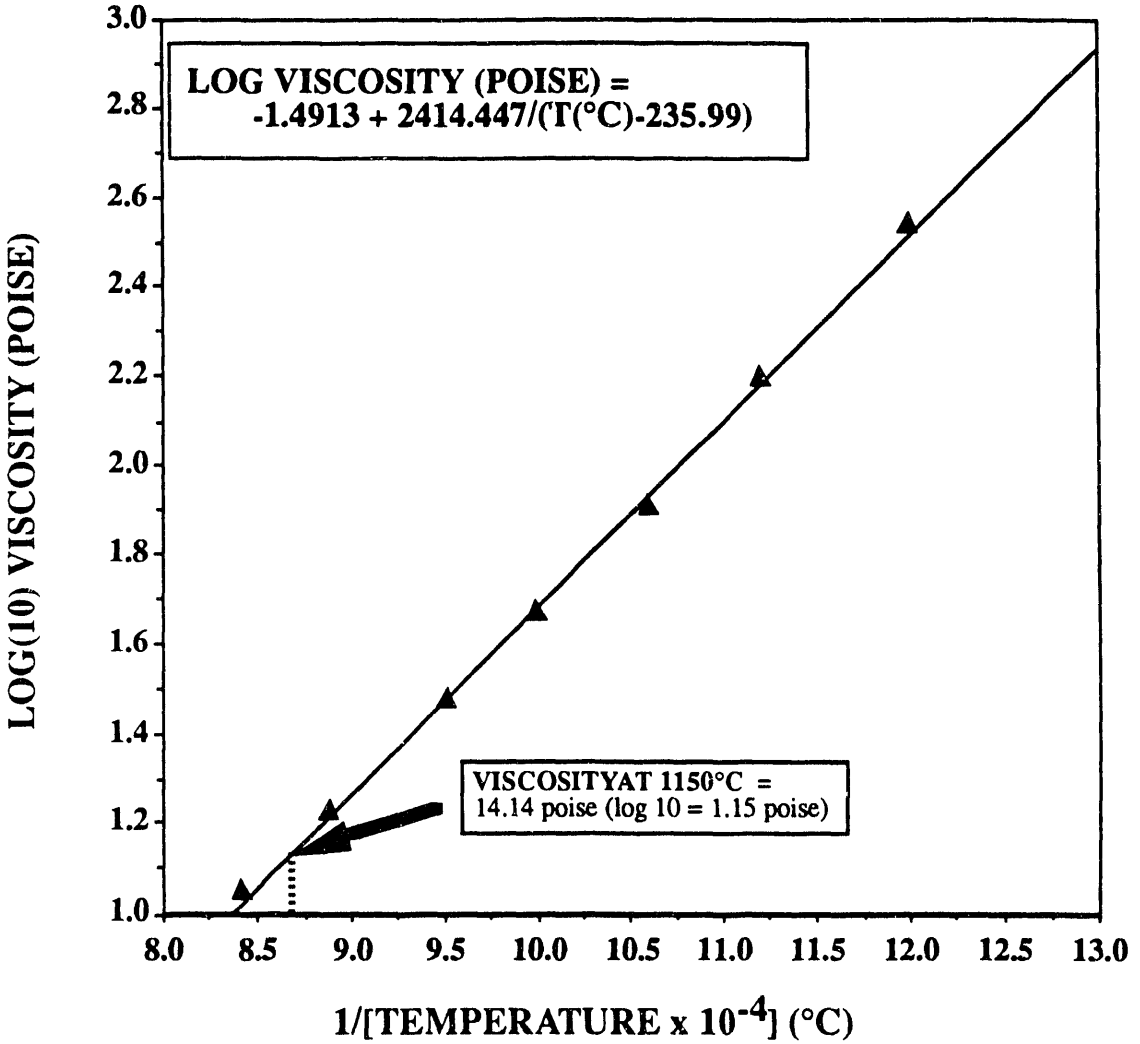

Figure 1. Fulcher plot of the measured viscosities of the EA glass as a function of temperature.

Table 3. PCT Analysis of the ARM-1 Standard Glass

SAMPLE	ADS #	RESEARCHER	NOTEBOOK	PCT VERSION	TYPE OF VESSEL	SIZE OF VESSEL (ML)
ARM-1-7-1	200067152	1	WSRC-NB-91-199	3.0	TEFLON	60
ARM-1-7-2	200067153	1	WSRC-NB-91-199	3.0	TEFLON	60
ARM-1-7-3	200067156	1	WSRC-NB-91-199	3.0	TEFLON	60
ARM-1-7-AVG						
ARM-1-7-1	200068356	2	WSRC-NB-91-200	3.0	TEFLON	60
ARM-1-7-2	200068357	2	WSRC-NB-91-200	3.0	TEFLON	60
ARM-1-7-3	200068358	2	WSRC-NB-91-200	3.0	TEFLON	60
ARM-1-7-AVG						
T-ARM-1-1	200069692	3	DPSTN-4793	3.0	TEFLON	60
T-ARM-1-2	200069693	3	DPSTN-4793	3.0	TEFLON	60
T-ARM-1-3	200069693	3	DPSTN-4793	3.0	TEFLON	60
T-ARM-1-AVG						
SS-ARM-1-1	200069695	3	DPSTN-4793	3.0	PARR STEEL	22
SS-ARM-1-2	200069698	3	DPSTN-4793	3.0	PARR STEEL	22
SS-ARM-1-3	200069699	3	DPSTN-4793	3.0	PARR STEEL	22
SS-ARM-1-AVG						
SS-ARM-1-1	200069701	3	DPSTN-4793	3.0	PARR STEEL	22
SS-ARM-1-2	200069702	3	DPSTN-4793	3.0	PARR STEEL	22
SS-ARM-1-AVG						
SSARM-1	200082096	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SSARM-2	200082097	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SSARM-3	200082098	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SS-ARM-AVG						
SSARM-1	200082945	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SSARM-2	200082946	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SSARM-3	200082947	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SSARM-AVG						
SRSSARM-1	200086332	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SRSSARM-2	200086333	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SRSSARM-3	200086334	4	WSRC-NB-92-232	5.0A	PARR STEEL	22
SRSSARM-AVG						
CUASARM-1	200086340	4	WSRC-NB-92-232	5.0A	STEEL CYLINDER	150
CUASARM-2	200086341	4	WSRC-NB-92-232	5.0A	STEEL CYLINDER	150
CUASARM-AVG						

Table 3. PCT Analysis of the ARM-1 Standard Glass (Continued)

SAMPLE	mL OF LEACHANT	GMS OF GLASS	MEASURED pH	CONCENTRATIONS (ppm) B	Li	Na*	Si
ARM-1-7-1	40	4.0	10.34	17.71	13.89	38.03	60.47
ARM-1-7-2	40	4.0	10.33	17.97	14.23	38.75	61.45
ARM-1-7-3	40	4.0	10.32	18.03	14.09	38.51	61.13
ARM-1-7-AVG			10.33	17.90	14.07	38.43	61.02
ARM-1-7-1	35	3.5	9.38	18.11	14.31	39.95	60.71
ARM-1-7-2	35	3.5	9.40	18.32	14.45	37.17	60.67
ARM-1-7-3	35	3.5	9.35	17.12	13.46	34.83	57.18
ARM-1-7-AVG			9.38	17.85	14.07	37.32	59.52
T-ARM-1-1	40	4.0	10.28	17.14	14.08	37.51	59.21
T-ARM-1-2	40	4.0	10.38	17.65	14.41	38.23	60.26
T-ARM-1-3	40	4.0	10.29	17.12	14.11	37.52	59.40
T-ARM-1-AVG			10.32	17.31	14.20	37.75	59.62
SS-ARM-1-1	19	1.9	10.38	18.71	15.01	39.84	62.66
SS-ARM-1-2	19	1.9	10.29	17.73	14.39	38.49	60.68
SS-ARM-1-3	19	1.9	10.29	19.50	15.25	40.87	63.38
SS-ARM-1-AVG			10.32	18.65	14.88	39.73	62.24
SS-ARM-1-1	15	1.5	10.34	18.13	14.60	38.78	61.22
SS-ARM-1-2	15	1.5	10.38	19.78	15.65	41.62	64.44
SS-ARM-1-AVG			10.36	18.96	15.13	40.20	62.83
SSARM-1	16	1.6	10.00	18.19	13.87	37.43	62.35
SSARM-2	16	1.6	9.89	17.90	13.75	36.89	62.25
SSARM-3	16	1.6	9.87	19.05	14.38	38.67	63.87
SS-ARM-AVG			9.92	18.38	14.00	37.66	62.82
SSARM-1	16	1.6	10.00	18.88	14.59	39.08	65.51
SSARM-2	16	1.6	9.97	19.59	14.96	39.95	66.80
SSARM-3	16	1.6	9.92	19.05	14.77	39.44	66.65
SSARM-AVG			9.96	19.17	14.77	39.49	66.32
SRSSARM-1	16	1.6	10.00	17.47	14.19	37.59	62.44
SRSSARM-2	16	1.6	10.05	22.34	16.94	44.92	70.40
SRSSARM-3	16	1.6	10.13	19.89	15.64	41.27	66.65
SRSARM-AVG				19.90	15.59	41.26	66.50
CUASARM-1	100	10	9.51	24.16	17.97	47.11	61.51
CUASARM-2	100	10	9.95	21.24	15.98	42.36	66.12
CUASARM-AVG			9.73	22.7	16.98	44.74	63.82

* measured by ICP

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EA Glass Analysis

The PCT leachate pH and leachate concentrations in ppm measured for the EA glass are given in Table 4. The leachates had to be diluted prior to analysis by ICP or AA in order to match the standardization concentrations of the respective instruments. Varying dilution factors were used by each researcher. The pH values given for researcher 2 were bias corrected on a $1/[H^+]$ linear basis based on the low value measured for the ARM-1 glass (Table 3). The solution data of researcher 1 had to be bias corrected for an error in dilution (Table 4 and 5).

The leachate concentrations measured for the respective elements in the EA glass, by the various researchers, in three different types of vessels, are in agreement (Table 4) . The leachate concentrations are normally reported as normalized elemental losses, NC_i, released from the glass in grams of glass per L of leachant (Table 5). This has the advantage that the release concentrations in parts per million are normalized by the weight fraction of that element present in the glass.

The normalized release, NC_i, is a function of (1) the mass fraction of that element in the glass, (2) the exposed surface area of the glass, and (3) the leachate volume. Since the latter two are held constant, the normalized release is expressed as:

$$NC_i = \frac{C_i}{F_i} \qquad (1)$$

where NC_i = normalized release ($g_{glass}/L_{leachant}$)

C_i = mass of element "i" in the solution (g_i/m^3)

F_i = fraction of element "i" in the glass (g_i/g_{glass})

The units of NC_i are normally expressed as grams of glass dissolved per liter of leachant. The normalized releases shown in Table 5 were calculated using the CELS analyzed glass composition given in Table 2. The normalized releases were calculated in grams of glass based on B, Li, Si, and Na leached per liter of leachate (g/L) as given in Equation 1. The values for both NC_i and log NC_i are tablulated in Table 5.

Table 4. PCT Analysis of the Environmental Assessment Glass

SAMPLE	ADS #	RESEARCHER	NOTEBOOK	PCT VERSION	TYPE OF VESSEL	SIZE OF VESSEL (ML)
EA-1-7-1	2000267144	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-1-7-2	2000267145	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-1-7-3	2000267148	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-1-AVG						
EA-2-7-1	2000267149	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-2-7-2	2000267150	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-2-7-3	2000267151	1	WSRC-NB-91-199	3.0	TEFLON	60
EA-2-AVG						
EA-7-1	200068359	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-7-2	200068360	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-7-3	200068361	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-7-4	200068362	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-7-5	200068363	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-7-6	200068364	2	WSRC-NB-91-200	3.0	TEFLON	60
EA-AVG						
T-EA-1	200069668	3	DPSTN-4793	3.0	TEFLON	60
T-EA-2	200069671	3	DPSTN-4793	3.0	TEFLON	60
T-EA-3	200069679	3	DPSTN-4793	3.0	TEFLON	60
T-EA-4	200069685	3	DPSTN-4793	3.0	TEFLON	60
EA-T-AVG						
SS-EA-19-1	200069669	3	DPSTN-4793	3.0	PARR STEEL	22
SS-EA-19-2	200069672	3	DPSTN-4793	3.0	PARR STEEL	22
SS-EA-19-3	200069677	3	DPSTN-4793	3.0	PARR STEEL	22
SS-EA-19-4	200069681	3	DPSTN-4793	3.0	PARR STEEL	22
EA-SS-19-AVG						
EA-SS-15-1	200069670	3	DPSTN-4793	3.0	PARR STEEL	22
EA-SS-15-2	200069673	3	DPSTN-4793	3.0	PARR STEEL	22
EA-SS-15-3	200069676	3	DPSTN-4793	3.0	PARR STEEL	22
EA-SS-15-4	200069686	3	DPSTN-4793	3.0	PARR STEEL	22
EA-SS-A5-AVG						

Table 4. PCT Analysis of the Environmental Assessment Glass

SAMPLE	ADS #	RESEARCHER	NOTEBOOK	PCT VERSION	TYPE OF VESSEL	SIZE OF VESSEL (ML)
SS-EA-1-7-1	200082096	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-1-7-2	200082097	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-1-7-3	200082098	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-1-7-AVG						
SS-EA-2-7-1	200082948	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-2-7-2	200082949	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-2-7-3	200082950	4	WSRC 92-232	5.0 A	PARR STEEL	22
SS-EA-2-7-AVG						
SRS-SEA-A-7-1	200086332	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-A-7-2	200086333	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-A-7-3	200086334	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-A-7-AVG						
SRS-SEA-B-7-1	200086357	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-B-7-2	200086350	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-B-7-3	200086359	4	WSRC 92-232	5.0 A	PARR STEEL	22
SRS-SEA-B-7-AVG						
CUASEA-A-7-1	200086342	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-A-7-2	200086343	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-A-7-3	200086344	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-A-7-AVG						
CUASEA-B-7-1	200086360	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-B-7-2	200086361	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-B-7-3	200086362	4	WSRC 92-232	5.0 A	STEEL CYLINDER	150
CUASEA-B-7-AVG						

Table 4. PCT Analysis of the Environmental Assessment Glass (Continued).

