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Pacific Northwest National Laboratory
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Waste Form Release Data Package for the 2005 Integrated Disposal Facility Performance

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H. T. Schaef
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September 2004

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

SUMMARY

The Hanford Site in southeastern Washington State has been used extensively to produce nuclear materials for the U.S. defense arsenal by the U.S. Department of Energy (DOE). A large inventory of radioactive and mixed waste has accumulated in 177 buried single- and double-shell tanks. Liquid waste recovered from the tanks will be pretreated to separate the low-activity fraction from the high-level and transuranic wastes. The low-activity waste (LAW) will be immobilized in glass, via vitrification, and placed into a near-surface disposal system on the Hanford Site. Before the immobilized low-activity waste (ILAW) can be placed into the disposal system, DOE must approve a performance assessment (PA), which is a document that describes the long-term impact of the disposal facility on public health and environmental resources.

A critical component of the PA will be to provide quantitative estimates of radionuclide release rates from the engineered portion of the disposal facilities (source term). Researchers from Pacific Northwest National Laboratory (PNNL) were selected by CH2M Hill Hanford Group to determine the experimentally derived input data on the three prototypic LAW glasses: LAWA44, LAWB45, and LAWC22. These data will be used for Subsurface Transport Over Reactive Multi-phases (STORM) simulations of the Integrated Disposal Facility (IDF) for immobilized low-activity waste (ILAW). The STORM code will be used to provide the near-field radionuclide release source term for a performance assessment to be issued in July 2005. Documented in this data package are data related to 1) kinetic rate law parameters for glass dissolution, 2) alkali (Na^+)-hydrogen (H^+) ion exchange rate, 3) chemical reaction network of secondary phases that form in accelerated weathering tests, and 4) thermodynamic equilibrium constants assigned to these secondary phases. The kinetic rate law and Na^+-H^+ ion exchange rate were determined from single-pass flow-through experiments. Pressurized unsaturated flow (PUF) and product consistency (PCT) tests were used for accelerated weathering or aging of the glasses to determine a chemical reaction network of secondary phases that form. The majority of the thermodynamic data used in this data package were extracted from the thermodynamic database package shipped with the geochemical code EQ3/6, version 8.0.

In addition to the experimentally derived input data for each of the representative waste glasses, this data package contains recommended effective diffusion coefficients for grouted secondary waste containing several key contaminants (Cr, I, NO_3, Hg, Tc, and U) obtained from a survey of the literature. These effective diffusion coefficients should be considered generic values; no secondary waste streams from vitrification operations have been produced at Hanford for testing. Therefore, the authors recommend that activities be initiated to generate IDF site-specific data on the release of key contaminants of concern from secondary waste solidified in cementitious waste forms.

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ACRONYMS

ANL	Argonne National Laboratory
ASTM	American Society for Testing and Materials
BFS	blast furnace slag
BKV	bulk vitrification
CSH	calcium silicate hydrate
DIW	deionized water
DOE	Department of Energy
EDXS	energy dispersive X-ray spectroscopy
ESP	Environmental Simulation Program
EXAFS	extend X-ray absorption fine-structure
HLW	high-level waste
HSE	Hanford soil microorganism extract
IAEA	International Atomic Energy Agency
ICP-OES	inductively coupled plasma-optical emission spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
IDF	integrated disposal facility
IEX	alkali-hydrogen exchange
ILAW	immobilized low activity waste
LAW	low-activity waste
LLW	low-level waste
MLLW	mixed-low level waste
M&TE	materials and test equipment
PA	performance assessment
PBS	phosphate-buffered saline
PCT	product consistency test
PEEK	polyetheretherketone
PNNL	Pacific Northwest National Laboratory
PUF	pressurized unsaturated flow
QA	quality assurance
QAPD	quality assurance program documents
SAED	selected area electron diffraction
SEM	scanning electron microscope
SPFT	single-pass flow-through (glass test)
SPS	sodium pyrophosphate solution
STORM	Subsurface Transport Over Reactive Multiphases (computer code)
S/V	surface area-to-solution volume ratio
THAM	*tris* (hydroxymethyl) aminomethane

TMS	Tetrakis (trimethylsilyl) silane
TPM	*Thiobacillus perometabolis*
TST	transition state theory
WTP	Waste Treatment Plant
XRD	X-ray diffraction

1.0 Introduction

The Hanford Site in southeastern Washington State has been used extensively to produce nuclear materials for the U. S. defense arsenal by the U.S. Department of Energy (DOE). A large inventory of radioactive and mixed waste has accumulated in 177 buried single- and double-shell tanks. Liquid waste recovered from the tanks will be pretreated to separate the low-activity fraction from the high-level and transuranic wastes. The low-activity waste (LAW) will be immobilized in glass, via vitrification, and placed into a near-surface disposal system on the Hanford Site. The LAW streams are divided into three classifications or compositional envelopes (Envelopes A, B, and C). In general, the chemical composition of each envelope is characteristic of one of the three major chemical separation processes used to extract plutonium; (REDOX [Envelope A]), and later, plutonium and uranium (bismuth phosphate [Envelope B] and PUREX [Envelope C]) from irradiated fuels at Hanford. For a detail discussion of the chemical composition and the variability associated with each envelope an interest reader should consult Muller et al. (2001).

The immobilized low-activity waste (ILAW) at Hanford is among the largest volumes of waste within the DOE complex and is one of the largest inventories of long-lived radionuclides planned for disposal in a low-level waste facility (approximately 2.4 million curies total activity). Before the ILAW can be disposed, DOE must approve a performance assessment (PA), which is a document that describes the long-term impacts of the disposal facility on public health and environmental resources. A sound scientific basis for determining the long-term release rates of radionuclides from LAW glasses must be developed if the PA is to be accepted by regulatory agencies, stakeholders, the public, and accord with the Tri-Party agreement. Currently, the Hanford Integrated Disposal Facility (IDF) Program is planning to issue a performance assessment (PA) in July of 2005. The major goals of the performance assessment activity are to:

- support the design of disposal facilities
- provide the technical basis for the DOE to authorize construction of disposal facilities
- obtain approval to dispose of immobilized low-activity Hanford tank waste and other wastes in those facilities
- provide a technical basis for final closure of the disposal facilities.

A critical component of the PA will be to provide quantitative estimates of radionuclide release rates from the engineered portion of the disposal facilities (source term). Computer models are essential for this purpose because the impact on groundwater resources must be projected out to time periods of 10,000 years and longer. Details on the recommended technical strategy for developing this source term have been published (McGrail et al., 2000b) and have undergone review by an international panel of experts. This data package was developed from a direct implementation of that technical strategy.

The computer model selected for modeling the radionuclide source-term is the Subsurface Transport Over Reactive Multiphases (STORM) code (McGrail and Bacon, 1998). The required inputs to this code will be derived from literature sources and from laboratory experiments with ILAW glasses. This report, therefore, functions to document the input data that will be used for STORM simulations. The STORM code requires input of two main general classifications of data: 1) multiphase flow, and 2) reactive transport. Multiphase flow input is defined in the near-field hydraulic properties data package (MEYER et al., 2004) or the far-field hydraulic properties data package (FAYER and SZECSODY, 2004). Experimentally derived input related to conducting reactive transport calculations is defined within this data package.

Laboratory testing provides a majority of the key input data required to assess the long-term performance of ILAW glasses with the STORM code. Test data from four principal methods, as described by McGrail et al. (MCGRAIL et al., 2000b), are discussed in this data package including the single-pass flow-through test (SPFT), pressurized unsaturated flow (PUF) test, and product consistency test (PCT). Each of these test methods focuses on different aspects of the glass corrosion process. Linkages between the test methods, their principal function, and the data they provide for STORM modeling is described in Table 1. The interested reader should consult McGrail et al. (MCGRAIL et al., 2000b) for additional details regarding these test methods and their use in evaluating long-term glass performance.

In addition to the SPFT, PUF, and PCT test results, this data package also contains empirical effective diffusion coefficients for several key contaminants (Cr, I, NO_3, Hg, Tc, and U) in grouted secondary waste. Secondary waste streams generated during vitrification operations are currently planned to be encapsulated in a cementitious waste form and disposed of in the IDF along with ILAW glass and spent melters. These diffusion coefficients will be used in source-term calculations with the STORM computer code to describe how these cementitious waste forms will impact overall contaminant release from the IDF.

Table 1. Overview of Test Methods Discussed in this Data Package

Test Method	Temperature Range	Duration	Data Provided	Purpose
SPFT	23 – 90°C	14 – 28 days	Dissolution rate as a function of temperature, pH, and solution composition	Parameterization of kinetic rate law for glass dissolution
PUF	40 – 100°C	Months to years	Effluent chemical composition and dissolution rate as a function of temperature and flow rate, secondary phases, hydraulic property changes	Highly accelerated test for glass screening, secondary phases for STORM reaction network, validation of STORM Code
PCT	20 to 100°C	Weeks to years	Solution composition and dissolution rate as a function of S/V ratio and temperature, secondary phases	Glass screening, secondary phases for STORM reaction network, calibration of reaction network with EQ3/6 code

PCT = product consistency test

PUF = pressurized unsaturated flow test

SPFT = single pass flow-through (glass test)

S/V = surface area-to-solution volume ratio

STORM – Subsurface Transport Over Reactive Multiphases

2.0 Laboratory Testing

Laboratory testing of a large number of prototypic ILAW glasses has been performed. The set of ILAW glasses investigated for this data package release are reference glass formulations provided to PNNL by the Waste Treatment Plant (WTP) and represent glass formulation from each Envelope; LAWA44 (Envelope A), LAWB45 (Envelope B), and LAWC22 (Envelope C). These glasses are expected to represent reasonable bounds on the range of performance of ILAW glass products to be eventually produced at Hanford based on the current understanding of the tank waste processing flow sheet, vitrification plant design, and current waste acceptance specifications. All of these are subject to change, which could and likely would impact long-term performance projections.

The LAWA44, LAWB45, and LAWC22 glasses are all simulated LAW glasses and contain no radioactive elements. An important addition to this data package is the inclusion of test data on two LAW glasses, LAWAN102 and LAWAP101 that were produced with actual tank waste. These glasses were made at the Savannah River National Laboratory and shipped to PNNL for testing. Their composition is provided in Table 2. Due to the limited quantity of these glasses, only accelerated corrosion testing was performed using the PUF test method.

2.1 Preliminaries

The interested reader should consult McGrail et al. (McGrail et al., 2000b) for a thorough discussion of how each of the tests described in this data package fit into an overall strategy to evaluate the long-term performance of ILAW glasses. All testing work reported in this data package was conducted in accordance with PNNL's Quality Management System Description and associated quality assurance program documents (QAPD), which are maintained electronically as part of the Standards Based Management System. All instrument calibrations and materials are traceable, test procedures and associated training activities are documented in detail, and test methods comply with established plans and procedures. Computer Software and Database Control procedures are being followed for data analysis software being used to store, sort, and reduce data.

All staff members contributing to this data package received proper technical and quality assurance training in accordance with QAPD Training and Qualification for Staff. Equipment is either calibrated periodically or at the time of use and the calibration status of each piece of equipment is documented through a material and test equipment (M&TE) sheet, which is maintained as a part of the QA file. The M&TE sheets specify the required calibration methods, usually include a calibration procedure, and document the status of the equipment. All equipment requiring calibration prior to its use will be so labeled.

Documented procedures were used for sample preparation, test performance, and sample analysis. Operations not specifically covered in a documented procedure were documented in a Laboratory Record Book. Comments regarding the test performance and test activities are contained in a Laboratory Record Book associated with each test.

2.2 Glass Formulations

The test results presented in the following sections will reference five different ILAW glass compositions. These are provided in Table 2 for reference. LAWA44, LAWB45, LAWC22, LAWAP101, and LAWAN102 are prototypic ILAW glasses. These glasses vary in the concentrations of SiO_2, Al_2O_3, B_2O_3, Fe_2O_3, TiO_2, ZnO, ZrO_2, MgO, and Na_2O across a wide composition range that covers, with high probability, the expected processing composition range for candidate ILAW glasses.

The glasses were prepared by mixing measured amounts of dried reagent-grade chemicals (oxides, fluorides, iodides, and sulphides) in an agate mill. The mixtures were melted in a Pt (10%) Rh crucible, and the molten glass was poured onto a cool stainless steel plate. Each glass was then subjected to heat treatment by placing the glass in a preheated oven at 930°C and then cooling at 21°C/hr. This cooling rate is consistent with a computed thermal profile for a 1.2m x 1.2m x 1m container that was the design being considered for LAW. The container design has since been modified to a cylinder of 1.2 m diameter x 2.3 m tall.

Table 2. Composition (Mass%) of Selected ILAW Glasses

Oxide	LAWA44	LAWB45	LAWC22	*LAWAN102	*LAWAP101
Al_2O_3	6.20%	6.13%	6.08%	6.19%	5.66%
B_2O_3	8.90%	12.34%	10.06%	10.05%	9.85%
CaO	1.99%	6.63%	5.12%	6.24%	2.00%
Cl	0.65%	0.01%	0.09%	0.03%	0.17%
Cr_2O_3	0.02%	0.07%	0.02%	0.08%	0.03%
F	0.01%	0.08%	0.16%		0.27%
Fe_2O_3	6.98%	5.26%	5.43%	6.94%	5.56%
HfO_2				0.05%	
K_2O	0.50%	0.26%	0.10%	0.19%	3.82%
Li_2O		4.62%	2.51%	2.76%	
MgO	1.99%	2.97%	1.51%	1.41%	1.49%
MnO			0.04%	0.03%	0.01%
MoO_3	0.01%			0.003%	
Na_2O	20.00%	6.50%	14.40%	11.23%	18.46%
NiO			0.03%	0.08%	0.01%
P_2O_5	0.03%	0.03%	0.17%	0.17%	0.09%
PbO_2			0.02%	0.02%	
Rh_2O_3				0.001%	
Re_2O_7	0.10%	0.01%	0.01%		
SO_3	0.10%	0.84%	0.34%	0.31%	0.31%
SiO_2	44.55%	47.86%	46.67%	47.41%	44.27%
SnO_2				0.002%	0.010%
SrO				0.02%	
TcO_2				0.0001%	0.001%
TiO_2	1.99%		1.14%	1.24%	2.01%
UO_2				0.001%	0.001%
V_2O_5				0.02%	0.01%
ZnO	2.96%	3.15%	3.07%	2.99%	2.97%
ZrO_2	2.99%	3.15%	3.03%	2.54%	3.01%

*Radioactive components are ^{99}Tc and ^{238}U

3.0 Kinetic Rate Law Parameters

To predict the long-term fate of glass in the subsurface over the period of regulatory concern, a mathematical model that describes glass reactivity is needed. Over the last few decades, a general rate equation has been fashioned to describe the dissolution of glass (and more ordered materials) into aqueous solution. As described below, the equation is based upon the Transition State Theory (TST) of chemical kinetics, in which the overall reaction rate is governed by the slowest elementary reaction. Elementary reactions have simple stoichiometry and can be combined as an overall reaction. In many cases, the elementary reactions can only be inferred. As an example of the elementary reaction, consider the dissolution of SiO_2 polymorphs to form silicic acid:

$$\mathrm{SiO_2}(s) + 2\mathrm{H_2O} \leftrightarrow \mathrm{SiO_2} \cdot 2\mathrm{H_2O}^{\ddagger} \rightarrow \mathrm{H_4SiO_4}(aq) \tag{1}$$

in which $SiO_2 \bullet 2H_2O^{\ddagger}$ represents an activated complex. Note that the reactants and the activated complex in Equation (1) are linked by a double-headed arrow symbolizing a reversible reaction. Equation (1) also illustrates that the TST formulation assumes the decay of the activated complex is an irreversible reaction.

With these assumptions, a general equation describing the rate of reaction as a function of pH, temperature, saturation state of the system, and the activities of rate enhancing or inhibiting species (AAGAARD and HELGESON, 1982) has been proposed

$$r = \vec{k}\nu_i a_{\mathrm{H^+}}^{-\eta} \exp\left(\frac{-E_a}{\mathrm{R}T}\right)\left[1-\left(\frac{Q}{K_g}\right)^{\sigma}\right]\prod_j a_j^{\eta_i}, \quad i = 1,2,\ldots \mathrm{N} \tag{2}$$

where r is the dissolution rate in g m^{-2} d^{-1}, $\vec{k}$ is the intrinsic rate constant in g m^{-2} d^{-1}, ν_i is the mass fraction of element i, $a_{\mathrm{H^+}}$ is the hydrogen ion activity, a_j is the activity of the *jth* aqueous species that acts as an inhibitor or catalyst, E_a is the activation energy in kJ mol^{-1}, R is the gas constant in kJ mo1^{-1} K^{-1}, T is the temperature in K, Q is the ion activity product, $K_g$is the pseudo-equilibrium constant for glass, η is the power law coefficient, and σ is the Temkin coefficient. Although there are a number of issues regarding the applicability of Equation (2) for modeling glass dissolution, McGrail et al. (MCGRAIL et al., 2000b) concluded that this rate law currently "…best describes the majority of the experimental data that has been gathered after over 35 years of studying the glass/water reaction processes." Consequently, parameterization of this equation is required to conduct source-term calculations with STORM code. Because the disposal system temperature is a known constant, the determination of five parameters; k, E_a, η, σ, K_g, is required for each glass formulation (neglecting the $\prod_j a_j^{\eta_i}$ term). The ion activity product (Q) is a variable and must be computed with STORM as a function of time and space for the disposal system. Lasaga (1995) convincingly argues that $\sigma = 1$ in the above equation because any value where $\sigma \neq 1$ is inconsistent with transition state theory. Consequently, $\sigma = 1$ is assumed for this work, thus eliminating σ as an unknown parameter in the rate law.

3.1 Experimental Materials and Methods

The experimental materials and methods section will discuss the techniques and procedures used to prepare each glass sample, buffer solutions, SPFT test, and calculate the dissolution rate and associated uncertainty.

3.1.1 Materials Preparation

The samples used in this study were prepared by crushing a sub-sample of glass in a ceramic ball mill. The crushed glass was then sieved into -100 + 200 mesh (149 to 75 μm diameter) size fractions, washed in deionized water (DIW), sonicated in DIW, rinsed in ethanol, and dried in a 90ºC oven. The specific surface area of each sample was calculated using a geometric formula (MCGRAIL et al., 1997). This formula assumes that the particles are spherical, size distributions of the grains are normally distributed, and that surface pits, cracks, and other forms of surface roughness do not affect the surface area (or at least are not important after a short time). Although all three of these assumptions may not be valid, results from LAW glass experiments using glass coupons, with a calculated and measured surface area, have shown that the geometric surface area best represents the overall glass surface area (MCGRAIL et al., 2000a).

3.1.2 Buffer Solutions

The solutions used to control the pH during the SPFT experiments are summarized in Table 3. Table 3 also contains a summary of the in-situ pH values computed at each test temperature using the thermodynamic software package EQ3NR (WOLERY, 1992). It is important to take into account the change in pH that occurs at different temperatures when computing dissolution rates from SPFT data as the in-situ pH can vary by as much as 1.5 pH units over the temperature range from 23º to 90ºC. These solutions were prepared by adding small amounts of the organic *tris* (hydroxmethl) aminomethane (THAM) buffer to DIW and adjusting the solution to the desired pH value using 15.8 M HNO_3 or 1 M LiOH. The THAM buffer range is between pH 7 to

Table 3. Composition of Solutions Used in SPFT Experiments. Solution pH values above 23ºC were calculated with EQ3NR Code V7.2b database.

Solution	Composition	pH @			
		23ºC	40ºC	70ºC	90ºC
1	0.05 M THAM + 0.047 M HNO_3	7.01	6.57	5.91	5.55
2	0.05 M THAM + 0.02 M HNO_3	8.32	7.90	7.25	6.89
3	0.05 M THAM + 0.0041 M HNO_3	8.99	8.67	8.08	7.72
4	0.05 M THAM + 0.003 M LiOH	9.99	9.55	8.88	8.52
5	0.0107 M LiOH + 0.010 M LiCl	11.00	10.89	10.43	10.06
6	0.0207 M LiOH + 0.010 M LiCl	12.02	11.74	11.08	10.70
7	0.05 M THAM + Si*	9.00	8.83	8.51	8.27

THAM = *tris* hydroxymethyl aminomethane buffer

*Correspond to the pH at Si saturation with respect to SiO_2(am)

10; therefore, the alkaline solutions, pH range 11 and 12, were prepared by adding LiOH and LiCl to DIW and adjusting the solution to the desired pH value using 15.8 M HNO_3 or 1 M LiOH.

Influent silicon concentration was varied from dilute to saturated with respect to amorphous silica [SiO_2(am)], based on the results from calculations using EQ3NR (WOLERY, 1992) for select experiments. It is important to note that the solubility behavior of SiO_2(am) changes with temperature; therefore, the target amount of Si added to each solution was adjusted to correspond to the experimental temperature being interrogated, resulting in Si solution concentrations that ranged from 15 to 140 ppm. These solutions were prepared by dissolving analytical grade silicic acid powder ($SiO_2 \cdot H_2O$) in a solution of 0.05 M THAM buffer and heating the mixture in a 90°C oven for no less than three days to facilitate complete dissolution. Upon complete dissolution, each solution was removed from the oven, allowed to cool, and pH adjusted (target pH = 9) using aliquots of 15.8 M HNO_3 or 1 M LiOH.

3.1.3 SPFT Apparatus

Dissolution experiments were conducted using the SPFT apparatus (Figure 1). The SPFT experimental system provides a continuous flow of fresh influent solution, prevents the build-up of reaction products, maintains the bulk solution composition throughout an experiment, provides a direct measure of the dissolution rate, and allows an investigator to study the reactivity of a material over a wide range of experimental conditions. This system has been extensively described by others (MCGRAIL et al., 2000a); and an interested reader should consult these references, as well as the references contained therein for more detail.

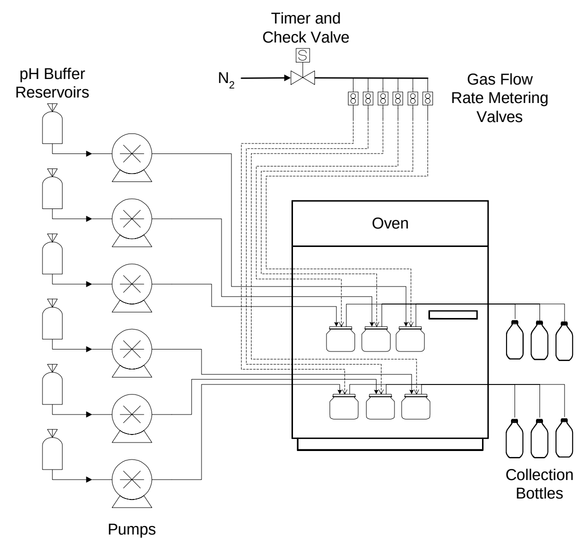

Figure 1. Schematic of the Single Pass Flow-Through (SPFT) Apparatus

In general, solution is transferred using a Kloehn syringe pump (Model 50300) from a reservoir bottle to a Teflon reactor and finally to a sample collection vial using 1.59-mm Teflon tubing. The Teflon reactor vessels consisted of two main pieces, (e.g., a top and bottom) that threaded together to form a cylinder with a 47.5-mm outer diameter and 63-mm height, with a total inner volume of approximately 80 mL. The relatively large diameter of the sample holder (40.6-mm inner diameter) allows the glass particles to form a thin layer at the reactor bottom and interact with the contacting solution. The effluent solutions were monitored for four major glass components, aluminum (Al), boron (B), sodium (Na), and silicon (Si) using inductively coupled plasma-optical emission spectroscopy (ICP-OES).

3.1.4 Dissolution Rate and Error Calculations

Dissolution rates, based on steady-state concentrations of elements in the effluent, are normalized to the amount of the element present in the sample by the following formula:

$$\text{Normalized dissolution rate}\,(\text{g m}^{-2}\text{d}^{-1}) = \frac{\left(C_i - \overline{C}_{i,b}\right) q}{f_i\, S} \tag{3}$$

where C_i is the concentration of the element, i, in the effluent (g L^{-1}), $\overline{C}_{i,b}$ is the average background concentration of the element of interest (g L^{-1}), q is the flow-through rate (L d^{-1}), f_i is the mass fraction of the element in glass (dimensionless), and S is the surface area of the sample (m^2). The value of f_i can be calculated from the chemical composition of the sample. Flow-through rates are determined by gravimetric analysis of the fluid collected in each effluent collection vessel upon sampling. The background concentration of the element of interest is determined, as previously discussed, by analyses of the starting input solution and the three blank solutions. Typically, background concentrations of elements are below their respective detection threshold. The detection threshold of any element is defined here as the lowest calibration standard that can be determined reproducibly during an analytical run within 10%. In cases where the analyte is below the detection threshold, the background concentration of the element is set at the value of the detection threshold.

Determining the experimental uncertainty of the dissolution rate takes into account uncertainties of each parameter in Equation (3). For uncorrelated random errors, the standard deviation of a function $f(x_1, x_2, \ldots x_n)$ is given by:

$$\sigma_f = \sqrt{\sum_{i=1}^{n} \left(\frac{\partial f}{\partial x_i} \right)^2 \sigma_i^2} \tag{4}$$

where σ_f is the standard deviation of the function f., x_i is the parameter i, and σ_i is the standard deviation of parameter i. Substituting (3) into (4) results in:

$$\sigma_{r_i} = \sqrt{\left(\frac{q}{f_i\, S} \right)^2 \left(\sigma_{C_i}^2 + \sigma_{\overline{C}_{i,b}}^2 \right) + \left(\frac{C_i - \overline{C}_{i,b}}{f_i\, S} \right)^2 \sigma_q^2 + \left(\frac{\left(C_i - \overline{C}_{i,b}\right) q}{f_i^2\, S} \right)^2 \sigma_{f_i}^2 + \left(\frac{\left(C_i - \overline{C}_{i,b}\right) q}{f_i\, S^2} \right)^2 \sigma_S^2} \tag{5}$$

Equation (5) can also be expressed in terms of the relative error, $\hat{\sigma}_{r_i} = \sigma_{r_i} / r_i$, and is given by

$$\hat{\sigma}_{r_i} = \sqrt{\frac{\left(\hat{\sigma}_{C_i} C_i \right)^2 + \left(\hat{\sigma}_{\overline{C}_{i,b}} \overline{C}_{i,b} \right)^2}{\left(C_i - \overline{C}_{i,b} \right)^2} + \hat{\sigma}_q^2 + \hat{\sigma}_{f_i}^2 + \hat{\sigma}_S^2} \tag{6}$$

Relative errors of 10%, 10%, 5%, 3%, and 15% for C_i, $\overline{C}_{i,b}$, q, f_i, and S, respectively, are typical for measurements conducted at PNNL. Although the absolute error in f_i is likely higher than 3%, this error is non-systematic and so does not contribute significantly to sample-to-sample uncertainty, which is the principal error of interest here. The conservative appraisal of errors assigned to the parameters in Equation (6), in addition to the practice of imputing detection threshold values to background concentrations, results in typical uncertainties of approximately ±35% on the dissolution rate.

