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MCC

Materials Characterization Center

**Product Consistency Test
Round Robin Conducted by the
Materials Characterization
Center—Summary Report**

G. F. Piepel
T. E. Jones

D. L. Eggett
G. B. Mellinger

September 1989

Prepared for the U.S. Department of Energy
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PRODUCT CONSISTENCY TEST ROUND ROBIN
CONDUCTED BY THE MATERIALS CHARACTERIZATION
CENTER - SUMMARY REPORT

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

A round robin involving seven laboratories was conducted to evaluate the effectiveness of the Savannah River Laboratory (SRL) Product Consistency Test (PCT) for discriminating between durabilities of similar glass compositions. Four glasses were tested in the PCT round robin: National Institute of Science and Technology (NIST) standard reference material SRM-623, Materials Characterization Center (MCC) reference glass ARM-1, and two glasses provided by SRL (referred to as SRL-G and SRL-P). The SRL-G and SRL-P glasses are similar in composition, with SRL-P having a higher alkali content

The PCT round robin data provide for assessing the ability to discriminate on the basis of individual elemental releases (Al, B, Fe, K, Li, Na, and Si). Multivariate discrimination techniques (i.e., considering several elemental releases simultaneously) can increase the ability to discriminate between similar glasses, but the PCT round robin was not designed to investigate multivariate techniques.

The ability to discriminate on an element-by-element basis depends on the short-term within-lab precision associated with PCT elemental releases, the number of PCTs performed on each glass, and the number of analyses performed on the leachate from each PCT.

Table S.1 quantifies the ability of a laboratory to discriminate between two similar glasses as a function of the number of replicate PCTs performed on each glass (n) and the number of analyses of each leachate (m). The entries in the table are the percent relative differences (PRDs) in elemental releases that are detectable with 95% confidence and a 5% false-alarm rate. Because results of the PCT round robin indicated that some laboratories have better precision than others, Table S.1 contains results for two levels of laboratory precision (level A denotes better precision than level B).

Table S.1 indicates that a "level A" laboratory performing two replicate PCTs per glass with one analysis per leachate will be able to reliably detect PRDs ranging from 15.2% for Si to 63.5% for Fe. For "level B" labs, the range is from 31.5% for Si to 160.6% for Fe. Hence, the ability to discriminate with the PCT is highly dependent on the analyte(s) of interest and the capability of the lab performing the test.

TABLE S.1. Percent Relative Differences in Elemental Releases from Two Glasses (detectable by the PCT with 95% confidence and 5% false-alarm rate) for Various Values of n and m and Two Levels of Laboratory Performance

m (a)	Level (b)	n (c)	Element						
			Al	B	Fe	K	Li	Na	Si
1	A	2	17.9	19.4	63.5	27.7	18.6	17.1	15.2
	A	3	9.9	10.8	35.2	15.4	10.3	9.5	8.4
	A	4	7.7	8.4	27.3	11.9	8.0	7.3	6.5
	A	5	6.5	7.1	23.2	10.1	6.8	6.2	5.6
	A	7	5.3	5.7	18.6	8.1	5.4	5.0	4.5
	A	10	4.3	4.6	15.1	6.6	4.4	4.1	3.6
	B	2	52.5	35.7	160.6	64.9	44.5	46.5	31.5
	B	3	29.1	19.8	89.1	36.0	24.7	25.8	17.5
	B	4	22.6	15.4	69.0	27.9	19.1	20.0	13.5
	B	5	19.1	13.0	58.6	23.7	16.2	16.9	11.5
	B	7	15.4	10.5	47.1	19.0	13.1	13.6	9.2
	B	10	12.5	8.5	38.1	15.4	10.6	11.0	7.5
2	A	2	14.6	15.9	55.4	18.2	12.9	11.8	10.1
	A	3	8.9	9.6	32.7	12.1	8.4	7.7	6.7
	A	4	7.0	7.6	25.7	9.7	6.8	6.2	5.4
	A	5	6.0	6.6	22.0	8.3	5.8	5.4	4.7
	A	7	4.9	5.3	17.8	6.8	4.8	4.4	3.8
	A	10	4.0	4.3	14.5	5.5	3.9	3.6	3.1
	B	2	42.9	27.2	107.2	43.1	30.7	31.3	26.2
	B	3	26.0	17.1	71.0	28.6	20.1	20.6	15.8
	B	4	20.7	13.6	57.2	23.0	16.2	16.7	12.5
	B	5	17.7	11.7	49.4	19.9	13.9	14.4	10.7
	B	7	14.4	9.5	40.2	16.2	11.4	11.7	8.7
	B	10	11.7	7.8	32.8	13.2	9.3	9.6	7.1

- (a) "m" denotes the number of times the leachate from each PCT is chemically analyzed. Increasing m beyond 2 is of negligible benefit in reducing the PRDs.
- (b) "A" denotes a higher level of lab performance (smaller within-lab standard deviation), while "B" denotes a lower level of lab performance (larger within-lab standard deviation). See Table 5.1 for the specific %RSD values.
- (c) "n" denotes the number of times the PCT is performed on each of the two glasses.

Table S.1 also illustrates the benefits of increasing the number of PCT replicates per glass (n) and the number of analyses per leachate (m). It is

clear that increasing n is of much more benefit than increasing m . In fact, the reason that the table only contains results for $m = 1, 2$ is that results for values up to $m = 5$ were nearly the same as for $m = 2$.

ACKNOWLEDGMENTS

The Material Characterization Center wishes to express its appreciation to the laboratories that participated in the round robin. We are indebted to Savannah River Laboratory technical staff for their review and comments on the round robin test instructions and to the Pacific Northwest Laboratory support staff that contributed to this document.

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1.0 INTRODUCTION

The Savannah River Laboratory (SRL) Product Consistency Test (PCT) was developed as a short duration leach test that could be used to evaluate the consistency of Defense Waste Processing Facility (DWPF) glass (Jantzen and Bibler 1987). The goals were to develop a test that would be sensitive to glass composition and homogeneity, rapid enough to support quality control of the production process, and easily conducted remotely to facilitate working with highly radioactive materials. Internal laboratory testing (Jantzen and Bibler 1987) at SRL indicated the following:

- The PCT was sensitive to glass composition and homogeneity.
- A 7-day test duration was adequate.
- Sample preparation, the test procedure, and vessel cleaning could be simplified for remote operation.
- The PCT could be reproduced with a precision of 2 to 3% by an investigator and 5 to 8% between investigators.

The long-term SRL goal is to show that the PCT can be used to demonstrate that DWPF glass meets the elemental and radionuclide release requirements of the Waste Acceptance Preliminary Specifications (WAPS).

The Materials Characterization Center (MCC) at Pacific Northwest Laboratory (PNL)(a) was requested by SRL to conduct a multi-laboratory round robin to evaluate the effectiveness of the PCT methodology. The PCT can be utilized in two modes. It can be used to discriminate between two different glass compositions tested at the same time (for example, between a standard reference material and a production material). Alternatively, results from a PCT of production material could be compared with an acceptance criterion or data obtained from prior testing. The round robin was designed primarily to evaluate the PCT methodology in the first mode; that is, comparing leachate values for glasses tested in parallel.

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Seven laboratories experienced in glass leach testing were selected to participate in the round robin. These laboratories are identified in Table 1.1. Four glasses were used in a series of three one-week leach tests. The glasses included two well-characterized reference glasses and two similar glasses provided by SRL. The two SRL glasses were prepared by a vendor and the compositional analysis was performed by both MCC and SRL.

The round robin was structured to evaluate the effectiveness of the PCT in distinguishing between glasses of similar compositions. The obtainable precision of the PCT is limited by, among other things, consistency of test sample preparation (crushing and sieving), variations in testing equipment and materials, experimental techniques of the laboratory conducting the leach test, and the precision and accuracy of the leachate analyses. The MCC has attempted to minimize the effects of the first two by providing each laboratory with all required test equipment and materials (except deionized water leachate). In addition, a chemical analysis standard solution was provided to each participating laboratory to monitor precision and accuracy of leachate analyses. Version 2.0 of the SRL-PCT Test Protocol (Jantzen and Bibler 1987) was used to develop test instructions for all round robin participants.

TABLE 1.1. Laboratories Participating in the Round Robin

Argonne National Laboratory
Catholic University of America
Corning Glass Works
Pacific Northwest Laboratory - MCC(a)
Pacific Northwest Laboratory - Glass Vitrification Group(a)
Savannah River Laboratory
University of Florida

(a) The two PNL groups worked independently and used different analytical support services.

2.0 FORMAT OF PCT ROUND ROBIN

It is anticipated that, in practice, the number of laboratories using the PCT protocol to evaluate radioactive glasses will be limited. These laboratories will be equipped with instrumentation and facilities for handling highly radioactive materials. Such laboratories will have highly structured standard operating procedures. Sample preparation will also be highly specialized because of the remote sample-handling requirements. In addition, routine use of the PCT will require dedicated and specialized analytical chemistry support services. Thus, the round robin was developed to mimic this type of laboratory operation. Participation was limited to experienced leach testing laboratories and detailed round robin protocols were developed. The MCC crushed and sieved all of the glass samples used in the round robin. All participants were provided with splits from the same batch of material. The decision to provide each participant with glass samples from the same batch of material removed one of the largest sources of interlab variability.

2.1 GLASSES TESTED

Four glasses were selected for inclusion in the round robin. These included MCC reference glass ARM-1, National Institute of Science and Technology (NIST)^(a) standard reference material SRM-623, and two glasses provided by SRL (denoted SRL-G and SRL-P). SRL-P is expected to be less durable than SRL-G. Glasses were submitted to participants as glasses A, B, C, and D, where:

<u>Generic Name</u>	<u>Actual Name</u>
Glass A	SRL-G
Glass B	SRM-623
Glass C	SRL-P
Glass D	ARM-1

Samples of the four glasses were mechanically crushed and sieved by hand to obtain suitable quantities of the -100 to +200-mesh fraction. The crushing procedure involved crushing ~20-gram pieces of glass in a tungsten carbide

(a) Formerly the National Bureau of Standards

disk mill for ~5 seconds. The crushed glass was then placed on a 100-mesh screen stacked on top of a 200-mesh screen and collection pan. The screen was manually rotated in a vigorous circular motion. After the 200-mesh screen was lightly covered with glass particles, the 100-mesh screen was removed and the 200-mesh screen manually rotated in a vigorous circular motion for ~30 seconds. The 200-mesh screen was then rotated through a +45 degree angle with some tapping on the side of the screen. This movement was continued until there was no evidence of materials passing through the 200-mesh screen. Glasses were not washed to remove fines.

Samples of the -100 to +200 mesh fraction of four glasses were submitted for chemical analysis. The SRL-G and SRL-P glasses were also analyzed by SRL. The results of these analyses are listed in Appendix B, Tables B.1 through B.4. Table 2.1 summarizes the SRL and MCC analyses of SRL-G and SRL-P, and the nominal compositions for ARM-1 and SRM-623.

2.2 CONTROLLED EXPERIMENTAL PARAMETERS

Each laboratory participating in the round robin was provided with a kit that included all the items listed in Table 2.2. In addition to the materials required to perform the test (glass samples, leach containers, etc.), a multi-element chemical-analysis standard solution was provided to each participant for submission to the participant's analytical laboratory with each set of leachate samples. This control standard was submitted as a double blind standard; that is, the analytical laboratory was unaware that control standards were included with samples. Finally, detailed round robin test instructions were developed from Version 2.0 of the SRL PCT protocol (Jantzen and Bibler 1987). A copy of the SRL-PCT round robin test instructions is included as Appendix A.

TABLE 2.1. Compositions (weight percent oxides) of the Four Glasses Tested in the PCT Round Robin

Oxide	SRL-G		SRL-P		ARM-1		SRM-623	
	SRL Anal.	MCC(a) Mean	SRL Anal.	MCC(a) Mean	Cert. Val.	MCC(b) Mean	NIST Nom.	MCC(b) Mean
Al ₂ O ₃	4.40	4.59	4.14	4.27	5.59	5.78	6.3	6.14
B ₂ O ₃	5.82	6.00	8.25	8.49	11.30	11.80	10.7	10.10
BaO	0.15	0.14	0.20	0.18	0.658	0.65	2.2	2.00
CaO	1.32	1.31	1.32	1.30	2.24	2.32	0.7	0.69
CeO ₂					1.51	1.42		
Cr ₂ O ₃	0.15	0.10	0.15	0.10				
Cs ₂ O	n.d.	0.03	n.d.	0.13	1.17	1.08		0.03
CuO	0.40	0.37	0.67	0.64				
Dy ₂ O ₃						0.02		
Eu ₂ O ₃						0.02		
Fe ₂ O ₃	12.53	12.03	11.51	10.63		0.05		0.09
K ₂ O	2.83	3.24	4.82	6.06			0.6	1.00
La ₂ O ₃						0.02		
Li ₂ O	3.67	3.80	3.29	3.41	5.08	4.82		
MgO	3.30	3.13	3.07	2.84				
MnO ₂	--	0.02	--	0.01		0.01		
MoO ₃					1.66	1.91		
Na ₂ O	6.92	8.28	7.52	9.13	9.66	9.73	6.4	6.46
Nd ₂ O ₃					5.96	5.52		
NiO	0.74	0.64	0.78	0.66				
P ₂ O ₅					0.65			
RhO ₂								
RuO ₂								
SiO ₂	56.63	53.97	52.91	50.83	46.50	45.60	73.0	71.40
SrO		0.01		0.01	0.453	0.47		0.03
TiO ₂	0.67	0.65	1.22	1.16	3.21	3.32		0.02
Y ₂ O ₃								
ZnO					1.46	1.47		
ZrO ₂		0.03		0.03	1.80	1.87		0.05

- (a) The average of three analyses performed within a short period of time.
 (b) The average of two analyses performed within a short period of time.

TABLE 2.2. Test Kit Contents

<u>Qty</u>	<u>Item or Material</u>
18	Cleaned Teflon™ leach containers
1	Set of leach container wrenches
66	Sample vials
20	Syringes
20	0.45-micron filters
4	Crushed glass samples (-100 to +200 Mesh) labeled A, B, C, & D
100	ml chemical-analysis standard solution
1	SRL-PCT instructions

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Seven-day leach tests were conducted for three consecutive weeks. Two blank leach tests were conducted each week. During the first week, the leach test for glass A (SRL-G) was conducted in triplicate. Each leachate was split into three aliquots; two were used for inductively coupled plasma emission spectroscopy (ICP) and one for anion analysis by ion chromatography (IC). Leachate samples and control standards were monitored for Na, Li, K, Al, Si, Fe, and B. In addition, leachate samples were also monitored for pH and the anions fluoride, chloride, nitrate, and sulfate.

3.0 RESULTS

Seven of the eight laboratories invited to participate returned experimental results to the MCC. Data sets were compiled for each of the four glasses, the blank tests, and chemical-analysis standard solution analyses. The experimental results and test setup information for each participating laboratory are contained in Appendix B.

3.1 PCT RESULTS FOR THE FOUR GLASSES

The release data from PCT testing of the four glasses SRL-G, SRL-P, MCC ARM-1, and NIST SRM-623 are given in Appendix B. Certain data were clearly outliers and were deleted from the data set. The deleted points are listed in Table 3.1.

TABLE 3.1. Glass Leachate Data Points Deleted as Outliers

Glass	Lab	Analyte	Week	Sample	Split	Outlying Value (mg/l)	Range of Other Values (mg/l)
SRL-G	Lab 3	Fe	2	1	1	11.41	2.88-8.20
	Lab 3	Si	1	1	1	74.69	105.6-167.0
	Lab 3	Si	1	2	2	89.05	105.6-167.0
	Lab 3	Si	1	3	2	85.53	105.6-167.0
	Lab 3	Si	2	1	1	90.76	105.6-167.0
	Lab 2	Si	2	1	2	182.0	105.6-167.0
SRL-P	Lab 3	Si	1	1	2	86.41	101.0-174.0
	Lab 2	B	2	1	2	7.60	21.8-41.0
MCC ARM-1	Lab 3	K	2	1	1	12.71	-.31-2.0
NIST SRM-623	Lab 3	K	2	1	2	7.69	0.010-2.0

As an example of why the above points were declared outliers, consider the Lab 2 data point for SRL-P, B, week 2, sample 1, and split 2, which had a value of 7.60. The value for split 1 was 35.10, and the range of values from the other labs was 21.8 to 41.0. The value 7.60 is clearly an outlier.

The PCT round robin data were statistically analyzed using SAS (1985b) to estimate the within-lab and between-lab precision of the PCT across all

participating laboratories. Tables C.1 and C.2 in Appendix C contain the consensus means, standard deviations, and percent relative standard deviations (%RSDs) for pH and each of seven main analytes, with results given for each of the four glasses tested. Because the Lab 2 PCT results on the four glasses differed significantly from those of the other participating labs, the statistical analyses were performed with (Table C.1) and without (Table C.2) the Lab 2 data. Additional discussion of the contents of Tables C.1 and C.2 are given in Appendix C.

The PCT round robin data for the four glasses were also analyzed lab-by-lab using SAS (1985b). Table C.3 in Appendix C contains the mean and within-lab standard deviation of each laboratory for pH and each of the seven analytes, with results given for each of the four glasses tested. These lab-by-lab estimates provide for comparing the performance of the participating laboratories and for determining the ability of the various labs to discriminate between two glasses with the PCT. These two topics are discussed in Sections 4 and 5, respectively. Additional details concerning Tables C.1 to C.3 are given in Appendix C.

3.2 STANDARD SOLUTION RESULTS

Each participant in the PCT round robin was provided sufficient multi-element chemical-analysis standard solution to allow two samples to be submitted for chemical analysis with each of the three groups of leachate samples. The results are given in Appendix B.

The standard solution data provide for assessing the precision and accuracy associated with the leachate analysis step of the PCT. Tables C.6 and C.7 in Appendix C contain means and standard deviations for concentrations of the seven elements contained in the standard. The results in Table C.6 are consensus values obtained using all data from all laboratories, while lab-by-lab results are given in Table C.7. Noticeably different means or standard deviations for a given lab are denoted by a star in Table C.7, and consensus within-lab standard deviations with and without the starred values are given.

The overall performance of laboratories on the standard solution is summarized in Table 3.2. Consensus means and within-lab %RSDs (without the starred values) are tabulated for each of the seven elements of the standard

solution and the four glasses tested. The consensus mean elemental concentrations for the standard solution compare very well with the nominal values, so the accuracy across labs appears to be very good. The consensus within-lab %RSDs for Al, B, Li, Na, and Si are all under 3%, while the %RSDs for Fe and K are under 4% and 5%, respectively.

In Table 3.2, the %RSDs for the standard solution represent analytical variability in the PCT, whereas %RSDs for the glass leachates represent both analytical and procedural PCT variability. In order to compare the glass %RSDs to the standard solution %RSDs, it is important that the mean concentration in the leachate is comparable to that in the standard solution, since %RSDs are not independent of concentration level. The standard solution concentration levels are close to those of the SRL-G and SRL-P leachates for all elements except Si(a), and they are close for selected elements in SRM-623 and ARM-1. Where comparisons are appropriate, it appears that analytic uncertainty is a significant contributor to within-lab imprecision in PCT results for Al, B, Li, Na, and Si. To improve PCT precision, the analytical imprecision must be reduced directly via improvement in analytical procedures or indirectly via averaging replicate analyses.

3.3 BLANK TEST RESULTS

Two experimental blanks were included each week with the glass leach tests. The blank tests involved all of the steps of the PCT, except that the glass was omitted. Blank solutions were treated following the same steps as leachate solutions.

Sodium, potassium, fluoride, chloride, and sulfate were the only species reported for most blank leachate samples (see Appendix B). The fluoride was probably leached from the Teflon leach vessels. It is likely that sodium and chloride were leached from the filters used in the test. Sub-ppm levels of alkali, alkaline earth, and some transition metal ions are commonly leached from many filters. Conversely, many metal ions at sub-ppm levels can be sorbed by filters. While not a problem in the round robin, loss of trace amounts of

-
- (a) The standard solution was formulated to have concentration levels close to those expected from PCT results on SRL-G and SRL-P, except for Si. To obtain a stable standard solution, a lower Si concentration was required.

TABLE 3.2. Consensus Means and Within-Lab %RSDs^(a) for the Standard Solution and the Four Glasses Tested in the PCT Round Robin

Element	Standard Solution			Four Glasses Tested in the PCT Round Robin							
	Nominal			SRL-G		SRL-P		NIST SRM-623		ARM-1	
		Mean	%RSD	Mean	%RSD	Mean	%RSD	Mean	%RSD	Mean	%RSD
Al	4.0	4.09	2.32	3.87	6.46	3.51	4.05	3.34	5.98	4.65	5.78
B	20.0	19.56	2.68	14.45	3.22	25.28	2.64	7.05	7.04	27.49	7.52
Fe	2.0	1.98	3.79	3.84	19.97	4.07	18.11	0.06	173.21	0.12	227.35
K	10.0	9.82	4.96	11.53	15.69	32.31	6.39	0.60	32.00	0.55	31.51
Li	12.0	12.05	1.58	15.23	3.90	15.88	4.64	0.05	87.04	21.73	5.40
Na	40.0	39.32	1.42	49.86	3.03	69.65	4.98	12.74	6.81	55.65	7.47
Si	40.0	40.76	2.20	112.36	2.76	109.69	2.91	46.10	8.06	80.16	4.89

(a) The standard solution consensus means and %RSDs were obtained from the entries in the "Without * Values" column of Table C.7 in Appendix C, where %RSD = Consensus SD/Consensus Mean. The means and %RSDs for the four PCT glasses were obtained in a similar fashion from the entries in the "Without Lab 2" column of Table C.3. The standard solution %RSDs contain only analytical variation, while the %RSDs for the four glasses contain PCT procedural as well as analytical variation.

metal ions during the filtration process could be a significant problem if radionuclide concentrations were important in assessing the durability of a specific glass.

Blank tests provide a means for assessing possible problems with the test protocol or materials. According to the SRL-PCT protocol, blank values should be subtracted from leachate values prior to data evaluation. However, in this study the blank data were treated independently so as to better assess the overall effects of test equipment and materials on round robin results. Also, the concentration values found in the blanks were so small as to be inconsequential when compared to concentrations in glass leachate samples. Hence, the elemental releases from the glasses were not blank-corrected in this study.