SAMPLE	mL OF LEACHANT	GMS OF GLASS	MEASURED pH	CONCENTRATIONS (ppm) B	Li	Na*	Si
EA-1-7-1[t]	40	4.00	11.80	567.96	210.71	1738.35	1048.41
EA-1-7-2[t]	40	4.00	11.79	593.57	211.19	1819.70	1061.93
EA-1-7-3[t]	40	4.00	11.80	605.97	212.86	1857.20	1070.91
EA-1-AVG			11.80	589.17	211.59	1805.08	1060.42
EA-2-7-1	40	4.00	11.86	468.52	163.27	1380.80	780.29
EA-2-7-2[t]	40	4.00	11.88	610.00	225.05	1854.87	1128.56
EA-2-7-3	40	4.00	11.88	523.05	171.77	1542.60	832.21
EA-2-AVG			11.87	533.86	186.70	1592.76	913.69
EA-7-1	35	3.50	12.01**	609.42	192.06	1685.50	908.43
EA-7-2	35	3.50	12.01**	615.07	187.92	1724.34	909.33
EA-7-3	35	3.50	12.01**	634.81	195.74	1770.69	938.30
EA-7-4	35	3.50	12.01**	638.54	204.01	1771.35	956.44
EA-7-5	35	3.50	12.01**	649.05	208.11	1789.02	965.06
EA-7-6	35	3.50	12.01**	584.70	186.73	1644.01	892.60
EA-AVG			12.01**	621.93	195.76	1730.82	928.36
T-EA-1	40	4.00	11.88	499.85	162.08	1429.74	763.41
T-EA-2	40	4.00	11.88	493.34	161.27	1408.62	746.67
T-EA-3	40	4.00	11.89	517.52	167.81	1480.44	782.22
T-EA-4	40	4.00	11.89	560.09	183.35	1572.63	825.27
EA-T-AVG			11.89	517.70	168.63	1472.86	779.39
SS-EA-19-1	19	1.90	11.92	577.41	180.78	1633.95	798.81
SS-EA-19-2	19	1.90	11.90	566.13	177.48	1604.19	791.43
SS-EA-19-3	19	1.90	11.95	576.06	180.48	1635.24	794.04
SS-EA-19-4	19	1.90	11.91	584.31	183.60	1650.21	803.25
EA-SS-19-AVG			11.92	575.98	180.59	1630.90	796.88
EA-SS-15-1	15	1.50	11.98	596.10	190.26	1670.40	846.96
EA-SS-15-2	15	1.50	11.92	601.41	191.52	1692.06	852.09
EA-SS-15-3	15	1.50	11.93	587.04	196.68	1640.88	848.55
EA-SS-15-4	15	1.50	11.95	572.67	193.11	1606.35	830.64
EA-SS-A5-AVG			11.95	589.31	192.89	1652.42	844.56

* measured by ICP

** bias corrected based on ARM-1 pH measurements

t solution data corrected for a dilution error

Table 4. PCT Analysis of the Environmental Assessment Glass (Continued).

SAMPLE	mL OF LEACHANT	GMS OF GLASS	MEASURED pH	CONCENTRATIONS (ppm) B	Li	Na*	Si
SS-EA-1-7-1	16	1.6	11.78	656.50	204.53	1808.68	956.18
SS-EA-1-7-2	16	1.6	11.77	654.11	206.95	1794.88	963.87
SS-EA-1-7-3	16	1.6	11.78	637.71	199.26	1754.74	936.13
SS-EA-1-7-AVG			11.78	649.44	203.58	1786.10	952.06
SS-EA-2-7-1	16	1.6	11.76	626.15	192.80	1711.27	909.10
SS-EA-2-7-2	16	1.6	11.77	614.53	191.51	1695.62	905.34
SS-EA-2-7-3	16	1.6	11.72	629.50	195.76	1723.18	925.18
SS-EA-2-7-AVG			11.75	623.39	193.35	1710.02	913.21
SRS-SEA-A-7-1	16	1.6	11.78	570.55	182.15	1586.75	853.72
SRS-SEA-A-7-2	16	1.6	11.78	573.93	178.56	1599.24	852.48
SRS-SEA-A-7-3	16	1.6	11.79	588.19	194.31	1616.04	885.21
SS-SEA-A-7-AVG			11.78	577.56	185.01	1600.68	863.80
SRS-SEA-B-7-1	16	1.6	11.78[t]	602.87	172.63	1678.49	884.79
SRS-SEA-B-7-2	16	1.6	11.78[t]	594.02	181.07	1689.32	886.22
SRS-SEA-B-7-3	16	1.6	11.79[t]	592.62	187.92	1683.49	908.28
SS-SEA-B-7-AVG			11.78	596.50	180.54	1683.76	893.09
CUASEA-A-7-1	100	10	11.76	599.59	192.38	1627.80	875.09
CUASEA-A-7-2	100	10	11.78	614.88	197.87	1682.85	913.44
CUASEA-A-7-3	100	10	11.77	560.10	184.42	1530.83	854.69
CUASEA-A-7-AVG			11.77	591.52	191.56	1613.83	881.07
CUASEA-B-7-1	100	10	11.76[t]	583.33	173.03	1670.90	880.57
CUASEA-B-7-2	100	10	11.78[t]	581.49	186.25	1681.90	895.29
CUASEA-B-7-3	100	10	11.77[t]	568.86	187.87	1663.43	909.35
CUASEA-B-7-AVG			11.77	577.89	182.38	1672.07	895.07

* measured by ICP

t leachate pH values for B replicates of these data sets are the same as the "A" replicates because the A and B replicates were the same leachate with different dilution factors before cation analysis

Table 5. PCT Analysis of the Environmental Assessment Glass.

SAMPLE	NORMALIZED MASS LOSS (g/L)				LOG NORMALIZED MASS LOSS (g/L)			
	B	Li	Na	Si	B	Li	Na	Si
EA-1-7-1[t]	16.18	10.64	13.95	4.60	1.21	1.03	1.14	0.66
EA-1-7-2[t]	16.91	10.67	14.60	4.66	1.23	1.03	1.16	0.67
EA-1-7-3[t]	17.26	10.75	14.91	4.70	1.24	1.03	1.17	0.67
EA-1-AVG	16.79	10.69	14.49	4.66	1.22	1.03	1.16	0.67
EA-2-7-1	13.35	8.25	11.08	3.43	1.13	0.92	1.04	0.53
EA-2-7-2[t]	17.38	11.37	14.89	4.95	1.24	1.06	1.17	0.69
EA-2-7-3	14.90	8.68	12.38	3.65	1.17	0.94	1.09	0.56
EA-2-AVG	15.21	9.43	12.78	4.01	1.18	0.97	1.10	0.60
EA-7-1	17.36	9.70	13.53	3.99	1.24	0.99	1.13	0.60
EA-7-2	17.52	9.49	13.84	3.99	1.24	0.98	1.14	0.60
EA-7-3	18.09	9.89	14.21	4.12	1.26	1.00	1.15	0.61
EA-7-4	18.19	10.30	14.22	4.20	1.26	1.01	1.15	0.62
EA-7-5	18.49	10.51	14.36	4.24	1.27	1.02	1.16	0.63
EA-7-6	16.66	9.43	13.19	3.92	1.22	0.97	1.12	0.59
EA-AVG	17.72	9.89	13.89	4.08	1.25	0.99	1.14	0.61
T-EA-1	14.24	8.19	11.47	3.35	1.15	0.91	1.06	0.53
T-EA-2	14.06	8.14	11.31	3.28	1.15	0.91	1.05	0.52
T-EA-3	14.74	8.48	11.88	3.43	1.17	0.93	1.07	0.54
T-EA-4	15.96	9.26	12.62	3.62	1.20	0.97	1.10	0.56
EA-T-AVG	14.75	8.52	11.82	3.42	1.17	0.93	1.07	0.53
SS-EA-19-1	16.45	9.13	13.11	3.51	1.22	0.96	1.12	0.54
SS-EA-19-2	16.13	8.96	12.87	3.47	1.21	0.95	1.11	0.54
SS-EA-19-3	16.41	9.12	13.12	3.49	1.22	0.96	1.12	0.54
SS-EA-19-4	16.65	9.27	13.24	3.53	1.22	0.97	1.12	0.55
EA-SS-19-AVG	16.41	9.12	13.09	3.50	1.22	0.96	1.12	0.54
EA-SS-15-1	16.98	9.61	13.41	3.72	1.23	0.98	1.13	0.57
EA-SS-15-2	17.13	9.67	13.58	3.74	1.23	0.99	1.13	0.57
EA-SS-15-3	16.72	9.93	13.17	3.72	1.22	1.00	1.12	0.57
EA-SS-15-4	16.32	9.75	12.89	3.65	1.21	0.99	1.11	0.56
EA-SS-A5-AVG	16.79	9.74	13.26	3.71	1.22	0.99	1.12	0.57

[t] solution data corrected for a dilution error

Table 5. PCT Analysis of the Environmental Assessment Glass (Continued).

SAMPLE	NORMALIZED MASS LOSS (g/L)				LOG NORMALIZED MASS LOSS (g/L)			
	B	Li	Na	Si	B	Li	Na	Si
SS-EA-1-7-1	18.70	10.33	14.52	4.20	1.27	1.01	1.16	0.62
SS-EA-1-7-2	18.64	10.45	14.41	4.23	1.27	1.02	1.16	0.63
SS-EA-1-7-3	18.17	10.06	14.08	4.11	1.26	1.00	1.15	0.61
SS-EA-1-7-AVG	18.50	10.28	14.33	4.18	1.27	1.01	1.16	0.62
SS-EA-2-7-1	17.84	9.74	13.73	3.99	1.25	0.99	1.14	0.60
SS-EA-2-7-2	17.51	9.67	13.61	3.97	1.24	0.99	1.13	0.60
SS-EA-2-7-3	17.93	9.89	13.83	4.06	1.25	1.00	1.14	0.61
SS-EA-2-7-AVG	17.76	9.77	13.72	4.01	1.25	0.99	1.14	0.60
SRS-SEA-A-7-1	16.25	9.20	12.73	3.75	1.21	0.96	1.10	0.57
SRS-SEA-A-7-2	16.35	9.02	12.84	3.74	1.21	0.96	1.11	0.57
SRS-SEA-A-7-3	16.76	9.81	12.97	3.89	1.22	0.99	1.11	0.59
SS-SEA-A-7-AVG	16.45	9.34	12.85	3.79	1.22	0.97	1.11	0.58
SRS-SEA-B-7-1	17.18	8.72	13.47	3.88	1.23	0.94	1.13	0.59
SRS-SEA-B-7-2	16.92	9.14	13.56	3.89	1.23	0.96	1.13	0.59
SRS-SEA-B-7-3	16.88	9.49	13.51	3.99	1.23	0.98	1.13	0.60
SS-SEA-B-7-AVG	16.99	9.12	13.51	3.92	1.23	0.96	1.13	0.59
CUASEA-A-7-1	17.08	9.72	13.06	3.84	1.23	0.99	1.12	0.58
CUASEA-A-7-2	17.52	9.99	13.51	4.01	1.24	1.00	1.13	0.60
CUASEA-A-7-3	15.96	9.31	12.29	3.75	1.20	0.97	1.09	0.57
CUASEA-A-7-AVG	16.85	9.67	12.95	3.87	1.23	0.99	1.11	0.59
CUASEA-B-7-1	16.62	8.74	13.41	3.87	1.22	0.94	1.13	0.59
CUASEA-B-7-2	16.57	9.41	13.50	3.93	1.22	0.97	1.13	0.59
CUASEA-B-7-3	16.21	9.49	13.35	3.99	1.21	0.98	1.13	0.60
CUASEA-B-7-AVG	16.46	9.21	13.42	3.93	1.22	0.96	1.13	0.59

Statistical Analysis of EA Glass Data

The SRTC EA glass durability measurements were evaluated statistically. Data for the Product Consistency Test (PCT) leachate variables: pH and concentrations, in C_i(ppm) and NC_i(g/L), of boron, lithium, sodium, and silicon were considered. The logNC_i(g/L) values (Table 5) were not separately evaluated as they are mathematically derived from the leachate concentrations in NC_i.

All of the researchers used either PCT Version 3.0 or 5.0 at the nominal test parameters. All of the researchers used a constant sample mass to solution volume of 1:10 which maintains the exposed glass surface area (SA) to solution volume (V) at a constant. Varying the available head space in the 22 mL steel vessels appeared to have no effect on the final leachate concentrations or on the measured pH. All of the researchers used the EA glass and ASTM-Type I water as the leachant. All testing was conducted at 90°C although different ovens were used by the different researchers. All testing was conducted over a 7 day period. Different pH meters were used by the different researchers. All test results are, therefore, considered experimentally comparable.

Six out of the twelve combinations of analyst and vessel type were examined (Figure 2). Not every researcher tested the EA glass in every type of vessel. This causes the data set to be unbalanced based on classification of analyst and vessel type. The pH values measured are considered to represent ten distinct sample populations (Figure 2). The samples are distinct because the analyst and leach vessel type varied between the populations and because the crushing and sieving of each "batch" of glass for replicate use represents another potential source of variance. Use of different ovens and different pH meters used by the different analysts is considered a part of the "sample-to-sample" variation. The leachate concentrations measured in ppm are considered to represent twelve distinct sample populations (levels of variance) because researcher 4 submitted two of the triplicate sets of PCT leachates for duplicate leachate analysis. Different dilution factors were used for the duplicate leachate analyses. These duplicate leachate analyses are identified as A/B pairs in Table 4. The ten pH populations and the twelve leachate concentration populations are segregated based on the "sample-to-sample" differences, with n_i observations per class. The varying observations per class causes the data set to be unbalanced.

The average and standard deviations of the 42 replicate EA glass durability analyses are given in Table 6. The pH data averages and standard deviations are based on 36 observations since researcher 4 analyzed the leachates of the A/B pairs given in Table 4 at different dilutions but only one pH measurement was made for each A/B pair. The mean of the means that were presented in Tables 4 and 5 was used to determine the averages reported in Table 6. By pooling the means within each of the populations,the data sets with higher numbers of replicate analyses are statistically considered equal to those with fewer replicate analyses. The standard deviations were calculated using the Statistical Analysis System (SAS®) Variance Components (VARCOMP) estimator (Appendix V). In this manner, the random effects which arise from all the "sample-to sample" classification effects, are used to estimate the pooled variances. A Type-I VARCOMP estimation model was employed which computes the sum of the squares for each effect, equates each mean square involving only random effects to its expected value, and solves the resulting system of equations. Two variance components are obtained which include an evaluation of both the random and fixed effects in the data, in this case the "sample-to-sample" variation, and the data error variation (Appendix V). The total standard deviation is equal to the square root of the sum of the two variance components. The total standard deviations derived by this methodology are given in Table 6.

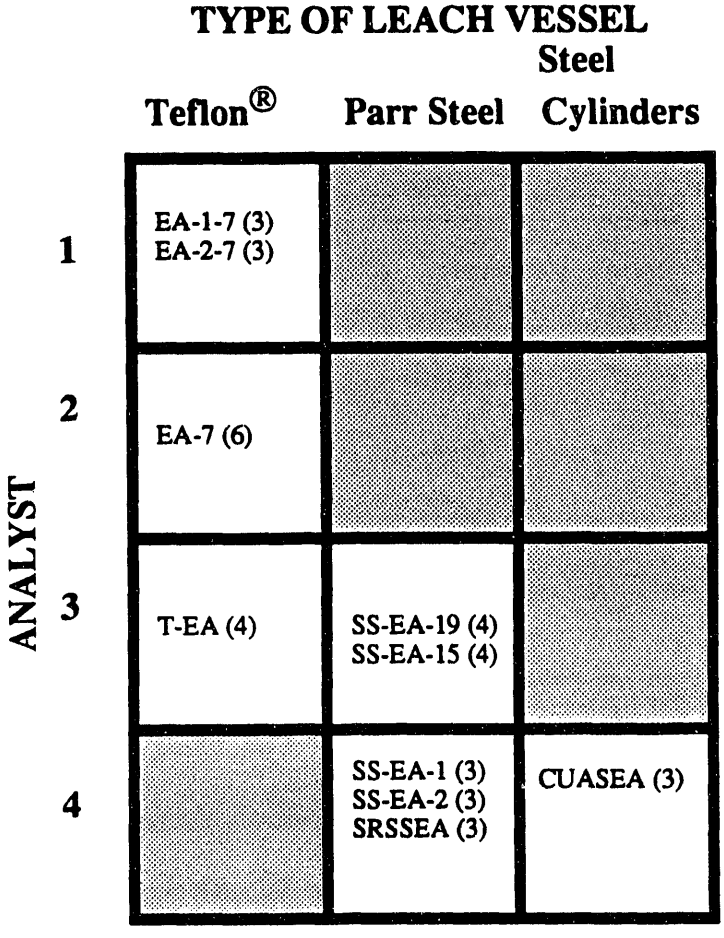

Figure 2. Schematic showing the samples used in this analysis. Although six out of the twelve possible combinations of analyst and leach vessel were examined, not every researcher tested the EA glass in every type of vessel. This shows the unbalanced nature of the data set based on classification of analyst and vessel type. The number in parentheses following each sample identification is the number of replicate EA durability tests performed by each analyst on each sample population.