3.1.5 SPFT Results

Dissolution rates and experimental conditions, including temperature, solution pH, flow-through rates, sample mass, and surface area, are listed in Appendix A. The majority of the rates reported are computed based on concentration of B. Boron is typically the most reliable index for matrix dissolution since it, along with Si and Al, forms the glass polymer network. In addition, when B is released during dissolution, it is not retained either in secondary minerals or "leach layers" that build up on the surface of glass. Other network forming elements, such as Al and Si, may be retained after initial release in experiments with slow flow-through rates and, clearly, neither Al nor Si can be used as an index of dissolution in cases where these elements are added to input solutions. Rates based on alkali elements, in this case, Na, are also subject to uncertainty under conditions of slow matrix dissolution rates.

As discussed in more detail below in Section 3.1.5.1.4 and 3.1.5.3.2, release of Na to solution is through two separate mechanisms; matrix dissolution and alkali-hydrogen exchange. For example, when flow-through rates are slow, the concentration of Si in solution in contact with glass builds up, causing the dissolution rate to decrease. Relatively large amounts of Na are released into solution, however, because the Na^+-H^+ exchange mechanism continues to operate. Thus, in this example, the calculated dissolution rate would be too fast. However, in many experiments the $\log_{10}$ dissolution rate based upon Al, B, Na, and Si agrees to within 0.2 log units and is reported as an average. In some extreme cases, the concentration of B in solution is below the detection threshold and we are forced to rely on concentrations of Al, Na, and Si to compute dissolution rates. This may occur, for example, when flow-through rates are very fast and concentrations of elements in the effluent are dilute. However, if these rates are in disagreement with each other, then the dissolution rates for that experiment are not reported.

To simplify presentation of the results, each data set has been divided into four sections. Each section will present the results of tests conducted to determine rate law parameters for each glass composition; LAWA44, LAWB45, and LAWC22. This section will be followed by a section that will compare the experimental results and relate these differences to glass structure and changes in glass composition.

3.1.5.1 SPFT Results for LAWA44 Glass

3.1.5.1.1 *Achievement of Steady-State and Consistency of Results*

Obtainment of valid dissolution rates depends on the glass-solution system reaching steady-state conditions. Figure 2 shows that these conditions are met for typical experiments at the four temperatures (23°, 40°, 70°, and 90°C) investigated. Concentrations of B are invariant with respect to time after approximately seven reactor volumes in these experiments. Although the 23°C results suggest that this test has not attained steady-state, an increase in the plots resolution illustrates that steady-state was achieved (Figure 2 inset plot). The results shown in this diagram are typically observed in all experiments.

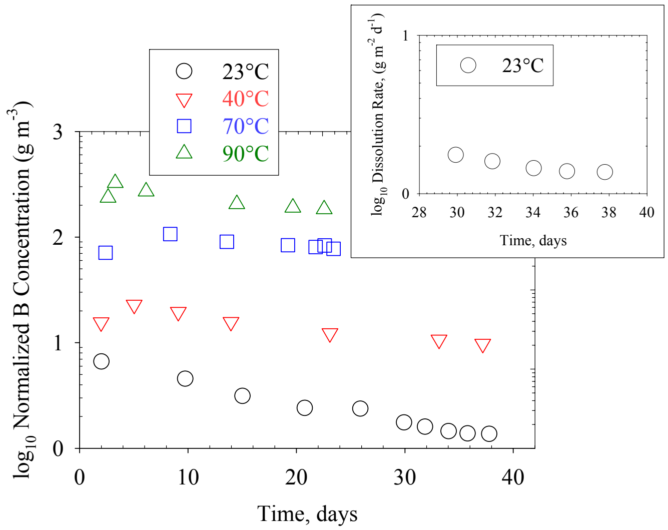

Figure 2. Normalized B Concentration as a Function of Time and Temperature for LAWA44 Glass with Increased Resolution for the 23°C Results Between Day 30 and 38.

3.1.5.1.2 *Effect of q/S Variations*

Figure 3 illustrates the effect of varying the ratio of flow-through rate, *q*, to sample surface area, *S*. Rates based on concentrations of Al, B, Na, and Si are plotted for the conditions of 40°C, pH (23°C) = 9. This figure illustrates that as the q/S ratio increases, dissolution rates increase and then reach a constant value, which is commonly referred to as the forward or maximum dissolution rate. Figure 3 also illustrates that over the range of *q*/*S* interrogated Al, B, Na, and Si are being released congruently from the glass, especially at higher *q*/*S* ratio. The evidence for congruent release is illustrated by the normalized release rates for Al, B, Na, and Si being within the experimental error of one another each *q*/*S* ratio.

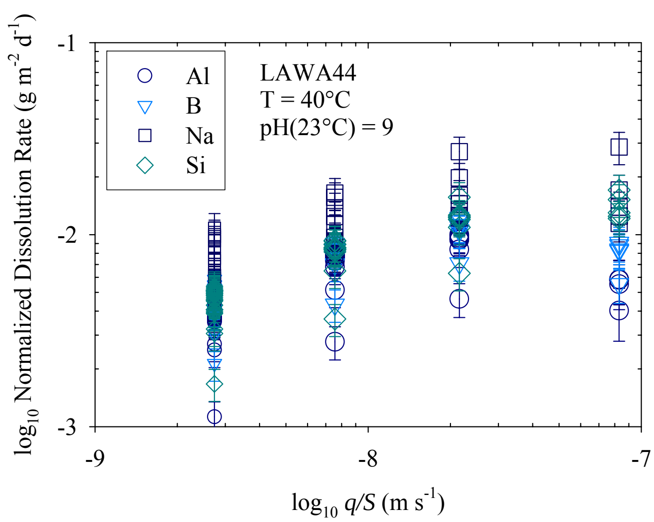

Figure 3. Effect of Variation in the Ratio of Flow Rate, *q*, to Sample Surface Area, *S*, on LAWA44 Glass Dissolution Rate

Dissolution rates decrease as the ratio of q/S decreases because when flow-through rates are low or sample surface area is high, the concentration of elements dissolved into solution are high. As the concentration of elements rise in solution increase, the solution approaches saturation with respect to some solid phase(s). Therefore, the dissolution rate decreases as the difference in chemical potential between glass and solution decreases.

3.1.5.1.3 *Effect of pH*

To determine the effect of pH on the dissolution rate, solution pH values were varied between 7 and 12 at temperatures of 23, 40, 70, and 90ºC. The in situ solution pH has been corrected for the effect of temperature using EQ3NR (Table 3). Figure 4 illustrates that as the pH increases from 7 to 12, the overall glass dissolution rate also increases. This direct relationship between the dissolution rate and pH, going from the neutral to alkaline pH range, is typical of other LAW glass formulations (McGrail et al., 2001a). Conducting a linear regression on the data at each temperature gave a slope η = 0.49 ±0.08 indicating that η does not depend on temperature within experimental error. Using this value for η, a non-linear regression was performed on the entire data set shown in Figure 4 using the kinetic rate law (McGrail et al., 2003)

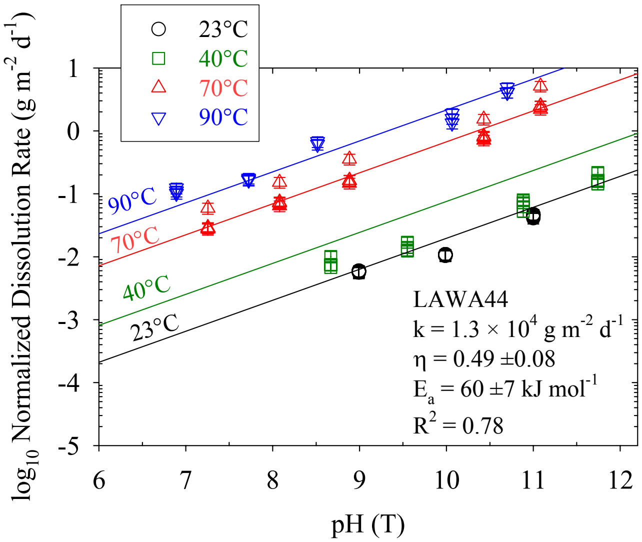

Figure 4. Normalized B Release Rate as a Function of pH and Temperature for LAWA44 Glass

$$J = k_o 10^{\eta[\mathrm{pH}]} \exp\left(\frac{-E_a}{\mathrm{R}T}\right) \tag{7}$$

where J is the normalized release rate, k_o is the intrinsic rate constant, η is the pH power law coefficient, E_a is the activation energy, R is the ideal gas constant, and T is the temperature. The resulting regression coefficients are $k_o = 1.3 \times 10^4$ g m^{-2} d^{-1}, $E_a = 60 \pm 7$ kJ mol^{-1} with a correlation coefficient (R^2) of 0.78. The value of E_a and η are within the experimental error of values reported for LAW glass formulation LAWBP1 (McGrail et al., 2001a), ($k_o = 3.4 \times 10^6$ g m^{-2} d^{-1}, $E_a = 68$ kJ mol^{-1}, and η = 0.35).

Figure 4 also illustrates that temperature has a strong effect on the dissolution rates. The apparent activation energy determined ($E_a = 60 \pm 7$ kJ mol^{-1}) corresponds to a surface controlled reaction process, ~ 41.8 to 83.7 kJ mol^{-1} (Lasaga, 1981). This value is in good agreement with the values reported for another LAW glass formulations and several SiO_2 polymorphs [LAWABP1 = 68 kJ mol^{-1} (McGrail et al., 2001a), quartz = 66 – 83 kJ mol^{-1} (Dove, 1994), SiO_2(am) = 74.5 kJ mol^{-1} (Icenhower and Dove, 2000), and cristobalite = 69 kJ mol^{-1} (Renders et al., 1995), suggesting that the rupture of the Si-O bond is the rate-limiting step in dissolution.

Another factor affecting glass dissolution that is observed when evaluating the dissolution rate as a function of pH and temperature is ion exchange. Ion exchange is a process by which H^+, contained in the solution, exchanges for the ions contained in the glass matrix, as illustrated by

$$\mathrm{Glass} \cdots \mathrm{Na} + \mathrm{H}^+ \xrightarrow{J_x} \mathrm{Glass} \cdots \mathrm{H} + \mathrm{Na}^+ \tag{8}$$

The addition of this mechanism may affect LAW glass performance because of the significant Na_2O content, almost 20% for LAWA44. Methods to quantify the alkali ion-exchange rate for the LAWA44 are discussed below.

3.1.5.1.4 *Effect of Alkali-Hydrogen Exchange*

The mechanism of alkali-hydrogen exchange (IEX) is widely recognized as an important process in glass dissolution (McGrail et al., 2001b). This IEX rate typically decreases with an increase in the solution pH or temperature, in other words, matrix dissolution becomes the dominant mechanism of dissolution. Consequently, as the solution SiO_2(aq) activity increases the divergence between the rate of matrix dissolution and IEX increases. Under these conditions, the IEX rate becomes more pronounced because as the ion activity product (Q) approaches saturation with respect to some secondary phase(s), the rate of matrix dissolution slows.

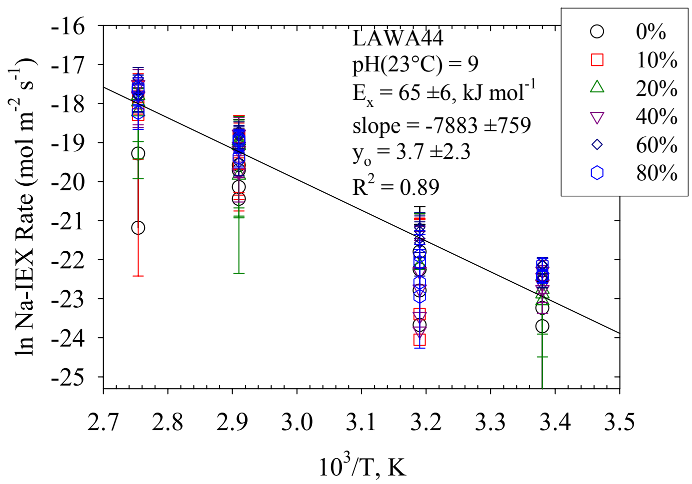

Figure 5. Na Ion Exchange Rate as a Function of Temperature with Changing a[SiO_2(aq)] for LAWA44 Glass

To compute the rate of ion exchange (IEX), the steady-state Na release rate was subtracted from the steady-state matrix dissolution rate, indexed by boron, and the resulting value was converted to moles of Na per square meter per second. Figure 5 illustrates the natural logarithm of the IEX rate versus 1/T for each SiO_2(aq) activity interrogated. Conducting a linear regression on the data and using these regressed coefficients Na-IEX rate at 15°C was computed, $r_x = 5.3 \times 10^{-11}$ mol m^{-2} s^{-1}. Using the slope an activation energy, $E_x = 65 \pm 6$ kJ mol^{-1}, for Na-IEX was computed. This value is slightly higher than the values computed for the LAW glass formulations, LAWABP1 ($E_x = 52$ kJ mol^{-1}) (McGrail et al., 2001a) and the bulk vitrification (BKV) baseline glass formulation, BKV1 ($E_x = 53 \pm 2$ kJ mol^{-1}).

3.1.5.1.5 *Effect of Solution Saturation State*

As previously discussed, experiments with input solutions doped with Si (ranging from 15 to 140 ppm) were conducted as a function of temperature at pH(23°C) = 9. Before discussing these results, it is important to determine the aqueous Si speciation at each temperature to correctly account for the change in Si speciation with temperature in the analysis. Therefore, the solution speciation of dissolved Si species was computed with the aid of the geochemical code EQ3NR (Wolery, 1992). Results of this computation shows that SiO_2(aq) was the dominant solution species in the buffer solution from 23 to 90°C, ranging from 90%, at 23ºC, to 87%, at 90ºC. The remaining 10 and 13%, at 23 and 90ºC respectively, corresponds to the solution species $HSiO_3^-$.

Normalized release rates for B and Na as a function of $a[SiO_2(aq)]$ are shown in Figure 6. The trend, a decrease in the dissolution rate with increasing $SiO_2(aq)$ activity, is similar to those obtained for several LAW glass formulations (McGrail et al., 2001a). As the activity $SiO_2(aq)$ increases, Figure 6 also shows an increasing discrepancy between the bulk glass dissolution rate, as indicated by the rate of B release, versus the normalized rate of Na release. The discrepancy has been assigned to a secondary reaction mechanism associated with Na ion exchange. However, unlike other LAW glass formulations, such as LAWABP1, the release rate of Na and B does not converge completely at 90°C. This is almost certainly due to decrease in the (Al+B):alkali (e.g., Na+Li+K) ratio, 0.58:1 for LAWA44 and 0.67:1 for LAWABP1, which suggest that LAWA44 may contain more non-bridging oxygen sites (NBO) in comparison to LAWABP1. McGrail et al. (2001b) has illustrated with simple four component glasses, that the number of NBO sites within the glass structure is directly correlated with Na ion-exchange rates in simple glasses.

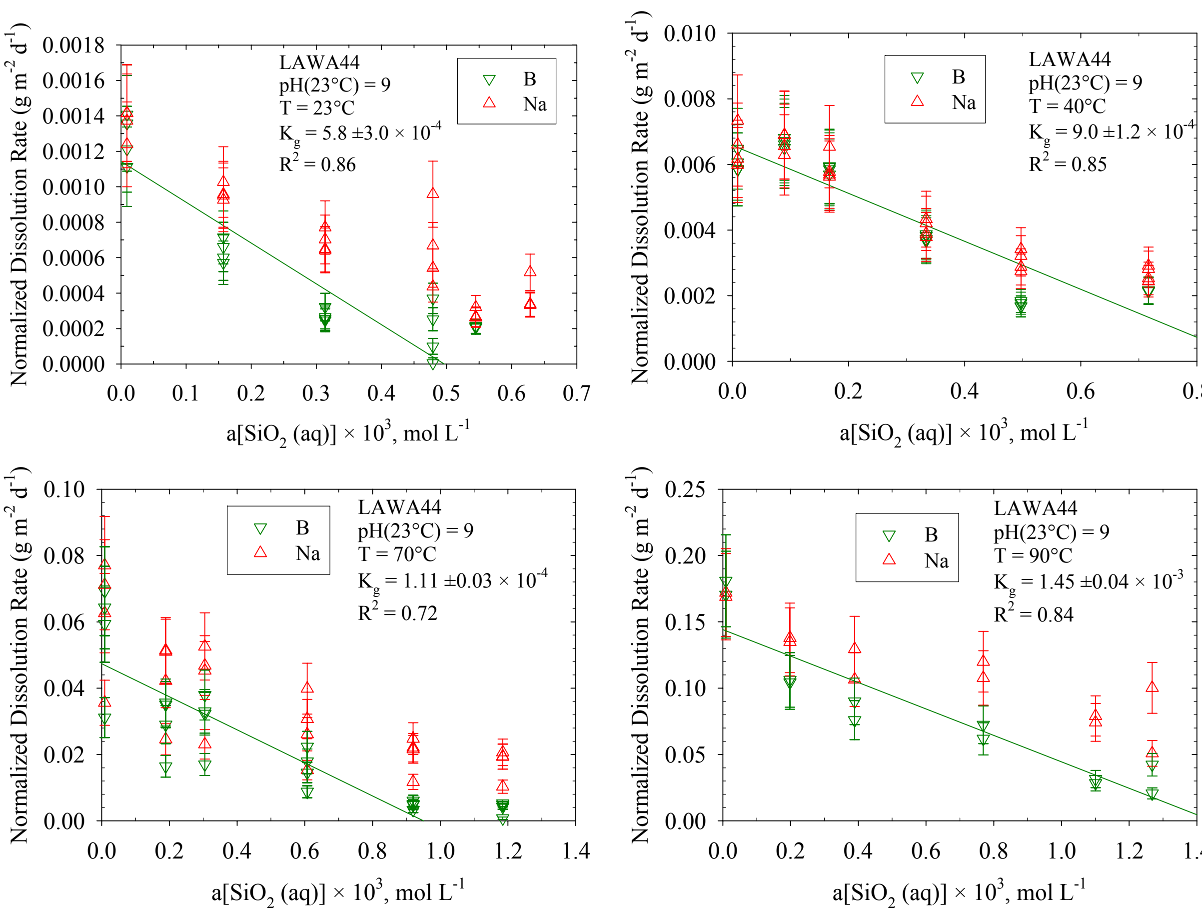

Figure 6. Normalized Release Rate with Respect to B and Na Versus $SiO_2(aq)$ Activity at 23, 40, 70, and 90ºC for LAWA44 Glass

By applying a linear fit to the normalized B release rates as they approached zero for the data shown in Figure 6, the x-intercept was determined at each temperature, which is equivalent to the pseudo-equilibrium constant (K_g). The estimated K_g values are given in Table 4 and also plotted versus inverse temperature in Figure 7, along with the temperature-dependent solubility products for quartz and SiO_2(am). The results show the K_g for BKV1 glass is intermediate between quartz and amorphous silica. The slope of a line regressed through the data also provides a crude estimate of the enthalpy of reaction, $\Delta H_r = 11 \pm 2$ kJ mol^{-1}. Using the regression line shown in Figure 7, the value for K_g at the disposal system temperature of 15°C was calculated and is provided in Table 4.

In addition to the test conducted on LAWA44 glass, kinetic rate law parameters were measured for LAWB45 glass. The results of these experiments are discussed within the next section.

Table 4. Estimate of the Pseudo-Equilibrium Constants for LAWA44 Glass as a Function of Temperature

T (°C)	K_g	Error	R^2
15	5.45E-04	-	-
23	5.75E-04	±3.0E-04	0.86
40	9.00E-04	±1.2E-05	0.85
70	1.11E-03	±3.4E-05	0.72
90	1.45E-03	±4.3E-05	0.84

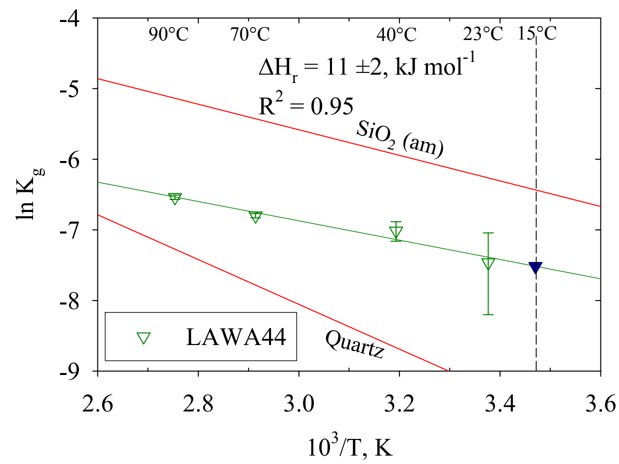

Figure 7. ln K_g vs. Inverse Temperature for LAWA44 Glass

3.1.5.2 SPFT Results for LAWB45 Glass

3.1.5.2.1 *Effect of pH*

Figure 8 illustrates the experimental results for LAWB45 as a function of pH and temperature. Unlike previous tests on LAW glass formulations, the dissolution rate for LAWB45 decreased from pH 7 to 8 and began increasing from 8 to 12. Therefore, the results at pH 7 were excluded from the non-linear regression analysis. Results from LAWB45 illustrate a trend typical of most LAW glass formulations, where the dissolution rate increases with an increase in pH and temperature. Therefore, the same process was used to evaluate the data and extract the corresponding kinetic rate law parameters.

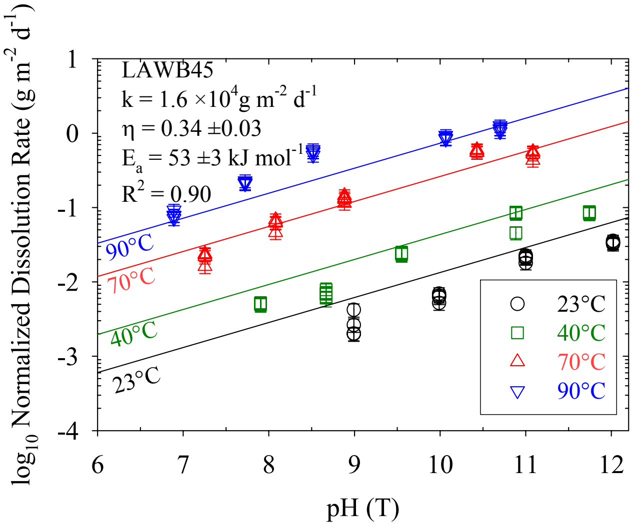

Figure 8. Normalized B Release Rate as a Function of pH and Temperature for LAWB45 Glass

Results from the linear regression at each temperature gave a slope η = 0.34 ±0.03 indicating that η does not depend on temperature within experimental error. Using the same non-linear regression technique as described in Section 3.1.5.1.3, the resulting regression coefficients are $\vec{k}$ = 1.6 × 10^4 g m^{-2} d^{-1}, E_a = 53 ±3 kJ mol^{-1} with a correlation coefficient (R^2) of 0.90. The value for E_a is slightly lower than other LAW glass formulations, but it still corresponds to a surface-controlled reaction process (LASAGA, 1981).

3.1.5.2.2 *Effect of Solution Saturation State*

As previously discussed in Section 3.1.5.1.5, experiments with input solutions doped with Si (ranging from 15 to 140 ppm) were conducted as a function of temperature at pH(23°C) = 9. Normalized release rates for B and Na as a function of *a*[SiO_2(aq)] are shown in Figure 9. Due to detection limit problems the Na results for 23°C are not displayed in Figure 9. The trend, a decrease in the dissolution rate with increasing *a*[SiO_2(aq)], is similar to those obtained for several LAW glass formulations (MCGRAIL et al., 2001a). Figure 9 also illustrates that LAWB45 has little to no alkali hydrogen exchange and suggest that matrix dissolution is the dominant mechanism of release. This is certainly due to the less than 6.5 weight % sodium load for this glass formulation in comparison to the 20% and 14% for LAWA44 and LAWC22, respectively. In comparison to LAWA44 and LAWC22, this glass formulation not only has lower alkali content but the Al and B content is higher, resulting in a ratio of (Al+B)/(Na+Li+K) of 0.91 to 1. Hence, almost all of the alkali ions are utilized in charge compensating AlO_2^- and BO_2^- groups in the glass, reducing the concentration of NBO sites that are susceptible to ion-exchange (MCGRAIL et al., 2001b). As a result, we assign a Na IEX rate of zero to LAWAB45 glass (r_x = 0).

The pseudo-equilibrium constant estimates are listed in Table 5 and displayed in Figure 10. The value for K_g at the disposal system temperature of 15°C is 5.2 × 10^{-4}, with a corresponding reaction enthalpy estimate of 9.9 ±3 kJ mol^{-1}. Kinetic rate law parameters for the Envelope C glass formulation LAWC22 will be discussed in the following section.