Tables C.4. and C.5. in Appendix C contain statistical results for the blank data. However, since less-than-detection-limit values were assigned the detection limit value for the purpose of statistical calculations, the means and standard deviations in Tables C.4. and C.5. are somewhat misleading. The means tend to be biased high, while standard deviations may be biased low or listed as zero.

4.0 COMPARISON OF THE PARTICIPATING LABORATORIES

In any round robin, a certain amount of lab-to-lab variation is expected. However, it is of interest to determine if any of the labs differ significantly from the others. Differences may exist between means or between within-lab standard deviations for any of the analytes (or pH) from any of the four glasses tested. The standard solution analyses may also be helpful in understanding differences among the labs. This section uses a graphical approach to compare results from the participating laboratories.

The ability to discriminate between two glasses based on the PCT depends on, among other things, the short-term within-lab precision of the PCT as applied by a particular laboratory. The purpose of comparing the mean and within-lab precision performance of the participating laboratories is to determine the range of performances that may occur in applying the PCT. In turn, this information will be used in Section 5 to quantify the ability to discriminate between similar glasses for laboratories with different levels of performance.

4.1 GRAPHICAL COMPARISON PROCEDURE

Under the assumption that there are no differences in means or within-lab standard deviations for the various labs, the means and standard deviations can be combined to form a consensus mean and standard deviation (for each glass and analyte or pH). If, however, a given lab has a mean or standard deviation that differs significantly from the others, it will differ significantly from the consensus value.

The American Society for Testing and Materials (ASTM) Standard Practice E691-87 (1987) discusses graphical methods for statistically comparing means and standard deviations of individual labs to the consensus values. For a given lab, glass, and analyte (or pH) we define:

h = the difference between the individual lab mean and the consensus mean over all labs, divided by the standard deviation of these differences from all labs,

k = the within-lab standard deviation of an individual lab divided by the pooled (i.e., all laboratories) estimate of within-lab standard deviation.

Hence, h and k measure differences of individual laboratory means and standard deviations from the consensus laboratory values. The lab-by-lab and consensus means and within-lab standard deviations given in Table C.3 of Appendix C were used to compute the h and k values for the glass elemental release and pH data for each lab. Means and standard deviations given in Table C.7 (with starred values) were used to compute h and k values for the standard solution data for each lab.

Plots of the h and k values were constructed using SAS (1985a) according to the Standard Practice for each of the four glasses and the standard solution data. The scales of h and k are unitless, so for a given glass or the standard solution, the data for all labs and all analytes (and pH) are plotted on a single plot. We focus on the comparisons in the plots, and refer the reader to ASTM (1987) for the details associated with constructing the plots.

4.2 COMPARING LABS BASED ON MEANS

Let us first consider the h -plots for the four glasses in Figures 4.1 through 4.4. These four plots used the "Without Lab 2" consensus means from Table C.3, since it is clear that Lab 2 differs from the other laboratories. The h value for each analyte/pH for each lab is plotted as a vertical bar with height equal to the h value. A vertical bar extending past the upper/lower dashed line indicates a significantly (statistically) higher/lower mean than the consensus mean.

With regard to pH, none of the labs have means that are significantly different from the consensus mean for any of the four glasses. The results were different for the seven analytes considered. For the SRL-G and SRL-P glasses, Lab 2 obtained significantly higher results than the consensus for all seven analytes (see Figures 4.1 and 4.2). Lab 2 was also significantly high for Al, Li, Na, and Si on the MCC ARM-1 glass (see Figure 4.3), and for Al, B, Na, and Si on the NIST SRM-623 glass (see Figure 4.4).

For the other six labs (excluding Lab 2), there are few analyte means that differ in a statistically significant way from the consensus values for the four glasses. Figures 4.1 through 4.4 show vertical bars near the dashed "significance limits" for some labs for certain glass/analyte combinations. For example, Lab 3 was low on K for SRL-G and SRL-P, Lab 4 was high on Fe for

FIGURE 4.1. H Plot Comparing Mean Performance of Laboratories for SRL-G

FIGURE 4.2. H Plot Comparing Mean Performance of Laboratories for SRL-P

FIGURE 4.3. H Plot Comparing Mean Performance of Laboratories for MCC ARM-1

FIGURE 4.4. H Plot Comparing Mean Performance of Laboratories for NIST SRM-623

FIGURE 4.5. H Plot Comparing Mean Performance of Laboratories for the Standard Solution

ARM-1, and Lab 1 was high on K for ARM-1. Note, however, that Fe and K were not contained in the MCC ARM-1 glass, and that Fe, K, and Li were not contained in the NIST SRM-623 glass. Hence, we conclude that the six labs (excluding Lab 2) agree reasonably well on the levels of the elemental releases from the four glasses.

Figure 4.5 contains the h plot for the standard solution analyses performed by the seven labs. Only Lab 3 shows any statistically significant differences from the consensus means: high on Fe and low on K. Note that the Lab 2 standard solution results agree very well with the standard solution consensus means, indicating that the Lab 2 accuracy problems with the four glasses probably weren't due to analytic biases.

4.3 COMPARING LABS BASED ON WITHIN-LAB STANDARD DEVIATIONS

The k plots for the four glasses are shown in Figures 4.6 through 4.9. These four plots used the "With Lab 2" consensus within-lab standard deviations from Table C.3, since it was determined that the Lab 2 within-lab standard deviations do not differ in a statistically significant way from the consensus values. The k value for each analyte/pH for each lab is plotted as a vertical bar with height equal to the k value. A vertical bar extending above the dashed line indicates that the within-lab standard deviation for that lab is significantly (statistically) larger than the pooled within-lab standard deviation. The significantly larger within-lab standard deviations indicated in Figures 4.6 through 4.9 are summarized in Table 4.1. Note that the elements Fe and K are not contained in MCC ARM-1 and that Fe, K, and Li are not contained in NIST SRM-623.

There is no consistency in the Table 4.1 findings over the four glasses, so it is difficult to make any firm conclusions. However, since there is reasonable agreement between Figures 4.6 and 4.7 for the SRL-G and SRL-P glasses (and it is for such similar glasses that the ability to discriminate is of interest), we focus on those findings. Figures 4.6 and 4.7 indicate that Lab 2 and Lab 4 tend to have somewhat larger within-lab standard deviations for several analytes and pH. These figures also indicate that Lab 3 appears to have somewhat larger within-lab standard deviations for Fe and K.

FIGURE 4.6. K Plot Comparing Within-Lab Standard Deviations for SRL-G

FIGURE 4.7. K Plot Comparing Within-Lab Standard Deviations for SRL-P

FIGURE 4.8. K Plot Comparing Within-Lab Standard Deviations for MCC ARM-1

FIGURE 4.9. K Plot Comparing Within-Lab Standard Deviations for NIST SRM-623

FIGURE 4.10. K Plot Comparing Within-Lab Standard Deviations for the Standard Solution

TABLE 4.1 Within-Lab Standard Deviations That Are Significantly Larger Than the Consensus Values

<u>Glass</u>	<u>Laboratory</u>	<u>Analyte or pH</u>
SRL-G	Lab 2	B, Na
	Lab 3	K
SRL-P	Lab 4	Li, Na, pH
	Lab 2	B, Si
MCC ARM-1	Lab 4	Fe(a)
NIST SRM-623	Lab 6	K(a)
	Lab 4	Fe(a), Li(a)
	Lab 1	pH
	Lab 3	Al, B, Na, Si

(a) These elements were not contained in the associated glasses.

Figure 4.10 contains the k plot for the standard solution analyses performed by the seven labs. Statistically significant higher-than-consensus within-lab standard deviations were found for Lab 4 for Al, Li, and Na, and for Lab 3 for Fe and K. These findings overlap somewhat with those from Figures 4.6 through 4.9, which indicates that some of the significantly larger within-lab standard deviations for Labs 3 and 4 on the four glasses could be due to greater analytical variation.

The above findings suggest that some laboratories may have better within-lab precision in performing the PCT and analyzing the leachate than other laboratories, and hence be better able to discriminate between two similar glasses. Quantitative measures of the ability to discriminate are discussed in Section 5.

4.4 DIFFERENCES NOT SEEN BECAUSE OF OUTLIER DELETIONS

In estimating the lab-by-lab means and within-lab standard deviations, certain data points were discarded as probable outliers. These points were identified previously in Table 3.1. Additional differences in means and standard deviations would have been observed had the deleted points been

included in the statistical analysis. The Lab 3 problems with Si on SRL-G and SRL-P are worth noting. In Figures 4.1 and 4.2 (for SRL-G and SRL-P), the Lab 3 mean for Si is indicated as being slightly above the consensus value, but this is the consequence of deleting several "low" outliers. Similarly in Figures 4.6 and 4.7 (for SRL-G and SRL-P), the Lab 3 standard deviation is indicated as comparing well to the consensus value, but it likely would have been significantly larger than the consensus value had the outlying data not been deleted.

included in the statistical analysis. The Lab 3 problems with 51 on SR1-6 and 51-9 are worth noting. In Figures 4.1 and 4.2 (for SR1-6 and SR1-9), the Lab 3 mean for 51 is indicated as being significantly above the consensus value, but this is the consensus value defined as several low outliers. Similarly in Figures 4.3 and 4.4 (for SR1-6 and SR1-9), the Lab 3 standard deviation is indicated as exceeding well to the consensus value, but it likely would have been significantly larger than the consensus value had the outlying data not been deleted.

5.0 ABILITY OF THE PCT TO DISCRIMINATE

The main goal of the PCT round robin is to determine the ability of labs to discriminate between two similar glasses tested at the same time using the PCT. The ability to discriminate is a function of the short-term within-lab precision, the number of replicate PCTs performed on each of the two glasses, and the number of analyses performed on the leachate from each PCT. Long-term within-lab variation and lab-to-lab variation are present in PCT results performed at a single lab within a short period of time, but may be considered as systematic errors in the short-term. It is assumed that these systematic errors affect both glasses equally, and hence do not interfere with discriminating between them.

If the goal were to make confidence statements about the "true" PCT releases of a given glass, long-term within-lab and lab-to-lab variation would need to be accounted for. This could be accomplished either by including estimates of these variations in the confidence statements, or by adjusting them out via bias corrections based on the results from testing a "standard glass" simultaneously with the glass of interest. These issues are not of direct interest in this report, but must eventually be considered in demonstrating that a given glass or production sample meets the WAPS release criterion.

5.1 PRELIMINARY DATA ASSESSMENT

The primary purpose of the MCC round robin was to evaluate the effectiveness of the PCT methodology in discriminating between glasses of similar composition tested at the same time. A preliminary evaluation of the data returned by each participant showed that, in most cases, the SRL-G glass could be distinguished from SRL-P with leachate data for a single element such as Na, K, or B. In addition, the four glasses used in the round robin could be easily distinguished using data for two elements (e.g., Si and Na or B and K). Figures 5.1 and 5.2 illustrate this. Figure 5.1 shows Si values plotted against Na using leachate data for the four glasses from Lab 2. Figure 5.2 shows a similar plot for K versus B with leachate data for the four glasses from Lab 5.

FIGURE 5.1. Plot of Si Versus Na Releases from PCTs of the Four Glasses by Lab 2

FIGURE 5.2. Plot of K Versus B Releases from PCTs of the Four Glasses by Lab 5

An examination of the data plotted in Figures 5.1 and 5.2 shows that the ability to distinguish between glasses tested in parallel depends on the within-lab precision. As the within-lab precision decreases, the clusters of data points for a specific glass will become more dispersed, and at some point begin to overlap with the points from another glass. For example, in Figure 5.1, the Si values are essentially identical for the SRL-G and SRL-P glasses. Thus, discrimination ability depends on differences in Na values. If the precision of Na values becomes worse, it will become increasingly more difficult to distinguish between the two materials. By the same argument, increased imprecision in Si values would lead to an inability to distinguish between ARM-1 and SRL-G.

Thus, the most important information to come from the assessment of round robin results is the estimates of within-lab precision. Given these estimates, it is possible to determine how similar leachate data can be for two glasses and still allow the PCT to distinguish between them. This issue is addressed in the following section.

5.2 QUANTIFYING THE ABILITY TO DISCRIMINATE

The within-lab standard deviations given in Table C.3 of Appendix C include week-to-week as well as within-week variations in performing the PCT and in analyzing leachates. We consider these variations as short-term, and hence the within-lab standard deviations given in Table C.3 (and partitions of them into procedural and analytical components) were used as the basis of our investigation concerning the PCT ability to discriminate.

It was seen in Section 4.3 that the within-lab standard deviations differed somewhat among the seven participating labs, and that they differed from analyte to analyte. In this section, when assessing the ability to discriminate, we will treat each analyte separately. However, rather than treating each laboratory separately, we consider two "levels" of laboratory precision. The k plots in Figures 4.6 and 4.7 for the SRL-G and SRL-P glasses suggest pooling the within-lab standard deviations of Labs 5, 6, and 7 to form a "Level A" precision description, and pooling the within-lab standard deviations of Labs 2, 3, and 4 to form a "Level B" precision description. Level A defines a better level of precision (lower within-lab standard

deviation) than does Level B. Lab 1 standard deviations seem to define an intermediate level of precision, and were not used in the Level A and B descriptions.

The PCT ability to discriminate between two glasses is quantified in terms of the percent relative differences (PRDs) in elemental releases that can be detected for a given number of replicate PCTs per glass and a given number of chemical analyses per leachate. These PRDs are obtained according to the formula:

$$PRD = \left(\frac{2 (t_{1-\alpha/2} + t_{1-\beta})^2 (RSDP^2 + RSDA^2/m)}{n} \right)^{0.5} \quad (5.1)$$

where PRD = the percent relative difference in elemental release between two glasses [e.g., $100(P-G)/G$ for the SRL-P and SRL-G glasses],

α = the probability of incorrectly deciding a difference exists between two glasses,

$1-\beta$ = the probability of detecting a percent relative difference of magnitude PRD,

$t_{1-\alpha/2}$, $t_{1-\beta}$ = upper $1-\alpha/2$ and $1-\beta$ percentiles of the Student's t distribution with f degrees of freedom,

f = the effective degrees of freedom associated with the estimate $RSDP^2 + RSDA^2/m$ given n PCT tests on each of the two glasses tested in parallel and m analyses per leachate, where

$$f = \frac{(RSDP^2 + RSDA^2/m)^2}{\frac{RSDP^4}{2(n-1)} + \frac{RSDA^4}{2n(m-1)}} \quad \text{for } m \geq 2$$

$$= 2n-2 \quad \text{for } m = 1$$

RSDP = the percent relative within-lab standard deviation associated with performing the PCT,

RSDA = the percent relative within-lab standard deviation associated with chemical analysis of PCT leachate,

m = the number of times the leachate from a PCT is chemically analyzed,

n = the number of replicate PCTs to be performed on each of the two glasses.

In order to calculate PRD values using Eq. (5.1) for various combinations of n and m , we need to select values of α and β , and to estimate RSDP and RSDA for Levels A and B of laboratory precision. For our purposes we choose $\alpha = 0.05$ and $\beta = 0.05$. This means that we want to be 95% confident that differences of size PRD will be detected, with only a 5% chance of a false alarm (i.e., declaring a negligible difference significant). There is no special reason why we chose $\alpha = \beta = 0.05$; there is nothing inherently preferable about 0.05 and it isn't necessary to choose $\alpha = \beta$.

Estimates of RSDP and RSDA for Levels A and B of laboratory precision are obtained by pooling values of these statistics from glasses SRL-G and SRL-P from Labs 5, 6, and 7 (for Level A) and from Labs 2, 3, and 4 (for Level B). Table 5.1 contains the individual lab and pooled estimates of RSDP and RSDA for Levels A and B for each of the seven analytes.

Table 5.2 presents the PRD values calculated from Eq. (5.1) for various values of n and m for Levels A and B of laboratory precision. The PRD drops dramatically when the number of replicates, n , increases from 2 to 3. The PRD continues to decrease (i.e., smaller differences can be detected) as n increases, but at a slower and slower rate. The PRD also drops when increasing m from 1 to 2, but the decreases are of much smaller magnitude than those obtained by increasing n . The PRD values were also calculated for $m = 3$ and 5, but the values of PRD obtained were very close to the values obtained for $m = 2$. Hence, the $m = 3$ and 5 results were not included in Table 5.2.

As an example of the use of Table 5.2, assume we want to know the ability of the PCT to discriminate between two similar glasses (with $\alpha = \beta = 0.05$) if three replicate PCTs of each glass are performed and each leachate is analyzed once (i.e., $n = 3$ and $m = 1$). If a Level A lab (e.g., Lab 5, 6, or 7 in this study) conducts the tests, it could expect to detect a B difference of 10.1% with 95% confidence. Larger differences than 10.1% would be detected with more than 95% confidence, while smaller differences than 10.1% would be

TABLE 5.1. Pooled Within-Lab %RSDs for Level A and Level B Laboratory Performance on the PCT (based on glasses SRL-G and SRL-P)

Source Var. (a)	Element	Glass	Level A				Level B			
			Lab 5	Lab 6	Lab 7	Pooled	Lab 2	Lab 3	Lab 4	Pooled
RSDP	Al	SRL-G	1.39	2.81	1.26		7.86	8.87	12.49	
		SRL-P	2.39	3.62	8.56	2.22	2.32	1.66	5.33	6.51
	B	SRL-G	3.95	8.88	1.88		6.35	2.35	3.91	
		SRL-P	2.93	(b)	1.76	2.41	5.89	1.43	2.91	4.21
	Fe	SRL-G	6.59	9.12	3.28		8.41	18.14	28.64	
		SRL-P	18.49	12.39	1.37	8.28	15.21	8.89	8.49	15.96
	K	SRL-G	2.87	2.84	2.43		6.86	(c)	(b)	
		SRL-P	1.88	(b)	(b)	2.41	5.32	8.36	5.17	6.36
	Li	SRL-G	2.36	8.29	1.48		4.13	1.86	7.56	
		SRL-P	2.69	(b)	2.19	1.99	3.39	1.67	6.69	4.71
	Na	SRL-G	1.63	(b)	8.94		7.67	8.98	4.38	
		SRL-P	(b)	(b)	2.58	1.81	5.28	1.18	5.11	4.72
	Si	SRL-G	(b)	1.88	8.87		4.82	1.89	4.85	
		SRL-P	1.16	2.83	1.92	1.49	5.59	3.38	3.23	3.95
RSDA	Al	SRL-G	1.47	8.68	1.11		4.38	3.39	2.72	
		SRL-P	1.56	8.47	8.91	1.11	4.15	1.18	2.48	3.23
	B	SRL-G	1.48	8.53	8.82		4.18	2.15	2.85	
		SRL-P	1.92	8.37	1.31	1.28	1.34	2.18	2.23	2.68
	Fe	SRL-G	2.98	4.17	3.84		5.66	23.87	4.16	
		SRL-P	2.37	2.85	2.47	3.18	13.88	25.73	1.59	15.49
	K	SRL-G	2.27	3.84	4.88		4.98	(c)	8.21	
		SRL-P	1.58	1.14	2.98	2.99	1.28	7.53	8.91	6.34
	Li	SRL-G	1.65	1.78	8.98		5.79	1.45	2.88	
		SRL-P	1.87	1.89	1.61	1.63	1.64	2.84	6.78	3.98
	Na	SRL-G	2.89	1.78	8.93		8.75	2.12	3.38	
		SRL-P	1.94	8.83	1.18	1.52	1.14	2.38	9.57	4.37
	Si	SRL-G	1.87	8.79	1.19		1.84	8.89	2.55	
		SRL-P	1.98	8.92	1.75	1.49	1.84	8.39	2.77	1.85

- (a) RSDP is the %RSD associated with performing the PCT. RSDA is the %RSD associated with chemical analysis of the leachates.
- (b) Zero values occurred here, but were not used in computing the pooled %RSD values so as not to dilute them.
- (c) Values much larger than those obtained by the other labs occurred here, but were not used in computing the pooled %RSD values so as not to inflate them.

TABLE 5.2. Percent Relative Differences in Elemental Releases from Two Glasses (detectable by the PCT with 95% confidence and 5% false-alarm rate) for Various Values of n and m and Two Levels of Laboratory Performance

m(a)	Level(b)	n(c)	Element						
			Al	B	Fe	K	Li	Na	Si
1	A	2	17.9	19.4	63.5	27.7	18.6	17.1	15.2
	A	3	9.9	10.8	35.2	15.4	10.3	9.5	8.4
	A	4	7.7	8.4	27.3	11.9	8.0	7.3	6.5
	A	5	6.5	7.1	23.2	10.1	6.8	6.2	5.6
	A	7	5.3	5.7	18.6	8.1	5.4	5.0	4.5
	A	10	4.3	4.6	15.1	6.6	4.4	4.1	3.6
	B	2	52.5	35.7	160.6	64.9	44.5	46.5	31.5
	B	3	29.1	19.8	89.1	36.0	24.7	25.8	17.5
	B	4	22.6	15.4	69.0	27.9	19.1	20.0	13.5
	B	5	19.1	13.0	58.6	23.7	16.2	16.9	11.5
	B	7	15.4	10.5	47.1	19.0	13.1	13.6	9.2
	B	10	12.5	8.5	38.1	15.4	10.6	11.0	7.5
2	A	2	14.6	15.9	55.4	18.2	12.9	11.8	10.1
	A	3	8.9	9.6	32.7	12.1	8.4	7.7	6.7
	A	4	7.0	7.6	25.7	9.7	6.8	6.2	5.4
	A	5	6.0	6.6	22.0	8.3	5.8	5.4	4.7
	A	7	4.9	5.3	17.8	6.8	4.8	4.4	3.8
	A	10	4.0	4.3	14.5	5.5	3.9	3.6	3.1
	B	2	42.9	27.2	107.2	43.1	30.7	31.3	26.2
	B	3	26.0	17.1	71.0	28.6	20.1	20.6	15.8
	B	4	20.7	13.6	57.2	23.0	16.2	16.7	12.5
	B	5	17.7	11.7	49.4	19.9	13.9	14.4	10.7
	B	7	14.4	9.5	40.2	16.2	11.4	11.7	8.7
	B	10	11.7	7.8	32.8	13.2	9.3	9.6	7.1

(a) "m" denotes the number of times the leachate from each PCT is chemically analyzed. Increasing m beyond 2 is of negligible benefit in reducing the PRDs.

(b) "A" denotes a higher level of lab performance (smaller within-lab standard deviation), while "B" denotes a lower level of lab performance (larger within-lab standard deviation). See Table 5.1 for the specific %RSD values.