Table 6. SAS Statistical Analysis of PCT Durability Measurements for the Environmental Assessment Glass.

	Leachate Concentrations				
	pH	B (ppm)	Li (ppm)	Na (ppm)	Si (ppm)
Mean*	11.85	587	190	1662	893
Standard Deviation	0.1	43	14.5	112	86
Relative Percent Standard Deviation	0.8	7.3	7.6	6.7	9.6

	Leachate Concentrations			
	B (g/L)	Li (g/L)	Na (g/L)	Si (g/L)
Mean*	16.695	9.565	13.346	3.922
Standard Deviation	1.222	0.735	0.902	0.376
Relative Percent Standard Deviation	7.31	7.68	6.76	9.58

* calculated as the mean of the means

Table 7. Correlation Matrix For the Leachate Analyses in ppm*

Variable	B (ppm)	Li (ppm)	Na (ppm)	Si (ppm)
B (ppm)	1.0000	0.7428	0.8848	0.6250
Li (ppm)		1.0000	0.8719	0.8849
Na (ppm)			1.0000	0.8595
Si (ppm)				1.0000

* Corresponds to data shown graphically in Figure 3.

The leachate chemistry is internally consistent as shown by the correlation matrix in Table 7. This is illustrated graphically by the scatter plots shown in Figure 3. The inner most ellipses define all the data that fits within a 95% confidence level. The outermost ellipses define all the data that fits within a 99% confidence level. The six samples shown as larger squares in the scatter plot are clearly outliers at the 95% confidence level. They represent the solution data of researcher 1 that was bias corrected for a dilution error. These data were retained in the VARCOMP statistical analysis in order to (1) evaluate the maximum intra-laboratory (between researcher) error and (2) because the data was statistically significant at the 99% confidence level.

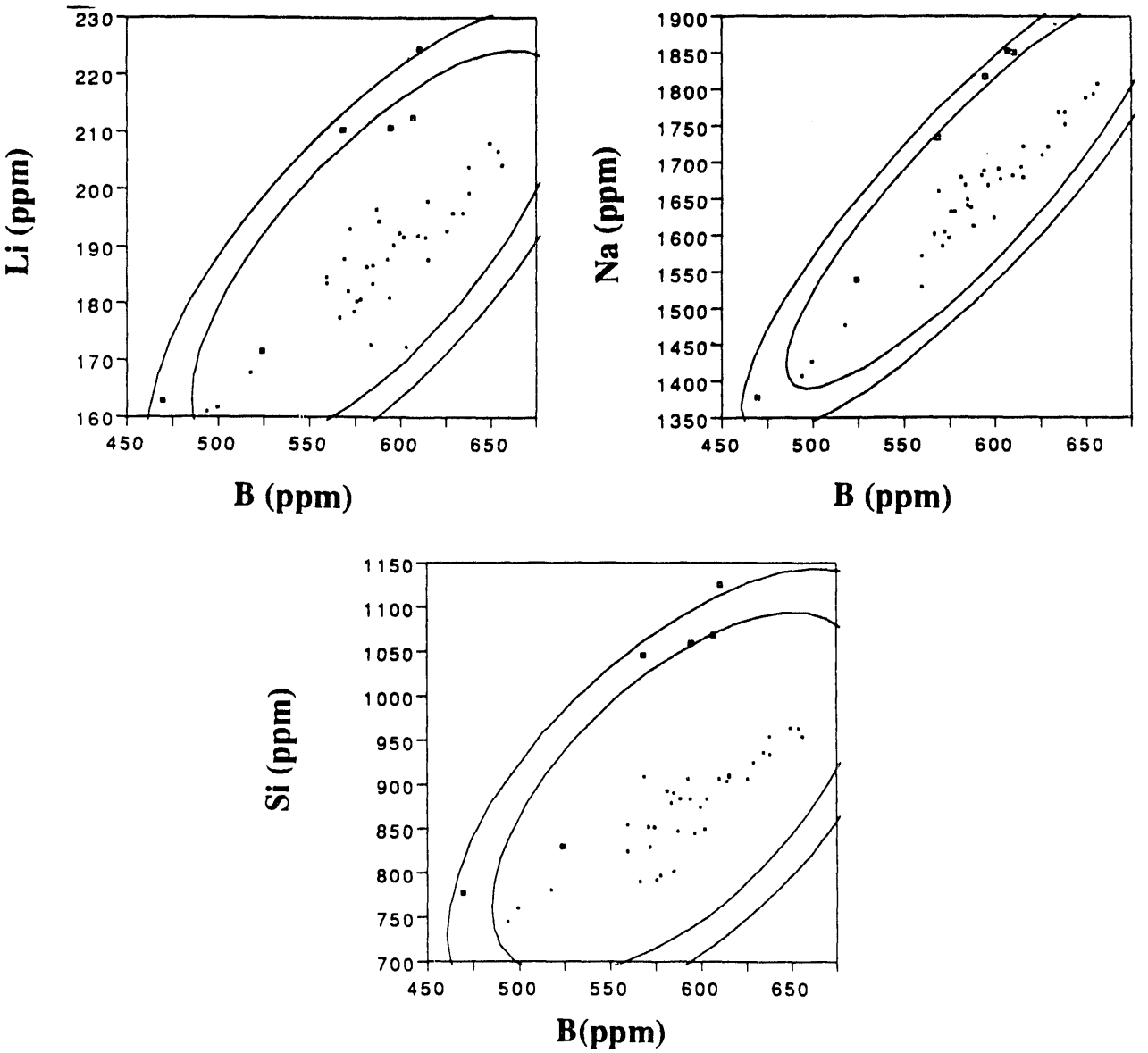

Figure 3. Scatter plots showing the internally consistency of the leachate data. The inner most density ellipses define the data which is statistically significant at the 95% confidence level. The outer most ellipses define the data which is statistically significant at the 99% confidence level (corresponds to the correlation matrix given in Table 7).

The average (mean of the means) pH values measured by the 4 researchers for the 10 populations of data is 11.85. The range and distribution of measurements for each of the researchers is shown graphically in Figure 4. In order to show whether differences in pH measurement and/or differences in leachate composition measurement were affected to a greater extent by the type of vessel that each researcher used or by "researcher-to-researcher" variability separate one-way analysis of variance were performed for "researcher-to-researcher" and "vessel type" variables.

A generalized example of the graphical representation of a one-way analysis of variance (ANOVA) is shown in Figure 5a. The graphical display shows the vertical distribution of response points for each factor examined. The groups of identical values are called categories or samples of the x variable. The basic fitting approach is to compute the mean response within each group. The diamond shapes on each figure are "means" diamonds. The line across each diamond represents the group mean. The diamond width represents the group sample size. The height of each diamond represents the 95% confidence interval for each group. The 95% confidence intervals are computed using the root mean square error from the sum total of response points for all factors and the square root of the number of data points within a specific group.[25] The "comparison" circles to the right of each figure is a 95% confidence circle useful for comparing the group means (Figure 5b). For each level of the response variable, a circle is drawn with its center at the mean and its diameter corresponding to the 95% confidence interval for the mean. Each group of means is compared visually by examining how the comparison circles intersect. If the circles intersect by an angle of more than 90 degrees or if they are nested, the means are not significantly different. The dotted horizontal line is the total response sample mean for the populations shown (Figure 5).

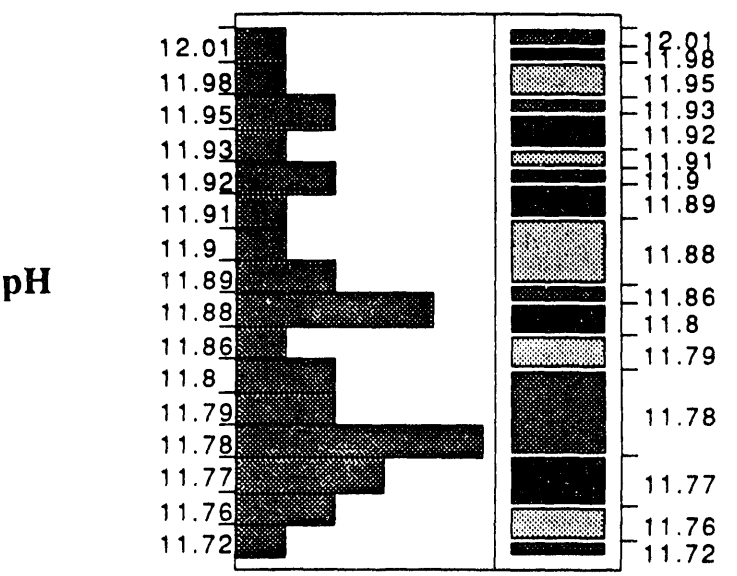

Figure 4. Distribution of the pH values measured by all researchers.

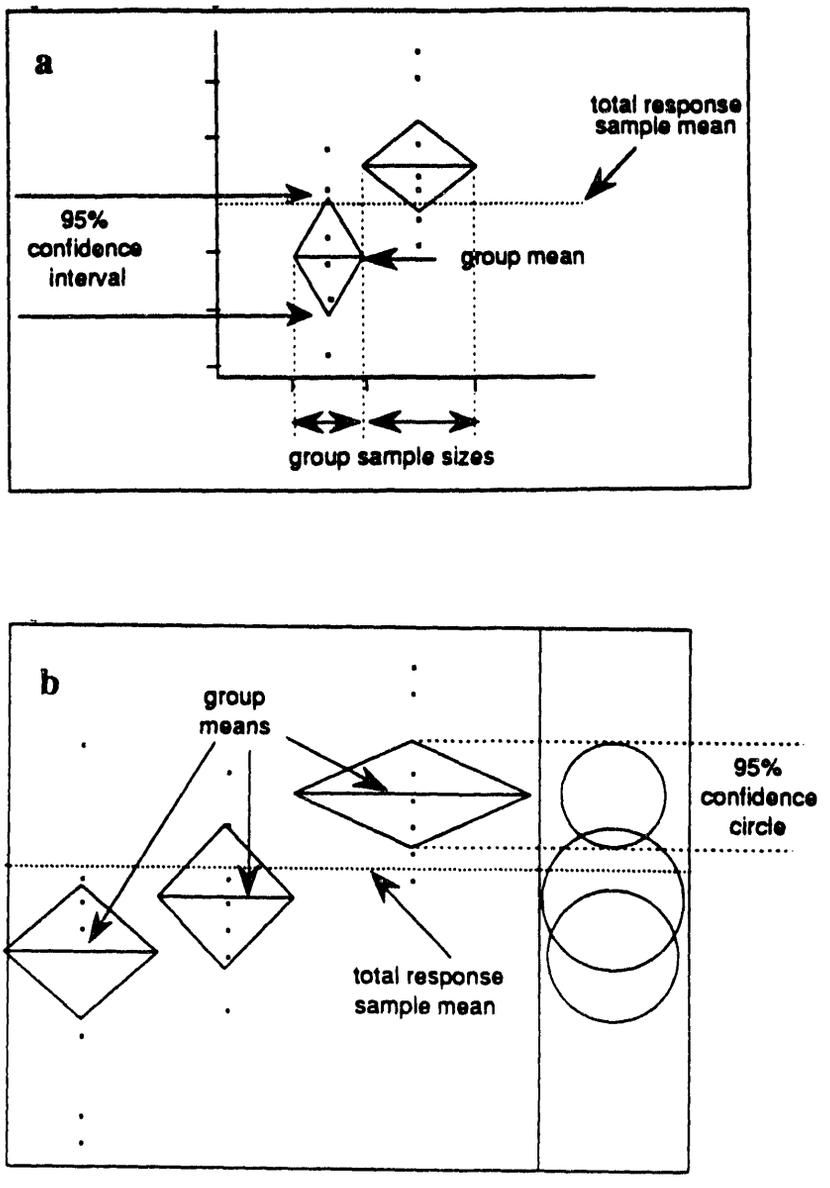

Figure 5. Graphical representation of the one-way analysis of variance which compares the mean response by variable group. The comparison circles are used for comparing the group means.

A comparison was made of an one-way analysis of variance of the measured leachate pH based on "analyst-to-analyst" variability and vessel type variability. In Figure 6a the grouping are by analyst while in Figure 6B the groupings are by leachate vessel type. The "analyst-to-analyst" variability for the pH measurement is shown in Figure 6a to be more significant (no overlapping comparison circles) than the pH variability caused by vessel type (partially overlapping comparison circles) shown in Figure 6b. Figure 6a shows that the pH values measured by researcher 4 were always biased low whether Parr steel bombs or steel cylinders were used as leach vessels. Figure 6a also shows that the pH values measured by researcher 1were always biased high. This was the data set for which the pH values were bias corrected based on the ARM-1 glass data as discusssed in the previous section and so these values may be biased higher due to errors associated with the bias correction of the raw pH data. Researchers 1 and 3 are closest to each other in pH measurement. Researcher 1 used only Teflon® vessels while Researcher 3 used a combination of Parr Steel and Teflon® leach vessels. Even for the pH data for the two closest researchers, there is a distinct "analyst-to-analyst" variation in thepH measurement (no overlapping comparison circles).

A similar comparison was made of the "analyst-to-analyst" variance and the vessel type variance for the response of the measured leachate concentrations for B, Li, Na, and Si (Figures 7-10). In each case the "analyst-to-analyst" variability is greater (Figures 7-10a), e.g. the comparison circles overlap less, than for the vessel type variability (Figures 7-10b). The leachate results shown in Figures 7-10b demonstrate that the comparison circles for the varying vessel types all overlap. The PCT response for the EA glass in the different vessels (Teflon®, Parr 304L stainless steel vessels with a smooth internal finish, and 304L stainless steel cylinders with a rougher internal finish) are comparable. Comparison of Figures 7-10a with Figures 7-10b indicates that the "analyst-to-analyst" variability is greater than the variability caused by using different types of leach vessels.

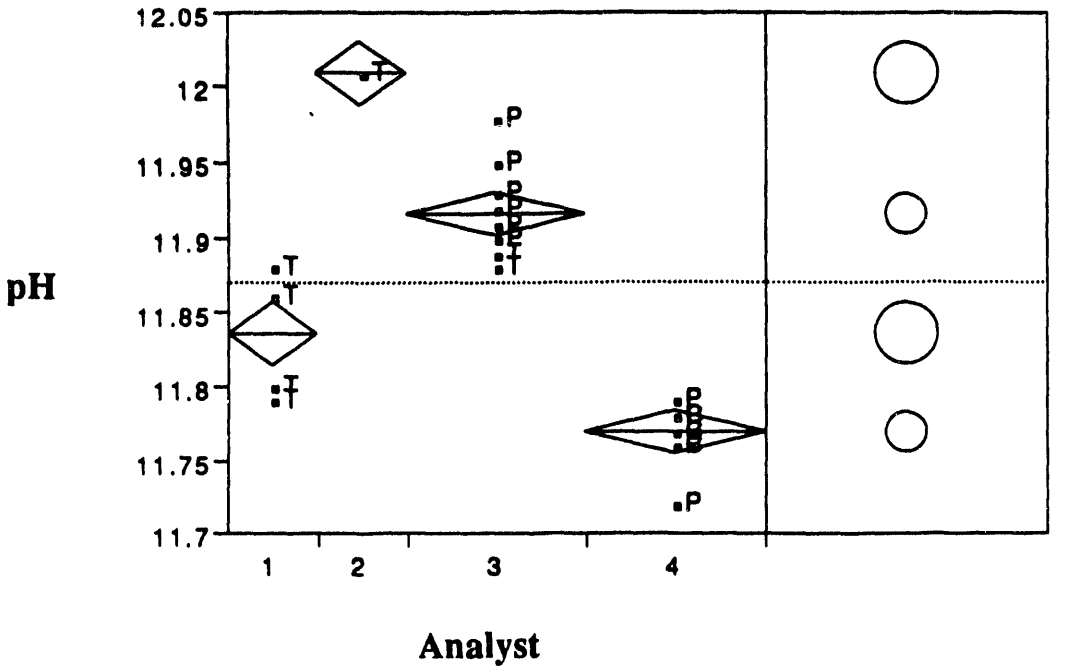

Figure 6a. One-way analysis of variance for the pH leachate measurements by analyst. The T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders.