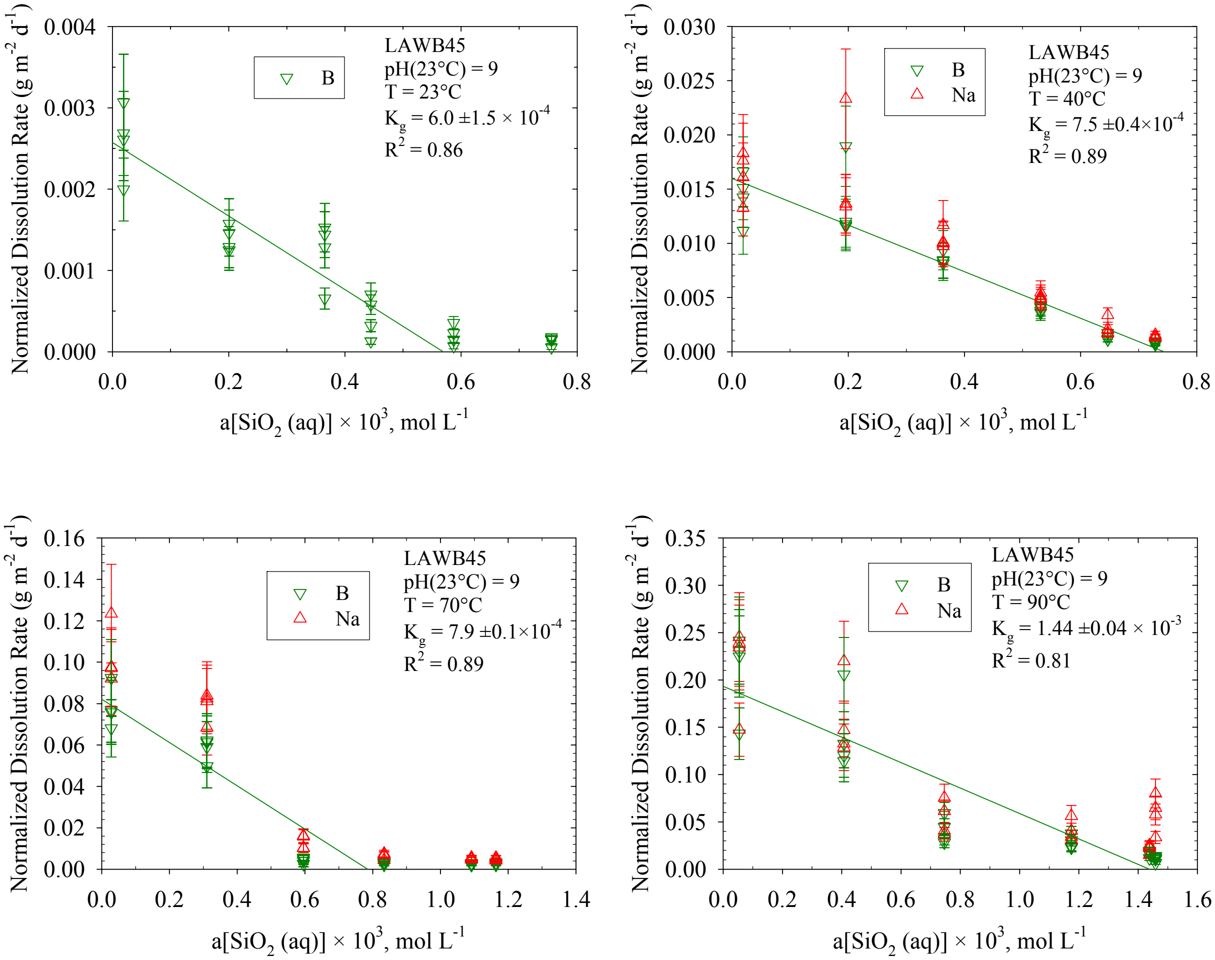

Figure 9. Normalized Release Rate with Respect to B and Na Versus SiO_2(aq) Activity at 23, 40, 70, and 90ºC for LAWB45 Glass

Table 5. Estimate of the Pseudo-Equilibrium Constants for LAWB45 Glass as a Function of Temperature

T (ºC)	K_g	Error	R^2
15	5.20E-04	-	-
23	6.0E-04	±1.5E-04	0.86
40	7.5E-04	±4.0E-05	0.89
70	7.9E-04	±1.0E-05	0.89
90	1.44E-03	±4.0E-05	0.81

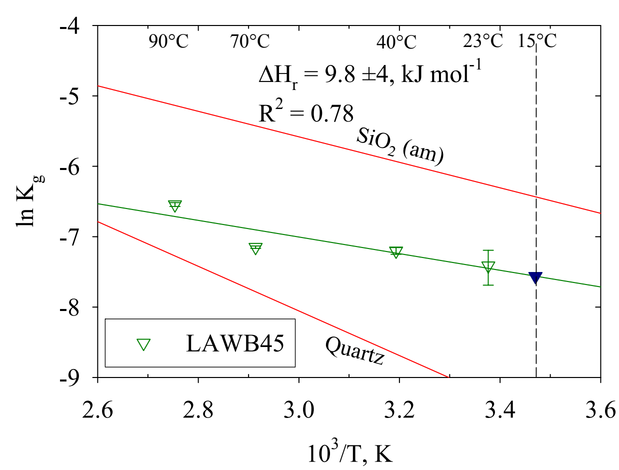

Figure 10. ln K_g vs. Inverse Temperature for LAWB45 Glass

3.1.5.3 SPFT Results For LAWC22 Glass

3.1.5.3.1 *Effect of pH*

Like LAWA44 and LAWB45, the Envelope C glass formulation, LAWC22, also illustrates a strong temperature and pH dependence (Figure 11). Therefore, as pH increases from 7 to 12, the overall glass dissolution rate also increases. As previously discussed for LAWA44 and LAWB45 a linear regression on the data at each temperature was conducted and we observed that η, 0.42 ±0.02, does not depend on temperature within experimental error. Using this value for η and conducting a non-linear regression on the entire data set shown in Figure 11, the resulting regression coefficients are $\vec{k} = 1.0 \times 10^5$ g m^{-2} d^{-1}, E_a = 64 ±2 kJ mol^{-1} with a correlation coefficient (R^2) of 0.96. These values are similar to previous values that have been reported for other LAW glass formulations (McGrail et al., 1997; 2001a), as well as the values contained in this report for LAWA44 and LAWB45.

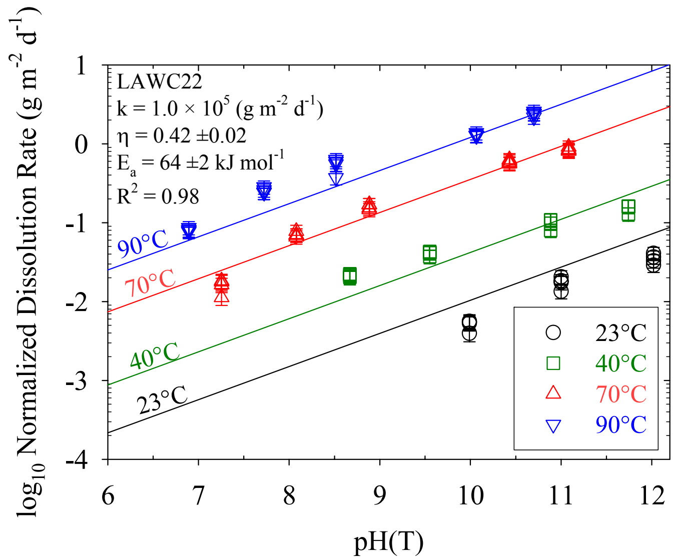

Figure 11. Normalized B Release Rate as a Function of pH and Temperature for LAWC22 Glass

3.1.5.3.2 *Effect of Alkali-Hydrogen Exchange*

As previously explained in Section 3.1.5.1.4, the rate of ion exchange (IEX) is computed by subtracting the rate of matrix dissolution from the Na release rate and converting the resulting value to moles of Na per square meter per second. Figure 12 shows the computed ion exchange rate from temperatures of 23 to 70ºC. These results show no ion-exchange rate dependence on pH. This is not unexpected because surface layers on waste glasses have been found to be strongly pH buffered relative to the bulk aqueous phase (Bunker, 1987).

Similar to LAWA44 glass, the effect of IEX was also observed in experiments where the concentration of Si in the influent solution was varied. Figure 13 illustrates the natural logarithm of the IEX rate versus 1/T for each SiO_2(aq) activity interrogated. Conducting a linear regression on the data resulted in an E_x = 45 ±4 kJ mol^{-1}. The resulting E_x correlates well with LAWABP1 (E_x = 52 kJ mol^{-1}) (McGrail et al., 2001a) but is approximately 10 kJ mol^{-1} lower than LAWA44 (E_x = 65 ±6 kJ mol^{-1}). The rate of Na-IEX for LAWC22 glass was computed at 15°C using these regressed coefficients and is $r_x = 1.2 \times 10^{-10}$ mol m^{-2} s^{-1}.

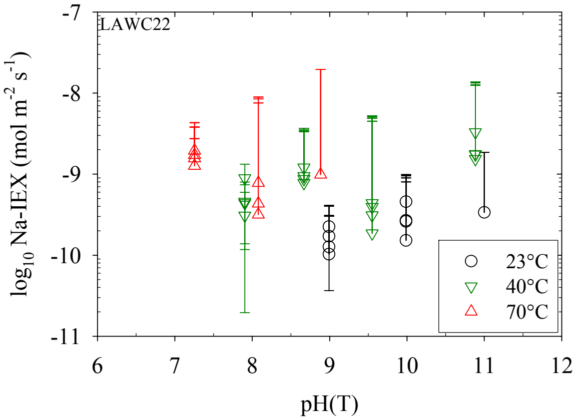

Figure 12. Na-IEX Rate as a Function of Solution pH and Temperature

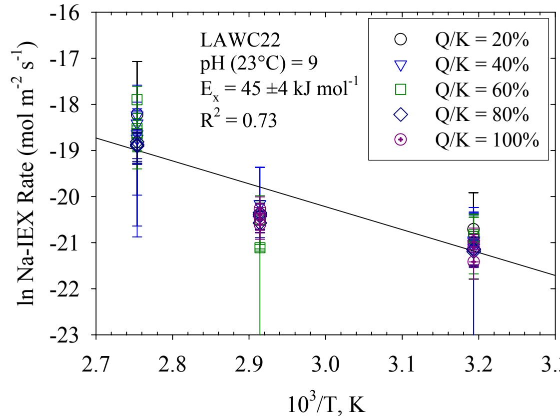

Figure 13. Na Ion Exchange Rate as a Function of Temperature with changing $a[SiO_2\ (aq)]$ for LAWC22 Glass

3.1.5.3.3 *Effect of Solution Saturation State*

Using the same technique as previously described in Section 3.1.5.1.5, several experiments were conducted as a function of $a[SiO_2(aq)]$ and temperature at a pH(23°C) of 9 on LAWC22 glass. Results shown in Figure 14 illustrate a typical trend, a decrease in the dissolution rate with increasing SiO_2(aq) activity and an increasing discrepancy between the B and Na release rate. In other words, as the activity of SiO_2(aq) increases the rate of glass dissolution decreases. As discussed in Section 3.1.5.1.5, this discrepancy has been assigned to a secondary reaction mechanism associated with Na ion exchange which is correlated to the concentration of NBO sites (McGrail et al., 2001b).

By applying a linear fit to the normalized B release rates as they approached zero for the data shown in Figure 14, the x-intercept was determined at each temperature, which is equivalent to the pseudo-equilibrium constant (K_g). The estimated K_g values are given in Table 6 and also plotted versus inverse temperature in Figure 15, along with the temperature-dependent solubility products for quartz and SiO_2(am). The results show the K_g for BKV1 glass is intermediate between quartz and amorphous silica. The slope of a line regressed through the data also provides a crude estimate of the enthalpy of reaction, $\Delta H_r = 12 \pm 2$ kJ mol^{-1}. Using the regression line shown in Figure 15, the value for K_g at the disposal system temperature of 15°C was calculated and is provided in Table 6.

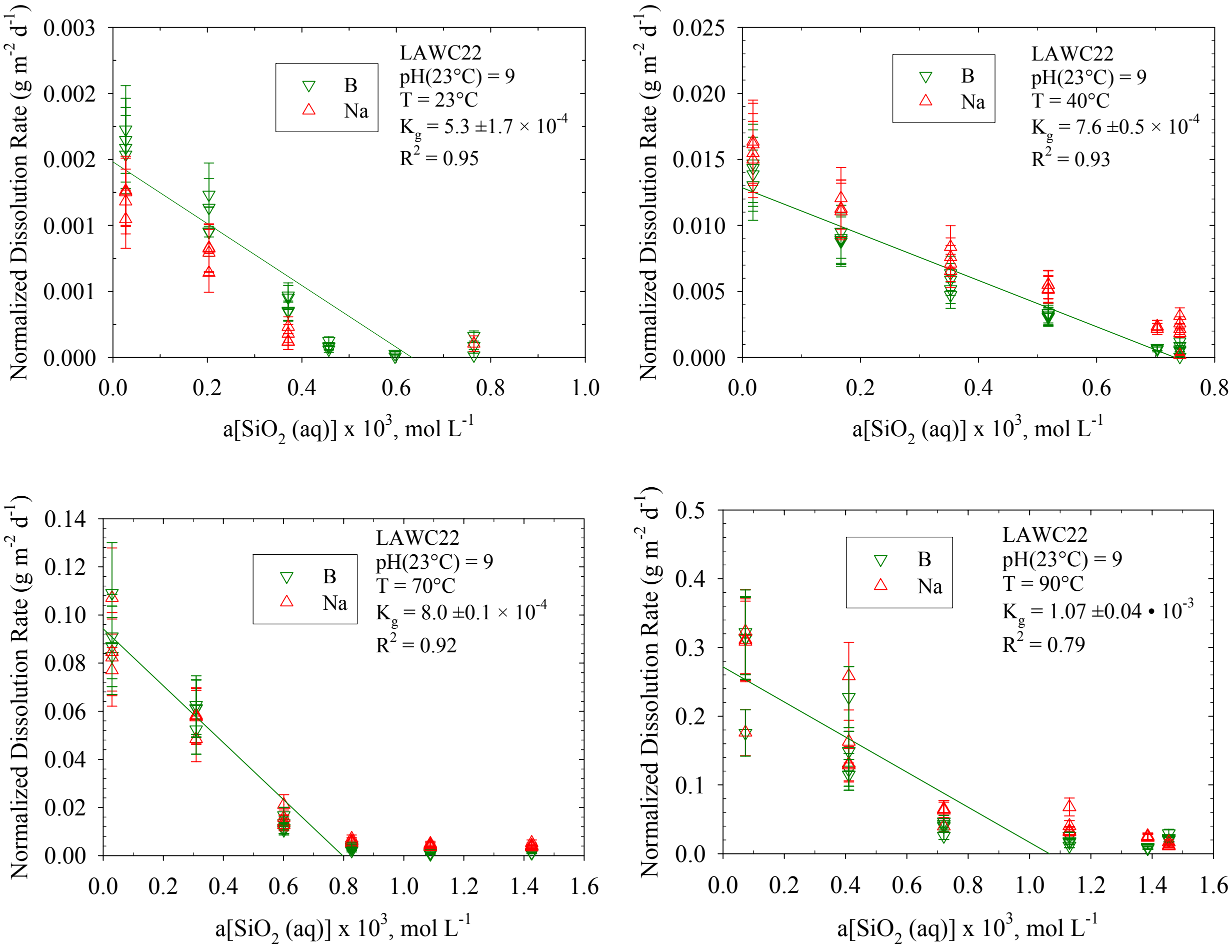

Figure 14. Normalized Release Rate with Respect to B and Na Versus SiO_2(aq) Activity at 23, 40, 70, and 90ºC for LAWC22 Glass.

Table 6. Estimate of the Pseudo-Equilibrium Constants for LAWC22 Glass as a Function of Temperature

T (ºC)	K_g	Error	R^2
15	4.96E-04	-	-
23	5.3E-04	±1.7E-04	0.93
40	7.6E-04	±5.0E-05	0.93
70	8.0E-04	±1.0E-05	0.92
90	1.07E-03	±4E-05	0.83

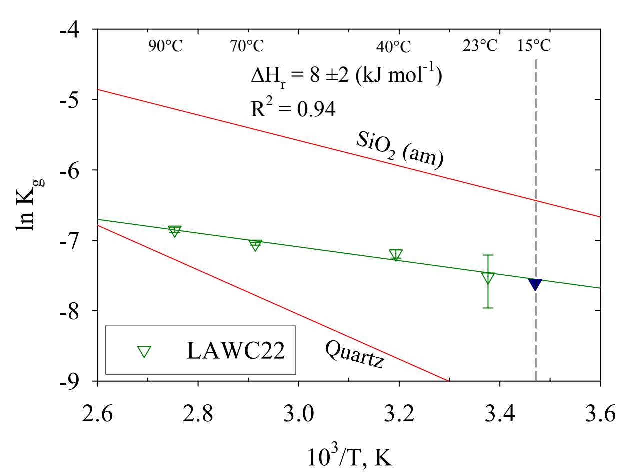

Figure 15. ln K_g vs. Inverse Temperature for LAWC22 Glass

3.2 Characterization of Glass Structure

To gain a more detailed understanding of the relationship between the local coordination geometry around silicon atoms and the effect this has on glass dissolution magic angle spinning nuclear magnetic resonance (MAS-NMR) and Raman spectroscopy were collected for the three prototypic LAW glasses formulation being investigated.

3.2.1 NMR Characterization

The local coordination geometry around silicon atoms within the glass structure was investigated at room temperature for each glass formulation; LAWA44, LAWB45, and LAWC22, using ^{29}Si MAS-NMR. The ^{29}Si spectra were obtained under MAS conditions at a magnetic field strength of 100 MHz frequency (e.g., 2.3T) using a Chemagnetics spectrometer. Each sample was analyzed with a spin speed of 4 kHz using a Chemagentics 2-channel MAS probe.

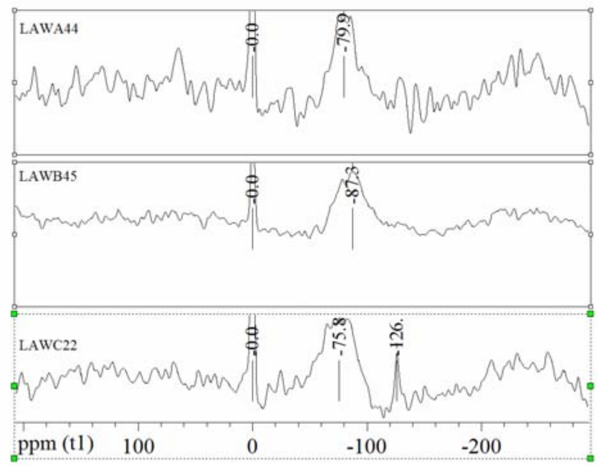

Figure 16. ^{29}Si Nuclear Magnetic Resonance (NMR) Spectra in ppm for LAWA44, LAWB45, and LAWC22 Glasses

Figure 16 shows the MAS-NMR spectra for each glass formulation. The observed chemical shifts were referenced against an internal standard Tetrakis (trimethylsilyl) silane (TMS), which gives sharp peaks at 0.0 and -126 ppm. Broad ^{29}Si peaks were observed, which is typical for Fe bearing borosilicate glasses. Previous MAS-NMR results show that octahedrally coordinated Si (Si^{VI}) has chemical shifts between -180 and -221 ppm (GRIMMER et al., 1986), where as tetrahedrally coordinated Si (Si^{IV}) has chemical shifts between -60 and -126 ppm (KIRKPATRICK, 1988). The ^{29}Si chemical shifts for LAWA44, -79.9 ppm, LAWB45, -87.3 ppm, and LAWC22, -75.8 ppm, confirm four-fold coordinated Si as the dominant local structure within each glass.

3.2.2 Raman Characterization

The Raman scattered light spectra was collected at room temperature in 180 mode with a fiber optic probe. Scattered laser light is passed through a holographic notch filter with an optical density of 4 but 80% transmissivity for Raman scattered light. The probe is coupled to a Holospec (Kaiser Optical Systems) spectrograph. The spectrograph features fast f/1.8 optics, HoloPlexTM transmission grating, and back illuminated CCD detector. Incident light was provided by a 532 nm diode-pumped ND:YAG laser delivering approximately 150 mW at the sample surface.

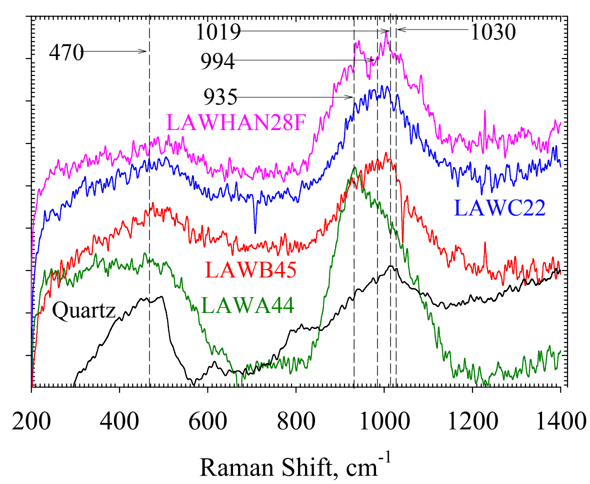

Figure 17. Raman Spectra of LAWA44, LAWB45, LAWC22 and Reference spectra for Quartz

Figure 17 shows the Raman spectra for each glass formulation; LAWA44, LAWB45, LAWC22, HAN28F, along with quartz reference spectra. The main feature of the spectra is the broad feature between 800 and 1200 cm^{-1} that can be assigned to different structural groups associated with the silicate framework. For HAN28F glass, two remarkably sharp peaks are evident at 935 and 990 cm^{-1} that can be assigned (BUNKER et al., 1988) to Q_1 and Q_2 silicate units in the glass, i.e., SiO_4 with only 1 or 2 bridging oxygens, respectively. The Raman spectra for LAWB45 is clearly shifted to the higher wave number region, at ~1004 cm^{-1}, suggesting that LAWB45 has a higher concentration of polymerized Q_3 ($\equiv Si-O^{-}Na^{+}$) and Q_4 ($\equiv Si-O-Si$) units. This conclusion correlates with the results obtained from SPFT tests conducted on LAWB45, where alkali-hydrogen ion exchange could not be quantified. In other words, LAWB45 has a higher polymerization state in comparison to the other LAW glasses; LAWA44, LAWC22, and LAWHAN28F, and is the result of a fewer NBO sites caused by the decreased Na load used for this glass formulation. LAWA44, at 935 cm^{-1}, and LAWC22, at 994 cm^{-1}, are shifted toward lower wave numbers in comparison to LAWB45 and the quartz reference spectra. This suggest that LAWA44 and LAWC22 contain less polymerized silicate units, caused by the excess alkali's contained within these glass compositions. Some caution is advised in interpreting these spectra because stretching modes associated with borate and borosilicate groups also appear in these same frequency bands (BRAY et al., 1980; DELL et al., 1983).

3.3 Summary of SPFT Test Results

A large body of SPFT data is provided in this section on three prototypic simulant glasses; LAWA44, LAWB45, and LAWC22, for LAW. Results from these experiments were used to derive the input parameters necessary to conduct long-term PA calculations with the STORM reactive transport computer code. A summary of the recommended best estimate rate law parameters is provided in Table 7.

Table 7. Summary of Best Estimate Rate Law Parameters for LAWA44, LAWB45, and LAWC22 Glasses at 15ºC.

Parameter	Meaning	LAWA44	LAWB45	LAWC22	Comments
$\vec{k}$	forward rate constant (g m^{-2} d^{-1})	1.3×10^4	1.6×10^4	1.0×10^5	
K_g	apparent equilibrium constant for glass based on activity product a[SiO_2(aq)]	5.45×10^{-4}	5.24×10^{-4}	5.25×10^{-4}	
η	pH power law coefficient	0.49 ±0.08	0.34 ±0.03	0.42 ±0.02	
E_a	activation energy of glass dissolution reaction (kJ mol^{-1})	60 ±7	53 ±3	64 ±2	
σ	Temkin coefficient	1	1	1	Assigned constant
r_x	Na ion-exchange rate (mol m^{-2} s^{-1})	5.3×10^{-11}	0	1.2×10^{-10}	No detectable ion exchange rate for LAWB45

4.0 Chemical Reaction Network

Low-Activity Waste (LAW) performance assessment models must account for the long-term corrosion rate of each LAW glass formulation. This corrosion rate is a key parameter affecting the overall performance of the integrated disposal facility (IDF). Therefore, having determined the kinetic rate law parameters for LAWA44, LAWB45, and LAWC22 glass samples as described in Section 3.1.5, the next set of required data to conduct source-term calculations with the STORM code is 1) a set of secondary phases that form from the long-term corrosion of these glasses in the disposal system environment, and 2) the precipitation-dissolution rate and/or solubility product for each of these phases. Although the suite of weathering products that will form as a consequence of the glass-water reactions cannot be determined a priori at this time, discussed by McGrail et al. (MCGRAIL et al., 2000b), laboratory tests can be used to simulate and accelerate the weathering process. To address these and other issues, experiments were conducted to evaluate the corrosion rate on two simulant (LAWB45 [Envelope B] and LAWC22 [Envelope C]) and two radioactive glass formulations made with actual Hanford waste (LAWAP101 [Envelope A] and LAWAN102 [Envelope C]), using the PUF apparatus. In addition to these PUF tests, static PCT were conducted on each of the three simulant glasses; LAWA44, LAWB45, and LAWC22.

The following section will provide a description of the apparatus or technique, experimental materials and methods, data analysis, and results for the PUF and PCT tests, respectively.

4.1 Pressurized Unsaturated Flow (PUF) Apparatus Experiments

The PUF apparatus allows for accelerated weathering experiments to be conducted under hydraulically unsaturated conditions, thereby mimicking the vadose zone environment while allowing the corroding glass to achieve a final reaction state. The PUF apparatus provides the capability to vary the volumetric water content from saturation to 20% of saturation or less, minimize the flow rate to increase liquid residence time, and operate at a maximum temperature of 100°C. The PUF column operates under a hydraulically unsaturated condition by creating a steady state vertical water flow, while maintaining uniform water content throughout the column, and by using gravity to assist in drainage.

The underlying principle for creating such conditions is Darcy's Law as modified by Richards (1931)

$$J_w = -K(\psi_m)\frac{\delta\psi}{\delta z} \qquad (9)$$

Where J_w is the volumetric flux density; m s^{-1}, ψ is the water potential (equal to the matric potential [ψ_m] + gravitational potential [ψ_g]); m, $K(\psi_m)$ is the hydraulic conductivity as a function of matrix potential; m s^{-1}, and z is the length of the column; m.

It can be shown that if uniform moisture content is established throughout the column equation reduces to:

$$J_w = K(\psi_m)\,. \qquad (10)$$

Equation (10) simply states that under uniform water content conditions, the volumetric flux density of water is equal to the unsaturated hydraulic conductivity.