(c) "n" denotes the number of times the PCT is performed on each of the two glasses.

detected with lesser confidence (the smaller the difference, the less the confidence). On the other hand, a Level B lab (e.g., Lab 2, 3, or 4 in this study) could only expect to detect a B difference of 22.8% with 95% confidence. We've used boron to illustrate the use of Table 5.2, but statements similar to those above could be made for the other elements.

5.3 ABILITY TO DISCRIMINATE BETWEEN SRL-G AND SRL-P

The SRL-G and SRL-P glasses were chosen for testing in the PCT round robin as examples of two waste glasses with dissimilar chemical durability. Given the general solution to the question, "How large must elemental release differences be to be detected with the PCT?" in Section 5.1, we investigated the experimental requirements to discriminate between SRL-G and SRL-P.

Suppose that the true elemental releases for SRL-G and SRL-P are adequately represented by the "Without Lab 2" consensus analyte concentration means from Table C.3. Using these values, the PRDs between SRL-G and SRL-P can be computed for each element. Then, solving Eq. (5.1) for n and substituting a value of m and the calculated PRDs, the number of replicate PCTs required to detect differences of size PRD are obtained. The results of these computations are given in Table 5.3 for $m = 1$. It is clear from the small values of n in Table 5.3 that the differences between SRL-G and SRL-P for B, K, and Na release are easily detectable with 95% confidence and 5% false-alarm rate given one analysis per leachate. The fact that SRL-G had higher elemental releases for Al and Si than did SRL-P (contrary to expectations, since SRL-P is less durable than SRL-G) and the larger numbers of PCTs required to detect Fe and Li differences suggest that these four elements are of little help (individually) in discriminating between SRL-G and SRL-P.

5.4 MULTIVARIATE DISCRIMINATION

The discussion in Section 5.2 presumed that elemental releases would be considered individually in trying to discriminate between two similar glasses. A multivariate approach that takes into account elemental release information for several elements simultaneously can be more efficient and less misleading

TABLE 5.3. The PRDs Between SRL-G and SRL-P and the Required Number of Replicate PCTs n on Each Glass to Detect Them (with 95% confidence and 5% false-alarm rate) for Two Levels of Laboratory Performance

Element	PRD $100(P-G)/G$	Number of PCTs (n) Per Glass Required to Detect PRD when $m = 1$	
		Level A	Level B
Al	-9.0	4	26
B	75.0	2	2
Fe	6.1	56	347
K	180.1	2	2
Li	4.3	10	78
Na	39.7	2	3
Si	-2.4	20	113

than a univariate approach (i.e., looking at each element individually). This is because a multivariate approach would make use of information concerning covariances among the elements, whereas a univariate approach does not.

It was not possible to investigate the PCT ability to multivariately discriminate between two glasses because of lack of appropriate data in the PCT round robin. Two types of data sets are needed to investigate multivariate discrimination. First, a data set of PCT release values is required for several glass compositions within a region for which discrimination ability is desired. If the discrimination contributions of k elements are to be assessed, data on at least $k+1$ compositions would be required. This data set would provide for developing a discriminant function that would quantify the relative discriminating worth of the various elements. Second, a data set of elemental releases from several PCTs per glass per lab would be required to assess the ability of a lab to discriminate using the multivariate discriminant function. At least $k+1$ PCTs per glass per lab are necessary in order to estimate the covariance matrix of the elemental releases of k elements, and the data points would need to include all sources of within-lab variation.

The PCT round robin does not provide sufficient data of either of the two types discussed above. Seven elemental releases were considered, and hence data for at least eight similar glasses would be required to develop a discriminant function, and at least eight PCTs (including all sources of

within-lab variation) per glass per lab would be required to assess the PCT ability to discriminate with the multivariate discriminant function. The PCT round robin only contained data for two similar glasses and the equivalent of three data points per glass per lab that contain all sources of short-term within-lab variation.

The inability to assess multivariate discrimination should not be construed as a shortcoming of the round robin, since a much larger study would have been required. Rather, it would be more efficient to collect appropriate data and investigate multivariate discrimination at one laboratory, with confirmatory testing at other labs at a later time.

Given the appropriate data, a multivariate version of Eq. (5.1) could be developed and used to quantify the differences in elemental releases that could be detected for a specified multivariate discriminant function.

6.0 CONCLUSIONS

In Section 6.1, results from this PCT round robin are briefly compared to those from the SRL internal round robin (Jantzen and Bibler 1987). In Section 6.2, the within-lab and total (within- and between-lab) precisions of the PCT for the SRL-G and SRL-P glasses are summarized by element and compared to the values noted by Jantzen and Bibler. In Section 6.3, conclusions are given regarding the ability of the PCT to discriminate between two glasses tested at the same time.

6.1 COMPARISON OF CONSENSUS MEAN VALUES WITH INTERNAL SRL ROUND ROBIN RESULTS

Results from this round robin can be compared with results from the internal round robin conducted by SRL in their assessment of the PCT methodology (Jantzen and Bibler 1987). The MCC ARM-1 glass was used in both round robins with very similar test parameters (seven-day test at $T=90^{\circ}\text{C}$ in Teflon vessels). For the four elements B, Si, Na, and Li, the consensus mean values listed in Table C.2 of Appendix C are between 16% and 26% higher than the values reported by Jantzen and Bibler. It is believed that these differences are associated with the crushing and sieving of the test glasses. Also, it is anticipated that if in the MCC round robin each laboratory had prepared their own test glasses, this contribution to lab-to-lab variability would probably have overshadowed the other sources of experimental variation.

6.2 COMPARISON OF %RSDs TO THOSE FROM THE SRL INTERNAL ROUND ROBIN

The PCT round robin conducted by the MCC for SRL produced data useful for estimating the magnitude of within-lab and between-lab standard deviations for concentrations of Al, B, Fe, K, Li, Na, and Si in PCT leachates. Within-lab %RSDs and total (within-lab and between-lab) %RSDs based on the SRL-G and SRL-P glasses are summarized in Table 6.1. It should be recalled that the %RSDs in Table 6.1 do not include variation due to glass preparation, since the MCC crushed and sieved the glass materials used by all participating labs. As noted in Section 6.1, including this source of variation would probably increase the %RSDs considerably.

TABLE 6.1. Within-Lab %RSDs and Total %RSDs Corresponding to Level A and B Labs Based on the SRL-G and SRL-P Glasses(a)

Element	Level A Lab		Level B Lab	
	Within-Lab %RSD	Total %RSD	Within-Lab %RSD	Total %RSD
Al	2.5	6.3	7.3	9.3
B	2.7	4.7	4.9	6.3
Fe	8.8	14.8	22.2	25.2
K	3.8	8.0	9.0	11.4
Li	2.6	2.8	6.2	6.3
Na	2.4	4.5	6.4	7.5
Si	2.1	2.8	4.4	4.7

(a) The within-lab %RSDs were obtained from Table 5.1 by taking the square root of the sum of squares of the pooled RSDP and RSDA values. The total %RSDs include the Level A or B within-lab %RSDs and a pooled (over SRL-G and SRL-P) value of lab-to-lab %RSD for each element. The lab-to-lab %RSDs for SRL-G and SRL-P were taken from Table C.2.

Jantzen and Bibler (1987) reported a 2 to 3% precision for tests repeated by the same investigator and 5 to 8% for tests performed by different investigators. The repeatability and reproducibility findings in Table 6.1 for Level A labs agree fairly well with the Jantzen and Bibler findings. Level A within-lab %RSDs for Al, B, Li, Na, and Si all fall within the 2 to 3% "same investigator" range reported. The values for K and Fe (3.8% and 8.8%, respectively) are above this range. Similarly, the Level A total %RSDs for all elements except Fe are inside or below the 5 to 8% "different investigator" range reported by Jantzen and Bibler.

The agreement is not as good for Level B labs. The Level B within-lab %RSDs for the seven elements range from approximately 5 to 22%, well outside the 2 to 3% range reported by Jantzen and Bibler. Level B total %RSD values for B, Li, Na, and Si are within the 5 to 8% range reported, while the values for Al and K are not too much higher at 9.3% and 11.4%, respectively. The Fe total %RSD value of 25.2% is considerably higher than the 5 to 8% range.

In summary, the above findings suggest that Level A laboratories performing the PCT on glasses similar to SRL-G and SRL-P can achieve within-lab precisions of 2 to 3 %RSD on Al, B, Li, Na, and Si. For these same

elements, Level B labs can achieve within-lab precisions of 5 to 9 %RSD. The %RSDs are higher for K, and quite a bit higher for Fe for both Level A and B labs. Lab-to-lab precision for all elements except Fe seems to be in the 3 to 8% range for Level A labs and 5 to 11% for Level B labs. The Fe values for Level A and B labs are approximately 15% and 25%, respectively.

6.3 CONCLUSIONS REGARDING PCT ABILITY TO DISCRIMINATE

The focus of this report was to assess the ability of the PCT to discriminate (element by element) between two glasses tested at the same time. In order to discriminate statistically, each of the two glasses must be tested by the PCT at least twice. The more times each glass is tested, the smaller the differences in elemental releases that can be detected. Furthermore, because analytical variation was seen to be a significant contributor to the within-lab imprecision of the PCT, multiple analyses of each leachate can be performed to enable smaller differences between glasses to be detected.

In this report, we focused on the discrimination testing situation where each of two glasses is tested n times using the PCT, with each leachate analyzed m times. The magnitude of PRDs that can be detected drops considerably for all elements when increasing n from 2 to 3, with lesser decreases in the detectable PRD as n increases beyond 3. Similarly, increasing m from 1 to 2 decreases PRD, but further increases (at least up to $m = 5$) have little further effect. Overall, the benefits of increasing n are much greater than those of increasing m . This is because increasing n reduces the effective analytical uncertainty as well as reducing the effective PCT procedural uncertainty, whereas reducing m only reduces the effective analytical uncertainty. Hence, even though analytical uncertainty is a significant contributor to the total uncertainty of results from a given PCT, replicating PCTs has more benefit (because both sources of uncertainty are reduced) than does replicating leachate analyses (because only the analytical uncertainty is reduced).

The ability to detect differences in two glasses appears to depend on the laboratory performing the PCT. The laboratories participating in the round robin roughly fell into two groups, denoted Level A (lower within-lab standard deviations) and Level B (higher within-lab standard deviations).

For the same number of PCTs per glass and analyses per leachate, Level A labs can detect differences two to four times smaller than Level B labs.

7.0 REFERENCES

American Society for Testing and Materials (ASTM). 1987. Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method, E691-87, American Society for Testing and Materials, Philadelphia, PA.

Jantzen, C.M., and N.E. Bibler. 1987. Product Consistency Test (PCT) for DWPF Glass: Part I. Test Development and Protocol, DPST-87-575, Savannah River Laboratory, Aiken, South Carolina.

SAS Institute Inc. 1985a. SAS/GRAPH User's Guide, Version 5 Edition. SAS Institute Inc., Cary, North Carolina.

SAS Institute Inc. 1985b. SAS User's Guide: Statistics, Version 5 Edition. SAS Institute Inc., Cary, North Carolina.

APPENDIX A

SRL-PCT TEST INSTRUCTIONS

SRL-PCT Round-Robin Test Instructions.

I. Introduction

This MCC round-robin test will evaluate the effectiveness of the Savannah River Laboratory Product Consistency Test (SRL-PCT) in distinguishing between specific glass compositions. The round-robin test is designed to evaluate the uncertainty of the leach test methodology, including the uncertainty associated with analytical measurements. A series of 1-week tests will be conducted over a three week time period to better reflect time dependent uncertainties. However, during the first week a triplicate leach test will be conducted with Glass A.

Selected laboratories will conduct SRL-PCT using four crushed glass samples provided by MCC. The contents of each Test Kit provided by the MCC are listed in Table 1. Each laboratory will conduct 4 tests plus 2 blanks the first week, repeating the tests plus blanks during the second and again during the third week. Leachate samples will be submitted to the analytical chemistry laboratory for analysis on a weekly basis. A multi-element control standard solution is provided for submission to the analytical laboratory with each set of leachate samples. Leachate samples and control standards will be monitored for Na, Li, K, Al, Si, Fe, and B. In addition, leachate samples will also be monitored for F, Cl, NO₃, SO₄, and pH.

Table 1. Test Kit Contents

20 Cleaned Teflon Leach Containers
1 Set of Leach Container ("green") Wrenches
72 Sample Vials
22 Syringes
22 0.45 micron Filters
4 Crushed Glass Samples (-100 to +200 Mesh) Labeled A, B, C, & D
120 ml ICP Control Standard Solution
SRL-PCT Test Instructions.

Leach test results will be returned to the MCC. Analytical uncertainties will be evaluated using results from the Control Standard analyses. Within laboratory variability will be assessed using the replicate leach

test data. Precision achievable by the SRL-PCT procedure will be evaluated through a statistical analysis of data from all of the laboratories.

II. Apparatus, Equipment, and Analytical Requirements

A. Leach Containers

Cleaned Teflon leach containers are provided by the MCC. These containers are ready for use. Care should be taken in handling the leach containers to avoid their contamination.

B. Environmental Chamber (Oven)

The temperature of the leach containers within the oven shall be controlled at $90^{\circ} \pm 2.0^{\circ}\text{C}$. Continuous monitoring of the temperature is recommended. Otherwise, the temperature should be observed and recorded daily on the Test Information Sheet (included as an attachment to this Test Instruction).

C. Balances

Balances shall provide the accuracies indicated below, depending on the material being weighed:

leachant + leach container	within 0.25% of the leachant mass
chemical reagents	within 0.25% of the reagent mass
specimens	within 0.5 mg.

D. Volume Measurements

Measure leachant volumes gravimetrically, assuming the density of water is 1.00 g/ml or use Class A (ASTM E288, E542, and E694) volumetric glassware.

E. Solution Analysis

Leachate samples should be analyzed using instrumentation calibrated with standards traceable to NBS, if possible. Precision, accuracy, and detection limits should be reported with the analytical data. Leachate samples and control standards will be monitored for Na, Li, K, Al, Si, Fe,

and B using inductively coupled plasma atomic emission spectroscopy (ICP) or atomic absorption spectroscopy (AA). In addition, leachate samples will also be analyzed for pH and for F, Cl, NO₃, and SO₄ by ion chromatography.

F. pH Measurements

pH meters shall be standardized with pH 10 and pH 7.0 buffer solutions. pH shall be measured to an accuracy of ± 0.2 pH units.

G. High-Purity Water

Deionized water will be used as the leachant in the test. This water shall meet the following specifications:

Specific Resistance >17.5 Mohm-cm at 25°C

pH 5.5 - 7.0

H. Measurement and Test Equipment

The table below shows the method and minimum calibration frequency for instrumentation used to perform the SRL-PCT. The researcher shall ensure that all instrumentation used in this test has been calibrated in accordance requirements outlined in this table.

Table 2. Measurement and Test Equipment Calibration

<u>Measurement</u>	<u>Device</u>	<u>Calibration Frequency and Method</u>
Temperature	Thermocouple or thermometer	6 mo. NBS standards or ice/boiling water
Mass	Balances	1 yr. using NBS standard masses
pH	pH Meter	Before each sample with commercial buffer solutions.
Volume	Volumetric flasks, pipets.	Use Class A glassware.

I. Test-Specimen Preparation

Four leach test glasses, labeled A, B, C, and D have been provided by the MCC. These glasses have been crushed and sieved to a -100 +200 mesh size fraction. The researcher shall dry each of these glass samples at 90°C for 24 hours and store each in a desiccator until used.

III. Test Instructions

Test instructions are divided into three parts: A) Leach Test Method, B) Leachate Analysis, and C) Data Reports. The leach test method is taken directly from the SRL-PCT Method (Product Consistency Test (PCT) for DWPF Glass: Part 1. Test Development and Protocol, DPST-87-575, July 1987). Leachate Analysis protocols were established to maintain uniformity in the data sets. Analytical Results sheets are provided to standardize reports.

III-A. Leach Test Method Protocols

As shown in the Test Matrix in Table 3, four leach tests (using the four glasses) and two blank tests are conducted each week. During the first week only, a triplicate leach test is conducted with Glass A. All information shall be recorded on the Test Information Sheet. (Note that a separate Test Information Sheet is provided for each week's testing.)

Table 3. Test Matrix*

<u>Week 1</u>	<u>Week 2</u>	<u>Week 3</u>
Blank - 1	Blank - 1	Blank - 1
Glass - A	Glass - A	Glass - A
Glass - A	Glass - B	Glass - B
Glass - A	Glass - C	Glass - C
Glass - B	Glass - D	Glass - D
Glass - C	Blank - 2	Blank - 2
Glass - D		
Blank - 2		

* All tests are 1 week at 90°C in high-purity water.

The following steps are to be followed for each test:

- 1) All glass samples shall be dried at 90°C for 24 hours and stored in a desiccator until use.
- 2) Determine the specific resistance of the high purity water in the leach tests. Also determine the pH of an aliquot of the water. Record the pH and the specific resistance on the Test Information Sheet. Discard the aliquot.
- 3) Place 4.00 ± 0.01 g of dried, powdered glass in a clean leach container. Record the exact weight and identification of the glass sample on the Test Information Sheet. For blank tests, no glass shall be added to the leach container. In all other respects, however, blank tests are performed in the same manner as tests in which glass is present. Blank tests shall be identified as Blank-1 and Blank-2 on the Test Information Sheet.
- 4) Add 40.0 ± 0.1 ml of high purity water to the leach container. Alternatively, 40.0 ± 0.1 g of water can be added gravimetrically (Assume the density of water is 1.00 g/ml.). Record the exact volume or weight of water added to the leach container on the Test Information Sheet.
- 5) Swirl to wet powder and remove trapped air.
- 6) Place cap on the leach container and hand tighten. With the green wrenches provided in the kit, tighten the leach containers one-quarter turn beyond hand tightening.
- 7) Weigh the filled and capped leach container and record this weight on the Test Information Sheet.
- 8) Place the leach container in a pre-heated oven ($90 \pm 2^\circ\text{C}$) and record the date and time (d:h:min) and oven temperature on the Test Information Sheet.
- 9) Samples shall not be agitated.
- 10) Re-weigh leach containers after 24 hours. Record the weight on the Test Information Sheet. Retighten the lids at this time. Record whether this was necessary. Calculate the mass loss of the leachant solution. If the mass loss is greater than 10%, terminate this test.
- 11) Within 24 hours of the termination of the test, boil required number of polyethylene sample vials in high purity water overnight. Polyethylene sample vials should be dried in an oven at 50°C for 4 hours or until dry.

12) The test period shall be controlled to within 2 % (7.0 days $\pm$ 3 hours). At the conclusion of the test period, remove leach containers from the oven and record the date and time (d:hr:min) on the Test Information Sheet.

13) Allow the leach container to air cool to room temperature.

14) Weigh the leach container and record final weight on the Test Information Sheet. Calculate the mass loss of the leachate solution. If the mass loss is greater than 10%, terminate this test.

15) Standardize the pH meter with pH 10 and pH 7 buffer solutions. Pipette a 2-3 ml aliquot of leachate into a clean, disposable, polyethylene beaker for pH determination. Measure the pH of the aliquot of unfiltered leachate and record on the Test Information Sheet. Discard aliquot. (When measuring pH in a series of leachates, re-check pH meter standardization between leachate samples.)

16) Remaining leachate solution is to be split into three samples of approximately 10 ml each - two for analysis of metals by inductively coupled plasma atomic emission spectrometry (ICP) and one for analysis of anions by ion chromatography.

- Draw a 10 ml aliquot of the remaining leachate through a 0.45 micron sterile filter into a sterile disposable syringe (provided in kit). Remove filter and transfer 10 ml of filtered leachate solution into a clean, pre-boiled polyethylene vial. Label this container for analysis of anions by ion chromatography.

- Filter the remaining leachate solution by drawing solution into the syringe through the 0.45 micron syringe filter, removing the filter, and transferring the solution into clean polyethylene vials. Remaining leachate should be split into two samples of approximately 10 ml each. Add sufficient concentrated high purity nitric acid to equal 1% of the leachate volume.

17) Pour 10 ml of Control Standard into one of the cleaned sample vials.

18) All samples should be identified only by the sample number given in Table 4, except for blanks. Samples from Blank runs should be identified as such to the analytical laboratory. Duplicate samples should not be identified as such to the analytical laboratory.

19) Submit samples for required analyses.

III-B. Leachate Analysis Protocols

Twenty-four samples will be submitted to the analytical laboratory for analysis the first week, 16 for analysis by ICP or AA and 8 for analysis by IC. Eighteen samples will be submitted to the analytical laboratory for analysis the last two weeks, 12 for analysis by ICP or AA and 6 for analysis by IC. The samples submitted for analysis by ICP or AA will include duplicate samples from each of the four glass leach tests plus a single sample from each of the two blank tests, and two ICP Control Standards. The samples submitted for analysis by IC will include a single sample from each glass leach test and each blank test. The samples submitted to the analytical laboratory should be identified only by sample number except for the blank samples. Blank samples should be identified as such so the analyst can treat it as something close to high-purity water. The analytical laboratory should be requested to analyze the samples in numerical order (i.e., 1-1 through 1-16). Leachate samples and control standards will be monitored for Na, Li, K, Al, Si, Fe, and B by ICP or AA. In addition, leachate samples will also be monitored for pH and for F, Cl, NO₃, and SO₄ by IC. The order in which samples are to be submitted to the analytical laboratory is listed below.

III-C. Data Reports

Each week's leach test start-up and end-of-test data should be recorded on the Test Information Sheet provided. Analytical results are tabulated on the Analytical Results Sheet (note that a separate set of Analytical Results Sheets is provided for each week's testing). Analytical data should be rounded to the appropriate number of significant figures.

The Analytical Precision and Detection Limits form should be completed by the analytical laboratory that completes the analyses.

At the conclusion of the test the Test Information Sheets, Analytical Results Sheets, and Analytical Precision and Detection Limits Sheet should be returned to:

Thomas E. Jones
Battelle, Pacific Northwest Laboratorie
3764 Building/ 300 Area
Richland, WA 99352

Any questions about the Test Instructions or requests for additional information about the test should be directed to Tom Jones at 509-376-3263 or to George Mellinger at 509-375-2152.