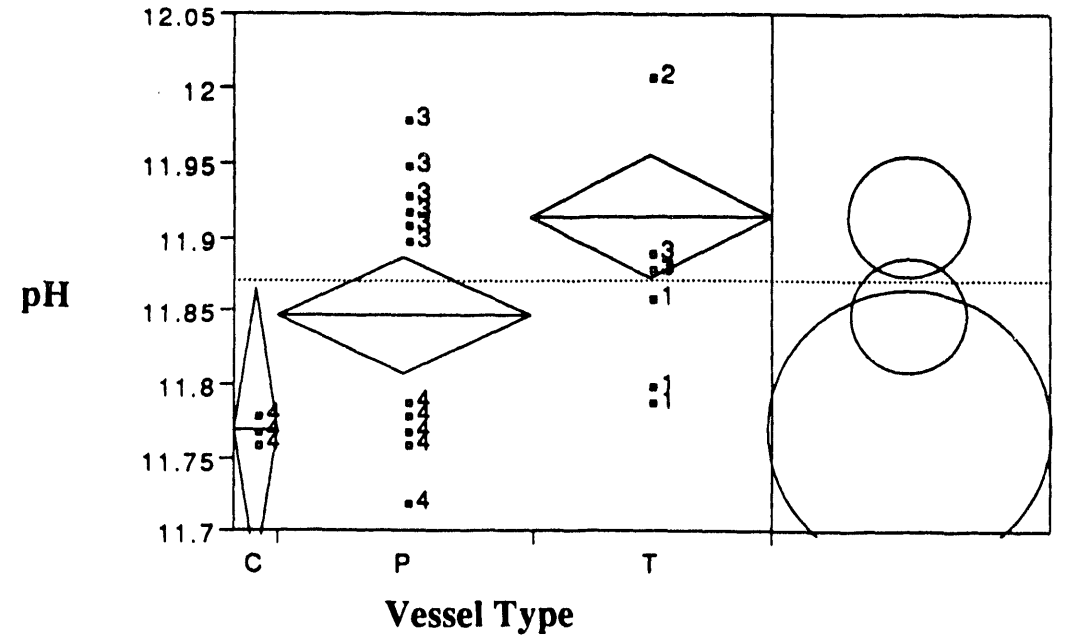

Figure 6b. One-way analysis of variance for the pH leachate measurements by vessel type (T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders). Labels on the data points represent the different analysts.

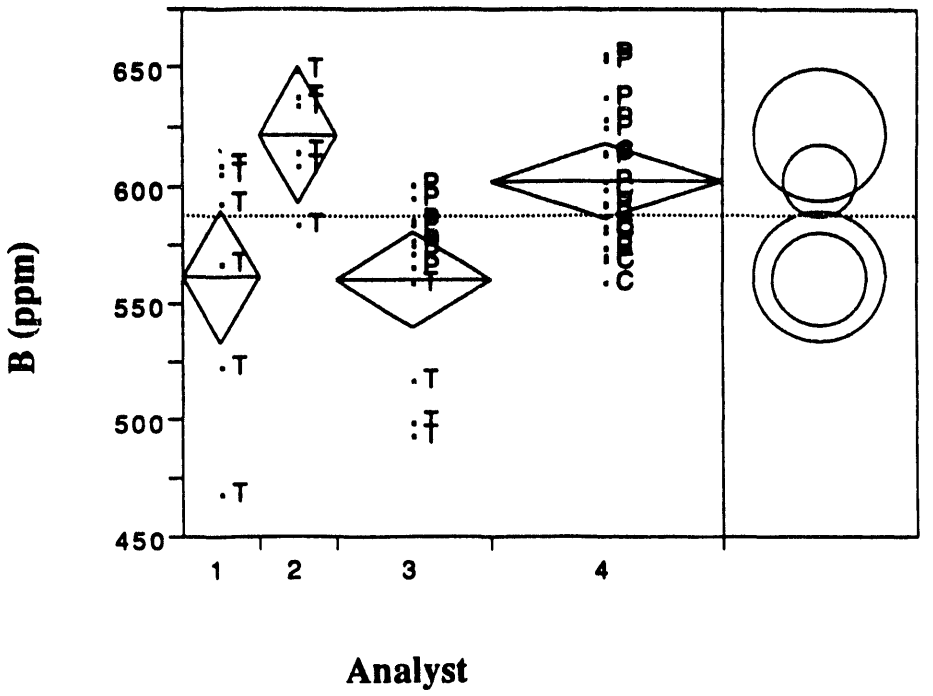

Figure 7a. One-way analysis of variance for the B concentration in ppm by analyst. The T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders.

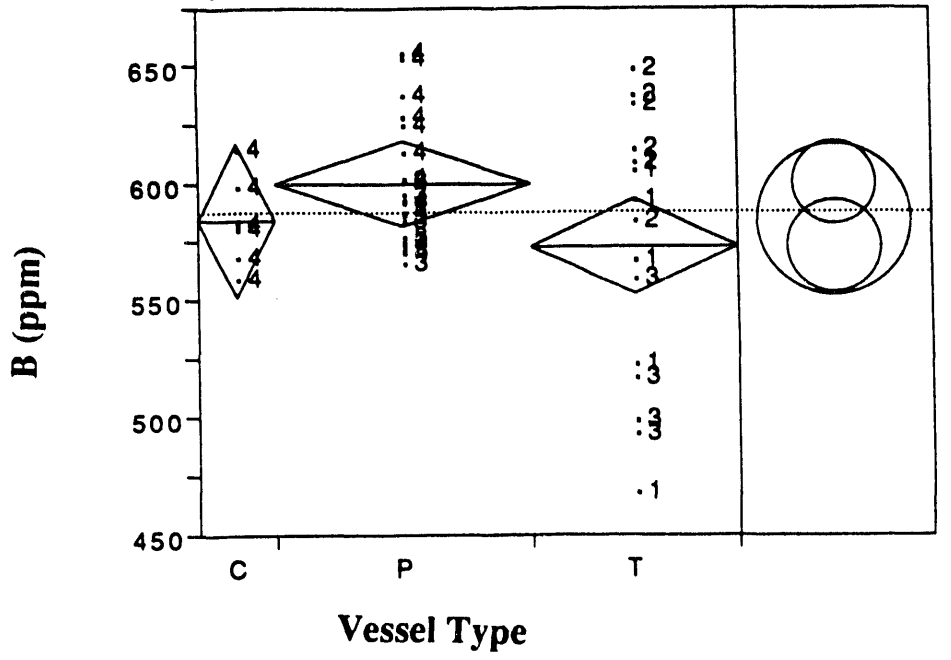

Figure 7b. One-way analysis of variance for the B concentration in ppm by vessel type (T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders). Labels on the data points represent the different analysts.

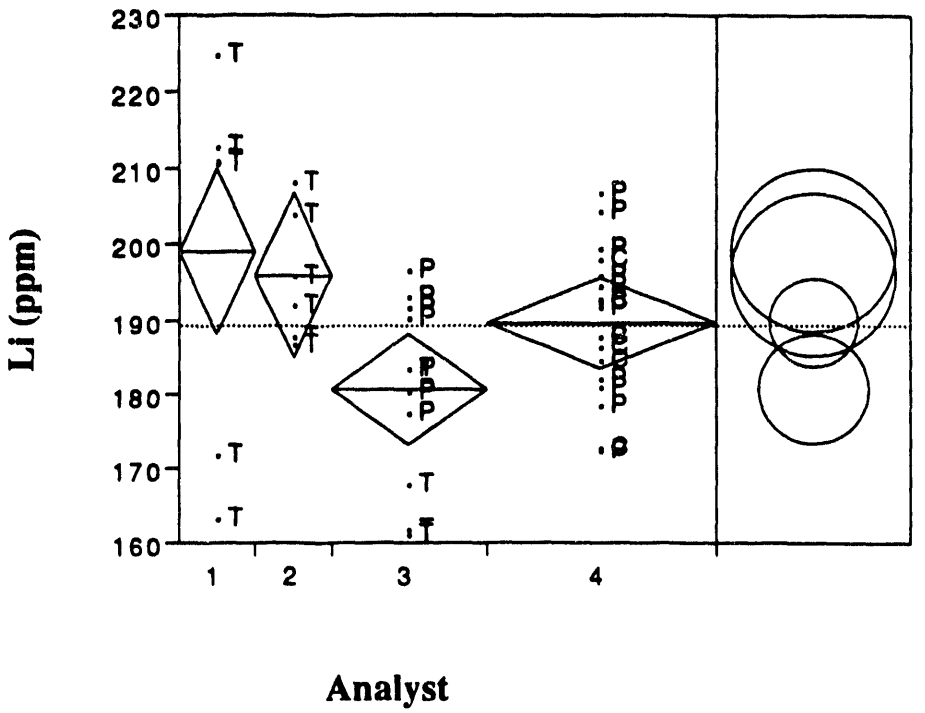

Figure 8a. One-way analysis of variance for the Li concentration in ppm by analyst. The T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders.

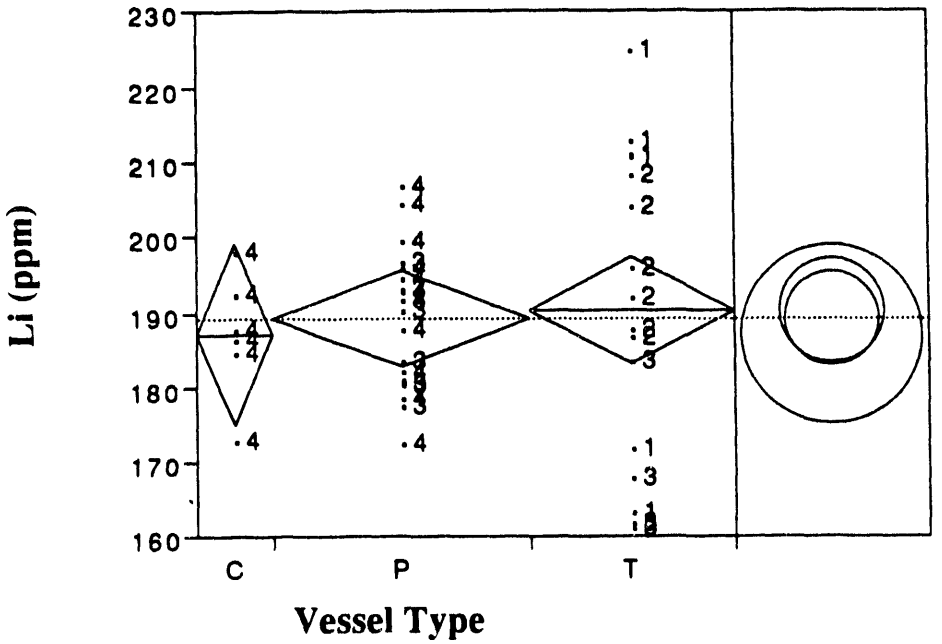

Figure 8b. One-way analysis of variance for the Li concentration in ppm by vessel type (T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders). Labels on the data points represent the different analysts.

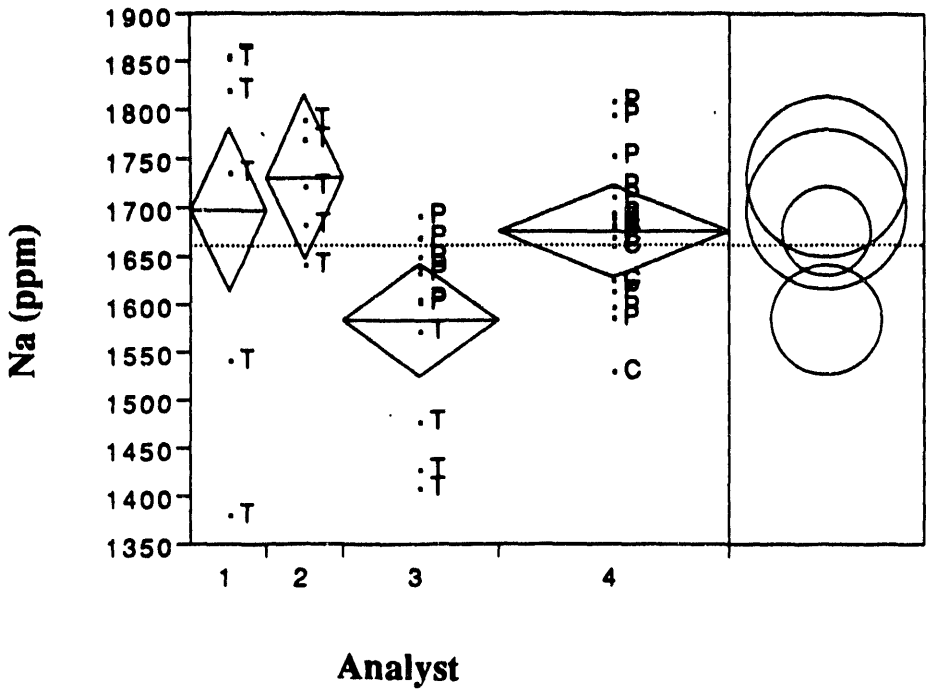

Figure 9a. One-way analysis of variance for the Na concentration in ppm by analyst. The T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders.

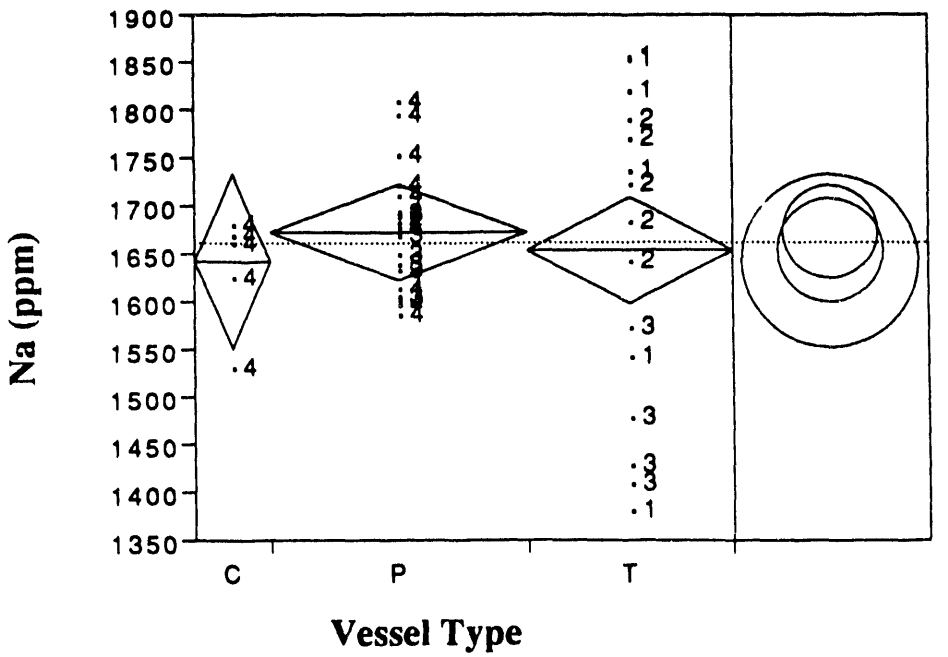

Figure 9b. One-way analysis of variance for the Na concentration in ppm by vessel type (T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders). Labels on the data points represent the different analysts.