4.1.1 Description of the PUF Apparatus

This system has been previously described in other publications, and an interested reader should consult these references, as well as the references contained therein for more detail. Only a general description will be provided within this document. In general, the PUF system consists of a column (7.62-cm length and 1.91-cm diameter) fabricated from a chemically inert material, polyetheretherketone (PEEK), so that dissolution reactions are not influenced by interaction with the column material. A porous titanium plate with nominal pore size of 0.2 μm is sealed in the bottom of the column to ensure an adequate pressure differential for the conductance of fluid while operating under unsaturated conditions (WIERENGA et al., 1993). Titanium (Ti) was chosen because it is highly resistant to corrosion and has excellent wetting properties. Once the porous titanium plate is water saturated, water but not air is allowed to flow through the 0.2 μm pores, as long as the applied pressure differential does not exceed the air entry relief pressure or "bubble pressure" of the Ti plate. If the pressure differential is exceeded, air will escape through the plate and compromise the ability to maintain unsaturated flow conditions in the column.

The computer control system runs LabVIEW™ (National Instruments Corporation) software for logging test data to a disk from several thermocouples, pressure sensors, in-line sensors for effluent pH and conductivity, and column weight from an electronic strain gauge to accurately track water mass balance and saturation level. The column also includes a "PUF port," which is an electronically actuated valve that periodically vents the column gases. The purpose of column venting is to prevent reduction in the partial pressure of important gases, especially O_2 and CO_2, which may be consumed in a variety of chemical reactions.

4.1.2 Experimental Materials and Methods

The materials and methods section provides information on the material preparation techniques, experimental setup, test conditions, and rate calculations that were used for the testing of several LAW glass compositions.

4.1.2.1 Materials Preparation

All glass samples used for these PUF tests were sieved into the -40 +60 mesh (420 to 250-μm diameter) size fraction. The sample preparation and surface area calculation process remained the same and is described in Section 3.1.1.

4.1.2.2 Experimental Setup

As described in Section 4.1.1, the basic PUF apparatus consists of a column where glass particles (or other material) of a known size and density are compacted to a known bulk density (g m^{-3}). The remaining void space (which is not filled by glass) represents the porosity (ε). Volumetric water content (θ) is the percent volume of water within the total fixed column volume. For example, when a 20-cm^3 column is packed with glass leaving a 50% void space (ε), the column is considered fully saturated when 10 mL of water (θ = 50%) is in the column at any given point in time. Using these same parameters, a column is considered unsaturated when $\theta < \varepsilon$. The rate of water flow through the column is the pore water velocity (U_p, m/s), which is simply the influent flux (m^3/s) divided by the cross-sectional area of the column (m^2) divided by θ. To determine the residence time for an aliquot of water to move through the column, the length (m) of the column is divided by U_p.

These experiments were performed at nominal flow rate of 2.0 mL d^{-1} and a temperature of 90°C. Each column was packed with the crushed and cleaned glass, giving an initial porosity of approximately 0.40 ±0.03, and then vacuum saturated with water at ambient temperature. A temperature controller was programmed to heat the column to 99°C in approximately 1 h (1°C/min). The column was allowed to initially desaturate during heating by gravity drainage and was also vented periodically to maintain an internal pressure less than the bubble pressure of the porous plate. After reaching 99°C, the influent valve was opened, and influent was set the appropriate flow rate. Column venting was set to occur once an hour, so that the partial pressure of O_2 and CO_2 could remain relatively constant. Effluent samples were collected in a receiving vessel, which was periodically drained into tared vials from which samples were extracted and acidified for elemental analysis by ICP-OES and inductively coupled plasma-mass spectrometry (ICP-MS).

4.1.2.3 Release Rate and Error Calculations

The results from chemical analyses on collected effluent samples are used to calculate a normalized release rate according to (McGrail et al., 2002)

$$r_i = \frac{4\varepsilon Q(c_{i\mathrm{L}} - c_{i\mathrm{b}})}{\theta s(1-\varepsilon)\rho\pi \mathrm{d}^2 \mathrm{L} f_i} \qquad (11)$$

where r_i is the normalized rate of ith element (g m^{-2} d^{-1}), $c_{i\mathrm{L}}$ is the effluent concentration of ith element (g m^{-3}), $c_{i\mathrm{b}}$ is the background concentration of ith element (g m^{-3}), d is the column diameter (m), f_i is the mass fraction of i^{th} element in the glass (unitless), L is the column length (m), Q is the volumetric flow rate (m^3 d^{-1}), s is the specific surface area of the glass sample (m^2 g^{-1}), ε is the porosity (unitless), ρ is the glass density (g m^{-3}), and θ is the volumetric water content (unitless).

An estimate in the uncertainty associated with the normalized rate will be calculated using standard error propagation theory, assuming the variables in Equation (11) are uncorrelated. In this case, the standard deviation of a function $f(x_1, x_2, \ldots x_n)$ is given by Equation (4) and assuming that the error associated with the background concentration ($C_{i,b}$), diameter (d), and column length (L) are negligible compared with the other variables, the relative standard deviation is given by

$$\sigma_{r_i} = r_i \sqrt{\left(\frac{\tilde{\sigma}_\varepsilon}{1-\varepsilon}\right)^2 + \left(\frac{\tilde{\sigma}_{c_{i,L}}}{1-c_{i,B}/c_{i,L}}\right)^2 + \tilde{\sigma}_Q^2 + \tilde{\sigma}_\theta^2 + \tilde{\sigma}_S^2 + \tilde{\sigma}_\rho^2 + \tilde{\sigma}_{f_i}^2} \qquad (12)$$

where the tilde over the σ symbol signifies the relative standard deviation for the subscripted parameter. In calculating the error bounds with Equation (12), typical fixed relative standard deviations have been estimated based upon repeatability of laboratory measurements:

$$\tilde{\sigma}_\varepsilon = 6\%, \quad \tilde{\sigma}_S = 20\%, \quad \tilde{\sigma}_Q = 2\%$$
$$\tilde{\sigma}_\rho = 5\%, \quad \tilde{\sigma}_{c_{i,L}} = 10\%, \quad \tilde{\sigma}_{f_{i,L}} = 10\%$$

The value of $\tilde{\sigma}_\theta$ is calculated from the variation in water content recorded by the data acquisition system over the discrete interval between each fluid sampling. A computer macro program is available to perform this calculation directly in the Excel™ spreadsheet used to store the sensor data.

4.1.3 PUF Test Results

For ease of discussion, the PUF results are separated into three sections; section one discusses the results from PUF test on the simulant glass composition LAWA44, whereas section two and three provide a progress report on two additional simulant glasses, LAWB45 and LAWC22, and two radioactive glass samples; LAWAN102 and LAWAP101, respectively.

A comprehensive list of the experimental conditions, including temperature, solution pH, volumetric water content, and the concentration of the major elements is given in Appendix B. As in the SPFT test, boron was considered as the primary element for determining the dissolution rate of the glass matrix.

4.1.3.1 PUF Results for LAWA44 Glass

Results from the computer-monitored test metrics for LAWA44 glass are shown in Figure 18. At about approximately day 150 in the test with LAWA44 glass, an electrical problem developed with the conductivity sensor. The sensor was repaired at approximately day 350. Because the sensor data are noisy, the data were smoothed using a bi-square weighting method where the smoothed data point, y_s, is given by $y_s = (1-\omega^2)^2$. The parameter ω is a weighting coefficient calculated from a window surrounding the smoothing location in the set of the independent variables. A low-order polynomial regression (order 2 in this case) is used to compute ω for each smoothed value. The smoothed data are provided as lines in Figure 18.

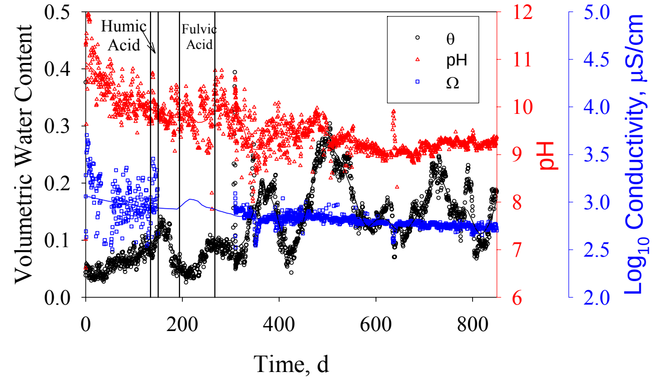

Figure 18. Computer Monitored Test Metrics From PUF Tests with LAWA44 Glass. Lines are bi-square smoothed fits to the raw data. The vertical lines give the periods where a 50 mg/L humic acid solution and a 10 mg/L fulvic acid solution was injected instead of deionized water.

A comparison of normalized release rates for the major components in LAWA44 glass is shown in Figure 19. Over the 850-day duration, the glass corrosion rate has slowed from an early-time rate of approximately 0.2 g m^{-2} d^{-1} to approximately 0.01 g m^{-2} d^{-1}. In comparison to previous PUF tests, the B release rate for LAWA44 glass is anywhere from 8 to 40X lower than the HLP glass series; HLP-9 glass (0.1 to 0.08 g m^{-2} d^{-1}), HLP-10 glass (0.1 to 0.08 g m^{-2} d^{-1}), and HLP-31 (0.4 g m^{-2} d^{-1}), and 10X lower than LAWABP1 glass (0.1 g m^{-2} d^{-1}) Therefore, these PUF test results indicate that LAWA44 glass performs well and is one of the more durable ILAW glasses tested to date.

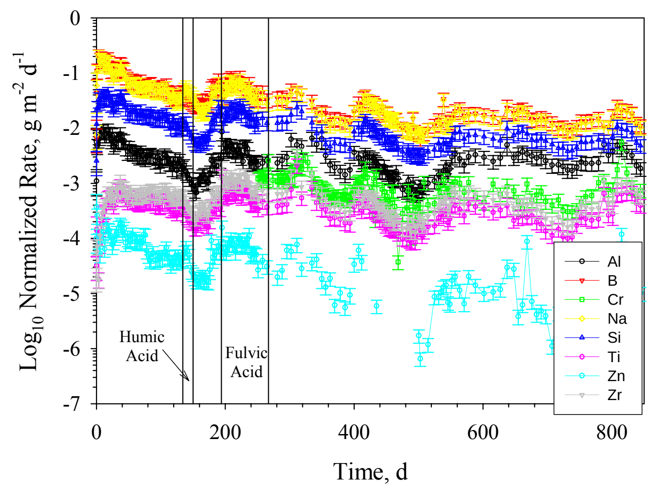

Figure 19. Normalized Release Rate for Selected Elements in PUF Tests with LAWA44 Glass

At approximately day 135, the DIW influent in the PUF test with LAWA44 glass was changed out for the 50 mg/L humic acid solution. As shown in Figure 18, no change in electrical conductivity or solution pH occurred immediately after the change to the humic acid solution. No change in the dissolution rate of the LAWA44 glass is evident either from the effluent chemical analysis, as shown in Figure 19, although the higher Na content of the humic acid solution is clearly detected over the injection period. Essentially identical results were obtained with the fulvic acid solution, i.e. no statistically significant change in dissolution rate was observed. These results are in accord with what was observed in SPFT experiments with the same organic acids (MCGRAIL et al., 2001a).

After termination of the PUF test with LAWA44 glass, the reacted solids were subsampled as found (loose and moist particles) at 1 to 5 mm intervals. These samples were analyzed for moisture content; by drying in glass vials at room temperature in a vacuum desiccators with $CaSO_4$ desiccant, and secondary alteration phases, using X-ray diffraction (XRD) and scanning electron microscopy (SEM).

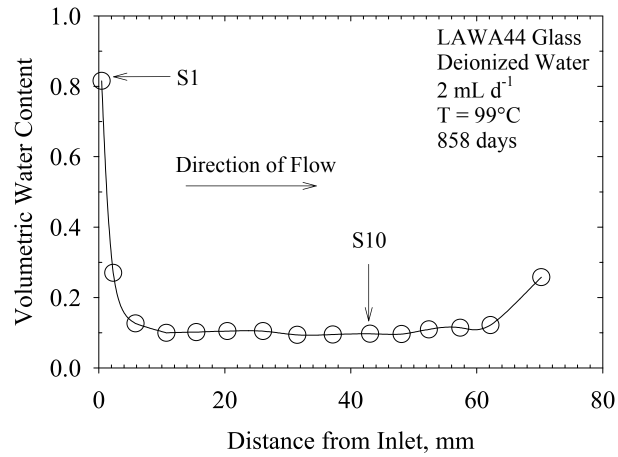

Figure 20. Moisture Fraction as a Function of Distance from the PUF Column Inlet for LAWA44 Glass

Figure 20 shows the post-test distribution of moisture in the PUF column as function of depth. The data are unusual as compared with other ILAW glasses we have tested in that no downstream peaks in water content were found. Peaks in water content have typically coincided with the onset of more extensive secondary phase formation (and consequent glass degradation). The lack of water content peaks suggests a more uniform and less extensive secondary phase formation with LAWA44 glass. This is indeed what is observed in scanning electron microscopy (SEM) images of the reacted solids from the PUF test, shown in Figure 21. The most extensive alteration is observed in sample S1 taken from the column inlet. As is typical of PUF reacted samples, glass alteration is observed only on portions of the grains that were in contact with water whereas other areas remain pristine. The background subtracted X-ray diffrac-

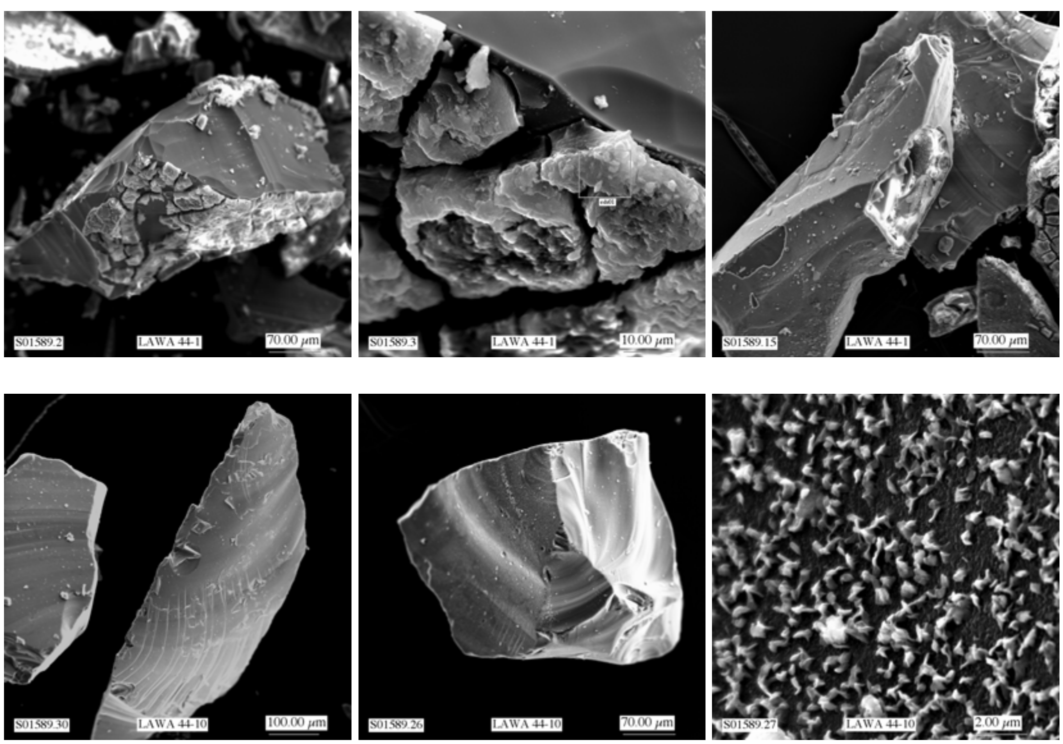

Figure 21. SEM Photographs of Reacted Grains of LAWA44 Glass After 858 Days in PUF Test at 2 mL/d and 99°C. The first row of pictures is from sample S1 at the column inlet. The second row is from sample S10, 44 mm downstream from the column inlet.

tion (XRD) pattern of the reacted sample (see Figure 22) contains low intensity broad reflections typical of clay minerals. The diffraction peaks in the tracing appear to be based on a first order basal reflection of 6.2° 2θ (14.1Å). Chlorite, a phyllosilicate mineral, has a basal series of diffractions peaks based on a first order reflection of 14.2 Å, with the odd ordered peaks having weak intensities as the iron content increases. Additionally, the diffraction peak located at 60.45° 2θ (1.54 Å) is similar to the 060 reflection characteristic of chlorite, which ranges between 1.538 Å and 1.549 Å (MOORE and REYNOLDS, 1989). Chlorite minerals commonly have a considerable range of substitutions for both trivalent and divalent ions, hence the phase ID of clinochlore should be considered qualitative in terms of the chemical makeup of the clay mineral. In contrast with sample S1, sample S10 taken further downstream shows only very thin alteration layers. High magnification images show sparse precipitates located on portions of the layer but these were not identifiable crystalline phases in the XRD analysis.

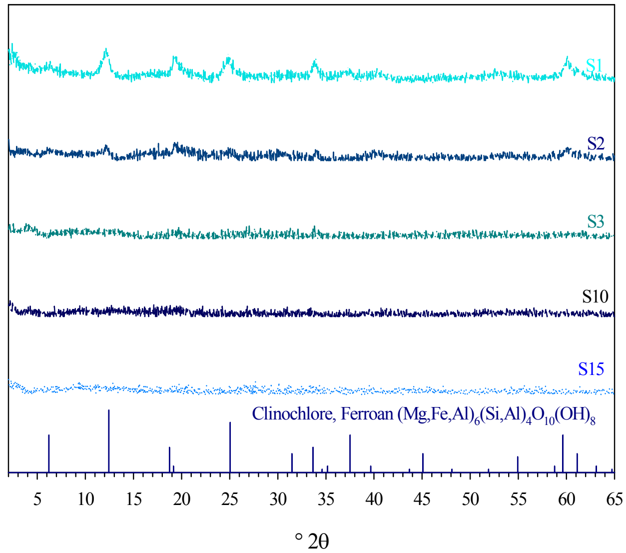

Figure 22. XRD Analyses of Reacted LAWA44 Glass Samples Taken from PUF Column After 859 days at 2 mL d^{-1} and 99°C.

4.1.3.2 PUF Results for LAWB45 and LAWC22 Glasses

Results from the computer monitored test metrics (e.g., volumetric water content [θ], pH, and electrical conductivity [Ω]), from the tests with LAWB45 and LAWC22 are shown in Figure 23. These test metrics, collected for more than 380 days (Figure 23), display that although periodic deviations in the volumetric water content occurred throughout the course of these test, an average of 12 and 15%, respectively, was obtained for each experiment. Periodic deviations in the effluent pH and electrical conductivity mirror the volumetric water content, which usually suggest the formation of secondary reaction products. Figure 23 also illustrates that effluent pH and electrical conductivity are moderate for both glass formulations, suggesting moderate corrosion rates. The electrical conductivity is highest for LAWC22, suggesting it is dissolving fastest in comparison to LAWB45. This is consistent with the higher Na_2O loading, 14 mass% for LAWC22, in comparison to 7 mass% for LAWB45.

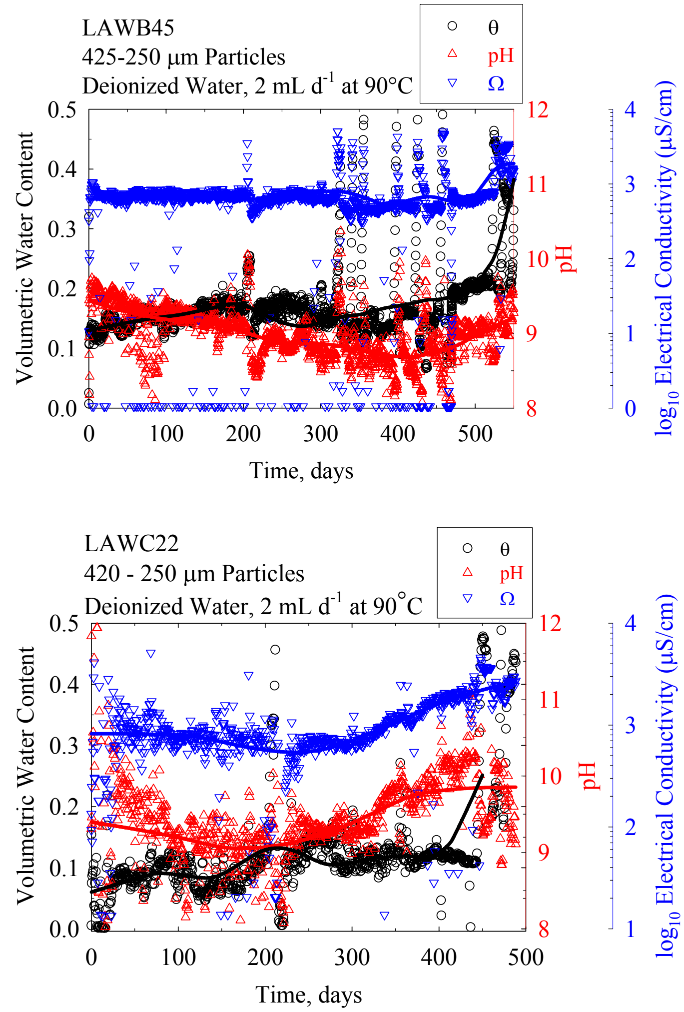

Figure 23. Computer Monitored Test Metrics from PUF Tests with LAWB45 (top) and LAWC22 (bottom) Glass Formulations. Lines are Bi-square Smoothed Fits to the Raw Data.

Results from effluent chemical analyses are shown in Figure 24. The observed differential rates of release are typical and the result of the element's solubility behavior in water. These results suggest that release of Al, Ca, and Si is solubility controlled; whereas B, Li, Na, and S release is not. As previously discussed, B is used to monitor the dissolution of the glass matrix, as no solid phases are expected to form that would affect its solution concentration. Therefore based on the B release data and as illustrated in Figure 24, the LAWC22 glass sample (from 0.08 to 0.1 g m^{-2} d^{-1}), is reacting faster than the LAWB45 glass sample (from 0.06 to 0.07 g m^{-2} d^{-1}). Again, these results are also consistent with the observed higher electrical conductivity and Na content of LAWC22.

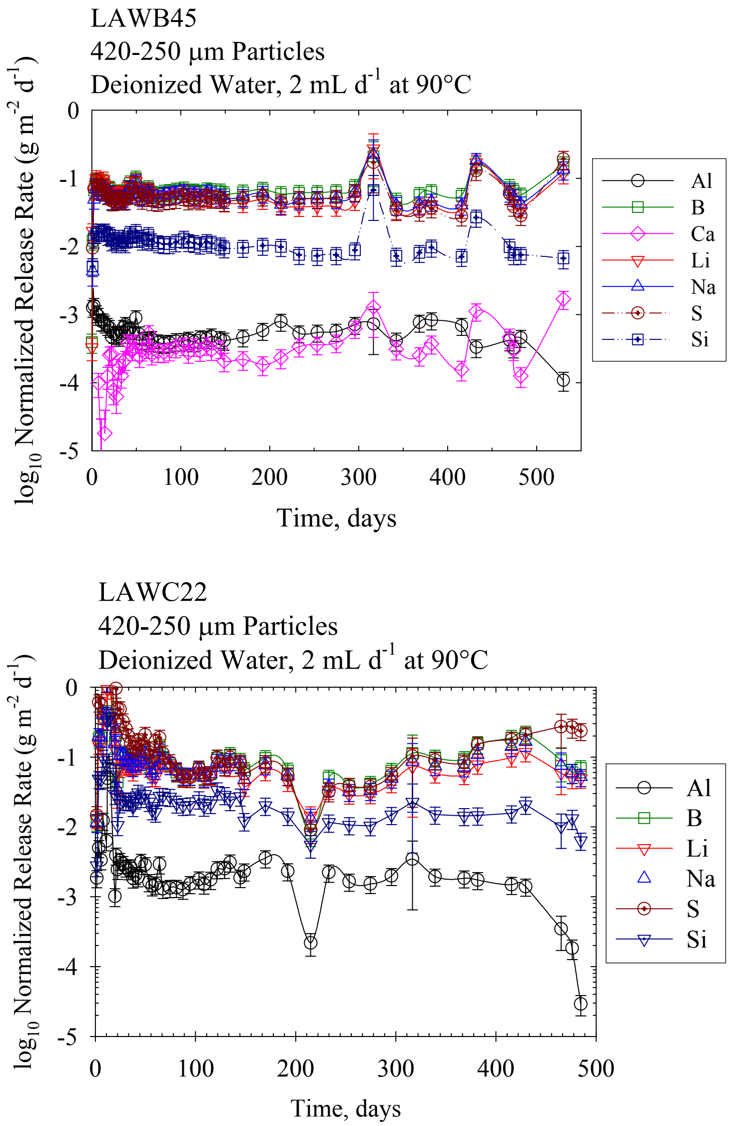

Figure 24. Normalized Release Rate for Selected Elements in PUF Test with LAWB45 (top) and LAWC22 (bottom) Glasses

As described in Section 4.1.3.1, characterization of the reacted solids for LAWB45 and LAWC22 PUF test were conducted after each test was terminated. Figure 25 shows the post-test volumetric water content for the LAWB45 and LAWC22 PUF columns as a function of depth.

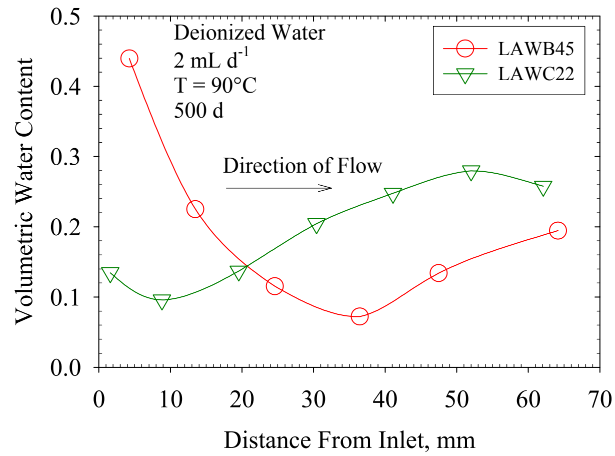

Figure 25. Volumetric Water Content as a Function of Distance from the PUF Column Inlet for LAWB45 and LAWC22.