Table 4. Leachate Sample Labeling Protocol

<u>Sample Number</u>	<u>Week 1</u>	<u>Week 2</u>	<u>Week 3</u>
<u>ICP Samples</u>			
1-1	Blank 1-ICP	2-1 Blank 1-ICP	3-1 Blank 1-ICP
1-2	Control Std-ICP	2-2 Control Std-ICP	3-2 Control Std-ICP
1-3	Glass A ₁ -ICP	2-3 Glass A-ICP	3-3 Glass A-ICP
1-4	Glass B-ICP	2-4 Glass B-ICP	3-4 Glass B-ICP
1-5	Glass A ₂ -ICP	2-5 Glass C-ICP	3-5 Glass C-ICP
1-6	Glass C-ICP	2-6 Glass D-ICP	3-6 Glass D-ICP
1-7	Glass A ₃ -ICP	2-7 Blank 2-ICP	3-7 Blank 2-ICP
1-8	Glass D - ICP	2-8 Glass D-ICP	3-8 Glass D-ICP
1-9	Blank 2-ICP	2-9 Glass C-ICP	3-9 Glass C-ICP
1-10	Glass A ₁ -ICP	2-10 Glass B-ICP	3-10 Glass B-ICP
1-11	Glass D-ICP	2-11 Glass A-ICP	3-11 Glass A-ICP
1-12	Glass A ₂ -ICP	2-12 Control Std-ICP	3-12 Control Std-ICP
1-13	Glass C-ICP		
1-14	Control Std-ICP		
1-15	Glass A ₃ - ICP		
1-16	Glass B - ICP		

Ion Chromatography Samples

<u>Sample Number</u>	<u>Week 1</u>	<u>Week 2</u>	<u>Week 3</u>
1-17	Blank 1-IC	2-13 Blank 1-IC	3-13 Blank 1-IC
1-18	Glass A ₁ -IC	2-14 Glass A-IC	3-14 Glass A-IC
1-19	Glass B-IC	2-15 Glass B-IC	3-15 Glass B-IC
1-20	Glass C-IC	2-16 Glass C-IC	3-16 Glass C-IC
1-21	Glass D-IC	2-17 Glass D-IC	3-17 Glass D-IC
1-22	Blank 2-IC	2-18 Blank 2-IC	3-18 Blank 2-IC
1-23	Glass A ₂ -IC		
1-24	Glass A ₃ -IC		

IV. Quality Assurance

No specific quality assurance requirements are associated with this activity other than that the work be conducted consistent with basic good laboratory practices.

Testing and analysis should be performed in accordance with your normal laboratory practices in order to provide a "real world" basis for discussion of results.

V. Test Schedule

- Shipment of Test Kits to participating laboratories - March 31, 1988.
- Receipt of analytical and test data from participating laboratories - June 10, 1988.
- Final Report transmitted to SRL and to PCT Round-Robin participants - September 30, 1988.

TEST INFORMATION SHEET

Laboratory ID _____ Test Week __1__

Oven Temperature: Day 1 _____, Day 2 _____, Day 3 _____, Day 4 _____,
Day 5 _____, Day 6 _____, Day 7 _____.

Start-Up Test Information

pH of High-Purity Water _____ Specific Resistance _____

Sample ID	Glass Specimen Wt., g.	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. after 24 hours	Date and Time In
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

End of Test Information

Sample ID	Date Out	Time Out	Total Wt, g	% Soln Wt. Loss	pH, Out
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

ANALYTICAL RESULTS SHEET

Laboratory ID _____ Test Week 1

<u>Analyte</u>	<u>Sample Number</u>				
	1-1	1-2	1-3	1-4	1-5
Na	_____	_____	_____	_____	_____
Li	_____	_____	_____	_____	_____
K	_____	_____	_____	_____	_____
Al	_____	_____	_____	_____	_____
Si	_____	_____	_____	_____	_____
Fe	_____	_____	_____	_____	_____
B	_____	_____	_____	_____	_____

<u>Analyte</u>	<u>Sample Number</u>				
	1-6	1-7	1-8	1-9	1-10
Na	_____	_____	_____	_____	_____
Li	_____	_____	_____	_____	_____
K	_____	_____	_____	_____	_____
Al	_____	_____	_____	_____	_____
Si	_____	_____	_____	_____	_____
Fe	_____	_____	_____	_____	_____
B	_____	_____	_____	_____	_____

ANALYTICAL RESULTS SHEET

Page 2:

Laboratory ID _____ Test Week 1

<u>Analyte</u>	<u>Sample Number</u>					
	1-11	1-12	1-13	1-14	1-15	1-16
Na	_____	_____	_____	_____	_____	_____
Li	_____	_____	_____	_____	_____	_____
K	_____	_____	_____	_____	_____	_____
Al	_____	_____	_____	_____	_____	_____
Si	_____	_____	_____	_____	_____	_____
Fe	_____	_____	_____	_____	_____	_____
B	_____	_____	_____	_____	_____	_____

<u>Analyte</u>	<u>Sample Number</u>							
	1-17	1-18	1-19	1-20	1-21	1-22	1-23	1-24
F	_____	_____	_____	_____	_____	_____	_____	_____
Cl	_____	_____	_____	_____	_____	_____	_____	_____
NO ₃	_____	_____	_____	_____	_____	_____	_____	_____
SO ₄	_____	_____	_____	_____	_____	_____	_____	_____

APPENDIX B

SRL-PCT ROUND ROBIN TEST DATA

APPENDIX B

SRL-PCT ROUND ROBIN TEST DATA

Appendix B contains all of the test data received from the SRL-PCT round robin participants. Tables B.1 through B.4 contain results from compositional analyses of the four test glasses. Tables B.5 through B.11 contain PCT data from each participant's laboratory.

TABLE B.1. MCC and SRL Analyses of SRL-G Glass

Oxide	Sample 1	Sample 2	Sample 3	Mean	Std Dev	SRL Analysis
Al ₂ O ₃	4.55	4.58	4.64	4.59	0.05	4.40
B ₂ O ₃	5.99	5.96	6.04	6.00	0.04	5.82
BaO	0.14	0.14	0.14	0.14	0.00	0.15
CaO	1.31	1.32	1.30	1.31	0.01	1.32
CeO ₂						
Cr ₂ O ₃	0.10	0.10	0.10	0.10	0.00	0.15
Cs ₂ O	0.03	0.03	0.03	0.03	0.00	n.d.
CuO	0.37	0.37	0.38	0.37	0.00	0.40
Dy ₂ O ₃						
Eu ₂ O ₃						
Fe ₂ O ₃	11.90	12.10	12.10	12.03	0.12	12.53
K ₂ O	3.00	3.92	2.80	3.24	0.60	2.83
La ₂ O ₃						
Li ₂ O	3.79	3.76	3.85	3.80	0.05	3.67
MgO	3.11	3.14	3.13	3.13	0.02	3.30
MnO ₂	0.02	0.02	0.02	0.02	0.00	--
MoO ₃						
Na ₂ O	8.30	8.27	8.26	8.28	0.02	6.92
Nd ₂ O ₃						
NiO	0.62	0.65	0.64	0.64	0.01	0.74
P ₂ O ₅						
RhO ₂						
RuO ₂						
SiO ₂	53.30	54.00	54.60	53.97	0.65	56.63
SrO	0.01			0.01		
TiO ₂	0.65	0.65	0.64	0.65	0.00	0.67
Y ₂ O ₃						
ZnO						
ZrO ₂	0.05	0.02	0.02	0.03	0.02	
TOTAL	97.24	99.03	98.70	98.32		99.53

TABLE B.2. MCC and SRL Analyses of SRL-P Glass

Oxide	Sample 1	Sample 2	Sample 3	Mean	Std Dev	SRL Analysis
Al2O3	4.30	4.18	4.33	4.27	0.08	4.14
B2O3	8.62	8.42	8.43	8.49	0.11	8.25
BaO	0.18	0.19	0.18	0.18	0.00	0.20
CaO	1.26	1.23	1.41	1.30	0.10	1.32
CeO2						
Cr2O3	0.10	0.10	0.09	0.10	0.00	0.15
Cs2O	0.13	0.14	0.13	0.13	0.01	n.d.
CuO	0.66	0.63	0.62	0.64	0.02	0.67
Dy2O3						
Eu2O3						
Fe2O3	10.80	10.60	10.50	10.63	0.15	11.51
K2O	5.26	6.01	6.90	6.06	0.82	4.82
La2O3						
Li2O	3.50	3.38	3.35	3.41	0.08	3.29
MgO	2.90	2.81	2.82	2.84	0.05	3.07
MnO2	0.01	0.01	0.02	0.01	0.00	--
MoO3						
Na2O	9.51	8.89	8.98	9.13	0.34	7.52
Nd2O3						
NiO	0.66	0.66	0.67	0.66	0.00	0.78
P2O5						
RhO2						
RuO2						
SiO2	51.50	50.50	50.50	50.83	0.58	52.91
SrO	0.01	0.01	0.01	0.01	0.00	
TiO2	1.18	1.15	1.14	1.16	0.02	1.22
Y2O3						
ZnO						
ZrO2		0.04	0.02	0.03	0.02	
TOTAL	100.57	98.95	100.10	99.87		99.85

TABLE B.3. MCC Analysis of ARM-1 Glass

Oxide	Sample 1	Sample 2	Mean	Std Dev	Certified Wt%	Reference Std Dev
Al2O3	5.77	5.78	5.78	0.01	5.590	0.060
B2O3	11.80	11.80	11.80	0.00	11.300	0.250
BaO	0.65	0.65	0.65	0.00	0.658	0.008
CaO	2.32	2.31	2.32	0.01	2.240	0.030
CeO2	1.42	1.41	1.42	0.01	1.510	0.040
Cr2O3						
Cs2O	1.09	1.06	1.08	0.02	1.170	0.030
CuO						
Dy2O3	0.02	0.02	0.02	0.00		
Eu2O3	0.02	0.02	0.02	0.00		
Fe2O3	0.05	0.05	0.05	0.00		
K2O						
La2O3	0.02	0.02	0.02	0.00		
Li2O	4.82	4.82	4.82	0.00	5.080	0.130
MgO						
MnO2	0.01		0.01			
MoO3	1.91	1.91	1.91	0.00	1.660	0.030
Na2O	9.59	9.87	9.73	0.20	9.660	0.110
Nd2O3	5.53	5.51	5.52	0.01	5.960	0.200
NiO						
P2O5					0.650	0.030
RhO2						
RuO2						
SiO2	45.50	45.70	45.60	0.14	46.500	0.900
SrO	0.47	0.47	0.47	0.00	0.453	0.005
TiO2	3.31	3.33	3.32	0.01	3.210	0.050
Y2O3						
ZnO	1.47	1.47	1.47	0.00	1.460	0.030
ZrO2	1.82	1.91	1.87	0.06	1.800	0.030
TOTAL	97.59	98.10	97.84		99.900	

TABLE B.4. MCC Analysis of SRM-623 Glass

Oxide	Sample 1	Sample 2	Mean	Std Dev	NIST Nominal Composition Wt%
Al2O3	6.13	6.14	6.14	0.01	6.3
B2O3	10.00	10.20	10.10	0.14	10.7
BaO	2.00	2.00	2.00	0.00	2.2
CaO	0.70	0.68	0.69	0.02	0.7
CeO2					
Cr2O3					
Cs2O	0.03	0.03	0.03	0.00	
CuO					
Dy2O3					
Eu2O3					
Fe2O3	0.12	0.06	0.09	0.04	
K2O	1.00		1.00		0.6
La2O3					
Li2O					
MgO					
MnO2					
MoO3					
Na2O	6.36	6.56	6.46	0.14	6.4
Nd2O3					
NiO					
P2O5					
RhO2					
RuO2					
SiO2	71.40	71.40	71.40	0.00	73.0
SrO	0.03	0.03	0.03	0.00	
TiO2	0.03	0.02	0.02	0.00	
Y2O3					
ZnO					
ZrO2	0.04	0.07	0.05	0.02	
TOTAL	97.84	97.19	97.51		99.9

Table B.5. Laboratory 1 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0428	152.4202	152.3865
Glass A1	4.0010	40.0104	153.7215	153.6877
Glass A2	4.0007	40.0348	154.4792	154.4471
Glass A3	4.0005	40.0128	156.6670	156.6343
Glass B	3.9995	40.0024	154.2427	154.2109
Glass C	4.0004	40.0270	155.9857	155.9558
Glass D	4.0004	40.0359	154.1013	154.0709
Blank 2	0.0000	40.0105	150.3386	150.3073

Sample ID	Total Weight, g	Weight Loss, g	pH, Out
Blank 1	152.3533	0.0669	6.80
Glass A1	153.6541	0.0674	10.61
Glass A2	154.4136	0.0656	10.62
Glass A3	156.6010	0.0660	10.61
Glass B	154.1749	0.0725	8.89
Glass C	155.9222	0.0635	10.82
Glass D	154.0392	0.0621	10.72
Blank 2	150.2744	0.0642	7.34

Day Oven
 Temperature

1	90.0
2	89.9
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 5.60
 Specific Resistance = 17.8 mohm-cm
 Date and Time In = 9-May-1988 9:40
 Date and Time Out = 16-May-1988 8:25

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	10.61		10.62		10.61
Na	49.10	49.2	49.60	48.0	49.00
Li	15.00	15.0	14.70	14.6	15.10
K	12.10	11.3	11.50	10.5	12.30
Al	4.20	4.1	4.10	4.0	4.50
Si	115.00	116.0	115.00	113.0	117.00
Fe	4.60	4.8	4.50	4.6	6.20
B	14.70	14.4	14.30	14.2	14.60
F	0.43		0.23		0.58
Cl	1.12		0.08		1.14
NO3	0.01		0.20		0.10
SO4	0.30		0.17		0.28

Analyte	Glass A3 Sample 1-15	Glass B Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.89		10.82	
Na	48.5	12.30	12.20	66.70	67.6
Li	15.0	<0.05	<0.05	15.70	15.7
K	12.6	<2.00	<2.00	31.10	33.9
Al	4.5	3.30	3.30	4.00	4.1
Si	116.0	46.90	46.90	112.00	112.0
Fe	6.2	<0.10	<0.10	6.50	6.6
B	14.6	7.13	7.09	25.30	25.5
F		0.80		1.11	
Cl		1.61		1.15	
NO3		0.10		0.10	
SO4		0.17		0.49	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.72		6.80	7.34	
Na	59.80	60.8	<0.50	<0.50	40.5
Li	23.60	23.7	<0.05	<0.05	12.1
K	<2.00	<2.0	<2.00	<2.00	9.7
Al	3.90	3.9	<0.10	<0.10	4.3
Si	89.50	89.7	<0.10	<0.10	42.2
Fe	<0.10	<0.1	<0.10	<0.10	2.0
B	32.10	31.9	0.01	0.01	20.2
F	0.50		1.10	0.54	
Cl	1.03		0.93	1.13	
NO3	2.00		0.10	0.09	
SO4	0.49		0.12	0.13	

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 1

Analyte Control Std.
 Sample 1-14

pH	
Na	39.7
Li	12.1
K	10.3
Al	4.3
Si	42.7
Fe	2.0
B	20.0
F	
Cl	
NO3	
SO4	

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0407	150.1864	150.1576
Glass A	4.0006	40.0300	155.9488	155.9233
Glass B	3.9997	40.0160	156.2811	156.2562
Glass C	4.0007	40.0026	154.3835	154.3583
Glass D	3.9996	40.0122	153.6811	153.6565
Blank 2	0.0000	40.0638	147.5072	147.4804

Sample ID	Total Weight, g	Weight Loss, g	pH, Out
Blank 1	150.1090	0.0774	7.33
Glass A	155.8784	0.0704	10.52
Glass B	156.2103	0.0708	8.36
Glass C	154.3115	0.0720	10.75
Glass D	153.6088	0.0477	10.62
Blank 2	147.4358	0.0446	7.29

Day	Oven Temperature
1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 6.40
 Specific Resistance = 17.8 mohm-cm
 Date and Time In = 16-May-1988 8:30
 Date and Time Out = 23-May-1988 8:00

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Sample 2-5 and 2-16
pH	10.52		8.36		10.75
Na	45.90	46.1	12.90	12.40	63.80
Li	13.90	14.0	<0.05	<0.05	14.70
K	11.70	12.4	<2.00	<2.00	32.20
Al	3.70	3.9	3.40	3.40	3.50
Si	108.00	111.0	48.60	48.60	107.00
Fe	3.90	4.1	<0.10	<0.10	4.10
B	13.20	13.9	7.20	7.18	23.90
F	0.84		0.58		0.71
Cl	0.11		0.40		0.12
NO3	0.10		0.13		0.08
SO4	0.17		0.15		0.37

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.62		7.33	7.29
Na	64.9	57.20	61.4	1.30	1.00
Li	14.9	22.00	23.4	<0.05	<0.05
K	30.8	<2.00	<2.0	<2.00	<2.00
Al	3.7	3.70	4.1	<0.10	<0.80
Si	111.0	81.50	92.1	<0.10	<0.10
Fe	4.4	<0.10	<0.1	<0.10	<0.10
B	25.1	30.60	33.4	0.07	<0.01
F		0.13		0.26	<0.10
Cl		0.15		0.08	0.08
NO3		2.00		0.09	0.09
SO4		0.37		0.05	0.02

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na	40.3	39.9
Li	11.8	11.7
K	10.5	9.9
Al	4.0	4.0
Si	39.8	41.6
Fe	1.9	1.9
B	19.0	18.9
F		
Cl		
NO3		
SO4		

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0316	153.2058	153.1833
Glass A	4.0009	40.0249	156.1837	156.1599
Glass B	4.0001	40.0080	156.1774	155.9045
Glass C	4.0001	40.0251	155.3342	155.0467
Glass D	4.0000	40.0358	154.3934	154.3679
Blank 2	0.0000	40.0354	149.2659	149.2429

Sample ID	Total Weight, g	Weight Loss, g	pH, Out
Blank 1	153.1406	0.0652	6.73
Glass A	156.1194	0.0643	10.55
Glass B	155.8350	0.3424	8.71
Glass C	154.9845	0.3497	10.70
Glass D	154.3243	0.0691	10.69
Blank 2	149.1995	0.0664	7.40

Day	Oven Temperature
1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 5.88
 Specific Resistance = 17.9 mohm-cm
 Date and Time In = 24-May-1988 8:00
 Date and Time Out = 31-May-1988 9:00

Table B.5. Laboratory 1 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	10.55		8.71		10.70
Na	48.00	47.4	12.40	12.20	68.00
Li	14.60	14.4	<0.05	<0.05	15.50
K	11.90	11.9	<2.00	<2.00	32.70
Al	4.10	4.2	3.20	3.20	3.70
Si	115.00	114.0	45.10	45.20	114.00
Fe	5.10	5.0	<0.10	<0.10	4.80
B	14.00	14.1	6.81	6.84	25.40
F	1.34		1.30		0.18
Cl	0.41		1.24		0.40
NO3	0.15		0.12		0.14
SO4	0.07		0.12		0.37

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Sample D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.69		6.73	7.40
Na	67.4	63.50	62.3	1.12	0.90
Li	15.4	23.60	23.4	<0.05	<0.05
K	33.3	<2.00	<2.0	<2.00	<2.00
Al	3.6	3.90	3.8	<0.10	<0.10
Si	114.0	90.70	89.8	<0.10	<0.10
Fe	4.8	<0.10	<0.1	<0.10	<0.10
B	25.4	32.30	32.1	<0.01	0.07
F		0.31		1.03	0.30
Cl		0.42		0.33	0.32
NO3		2.00		0.10	0.13
SO4		0.40		<0.02	<0.02

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	39.0	39.0
Li	12.1	11.6
K	9.3	9.2
Al	4.2	4.2
Si	43.1	42.7
Fe	2.0	1.9
B	19.8	19.6
F		
Cl		
NO3		
SO4		

Table B.6. Laboratory 2 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0129	151.1520	150.8314
Blank 2	0.0000	40.0012	151.0736	150.8753
Sample A-1	4.0016	40.0220	155.0382	154.1275
Sample A-2	4.0038	43.9990	155.2914	155.1097
Sample A-3	4.0025	44.0100	154.9320	154.2846
Sample B	4.0064	44.0190	155.2022	154.4203
Sample C	4.0025	44.0000	155.3177	155.1016
Sample D	4.0013	44.0060	155.1383	155.0574

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.4592	0.3722	4.5
Blank 2	143.5547	7.5190	Terminated
Sample A-1	148.3864	5.7411	Terminated
Sample A-2	154.2808	1.1060	10.2
Sample A-3	153.5808	1.3510	10.3
Sample B	149.3271	5.8750	Terminated
Sample C	154.6585	0.6592	10.4
Sample D	154.8165	0.3220	10.4

Day Oven
 Temperature

1	90.0
2	90.0
3	91.0
4	91.0
5	91.0
6	91.0
7	91.0

pH of High Purity Water = 6.70
 Specific Resistance = 18.0 mohm-cm
 Date and Time In = 12-May-1988 11:30
 Date and Time Out = 19-May-1988 13:00

Table B.6. Laboratory 2 Test Data (cont.)

WEEK 1

Analyte	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24	Glass A3 Sample 1-15	Glass C Samples 1-6 and 1-20
pH	10.20		10.30		10.40
Na	74.50	73.5	73.50	73.6	92.60
Li	21.90	21.9	22.10	22.0	21.40
K	17.00	17.0	17.00	17.0	43.80
Al	4.50	4.5	4.30	4.3	4.70
Si	151.00	155.0	153.00	153.0	149.00
Fe	6.20	7.1	6.20	6.3	8.90
B	23.50	23.4	23.40	23.4	36.90
F	1.50		2.30		1.60
Cl	0.92		1.10		0.90
NO3	0.12		0.23		0.12
SO4	0.36		0.41		0.68

Analyte	Glass C Sample 1-13	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Control Std. Sample 1-2
pH		10.400		4.500	
Na	95.3	59.400	59.200	0.250	38.60
Li	21.3	25.000	25.000	0.013	11.80
K	43.8	<0.200	<0.200	<0.200	9.11
Al	4.7	5.800	5.800	<0.100	4.00
Si	153.0	87.000	87.000	<1.000	38.80
Fe	9.3	<0.004	<0.004	<0.004	1.91
B	36.8	29.800	30.600	<0.060	20.30
F		1.500		1.500	
Cl		0.990		0.940	
NO3		0.170		<0.050	
SO4		0.520		0.130	

Analyte Control Std.
Sample 1-14

pH	
Na	38.60
Li	11.70
K	9.10
Al	4.00
Si	38.60
Fe	1.93
B	20.30
F	
Cl	
NO3	
SO4	

Note: Due to problems with certain tests or analyses, results were not reported for Samples 1-3 and 1-10 of Glass A1, Samples 1-4 and 1-16 of Glass B, and Sample 1-9 of Blank 2.