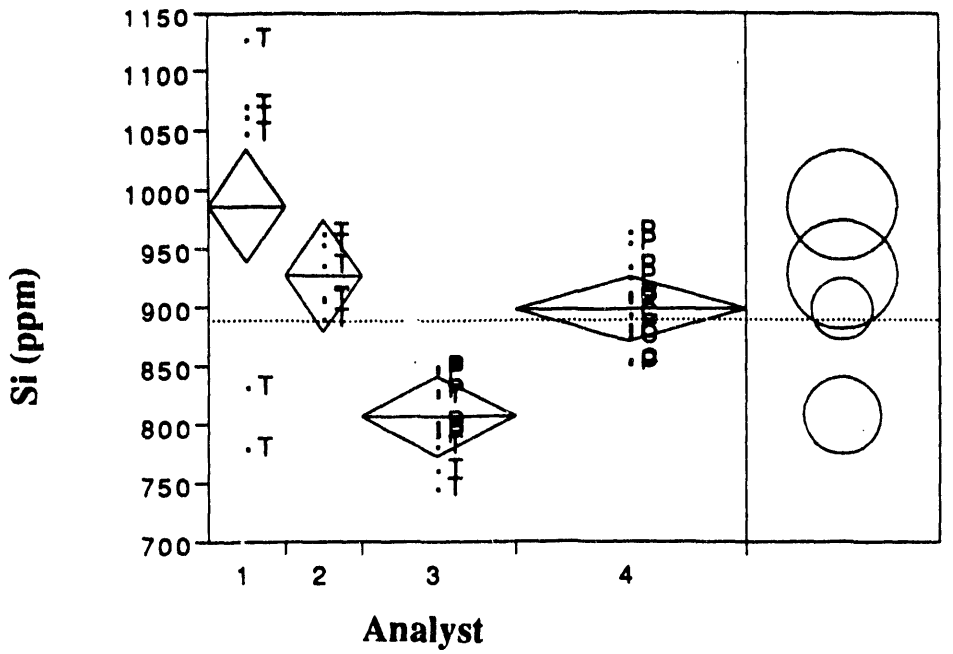

Figure 10a. One-way analysis of variance for the Si concentration in ppm by analyst. The T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders.

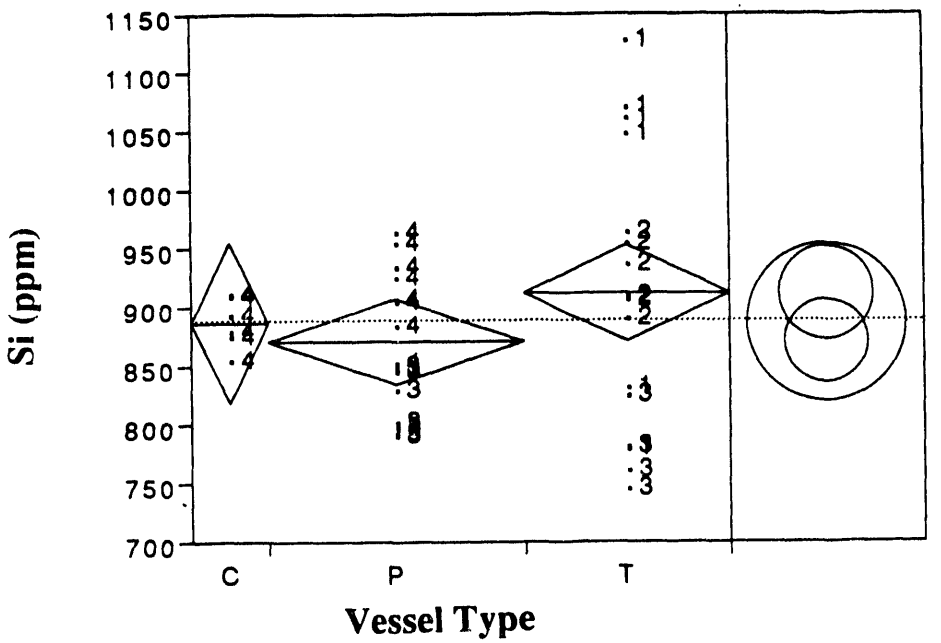

Figure 10b.One-way analysis of variance for the Si concentration in ppm by vessel type (T indicates Teflon® vessels, the P indicates the Parr 304L steel vessels, and the C indicates the large 304L steel cylinders). Labels on the data points represent the different analysts.

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CONCLUSIONS

The chemical analysis of the EA glass indicates that the glass is within the target composition specified and has an Fe^{2+}/Fe^{3+} ratio of 0.23 compared to Corning Glass Works' value of 0.22. The chemical analyses in this study verify the Corning Glass Works analysis except for the lower concentration of La_2O_3 measured in this study. In addition, minor amounts of ZnO, Cl and F were detected in the glass. The presence of trace amounts of anions is not considered significant because the analytic determinations were so close to the detection limits of the measurement technique.

The chemical composition of the 1000 pounds of glass was determined to be homogeneous. The glass was x-ray amorphous and found to be composed of individual grains which varied in redox but were homogeneously distributed. The PCT leachate data of the EA glass appears to be internally consistent. No significant long term or short term instrumental analytic bias was observed. The leachate results were comparable in Teflon®, Parr 304L stainless steel vessels with a smooth internal finish, and 304L stainless steel vessels with a rougher internal finish. Comparison of the PCT leachate data for the EA glass indicates that the "analyst-to-analyst" variability is greater than the variability caused by using different types of leach vessels.

The EA glass fabricated by Corning Glass Works is suitable as a durability and/or redox Standard Reference Material.

ACKNOWLEDGEMENT

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REFERENCES

1. **Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms**, U. S. Department of Energy, Office of Environmental Restoration and Waste Management, USDOE Document DOE-DWPD-FY93-0288, Washington, DC (February, 1993).

2. C. M. Jantzen and N. E. Bibler, **"Product Consistency Test (PCT) and Test Protocol,"** USDOE Report DPST-87-575, E.I duPont deNemours & Co, Savannah River Laboratory, Aiken, SC (1987).

3. C. M. Jantzen and N. E. Bibler, **"Nuclear Waste Product Consistency Test (PCT) -Version 3.0,"** USDOE Report WSRC-TR-90-539, Rev. 1, Westinghouse Savannah River Co., Savannah River Laboratory, Aiken, SC (November, 1990).

4. C. M. Jantzen, N. E. Bibler, D.C. Beam, W.G. Ramsey, B.J. Waters **"Nuclear Waste Product Consistency Test (PCT) -Version 5.0,"** USDOE Report WSRC-TR-90-539, Rev. 2, Westinghouse Savannah River Co., Savannah River Laboratory, Aiken, SC (January, 1992).

5. N.E. Bibler and C.M. Jantzen, **"The Product Consistency Test and Its Role in the Waste Acceptance Process for DWPF Glass,"** Waste Management '89, Volume I, R.G. Post and M.E. Wacks (Eds.), University of Arizona, 743-749 (1989).

6. C.M. Jantzen and N.E. Bibler, **"The Product Consistency Test for the DWPF Wasteform,"** Requirements for Waste Acceptance and Quality Control, Proceedings of the 2nd International Seminar on Radioactive Waste Products, E. Warnecke, R. Odoj, and R. Simon (Eds.), Kernforschunganlanger (KFA) Research Center, Julich, Federal Republic of Germany, 609-622 (1990).

7. G. F. Piepel, T. E. Jones, D. L. Eggett, G. B. Mellinger, **"Product Consistency Test Round Robin Conducted by the Materials Characterization Center - Summary Report,"** USDOE Report PNL-6967, Materials Characterization Center, Battelle Pacific Northwest Laboratories, Richland, WA (1989).

8. N. E. Bibler and J. K. Bates, **"Product Consistency Leach Tests of Savannah River Site Radioactive Waste Glasses,"** Scientific Basis for Nuclear Waste Management, XIII, V. M. Oversby and P. W. Brown (Eds.), Materials Research Society, Pittsburgh, PA, 327-338 (1990).

9. U.S. Department of Energy, **"Environmental Assessment Waste Form Selection for SRP High-Level Waste,"** U.S. DOE Report DOE-EA-0179 (July, 1982).

10. C.M. Jantzen, **"Relationship of Glass Composition to Glass Viscosity, Resistivity, Liquidus Temperature, and Durability: First Principles Process-Product Models for Vitrification of Nuclear Waste,"** Proceedings of the 5th International Symposium on Ceramics in Nuclear Waste Management, G.G. Wicks, D.F. Bickford, and R. Bunnell (Eds.), American Ceramic Society, Westerville, OH, 37-51 (1991).

11. M. J. Plodinec, **"Factors Affecting the Iron Oxidation State and Foaming in SRP Waste Glass,"** Proceedings of the Symposium on High Temperature Materials Chemistry, D. D. Cubicciotti and D. L. Hildebrand (Eds.), The Electrochemical Society, Pennington, New Jersey, 201-209 (1982).

12. C. M. Jantzen, D. F. Bickford and D. G. Karraker, **"Time-Temperature-Transformation Kinetics in SRL Waste Glass,"** Advances in Ceramics, V. 8, G. G. Wicks and W. A. Ross (Eds.), 30-38 (1984).

13. D. F. Bickford and R. B. Diemer, Jr., **"Redox Control of Electric Melters with Complex Feed Compositions, Part I. Analytical Methods and Models,"** J. Non-Cryst. Solids, 84, 276-284 (1986).

14. D. F. Bickford and R. B. Diemer, Jr., D. C. Iverson **"Redox Control of Electric Melters with Complex Feed Compositions, Part II. Preliminary Limits for Radioactive Waste Melters,"** J. Non-Cryst.Solids, 84, 285-291 (1986).

15. D. F. Bickford, R. C. Probst, and M. J. Plodinec, **"Control of Radioactive Waste Glass Melters: Part III. Glass Electrical Stability,"** Advances in the Fusion of Glass, D. F. Bickford, et. al. (Eds.), The American Ceramic Society, Westerville, OH, 19.1-19.17 (1988).

16. L. R. Bunnell, **"Laboratory Work in Support of West Valley Glass Development,"** USDOE Report PNL-6539, Battelle Pacific Northwest Laboratory, Richland, WA,(May, 1988).

17. C.M. Jantzen and M.J. Plodinec, **"Composition and Redox Control of Waste Glasses: Recommendation for Process Control Limit,"** USDOE Report DPST-86-773, E.I. duPont deNemours & Co., Savannah River Laboratory, Aiken, SC (November, 1986).

18. C.M. Jantzen, **"Verification and Standardization of Glass Redox Measurement for DWPF,"** USDOE Report DPST-89-222, E.I. duPont deNemours & Co., Savannah River Laboratory, Aiken, SC (January, 1989).

19. G.F. Piepel and G.B. Mellinger, **"Statistical Aspects of Compliance with the WAPS Radionuclide Release Specification,"** Proceedings of the 4th International Symposium on Ceramics in Nuclear Waste Management, III, G.B. Mellinger (Ed.), Ceramic Transactions, V. 9, American Ceramic Society, Westerville, OH, 483-494 (1990).

20. C.M. Jantzen, **"Verification of Glass Composition and Strategy for SGM and DWPF Glass Composition Determination,"** USDOE Report DPST-86-708, E.I. duPont deNemours & Co., Savvanah River Laboratory, Aiken, SC (March 30, 1987).

21. C.M. Jantzen, **"Composition of Linde IE95 (AW500) Zeolite Fraction of Sludge,"** USDOE Report DPST-88-623, E.I. duPont deNemours & Co., Savannah River Laboratory, Aiken, SC (June, 1988).

22. E.W. Baumann, **"Colorimetric Determination of Iron (II) and Iron (III) in Glass,"** Analyst, v. 117, 913-916 (1992).

23. **Waste Form Compliance Plan for the Defense Waste Processing Facility,** Revision 0, USDOE Document WSRC-SW4-6, Westinghouse Savannah River Company, Aiken, SC, March 1990.

24. T.A. Policke, **"Demonstration of Method DPST-88-272, Sodium Peroxide Fusion Dissolution of Sludge, Glass, and Melter Feed for Elemental Analysis,"** USDOE Report WSRC-TR-92-313, Westinghouse Savannah River Company, Aiken, SC (June, 1992).

25. SAS Institute INc, **"JMP™ User's Guide Version 1.0,"** p.319-323 (September, 1989).

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APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Sample 1

	Dissolution 1		Dissolution 2		Dissolution 3	
	Read 1	Read 2	Read 1	Read 2	Read 1	Read 2
Al2O3	3.75	3.72	3.72	3.72	3.69	3.69
B2O3	11.1	11.2	11.2	11.2	11.3	11.4
CaO	1.12	1.12	1.12	1.12	1.11	1.11
Fe2O3	7.39	7.38	7.52	7.52	7.36	7.31
FeO	1.45	1.46	1.36	1.36	1.47	1.48
K2O	0.04	0.04	0.04	0.04	0.04	0.04
La2O3	0.42	0.42	0.42	0.42	0.42	0.42
Li2O	4.28	4.29	4.25	4.24	4.26	4.26
MgO	1.74	1.72	1.72	1.72	1.72	1.71
MnO	1.35	1.34	1.35	1.35	1.35	1.34
Na2O	16.8	16.8	16.8	16.8	16.8	16.8
NiO	0.58	0.57	0.57	0.57	0.57	0.57
SiO2	49.3	48.9	49.0	49.0	48.6	48.5
TiO2	0.71	0.70	0.70	0.70	0.70	0.69
ZrO2	0.46	0.46	0.48	0.47	0.46	0.46
Total	100.49	100.12	100.25	100.23	99.85	99.78
Fe2O3(TOT)	9.01	9.01	9.04	9.04	9.00	8.96
Fe(TOT)	6.30	6.30	6.32	6.32	6.29	6.26
FeO	1.45	1.46	1.36	1.36	1.47	1.48
Fe(+2)	1.13	1.13	1.06	1.06	1.14	1.15
Fe(+3)	5.17	5.16	5.26	5.26	5.15	5.11
Fe2O3(+3)	7.39	7.38	7.52	7.52	7.36	7.31
Fe+2/Fe+3	0.22	0.22	0.20	0.20	0.22	0.22

APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Sample 2

	Dissolution 1		Dissolution 2		Dissolution 3	
	Read 1	Read 2	Read 1	Read 2	Read 1	Read 2
Al2O3	3.67	3.73	3.72	3.69	3.69	3.70
B2O3	11.2	11.3	11.2	11.3	11.4	11.3
CaO	1.11	1.12	1.12	1.11	1.12	1.12
Fe2O3	7.27	7.35	7.39	7.36	7.40	7.40
FeO	1.47	1.48	1.48	1.50	1.48	1.49
K2O	0.04	0.04	0.04	0.04	0.04	0.04
La2O3	0.42	0.42	0.42	0.42	0.41	0.42
Li2O	4.27	4.28	4.26	4.25	4.27	4.24
MgO	1.71	1.71	1.71	1.71	1.72	1.72
MnO	1.33	1.32	1.34	1.33	1.35	1.35
Na2O	16.8	16.8	16.8	16.8	16.8	16.8
NiO	0.56	0.56	0.57	0.57	0.57	0.57
SiO2	48.7	48.8	48.8	48.5	48.7	48.8
TiO2	0.69	0.70	0.70	0.70	0.70	0.70
ZrO2	0.47	0.47	0.48	0.47	0.46	0.47
Total	99.71	100.08	100.03	99.75	100.11	100.12
Fe2O3 (TOT)	8.91	9.00	9.04	9.03	9.05	9.06
FeO(TOT)	6.23	6.29	6.32	6.31	6.33	6.33
FeO	1.47	1.48	1.48	1.50	1.48	1.49
Fe(+2)	1.14	1.15	1.15	1.17	1.15	1.16
Fe(+3)	5.09	5.14	5.17	5.15	5.18	5.18
Fe2O3(+3)	7.27	7.35	7.39	7.36	7.40	7.40
Fe+2/Fe+3	0.22	0.22	0.22	0.23	0.22	0.22

APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Sample 3

	Dissolution 1		Dissolution 2		Dissolution 3	
	Read 1	Read 2	Read 1	Read 2	Read 1	Read 2
Al2O3	3.66	3.70	3.68	3.72	3.73	3.71
B2O3	11.3	11.3	11.2	11.3	11.4	11.4
CaO	1.10	1.12	1.11	1.12	1.12	1.12
Fe2O3	7.21	7.27	7.44	7.50	7.43	7.41
FeO	1.47	1.47	1.38	1.38	1.43	1.43
K2O	0.04	0.04	0.04	0.04	0.04	0.04
La2O3	0.42	0.42	0.41	0.41	0.42	0.42
Li2O	4.27	4.28	4.25	4.25	4.27	4.25
MgO	1.69	1.70	1.71	1.72	1.73	1.72
MnO	1.32	1.33	1.34	1.35	1.35	1.35
Na2O	16.8	16.8	16.9	16.9	16.8	16.7
NiO	0.56	0.57	0.57	0.57	0.57	0.57
SiO2	48.0	48.3	48.6	48.9	49.3	49.1
TiO2	0.69	0.69	0.69	0.70	0.70	0.70
ZrO2	0.44	0.45	0.45	0.45	0.44	0.44
Total	98.97	99.44	99.77	100.31	100.73	100.36
Fe2O3(TOT)	8.85	8.91	8.98	9.04	9.02	9.00
Fe(TOT)	6.19	6.23	6.28	6.32	6.30	6.29
FeO	1.47	1.47	1.38	1.38	1.43	1.43
Fe(+2)	1.14	1.14	1.07	1.07	1.11	1.11
Fe(+3)	5.04	5.09	5.20	5.25	5.19	5.18
Fe2O3(+3)	7.21	7.27	7.44	7.50	7.43	7.41
Fe+2/Fe+3	0.23	0.22	0.21	0.20	0.21	0.21

APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Sample 4

	Dissolution 1		Dissolution 2		Dissolution 3	
	Read 1	Read 2	Read 1	Read 2	Read 1	Read 2
Al2O3	3.67	3.67	3.75	3.72	3.68	3.69
B2O3	11.1	11.1	11.3	11.2	11.4	11.4
CaO	1.11	1.11	1.13	1.12	1.11	1.12
Fe2O3	7.33	7.34	7.49	7.45	7.39	7.41
FeO	1.42	1.43	1.42	1.41	1.40	1.40
K2O	0.04	0.04	0.04	0.04	0.04	0.04
La2O3	0.41	0.41	0.42	0.42	0.41	0.41
Li2O	4.28	4.28	4.26	4.26	4.26	4.26
MgO	1.70	1.70	1.73	1.72	1.71	1.72
MnO	1.33	1.33	1.35	1.35	1.35	1.35
Na2O	16.8	16.9	16.8	16.9	16.8	16.7
NiO	0.56	0.56	0.57	0.57	0.57	0.57
SiO2	48.2	48.5	49.1	48.8	48.6	48.8
TiO2	0.69	0.69	0.70	0.70	0.69	0.69
ZrO2	0.45	0.45	0.47	0.47	0.45	0.45
Total	99.09	99.51	100.53	100.13	99.86	100.01
Fe2O3(TOT)	8.91	8.93	9.07	9.02	8.95	8.97
Fe(TOT)	6.23	6.24	6.34	6.30	6.26	6.27
FeO	1.42	1.43	1.42	1.41	1.40	1.40
Fe(+2)	1.10	1.11	1.10	1.10	1.09	1.09
Fe(+3)	5.12	5.13	5.24	5.21	5.17	5.18
Fe2O3(+3)	7.33	7.34	7.49	7.45	7.39	7.41
Fe+2/Fe+3	0.22	0.22	0.21	0.21	0.21	0.21

APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Sample 5

	Dissolution 1		Dissolution 2		Dissolution 3	
	Read 1	Read 2	Read 1	Read 2	Read 1	Read 2
Al2O3	3.70	3.68	3.70	3.72	3.69	3.69
B2O3	11.3	11.3	11.2	11.2	11.4	11.4
CaO	1.11	1.11	1.12	1.13	1.12	1.12
Fe2O3	7.31	7.29	7.35	7.41	7.38	7.35
FeO	1.48	1.49	1.48	1.49	1.46	1.45
K2O	0.04	0.04	0.04	0.04	0.04	0.04
La2O3	0.42	0.41	0.41	0.42	0.41	0.41
Li2O	4.28	4.29	4.28	4.25	4.23	4.26
MgO	1.71	1.70	1.71	1.73	1.73	1.72
MnO	1.33	1.33	1.34	1.35	1.35	1.35
Na2O	16.8	16.9	16.9	16.9	16.7	16.7
NiO	0.56	0.57	0.57	0.58	0.57	0.57
SiO2	48.5	48.4	48.6	49.0	48.9	48.7
TiO2	0.69	0.69	0.70	0.70	0.69	0.69
ZrO2	0.47	0.47	0.48	0.48	0.46	0.46
Total	99.70	99.67	99.88	100.40	100.13	99.91
Fe2O3(TOT)	8.96	8.95	9.00	9.07	9.01	8.97
Fe(TOT)	6.26	6.26	6.29	6.34	6.30	6.27
FeO	1.48	1.49	1.48	1.49	1.46	1.45
Fe(+2)	1.15	1.16	1.15	1.16	1.13	1.13
Fe(+3)	5.11	5.10	5.14	5.18	5.16	5.14
Fe2O3(+3)	7.31	7.29	7.35	7.41	7.38	7.35
Fe+2/Fe+3	0.22	0.23	0.22	0.22	0.22	0.22

APPENDIX I Corning Engineering Laboratory Services (CELS) Chemical Analysis of the Environmental Assessment (EA) Glass

LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-036

Exhibit A: Quantitative Chemical Analysis

Sample Description: 1000 lb. Standard

Summary

	Target	+/-	Mean	Dif
Al2O3	3.67	0.18	3.70	0.03
B2O3	11.1	0.56	11.3	0.2
CaO	1.13	0.06	1.12	-0.01
Fe2O3	8.08	0.40	7.38	-0.70
FeO	0.89		1.45	
K2O	0.04	0.004	0.04	0.00
La2O3	0.41	0.04	0.42	0.01
Li2O	4.28	0.21	4.26	-0.02
MgO	1.66	0.08	1.72	0.06
MnO	1.34	0.07	1.34	0.00
Na2O	16.7	0.84	16.8	0.10
NiO	0.61	0.06	0.57	-0.04
SiO2	48.95	4.49	48.73	-0.22
TiO2	0.71	0.07	0.70	-0.01
ZrO2	0.41	0.04	0.46	0.05
Total	99.99		99.96	
Redox	.1-.3		.22	

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

```
1          OPTIONS LINESIZE=75;
2          DATA CORNING;
3          INPUT AL2O3 B2O3 CAO FE2O3 FEO K2O LA2O3
4          LI2O MGO MNO NA2O NIO SIO2 TIO2
5          ZRO2 SAMPLE DISSOL READ;
6          CARDS;

NOTE: SAS went to a new line when INPUT statement reached past the end
of
      a line.
NOTE: The data set WORK.CORNING has 30 observations and 18 variables.
NOTE: The DATA statement used 0.06 CPU seconds and 4206K.

97         ;
98         PROC PRINT;

NOTE: The PROCEDURE PRINT printed pages 1-2.
NOTE: The PROCEDURE PRINT used 0.04 CPU seconds and 4318K.

99         PROC VARCOMP METHOD=TYPE1;
100        CLASS SAMPLE DISSOL;
101        MODEL AL2O3 B2O3 CAO FE2O3 FEO K2O LA2O3
102        LI2O MGO MNO NA2O NIO SIO2 TIO2
103        ZRO2 = SAMPLE DISSOL(SAMPLE);
NOTE: The PROCEDURE VARCOMP printed pages 3-18.
NOTE: The PROCEDURE VARCOMP used 0.08 CPU seconds and 4522K.

NOTE: The SAS session used 0.36 CPU seconds and 4522K.
NOTE: SAS Institute Inc., SAS Campus Drive, Cary, NC USA 27513-2414
```

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure
Class Level Information

Class	Levels	Values
SAMPLE	5	1 2 3 4 5
DISSOL	3	1 2 3

Number of observations in data set = 30

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: AL2O3

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00140000	0.00035000
DISSOL(SAMPLE)	10	0.00896667	0.00089667
Error	15	0.00545000	0.00036333
Corrected Total	29	0.01581667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00009111
Var(DISSOL(SAMPLE))	0.00026667
Var(Error)	0.00036333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: B2O3

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.02866667	0.00716667
DISSOL(SAMPLE)	10	0.21000000	0.02100000
Error	15	0.03500000	0.00233333
Corrected Total	29	0.27366667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00230556
Var(DISSOL(SAMPLE))	0.00933333
Var(Error)	0.00233333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: CAO

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00003333	0.00000833
DISSOL(SAMPLE)	10	0.00073333	0.00007333
Error	15	0.00050000	0.00003333
Corrected Total	29	0.00126667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00001083
Var(DISSOL(SAMPLE))	0.00002000
Var(Error)	0.00003333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: FE2O3

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.01758000	0.00439500
DISSOL(SAMPLE)	10	0.12926667	0.01292667
Error	15	0.01225000	0.00081667
Corrected Total	29	0.15909667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00142194
Var(DISSOL(SAMPLE))	0.00605500
Var(Error)	0.00081667

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: FEO

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.02358667	0.00589667
DISSOL(SAMPLE)	10	0.02530000	0.00253000
Error	15	0.00065000	0.00004333
Corrected Total	29	0.04953667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	0.00056111
Var(DISSOL(SAMPLE))	0.00124333
Var(Error)	0.00004333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: K2O

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00000000	0.00000000
DISSOL(SAMPLE)	10	0.00000000	0.00000000
Error	15	0.00000000	0.00000000
Corrected Total	29	0.00000000	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00000000
Var(DISSOL(SAMPLE))	-0.00000000
Var(Error)	0.00000000

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: LA2O3

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00021333	0.00005333
DISSOL(SAMPLE)	10	0.00033333	0.00003333
Error	15	0.00015000	0.00001000
Corrected Total	29	0.00069667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	0.00000333
Var(DISSOL(SAMPLE))	0.00001167
Var(Error)	0.00001000

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: LI2O

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00011333	0.00002833
DISSOL(SAMPLE)	10	0.00493333	0.00049333
Error	15	0.00185000	0.00012333
Corrected Total	29	0.00689667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00007750
Var(DISSOL(SAMPLE))	0.00018500
Var(Error)	0.00012333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: MGO

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00038000	0.00009500
DISSOL(SAMPLE)	10	0.00236667	0.00023667
Error	15	0.00080000	0.00005333
Corrected Total	29	0.00354667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00002361
Var(DISSOL(SAMPLE))	0.00009167
Var(Error)	0.00005333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: MNO

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00033333	0.00008333
DISSOL(SAMPLE)	10	0.00233333	0.00023333
Error	15	0.00035000	0.00002333
Corrected Total	29	0.00301667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00002500
Var(DISSOL(SAMPLE))	0.00010500
Var(Error)	0.00002333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: NA2O

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00200000	0.00050000
DISSOL(SAMPLE)	10	0.08000000	0.00800000
Error	15	0.02500000	0.00166667
Corrected Total	29	0.10700000	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00125000
Var(DISSOL(SAMPLE))	0.00316667
Var(Error)	0.00166667

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: NIO

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00011333	0.00002833
DISSOL(SAMPLE)	10	0.00043333	0.00004333
Error	15	0.00020000	0.00001333
Corrected Total	29	0.00074667	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.00000250
Var(DISSOL(SAMPLE))	0.00001500
Var(Error)	0.00001333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: SIO2

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.18466667	0.04616667
DISSOL(SAMPLE)	10	1.99333333	0.19933333
Error	15	0.46500000	0.03100000
Corrected Total	29	2.64300000	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	-0.02552778
Var(DISSOL(SAMPLE))	0.08416667
Var(Error)	0.03100000

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: TIO2

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00022000	0.00005500
DISSOL(SAMPLE)	10	0.00050000	0.00005000
Error	15	0.00020000	0.00001333
Corrected Total	29	0.00092000	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	0.00000083
Var(DISSOL(SAMPLE))	0.00001833
Var(Error)	0.00001333

APPENDIX II Statistical Analysis of Corning Engineering Laboratory Services (CELS) Chemical Composition Data

Variance Components Estimation Procedure

Dependent Variable: ZRO2

Source	DF	Type I SS	Type I MS
SAMPLE	4	0.00255333	0.00063833
DISSOL(SAMPLE)	10	0.00166667	0.00016667
Error	15	0.00025000	0.00001667
Corrected Total	29	0.00447000	

Source	Expected Mean Square
SAMPLE	Var(Error) + 2 Var(DISSOL(SAMPLE)) + 6 Var(SAMPLE)
DISSOL(SAMPLE)	Var(Error) + 2 Var(DISSOL(SAMPLE))
Error	Var(Error)

Variance Component	Estimate
Var(SAMPLE)	0.00007861
Var(DISSOL(SAMPLE))	0.00007500
Var(Error)	0.00001667