The volumetric water content distribution suggests that more extensive secondary phase formation has occurred within the first 10 mm of the inlet port for the LAWB45 test (Figure 25). Bulk powder XRD was used to confirm presence of and identify the secondary phase(s) that formed (Figure 26). The most intense reflection is for sample LAWB45-1 at 6° 2θ as compared with the other 5 subsamples. This subsample also showed reflections at 19.8 and 61.3° 2θ. These reflections are distinctive of a 14 Å clay mineral and closely match nontronite, an Fe-rich smectite [$Na_{0.3}Fe_2Si_4O_{10}(OH)_2 \cdot 4H_2O$]. In addition to LAWWB45-1, possible nontronite reflections were also observe for the other five subsamples that were removed from various positions in the PUF column; LAWB45-2, -3, -4, -5, and -6.

Unlike LAWB45, LAWC22 had the highest volumetric water content within the last 10 mm of the column (Figure 25). XRD analysis of the reacted glass removed from this section, LAWC22-6, produced a single broad reflection at 6.9 °2θ, typical of the 2:1 layer silicate clay, most likely sepiolite (Figure 26). No additional crystalline phases were observed in the other six subsamples; LAWC22-1, -2, -3, -4, and -5.

In addition to these PUF test, two additional PUF test on LAW glass made with actual Hanford tank, LAWAN102 and LAWAP101 waste are still in progress and are discussed in the following section.

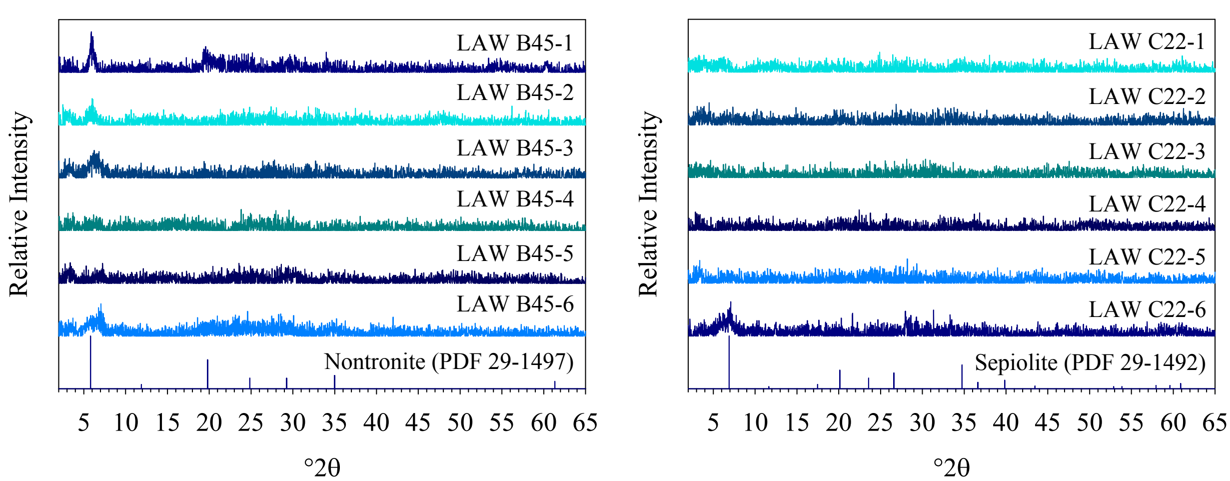

Figure 26. XRD Analyses of Reacted LAWB45 Glass Samples Taken from PUF Column After 530 days at 2 mL d^{-1} and 99°C

4.1.3.3 PUF Results for LAWAN102 and LAWAP101 Glasses

The computer monitored test metrics results for the PUF tests with LAWAN102 and LAWAP101 are shown in Figure 27. The data were current as of the time this report was written; this test is still in progress. The LAWAP101 results show a rapid increase in pH along with a relatively high reading for electrical conductivity during the first 40 days of testing. The measured pH and electrical conductivity (Figure 27) combined with the B and Na release rate data (Figure 28) indicate a significant rate of glass corrosion in the early stages of the test. However, pH, electrical conductivity, B, and Na release rates have declined with time.

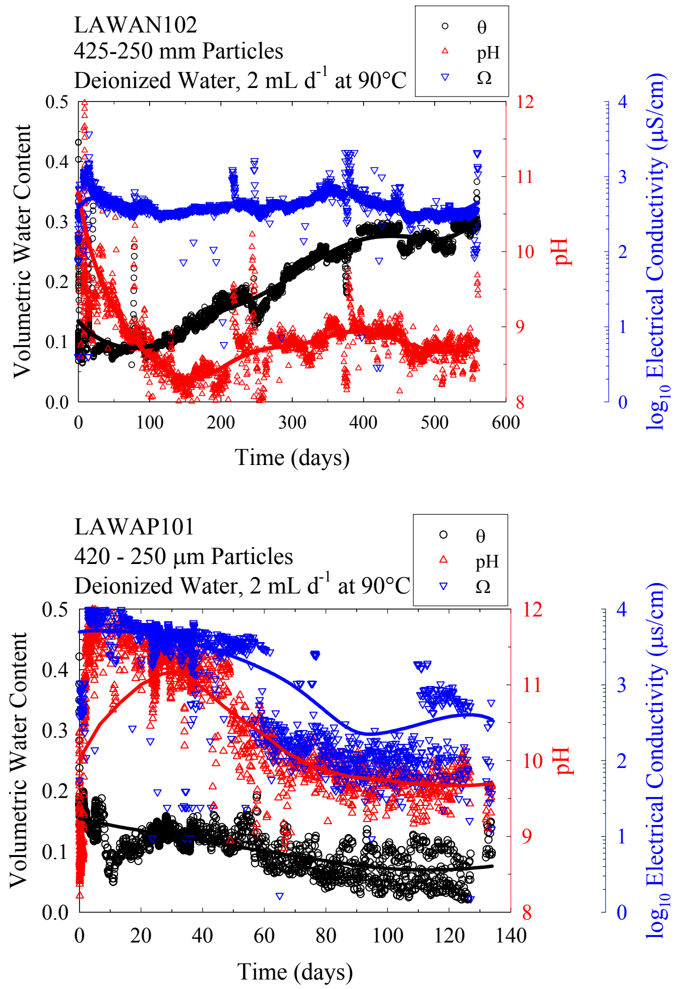

Figure 27. Computer Monitored Test Metrics from PUF Tests with LAWAN102 (top) and LAWAP101 (bottom) Glass Formulations. Lines are Bi-square Smoothed Fits to the Raw Data.

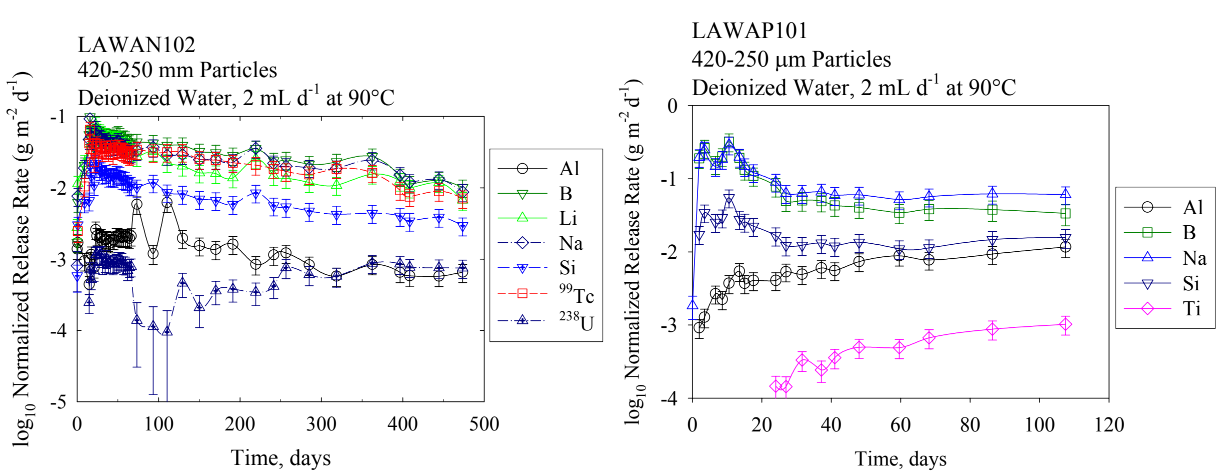

Figure 28. Normalized Release Rate for Selected Elements in PUF Test with LAWAN102 (left) and LAWAP101 (right) Glasses.

The results from effluent chemical analyses on LAWAN102 are shown in Figure 28. As discussed in Section 4.1.3.2, differential rates of release are observed for each major glass component, which reflects their solubility behavior in water. Boron and Na are highly soluble, and so have the highest elemental release rates. Bulk dissolution behavior is typically indexed by the rate of B release, as no solid phases are expected to form that would affect its solution concentration. A comparison of ^{99}Tc to B release rates from LAWAN102 indicates that ^{99}Tc is being released congruently with Na and B within experimental measurement error. There is no evidence of significant incorporation of ^{99}Tc into alteration phases, as has been observed in static, water-saturated corrosion tests (MATTIGOD et al., 2002).

4.1.4 Summary of PUF Results

PUF test were conducted on three prototypic stimulant glasses; LAWA44, LAWB45, and LAWC22, as well as two LAW glasses produced with actual tank waste, LAWAN102 and LAWAP101. A summary of the steady state B release rates for these LAW glasses are provided in Table 8 along with the LAWABP1 for comparison. All the test glasses have good long-term performance indicators with LAWA44 being somewhat better than other tested glasses, factoring in the declining reaction rates observed with longer test durations.

Table 8. Summary of the Long-Term B Release Rates for PUF Tests on LAWA44, LAWB45, LAWC22, LAWAP101, and LAWAN102

Sample ID	B Release Rate, g m^{-2} d^{-1}	Test Duration, days
LAWA44	0.0083 ±0.002	850
LAWB45	0.066 ±0.018	500
LAWC22	0.077 ±0.021	500
LAWAN102	0.048 ±0.013	350
LAWAP101	0.063 ±0.017	250
LAWABP1	0.1	188

One consistent theme observed in each PUF test is the formation of mineral phases that range both in composition as well as the degree of crystallinity. We conclude that this observation is result of compositional differences between each LAW glass formulation as well as the dynamic nature of this test. In addition to PUF test, PCT experiments were conducted to determine the secondary phase paragenesis for each glass composition.

4.2 Product Consistency Test (PCT) Experiments

The PCT has been standardized as an American Society for Testing and Materials (ASTM) standard procedure (ASTM, 1994). The ASTM standard includes two methods: PCT Method A was developed specifically for verifying process control during production of vitrified high-level waste (HLW) forms and is conducted with specific values of test parameters; PCT Method B does not specify the values of test parameters. Because the PCT Method B encompasses commonly used variations of test parameters, PCT Method B was used in this work.

4.2.1 Experimental Materials and Methods

The materials and methods section provides information on the material preparation techniques, experimental setup, test conditions, and rate calculations that were used for the testing of several LAW glass compositions.

Each of the glass samples used in PCT tests were sieved and washed using the same procedure as described in Section 3.1.1. The PCTs were conducted by placing a fixed amount of crushed glass with DIW in a Teflon reaction vessel at 90°C. Two glass surface-area-to-solution volume ratios (S/V) were used: 1) 1 g of glass per 10 mL of DIW to give an S/V of 2000 m^{-1}, and 2) 1 g of glass per 1 mL of DIW to give an S/V of 20,000 m^{-1}. To limit water loss for long-duration experiments, the Teflon PFA reactors were sealed inside a stainless steel Parr reactor. At the end of the test, the solution is analyzed for pH and the concentrations of dissolved glass components. The reacted glass surface was also analyzed to help characterize any alteration phases formed during the test.

4.2.2 PCT Test Results

4.2.2.1 LAWA44 Glass

The boron release data from the PCT experiments on each of the glass formulations was used to compute a reaction progress value as a function of test duration. Reaction progress is simply the moles of glass dissolved in 1 kg of water. The results are shown in Figure 29.

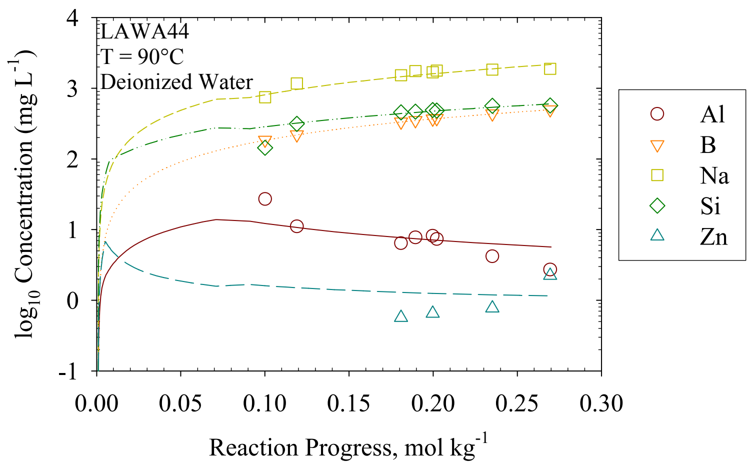

Figure 29. Comparison of PCT Solution Concentration Data (symbols) with the Solution Composition Calculated with the EQ3/6 Code (lines) for LAWA44 Glass

Using the B release data from the PCT experiments with LAWA44 glass, a reaction progress value was calculated as a function of test duration. Reaction progress is simply the moles of glass dissolved in 1 kg of water. The results are shown in Figure 29. Also shown on the figure is the predicted elemental solution concentration from the EQ3/6 version 8.0 code (WOLERY and DAVELER, 1992). These curves were obtained by allowing a paragenetic sequence of alteration phases to form in the simulation, as shown in Figure 30. Agreement with the experimental data is good. To adequately reproduce the PCT data, it was necessary to adjust the log K upward for several of the phases (labeled as amorphous). This

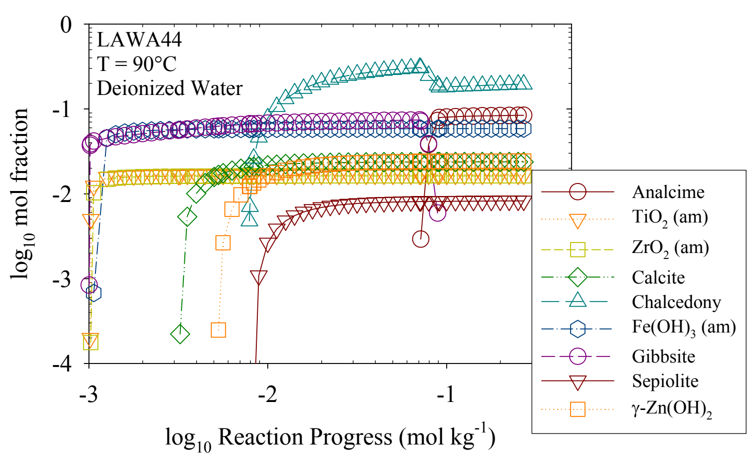

Figure 30. Predicted Paragenetic Sequence of Alteration Phases Formed During the Reaction of LAWA44 Glass in Deionized Water

is a consequence of the fact that amorphous solids rather than their crystalline analogs often form in laboratory experiments with waste glasses. The amorphous solids are typically much more soluble and this is reflected in the equilibrium constant. The log K values assigned to each of the phases used in the simulations are provided in Table 9.

Figure 31 and Figure 32 display the results from an X-ray diffraction and scanning electron microscopy analysis of the post-test reacted glass. The XRD analyses confirm the presence of the zeolite mineral, analcime ($Na_{0.96}Al_{0.96}Si_{2.04}$•$H_2O$) along with another zeolite phase; analcime was also predicted to form in the EQ3NR simulations. The SEM images of the reacted grains show needle-like crystalline phases, in the foreground, and a gel like-phase, in the background. Results from EDS analyses suggest that these phases are mainly composed of Al, Fe, Na, and Si, with minor amounts of K.

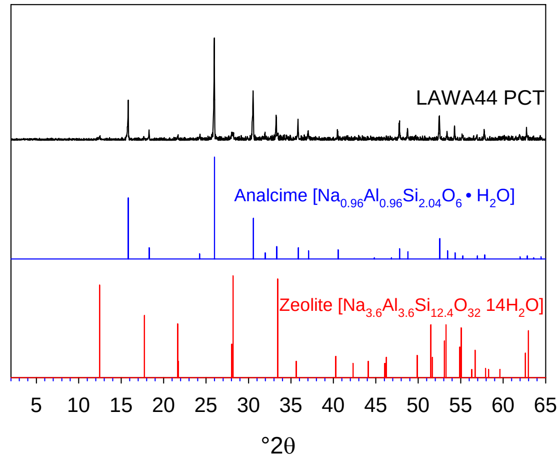

Figure 31. XRD Results of the PCT test reacted LAWA44

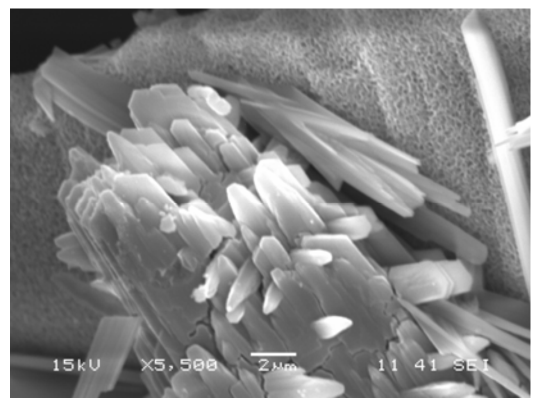

Figure 32. SEM Results of the Reacted LAWA44 Glass After 350 d PCT Test

Table 9. Secondary Phase Reaction Network for LAWA44 Glass. log K is calculated at 15°C

Phase	Reaction	log K
Analcime $Na_{0.96}Al_{0.96}Si_{2.04}O_6 \cdot H_2O$	Analcime = $0.96AlO_2^- + 0.96Na^+ + 2.04SiO_2(aq)$	-13.47
TiO_2 (am)	TiO_2 (am) + $2H_2O = Ti(OH)_4(aq)$	-6.56
ZrO_2 (am)	ZrO_2 (am) + $2H_2O = Zr(OH)_4(aq)$	-6.73
Calcite $CaCO_3$	Calcite + $H^+ = Ca^{2+} + HCO_3^-$	2.00
Chalcedony SiO_2	Chalcedony = $SiO_2(aq)$	-3.64
$Fe(OH)_3$ (am)	$Fe(OH)_3$ (am) = $Fe(OH)_3(aq)$	-2.33
Gibbsite $Al(OH)_3$	Gibbsite = $AlO_2^- + H^+ + H_2O$	-15.61
Sepiolite $Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$	Sepiolite + $8H^+ = 4Mg^{2+} + 6SiO_2(aq) + 11H_2O$	31.29
Zinc Hydroxide $Zn(OH)_2$(gamma)	$Zn(OH)_2$(gamma) + $2H^+ = 2H_2O + Zn^{2+}$	11.88

4.2.2.2 LAWB45 and LAWC22 Glasses

Figure 33 summarizes the available PCT data on LAWB45 and LAWC22 glasses to date. Using the B release data from these PCT experiments, a reaction progress value was calculated as a function of test duration. Reaction progress is simply the moles of glass dissolved in 1 kg of water. The results shown in Figure 33 suggest that B, Li, and Na are being released congruently, whereas Al and Si are not. Currently, no attempts have been made to model the solution composition data as additional, longer-duration tests with these glasses remain in progress. So far, the dissolution behavior of LAWB45 and LAWC22 glasses are entirely normal with no indications of reaction rate acceleration due to secondary phase formation.

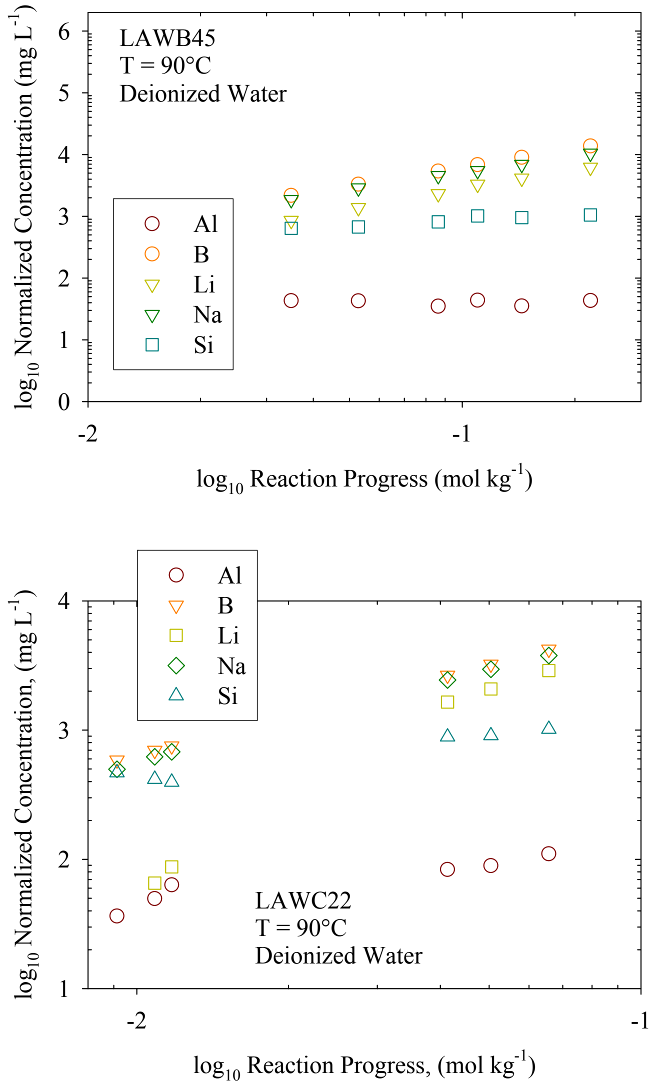

Figure 33. PCT-B Results for LAWB45 (top) and LAWC22 (bottom) Glasses

5.0 Microbial Degradation Experiments

Microbes (bacteria, fungi and lichens) are widely recognized as playing an important role in numerous low-temperature geochemical processes. Weathering of silicates in nature is one of these processes. Microbes use the substrate as a source of energy or trace elements that enhances their survival and proliferation in a microbial community (EHRLICH, 1996).

Numerous studies on microbial-mediated dissolution of basaltic glasses have been conducted because of important role that alteration plays in marine chemistry (ALT and MATA, 2000). A few earlier investigations have focused on whether a direct attack by microbes can cause the breakdown of quartz and glass. Microbial attack on antique glasses at archaeological sites has shown to be much faster than abiotic corrosion processes alone (KRUMBEIN, 1983). Organic acids produced as metabolic byproducts are confined in biofilm microenvironments that have lower pH than the bulk fluid and thus generate locally enhanced rates of corrosion (LIERMANN et al., 2000). The organic acids (or base) may also directly enhance hydrolysis of Si–O and Al–O bonds or act as ligands that enhance silica solubility (EHRLICH, 1996).

Low-activity waste glasses contain Cr, F, Mg, P, S, and Zn in much higher concentration than native Hanford soil. Microbial communities may therefore be attracted to the relatively large concentration of these important elements in the disposal system. Also, the transition to an IDF means that ILAW glass forms may be disposed in proximity to a variety of different wastes, including those that could supply a source of organic carbon. Clearly an investigation of LAW glass degradation due to microorganisms is needed.

Progress to date and the critical findings from the experimental investigation of the biodegradation of ILAW glass media is summarized in this section. Testing commenced in August 2001. An experimental procedure was developed during FY01 for the investigation of ILAW glass degradation due to Hanford microorganisms. The test design was developed with the following considerations: 1) avoid the use of glass containers, 2) separate chemical and microbial effects on degradation by statistical design of the experimental matrix, and 3) devise a sterile method for periodic analysis of the bacteria-doped fluids in contact with the glass. Sample preparation, equipment used, test matrix, and testing procedures used are described in this section.

5.1 Experimental Methods

Summarized in Table 10 is the matrix of experimental variables used. The preparation and surface area calculation process for the LAWA44 glass used in these experiments remained the same and is described in Section 3.1.1.

Table 10. Matrix of Experimental Variable in the Glass Biodegradation Experiments

Variable	Value/description	
Glass type	1	LAWA44 (75 – 150 μm)
Glass surface area	1	500-1000 cm^2/g
Glass/Solution Ratio	1	1:100
Carbon content	2	0, 0.1%
Microbial Culture	3	none, Hanford, Pure
pH	1	7
Temperature	2	19 and 40°C

Microorganisms used in the tests were obtained from two sources: 1) solution extract from a composite of Hanford soils representative of the proposed ILAW disposal facility, and 2) a pure culture of *Thiobacillus perometabolis* (TPM) obtained from a commercial supplier. This bacteria strain is prescribed by ASTM G160-98 (ASTM, 2002) for similar degradation studies.

Solutions used in the glass corrosion experiments were the same as those used to culture the TPM or to extract microorganisms from the Hanford soil. A phosphate-buffered-saline (PBS) solution with a pH of 7 was used for suspension of the TPM. Hanford soil extract was prepared by adding 1.0 g of Hanford sediment to 20 mL DIW. The pH was adjusted to ~8 with $NaHCO_3$ buffer. The slurry was shaken well for 10 to 15 minutes. After shaking, the slurry was sonicated for one hour. The supernatant was removed and transferred to a clean tube and sealed. After 24 hours, 5 mL of the supernatant was suspended directly into DIW or a 0.1% sodium pyrophosphate solution (SPS) at pH 7. As will be demonstrated later, this procedure resulted in the generation of a suspension of colloid size particles of Hanford soil in addition to any microbes present in the sample. The bacteria were grown overnight in nutrient broth (ATCC Culture Medium 528) and resuspended in either DIW or their respective phosphate buffer solution prior to use. One set of experiments was also setup with an added carbon source, a 0.1% (by volume) yeast extract solution. All chemicals used in the experiments were of reagent grade. The cell density of the suspended bacterial culture used in all the experimental vials was determined on a Beckman DU-70 spectrophotometer, based on optical density measurements.

Results from analysis of samples for key glass constituents in the original experimental solution prior to any contact with glass are shown in Table 11. High concentrations of Na in these solutions (except DIW) are due to the presence of Na in the buffer solutions.

An abridged test matrix, summarizing the experimental cells and the associated variation in the experimental parameters are listed in Appendix D. Appendix D also provides a list of the blanks and controls, some of which have glass powder without any bacterial culture present.