Table B.6. Laboratory 2 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	40.0030	151.3915	151.2448
Blank 2	0.000	40.0000	151.5684	151.4713
Sample A	4.000	44.0100	155.1460	155.0318
Sample B	4.000	44.0200	154.8633	154.7411
Sample C	4.003	44.0200	155.5740	155.4858
Sample D	4.001	43.9511	155.7585	155.6346

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	140.7961	10.5954	Terminated
Blank 2	151.3868	0.1816	4.5
Sample A	154.8444	0.3016	10.2
Sample B	154.5321	0.3310	8.7
Sample C	155.3119	0.2585	10.4
Sample D	155.0838	0.6747	10.5

Day	Oven Temperature
1	91.0
2	91.0
3	91.0
4	91.0
5	91.0
6	91.0
7	91.0

pH of High Purity Water = 6.20
 Specific Resistance = 18.0 mohm-cm
 Date and Time In = 18-May-1988 15:30
 Date and Time Out = 25-May-1988 16:30

Table B.6. Laboratory 2 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	10.200		8.700		10.40
Na	70.100	70.6	18.200	18.100	92.20
Li	21.200	24.8	<0.002	<0.002	20.50
K	17.500	20.0	<0.200	<0.200	44.50
Al	5.000	5.6	5.500	5.200	4.90
Si	167.000	182.0	72.000	68.300	158.00
Fe	7.000	7.7	<0.004	<0.004	7.00
B	22.400	24.9	11.500	10.800	35.10
F	1.500		1.900		1.50
Cl	0.120		0.780		0.16
NO3	0.068		0.120		<0.05
SO4	0.280		<0.100		0.57

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 2 Samples 2-7 and 2-18	Control Std. Sample 2-2
pH		10.500		4.500	
Na	92.3	68.700	69.200	0.270	38.00
Li	20.9	26.500	28.800	<0.002	12.00
K	45.4	<0.200	<0.200	<0.200	9.90
Al	4.9	7.100	7.400	<0.060	4.20
Si	163.0	104.000	110.000	<1.000	42.00
Fe	4.8	<0.004	<0.004	<0.004	1.96
B	7.6	32.400	34.500	<0.060	20.20
F		1.600		1.300	
Cl		0.230		0.044	
NO3		0.140		0.056	
SO4		0.440		<0.100	

Analyte Control Std.
 Sample 2-12

pH	
Na	37.10
Li	11.70
K	9.80
Al	4.20
Si	42.50
Fe	1.95
B	20.20
F	
Cl	
NO3	
SO4	

Note: Due to problems with certain tests or analyses, results were not reported for Sample 2-1 of Blank 1.

Table B.6. Laboratory 2 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	40.0080	150.8748	150.8503
Blank 2	0.000	40.1490	151.3118	151.2648
Sample A	4.002	43.9980	155.0802	155.0475
Sample B	4.001	44.0155	154.9795	154.8385
Sample C	4.008	44.0250	155.2536	155.1737
Sample D	4.000	44.0170	155.4061	155.3900

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.6954	0.1794	4.8
Blank 2	151.1337	0.1781	4.5
Sample A	154.9520	0.1282	10.3
Sample B	154.7167	0.2628	8.7
Sample C	155.0317	0.2219	10.5
Sample D	155.2720	0.1341	10.5

Day	Oven Temperature
1	91.0
2	91.0
3	91.0
4	91.0
5	91.0
6	91.0
7	91.0

pH of High Purity Water = 6.24
 Specific Resistance = 17.5 mohm-cm
 Date and Time In = 19-May-1988 17:00
 Date and Time Out = 26-May-1988 16:30

Table B.6. Laboratory 2 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	10.30		8.700		10.500
Na	60.80	61.8	18.000	18.300	104.000
Li	20.50	19.2	<0.002	<0.002	22.200
K	16.20	15.3	<0.200	<0.200	49.000
Al	5.30	5.1	5.300	5.500	5.400
Si	155.00	149.0	69.000	69.300	173.000
Fe	8.20	7.9	<0.004	<0.004	9.500
B	20.30	19.5	11.000	11.000	40.000
F	2.00		2.400		1.500
Cl	0.10		0.850		0.210
NO3	0.13		0.110		0.062
SO4	0.26		<0.100		0.700

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.500		4.800	4.500
Na	103.9	59.300	60.300	0.400	0.300
Li	22.9	25.400	25.700	<0.002	<0.002
K	50.1	<0.200	<0.200	<0.200	<0.200
Al	4.9	6.300	6.500	<0.060	<0.060
Si	174.0	91.000	94.700	<0.300	<0.300
Fe	8.0	<0.004	<0.004	<0.004	<0.004
B	41.0	30.100	31.200	<0.060	<0.060
F		1.900		1.500	1.600
Cl		0.180		0.048	0.043
NO3		0.170		<0.050	0.085
SO4		0.490		<0.100	<0.100

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	38.0	38.30
Li	10.0	11.70
K	8.5	9.70
Al	3.7	4.10
Si	37.7	41.50
Fe	1.7	1.92
B	17.9	20.00
F		
Cl		
NO3		
SO4		

Table 8.7. Laboratory 3 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40	150.59	150.59
Blank 2	0.0000	40	150.49	150.49
A-1	4.0003	40	154.72	154.72
A-2	4.0000	40	154.85	154.85
A-3	4.0004	40	154.07	154.11
B-1	4.0003	40	154.67	154.51
C-1	4.0000	40	154.89	154.86
D-1	4.0004	40	154.63	154.65

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.54	0.05	4.75
Blank 2	150.44	0.05	4.53
A-1	154.67	0.05	10.24
A-2	154.72	0.13	10.22
A-3	154.05	0.02	10.23
B-1	154.45	0.22	8.60
C-1	154.81	0.08	10.42
D-1	154.60	0.03	10.35

Day	Oven Temperature
1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 5.59
 Specific Resistance = 1.05 mohm-cm
 Date and Time In = 28-May-1988 8:25
 Date and Time Out = 04-Jun-1988 8:25

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	10.24		10.22		10.23
Na	53.11	52.87	53.06	50.26	49.63
Li	15.52	15.65	15.43	15.00	14.68
K	11.45	10.25	9.38	10.15	17.40
Al	4.25	4.08	3.94	3.78	3.89
Si	74.69	112.22	114.35	89.05	112.07
Fe	4.39	6.26	3.51	4.96	5.26
B	15.39	14.93	15.21	14.82	14.32
F	0.51		0.46		0.33
Cl	0.19		0.05		0.13
NO3	0.10		0.04		0.11
SO4	0.23		0.22		0.23

Analyte	Glass A3 Sample 1-15	Glass 8 Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.600		10.42	
Na	50.75	13.360	8.48	74.88	70.92
Li	15.18	<0.004	0.02	16.68	16.05
K	11.49	<0.515	0.82	33.91	30.56
Al	4.17	3.650	2.51	3.80	3.70
Si	85.53	30.240	27.64	109.22	86.41
Fe	5.85	<0.030	<0.03	4.91	7.57
B	14.51	7.220	4.24	26.64	25.59
F		0.960		0.27	
Cl		0.770		0.17	
NO3		0.090		0.10	
SO4		0.070		0.43	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.350		4.750	4.530	
Na	54.850	53.910	0.460	0.980	40.45
Li	21.160	21.020	0.010	0.005	11.93
K	<0.515	<0.515	<0.515	<0.515	7.45
Al	4.960	4.910	0.090	0.070	4.33
Si	72.690	71.480	0.940	3.780	36.19
Fe	<0.030	<0.030	<0.030	<0.030	2.07
B	26.160	26.230	<0.016	0.530	20.22
F	0.220		0.350	0.880	
Cl	0.120		0.240	0.050	
NO3	0.090		0.040	0.110	
SO4	0.350		0.070	0.030	

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 1

Analyte Control Std.
 Sample 1-14

pH	
Na	38.73
Li	11.77
K	9.98
Al	4.30
Si	36.39
Fe	2.70
B	19.38
F	
Cl	
NO3	
SO4	

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40	150.62	150.55
A	4.0002	40	154.37	154.29
B	4.0000	40	154.86	154.27
C	4.0003	40	154.31	154.25
D	4.0002	40	154.25	154.17
Blank 2	0.0000	40	151.01	150.95

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.51	0.11	5.33
A	154.24	0.13	10.26
B	154.22	0.64	8.65
C	154.21	0.10	10.44
D	154.14	0.11	10.37
Blank 2	150.92	0.09	4.60

Day Oven
 Temperature

1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 5.66

Specific Resistance = 1.13 mohm-cm

Date and Time In = 07-Jun-1988 11:11

Date and Time Out = 14-Jun-1988 10:20

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	10.26		8.650		10.44
Na	51.51	50.47	13.580	13.64	69.74
Li	15.37	15.21	<0.004	0.01	15.88
K	7.18	7.77	<0.515	7.69	24.93
Al	4.08	4.07	3.490	3.68	3.75
Si	90.76	117.44	45.700	44.94	109.60
Fe	11.41	3.09	0.030	<0.03	3.18
B	14.31	13.82	6.800	7.31	24.46
F	0.27		1.260		<0.02
Cl	1.02		0.550		0.07
NO3	0.11		0.040		0.09
SO4	0.33		0.090		0.42

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.37		5.330	4.600
Na	69.48	58.98	59.560	0.090	1.400
Li	15.39	22.74	22.730	<0.004	0.160
K	26.28	12.71	<0.515	<0.515	<0.515
Al	3.76	4.33	4.340	<0.041	0.100
Si	109.24	82.23	80.920	<0.044	2.250
Fe	4.52	0.16	<0.030	<0.030	<0.030
B	25.33	29.50	28.590	0.420	1.390
F		0.05		0.890	0.940
Cl		0.06		0.800	<0.020
NO3		0.08		0.110	0.050
SO4		0.40		0.140	0.070

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na	38.16	38.37
Li	11.49	11.67
K	3.20	9.44
Al	4.15	4.04
Si	35.71	38.70
Fe	3.29	1.90
B	18.08	19.33
F		
Cl		
NO3		
SO4		

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40	148.66	148.61
A	4.0001	40	154.46	154.44
B	4.0003	40	155.05	155.04
C	4.0003	40	154.69	154.68
D	4.0002	40	154.31	154.28
Blank 2	0.0000	40	150.63	150.62

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	148.59	0.07	4.49
A	154.40	0.06	10.20
B	155.00	0.05	8.65
C	154.65	0.04	10.39
D	154.25	0.06	10.30
Blank 2	150.58	0.05	4.31

Day	Oven Temperature
1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 5.60
 Specific Resistance = 1.34 mohm-cm
 Date and Time In = 14-Jun-1988 10:07
 Date and Time Out = 21-Jun-1988 9:35

Table B.7. Laboratory 3 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	10.200		8.650		10.39
Na	51.950	50.68	13.710	12.57	73.10
Li	15.490	15.36	0.005	0.01	16.42
K	<0.515	5.89	<0.515	0.10	29.19
Al	4.230	3.99	3.650	3.56	3.91
Si	116.990	117.10	48.290	48.21	116.93
Fe	3.800	3.39	0.180	0.04	4.22
B	14.760	14.19	7.190	7.23	26.00
F	0.090		1.150		0.04
Cl	0.040		0.500		0.09
NO3	<0.020		0.100		<0.02
SO4	0.220		0.070		0.41

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.300		4.490	4.310
Na	71.91	56.390	56.620	0.960	0.500
Li	16.31	21.740	22.040	<0.004	0.040
K	25.40	<0.515	<0.515	<0.515	<0.515
Al	3.89	5.020	5.050	<0.041	<0.041
Si	117.73	83.170	81.700	0.230	<0.044
Fe	5.06	0.100	0.030	<0.030	0.020
B	25.88	27.250	27.760	0.140	0.480
F		0.380		0.700	1.340
Cl		0.190		<0.020	0.390
NO3		0.110		<0.020	0.130
SO4		0.370		0.020	0.080

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	39.390	38.46
Li	12.020	11.78
K	<0.515	4.92
Al	4.300	4.16
Si	38.130	38.37
Fe	2.020	2.07
B	19.820	19.22
F		
Cl		
NO3		
SO4		

Table B.8. Laboratory 4 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0067	150.95	150.91
Sample A-1	4.0001	40.0112	155.06	155.06
Sample A-2	4.0000	40.0060	154.83	154.80
Sample A-3	4.0003	40.0070	155.28	155.25
Sample B	4.0004	40.0050	155.30	155.28
Sample C	4.0003	40.0074	154.98	154.95
Sample D	4.0002	40.0043	155.34	155.31
Blank 2	0.0000	40.0045	151.43	151.41

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.86	0.09	4.92
Sample A-1	154.97	0.09	10.39
Sample A-2	154.74	0.09	10.37
Sample A-3	155.19	0.09	10.30
Sample B	155.22	0.08	8.75
Sample C	154.88	0.10	10.48
Sample D	155.25	0.09	10.35
Blank 2	151.35	0.08	4.69

Day Oven
 Temperature

1	90.0
2	90.0
3	90.0
4	90.0
5	90.2
6	90.1
7	90.0

pH of High Purity Water = 6.0

Specific Resistance = >17.5 mohm-cm

Date and Time In = 28-Apr-1988 12:20

Date and Time Out = 05-May-1988 12:20

Table B.8. Laboratory 4 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	10.39		10.37		10.30
Na	46.80	48.60	47.90	49.70	49.50
Li	16.60	16.90	17.00	17.50	17.50
K	11.00	12.40	11.50	12.60	11.90
Al	3.75	3.74	3.79	3.84	3.68
Si	107.00	108.00	108.00	110.00	110.00
Fe	2.97	3.05	3.25	3.20	5.13
B	15.20	15.70	15.40	15.50	16.20
F	0.64		0.68		0.68
Cl	0.92		2.30		5.30
NO3	<0.10		<0.10		<0.10
S04	<0.05		<0.05		0.35

Analyte	Glass A3 Sample 1-15	Glass 8 Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.75		10.48	
Na	50.90	12.60	13.00	65.40	67.20
Li	17.80	0.29	0.33	16.80	19.40
K	12.60	0.47	0.48	31.50	32.80
Al	3.74	3.22	3.33	3.34	3.37
Si	112.00	46.70	47.10	107.00	109.00
Fe	4.85	0.39	0.47	3.12	3.10
B	15.40	7.40	7.20	27.10	26.90
F		1.00		0.84	
Cl		2.00		1.00	
NO3		<0.10		<0.10	
S04		<0.05		<0.05	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.35		4.92	4.69	
Na	53.00	52.70	0.37	0.26	36.90
Li	23.30	23.30	0.02	0.03	13.80
K	0.26	0.68	0.08	0.04	9.30
Al	5.00	5.15	0.01	0.01	5.37
Si	75.70	76.60	0.01	0.04	40.40
Fe	1.31	1.47	0.00	0.31	2.17
B	27.40	27.40	-0.10	0.00	21.00
F	1.00		0.64	0.84	
Cl	6.00		0.92	2.00	
NO3	<0.10		<0.10	<0.10	
S04	0.65		<0.05	<0.05	

Table B.8. Laboratory 4 Test Data (cont.)

WEEK 1

Analyte Control Std.
 Sample 1-14

pH	
Na	40.50
Li	14.00
K	10.40
Al	5.30
Si	42.00
Fe	2.04
B	20.30
F	
Cl	
NO3	

Table B.B. Laboratory 4 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0001	151.36	151.33
Sample A	4.0001	40.0062	155.77	155.76
Sample B	4.0002	40.0014	154.86	154.84
Sample C	4.0002	40.0058	154.95	154.92
Sample D	4.0001	40.0074	155.58	155.57
Blank 2	0.0000	40.0043	150.99	150.98

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	151.27	0.09	5.19
Sample A	155.70	0.07	10.32
Sample B	154.80	0.06	8.76
Sample C	154.87	0.08	10.51
Sample D	155.51	0.07	10.38
Blank 2	150.93	0.06	4.88

Day	Oven Temperature
1	89.5
2	90.0
3	90.0
4	90.0
5	90.0
6	89.9
7	89.9

pH of High Purity Water = 5.90
 Specific Resistance = >17.5 mohm-cm
 Date and Time In = 10-May-1988 13:30
 Date and Time Out = 17-May-1988 13:30

Table B.8. Laboratory 4 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	10.32		8.76		10.51
Na	50.30	50.40	12.00	12.20	68.30
Li	14.40	14.80	0.04	0.21	15.30
K	12.10	11.70	0.21	0.05	31.80
Al	3.73	3.87	3.00	3.25	3.43
Si	108.00	108.00	45.60	44.70	104.00
Fe	2.98	3.31	-0.08	-0.11	3.72
B	14.50	14.30	7.08	7.02	25.40
F	1.75		1.75		1.75
Cl	1.19		1.68		1.22
NO ₃	0.08		0.16		0.13
SO ₄	0.32		0.13		0.47

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.38		5.19	4.88
Na	68.70	52.80	52.90	0.59	0.13
Li	15.80	19.80	19.90	-0.01	0.02
K	32.50	-0.08	0.32	0.35	-0.03
Al	3.42	4.60	4.60	0.08	0.05
Si	103.00	73.90	71.70	0.40	0.03
Fe	3.80	-0.05	0.19	0.17	-0.02
B	25.10	26.30	25.70	0.19	0.14
F		2.25		1.81	1.15
Cl		1.25		0.50	1.25
NO ₃		0.08		<0.01	0.25
SO ₄		0.45		0.05	0.16

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na	41.30	42.20
Li	11.80	12.10
K	10.00	9.80
Al	4.28	4.29
Si	41.40	41.30
Fe	2.14	1.78
B	19.70	19.80
F		
Cl		
NO ₃		
SO ₄		

Table B.8. Laboratory 4 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0014	151.34	151.33
Sample A	4.0001	40.0006	155.04	155.02
Sample B	4.0002	40.0009	154.97	154.94
Sample C	4.0002	40.0040	155.22	155.20
Sample D	4.0001	40.0022	155.70	155.65
Blank 2	0.0000	40.0009	151.80	151.77

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	151.26	0.08	4.54
Sample A	154.97	0.07	10.29
Sample B	154.87	0.10	8.73
Sample C	155.14	0.08	10.17
Sample D	155.60	0.10	10.41
Blank 2	151.73	0.07	4.60

Day	Oven Temperature
1	89.5
2	90.0
3	90.0
4	90.0
5	90.0
6	89.5
7	90.0

pH of High Purity Water = 6.04
 Specific Resistance = >17.5 mohm-cm
 Date and Time In = 18-May-1988 13:18
 Date and Time Out = 25-May-1988 13:30

Table B.8. Laboratory 4 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Sample 3-5
pH	10.29		8.73		10.17
Na	52.40	56.90	12.20	13.60	71.80
Li	15.00	14.70	0.15	0.16	14.80
K	12.30	14.00	0.31	0.17	34.40
Al	4.71	5.07	3.51	3.74	3.70
Si	116.00	125.00	48.20	50.90	110.00
Fe	5.94	6.30	0.01	0.00	3.69
B	15.50	16.50	7.54	8.07	26.50
F	1.56		2.13		
Cl	0.85		0.90		
NO3	<0.10		0.16		
SO4	0.23		0.13		

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.41		4.54	4.60
Na	88.50	58.90	64.70	0.13	0.16
Li	15.30	20.30	22.20	0.18	-0.01
K	41.70	0.13	-0.31	0.04	0.05
Al	3.91	4.77	5.22	0.01	0.01
Si	117.00	79.90	86.80	0.04	0.06
Fe	3.80	-0.01	-0.03	0.00	0.00
B	27.90	29.80	32.30	0.01	0.01
F		2.19		2.00	1.10
Cl		1.25		0.85	0.87
NO3		<0.10		<0.10	0.16
SO4		0.42		0.10	0.10

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	41.70	43.30
Li	11.90	12.10
K	9.36	11.00
Al	4.58	4.59
Si	42.70	43.40
Fe	1.88	1.91
B	20.30	20.80
F		
Cl		
NO3		
SO4		

Table B.9. Laboratory 5 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Sample A-1	4.00	40.18	155.30	155.30
Sample A-2	3.99	40.04	155.17	155.14
Sample A-3	3.99	40.04	154.95	154.95
Sample B	3.99	40.11	155.48	155.48
Sample C	4.00	40.10	155.33	155.28
Sample D	4.00	39.99	155.04	155.02
Blank 1	0.00	40.02	151.12	151.11
Blank 2	0.00	40.00	151.20	151.20

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Sample A-1	155.24	0.06	11.2
Sample A-2	155.08	0.09	11.2
Sample A-3	154.89	0.06	11.2
Sample B	155.44	0.04	9.0
Sample C	155.22	0.11	11.4
Sample D	154.97	0.07	11.3
Blank 1	151.06	0.06	4.2
Blank 2	151.15	0.05	4.3

Day Oven
 Temperature

1	90.0
2	90.0
3	89.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 6.00
 Specific Resistance = 18.2 mohm-cm
 Date and Time In = 06-Jul-1988 14:43
 Date and Time Out = 13-Jul-1988 14:42

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	11.200		11.20		11.200
Na	51.000	50.90	50.90	49.10	50.600
Li	16.080	15.83	15.93	15.59	15.980
K	13.000	12.50	12.60	12.40	12.500
Al	3.560	3.54	3.47	3.44	3.390
Si	115.000	117.00	113.00	117.00	114.000
Fe	3.590	3.77	3.12	3.27	3.080
B	13.900	13.80	13.62	13.50	13.700
F	0.590		0.77		0.700
Cl	0.120		1.10		0.097
NO3	0.067		<0.05		<0.050
SO4	0.029		1.80		0.240

Analyte	Glass A3 Sample 1-15	Glass B Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		9.00		11.40	
Na	49.50	14.20	12.30	70.10	66.60
Li	15.90	<0.01	<0.01	16.59	16.17
K	12.00	0.33	0.33	33.50	32.40
Al	3.44	3.17	3.15	3.09	3.08
Si	121.00	48.50	51.60	110.00	115.00
Fe	3.24	0.02	<0.01	3.15	3.26
B	13.80	6.75	6.75	23.70	23.60
F		0.88		0.98	
Cl		0.67		1.30	
NO3		<0.05		0.11	
SO4		<0.05		0.64	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	11.300		4.20	4.30	
Na	54.500	55.50	0.87	1.05	40.40
Li	22.250	22.32	<0.01	<0.01	12.69
K	<0.100	<0.10	<0.10	<0.10	10.20
Al	4.620	4.74	<0.10	<0.10	3.83
Si	81.800	85.20	<0.10	<0.10	42.00
Fe	<0.010	<0.01	<0.01	<0.01	2.03
B	24.800	25.40	<0.05	<0.05	18.80
F	0.590		1.10	0.74	
Cl	0.390		<0.05	0.67	
NO3	0.063		<0.05	<0.05	
SO4	0.430		<0.05	1.80	