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APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 1-TOP-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.798	1.8895	3.3973	1.05	3.5798	3.4511
CaO	MW DISS/ICP	0.856	1.3992	1.1977	1.00	1.1977	1.2167
Fe2O3	MW DISS/ICP	6.462	1.4297	7.4687	1.00	7.4687	7.5869
FeO	REDOX	N/A	1.2865	1.5928	1.00	1.5928	1.6180
MgO	MW DISS/ICP	1.070	1.6583	1.7744	1.00	1.7744	1.8025
MnO	MW DISS/ICP	1.049	1.2912	1.3545	1.00	1.3545	1.3759
Na2O	MW DISS/ICP	11.990	1.3480	16.1625	1.04	16.8614	16.4184
Li2O	MW DISS/ICP	1.947	2.1525	4.1909	1.00	4.1909	4.2573
NiO	MW DISS/ICP	0.412	1.2726	0.5243	1.00	0.5243	0.5326
SiO2	Na2O2 DISS/ICP	22.425	2.1393	47.9738	1.02	49.0271	48.7333
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B2O3	Na2O2 DISS/ICP	3.453	3.2201	11.1190	1.00	11.1190	11.2950
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.359	1.3508	0.4849	1.00	0.4849	0.4926
TiO2	MW DISS/ICP	0.385	1.6680	0.6422	1.00	0.6422	0.6523
K2O	MW DISS/AA	0.035	1.2046	0.0420	1.00	0.0420	0.0427
Cs2O	MW DISS/AA	0.000	1.0602	0.0000	1.00	0.0000	0.0000
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.226	1.1728	0.2651	1.00	0.2651	0.2692
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.202	1.2447	0.2514	1.00	0.2514	0.2554
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.237					
SUMS		52.669		98.4415		100.3761	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 2-TOP-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.844	1.8895	3.4842	1.05	3.6714	3.5137
CaO	MW DISS/ICP	0.872	1.3992	1.2201	1.00	1.2201	1.2304
Fe2O3	MW DISS/ICP	6.457	1.4297	7.4871	1.00	7.4871	7.5504
FeO	REDOX	N/A	1.2865	1.5698	1.00	1.5698	1.5830
MgO	MW DISS/ICP	1.078	1.6583	1.7876	1.00	1.7876	1.8028
MnO	MW DISS/ICP	1.060	1.2912	1.3687	1.00	1.3687	1.3802
Na2O	MW DISS/ICP	12.109	1.3480	16.3229	1.04	17.0287	16.4610
Li2O	MW DISS/ICP	1.970	2.1525	4.2404	1.00	4.2404	4.2763
NiO	MW DISS/ICP	0.410	1.2726	0.5218	1.00	0.5218	0.5262
SiO2	Na2O2 DISS/ICP	22.497	2.1393	48.1278	1.02	49.1845	48.5348
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B2O3	Na2O2 DISS/ICP	3.516	3.2201	11.3219	1.00	11.3219	11.4176
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.354	1.3508	0.4782	1.00	0.4782	0.4822
TiO2	MW DISS/ICP	0.389	1.6680	0.6489	1.00	0.6489	0.6543
K2O	MW DISS/AA	0.047	1.2046	0.0561	1.00	0.0561	0.0566
Cs2O	MW DISS/AA	0.004	1.0602	0.0043	1.00	0.0043	0.0044
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.242	1.1728	0.2838	1.00	0.2838	0.2862
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.191	1.2447	0.2377	1.00	0.2377	0.2397
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.233					
SUMS		53.040		99.1614		101.1110	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 3-TOP-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.892	1.8895	3.5749	1.05	3.7670	3.6174
CaO	MW DISS/ICP	0.872	1.3992	1.2201	1.00	1.2201	1.2346
Fe2O3	MW DISS/ICP	6.549	1.4297	7.4845	1.00	7.4845	7.5735
FeO	REDOX	N/A	1.2865	1.6904	1.00	1.6904	1.7105
MgO	MW DISS/ICP	1.089	1.6583	1.8059	1.00	1.8059	1.8274
MnO	MW DISS/ICP	1.071	1.2912	1.3829	1.00	1.3829	1.3993
Na2O	MW DISS/ICP	12.326	1.3480	16.6154	1.04	17.3339	16.8130
Li2O	MW DISS/ICP	1.988	2.1525	4.2792	1.00	4.2792	4.3301
NiO	MW DISS/ICP	0.422	1.2726	0.5370	1.00	0.5370	0.5434
SiO2	Na2O2 DISS/ICP	22.122	2.1393	47.3256	1.02	48.3647	47.8883
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B2O3	Na2O2 DISS/ICP	3.485	3.2201	11.2220	1.00	11.2220	11.3555
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.339	1.3508	0.4579	1.00	0.4579	0.4634
TiO2	MW DISS/ICP	0.396	1.6680	0.6605	1.00	0.6605	0.6684
K2O	MW DISS/AA	0.031	1.2046	0.0377	1.00	0.0377	0.0382
Cs2O	MW DISS/AA	0.004	1.0602	0.0042	1.00	0.0042	0.0043
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.243	1.1728	0.2850	1.00	0.2850	0.2884
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.194	1.2447	0.2415	1.00	0.2415	0.2443
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.251					
SUMS		53.023		98.8249		100.7744	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 1-MISC-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.779	1.8895	3.3614	1.05	3.5420	3.3976
CaO	MW DISS/ICP	0.881	1.3992	1.2327	1.00	1.2327	1.2460
Fe203	MW DISS/ICP	6.437	1.4297	7.4277	1.00	7.4277	7.5077
FeO	REDOX	N/A	1.2865	1.5974	1.00	1.5974	1.6146
MgO	MW DISS/ICP	1.073	1.6583	1.7794	1.00	1.7794	1.7985
MnO	MW DISS/ICP	1.051	1.2912	1.3571	1.00	1.3571	1.3717
Na2O	MW DISS/ICP	12.017	1.3480	16.1989	1.04	16.8993	16.3734
Li2O	MW DISS/ICP	1.947	2.1525	4.1909	1.00	4.1909	4.2360
NiO	MW DISS/ICP	0.421	1.2726	0.5358	1.00	0.5358	0.5415
SiO2	Na2O2 DISS/ICP	22.569	2.1393	48.2819	1.02	49.3419	48.8018
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B203	Na2O2 DISS/ICP	3.516	3.2201	11.3219	1.00	11.3219	11.4438
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.327	1.3508	0.4417	1.00	0.4417	0.4465
TiO2	MW DISS/ICP	0.386	1.6680	0.6438	1.00	0.6438	0.6508
K2O	MW DISS/AA	0.034	1.2046	0.0408	1.00	0.0408	0.0413
Cs2O	MW DISS/AA	0.004	1.0602	0.0043	1.00	0.0043	0.0044
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.228	1.1728	0.2674	1.00	0.2674	0.2703
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.202	1.2447	0.2514	1.00	0.2514	0.2541
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.239					
SUMS		52.872		98.9346		100.8756	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 2-MISC

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.910	1.8895	3.6089	1.05	3.8028	3.6870
CaO	MW DISS/ICP	0.820	1.3992	1.1473	1.00	1.1473	1.1722
Fe203	MW DISS/ICP	7.063	1.4297	8.3043	1.00	8.3043	8.4838
FeO	REDOX	N/A	1.2865	1.6141	1.00	1.6141	1.6490
MgO	MW DISS/ICP	1.037	1.6583	1.7197	1.00	1.7197	1.7568
MnO	MW DISS/ICP	1.020	1.2912	1.3170	1.00	1.3170	1.3455
Na2O	MW DISS/ICP	11.640	1.3480	15.6907	1.04	16.3692	16.0300
Li2O	MW DISS/ICP	1.868	2.1525	4.0209	1.00	4.0209	4.1078
NiO	MW DISS/ICP	0.394	1.2726	0.5014	1.00	0.5014	0.5122
SiO2	Na2O2 DISS/ICP	22.126	2.1393	47.3342	1.02	48.3734	48.3575
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B203	Na2O2 DISS/ICP	3.342	3.2201	10.7616	1.00	10.7616	10.9942
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.515	1.3508	0.6957	1.00	0.6957	0.7107
TiO2	MW DISS/ICP	0.369	1.6680	0.6155	1.00	0.6155	0.6288
K2O	MW DISS/AA	0.036	1.2046	0.0432	1.00	0.0432	0.0442
Cs2O	MW DISS/AA	0.000	1.0602	0.0000	1.00	0.0000	0.0000
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.222	1.1728	0.2604	1.00	0.2604	0.2660
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.200	1.2447	0.2489	1.00	0.2489	0.2543
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.216					
SUMS		52.562		97.8837		99.7953	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 3-MISC-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.740	1.8895	3.2877	1.05	3.4643	3.4040
CaO	MW DISS/ICP	0.855	1.3992	1.1963	1.00	1.1963	1.2386
Fe2O3	MW DISS/ICP	6.292	1.4297	7.3255	1.00	7.3255	7.5846
FeO	REDOX	N/A	1.2865	1.5029	1.00	1.5029	1.5561
MgO	MW DISS/ICP	1.060	1.6583	1.7578	1.00	1.7578	1.8200
MnO	MW DISS/ICP	1.031	1.2912	1.3312	1.00	1.3312	1.3783
Na2O	MW DISS/ICP	11.913	1.3480	16.0587	1.04	16.7531	16.6268
Li2O	MW DISS/ICP	1.919	2.1525	4.1306	1.00	4.1306	4.2768
NiO	MW DISS/ICP	0.393	1.2726	0.5001	1.00	0.5001	0.5178
SiO2	Na2O2 DISS/ICP	21.868	2.1393	46.7822	1.02	47.8093	48.4372
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B2O3	Na2O2 DISS/ICP	3.453	3.2201	11.1190	1.00	11.1190	11.5124
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.309	1.3508	0.4174	1.00	0.4174	0.4322
TiO2	MW DISS/ICP	0.375	1.6680	0.6255	1.00	0.6255	0.6476
K2O	MW DISS/AA	0.031	1.2046	0.0372	1.00	0.0372	0.0385
Cs2O	MW DISS/AA	0.004	1.0602	0.0043	1.00	0.0043	0.0045
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.225	1.1728	0.2639	1.00	0.2639	0.2732
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.195	1.2447	0.2427	1.00	0.2427	0.2513
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.228					
SUMS		51.663		96.5832		98.4813	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 1-B-3

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.722	1.8895	3.2537	1.05	3.4285	3.3640
CaO	MW DISS/ICP	0.895	1.3992	1.2523	1.00	1.2523	1.2947
Fe203	MW DISS/ICP	6.370	1.4297	7.2916	1.00	7.2916	7.5387
FeO	REDOX	N/A	1.2865	1.6338	1.00	1.6338	1.6891
MgO	MW DISS/ICP	1.061	1.6583	1.7595	1.00	1.7595	1.8191
MnO	MW DISS/ICP	1.041	1.2912	1.3438	1.00	1.3438	1.3893
Na2O	MW DISS/ICP	12.037	1.3480	16.2252	1.04	16.9268	16.7752
Li2O	MW DISS/ICP	1.936	2.1525	4.1675	1.00	4.1675	4.3087
NiO	MW DISS/ICP	0.409	1.2726	0.5202	1.00	0.5202	0.5379
SiO2	Na2O2 DISS/ICP	21.687	2.1393	46.3950	1.02	47.4136	47.9676
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B203	Na2O2 DISS/ICP	3.441	3.2201	11.0804	1.00	11.0804	11.4559
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.323	1.3508	0.4362	1.00	0.4362	0.4510
TiO2	MW DISS/ICP	0.394	1.6680	0.6564	1.00	0.6564	0.6786
K2O	MW DISS/AA	0.032	1.2046	0.0385	1.00	0.0385	0.0399
Cs2O	MW DISS/AA	0.004	1.0602	0.0042	1.00	0.0042	0.0044
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.254	1.1728	0.2979	1.00	0.2979	0.3080
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.294	1.2447	0.3655	1.00	0.3655	0.3779
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.249					
SUMS		51.898		96.7215		98.6165	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 2-B-A

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.785	1.8895	3.3728	1.05	3.5539	3.4285
CaO	MW DISS/ICP	0.822	1.3992	1.1501	1.00	1.1501	1.1692
Fe203	MW DISS/ICP	6.163	1.4297	7.0210	1.00	7.0210	7.1372
FeO	REDOX	N/A	1.2865	1.6110	1.00	1.6110	1.6377
MgO	MW DISS/ICP	1.029	1.6583	1.7058	1.00	1.7058	1.7341
MnO	MW DISS/ICP	1.005	1.2912	1.2982	1.00	1.2982	1.3197
Na2O	MW DISS/ICP	11.697	1.3480	15.7676	1.04	16.4493	16.0284
Li2O	MW DISS/ICP	1.874	2.1525	4.0342	1.00	4.0342	4.1009
NiO	MW DISS/ICP	0.403	1.2726	0.5129	1.00	0.5129	0.5213
SiO2	Na2O2 DISS/ICP	22.958	2.1393	49.1140	1.02	50.1924	49.9264
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B203	Na2O2 DISS/ICP	3.466	3.2201	11.1609	1.00	11.1609	11.3455
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.314	1.3508	0.4237	1.00	0.4237	0.4308
TiO2	MW DISS/ICP	0.379	1.6680	0.6315	1.00	0.6315	0.6420
K2O	MW DISS/AA	0.032	1.2046	0.0381	1.00	0.0381	0.0387
Cs2O	MW DISS/AA	0.004	1.0602	0.0043	1.00	0.0043	0.0044
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.243	1.1728	0.2850	1.00	0.2850	0.2897
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.194	1.2447	0.2416	1.00	0.2416	0.2456
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.255					
SUMS		52.368		98.3728		100.3141	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 2-M-1

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.783	1.8895	3.3690	1.05	3.5499	3.4060
CaO	MW DISS/ICP	0.889	1.3992	1.2439	1.00	1.2439	1.2576
Fe2O3	MW DISS/ICP	6.599	1.4297	7.7587	1.00	7.7587	7.8440
FeO	REDOX	N/A	1.2865	1.5080	1.00	1.5080	1.5246
MgO	MW DISS/ICP	1.086	1.6583	1.8009	1.00	1.8009	1.8207
MnO	MW DISS/ICP	1.067	1.2912	1.3777	1.00	1.3777	1.3928
Na2O	MW DISS/ICP	12.349	1.3480	16.6465	1.04	17.3662	16.8294
Li2O	MW DISS/ICP	1.973	2.1525	4.2469	1.00	4.2469	4.2935
NiO	MW DISS/ICP	0.428	1.2726	0.5447	1.00	0.5447	0.5507
SiO2	Na2O2 DISS/ICP	22.216	2.1393	47.5267	1.02	48.5702	48.0489
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B2O3	Na2O2 DISS/ICP	3.471	3.2201	11.1770	1.00	11.1770	11.2998
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.340	1.3508	0.4594	1.00	0.4594	0.4644
TiO2	MW DISS/ICP	0.401	1.6680	0.6682	1.00	0.6682	0.6755
K2O	MW DISS/AA	0.029	1.2046	0.0345	1.00	0.0345	0.0348
Cs2O	MW DISS/AA	0.004	1.0602	0.0043	1.00	0.0043	0.0044
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.240	1.1728	0.2818	1.00	0.2818	0.2849
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.213	1.2447	0.2651	1.00	0.2651	0.2680
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.216					
SUMS		53.088		98.9132		100.8574	100.0000

APPENDIX III Savannah River Technology Center (SRTC) Chemical Analysis of the Environmental Assessment (EA) Glass

GLASS ID= 2-M-3

	ANALYTIC TECHNIQUE	ELEMENT WT%	GRAV FACTOR	OXIDE WT%	BIAS CORRECT FACTOR	BIAS CORRECT OXIDE WT%	NORM OXIDE WT%
Al2O3	Na2O2 DISS/ICP	1.830	1.8895	3.4578	1.05	3.6435	3.4001
CaO	MW DISS/ICP	1.060	1.3992	1.4825	1.00	1.4825	1.4577
Fe203	MW DISS/ICP	7.022	1.4297	8.2560	1.00	8.2560	8.1183
FeO	REDOX	N/A	1.2865	1.6047	1.00	1.6047	1.5779
MgO	MW DISS/ICP	1.189	1.6583	1.9717	1.00	1.9717	1.9388
MnO	MW DISS/ICP	1.149	1.2912	1.4836	1.00	1.4836	1.4588
Na2O	MW DISS/AA	12.500	1.3480	16.8500	1.00	16.8500	16.5689
Li2O	MW DISS/ICP	2.125	2.1525	4.5741	1.00	4.5741	4.4978
NiO	MW DISS/ICP	0.471	1.2726	0.5998	1.00	0.5998	0.5898
SiO2	Na2O2 DISS/ICP	22.554	2.1393	48.2498	1.02	49.3091	47.4449
Cr2O3	MW DISS/ICP	0.000	1.4616	0.0000	1.00	0.0000	0.0000
B203	Na2O2 DISS/ICP	3.520	3.2201	11.3348	1.00	11.3348	11.1457
UO2			1.1344	0.0000		0.0000	0.0000
ThO2			1.1379	0.0000		0.0000	0.0000
SrO	MW DISS/ICP	0.000	1.1826	0.0000		0.0000	0.0000
ZrO2	MW DISS/ICP	0.353	1.3508	0.4763	1.00	0.4763	0.4683
TiO2	MW DISS/ICP	0.434	1.6680	0.7239	1.00	0.7239	0.7118
K2O	MW DISS/AA	0.031	1.2046	0.0369	1.00	0.0369	0.0362
Cs2O	MW DISS/AA	0.004	1.0602	0.0042	1.00	0.0042	0.0042
Sb2O3			1.1970	0.0000		0.0000	0.0000
P2O5	MW DISS/ICP	0.000	2.2910	0.0000	1.00	0.0000	0.0000
Nd2O3			1.1660	0.0000		0.0000	0.0000
La2O3	MW DISS/ICP	0.282	1.1728	0.3304	1.00	0.3304	0.3249
Y2O3			1.2699	0.0000		0.0000	0.0000
BaO	MW DISS/ICP	0.000	1.1165	0.0000	1.00	0.0000	0.0000
PbO	MW DISS/ICP	0.000	1.0772	0.0000		0.0000	0.0000
CeO2			1.2284	0.0000		0.0000	0.0000
MoO3	MW DISS/ICP	0.000	1.5003	0.0000	1.00	0.0000	0.0000
ZnO	MW DISS/ICP	0.209	1.2447	0.2601	1.00	0.2601	0.2558
CuO	MW DISS/ICP	0.000	1.2518	0.0000	1.00	0.0000	0.0000
Fe2+/Fe3+		0.216					
SUMS		54.732		101.6965		102.9416	100.0000