Table 11. Concentrations (ppb) of Constituents in Initial Solutions Without Glass Contact

Sample Description	Al	B	Na	Si
Distilled Water	14 ±4	12 ±11	493 ±429	402 ±161
Phosphate-Buffered-Saline	27 ±7	45 ±15	3100000 ±345000	682 ±283
Sodium Pyrophosphate Solution	37 ±33	16 ±11	301000 ±33160	381 ±263

5.2 Test Equipment

The glass degradation experiments were set up under aerobic conditions using 50-mL Teflon flasks with air-tight screw caps. The caps were fitted with gas-tight valves (locking), which would allow removal of solution with a needle and sterile disposable syringe. The glass was weighed, placed in each flask, sealed, and then sterilized by autoclaving. In addition to autoclaving the glass sample, any equipment not sterilized previously by gamma irradiation was autoclaved. All preparation was done in a sterile hood. Each flask was inoculated with a known mass of bacterial culture and 50 mL of corresponding solution. After being inoculated, each flask was placed in a secure covered area on a bench top for the 19°C experiments and in an incubator for the 40°C experiments. After the initiation of incubation, glass degradation kinetics is monitored by a periodic measurement of the solution concentration of major glass components (Al, B, Na, Si), pH, and cell density in the vial solution. No monitoring of gases (including CO_2) in the flasks was conducted. The reactor contents were not subjected to mixing or stirring.

5.3 Sampling Procedure

Solution samples were collected in a sterile hood. At sampling, each flask is unlocked, a needle inserted, 1 mL of solution removed approximately 25.4 to 38 mm from top of the flask. The 1 mL of solution is then placed in a sterile 5 mL falcon tube and diluted to a total volume of 5 mL. The tubes were labeled and tightly sealed. Blanks and controls were sampled in the same manner and stored for later analysis.

5.4 Results

Figure 34 shows a representative picture of the reactor flasks. Cloudiness of the solution is due to microbial growth. The concentration of Al, B and Si in the flasks containing TPM, HSE, and no culture (blanks) for both the 19 and 40°C experiments are listed in Appendix D. Although the details will not be presented here, the majority of the data for the TPM culture show no statistically significant deviations from the control samples. In contrast, the data from flasks containing the Hanford soil microorganisms (HSE) yielded significantly higher concentrations of Al, B and Si when compared with majority of the control samples. This does not appear to be pH related as the pH of all samples falls within a narrow range (5.5 to 7.5).

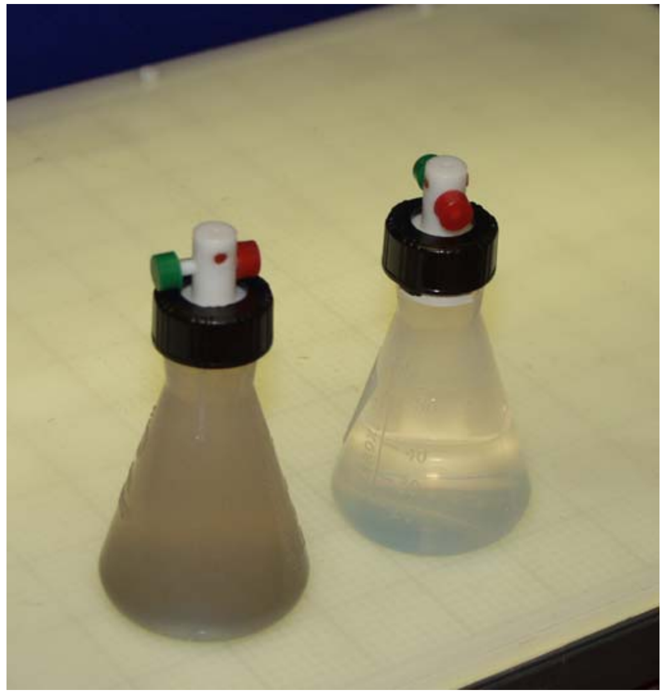

Figure 34. Visual Observation of Bacterial Growth After 14 Weeks. Right: Exp # 31 DIW; Left: Exp # 15 glass, HSE, added Carbon at 19°C

A comparison of the boron release data from the control experiments and the experiments conducted with HSE is given in Figure 35. The data clearly show enhanced glass corrosion (over 5X) in the experiments with HSE. Similar effects were observed at 19°C. *However, we do not believe that these results represent evidence of microbial enhanced degradation of LAWA44 glass*. A small portion of the reacted solids was removed from the bottom of one of the HSE vessels and analyzed by SEM and XRD. Figure 36 shows a SEM photograph taken on a sample removed from test MBD44-16. A grain of LAWA44 glass is clearly visible in the back of the photograph; in the foreground are colloid-size particles that appear very similar in morphology to minerals present in Hanford soil. XRD analyses of the MBD44-16 sample (see Figure 37) clearly shows the major crystalline phases present are identical to those contained in Hanford soil. Based on the small amount of glass that has reacted, we believe that the large volume of mineral phases observed in these experiments was most likely introduced from the HSE solution. In addition to that lack of glass reaction, Figure 36 suggests that these phases settled out of solution and were not created as a reaction product at the glass/water interface.

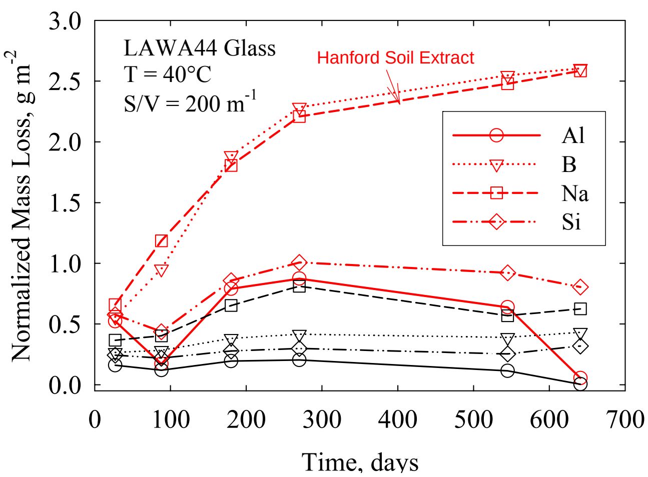

Figure 35. Comparison of Element Release Rates From LAWA44 Glass in Static Tests Conducted with DIW Only (black data points) versus Hanford Soil Extract (red data points)

The introduction of Hanford soil minerals (plus any microbes present in the soil) was not considered during the initial planning for these experiments. Because of the high-surface area of these minerals in comparison with the glass, it is highly probable that they act as low surface-energy templates for additional precipitation, which causes the glass to dissolve faster to maintain stable concentrations of silicic acid. We believe this abiotic mechanism is the most probable cause of the increased glass degradation rate shown in Figure 35, but acknowledge that it is impossible to rule out a biotic or bio-assisted mineralization process in these tests. Interestingly though, it was the interfaces between ILAW glass and Hanford soil that were predicted in reactive transport simulations to have the maximum glass dissolution rates in the ILAW disposal facility (MANN et al., 2001), again due to chemical effects (and hydraulic effects) at the glass/soil interfaces. These calculations were completed well *before* the experiments discussed here were even begun. Hence, the experimental results shown in Figure 35 represent a true (if accidental) validation of the computational chemical model being used for long-term performance evaluations of LAW glass.

Figure 36. SEM Picture of Reacted Solids Removed From Static Corrosion Test with HSE Solution After 700 d at 40°C. Solids in the foreground are minerals extracted from Hanford Soil during preparation of the HSE solution.

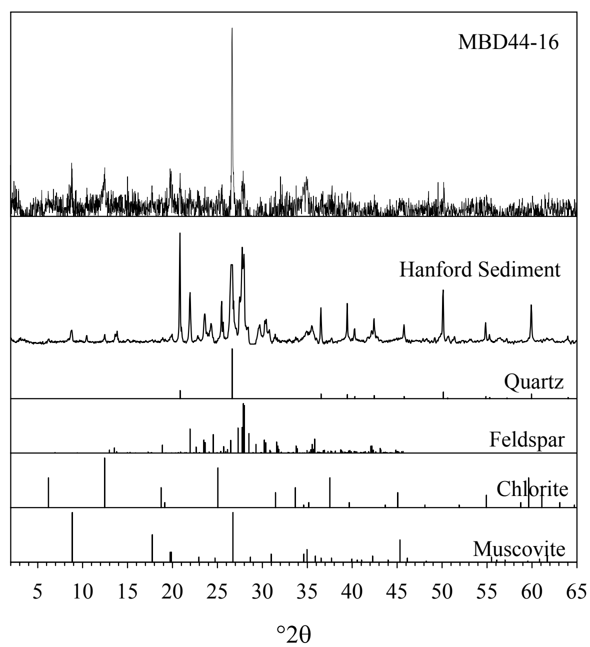

Figure 37. Comparison of XRD Patterns for Reacted Solids Removed After 700 days from Test MBD44-16 and Hanford Soil

6.0 Release of Contaminants from Secondary Waste

Presently, no published data are available for quantifying the release of contaminants of concern from secondary waste streams that will be solidified in a likely cement-based waste form and disposed in the IDF. The secondary waste stream of most interest for the IDF PA is projected to be slurries generated from caustic scrubbing of off-gasses being vented from the WTP and any other alternative treatment technology (e.g., bulk vitrification and/or steam reformation) being evaluated. The projected composition of the caustic scrubber secondary waste stream is shown in Table 12. This recipe, which is normalized to a 5 M Na concentration, is being used in some preliminary waste solidification studies funded by CH2M-Hill Hanford Group (contract to Center for Laboratory Services) and by DOE Headquarters (contract to Vanderbilt University). Table 12 also shows that Na makes up 9.52 wt% of the stimulant. For comparison, the projected average caustic scrubber secondary waste effluent from the alkaline line effluent collection tanks is 4.14 wt% Na. Leanne Mahoney[1] used the Environmental Simulation Program (ESP) model (OLI Corporation) to predict that all the chemicals listed in Table 12 will dissolve to make up a 5 M Na solution that has a solution pH of 13.5 and a specific gravity of 1.21 g cm^{-3}.

Table 12. Secondary Waste Simulant Recipe.

Reagent	Reagent (g) needed to make up: 1 kg 5 M Na simulant	1 L 5 M Na simulant
H_2O	659.99	796.61
NH_4OH	82.96	100.13
NaOH	7.599	9.172
$NaCH_3COO$	14.67	17.70
$NaNO_3$	3.099	3.741
$Na_2CO_3.H_2O$	231.68	279.64

As previously stated, contaminant release data for this specific waste stream after solidification in cement/grout are not currently available, but for the purpose of this data package we have elected to use release data obtained from the nuclear waste literature. The cement/grout-based solidified waste forms (e.g., Portland cement and mixed cement, slag, fly ash or other pozzolan etc.) used in these studies are mixed with highly saline and often caustic liquid wastes and are therefore expected to be similar to the expected waste form produced when mixed with secondary waste. By the next PA, more IDF site-specific data should be available to add technical defensibility to future performance predictions. We begin with a brief overview of key chemical processes important in production of cementitious waste forms.

[1] Personal Communication between the authors and Leanne Mahoney at Pacific Northwest National Laboratory, Richland, WA

6.1 Product Characteristics

Production of cementitious waste forms is expected to be performed by mixing dry reagents with the waste feed. Typical dry reagents consist of 1) Portland cement, 2) fly ash, 3) blast furnace slag (BFS), and 4) ferrous sulfate monohydrate (1988; LANGTON, 1989). The BFS and ferrous sulfate are used in some formulations to reduce redox sensitive elements (such as Tc, U, and Cr), causing them to be precipitated as insoluble compounds and thereby lowering their release rate from the cement. Hydration and setting of the cement begins upon mixing water with the dry reagents. Each component contributes to a complex set of chemical reactions that consume water, produce heat, and form calcium-silicate-hydrate (CSH) gel. A generalized reaction scheme is given by

$$Ca_3SiO_5 + 3H_2O \rightarrow xCaH_2SiO_4 \cdot (1-x)SiO_2 + (3-x)Ca(OH)_2 \qquad (13)$$

$$Ca_2SiO_4 + 2H_2O \rightarrow xCaH_2SiO_4 \cdot (1-x)SiO_2 + (2-x)Ca(OH)_2 \qquad (14)$$

where x is the Ca/Si ratio of the CSH gel. The CSH can be considered a solid solution consisting of a non-ideal mixture of the end-member components CaH_2SiO_4(s) and SiO_2(s) (RAHMAN et al., 1999). The calcium hydroxide produced from reactions (13) and (14) reacts with silica and calcium aluminates in reactions such as

$$Ca_4Al_2Fe_2O_{10} + 4Ca(OH)_2 + 22H_2O \rightarrow Ca_8Al_2Fe_2O_{14} \cdot 26H_2O \qquad (15)$$

$$Ca_3Al_2O_6 + Ca(OH)_2 + 12H_2O \rightarrow Ca_4Al_2O_7 \cdot 13H_2O \qquad (16)$$

Reactions (13) thru (16) (along with many others) produce solid particles (e.g., portlandite phases) that continue to grow with time (PETERSON et al., 2002) and develop a macroscopic fine-scale pore structure which trap and limit the transport of contaminants contained within the cement matrix. Hydration of BFS initially proceeds much slower than Portland cement, but the products of hydration are similar in terms of chemical make-up, i.e. CSH. Hydration of BFS depends on the activation of the glass component by hydroxyl and alkali ions available from the Portland cement hydration. Activation of the glass is relatively slow and causes a delay in the hydration of slag, which is reflected in slower setting and lower early strength development compared to Portland cement. BFS hydration products are generally found to be more gel-like, as compared to cement, and tend to fill voids in the cement paste, increased strength, and enhanced durability.

A significant factor that affects long-term contaminant fate and transport predictions are the chemical reaction pathways that occur as cementitious waste forms interact with the atmosphere and water in contact with them within a subsurface burial ground. Most contaminants are metal-like and thus their aqueous solution chemistry is quite sensitive to pH conditions. The composition of pore water that evolves during the degradation of cement in water has been studied extensively in the laboratory and with computer modeling techniques. The chemical reactions associated with the hydration of cement are described in detail in IAEA (1993), Atkins and Glasser (1992), Reardon (1992), and the references cited therein. The pH changes that occur as the result of cement and water reactions are shown schematically as a function of time in Figure 38.

The dissolution of the CSH and portlandite phases, solids located on the right hand side of equations (15) and (16), which may constitute as much as 75 wt% of the hydrated cement, has an important role in buffering the pH of the resulting pore fluids. As groundwater reacts with the cement, dissolution of the alkali hydroxide phases present in relatively minor amounts can result in initially high pH values (approximately 13.5). As these phases are leached from the cement, the pore fluid pH decreases to approximately 12.5 and is buffered by the dissolution of free portlandite contained in the cement.

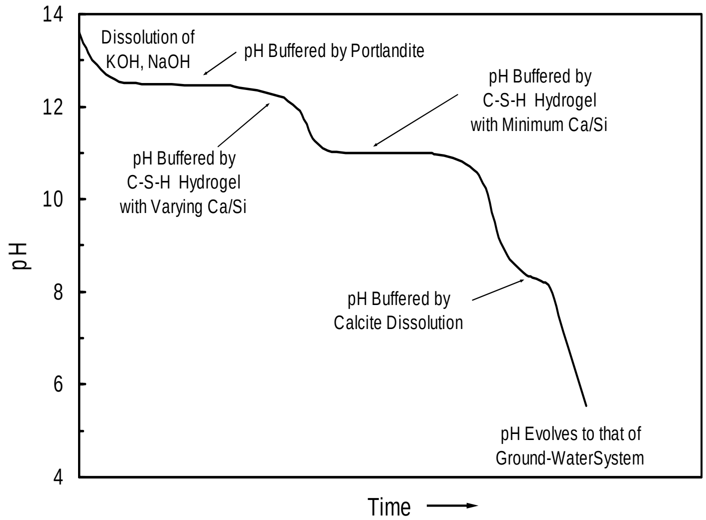

Figure 38. Change of Pore Water pH Resulting from Reactions of Cement Components

Eventually the portlandite is depleted and the pore fluid pH continues to decreases to approximately 10.5, where it is controlled by the incongruent dissolution of CSH. The solubility properties of CSH, however, vary as a function of its calcium/silicon ratio (Ca/Si ratio). The incongruent dissolution of the CSH produces mainly dissolved $Ca(OH)_2$ and only traces of dissolved SiO_2. During this process, the Ca/Si ratio of the remaining CSH solid decreases depending on solid/solution ratio (BERNER, 1992). When the dissolution of CSH is complete, the pH of the cement pore fluid will continue to decrease to a value buffered by the host groundwater or vadose zone porewater. This continuous pH change will also be affected to a limited extent by the dissolution of any calcite that precipitated at the high pH conditions during the early stages of cement dissolution.

The timeframe required for the porewater pH to change from 13.5 to that of the groundwater is determined by the rate at which water migrates through the cement system. For example, calculations by Atkinson et al. (1989) indicate that the pH of the near-field pore water would remain above 10.5 for several hundred thousand years for designs of radioactive waste disposal systems being considered in the United Kingdom. Criscenti et al. (1996) performed calculations for three rows of 55-gallon drums stacked on top of each other in a shallow land burial ground in the arid Hanford environment for various scenarios. For all scenarios modeled, the system pH did not decrease below 10 for 10,000 years because CSH gel remained to buffer the pH. For a scenario of one barrel filled only one-third with cement at the highest recharge rate (5 cm/yr), the CSH gel would completely dissolve in 4,000 years, and the pH would drop below 10.

Another parameter that can vary significantly in cement pore water and influence radionuclide adsorption potential is the solution redox potential, Eh. The major constituent that can influence the Eh of cement pore fluids is the sulfur contained in compounds found in slags that are often used in tailoring solidification of radioactive wastes. For details, the reader is referred to the discussions on this topic in Angus and Glasser (1985), Atkins and Glasser (1992), and references contained therein. The Eh conditions of the disposal facility may also be lowered by corrosion of iron containers (EWART et al., 1988).

In summary, fresh cement/concrete is such a highly reactive and unstable assemblage of solids that care must be taken when predicting the release of contaminants because of wide swings in pH caused by the $Ca(OH)_2$ and CSH components of hydrated cement. It is likely that some co-precipitation loss of metal-like contaminants occurs during short term laboratory leach testing that generally studies only the early-time high pH portion of the evolving system. Thus, the very long-term release of metal-like contaminants from cementitious solid waste forms for the later stages of weathering are not available and could be underestimated by available short-term empirical laboratory studies.

6.2 Release Modeling

The framework for modeling the long-term performance of vitrified waste (MCGRAIL et al., 2000b) is based on a mechanism in which matrix hydrolysis and contaminant release are controlled by the rate that chemical bonds are broken. While similar arguments can be made regarding the importance of modeling chemical reactions and transport in cement pore waters (BACON et al., 2002), with cementitious waste forms, a physical model of contaminant diffusion has been almost universally adopted (COOK, 2000). Empirical effective diffusion coefficients measured in short-term laboratory experiments are widely used to model the long-term performance of cementitious waste forms (ALBENESIUS, 2001). These diffusion measurements have changed little since the IAEA method was proposed by Hespe (1971) over 30 years ago. The effective diffusion coefficients measured for each contaminant are used for a diffusion-controlled transport analysis in the continuous pore network of the cement coupled with diffusive-advective transport in idealized fractures. Because waste-form specific data for secondary wastes is not available at this time, it is prudent to utilize the simpler diffusion-based modeling approach for the 2005 IDF PA. Further, no geochemical reaction pathway or mathematical constructs have been created to address the fate of trace contaminants bound in the cementitious solids as they weather/react over long time frames. The previous section summarizes the evolution of porewater pH, one of the key variables that control the fate of metallic contaminants. Thus, there is a second reason for relying upon simple models for the 2005 IDF PA.

Diffusional transport of species through cement is best treated as a combination of physical transport and chemical interactions. The chemical interactions can have important retarding effects on final transport rates. The intrinsic diffusion coefficient (D_i) is a measure of the physical contribution to diffusion and depends on the tortuosity (τ), constrictivity (δ), and porosity (ε) of the cement, which influence the diffusion coefficient of free water, D_f , by

$$D_i = D_f \frac{\varepsilon\delta}{\tau^2} \tag{17}$$

Chemical interactions can be quite varied (ion exchange, precipitation, specific and irreversible adsorption and each process may have fast or slow kinetics). The simplest process that is mathematically readily tractable is ion exchange with fast kinetics and a linear isotherm. This simple chemical process gives rise to the following equation where the modified diffusion coefficient is called the effective diffusion coefficient, D_e, and is related to the intrinsic diffusion coefficient by a chemical capacity factor, α

$$D_e = \frac{D_i}{\alpha} \tag{18}$$

The capacity factor is the ratio of the moles of contaminant per unit volume of water-saturated solid (C_s) to the moles per unit volume of contaminant in the liquid, C_L. The capacity factor is related to the K_d (mL/g) by the following equation:

$$\alpha = \varepsilon + \rho K_d \tag{19}$$

where ρ is the is the bulk density of the porous solid. Again we stress that this relationship requires fast and reversible chemical reaction processes and that sorption satisfies the linear isotherm constraint (adsorption is independent of contaminant concentration). Few chemical reactions for contaminants meet these requirements.

Regardless, this simple construct is often applied in quantifying the release of contaminants from cementitious waste forms because it allows one to separate the physical and chemical processes that control transport. There are several experimental methods that one can use to measure the K_d (and then compute α) after also measuring the porosity and bulk density of the waste form. Conversely, one can measure the effective diffusion coefficient using through diffusion cells, penetration profiles of a contaminant into a solid porous medium, or out diffusion of contaminants (leaching tests). In Section 6.4.1, we review the relevant literature on iodine release from cementitious waste forms.

6.3 Effective Diffusion Coefficients for Key Contaminants to be Disposed in IDF

Table 13 contains "proxy" effective diffusion coefficients for key contaminants of concern for cementitious/grout solidified secondary wastes destined for disposal in IDF. These values are not site-specific or of the same pedigree as the release parameters tabulated for ILAW glass in other sections of this data package or for the K_d values presented in the companion geochemistry data package (KRUPKA et al., 2004). By the next detailed IDF performance assessment, scheduled in 2010, site-specific release data for key contaminants from cement/grout solidified secondary waste will replace the "proxy" values shown in Table 13. It is also plausible that more sophisticated release conceptual models, more in line with the constructs used for glass as described within other sections of this data package, will be available for the 2010 PA activity.

Table 13 was mainly generated from a review of several previous data compilations for either leach results (effective diffusion coefficients), desorption K_d results for release of contaminants from spiked grouts/cements or from adsorption K_d results for uncontaminated grouts/cements placed in spiked solutions. Further, we searched two electronic data bases, on-line documents at DOE-OSTI at http://www.osti.gov/bridge/search.easy.jsp and *Web of Science* for journal manuscripts from 1980 to 2004. Only a few specific references were found with useful data beyond past compilations: Serne et al. (1995), Krupka and Serne (1996; 2001), Bradbury and Sarott (1995), and Bradbury and Van Loon (1998) and references cited within these compilations. All these sources were used to populate Table 13.

Two categories of effective diffusion coefficients are listed. The first column represents values that should be considered as most probable, meaning that the values represent projected releases of the contaminant under the baseline or most likely conditions to be found in the IDF. The second column represents higher release values that can be used to account for unexpected or adverse conditions and to allow "conservative" calculations of release. In addition, values are provided for different valence states/physical forms or species for some of the contaminants and for iodine and uranium the type of grout or cement is split into categories. In Section 6.4, it is shown that type of grout (oxidizing or reducing) can alter the speciation of iodate. Further, from geochemical principles and empirical data in the waste management literature it is known that uranium(VI) sequestration into cement/grout is highly sensitive to the pH and dissolved carbonate content of the porewater. As summarized in Section 6.1 and discussed in more detail within Krupka and Serne (1996), cement porewater evolves with time from a highly caustic and carbonate deficient solution towards a moderately caustic less carbonate deficient, and finally to a near neutral pH solution that is in equilibrium with atmospheric carbon dioxide. Therefore, the release properties for uranium that is solidified in cement/grout will change significantly over time as the solid weathers from contact with atmospheric carbon dioxide and recharge water.

Other considerations in using Table 13 are that for some listed contaminants either no data at all (e.g., for Hg) or no data closely similar to projected IDF specific conditions were found (e.g., uranium in aged/weathered cements) such that the chosen values are qualified with the designation “guess.” Assigning the “guess” attribution should be a flag that the value is a subjective choice based on the “expert opinion” of R. J. Serne, staff scientist at PNNL. For those values in Table 13 that are based on the generic literature a reference or rationale for choosing the value is identified.

Table 13. Most Probable and Conservative Estimates for "Proxy" Effective Diffusion Coefficients ($cm^2 s^{-1}$) for Key Contaminants in Secondary Waste Solidified in Cementitious Waste Forms.