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 1

Analyte Control Std.
Sample 1-14

pH	
Na	39.90
Li	12.56
K	9.69
Al	3.83
Si	44.40
Fe	2.04
B	18.80
F	
Cl	
NO3	
SO4	

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Sample A	4.00	40.00	154.79	154.74
Sample B	3.99	39.99	155.04	155.03
Sample C	3.99	40.00	155.49	155.44
Sample D	3.99	40.00	155.44	155.42
Blank 1	0.00	39.92	150.72	150.72
Blank 2	0.00	39.99	151.29	151.27

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Sample A	154.70	0.09	11.2
Sample B	154.99	0.05	9.1
Sample C	155.41	0.08	11.4
Sample D	155.36	0.08	11.2
Blank 1	150.69	0.03	4.4
Blank 2	151.23	0.06	4.4

Day	Oven Temperature
1	90.0
2	90.0
3	90.0
4	90.0
5	90.0
6	90.0
7	90.0

pH of High Purity Water = 6.10

Specific Resistance = 18.2 mohm-cm

Date and Time In = 13-Jul-1988 14:22

Date and Time Out = 20-Jul-1988 14:08

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	11.20		9.100		11.400
Na	54.20	51.20	13.000	12.50	70.600
Li	16.52	15.96	<0.010	<0.01	16.460
K	13.30	12.90	0.320	0.36	34.200
Al	3.64	3.50	3.260	3.10	3.240
Si	115.00	114.00	49.200	46.80	109.000
Fe	3.16	3.20	<0.010	<0.01	3.360
B	14.10	13.50	6.860	6.34	24.000
F	0.62		1.100		0.570
Cl	1.20		1.800		0.220
NO3	0.08		0.099		0.063
SO4	0.34		0.160		0.440

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		11.20		4.40	4.400
Na	69.80	57.60	57.40	0.36	0.080
Li	16.64	22.40	22.80	<0.01	<0.010
K	33.80	0.30	<0.10	<0.10	<0.100
Al	3.12	4.62	4.62	<0.10	<0.100
Si	107.00	81.20	81.00	<0.10	<0.100
Fe	3.20	0.02	<0.01	<0.01	<0.010
B	23.00	25.80	25.80	<0.05	<0.050
F		0.42		0.76	0.780
Cl		0.17		1.10	1.000
NO3		<0.05		0.07	0.058
SO4		0.38		0.12	1.700

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na	41.20	40.60
Li	12.76	12.92
K	10.10	10.20
Al	3.88	3.96
Si	41.80	43.20
Fe	2.02	2.08
B	18.90	19.10
F		
Cl		
NO3		
SO4		

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Sample A	4.00	40.02	154.86	154.83
Sample B	3.99	39.99	154.92	154.87
Sample C	4.00	40.01	155.10	155.05
Sample D	3.99	40.00	155.33	155.24
Blank 1	0.00	39.99	151.23	151.18
Blank 2	0.00	40.00	150.70	150.66

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Sample A	154.80	0.06	11.2
Sample B	154.85	0.07	9.1
Sample C	155.03	0.07	11.5
Sample D	155.22	0.11	11.4
Blank 1	151.17	0.06	4.3
Blank 2	150.64	0.06	4.2

Day	Oven Temperature
1	90.0
2	90.0
3	91.0
4	91.0
5	91.0
6	90.0
7	91.0

pH of High Purity Water = 5.90

Specific Resistance = 18.2 mohm-cm

Date and Time In = 20-Jul-1988 14:10

Date and Time Out = 27-Jul-1988 14:10

Table B.9. Laboratory 5 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	11.200		9.100		11.50
Na	52.000	51.80	13.200	12.34	69.80
Li	15.500	14.92	<0.010	<0.01	15.74
K	13.300	13.50	0.400	0.32	34.40
Al	3.520	3.58	3.060	3.04	3.28
Si	115.000	115.00	48.200	48.20	112.00
Fe	3.560	3.70	0.020	0.02	4.00
B	12.600	12.60	6.140	6.16	21.80
F	0.390		1.500		0.98
Cl	0.091		1.600		0.26
NO3	<0.050		0.085		0.12
SO4	0.200		0.150		0.50

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		11.40		4.300	4.200
Na	70.40	53.80	55.80	0.720	0.660
Li	15.16	20.20	20.60	<0.010	<0.010
K	35.00	<0.10	<0.10	<0.100	<0.100
Al	3.30	4.76	4.98	<0.100	<0.100
Si	112.00	79.40	84.40	<0.100	<0.100
Fe	4.06	<0.01	<0.01	<0.010	<0.010
B	22.20	21.80	23.20	<0.050	<0.050
F		0.41		0.830	1.100
Cl		0.19		0.077	0.075
NO3		0.11		<0.050	0.085
SO4		0.42		<0.050	<0.050

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	41.00	41.40
Li	12.72	12.32
K	10.20	10.30
Al	3.84	3.84
Si	43.80	43.20
Fe	2.06	2.10
B	18.00	17.90
F		
Cl		
NO3		
SO4		

Table B.10. Laboratory 6 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	40.01	150.35	150.32
Sample A1	4.003	40.00	155.85	155.80
Sample A2	4.000	40.01	156.41	156.39
Sample A3	4.001	39.99	155.75	155.73
Sample B	4.000	40.00	155.88	155.80
Sample C	4.002	39.99	154.13	154.10
Sample D	4.001	40.02	155.49	155.48
Blank 2	0.000	40.01	152.43	152.42

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.27	0.05	5.00
Sample A1	152.36	0.05	4.44
Sample A2	155.75	0.05	10.40
Sample A3	156.34	0.05	10.42
Sample B	155.67	0.05	10.42
Sample C	155.75	0.05	8.76
Sample D	154.05	0.05	10.62
Blank 2	155.42	0.06	10.55

Day Oven
 Temperature

1	91.2
2	90.4
3	
4	90.7
5	
6	
7	90.6

pH of High Purity Water = 5.67

Specific Resistance = 17.0 mohm-cm

Date and Time In = 04-Aug-1988 13:25

Date and Time Out = 11-Aug-1988 13:25

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	9.80		9.82		9.82
Na	46.00	45.20	44.60	45.80	46.30
Li	15.50	15.40	15.30	15.40	15.50
K	12.50	12.00	12.70	12.30	12.40
Al	3.90	3.90	3.83	3.83	4.08
Si	107.00	108.00	106.00	107.00	107.00
Fe	3.48	3.62	3.35	3.24	4.07
B	14.90	14.90	14.70	14.80	14.90
F	1.90		1.90		1.90
Cl	0.02		0.20		0.20
NO3	<0.40		<0.40		<0.40
SO4	<0.50		<0.50		<0.50

Analyte	Glass A3 Sample 1-15	Glass B Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.200		10.10	
Na	46.10	12.600	12.000	69.50	68.00
Li	15.70	0.005	0.008	15.50	16.00
K	12.00	<0.200	<0.200	31.30	31.40
Al	4.08	3.430	3.430	3.52	3.52
Si	108.00	45.900	46.000	106.00	105.00
Fe	4.28	0.016	0.017	3.70	3.71
B	15.00	7.310	7.330	25.80	25.90
F		1.700		1.90	
Cl		0.500		0.20	
NO3		<0.400		<0.40	
SO4		<0.500		<0.50	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.050		4.0200	4.050	
Na	48.300	46.70	0.8300	<0.480	37.70
Li	21.200	20.80	<0.0014	0.003	12.60
K	<0.200	<0.20	0.2600	<0.200	10.00
Al	4.920	4.90	<0.4800	<0.014	4.29
Si	75.800	76.00	0.1390	0.214	41.30
Fe	0.014	0.01	0.0050	0.003	1.99
B	25.700	25.70	<0.0080	0.290	20.30
F	1.900		1.7000	1.700	
Cl	0.200		0.1000	0.900	
NO3	<0.400		<0.4000	<0.400	
SO4	<0.500		<0.5000		

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 1

Analyte Control Std.
 Sample 1-14

pH	
Na	38.30
Li	12.80
K	9.30
Al	4.35
Si	41.60
Fe	2.04
B	20.60
F	
Cl	
NO3	
SO4	

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	39.99	150.40	150.38
Blank 2	0.000	40.01	152.62	152.59
Sample A	4.001	40.00	153.10	153.08
Sample B	4.001	40.02	154.21	154.17
Sample C	4.002	40.00	155.88	155.85
Sample D	4.000	40.00	153.36	153.32

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.33	0.07	5.08
Blank 2	152.54	0.08	4.37
Sample A	153.03	0.07	10.42
Sample B	154.12	0.09	8.86
Sample C	155.81	0.07	10.58
Sample D	153.27	0.09	10.53

Day	Oven Temperature
1	90.1
2	90.5
3	
4	
5	90.6
6	90.5
7	90.4

pH of High Purity Water = 5.81

Specific Resistance = 17.0 mohm-cm

Date and Time In = 11-Aug-1988 15:03

Date and Time Out = 18-Aug-1988 13:30

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	10.42		8.860		10.58
Na	45.50	47.10	12.200	12.300	69.50
Li	15.00	15.20	0.008	0.008	16.00
K	12.10	11.00	1.200	<0.200	32.00
Al	3.78	3.80	3.380	3.510	3.50
Si	110.00	109.00	46.000	46.700	110.00
Fe	3.48	3.62	0.075	0.016	3.61
B	14.70	14.70	7.240	7.350	25.90
F	1.40		1.200		1.80
Cl	1.20		1.400		1.00
NO ₃	<0.40		<0.40		<0.40
SO ₄	<0.50		<0.50		0.50

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.530		5.0800	4.3700
Na	68.50	47.400	47.00	0.0710	0.0380
Li	16.20	20.500	20.30	0.0018	<0.0014
K	31.00	0.800	0.80	1.0000	<0.2000
Al	3.46	4.900	4.86	<0.0140	<0.0140
Si	109.00	76.200	75.90	0.2100	0.2430
Fe	3.63	0.011	0.01	<0.0025	<0.0025
B	25.70	25.400	25.20	0.0080	0.0140
F		1.500		1.5000	1.4000
Cl		<0.100		<0.1000	<0.1000
NO ₃		<0.400		<0.4000	<0.4000
SO ₄		<0.500		<0.5000	<0.5000

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na	37.60	38.30
Li	12.20	12.50
K	10.10	10.00
Al	4.30	4.31
Si	41.50	41.50
Fe	2.01	2.01
B	20.30	20.20
F		
Cl		
NO ₃		
SO ₄		

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	39.99	149.66	149.63
Blank 2	0.0000	39.99	150.18	150.15
Sample A	3.9998	39.98	155.89	155.85
Sample B	4.0000	40.00	155.88	155.85
Sample C	4.0000	39.99	156.03	156.01
Sample D	4.0010	40.01	156.33	156.30

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	149.59	0.07	5.84
Blank 2	150.12	0.06	4.78
Sample A	155.75	0.14	10.44
Sample B	155.82	0.06	8.93
Sample C	155.97	0.06	10.63
Sample D	156.27	0.06	10.56

Day	Oven Temperature
1	90.4
2	90.5
3	
4	
5	90.5
6	90.5
7	90.5

pH of High Purity Water = 5.83
 Specific Resistance = 15.0 mohm-cm
 Date and Time In = 18-Aug-1988 14:27
 Date and Time Out = 25-Aug-1988 13:38

Table B.10. Laboratory 6 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	10.44		8.930		10.63
Na	45.20	47.40	12.800	12.400	69.40
Li	14.80	15.70	0.006	0.008	15.90
K	12.00	11.00	<0.200	<0.200	31.00
Al	3.80	3.88	3.460	3.490	3.77
Si	109.00	111.00	47.000	47.500	110.00
Fe	3.06	3.40	0.020	0.050	4.59
B	14.50	14.70	7.330	7.390	25.80
F	0.40		0.400		0.50
Cl	0.30		0.600		0.10
NO3	<0.40		<0.400		<0.40
SO4	<0.50		<0.500		<0.50

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.560		5.8400	4.7800
Na	69.20	65.500	64.800	0.9510	0.6460
Li	16.50	24.500	25.200	0.0024	<0.0014
K	31.00	0.600	<0.200	0.5000	<0.2000
Al	3.78	3.850	3.860	0.0240	0.0240
Si	112.00	86.800	87.200	0.2210	0.2310
Fe	4.87	0.019	0.013	0.0090	0.0090
B	26.00	33.800	34.100	0.0220	0.0180
F		0.500		<0.2000	0.4000
Cl		0.200		0.2000	1.0000
NO3		<0.400		<0.4000	<0.4000
SO4		<0.500		<0.5000	<0.5000

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	38.60	38.60
Li	12.60	12.60
K	9.00	9.00
Al	4.32	4.33
Si	41.60	41.60
Fe	2.01	2.05
B	20.30	20.30
F		
Cl		
NO3		
SO4		

Table B.11. Laboratory 7 Test Data

WEEK 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0	40	150.96	150.96
Sample A1	4	40	154.38	154.13
Sample A2	4	40	154.38	154.00
Sample A3	4	40	154.55	154.54
Sample B	4	40	154.83	154.80
Sample C	4	40	154.54	154.54
Sample D	4	40	155.20	155.20
Blank 2	0	40	150.43	150.43

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.93	0.03	4.02
Sample A1	154.09	0.29	9.80
Sample A2	153.96	0.42	9.82
Sample A3	154.50	0.05	9.82
Sample B	154.75	0.08	8.20
Sample C	154.49	0.05	10.10
Sample D	155.14	0.06	10.05
Blank 2	150.40	0.03	4.05

Day Oven
 Temperature

1	90.0
2	90.2
3	90.8
4	
5	
6	91.0
7	90.0

pH of High Purity Water = 5.50
 Specific Resistance = 16.5 mohm-cm
 Date and Time In = 27-Apr-1988 9:40
 Date and Time Out = 04-May-1988 9:40

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	9.800		9.820		9.820
Na (ICP)	50.280	49.780	50.990	51.350	52.010
Na (AA)	55.130	56.250	56.130	56.250	55.130
Li	14.490	14.640	14.740	15.070	14.980
K	12.940	14.460	12.870	13.640	12.530
Al	3.654	3.681	3.560	3.640	3.518
Si	105.600	105.900	106.200	109.700	108.000
Fe	3.225	3.369	3.179	3.447	2.882
B	14.440	14.550	14.650	14.960	14.980
F	<1.000		<1.000		<1.000
Cl	<1.000		<1.000		<1.000
NO3	<1.500		<1.500		<1.500
SO4	<0.500		4.770		<0.500

Analyte	Glass A3 Sample 1-15	Glass B Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.2000		10.100	
Na (ICP)	51.320	13.4600	12.960	66.320	67.920
Na (AA)	56.250	14.8600	14.510	75.200	74.300
Li	14.990	0.0399	<0.020	14.650	15.200
K	13.360	0.2200	<0.010	32.800	35.800
Al	3.543	3.3360	3.354	3.104	3.164
Si	108.500	44.6900	44.640	101.000	105.500
Fe	3.005	<0.0200	<0.020	3.048	3.238
B	14.960	7.1320	7.105	24.460	25.230
F		<1.0000		<1.000	
Cl		<1.0000		<1.000	
NO3		<1.5000		<1.500	
SO4		<0.5000		<0.500	

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.050		4.0200	4.0500	
Na (ICP)	50.790	50.570	0.9558	0.1220	38.620
Na (AA)	56.550	55.950	0.9500	0.0440	43.060
Li	19.330	19.600	<0.0200	0.0200	11.320
K	<0.010	<0.010	0.4500	<0.0100	9.660
Al	4.992	5.025	0.0172	0.0532	3.938
Si	72.120	72.840	<0.0200	0.0956	39.020
Fe	<0.020	<0.020	<0.0200	<0.0200	1.962
B	23.940	24.240	<0.0200	0.0657	18.960
F	<1.000		<1.0000	<1.0000	
Cl	<1.000		<1.0000	<1.0000	
NO3	<1.500		<1.5000	4.6400	
SO4	<0.500		<0.5000	<0.5000	

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 1

Analyte	Control Std. Sample 1-14
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pH	
Na (ICP)	37.650
Na (AA)	43.310
Li	11.010
K	11.350
Al	3.872
Si	38.450
Fe	1.943
B	18.560
F	
Cl	
NO3	
SO4	

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0	40	146.83	146.83
Glass A	4	40	155.26	155.26
Glass B	4	40	154.64	154.62
Glass C	4	40	154.70	154.69
Glass D	4	40	154.77	154.76
Blank 2	0	40	150.63	150.63

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	146.76	0.07	4.19
Glass A	155.18	0.08	9.84
Glass B	154.53	0.11	8.22
Glass C	154.60	0.10	10.24
Glass D	154.66	0.11	10.20
Blank 2	150.57	0.06	5.13

Day Oven
 Temperature

1	90.0
2	90.0
3	
4	
5	91.0
6	91.0
7	91.0

pH of High Purity Water = 5.60
 Specific Resistance = 16.5 mohm-cm
 Date and Time In = 05-May-1988 9:22
 Date and Time Out = 12-May-1988 9:22

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Samples 2-5 and 2-16
pH	9.840		8.220		10.240
Na (ICP)	52.170	50.980	14.060	13.360	70.760
Na (AA)	54.700	52.940	15.290	14.900	73.260
Li	15.320	15.250	<0.020	<0.200	15.830
K	12.360	12.500	0.120	0.080	33.270
Al	3.595	3.557	3.481	3.417	3.193
Si	109.700	109.700	47.180	46.740	108.100
Fe	3.172	3.248	<0.020	<0.020	3.275
B	14.940	14.870	7.532	7.486	26.000
F	<1.000		<1.000		<1.000
Cl	1.530		2.110		
NO3	<1.500		<1.500		<1.500
SO4	<0.500		<0.500		<0.500

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.200		4.1900	5.130
Na (ICP)	69.610	51.160	49.320	0.8792	0.729
Na (AA)	72.090	53.330	52.160	0.9300	0.900
Li	15.690	19.910	19.490	<0.0200	<0.020
K	33.050	<0.010	<0.010	<0.0100	<0.010
Al	3.176	5.152	5.076	<0.0200	<0.020
Si	107.600	74.070	72.810	<0.0200	<0.020
Fe	3.290	<0.020	<0.020	<0.0200	<0.020
B	25.750	24.040	23.600	<0.0200	0.057
F		<1.000		<1.0000	<1.000
Cl		1.700		3.6500	<1.000
NO3		<1.500		<1.5000	<1.500
SO4		<0.500		<0.5000	<0.500

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
pH		
Na (ICP)	39.06	38.970
Na (AA)	43.76	41.610
Li	11.61	11.570
K	10.13	9.770
Al	4.01	3.998
Si	39.99	40.330
Fe	2.05	2.025
B	19.27	19.220
F		
Cl		
NO3		
SO4		

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0	40	150.76	150.72
Sample A	4	40	154.65	154.65
Sample B	4	40	155.18	155.15
Sample C	4	40	155.28	155.25
Sample D	4	40	154.51	154.49
Blank 2	0	40	150.95	150.92

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	150.65	0.11	4.16
Sample A	154.57	0.08	9.82
Sample B	155.09	0.09	8.18
Sample C	155.18	0.10	10.21
Sample D	154.45	0.06	10.17
Blank 2	150.86	0.09	4.17

Day	Oven Temperature
1	91.0
2	91.0
3	
4	
5	91.0
6	91.0
7	91.0

pH of High Purity Water = 5.48
 Specific Resistance = 16.5 mohm-cm
 Date and Time In = 12-May-1988 9:35
 Date and Time Out = 19-May-1988 9:35

Table B.11. Laboratory 7 Test Data (cont.)

WEEK 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	9.82		8.180		10.210
Na (ICP)	51.36	51.290	14.210	13.380	71.620
Na (AA)	54.32	54.130	14.590	14.940	74.720
Li	14.78	14.990	<0.020	<0.020	15.650
K	12.67	12.170	0.178	0.071	34.320
Al	3.48	3.561	3.456	3.441	3.180
Si	107.80	109.800	47.660	47.470	108.500
Fe	3.03	3.216	<0.020	<0.020	3.283
B	14.58	14.760	7.539	7.500	25.900
F	<1.00		<1.000		<1.000
Cl	1.14		<1.000		<1.000
NO3	<1.50		<1.500		<1.500
SO4	<0.50		<0.500		<0.500

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Glass D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		10.170		4.1600	4.1700
Na (ICP)	71.360	53.660	53.180	0.8616	0.7630
Na (AA)	74.520	57.460	55.300	0.9750	0.9400
Li	15.720	20.470	20.640	<0.0200	<0.0200
K	33.810	<0.010	<0.010	0.0880	<0.0100
Al	3.213	5.187	5.174	<0.0200	<0.0200
Si	109.200	76.360	76.740	<0.0200	<0.0200
Fe	3.330	<0.020	<0.020	<0.0200	<0.0200
B	26.030	25.050	25.250	0.3340	0.0625
F		<1.000		<1.0000	<1.0000
Cl		<1.000		<1.0000	<1.0000
NO3		<1.500		<1.5000	<1.5000
SO4		<0.500		<0.5000	<0.5000

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na (ICP)	38.530	38.700
Na (AA)	42.360	42.560
Li	11.270	11.300
K	10.040	9.750
Al	3.866	3.896
Si	39.050	39.720
Fe	1.917	1.917
B	18.790	18.930
F		
Cl		
NO3		
SO4		

APPENDIX C

ESTIMATES OF BETWEEN-LAB AND WITHIN-LAB PRECISION

APPENDIX C

ESTIMATES OF BETWEEN-LAB AND WITHIN-LAB PRECISION

The results of the statistical analyses to estimate between-lab and within-lab standard deviations are given in Tables C.1 through C.7. The results in each table are discussed below. The data given in Appendix B were used as the basis of the statistical analysis. The data points identified in Table 3.1 of the text were deleted from the data set (as outliers) for the purposes of the statistical analyses.