APPENDIX IV Multielement Solution Standard-Researcher 1

Element	Concen. Standard (ug/mL)	Run before Samples-1 (ug/mL)	Run before Samples-2 (ug/mL)	Run after 5 Samples-1 (ug/mL)	Run after 5 Samples-2 (ug/mL)
Na (ICP)	50.10	49.20	49.62	49.00	49.55
Na (AA)		46.42	45.00	47.18	46.35
Si	50.10	44.68	44.96	45.41	45.17
B	20.00	19.64	19.74	19.81	19.75
K	10.00	9.65	9.52	9.56	9.50
Li	10.00	9.88	9.93	9.96	9.94
Al	4.06	3.45	3.42	3.37	3.36
Fe	3.98	4.19	4.21	4.21	4.21

Element	Concen. Standard (ug/mL)	Average Bias before Leachate Analysis (ug/mL)	Average Bias after 5 Leachate Analyses (ug/mL)
Na (ICP)	50.10	-0.69	-0.82
Na (AA)		-4.39	-3.34
Si	50.10	-5.28	-4.81
B	20.00	-0.31	-0.22
K	10.00	-0.41	-0.47
Li	10.00	-0.10	-0.05
Al	4.06	-0.62	-0.69
Fe	3.98	0.22	0.23

APPENDIX IV Multielement Solution Standard-Researcher 1

Element	Concen. Standard (ug/mL)	Run after 10 Samples-1 (ug/mL)	Run after 10 Samples-2 (ug/mL)	Run after 15 Samples-1 (ug/mL)	Run after 15 Samples-2 (ug/mL)
Na (ICP)	50.10	49.55	49.52	49.39	49.34
Na (AA)		49.31	52.13	51.09	52.13
Si	50.10	45.34	45.05	45.15	44.91
B	20.00	19.76	19.73	19.61	19.60
K	10.00	9.52	9.65	9.79	9.61
Li	10.00	9.94	9.92	9.89	9.88
Al	4.06	3.33	3.27	3.32	3.29
Fe	3.98	4.21	4.20	4.19	4.19

Element	Concen. Standard (ug/mL)	Average Bias after 10 Leachate Analyses (ug/mL)	Average Bias after 15 Leachate Analyses (ug/mL)
Na (ICP)	50.10	-0.57	-0.74
Na (AA)		0.62	1.51
Si	50.10	-4.91	-5.07
B	20.00	-0.25	-0.39
K	10.00	-0.41	-0.30
Li	10.00	-0.07	-0.12
Al	4.06	-0.76	-0.76
Fe	3.98	0.22	0.21

APPENDIX IV Multielement Solution Standard-Researcher 1

Element	Concen. Standard (ug/mL)	Run after 20 Samples-2 (ug/mL)	Run after 20 Samples-2 (ug/mL)	Run after 25 Samples-2 (ug/mL)	Run after 25 Samples-2 (ug/mL)
Na (ICP)	50.10	49.52	49.61	49.37	49.11
Na (AA)		50.94	49.90	50.35	50.20
Si	50.10	45.16	45.06	45.00	44.53
B	20.00	19.63	19.67	19.57	19.45
K	10.00	9.56	9.52	9.56	9.42
Li	10.00	9.89	9.93	9.87	9.84
Al	4.06	3.25	3.28	3.29	3.25
Fe	3.98	4.20	4.21	4.18	4.16

Element	Concen. Standard (ug/mL)	Average Bias after 20 Leachate Analyses (ug/mL)	Average Bias after 25 Leachate Analyses (ug/mL)
Na (ICP)	50.10	-0.53	-0.86
Na (AA)		0.32	0.18
Si	50.10	-4.99	-5.34
B	20.00	-0.35	-0.49
K	10.00	-0.46	-0.51
Li	10.00	-0.09	-0.15
Al	4.06	-0.80	-0.79
Fe	3.98	0.22	0.19

APPENDIX IV Multielement Solution Standard-Researcher 1

Element	Concen. Standard (ug/mL)	Run after30 Samples-2 (ug/mL)	Run after 30 Samples-2 (ug/mL)	Run after 35 Samples-2 (ug/mL)	Run after 35 Samples-2 (ug/mL)
Na (ICP)	50.10	49.09	48.98	49.20	49.08
Na (AA)		49.30	49.45	49.77	52.25
Si	50.10	44.61	44.26	44.66	44.32
B	20.00	19.38	19.36	19.49	19.46
K	10.00	9.64	9.67	9.66	9.92
Li	10.00	9.83	9.82	9.86	9.85
Al	4.06	3.25	3.23	3.27	3.24
Fe	3.98	4.14	4.13	4.15	4.14

Element	Concen. Standard (ug/mL)	Average Bias after 30 Leachate Analyses (ug/mL)	Average Bias after 35 Leachate Analyses (ug/mL)
Na (ICP)	50.10	-1.07	-0.96
Na (AA)		-0.73	0.91
Si	50.10	-5.67	-5.61
B	20.00	-0.63	-0.52
K	10.00	-0.34	-0.21
Li	10.00	-0.18	-0.14
Al	4.06	-0.82	-0.81
Fe	3.98	0.15	0.16

APPENDIX IV Multielement Solution Standard-Researcher 1

Element	Concen. Standard (ug/mL)	Run after 40 Samples-2 (ug/mL)	Run after 40 Samples-2 (ug/mL)	Run after 45 Samples-2 (ug/mL)	Run after 45 Samples-2 (ug/mL)
Na (ICP)	50.10	50.03	50.01	49.59	49.75
Na (AA)		50.35	50.79	48.90	49.34
Si	50.10	45.53	45.35	44.97	44.98
B	20.00	19.92	19.90	19.67	19.69
K	10.00	9.54	9.57	9.68	9.59
Li	10.00	9.94	9.93	9.86	9.88
Al	4.06	3.25	3.25	3.27	3.35
Fe	3.98	4.21	4.21	4.18	4.20

Element Element	Concen. Standard Standard (ug/mL)	Average Bias after 40 Leachate Analyses (ug/mL)	Average Bias after 45 Leachate Analyses (ug/mL)
Na (ICP)	50.10	-0.08	-0.43
Na (AA)		0.47	-0.98
Si	50.10	-4.66	-5.13
B	20.00	-0.09	-0.32
K	10.00	-0.45	-0.37
Li	10.00	-0.07	-0.13
Al	4.06	-0.81	-0.75
Fe	3.98	0.23	0.21

ELEMENT	TOTAL AVERAGE BIAS (ug/mL)
Na (ICP)	**-0.69**
Na (AA)	**-0.53**
Si	**-5.15**
B	**-0.36**
K	**-0.39**
Li	**-0.11**
Al	**-0.76**
Fe	**0.21**

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Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

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OPTIONS LINESIZE=75;
DATA EA;
INPUT GLASS $ VESSEL $ WHO PH PPMB PPMLI PPMNA PPMSI ANALNUM;
CARDS;
EA-1-7 Teflon 1 11.8 567.96 210.71 1738.35 1048.41 1
EA-1-7  Teflon 1 11.79 593.57 211.19 1819.7 1061.93 2
EA-1-7 Teflon 1 11.8 605.97 212.86 1857.2 1070.91 3
EA-2-7  Teflon 1 11.86 468.52 163.27 1380.8 780.29 1
EA-2-7 Teflon 1 11.88 610 225.05 1854.87 1128.56 2
EA-2-7 Teflon 1 11.88 523.05 171.77 1542.6 832.21 3
EA-7  Teflon 2 12.01 609.42 192.06 1685.5 908.43 1
EA-7 Teflon 2 12.01 615.07 187.92 1724.34 909.33 2
EA-7  Teflon 2 12.01 634.81 195.74 1770.69 938.3 3
EA-7 Teflon 2 12.01 638.54 204.01 1771.35 956.44 4
EA-7 Teflon 2 12.01 649.05 208.11 1789.02 965.06 5
EA-7  Teflon 2 12.01 584.7 186.73 1644.01 892.6  6
T-EA Teflon 3 11.88 499.85 162.08 1429.74 763.41 1
T-EA  Teflon 3 11.88 493.34 161.27 1408.62 746.67 2
T-EA Teflon 3 11.89 517.52 167.81 1480.44 782.22 3
T-EA  Teflon 3 11.89 560.09 183.35 1572.63 825.27 4
SS-EA-19  Parr 3 11.92 577.41 180.78 1633.95 798.81 1
SS-EA-19  Parr 3 11.9 566.13 177.48 1604.19 791.43 2
SS-EA-19 Parr 3 11.95 576.06 180.48 1635.24 794.04 3
SS-EA-19  Parr 3 11.91 584.31 183.6 1650.21 803.25 4
EA-SS-15 Parr 3 11.98 596.1 190.26 1670.4 846.96 1
EA-SS-15 Parr 3 11.92 601.41 191.52 1692.06 852.09 2
EA-SS-15  Parr 3 11.93 587.04 196.68 1640.88 848.55 3
EA-SS-15 Parr 3 11.95 572.67 193.11 1606.35 830.64 4
SS-EA-1 Parr 4 11.78 656.498 204.529 1808.6766 956.182 1
SS-EA-1 Parr 4 11.77 654.111 206.947 1794.881 963.87 2
SS-EA-1 Parr 4 11.78 637.712 199.259 1754.736 936.125 3
SS-EA-2 Parr 4 11.76 629.153 192.779 1711.273 909.1 1
SS-EA-2 Parr 4 11.77 614.528 191.508 1695.618 905.3 2
SS-EA-2 Parr 4 11.72 629.501 195.755 1723.177 925.2 3
SRSSEA-A Parr 4 11.78 570.55 182.154 1586.749 853.717 1
SRSSEA-A Parr 4 11.78 573.929 178.558 1599.242 852.477 2
SRSSEA-A Parr 4 11.79 588.189 194.306 1628.0444 885.213 3
SRSSEA-B Parr 4       602.868 172.633 1678.486 884.787 1
SRSSEA-B Parr 4       594.016 181.068 1689.321 886.221 2
SRSSEA-B Parr 4       592.616 187.919 1683.487 908.275 3
CUASEA-A Bomb 4 11.76 559.594 192.384 1627.798 875.09 1
CUASEA-A Bomb 4 11.78 614.877 197.871 1682.854 913.437 2
CUASEA-A Bomb 4 11.77 560.1 184.417 1530.83 854.692 3
CUASEA-B Bomb 4       583.325 173.033 1670.898 880.574 1
CUASEA-B Bomb 4       581.491 186.252 1681.898 895.294 2
CUASEA-B Bomb 4       568.855 187.869 1663.428 909.347 3
;
PROC VARCOMP DATA=EA METHOD=TYPE1;
CLASS GLASS;
MODEL PH PPMB PPMLI PPMNA PPMSI = GLASS;
```

Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

Variance Components Estimation Procedure
Class Level Information

Class	Levels	Values
GLASS	12	CUASEA-A CUASEA-B EA-SS-15 EA-1-7 EA-2-7 EA-7 SRSSEA-A SRSSEA-B SS-EA-1 SS-EA-19 SS-EA-2 T-EA

Number of observations in data set = 42

Group	Obs	Dependent Variables
1	36	PH
2	42	BGL LIGL NAGL SIGL

NOTE: Variables in each group are consistent with respect to the presence or absence of missing values.

Dependent Variable: PH

Source	DF	Type I SS	Type I MS
GLASS	9	0.28903056	0.03211451
Error	26	0.00566667	0.00021795
Corrected Total	35	0.29469722	

Source	Expected Mean Square
GLASS	Var(Error) + 3.5741 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	0.00892443
Var(Error)	0.00021795

Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

Variance Components Estimation Procedure

Dependent Variable: PPMB

Source	DF	Type I SS	Type I MS
GLASS	11	52434.52521274	4766.77501934
Error	30	19789.33159168	659.64438639
Corrected Total	41	72223.85680442	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	1180.03380126
Var(Error)	659.64438639

Dependent Variable: PPMLI

Source	DF	Type I SS	Type I MS
GLASS	11	4930.51609574	448.22873598
Error	30	3496.70985334	116.55699511
Corrected Total	41	8427.22594907	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	95.29374644
Var(Error)	116.55699511

Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

Variance Components Estimation Procedure

Dependent Variable: PPMNA

Source	DF	Type I SS	Type I MS
GLASS	11	323215.55216378	29383.23201489
Error	30	175971.01408461	5865.70046949
Corrected Total	41	499186.56624838	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	6756.90272013
Var(Error)	5865.70046949

Dependent Variable: PPMSI

Source	DF	Type I SS	Type I MS
GLASS	11	205086.90015050	18644.26365005
Error	30	82787.60125733	2759.58670858
Corrected Total	41	287874.50140783	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	4563.88106154
Var(Error)	2759.58670858

Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

Variance Components Estimation Procedure

Dependent Variable: BGL

Source	DF	Type I SS	Type I MS
GLASS	11	42.56014579	3.86910416
Error	30	16.06263877	0.53542129
Corrected Total	41	58.62278456	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	0.95781187
Var(Error)	0.53542129

Dependent Variable: LIGL

Source	DF	Type I SS	Type I MS
GLASS	11	12.57656386	1.14332399
Error	30	8.91926807	0.29730894
Corrected Total	41	21.49583193	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	0.24307149
Var(Error)	0.29730894

Appendix V Statistical Analysis of Savannah River Technology Center (SRTC) Durability Measurements

Variance Components Estimation Procedure

Dependent Variable: NAGL

Source	DF	Type I SS	Type I MS
GLASS	11	20.81882262	1.89262024
Error	30	11.33457008	0.37781900
Corrected Total	41	32.15339270	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	0.43522274
Var(Error)	0.37781900

Dependent Variable: SIGL

Source	DF	Type I SS	Type I MS
GLASS	11	3.95212326	0.35928393
Error	30	1.59535692	0.05317856
Corrected Total	41	5.54748018	

Source	Expected Mean Square
GLASS	Var(Error) + 3.4805 Var(GLASS)
Error	Var(Error)

Variance Component	Estimate
Var(GLASS)	0.08794818
Var(Error)	0.05317856

DATE
FILMED
9/20/93

END