Element	Waste Form Species	Waste Form Type	Effective Diffusion Coefficient		Reference/ Rationale
			Most Probable	Conservative	
			-------------------------- $cm^2 s^{-1}$ --------------------------		
N	NO_3^-	any cement/grout	5×10^{-9}	3×10^{-8}	(SERNE et al., 1992)
	NO_2^-	any cement/grout	5×10^{-9}	3×10^{-8}	(SERNE et al., 1992)
I	I^- (free)	any cement/grout	2.6×10^{-9}	1×10^{-8}	(ATKINS et al., 1988)
	IO_3^-(free)	any cement/grout	2.6×10^{-9}	1×10^{-8}	(ATKINS et al., 1988)
	I^- (insoluble salt)	any cement/grout	2.3×10^{-10}	1×10^{-9} (guess)	(KALININ et al., 1983)
	IO_3^- (insoluble salt)	cement/oxidizing grout	5.0×10^{-11}	3.1×10^{-9}	(CLARK, 1977), (KALININ et al., 1983)
	IO_3^- (insoluble salt)	reducing grout	2.6×10^{-10} (guess)	1×10^{-9} (guess)	
Tc	TcO_4^-	any cement/grout	5×10^{-10}	1×10^{-8}	(SERNE et al., 1992)
	Tc(IV)	any cement/grout	5×10^{-12} (guess)	5×10^{-11} (guess)	
Cr	Cr(VI)	any cement/grout	5×10^{-11}	5×10^{-10} (guess)	(SERNE et al., 1992)
	Cr(III)	any cement/grout	1×10^{-12} (guess)	1×10^{-11} (guess)	
Hg	Hg(I) free	any cement/grout	1×10^{-11} (guess)	1×10^{-10}(guess)	
	Hg(II) free	any cement/grout	1×10^{-11} (guess)	1×10^{-10}(guess)	
	Hg(I) (insoluble salt)	any cement/grout	1×10^{-12}(guess)	1×10^{-11} (guess)	
	Hg(Ii) (insoluble salt)	any cement/grout	1×10^{-12}(guess)	1×10^{-11} (guess)	
U	U(VI)	fresh cement/grout	1×10^{-12}	1×10^{-11} (guess)	(SERNE et al., 1992)
	U(IV)	fresh cement/grout	1×10^{-13} (guess)	1×10^{-12} (guess)	
	U(VI)	aged cement/grout	1×10^{-11} (guess)	1×10^{-10}(guess)	
	U(IV)	aged cement/grout	1×10^{-12} (guess)	1×10^{-11} (guess)	

6.4 Iodine Release From Secondary Waste

The radionuclide ^{129}I is a key contaminant of concern because of its mobility in Hanford sediments and long half-life (MANN et al., 2001). A key factor affecting the distribution of ^{129}I in waste to be disposed in the IDF is volatilization during waste form processing. Mann et al. (MANN et al., 2003a) have estimated that as much as 100% of the ^{129}I sent to the WTP or to supplemental treatment processes may be volatilized, captured in off-gas treatment systems, and sent to secondary waste treatment. Secondary waste streams are assumed to be encapsulated in a grouted waste form as Category 3 low-level waste (LLW) or mixed low-level waste (MLLW). Because the impact to groundwater from secondary waste was found to be much higher than calculated impacts for the other waste forms (e.g., ILAW and the proposed alternative waste technologies) disposed in the IDF (MANN et al., 2003b), it is important to develop the input data to assess ^{129}I release rates from secondary waste. Unfortunately, no process-specific work has been performed to characterize the chemical form of ^{129}I that would be sent to secondary waste treatment nor have ^{129}I release studies been performed on secondary waste forms. Hence, the objective of this section is to review the available literature on iodine release from cementitious waste forms to provide recommendations for release modeling and the required input parameters. We begin with a brief overview of key chemical processes important in production of cementitious waste forms.

6.4.1 Literature Review

Although the literature on leaching of cementitious waste forms is extensive, studies specific to iodine are relatively sparse. Atkinson and Nickerson (1988) performed such tests using a pure Portland cement mixed with distilled water at a cement to water ratio of 0.4. The reacted solids were cured for 2 days at room temperature and then for an additional 3 days at 56°C. The batch K_d for iodide was determined on crushed cement equilibrated with cement-equilibrated water (pH ~ 12.5). The K_d for iodide was measured as a function of time at room temperature, solid particle size used, solid-to-solution ratio, and initial concentration of the iodide added. The behavior of the iodide was rather complicated in comparison to Sr and Cs. The data suggested that the adsorption was highly dependent on the concentration of iodide present (non-linear isotherm), time (kinetics) and particle size of the crushed cement. The calculated capacity factor term, see Equation (18) and (19), varied from 3 to 2000 as the effective iodide concentration in the "equilibrium" solution in contact with the crushed cement decreased from 10^{-2} to 10^{-8} M. On a positive note, the iodide desorption K_d appeared to be the same as the adsorption K_d within experimental error so that adsorption was reversible.

Atkinson and Nickerson (1988) also performed diffusion tests on a slab of cement (5 mm thick) placed between two reservoirs of water; one reservoir was filled with a known concentration of iodide (10^{-4} M as KI) and the other reservoir with no iodide. The appearance of radioiodide in the clean reservoir was monitored as a function of time. From this type of test method, one can estimate both the intrinsic diffusion coefficient, D_i, and the capacity factor, α, from the results. The steady state flux into the second reservoir is related to the physical term, D_i and the rate of build up of contaminant in the second reservoir is related to the chemical term. Again, the capacity term was found to be highly sensitive to the amount of iodide present. At high concentrations or more correctly mass amounts, there was little interaction between the iodide and the cement so that the capacity term was about the same as the porosity (0.3). The intrinsic diffusion coefficient for a case with high iodide mass being present varied from 0.7 to 1.2×10^{-7} cm^2 s^{-1}. For the case where the initial iodide concentration in the "hot" reservoir was 10^{-4} M, the chemical capacity term, α, was found to be 2.6 and the intrinsic diffusion coefficient was 0.5×10^{-7} $cm^2\ s^{-1}$. The chemical capacity term at 2.6 is much lower than the value (30) calculated from the batch K_d methodology for an equilibrium solution concentration of 10^{-4} M iodide.

In a third type of test, Atkinson and Nickerson (1988) ran diffusion experiments on 50-mm-diameter by 10-mm-thick pucks with the cylindrical edges coated with epoxy such that only the circular (axial) faces were exposed to contaminant-laden [10^{-4} M iodide] equilibrated-cement water [200 mL] for between 17 and 53 days. The test was performed at 30°C with the water stirred continuously. The change in radioiodide tracer with time in the solution was monitored. After the stated time periods, the contaminant laden solution was replaced by fresh equilibrated cement porewater and the out diffusion of iodide was monitored in the replacement solution versus time. Iodide results from this test yielded a capacity factor of 30 for iodide while diffusing into the cement and the resultant physically controlled instrinsic diffusion coefficient was 1.5×10^{-7} $cm^2\ s^{-1}$.

A final experiment was performed by Atkinson and Nickerson (1988) where the penetration profile was measured on a 50-mm-diameter by 45-mm "rod" of cement coated with epoxy on all but one of the cylindrical faces that was then submerged in iodide laden cement equilibrated solution [10^{-4} M iodide] for 21 days at 25°C. At the end of 21 days, the rod was sectioned into fine slices. Each slice was ground and the activity of ^{131}I tracer was measured as a function of depth from the face. The iodide data for this test methodology was difficult to interpret because the penetration profile showed nearly constant iodide concentrations through the first 5 mm and then a rapid drop to zero. The highly non-linear nature of iodide sorption was assumed to be the cause of the atypical penetration profile. The data could not be fit to a simple diffusion model and so no valid diffusion parameters were obtained from this test.

Atkinson and Nickerson (1988) conclude that most contaminants solidified into cementitious waste forms do not abide by the assumptions used in simple diffusion models. The sorption processes of most contaminants do not conform to the simple conceptual models and mathematical models available. Thus only relatively crude agreement should be expected between the results of different testing methodologies. For the particular case of iodide, the authors believe that the factor of 20 difference in capacity factor (the chemical portion of the transport) is caused by a combination of the non-linear adsorption properties and the presence of two types of porosity within cement, a relatively low fraction of well connected "fast" and a larger portion of more restricted porosity "slow." Other rocks such as granite also exhibit this dual porosity. Atkinson and Nickerson (1988) recommended an intrinsic diffusion coefficient for pure Portland cement be set at $9 \pm 2 \times 10^{-12}$ $m^2\ s^{-1}$ and the chemical capacity term at 35 ±15 for iodide when present at < 10^{-4} M in solution.

Table 14. Average Leach Rate of Four Iodine Bearing Salts From Portland Cement

Salt	Initial	After 311 days	D_e	D_e
Type	cm/day	cm/day	cm^2/day	cm^2/s
$Ba(IO_3)_2$	6×10^{-3}	2×10^{-6}	6×10^{-7}	6.9E-12
$Pb(IO_3)_2$	5×10^{-2}	2×10^{-6}	9×10^{-7}	1.0E-11
$Cu(IO_3)_2$	3×10^{-2}	3×10^{-6}	6×10^{-7}	6.9E-12
PbI_2	3×10^{-2}	2×10^{-5}	2×10^{-5}	2.3E-10

Kalinin et al. (1983) solidified large quantities (9 wt. %) of individual iodate and iodide salts (Ba, Pb, Cu) into pure Portland cement and leached the resultant solids in distilled water. Iodate and/or iodine in the leachates were determined as a function of time and solution replacement frequency. The distilled water reacted with the cement solids to form a very alkaline pH system (11 to 12, with long time average ~11). The leach rates (R) of iodate and iodide were calculated and are shown in Table 14. The data in Table 14 shows the typical cement leaching trends where the rate for the first several days to a few weeks is larger than the leach rates after a few months to several years. Within experimental error, the authors suggest that initially only the barium iodate form leaches differently (more slowly) than the other forms. After about one year, all the iodate and iodide salts are leaching almost one hundred to one thousand times slower than the original leach rate. The lead iodide salt "instantaneous" leach rate after one year is about ten times faster than for the iodate salts. These data can be converted to apparent diffusion leach rates in the vein of the ANS16.1 protocol to produce effective diffusion coefficient values that can be used in long term PA calculations. The apparent diffusion coefficients for the year long test results have been converted in the fourth and fifth column of Table 14. The relevance of these data to secondary waste streams generated from vitrification processes at Hanford is unclear; these waste streams would contain orders of magnitude lower iodine concentrations than was used in this study and may have very low concentrations of heavy metals (barium, lead, or copper). The magnitude of the effective diffusivities is near those assumed in the IDF Risk Assessment (MANN et al., 2003a) but orders of magnitude smaller than those measured by Atkinson and Nickerson (1988).

Clark (1977) solidified iodate liquid wastes by first forming insoluble barium iodate (mixing iodic acid [HIO_3] with a slight excess of barium hydroxide), then mixed the resultant slurry (salt plus water formed upon mixing the acid and base) with Portland cement [Type I] at water to cement ratios of 0.76 to 0.87. The final hardened cements contained between 2.9 to 9.07 % wt iodine. After curing in closed containers maintained at 100 % relative humidity [water saturated], the hardened waste forms [5-cm diameter by 5-cm height] were leached in 300 mL DIW using a variant of the IAEA intermittent solution replacement test (HESPE, 1971). Leach tests were performed for up to 500 days with solution replacement starting with daily increments and ending with 28-day replacement increments.

The experimental data showed some deviation from the simple diffusion theory but the deviation (a slowing in cumulative mass leached versus square root of time) is observed in most leaching data for cement solidified waste. Clark (1977) presents two plots with the leach data however no effective diffusion coefficients are derived and when one takes data off the plots to calculate the effective diffusion coefficient the values are not realistic; values are at least four orders of magnitude too large. If we assume that the authors inverted their scale correction noted in the manuscript (they claim to have reduced the values on the Y axis by a factor of 100) such that the true scale correction should have been that they increased the values by 100, then the effective diffusion coefficients calculated seem reasonable. Clark's data suggest that the leaching of iodate from solidified cement waste forms is dependent on the concentration of barium iodate salt present in the solid cement. For iodide concentrations between 5.4 and 11.9 wt % the leach rate is similar but for cements containing only 2.9 % wt iodate the leaching is significantly lower. For the higher range of iodide the effective diffusion coefficient (assuming our correction to the plotted data is accurate) was 3.6×10^{-10} cm^2 s^{-1} and for the cement that contained only 2.9 % wt iodate the corrected effective diffusion coefficient was 3.6×10^{-11} cm^2 s^{-1}. These values seem reasonable for an moderately insoluble salt solidified into pure cement. The effective diffusion coefficient for barium iodate solidified into pure Portland cement Type I in Clark (1977) for high loading of iodine species is 60 times larger than the value found by Kalinin et al. (1983) for similarily high loadings. We suspect that the rather high water to solids ratio (0.8) used by Clark (1977) might account for some of the higher release, although no water to solids ratio information is available in Kalinin et al. (1983). In most instances a water to solids ratio of 0.4 to 0.6 by weight is more common.

Scheele et al. (1984) also solidified various iodine bearing salts in Portland Type III cements using a ratio of 1×10^{-3} M of iodine per gram of dry cement and a water to cement ratio of 0.3. This is an effective loading of ~13 wt %, orders of magnitude higher than will occur in the secondary wastes disposed in the IDF. The article does not present quantitative information such as apparent diffusion coefficients that are readily usable for long-term PA calculations. Both static and modified IAEA tests (intermittent solution replenishment tests) using distilled water and in a few cases Columbia River and seawater were performed for up to 120 days. All the specimens show the typical trend of faster leach rates for the first several days to a few weeks and then a dramatic slowing down. Using some static leach test data, the authors suggest the best form of sequestering iodine is as AgI and that if solidified in a 55-g drum, only 1% of the iodide would be leached in 4,000 years. In other tests using barium and calcium iodate as the iodide product and dynamic leach tests where solutions are changed out, dynamic leaching was a factor of ten faster than static leaching. It would take 5 years for 1% of the iodine to be leached from this "scenario." The overall conclusions presented by the authors include "there is a considerable difference in the leach resistance among various iodine compounds in Portland cement, silver iodide showed the best leach resistance."

Toyohara et al. (2000; 2002) used batch adsorption tests wherein various mixtures of calcium solids and alumina cement were hydrated and cured and then ground up. The crushed alumina-calcium "cement" product was then contacted with solutions with various concentrations of dissolved potassium iodide. A standard batch K_d adsorption test was then performed to see which ground up "cement" removed the most iodide. The solid-to-solution ratio for the batch adsorption test was 1 part crushed cement to 10 parts iodide bearing solution. Initial iodide concentrations varied from 10^{-1} to 10^{-8} M. The contact time was 7 days, with shaking twice a day, at 25°C in most cases and 35°C for evaluating the effects of temperature. The leachates were filtered through 0.45-micron membranes and iodide was measure by ICP-OES for tests where total I was 10^{-4} M and higher and gamma counting of the radiotracer ^{125}I at the lower concentrations. Container and filter adsorption was determined to be variable but low 0.2 to 8% such that no corrections were made to the equation used to calculate the K_d. Note that this is not a very wise choice for situations where total adsorption is low and where 8% of the adsorbate is removed by the container walls and filters. The authors found that a mixture of 100 parts of alumina cement and 15.5 parts of gypsum [$CaSO_4 \cdot 2H_2O$] mixed with water at a ratio of two parts dry blend to one part water yielded the best solidification formulation. This formulation gave an iodide K_d value of 200 ±20 mL g^{-1}. The second paper also shows that the iodide adsorption is reversible when iodide-contacted crushed alumina cement was rinsed in fresh distilled water. Although the high K_d is encouraging for iodine retention, the applicability of the information in these two manuscripts to the IDF PA is tenuous. Alumina cement is a mix of the oxides shown in Table 15 and is used commonly in Japan. The cement is highly enriched in alumina and significantly deficient in calcium oxide and silica in comparison to Portland cement. Unless the Hanford contractors widen formulations to be considered for secondary waste to include alumina cement mixtures the results indicated in this paper are not transferable.

Table 15. Composition of Alumina Cement

Oxide	Wt %
Al_2O_3	67.5
CaO	26.2
LOI	5
SO_3	0.3
MgO	0.13
SiO_2	0.13
Fe_2O_3	0.07

LOI = loss on ignition

Toyohara et al. (2000; 2002) also describe detailed XRD and SEM characterization of the reaction products that suggest that the iodide substitutes for a hydroxyl into the structure of a tetra-calcium aluminum hydrate ($4CaO \cdot Al_2O_3 \cdot 13H_2O$) to form ($3CaO \cdot Al_2O_3 \cdot CaI_2 \cdot 12H_2O$). The articles also described physical stability testing to ensure that the solidified product is mechanically robust. The detailed solid phase characterization is a valuable tool to use in attempting to elucidate the chemical reactions that control the removal of iodide from solution.

Bonhoure et al. (2002) used state-of-the-art X-ray absorption spectroscopy to study the molecular bonding environment of iodide and iodate with solids present in hardened cement paste (C-S-H gels) and one more crystalline end member of the gels, calcium silica hydrate. One technique that allows interrogation of the valence state of the sequestered iodine species showed that iodide remained iodide and iodate remained iodate upon their being sequestered in pure Portland cement or onto the calcium silica hydrate. No oxidation or reduction reactions changed the iodine speciation. Using a second technique, extended X-ray absorption fine structure (EXAFS) that interrogates the nearest neighbor atoms around the probed atom, it was found that the iodide EXAFS spectra were too weak to deconvolute any meaningful data. For the iodate, EXAFS shows the iodine-oxygen bonds within the iodate species [IO_3^-] remained typical of the bond lengths observed for iodate in aqueous solutions. Thus, no significant structural changes seem to occur when iodate is sequestered into the cement solids. This type of molecular probing of contaminants associated with solids may prove essential at determining the chemical processes that control the long-term fate of contaminants incorporated into cementitious waste forms. As the techniques evolve and instrumentation becomes more sensitive, our understanding of these complex interactions may progress at a faster pace and also become less expensive.

In an attempt to elucidate the chemical mechanisms that cause iodine species to associate with cementitious solids, Atkins et al. (1988) prepared iodide and iodate bearing cements. They used two types of cements, ordinary Portland cement Type I and a “grout” mix of 85% blast furnace slag and 15% Portland cement Type I. Both dry blends were mixed with the iodine containing water (1300 mg L^{-1}, 0.01 M iodine as iodide and iodate from potassium salts) at a ratio of 0.5 solid to water ratio. The porewater of the curing solids were squeezed out at various times (tens of days to 300 days) and the speciation of dissolved iodine was measured. For the tests where iodide was originally present, iodide remained the species in the pore fluids regardless of which dry blend was used as a solidification agent. In other work referenced in the paper, a 10^{-4} M solution of KI at pH = 13 was subjected to tens times normal oxygen concentrations and after four months no iodide had been oxidized to iodate as "theoretical" Eh-pH diagrams suggest could occur. Thus in the short term (months to a few years) the iodide oxidation at room temperature by dissolved oxygen does not appear to be kinetically favorable. After ~300 days of curing, the iodide originally present is largely removed from the pore solution by reaction with the solids. For the pure Portland cement system, ~98% of the added iodide is removed from the dissolved state and ~77% is removed from the blast furnace slag "grout" system.

Thermodynamic calculations using the measured iodide concentrations and estimated concentrations of dissolved metals (silver, mercury and lead) suggest that no pure phase iodide compounds were likely forming. The removal of the iodide from solution must have been by incorporation into secondary mineral structures or adsorption. Adsorption seems unlikely because most mineral surfaces have a net negative charge at these high pH values. Perhaps the iodide anion is substituting for sulfate in cement forming minerals. Höglund et al. (1985) also found that pure Portland cement removed more iodide from solution than slag based cements in adsorption tests. No mechanisms that could explain the observations were apparent. Iodate added to the blast furnace slag cement was converted to iodide likely by reduction from dissolved sulfide. The tests with iodate doped pure Portland cement did not yield useable results because of detection limit problems. Iodate is readily removed from solution by both solidification agents (99% removed by pure Portland cement and 86% removed by the blast furnace slag blend). At the high concentration of iodate used in the tests, precipitation of alkaline-earth iodates might have occurred initially but for waste solidification of more dilute iodine bearing wastes such direct precipitation is unlikely. Again, co-precipitation (incorporation of iodine species for another more common anion) into cement forming minerals is the more realistic process. Adsorption is another possibility but the surfaces of most minerals would tend to repel anions at the pH conditions in "young" cement.

Atkins et al. (1988) also performed adsorption tests using two "minerals," hydrotalcite and calcium silicate hydrogel. The former is the most abundant solid that forms as blast furnace slag blend hydrates and the latter forms when Portland cement hydrates. Hydrotalcite does adsorb anions, including carbonate and hydroxide. Hydrotalcite "adsorbed" less than 20% of either iodide or iodate when present at ~10^{-3} M and less than 5% was "adsorbed" when the iodine species concentration was 10^{-5} M. The calcium silicate hydrogel also did not adsorb much iodide present at the same concentrations after 14 to 42 days of contact. However, the calcium silicate hydrogel did "adsorb" iodate (when present between 10^{-4} and 10^{-3} M) perhaps via precipitation of calcium iodate. In practical waste solidification scenarios, iodate concentrations may never reach these values so direct precipitation (at least with Ca^{2+}) is less likely. The authors also conclude, in agreement to the X-ray absorption spectroscopy studies of Bonhoure et al. (2002), that no oxidation-reduction reactions at the surfaces of the solids change the speciation of the iodide to iodate or vice-versa.

It can be concluded from this and most of the other cited studies that iodide-iodate release from cement-containing solidification products is not well understood in terms of the underlying chemical reactions that cause iodine species to disappear from the pore fluids as the solids form during hydration of the dry blend. As a corollary, it is also not well understood what will happen to the sequestered iodine species as the solids continue to evolve and weather from further contact with recharge water, the gases in the partially saturated pores and with the vadose zone sediments.

Further, it would appear that solidification of free iodine species (soluble iodate or iodide) into pure Portland cement does not sequester the iodine species adequately unless perhaps the concentration of total iodine (stable and radioactive) is at trace concentrations ($<10^{-5}$ M) in the waste stream. If the total iodine concentrations in the waste stream are greater we recommend that some pre-treatment to form a sparingly soluble salt be performed. One recommended salt is barium iodate. It is not clear whether barium iodide would be sequestered as readily as barium iodate, therefore some redox manipulation might be required. However, as shown by Atkins et al. (1988), if one solidifies aqueous solutions of iodate in a grout mixture that contains blast furnace slag iodate may be reduced to iodide by the sulfur species in the slag. Thus the pretreatment step to form insoluble barium iodates prior to solidification may be counteracted by using a dry blend that contains significant reductants (i.e., blast furnace slag). No one has studied the iodine speciation for insoluble salts being solidified into grout blends with significant masses of reductants, such as blast furnace slag. Thus it might be possible that iodate bound in an insoluble salt such as barium iodate may not be reduced to iodide.

6.4.2 Iodine Parameter Recommendations

In summary, the review of available literature has limited information on which one can make defensible recommendations on how to parameterize a release model for iodine species from cementitious waste forms. We recommend that experimental activities be started as soon as possible to determine a good waste form for secondary waste. One key technical issue will be whether the iodine species in the secondary waste stream should first be converted to an insoluble salt such as barium iodate before cement/grout solidification to assure adequately low releases from the waste form. Once representative types of solid waste has been prepared with iodine species (both aqueous (free) iodine species and insoluble iodine salts), laboratory experiments that combine leaching/diffusion techniques and detailed pre- and post-leach test solid phase characterization should be undertaken. Some added details on a rational testing and complementary geochemical and mass transport modeling efforts are found in McGrail et al. (2003).

To accommodate the immediate need for parameters to allow computations of the impact from secondary waste for the 2005 IDF PA, we suggest using the results from Atkinson and Nickerson (1988) as representing upper bound or conservative values for effective diffusion coefficients, especially for waste forms containing only free iodide species. Their experiments were conducted with ordinary Portland cement and had no additives that could potentially attenuate iodine release rates. Effective diffusion coefficient values for waste forms in which the iodine species are first converted to an insoluble salt are represented by the data presented in Kalinin et al. (1983) and Clark et al. (1977) where iodine releases may have been attenuated by formation of sparingly soluble iodide or iodates are also shown in Table 16 and they are closer to the values used in the recent IDF Risk Assessment (MANN et al., 2003a). It should be noted that the mass of iodine species loaded into cement or grout impacts the leaching. Higher loadings of iodine species appears to release the iodine at faster rates, perhaps indicative of the non-linear adsorption effects of the minerals formed in the cement/grout gel. As a sensitivity case, we also recommend calculating iodine release rates that are controlled at a fixed concentration determined from the solubility product of silver iodide ($K_{sp} = 9 \times 10^{-17}$). Table 16 gives estimates of the conservative, most probable, and sensitivity case values.

Table 16. Recommended Values to Use in Simple Diffusion Controlled Release Conceptual Models for Iodine Solidified in Cement and Solubility-limited Release Model

Diffusivity Values	**D_e (cm^2/s)**
Conservative and/or Soluble Iodine (no attempts to sequester I before solidification)	2.6×10^{-9}
Iodine insoluble salt (e.g., barium iodate)[(a)] formed and then solidified. > 3% loading	5×10^{-11}
Solubility Values	**Molarity (mol/L)**
Iodine insoluble salt (e.g., barium iodate) formed and then solidified. < 3% loading	3×10^{-11} M
Solubility	1×10^{-8} M

[(a)]value is geometric mean of Kalinin et al. (1983) and Clark (1977) for high iodate loading

7.0 Conclusion

In this report, a large body of data is presented on the corrosion behavior of three prototypic simulant glasses for LAW: LAWA44, LAWB45, and LAWC22. In addition to these three simulant glass compositions, PUF test results on two glasses, LAWAN102 and LAWAP101, made with actual Hanford tank waste are also discussed. Four test methods; SPFT, PUF, PCT, and microbial degradation experiments, were used in combination to examine the corrosion behavior of the glass over a wide range of conditions.

Results from these experiments were used to develop the parameters necessary to conduct long-term PA calculations using the STORM reactive transport computer code. Table 17 provides the recommended parameters for three simulant glasses, plus LAWBP1 for comparison (2001a). Recommended values for the diffusion- and solubility-controlled release of key contaminants of concern from solidified cementitious secondary waste forms were derived from literature sources and are provided in Section 6.3, Table 13, and Table 16. Caution is advised on using generic literature values because of the wide variability in release data for contaminants of concern solidified in cement/grout. Therefore, the authors recommend that activities be initiated to generate IDF site-specific data on the release of these contaminants from secondary waste solidified in cement or grout waste forms. This site specific data will be a critical component in the evaluation of how secondary waste will impact contaminant release rates from the IDF.

Table 17. Summary of Best Estimate Rate Law Parameters for LAWA44, LAWB45, and LAWC22 Glasses at 15ºC.

Parameter	Meaning	LAWABP1	LAWA44	LAWB45	LAWC22	Comments
$\bar{k}$	forward rate constant (g m^{-2} d^{-1})	3.4×10^6	1.3×10^4	1.6×10^4	1.0×10^5	
K_g	apparent equilibrium constant for glass based on activity product a[SiO_2(aq)]	4.9×10^{-4}	5.45×10^{-4}	5.24×10^{-4}	5.25×10^{-4}	
η	pH power law coefficient	0.35	0.49 ±0.08	0.34 ±0.03	0.42 ±0.02	
E_a	activation energy of glass dissolution reaction (kJ mol^{-1})	68	60 ±7	53 ±3	64 ±2	
σ	Temkin coefficient	1	1	1	1	Assigned constant
r_x	Na ion-exchange rate (mol m^{-2} s^{-1})	3.4×10^{-11}	5.3×10^{-11}	0	1.2×10^{-10}	No detectable ion exchange rate for LAWB45

8.0 References

Aagaard, P. and H. C. Helgeson. 1982. "Thermodynamic and Kinetic Constraints on Reaction Rates Among Minerals and Aqueous Solutions. I. Theoretical Considerations." *Am. J. Sci.* **282**:237-285.