C.1 PCT TESTING OF THE FOUR GLASSES--OVERALL ESTIMATES OF PRECISION

Tables C.1 and C.2 contain means, standard deviations, and percent relative standard deviations (%RSDs) for pH and concentrations of seven elements, with results given for each of the four glasses tested. Both within-lab and between-lab standard deviations are given. Because the Lab 2 PCT results on the four glasses differed significantly from those of the other participating labs, the statistical analyses were performed with (Table C.1) and without (Table C.2) the Lab 2 data. The analyte release concentrations were not blank corrected prior to statistical analyses because of negligible analyte concentrations in the blanks (see Section C.3).

The "Consensus Mean" column in Tables C.1 and C.2 contains the consensus means computed across labs, weeks, samples, and analyses. The means were computed by averaging across analyses, then across samples (for SRL-G in week 1), then across weeks, and finally across labs. This approach allows for appropriate estimation of mean performance when the numbers of weeks, samples, or analyses differ. Because there are no certified standard values for PCT leaching, it is not possible to assess whether the consensus means are biased.

There are several sources of variation that contribute to within-lab variation, and the PCT round robin was conducted so as to assess these in a general way. Each lab tested each of the four glasses once in each of three weeks (the SRL-G glass was tested three times during week 1), and the leachates were split and each split was analyzed once. Hence, within a lab there is week-to-week variation, sample-to-sample (within week) variation for

SRL-G glass in week 1, and analysis-to-analysis variation. These sources of variation are respectively denoted as "Week", "Sample" and "Analysis" in the SD (standard deviation) and %RSD (percent relative standard deviation) columns of Tables C.1 and C.2. Note that it is only possible to separately estimate "Week" and "Sample" variation for SRL-G glass; for the other three glasses the "Sample" variation is included in the "Week" variation.

Note that the way in which the PCT round robin was conducted does not allow for complete separation of PCT procedural and leachate analysis within-lab standard deviations. The "Analysis" columns in Tables C.1 and C.2 contain estimates of uncertainty for analyses performed at the same time. Variation in analyses performed over the three weeks is included with the PCT procedural variation over the three weeks in the "Week" columns of Tables C.1 and C.2. Hence, there is not a complete separation of "procedural" and "analytic" sources of variation.

The estimates of lab-to-lab variation in PCT results for each glass and element are given in the "Labs" columns of Tables C.1 and C.2. Estimates of the combined lab-to-lab and within-lab variation are given in the "Total" columns. Note that all SDs or %RSDs given in Tables C.1 and C.2 are the uncertainties associated with a single leachate analysis of a single PCT test. The overall means, being averages over multiple analyses of multiple tests, would have less uncertainty than that indicated in the "Total" columns.

In closing this section, we note that the consensus means, lab-to-lab standard deviations, and total standard deviations are not the primary interests in the PCT round robin. Rather, the interest is in the ability of the PCT to discriminate between similar glasses. This depends on within-lab precision, which we focus on in the following section.

C.2 PCT TESTING OF THE FOUR GLASSES--WITHIN-LAB PRECISION BY LABORATORY

Table C.3 presents analyte and pH means and standard deviations by laboratory for each of the four glasses tested. The standard deviations are given in parentheses under the corresponding means. Table C.3 also gives the consensus means and within-lab standard deviations, with and without the Lab 2 data. The consensus means and standard deviations can be used to judge whether individual labs differ significantly from the consensus values. A

graphical technique discussed in Section 4 of the main text uses the results of Table C.3 to compare the performance of the participating labs.

C.3 STATISTICAL ANALYSIS OF PCT BLANKS DATA AND STANDARD SOLUTION ANALYSES

Tables C.4 and C.6 contain similar results to those in Table C.1, for the blank PCT tests and the standard solution analyses, respectively. The Lab 2 results on the blanks and standard solution analyses did not differ significantly from those of the other labs, so different analyses with and without Lab 2 were not required.

Tables C.5 and C.7 present similar results to those in Table C.3 for the blank PCT tests and standard solution analyses, respectively. Means or standard deviations from a lab that differ considerably from the values for the other labs are denoted by a star (*). Consensus means and standard deviations are computed with and without the starred values.

The blank PCT results contained a number of "below detection limit" indications, which were replaced by detection limit values for purposes of the statistical analyses leading to Tables C.4 and C.5. The consequences of having "below detection limit" values and handling them in this way are concentration means that may be biased high, and standard deviations that may be biased low. However, since the blank test results were only used for a general check and not for blank correction, there is little reason to focus much attention on the blank results.

TABLE C.1. Means, Standard Deviations, and Relative Standard Deviations of Analyte Concentrations and pH for each of the Four Glasses Tested in the PCT Round Robin (All Laboratories).

Glass	Analyte	Consensus Mean(a)	SD(b)					%RSD(c)				
			Labs	Week	Sample	Analysis	Total	Labs	Week	Sample	Analysis	Total
SRL-G	Al	4.028	0.376	0.000	0.271	0.113	0.477	9.33	0.00	6.74	2.80	11.85
SRL-G	B	15.573	2.843	0.000	0.666	0.402	2.948	18.26	0.00	4.27	2.58	18.93
SRL-G	Fe	4.329	1.169	0.000	0.767	0.358	1.443	27.00	0.00	17.73	8.26	33.34
SRL-G	K	12.338	2.015	0.000	1.513	1.148	2.769	16.33	0.00	12.27	9.30	22.45
SRL-G	Li	16.140	2.233	0.000	0.657	0.512	2.364	13.84	0.00	4.07	3.17	14.77
SRL-G	Na	52.519	7.181	0.000	2.255	1.024	7.596	13.67	0.00	4.29	1.95	14.46
SRL-G	Si	110.786	15.480	0.000	3.042	2.132	15.919	13.03	0.00	2.56	1.79	13.40
SRL-G	pH	10.402	0.369	0.021	0.028	.	0.390	3.74	0.20	0.27	.	3.75
SRL-P	Al	3.709	0.536	0.161	.	0.096	0.568	14.44	4.35	.	2.59	15.31
SRL-P	B	27.025	4.345	1.173	.	0.460	4.524	16.08	4.34	.	1.70	16.74
SRL-P	Fe	4.619	1.399	0.071	.	0.638	1.768	30.30	10.87	.	13.62	38.27
SRL-P	K	34.277	5.017	1.912	.	1.597	5.601	14.64	5.50	.	4.66	16.34
SRL-P	Li	16.666	1.951	0.729	.	0.491	2.140	11.69	4.37	.	2.94	12.83
SRL-P	Na	73.615	9.344	3.392	.	2.602	10.327	12.71	4.61	.	3.81	14.05
SRL-P	Si	117.115	18.008	5.194	.	2.053	18.854	15.38	4.44	.	1.75	16.10
SRL-P	pH	10.603	0.375	0.087	.	.	0.384	3.53	0.82	.	.	3.63
ARM-1	Al	4.914	0.695	0.392	.	0.120	0.606	14.13	7.97	.	2.43	16.41
ARM-1	B	20.053	2.429	2.307	.	0.766	3.436	8.66	8.22	.	2.73	12.25
ARM-1	Fe(d)	0.101	0.000	0.288	.	0.052	0.293	0.00	285.48	.	51.11	290.02
ARM-1	K(d)	0.499	0.629	0.129	.	0.134	0.656	126.07	25.79	.	26.95	131.47
ARM-1	Li	22.353	1.584	1.333	.	0.544	2.140	7.08	5.96	.	2.43	9.58
ARM-1	Na	56.652	2.233	4.941	.	1.275	5.570	3.94	8.72	.	7.25	9.83
ARM-1	Si	82.372	6.072	5.291	.	2.491	8.430	7.37	6.42	.	3.02	10.23
ARM-1	pH	10.550	0.342	0.059	.	.	0.347	3.24	0.56	.	.	3.29
SRM-623	Al	3.633	0.707	0.079	.	0.203	0.740	19.46	2.17	.	5.59	20.36
SRM-623	B	7.625	1.414	0.184	.	0.506	1.511	16.55	2.15	.	6.64	19.82
SRM-623	Fe(d)	0.049	0.000	0.096	.	0.028	0.100	0.00	198.43	.	57.53	204.68
SRM-623	K(d)	0.543	0.600	0.000	.	0.200	0.633	110.55	0.00	.	36.78	116.51
SRM-623	Li(d)	0.047	0.059	0.033	.	0.040	0.079	126.26	70.40	.	85.19	167.82
SRM-623	Na	13.512	1.068	0.000	.	0.909	2.077	13.82	0.00	.	6.73	15.37
SRM-623	Si	49.462	7.893	4.274	.	1.069	9.039	15.96	8.64	.	2.16	18.28
SRM-623	pH	8.693	0.235	0.114	.	.	0.261	2.71	1.31	.	.	3.01

- (a) Consensus means were obtained by averaging over aliquot analyses, then over samples within week (only for SRL-G, Week 1), then over weeks, and finally over labs. Values for analyte mean concentrations are in units of mg/l.
- (b) Statistical variance component estimation techniques were used to estimate the various sources of within-lab variation and lab-to-lab variation. All standard deviations are in units of mg/l and quantify the uncertainty in a single value.
- (c) %RSD is obtained by dividing the corresponding SD value by the consensus mean and multiplying by 100%.
- (d) This element was not present in the glass, so that the means and standard deviations characterize detection-limit noise.

TABLE C.2. Means, Standard Deviations, and Relative Standard Deviations of Analyte Concentrations and pH for each of the Four Glasses Tested in the PCT Round Robin (All Laboratories except Lab 2).

Glass	Analyte	Consensus Mean(a)	SD(b)					%RSD(c)				
			Labs	Week	Sample	Analysis	Total	Labs	Week	Sample	Analysis	Total
SRL-G	Al	3.872	0.184	0.248	0.121	0.088	0.343	4.74	6.40	3.13	2.28	8.86
SRL-G	B	14.448	0.554	0.000	0.385	0.262	0.724	3.84	0.00	2.67	1.81	5.01
SRL-G	Fe	3.836	0.340	0.545	0.638	0.347	0.968	8.87	14.20	18.58	9.06	25.24
SRL-G	K	11.533	0.985	0.000	1.558	1.173	2.185	0.54	0.00	13.51	10.17	18.94
SRL-G	Li	15.229	0.168	0.858	0.000	0.281	0.734	1.09	4.32	0.00	1.84	4.82
SRL-G	Na	49.860	1.919	0.000	1.178	1.073	2.493	3.85	0.00	2.36	2.15	5.00
SRL-G	Si	112.362	2.006	3.128	0.000	1.902	4.175	1.79	2.78	0.00	1.89	3.72
SRL-G	pH	10.427	0.414	0.023	0.020	.	0.415	3.97	0.22	0.20	.	3.98
SRL-P	Al	3.508	0.232	0.159	.	0.062	0.288	6.62	4.55	.	1.76	8.22
SRL-P	B	25.283	0.997	0.641	.	0.453	1.269	3.94	2.53	.	1.79	5.02
SRL-P	Fe	4.069	0.584	0.888	.	0.523	1.043	14.36	16.90	.	12.86	25.84
SRL-P	K	32.306	1.642	1.658	.	1.709	2.892	5.08	5.13	.	5.29	8.95
SRL-P	Li	15.879	0.000	0.836	.	0.513	0.817	0.00	4.01	.	3.23	5.15
SRL-P	Na	69.648	0.000	2.502	.	2.992	3.901	0.00	3.59	.	4.30	5.60
SRL-P	Si	109.690	0.000	3.231	.	1.924	3.761	0.00	2.95	.	1.75	3.43
SRL-P	pH	10.631	0.398	0.091	.	.	0.408	3.74	0.85	.	.	3.84
ARM-1	Al	4.852	0.337	0.304	.	0.114	0.468	7.24	6.54	.	2.46	10.06
ARM-1	B	27.489	2.198	2.404	.	0.715	3.335	8.00	8.74	.	2.60	12.13
ARM-1	Fe(d)	0.117	0.000	0.300	.	0.058	0.313	0.00	283.29	.	47.58	267.55
ARM-1	K(d)	0.549	0.668	0.139	.	0.146	0.698	121.46	25.33	.	26.58	128.88
ARM-1	Li	21.734	0.595	1.350	.	0.442	1.540	2.74	6.21	.	2.03	7.09
ARM-1	Na	55.647	0.021	4.855	.	1.384	5.082	1.12	8.73	.	2.45	9.13
ARM-1	Si	80.165	3.844	3.966	.	2.421	8.031	4.80	4.95	.	3.02	7.52
ARM-1	pH	10.564	0.368	0.060	.	.	0.373	3.48	0.58	.	.	3.53
SRW-623	Al	3.343	0.045	0.088	.	0.205	0.228	1.36	2.64	.	6.15	6.83
SRW-623	B	7.050	0.264	0.175	.	0.521	0.609	3.74	2.48	.	7.39	8.84
SRW-623	Fe(d)	0.056	0.000	0.100	.	0.030	0.104	0.00	177.18	.	52.68	184.86
SRW-623	K(d)	0.600	0.630	0.074	.	0.199	0.665	104.94	12.29	.	33.18	110.75
SRW-623	Li(d)	0.054	0.061	0.034	.	0.042	0.082	112.58	62.83	.	77.44	150.38
SRW-623	Na	12.739	0.139	0.000	.	0.951	0.961	1.09	0.00	.	7.47	7.55
SRW-623	Si	46.097	0.000	4.385	.	0.942	4.465	0.00	9.47	.	2.04	9.69
SRW-623	pH	8.692	0.254	0.119	.	.	0.280	2.92	1.37	.	.	3.23

- (a) Consensus means were obtained by averaging over aliquot analyses, then over samples within week (only for SRL-G, Week 1), then over weeks, and finally over labs. Values for analyte mean concentrations are in units of mg/l.
- (b) Statistical variance component estimation techniques were used to estimate the various sources of within-lab variation and lab-to-lab variation. All standard deviations are in units of mg/l and quantify the uncertainty in a single value.
- (c) %RSD is obtained by dividing the corresponding SD value by the consensus mean and multiplying by 100%.
- (d) This element was not present in the glass, so that the means and standard deviations characterize detection-limit noise.

TABLE C.3. Analyte and pH Means and Within-Lab Standard Deviations by Laboratory for Each of the Four Glasses Tested in the PCT Round Robin

Glass	Analyte	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Consensus Mean(a) (Consensus Within-lab SD)	
									With Lab 2	Without Lab 2
SRL-G	Al	4.061 (0.233) (b)	4.967 (0.444)	4.068 (0.143)	4.149 (0.531)	3.531 (0.072)	3.858 (0.104)	3.565 (0.060)	4.028 (0.286)	3.872 (0.250)
	B	14.022 (0.430)	22.325 (1.694)	14.488 (0.481)	15.322 (0.724)	13.373 (0.565)	14.722 (0.141)	14.777 (0.191)	15.573 (0.771)	14.448 (0.465)
	Fe	4.733 (0.736)	7.283 (0.738)	3.908 (1.100)	4.336 (1.251)	3.385 (0.245)	3.484 (0.349)	3.173 (0.160)	4.329 (0.762)	3.836 (0.768)
	K	11.889 (0.583)	17.187 (1.346)	7.455 (4.217)	12.350 (0.767)	13.000 (0.455)	11.789 (0.550)	12.717 (0.662)	12.338 (1.751)	11.533 (1.810)
	Li	14.450 (0.415)	21.608 (1.536)	15.319 (0.270)	15.550 (1.235)	15.778 (0.457)	15.272 (0.273)	14.996 (0.249)	18.140 (0.800)	15.229 (0.594)
	Na	47.533 (1.281)	68.475 (5.278)	51.308 (1.199)	51.300 (2.782)	51.844 (1.344)	48.089 (0.821)	51.285 (0.678)	52.519 (2.437)	49.860 (1.512)
	Si	113.111 (2.761)	157.333 (0.830)	115.788 (2.215)	112.556 (5.970)	115.222 (2.154)	108.889 (1.459)	108.606 (1.598)	118.786 (3.857)	112.362 (3.096)
	pH	10.561 (0.039)	10.250 (0.050)	10.230 (0.024)	10.321 (0.039)	11.200 (0.000)	10.424 (0.013)	9.824 (0.013)	10.402 (0.030)	10.427 (0.026)
SRL-P	Al	3.767 (0.213)	4.917 (0.234)	3.802 (0.078)	3.528 (0.207)	3.105 (0.091)	3.592 (0.131)	3.172 (0.034)	3.709 (0.158)	3.508 (0.142)
	B	25.100 (0.551)	37.483 (2.266)	25.650 (0.668)	26.483 (0.970)	23.050 (0.808)	25.850 (0.096)	25.582 (0.561)	27.025 (1.058)	25.283 (0.667)
	Fe	5.200 (0.985)	7.917 (1.630)	4.910 (1.337)	3.538 (0.300)	3.505 (0.377)	4.018 (0.511)	3.244 (0.092)	4.619 (0.920)	4.069 (0.737)
	K	32.333 (1.112)	46.100 (2.518)	28.378 (3.193)	34.117 (3.515)	33.003 (0.813)	31.283 (0.358)	33.842 (1.009)	34.277 (2.138)	32.308 (2.065)
	Li	15.317 (0.385)	21.533 (0.801)	16.122 (0.415)	16.233 (1.548)	16.127 (0.526)	16.017 (0.302)	15.457 (0.412)	18.806 (0.746)	15.879 (0.736)
	Na	86.400 (1.533)	96.717 (5.220)	71.872 (1.893)	71.650 (7.775)	89.550 (1.351)	89.017 (0.570)	89.598 (1.919)	73.515 (3.770)	69.648 (3.469)
	Si	111.667 (2.357)	161.667 (9.410)	111.990 (3.789)	108.333 (4.607)	110.833 (2.544)	108.667 (2.427)	106.850 (2.774)	117.115 (4.625)	109.690 (3.194)
	pH	10.757 (0.049)	10.433 (0.047)	10.417 (0.021)	10.387 (0.154)	11.433 (0.047)	10.610 (0.022)	10.183 (0.060)	10.603 (0.071)	10.631 (0.074)

TABLE C.3. (Continued)

Glass	Analyte	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Consensus Mean ^(a) (Consensus Within-lab SD)	
									With Lab 2	Without Lab 2
SRM-623	Al	3.300 (0.050) (b)	5.375 (0.130)	3.423 (0.414)	3.342 (0.233)	3.130 (0.074)	3.450 (0.043)	3.414 (0.053)	3.633 (0.191)	3.343 (0.200)
	B	7.042 (0.157)	11.075 (0.259)	8.665 (1.097)	7.385 (0.354)	6.500 (0.296)	7.325 (0.045)	7.382 (0.188)	7.625 (0.470)	7.050 (0.496)
	Fe(c)	0.100 (0.000)	0.004 (0.000)	0.057 (0.055)	0.113 (0.229)	0.015 (0.005)	0.032 (0.023)	0.020 (0.000)	0.049 (0.089)	0.056 (0.097)
	K	2.000 (0.000)	0.200 (0.000)	0.497 (0.229)	0.282 (0.156)	0.343 (0.029)	0.367 (0.373)	0.113 (0.070)	0.543 (0.178)	0.600 (0.192)
	Li(c)	0.050 (0.000)	0.002 (0.000)	0.009 (0.006)	0.197 (0.098)	0.010 (0.000)	0.007 (0.001)	0.053 (0.066)	0.047 (0.044)	0.054 (0.047)
	Na	12.400 (0.238)	18.150 (0.112)	12.557 (1.063)	12.600 (0.554)	12.923 (0.661)	12.383 (0.261)	13.572 (0.431)	13.512 (0.805)	12.739 (0.868)
	Si	46.883 (1.409)	69.650 (1.404)	40.837 (0.533)	47.200 (1.990)	48.750 (1.480)	46.517 (0.598)	46.397 (1.257)	49.462 (3.480)	46.097 (3.715)
	pH	8.653 (0.220)	8.700 (0.000)	8.633 (0.024)	8.747 (0.012)	9.067 (0.047)	8.850 (0.070)	8.200 (0.016)	8.693 (0.090)	8.692 (0.097)
ARM-1	Al	3.883 (0.121)	6.483 (0.604)	4.768 (0.310)	4.890 (0.249)	4.723 (0.129)	4.548 (0.491)	5.101 (0.075)	4.914 (0.338)	4.652 (0.269)
	B	32.007 (0.818)	31.433 (1.609)	27.582 (1.203)	28.150 (2.254)	24.467 (1.466)	28.317 (3.988)	24.353 (0.597)	28.053 (2.009)	27.489 (2.060)
	Fe(c)	0.100 (0.000)	0.004 (0.000)	0.063 (0.050)	0.480 (0.650)	0.027 (0.033)	0.013 (0.003)	0.020 (0.000)	0.101 (0.247)	0.117 (0.266)
	K(c)	2.000 (0.000)	0.200 (0.000)	0.515 (0.000)	0.107 (0.312)	0.133 (0.075)	0.467 (0.276)	0.010 (0.000)	0.499 (0.160)	0.549 (0.173)
	Li	23.283 (0.584)	26.067 (1.324)	21.905 (0.678)	21.467 (1.520)	21.762 (0.985)	22.083 (1.986)	19.907 (0.493)	22.353 (1.196)	21.734 (1.174)
	Na	80.833 (1.994)	82.683 (4.448)	58.718 (2.028)	55.833 (4.540)	55.767 (1.389)	53.283 (0.408)	51.447 (1.512)	50.852 (4.199)	55.847 (4.155)
	Si	80.883 (3.417)	95.617 (0.639)	78.698 (4.737)	77.433 (4.880)	82.167 (2.011)	79.650 (5.200)	74.157 (1.790)	82.372 (4.882)	80.165 (3.920)
	pH	10.077 (0.042)	10.467 (0.047)	10.340 (0.029)	10.380 (0.024)	11.300 (0.002)	10.547 (0.012)	10.140 (0.065)	10.550 (0.049)	10.564 (0.049)

(a) The consensus means, with and without Lab 2 are from Table C.1 and C.2, respectively. The consensus (pooled) estimates of within-lab standard deviation are the root mean squares of the individual lab values, with and without Lab 2.

(b) The first number is the mean analyte concentration, while the second number in parentheses is the within-lab standard deviation (both in units of mg/l).

(c) This element was not present in the glass, so that the means and standard deviations characterize detection-limit noise.

TABLE C.4. Means, Standard Deviations, and Relative Standard Deviations of Analytes and pH for the Blanks Tested in the PCT Round Robin (All Laboratories).

Analyte	Consensus Mean(a)	SD(b)				%RSD(c)			
		Labs	Week	Within Week	Total	Labs	Week	Within Week	Total
Al	0.00453	0.000	0.000	0.078	0.078	0.00	0.00	91.73	91.73
B	0.11378	0.141	0.056	0.191	0.244	123.73	48.86	168.00	214.29
Cl	0.64098	0.000	0.109	0.672	0.698	0.00	29.50	104.86	108.93
F	1.02095	0.387	0.333	0.291	0.588	37.88	32.59	28.64	57.55
Fe	0.03250	0.016	0.000	0.052	0.055	49.58	0.00	160.69	168.16
K	0.43971	0.089	0.000	0.178	0.191	15.72	0.00	40.53	43.47
Li	0.02334	0.008	0.000	0.037	0.038	26.04	0.00	158.63	160.75
Na	0.57516	0.000	0.236	0.307	0.387	0.00	40.97	53.38	67.29
No	0.40595	0.000	0.000	0.720	0.720	0.00	0.00	177.26	177.26
Si	0.36270	0.322	0.152	0.581	0.681	88.85	41.79	160.07	187.79
So	0.27881	0.143	0.000	0.348	0.378	51.41	0.00	124.85	135.02
pH	4.95357	0.911	0.047		0.912	18.39	0.95		18.41

- (a) Consensus means were obtained by averaging within-week results, then averaging week-to-week results, and then averaging over labs. Analyte concentrations are in units of mg/l.
- (b) Statistical variance component estimation techniques were used to estimate the various sources of within-lab variation and lab-to-lab variation. All standard deviations are in units of mg/l and quantify the uncertainty in a single value.
- (c) %RSD is obtained by dividing the corresponding SD value by the overall mean and multiplying by 100%.

TABLE C.5. Analyte Means and Within-Lab Standard Deviations by Laboratory for the Blanks Tested in the PCT Round Robin

Analyte	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Consensus Mean ^(a) (Consensus Within-Lab SD)	
								With * Values	Without * Values
Al	0.217 (0.000) (b)	0.073 (0.000)	0.053 (0.044)	0.028 (0.027)	0.100 (0.000)	0.095 (0.176)*	0.025 (0.020)	0.085 (0.070)	0.085 (0.024)
B	0.030 (0.031)	0.060 (0.000)	0.497* (0.443)*	0.057 (0.078)	0.050 (0.000)	0.060 (0.104)	0.043 (0.028)	0.114 (0.175)	0.050 (0.055)
Cl	0.478 (0.407)	0.343 (0.415)	0.263 (0.285)	1.065* (0.471)	0.495 (0.456)	0.400 (0.419)	1.442* (1.360)*	0.641 (0.641)	0.396 (0.414)
F	0.655 (0.404)	1.450 (0.111)	0.850 (0.295)	1.257 (0.491)	0.885 (0.154)	1.150 (0.667)	1.000 (0.000)	1.021 (0.373)	1.021 (0.373)
Fe	0.100 (0.000)	0.004 (0.000)	0.012 (0.007)	0.077 (0.123)*	0.010 (0.000)	0.005 (0.004)	0.020 (0.000)	0.033 (0.047)	0.033 (0.003)
K	2.000* (0.000)	0.200 (0.000)	0.200 (0.000)	0.000 (0.122)	0.100 (0.000)	0.393 (0.365)	0.096 (0.164)	0.440 (0.158)	0.180 (0.158)
Li	0.050 (0.000)	0.000 (0.000)	0.038 (0.057)	0.038 (0.065)	0.010 (0.000)	0.002 (0.001)	0.020 (0.007)	0.023 (0.033)	0.023 (0.033)
Na	0.067 (0.523)	0.290 (0.050)	0.732 (0.428)	0.273 (0.166)	0.023 (0.321)	0.503 (0.349)	0.718 (0.277)	0.575 (0.336)	0.575 (0.336)
No	0.100 (0.014)	0.050 (0.037)	0.000 (0.046)	0.120 (0.100)	0.061 (0.036)	0.400 (0.000)	2.023* (1.729)*	0.400 (0.655)	0.137 (0.048)
Si	0.100 (0.000)	0.767 (0.000)	1.233* (1.393)*	0.097 (0.136)	0.100 (0.000)	0.210 (0.033)	0.033 (0.036)	0.363 (0.529)	0.218 (0.055)
So	0.050 (0.053)	0.110 (0.053)	0.068 (0.039)	0.085 (0.058)	0.020 (0.012)*	0.500 (0.000)	0.500 (0.000)	0.279 (0.309)	0.279 (0.039)
pH	7.148* (0.000)	4.650 (0.000)	4.668 (0.050)	4.803 (0.153)	4.300 (0.058)	4.918 (0.000)	4.287 (0.000)	4.954 (0.065)	4.588 (0.065)

(a) The consensus means and standard deviations were computed with and without the starred (*) values. The consensus (pooled) estimates of within-lab standard deviation are the root means squares of the individual lab values.

(b) The first number is the mean analyte concentration, while the second number in parentheses is the within-lab standard deviation (both in units of mg/l). Starred (*) values are those that differ noticeably from the values for the other labs.

TABLE C.6. Means, Standard Deviations, and Relative Standard Deviations of Analyte Concentrations for the Standard Solution Analyzed in the PCT Round Robin (All Laboratories).

Analyte	Consensus Mean(a)	SD(b)				%RSD(c)			
		Labs	Week	Analysis	Total	Labs	Week	Analysis	Total
Al	4.188	0.237	0.221	0.071	0.331	5.67	5.28	1.70	7.93
B	19.561	0.532	0.410	0.442	0.804	2.72	2.10	2.26	4.11
Fe	2.031	0.102	0.088	0.219	0.241	5.00	0.00	10.79	11.89
K	9.258	1.226	0.777	1.378	2.000	13.25	8.39	14.86	21.60
Li	12.048	0.429	0.444	0.307	0.689	3.56	3.68	2.55	5.72
Na	39.325	0.984	0.732	0.766	1.433	2.45	1.86	1.95	3.64
Si	40.761	1.716	0.780	0.970	2.120	4.21	1.91	2.38	5.20

(a) Consensus means were obtained by averaging over analyses, then over weeks, and then over labs. Analyte concentrations are in units of mg/l.

(b) Statistical variance component estimation techniques were used to estimate the various sources of within-lab variation and lab-to-lab variation. All standard deviations are in units of mg/l and quantify the uncertainty in a single value.

(c) %RSD is obtained by dividing the corresponding SD value by the consensus mean and multiplying by 100%.

TABLE C.7. Analyte Concentration Means and Within-Lab Standard Deviations for the Standard Solution Tested in the PCT Round Robin.

Analyte	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Consensus Mean(a) (Consensus Within-Lab SD)	
								With * Values	Without * Values
Al	4.167 (0.086) (b)	4.033 (0.170)	4.213 (0.105)	4.735* (0.442)*	3.863 (0.046)	4.317 (0.020)	3.930 (0.057)	4.180 (0.189)	4.088 (0.095)
B	19.583 (0.484)	19.817 (0.863)	19.342 (0.859)	20.317 (0.474)	18.583 (0.480)	20.333 (0.125)	18.955 (0.243)	19.561 (0.524)	19.561 (0.524)
Fe	1.950 (0.050)	1.895 (0.089)	2.342* (0.496)*	1.987 (0.141)	2.055 (0.028)	2.018 (0.020)	1.969 (0.051)	2.031 (0.200)	1.979 (0.075)
K	9.817 (0.478)	9.352 (0.495)	5.865* (3.526)*	9.977 (0.591)	10.115 (0.199)	9.567 (0.478)	10.117 (0.576)	9.258 (1.407)	9.824 (0.487)
Li	11.900 (0.200)	11.483 (0.672)*	11.777 (0.171)	12.817 (0.915)*	12.662 (0.186)	12.550 (0.180)	11.347 (0.201)	12.048 (0.458)	12.048 (0.190)
Na	39.733 (0.579)	38.100 (0.510)	38.935 (0.800)	40.983 (2.015)*	40.750 (0.509)	38.183 (0.398)	38.588 (0.459)	39.325 (0.920)	39.325 (0.557)
Si	42.017 (1.098)	40.183 (1.870)*	37.248 (1.181)	41.867 (0.979)	43.067 (0.921)	41.517 (0.107)	39.427 (0.643)	40.761 (1.091)	40.761 (0.897)

(a) The consensus means and standard deviations were computed with and without the starred (*) values. The consensus (pooled) estimates of within-lab standard deviation are the root mean squares of the individual lab values.

(b) The first number is the mean analyte concentration, while the second number in parentheses is the within-lab standard deviation (both in units of mg/l). Starred (*) values are those that differ noticeably from the values for the other labs.

APPENDIX D

NEW LAB 2 DATA AND SUMMARY STATISTICS

APPENDIX D

NEW LAB 2 DATA AND SUMMARY STATISTICS

It was noted in the main body of the report that Lab 2 obtained significantly larger elemental releases for all four of the glasses than did the other participating labs. The Lab 2 results for the standard solution, however, were similar to those of the other labs. This suggested that the problem was in the performance of the PCT rather than in the chemical analyses. Investigation by Lab 2 indicated that the tests were conducted at approximately 5-6°C above the nominal 90°C stated in the PCT protocol.

Another test kit was sent to Lab 2 and the tests were repeated, although within a shorter period of time. The three runs of the experiment, which were to have been performed in three successive weeks according to the experiment protocol, were actually started (and hence completed) on three successive days. Hence, the results might be expected to be less variable than if obtained from tests conducted during separate weeks.

The new data from Lab 2 are contained in Table D.1, which is in the same format as Tables B.5 through B.11 of Appendix B. The three runs are denoted "Run 1", "Run 2" and "Run 3" in Table D.1 rather than the "Week 1", "Week 2", and "Week 3" used in Tables B.5 through B.11. Also, note that the "Run 3" test was not performed on Glass D (ARM-1) because of insufficient glass sample.

Table D.2 contains means, within-lab standard deviations (SDs), and within-lab percent relative standard deviations (%RSDs) for the new Lab 2 data. Values of these summary statistics are given for the blank tests and standard solution analyses as well as for the PCT results from the four glasses tested. Note that the within-lab SDs and %RSDs contain different sources of variation for the different glasses, blanks, and standard solution. A summary of the sources of variation included in the SDs and %RSDs is given in a footnote of Table D.2. Keep in mind that the new Lab 2 data were not conducted over the round robin protocol period of three weeks, and hence the data are expected to be somewhat less variable.

The means and standard deviations summarized in Table D.2 are comparable to the values for the other participating labs. Hence, it appears that the

problems experienced by Lab 2 were resolved in the new set of tests and results comparable to those of the other labs were obtained.

TABLE D.1. Laboratory 2 New Test Data

RUN 1

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.0000	40.0208	144.5996	144.4442
Blank 2	0.0000	40.128	144.0389	144.0270
Sample A-1	4.025	44.025	150.6660	150.1223
Sample A-2	4.0018	44.1446	147.9692	147.9555
Sample A-3	4.0041	44.0246	147.8175	147.8060
Sample B	4.0010	44.072	150.9988	150.9847
Sample C	4.0009	43.978	148.5060	148.4944
Sample D	4.0015	44.086	151.2509	151.2377

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	144.3596	0.24	5.59
Blank 2	143.9718	0.0671	5.54
Sample A-1	150.0600	0.606	10.35
Sample A-2	147.8989	0.0703	10.33
Sample A-3	147.7487	0.0688	10.35
Sample B	150.9281	0.0707	8.82
Sample C	148.4345	0.0715	10.53
Sample D	151.1848	0.0661	10.46

Day	Oven Temperature
-----	------------------

1	89.0
2	89.0
3	89.0
4	89.5
5	90.0
6	89.0
7	90.0

pH of High Purity Water = 5.95
 Specific Resistance = 18.3 mohm-cm
 Date and Time In = 27-March-1989 13:00
 Date and Time Out = 3-April-1989 11:30

TABLE D.1. Laboratory 2 New Test Data (Continued)

RUN 1

Analyte	Glass A1 Samples 1-3 and 1-18	Glass A1 Sample 1-10	Glass A2 Samples 1-5 and 1-23	Glass A2 Sample 1-12	Glass A3 Samples 1-7 and 1-24
pH	10.35		10.33		10.35
Na	50.00	47.3	51.00	46.5	51.20
Li	15.20	14.8	15.20	14.2	15.80
K	11.90	11.6	12.20	11.7	12.20
Al	3.80	3.5	3.80	3.5	3.60
Si	108.40	103.0	110.00	103.4	110.00
Fe	3.90	3.6	3.00	3.0	3.20
B	14.60	14.6	14.70	14.0	14.80
F					
Cl					
N03					
S04					

Analyte	Glass A3 Sample 1-15	Glass B Samples 1-4 and 1-19	Glass B Sample 1-16	Glass C Samples 1-6 and 1-20	Glass C Sample 1-13
pH		8.82		10.53	
Na	47.0	13.10	12.00	63.40	65.7
Li	14.2	<0.06	<0.06	14.50	14.4
K	11.4	0.40	0.80	30.00	30.4
Al	3.4	3.20	3.20	3.50	3.8
Si	102.3	41.60	44.80	99.00	102.0
Fe	3.2	<0.01	<0.01	4.20	4.2
B	14.0	6.90	6.80	23.50	23.5
F					
Cl					
N03					
S04					

Analyte	Glass D Samples 1-8 and 1-21	Glass D Sample 1-11	Blank 1 Samples 1-1 and 1-17	Blank 2 Samples 1-9 and 1-22	Control Std. Sample 1-2
pH	10.46		5.59	5.54	
Na	53.30	60.2	<0.10	0.90	37.2
Li	20.70	23.4	<0.06	<0.06	11.0
K	<0.30	<0.3	<0.30	<0.30	9.0
Al	4.10	4.8	<0.30	<0.30	3.7
Si	73.10	81.0	6.00	3.00	40.3
Fe	<0.01	<0.01	<0.01	<0.01	1.9
B	27.40	30.8	<0.01	<0.01	18.4
F					
Cl					
N03					
S04					

TABLE D.1. Laboratory 2 New Test Data (cont.)

RUN 1

Analyte	Control Std. Sample 1-14
pH	
Na	36.0
Li	10.8
K	8.7
Al	3.4
Si	45.2
Fe	1.8
B	18.0
F	
Cl	
NO3	
SO4	

TABLE D.1. Laboratory 2 New Test Data (cont.)

RUN 2

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	40.046	147.3776	147.3307
Blank 2	0.000	40.1806	147.3918	147.3727
Sample A	3.9972	44.0761	145.4861	145.4680
Sample B	3.9932	44.0371	147.6448	147.6322
Sample C	4.0004	44.0673	151.1947	151.1789
Sample D	4.0005	44.0371	147.7309	147.7177

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	147.2690	0.1086	5.13
Blank 2	147.3177	0.0741	5.12
Sample A	145.4071	0.0790	10.34
Sample B	147.5736	0.0712	8.88
Sample C	151.1239	0.0708	10.5
Sample D	147.6591	0.0718	10.45

Day	Oven Temperature
1	89.0
2	89.0
3	89.0
4	90.0
5	89.0
6	90.0
7	89.0

pH of High Purity Water = 6.30
 Specific Resistance = 18.3 mohm-cm
 Date and Time In = 28-March-1989 13:00
 Date and Time Out = 4-April-1989 11:30

TABLE D.1. Laboratory 2 New Test Data (cont.)

RUN 2

Analyte	Glass A Samples 2-3 and 2-14	Glass A Sample 2-11	Glass B Samples 2-4 and 2-15	Glass B Sample 2-10	Glass C Sample 2-5 and 2-16
pH	10.34		8.88		10.50
Na	47.30	48.8	13.30	13.50	67.00
Li	14.30	13.8	<0.06	<0.06	15.10
K	11.90	11.6	0.50	0.50	31.70
Al	3.90	3.9	3.60	3.80	3.70
Si	102.00	105.0	44.00	43.00	110.00
Fe	3.10	2.9	<0.01	<0.01	3.80
B	13.80	13.5	7.00	7.00	26.40

F
Cl
NO3
SO4

Analyte	Glass C Sample 2-9	Glass D Samples 2-6 and 2-17	Glass D Sample 2-8	Blank 1 Samples 2-1 and 2-13	Blank 2 Samples 2-7 and 2-18
pH		10.45		5.13	5.12
Na	65.4	62.60	65.8	0.38	0.36
Li	15.0	24.40	25.0	<0.06	<0.06
K	31.0	<0.30	<0.3	0.50	0.60
Al	3.3	4.20	4.3	<0.30	<0.30
Si	103.0	84.90	85.0	<0.20	<0.20
Fe	3.7	<0.01	<0.01	<0.01	<0.01
B	24.4	34.00	34.7	0.11	0.11

F
Cl
NO3
SO4

Analyte	Control Std. Sample 2-2	Control Std. Sample 2-12
---------	----------------------------	-----------------------------

pH		
Na	43.0	40.0
Li	11.4	11.1
K	9.8	9.6
Al	4.4	4.5
Si	44.0	45.0
Fe	1.9	2.0
B	19.1	19.5

F
Cl
NO3
SO4

TABLE D.1. Laboratory 2 New Test Data (cont.)

RUN 3

Sample ID	Glass Specimen Weight, g	Weight of Leachant, g	Total Wt of Leach Container, g	Total Wt. After 24 Hours
Blank 1	0.000	39.992	144.2074	144.1793
Blank 2	0.000	40.0367	144.3375	144.3118
Sample A	3.9973	44.0161	148.2794	148.2646
Sample B	3.9956	44.096	148.1517	148.1409
Sample C	3.9956	44.0539	151.3570	151.3440
Sample D	-----Not enough sample for the third run-----			

Sample ID	Total Wt, g	Weight Loss, g	pH, Out
Blank 1	144.1260	0.0814	5.53
Blank 2	144.2552	0.0823	5.55
Sample A	148.2086	0.0708	10.35
Sample B	148.0816	0.0701	8.89
Sample C	151.2873	0.0697	10.53
Sample D	-----Not enough sample-----		

Day	Oven Temperature
1	89.0
2	89.0
3	89.0
4	89.0
5	90.0
6	89.0
7	89.0

pH of High Purity Water = 6.22
 Specific Resistance = 18.3 mohm-cm
 Date and Time In = 29-March-1989 13:00
 Date and Time Out = 5-April-1989 11:30

TABLE D.1. Laboratory 2 New Test Data (cont.)

RUN 3

Analyte	Glass A Samples 3-3 and 3-14	Glass A Sample 3-11	Glass B Samples 3-4 and 3-15	Glass B Sample 3-10	Glass C Samples 3-5 and 3-16
pH	10.35		8.89		10.53
Na	47.00	47.7	14.00	13.00	66.60
Li	14.20	14.1	<0.06	<0.06	15.20
K	11.00	11.0	<0.30	<0.30	31.50
Al	3.50	3.5	3.50	3.40	3.80
Si	105.00	105.5	56.80	53.00	109.00
Fe	3.50	3.5	0.02	0.02	5.60
B	14.00	14.0	7.50	7.50	24.80
F					
Cl					
NO3					
SO4					

Analyte	Glass C Sample 3-9	Glass D Samples 3-6 and 3-17	Sample D Sample 3-8	Blank 1 Samples 3-1 and 3-13	Blank 2 Samples 3-7 and 3-18
pH		---not enough sample---		5.53	5.55
Na	68.3	"		1.00	0.20
Li	15.6	"		<0.06	<0.06
K	32.6	"		<0.30	<0.30
Al	4.2	"		<0.30	<0.30
Si	104.0	"		11.00	8.00
Fe	5.8	"		<0.01	<0.01
B	25.4	---not enough sample---		0.20	0.20
F					
Cl					
NO3					
SO4					

Analyte	Control Std. Sample 3-2	Control Std. Sample 3-12
pH		
Na	41.0	40.3
Li	12.0	12.0
K	10.1	10.0
Al	4.4	4.3
Si	45.8	50.2
Fe	2.0	2.0
B	20.4	20.1
F		
Cl		
NO3		
SO4		

TABLE D.2. Summary Statistics for the Lab 2 New Data

Glass or Soln.	(a) Stat.	Analyte (mg/l)							pH
		Na	Li	K	Al	Si	Fe	B	
SRL-G	MEAN	48.38	14.58	11.65	3.64	105.46	3.29	14.2	10.34
	SD	2.32	0.81	0.54	0.222	3.99	0.397	0.547	0.011
	%RSD	4.80	5.54	4.62	6.11	3.78	12.06	3.85	0.11
SRL-P	MEAN	66.07	14.97	31.20	3.72	104.50	4.55	24.67	10.52
	SD	1.74	0.50	1.01	0.32	4.35	1.02	1.19	0.017
	%RSD	2.63	3.31	3.25	8.51	4.16	22.48	4.80	0.16
ARM-1	MEAN	60.48	23.38	0.30*	4.35	81.0	0.01*	31.72	10.46
	SD	5.91	2.11	0.00*	0.353	6.24	0.00*	3.91	0.007
	%RSD	9.78	9.04	0.00*	8.13	7.71	0.00*	12.32	0.07
SRM-623	MEAN	13.15	0.06*	0.467	3.45	47.20	0.013*	7.12	8.86
	SD	0.68	0.00*	0.192	0.26	6.83	0.006*	0.34	0.038
	%RSD	5.15	0.00*	41.03	7.48	14.47	43.09*	4.80	0.43
BLANK	MEAN	0.49	0.06	0.383	0.30	4.73	0.01	0.107	5.41
	SD	0.46	0.00	0.147	0.00	4.81	0.00	0.095	0.25
	%RSD	94.28	0.00	38.40	0.00	101.68	0.00	89.08	4.58
STD. SOLN.	MEAN	39.58	11.38	9.53	4.12	45.08	1.93	19.25	.
	SD	2.79	0.57	0.63	0.50	3.29	0.087	1.04	.
	%RSD	7.04	5.02	6.57	12.21	7.30	4.48	5.42	.

(a) MEAN is the mean of the observations. SD is the within-lab standard deviation and %RSD is the within-lab percent relative standard deviation, where $\%RSD = 100 \times (SD/MEAN)$. SD was obtained as the square root of the sum of two (or three, in the case of SRL-G) variance components, as indicated in the following chart:

Glass	Run-to-run	Within-run	
SRL-G	S+P+A	S+P and A	
SRL-P	S+P+A	A	S = sample-to-sample
ARM-1	S+P+A	A	P = PCT procedure
SRM-623	S+P+A	A	A = analytic
BLANK	P+A	P+A	
STD SOLN	A	A	

The three runs were started on three consecutive days, and were not performed within three separate weeks as called for by the test protocol.

* Denotes that the indicated element was nominally not contained in the associated glass. Detection limits were used in place of the "less than" values reported by Lab 2.

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