Albenesius, E. L. 2001. *Computer Modeling of Saltstone Landfills by Intera Environmental Consultants.* DPST-83-529, Savannah River Site, Aiken, South Carolina.

Alt, J. C. and P. Mata. 2000. "On the Role of Microbes in the Alteration of Submarine Basaltic Glass: A TEM Study." *Earth Planet. Sci. Let.* **181**:301-313.

Angus, M. J. and F. P. Glasser. 1985. "The Chemical Environment in Cement Matrices." *Mat. Res. Soc. Symp. Proc.* **50**:547-556.

ASTM. 1994. *Standard Test Methods for Determining Chemical Durability of Nuclear Waste Glasses: The Product Consistency Test (PCT).* ASTM C1285, American Society for Testing and Materials, Philadelphia, Pennsylvania.

ASTM. 2002. *Standard Practice for Evaluating Microbial Susceptibility of Nonmetallic Materials by Laboratory Soil Burial.* G160-98, ASTM International, West Conshohocken, Pennsylvania.

Atkins, M., A. N. Beckley, and F. P. Glasser. 1988. "Influence of Cement on the Near-Field Environment and Its Specific Interactions with Uranium and Iodine." *Radiochim. Acta* **44-5**:255-261.

Atkins, M. and F. P. Glasser. 1992. "Application of Portland-Cement-Based Materials to Radioactive Waste Immobilization." *Waste Management* **12**:105-131.

Atkinson, A. and A. K. Nickerson. 1988. "Diffusion and Sorption of Cesium, Strontium, and Iodine in Water-Saturated Cement." *Nuc. Tech.* **81**(1):100-113.

Atkinson, A., N. M. Everitt, and R. M. Guppy. 1989. "Time Dependence of pH in a Cementitious Repository." *Mat. Res. Soc. Symp. Proc.* **127**:439-446.

Bacon, D. H., B. P. McGrail, V. L. Freedman, G. Ventura, P. Risoluti, and K. M. Krupka. 2002. "Performance Assessment of Low-Level Waste Disposal Facilities Using Coupled Unsaturated Flow and Reactive Transport Simulators." *Mat. Res. Soc. Symp. Proc.* **713**:267-274.

Berner, U. R. 1992. "Evolution of Pore Water Chemistry During Degradation of Cement in a Radioactive Waste Repository." *Waste Management* **12**:201-219.

Bonhoure, I., A. M. Scheidegger, E. Wieland, and R. Dahn. 2002. "Iodine Species Uptake by Cement and CSH Studied by I K-edge X-ray Absorption Spectroscopy." *Radiochim. Acta* **90**(9-11):647-651.

Bradbury, M. H. and F. A. Sarott. 1995. *Sorption Databases for the Cementitious Near Field of a L/ILW Repository for Performance Assessment.* CH-5232, PSI Bericht 95-06, Paul Scherrer Institut, Villigen PSI, Switzerland.

Bradbury, M. H. and L. R. Van Loon. 1998. *Cementitious Near-Field Sorption Data Bases for Performance Assessment of a L/ILW Repository in a Palfris Marl Host Rock. CEM-94: Update I.* CH-5232, PSI Bericht. 98-01, Paul Scherrer Institut, Villigen PSI, Switzerland.

Bray, P. J., S. A. Feller, G. E. Jellison, and Y. H. Yun. 1980. "B-10 NMR-Studies of the Structure of Borate Glasses." *J. Non-Cryst. Solids* **38-9**(MAY-):93-98.

Bunker, B. C. 1987. "Waste Glass Leaching: Chemistry and Kinetics." *Mat. Res. Soc. Symp. Proc.* **84**:493-507.

Bunker, B. C., D. R. Tallant, T. J. Headley, G. L. Turner, and R. J. Kirkpatrick. 1988. "The Structure of Leached Sodium Borosilicate Glass." *Phys. Chem. Glasses* **29**(3):106-120.

Clark, W. E. 1977. "The Isolation of Radioiodine with Portland Cement. Part I: Scoping Leach Studies." *Nuc. Tech.* **36**:215-221.

Cook, J. R. 2000. *Radiological Performance Assessment for the E-Area Vaults Disposal Facility.* WSRC-RP-94-0218, Savannah River Site, Aiken, South Carolina.

Criscenti, L. J., R. J. Serne, K. M. Krupka, and M. I. Wood. 1996. *Predictive Calculations to Assess the Long-Term Effect of Cementitious Materials on the pH and Solubility of Uranium(VI) in a Shallow-Land Disposal Environment.* PNNL-11182, Pacific Northwest National Laboratory, Richland, WA.

Dell, W. J., P. J. Bray, and S. Z. Xiao. 1983. "B-11 NMR-Studies and Structural Modeling of Na_2O-B_2O_3-SiO_2 Glasses of High Soda Content." *J. Non-Cryst. Solids* **58**(1):1-16.

Dove, P. M. 1994. "The Dissolution Kinetics of Quartz in Sodium Chloride Solutions at 25°C to 300°C." *Am. J. Sci.* **294**:665-712.

Ehrlich, H. L. 1996. "How Microbes Influence Mineral Growth and Dissolution." *Chem. Geol.* **132**:5-9.

Ewart, F. S., S. W. Pugh, and D. Woodwark. 1988. *Chemical and Microbiological Effects in the Near-Field: Current Status.* Report NSS/G103, U.K. Nirex Ltd., Hartwell, United Kingdom.

Fayer, M. J. and J. E. Szecsody. 2004. *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment.* PNNL-14744, Pacific Northwest National Laboratory, Richland, Washington.

Grimmer, A. R., F. Vonlampe, and M. Magi. 1986. "Solid-State High-Resolution Si-29 MAS NMR of Silicates with Sixfold Coordinated Silicon." *Chem. Phys. Letters* **132**(6):549-553.

Hespe, E. D. 1971. Leach Testing of Immobilized Radioactive Waste Solids: A Proposal for a Standard Method. In *Atomic Energy Review*, Vol. 9, pp. 195-207. International Atomic Energy Agency, Vienna, Austria.

Höglund, S., L. Eliasson, B. Allard, K. Andersson, and B. Torstenfelt. 1985. "Sorption of Some Fission Products and Actinides in Concrete Systems." *Mat. Res. Soc. Symp. Proc.* **50**:683-690.

IAEA. 1993. *Improved Cement Solidification of Low- and Intermediate-Level Radioactive Wastes.* Technical Reports Series No. 350, International Atomic Energy Agency (IAEA), Vienna.

Icenhower, J. P. and P. A. Dove. 2000. "The Dissolution Kinetics of Amorphous Silica Into Sodium Chloride Solutions: Effects of Temperature and Ionic Strength." *Geochim. Cosmochim. Acta* **64**(24):4193-4203.

Kalinin, N. N., A. N. Elizarova, V. N. Shchebetkovskii, Y. V. Kuznetsov, and V. K. Isupov. 1983. "Leaching of Iodine from Cement and Bitumen Compositions Containing Various Iodine Compounds." *Soviet Radiochemistry* **25**(4):505-510.

Kirkpatrick, R. J. 1988. "MAS NMR-Spectroscopy of Minerals and Glasses." *Reviews in Mineralogy* **18**:341-403.

Krumbein, W. E. 1983. *Microbial Geochemistry*. Blackwell Scientific Publications.

Krupka, K. M. and R. J. Serne. 1996. *Performance Assessment of Low-Level Radioactive Waste Disposal Facilities: Effect on Radionuclide Concentrations by Cement/Ground-Water Interactions.* NUREG/CR-6377, prepared for the Nuclear Regulatory Commission by Pacific Northwest National Laboratory, Washington, D. C.

Krupka, K. M. and R. J. Serne. 2001. *Radionuclide K_d Values for Cementitious Systems.* PNWD-3127, prepared for the Italian National Agency for New Technology, Energy, and Environment (ENEA), Rome, Italy, by Battelle Pacific Northwest Division, Richland, Washington.

Krupka, K. M., R. J. Serne, and D. I. Kaplan. 2004. *Geochemical Data Package for the 2005 Hanford Integrated Disposal Facility Performance Assessment (IDF PA).* PNNL-13037, Rev. 2, Pacific Northwest National Laboratory, Richland, Washington.

Langton, C. A., S. B. Oblath, D. W. Pepper, and E. L. Wilhite. 1988. "Waste Salt Disposal at the Savannah River Plant." *Chem. Eng. Comm.* **66**:189-199.

Langton, C. A. 1989. *Slag-Based Materials for Toxic Metal and Radioactive Waste Stabilization.* DP-MS-87-95, Rev. 2, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, South Carolina.

Lasaga, A. C. 1981. Transition State Theory. In *Reviews in Mineralogy*, Vol. 8 (ed. P. H. Ribbe), Washington D. C.

Lasaga, A. C. 1995. Fundamental Approaches in Describing Mineral Dissolution and Precipitation Rates. In *Chemical Weathering Rates of Silicate Minerals*, Vol. 31 (ed. A. F. White and S. L. Brantley), pp. 23-86. Mineralogical Society of America, Washington, D. C.

Liermann, L. J., A. S. Barnes, B. E. Kalinowski, X. Zhou, and S. L. Brantley. 2000. "Microenvironments of pH in Biofilms Grown on Dissolving Silicate Surfaces." *Chem. Geol.* **171**:1-16.

Mann, F. M., R. J. Puigh, II, S. H. Finfrock, E. J. Freeman, R. Khaleel, D. H. Bacon, M. P. Bergeron, B. P. McGrail, S. K. Wurstner, K. Burgard, W. R. Root, and P. E. LaMont. 2001. *Hanford Immobilized Low-Activity Tank Waste Performance Assessment: 2001 Version.* DOE/ORP-2000-24 Rev. 0, U.S. Department of Energy, Richland, Washington.

Mann, F. M., R. J. Puigh, S. H. Finfrock, and R. Khaleel. 2003a. *Integrated Disposal Facility Risk Assessment.* RPP-15834, Rev. 0, CH2M Hill Hanford Group, Inc., Richland, Washington.

Mann, F. M., B. P. McGrail, D. H. Bacon, R. J. Serne, K. M. Krupka, R. J. Puigh, R. Khaleel, and S. H. Finfrock. 2003b. *Risk Assessment Supporting the Decision on the Initial Selection of Supplemental ILAW Technologies.* RPP-17675, Rev. 0, CH2M Hill Hanford Group, Inc., Richland, Washington.

Mattigod, S. V., R. J. Serne, B. P. McGrail, and V. L. Legore. 2002. "Radionuclide Incorporation in Secondary Crystalline Minerals From Chemical Weathering of Waste Glasses." *Mat. Res. Soc. Symp. Proc.* **713**:597-605.

McGrail, B. P., W. L. Ebert, A. J. Bakel, and D. K. Peeler. 1997. "Measurement of Kinetic Rate Law Parameters on a Na-Ca-Al Borosilicate Glass for Low-Activity Waste." *J. Nuc. Mat.* **249**:175-189.

McGrail, B. P. and D. H. Bacon. 1998. *Selection of a Computer Code for Hanford Low-Level Waste Engineered-System Performance Assessment.* PNNL-10830, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

McGrail, B. P., J. P. Icenhower, P. F. Martin, D. R. Rector, H. T. Schaef, E. A. Rodriguez, and J. L. Steele. 2000a. *Low-Activity Waste Glass Studies: FY2000 Summary Report.* PNNL-13381, Pacific Northwest National Laboratory, Richland, Wa.

McGrail, B. P., D. H. Bacon, W. L. Ebert, and K. P. Saripalli. 2000b. *A Strategy to Conduct an Analysis of the Long-Term Performance of Low-Activity Waste Glass in a Shallow Subsurface Disposal System at Hanford.* PNNL-11834 Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

McGrail, B. P., J. P. Icenhower, P. F. Martin, H. T. Schaef, M. J. O'Hara, E. A. Rodriguez, and J. L. Steele. 2001a. *Waste Form Release Data Package for the 2001 Immobilized Low-Activity Waste Performance Assessment.* PNNL-13043 Rev. 2, Pacific Northwest National Laboratory, Richland, Washington.

McGrail, B. P., J. P. Icenhower, D. K. Shuh, P. Liu, J. G. Darab, D. R. Baer, S. Thevuthasen, V. Shutthanandan, M. H. Engelhard, C. H. Booth, and P. Nachimuthu. 2001b. "The Structure of Na_2O-Al_2O_3-SiO_2 Glass: Impact on Sodium Ion Exchange in H_2O and D_2O." *J. Non-Cryst. Solids* **296**(1-2):10-26.

McGrail, B. P., J. P. Icenhower, D. H. Bacon, J. D. Vienna, K. P. Saripalli, H. T. Schaef, P. F. Martin, R. D. Orr, E. A. Rodriguez, and J. L. Steele. 2002. *Low-Activity Waste Glass Studies: FY2002 Summary Report.* PNNL-14145, Pacific Northwest National Laboratory, Richland, Washington.

McGrail, B. P., D. H. Bacon, R. J. Serne, and E. M. Pierce. 2003. *A Strategy to Assess Performance of Selected Low-Activity Waste Forms in an Integrated Disposal Facility.* PNNL-14362, Pacific Northwest National Laboratory, Richland, Washington.

Meyer, P. D., K. P. Saripalli, and V. L. Freedman. 2004. *Near-Field Hydrology Data Package for the Integrated Disposal Facility 2005 Performance Assessment.* PNNL-14700, Pacific Northwest National Laboratory, Richland, Washington.

Moore, D. M. and R. C. Reynolds. 1989. *X-Ray Diffraction and the Identification and Analysis of Clay Minerals*. Oxford University Press.

Muller, I. S., A. C. Buechele, and I. L. Pegg. 2001. *Final Report: Glass Formulation and Testing with RPP-WTP LAW Simulants.* VSL-01R3560-2, Vitreous State Laboratory, Catholic University of America, Washington, D.C.

Peterson, V., B. Hunter, A. Ray, and L. P. Aldridge. 2002. "Rietveld Refinement of Neutron, Synchrotron and Combined Powder Diffraction Data of Cement Clinker." *Appl. Phys. A-Mater. Sci. Process.* **74**:S1409-S1411.

Rahman, M. M., S. Nagasaki, and S. Tanaka. 1999. "A Model for Dissolution of CaO-SiO_2-H_2O Gel at Ca/Si<1 by Considering Disordered Structure." *Material Research Symposium Proceedings* **556**:1237-1244.

Reardon, E. J. 1992. "Problems and Approaches to the Prediction of the Chemical Composition in Cement/Water Systems." *Waste Management* **12**:221-239.

Renders, P. J. N., C. H. Gammons, and H. L. Barnes. 1995. "Precipitation and Dissolution Rate Constants for Cristobalite from 150°C to 300°C." *Geochim. Cosmochim. Acta* **59**(1):77-85.

Richards, L. A. 1931. "Capillary Conduction of Liquids Through Porous Mediums." *Physics* **1**:318-333.

Scheele, R. D., L. L. Burger, and K. D. Wiemers. 1984. "Leach Resistance of Iodine Compounds in Portland-Cement." *ACS Symposium Series* **246**:373-387.

Serne, R. J., R. O. Lokken, and L. J. Criscenti. 1992. "Chracterization of Grouted Low-Level Waste to Support Performance Assessment." *Waste Management* **12**:217-287.

Serne, R. J., W. J. Martin, and V. L. Legore. 1995. *Leach Test of Cladding Removal Waste Grout Using Hanford Groundwater.* Pacific Northwest National Laboratory, Richland, WA.

Toyohara, M., M. Kaneko, H. Ueda, N. Mitsutsuka, H. Fujihara, T. Murase, and N. Saito. 2000. "Iodine Sorption Onto Mixed Solid Alumina Cement and Calcium Compounds." *J. Nuc. Sci. Tech.* **37**(11):970-978.

Toyohara, M., M. Kaneko, N. Mitsutsuka, H. Fujihara, N. Saito, and T. Murase. 2002. "Contribution to Understanding Iodine Sorption Mechanism Onto Mixed Solid Alumina Cement and Calcium Compounds." *J. Nuc. Sci. Tech.* **39**(9):950-956.

Wierenga, P. J., M. H. Young, G. W. Gee, R. G. Hills, C. T. Kincaid, T. J. Nicholson, and R. E. Cady. 1993. *Soil Characterization Methods for Unsaturated Low-Level Waste Sites.* PNL-8480, Pacific Northwest Laboratory, Richland, Washington.

Wolery, T. J. 1992. *EQ3NR, A Computer Program for Geochemical Aqueous Speciation-Solubility Calculations: Theoretical Manual, User's Guide, and Related Documentation (Version 7.0).* UCRL-MA-110662 PT III, LLNL, Livermore, CA.

Wolery, T. J. and S. A. Daveler. 1992. *EQ6, A Computer Program for Reaction Path Modeling of Aqueous Geochemical Systems: Theoretical Manual, User's Guide, and Related Documentation (Version 7.0).* UCRL-MA-110662 PT IV, Lawrence Livermore National Laboratory, Livermore, California.

Appendix A
Single-Pass Flow-Through Test Results

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LAWA44																
Exp. #1																
LW44-1.0	-	40	-	-	9	-	-	(2)	-	57	-	(48)	-	(133)	-	-
LW44-1.1	-	40	-	-	9	-	-	(2)	-	68	-	(73)	-	(14)	-	-
LW44-1.2	-	40	-	-	9	-	-	(2)	-	67	-	(48)	-	(16)	-	-
LW44-1.3	0	40	1.2E-05	1.11	9	1.000	0.020	100	2.18E-03	127	1.19E-03	3601	1.47E-02	ND	1.25E-03	5.02E-09
LW44-1.6	0	40	1.1E-05	5.09	9	1.000	0.020	249	5.19E-03	305	4.25E-03	3288	1.26E-02	1677	4.52E-03	2.97E-09
LW44-1.9	0	40	1.1E-05	10.95	9	0.999	0.020	279	5.81E-03	400	5.93E-03	2133	8.12E-03	2031	5.51E-03	9.24E-10
LW44-1.12	0	40	1.2E-05	15.85	9	0.999	0.020	281	5.99E-03	399	6.05E-03	1814	7.04E-03	2081	5.78E-03	4.19E-10
LW44-1.14	0	40	7.0E-06	19.05	9	0.999	0.020	334	4.26E-03	455	4.22E-03	2063	4.80E-03	2435	4.06E-03	2.16E-10
LW44-1.15	0	40	1.1E-05	20.85	9	0.998	0.020	310	6.48E-03	422	6.33E-03	1930	7.33E-03	2252	6.13E-03	3.41E-10
LW44-1.16	0	40	1.1E-05	22.13	9	0.998	0.020	290	6.06E-03	418	6.27E-03	1741	6.61E-03	2135	5.81E-03	2.17E-10
LW44-1.17	0	40	1.1E-05	24.27	9	0.998	0.020	282	5.85E-03	377	5.51E-03	1639	6.17E-03	2069	5.59E-03	1.26E-10
LW44-1.18	0	40	1.2E-05	26.07	9	0.998	0.020	274	5.85E-03	392	5.96E-03	1547	5.98E-03	2014	5.61E-03	5.23E-11
Exp. #2																
LW44-2.0	-	40	-	-	9	-	-	(3)	-	75	-	(138)	-	9709	-	-
LW44-2.1	-	40	-	-	9	-	-	(6)	-	81	-	(80)	-	9900	-	-
LW44-2.2	-	40	-	-	9	-	-	(3)	-	171	-	(237)	-	9706	-	-
LW44-2.3	1.00E+01	40	1.1E-05	1.11	9	1.002	1.002	ND	1.94E-03	150	7.14E-04	2838	1.05E-02	10219	1.24E-03	3.40E-09
LW44-2.6	1.00E+01	40	1.1E-05	5.09	9	1.002	1.002	315	6.16E-03	344	3.91E-03	3196	1.12E-02	11591	4.79E-03	2.03E-09
LW44-2.9	1.00E+01	40	1.1E-05	10.95	9	1.001	1.001	358	7.20E-03	412	5.18E-03	2368	8.40E-03	11996	6.00E-03	4.77E-10
LW44-2.12	1.00E+01	40	1.1E-05	15.85	9	1.001	1.001	346	7.12E-03	401	5.11E-03	2003	7.19E-03	11607	5.08E-03	2.93E-11
LW44-2.14	1.00E+01	40	1.1E-05	19.05	9	1.000	1.000	349	7.12E-03	423	5.46E-03	2016	7.18E-03	11887	5.80E-03	2.41E-11
LW44-2.15	1.00E+01	40	1.1E-05	20.85	9	1.000	1.000	339	6.81E-03	414	5.22E-03	1974	6.90E-03	11754	5.35E-03	3.59E-11
LW44-2.16	1.00E+01	40	1.1E-05	22.13	9	1.000	1.000	333	6.71E-03	407	5.13E-03	1961	6.89E-03	11613	4.99E-03	6.91E-11
LW44-2.17	1.00E+01	40	1.1E-05	24.27	9	0.999	0.999	324	6.50E-03	391	4.82E-03	1812	6.29E-03	11784	5.43E-03	-
LW44-2.18	1.00E+01	40	1.1E-05	26.07	9	0.999	0.999	325	6.61E-03	403	5.11E-03	1860	6.56E-03	11774	5.48E-03	-
Exp. #3																
LW44-3.0	1.61E+04	40	-	-	9	-	-	(4)	-	57	-	(35)	-	17743	-	-
LW44-3.1	1.61E+04	40	-	-	9	-	-	(4)	-	71	-	(72)	-	18017	-	-
LW44-3.2	1.61E+04	40	-	-	9	-	-	(2)	-	73	-	(128)	-	17946	-	-
LW44-3.3	1.61E+04	40	1.2E-05	1.11	9	1.002	0.020	119	2.45E-03	140	1.31E-03	3022	1.16E-02	18427	1.48E-03	3.66E-09
LW44-3.6	1.61E+04	40	1.2E-05	5.09	9	1.002	0.020	275	5.78E-03	296	4.11E-03	3051	1.18E-02	19839	5.47E-03	2.40E-09
LW44-3.9	1.61E+04	40	1.2E-05	10.95	9	1.001	0.020	306	6.48E-03	308	4.35E-03	2029	7.79E-03	19967	5.87E-03	5.20E-10
LW44-3.12	1.61E+04	40	1.2E-05	15.85	9	1.001	0.020	290	6.34E-03	290	4.16E-03	1759	6.93E-03	19149	3.66E-03	2.35E-10
LW44-3.14	1.61E+04	40	1.2E-05	19.05	9	1.001	0.020	296	6.49E-03	318	4.68E-03	1757	6.93E-03	19634	5.09E-03	1.73E-10
LW44-3.15	1.61E+04	40	1.1E-05	20.85	9	1.000	0.020	294	5.69E-03	320	4.17E-03	1640	5.69E-03	19631	4.49E-03	-
LW44-3.16	1.61E+04	40	1.2E-05	22.13	9	1.000	0.020	282	5.94E-03	311	4.38E-03	1726	6.54E-03	19197	3.66E-03	2.38E-10

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-3.17	1.61E+04	40	1.2E-05	24.27	9	1.000	0.020	276	5.85E-03	267	3.60E-03	1487	5.63E-03	19048	3.26E-03	-
LW44-3.18	1.61E+04	40	1.2E-05	26.07	9	0.999	0.020	275	5.92E-03	300	4.26E-03	1502	5.77E-03	19133	3.56E-03	-
Exp. #4																
LW44-4.0	3.21E+04	40	-	-	9	-	-	(2)	-	73	-	(62)	-	38504	-	-
LW44-4.1	3.21E+04	40	-	-	9	-	-	(3)	-	82	-	(60)	-	38812	-	-
LW44-4.2	3.21E+04	40	-	-	9	-	-	(3)	-	72	-	(262)	-	38175	-	-
LW44-4.3	3.21E+04	40	1.2E-05	1.11	9	1.008	0.020	112	2.43E-03	144	1.27E-03	2956	1.17E-02	39523	3.03E-03	3.72E-09
LW44-4.6	3.21E+04	40	1.2E-05	5.09	9	1.008	0.020	189	3.92E-03	185	1.94E-03	2614	9.75E-03	39739	3.47E-03	2.33E-09
LW44-4.9	3.21E+04	40	1.2E-05	10.95	9	1.008	0.020	185	3.92E-03	166	1.64E-03	1591	5.86E-03	40076	4.50E-03	7.75E-10
LW44-4.12	3.21E+04	40	1.2E-05	15.85	9	1.007	0.020	188	4.08E-03	160	1.55E-03	1276	4.69E-03	39503	2.93E-03	2.45E-10
LW44-4.14	3.21E+04	40	1.2E-05	19.05	9	1.007	0.020	191	4.10E-03	173	1.78E-03	1253	4.56E-03	39782	3.71E-03	1.85E-10
LW44-4.15	3.21E+04	40	1.2E-05	20.85	9	1.007	0.020	184	3.87E-03	171	1.71E-03	1189	4.21E-03	39616	3.16E-03	1.32E-10
LW44-4.16	3.21E+04	40	1.2E-05	22.13	9	1.007	0.020	181	3.82E-03	169	1.67E-03	1218	4.33E-03	39629	3.20E-03	2.05E-10
LW44-4.17	3.21E+04	40	1.2E-05	24.27	9	1.006	0.020	177	3.73E-03	149	1.31E-03	1108	3.89E-03	39419	2.61E-03	6.55E-11
LW44-4.18	3.21E+04	40	1.2E-05	26.07	9	1.006	0.020	174	3.67E-03	169	1.68E-03	1076	3.79E-03	39996	4.27E-03	4.51E-11
Exp. #5																
LW44-5.0	4.78E+04	40	-	-	9	-	-	(2)	-	67	-	(13)	-	54164	-	-
LW44-5.1	4.78E+04	40	-	-	9	-	-	(2)	-	66	-	(57)	-	54165	-	-
LW44-5.2	4.78E+04	40	-	-	9	-	-	(1)	-	70	-	(6)	-	55688	-	-
LW44-5.3	4.78E+04	40	1.3E-05	1.11	9	1.001	0.020	115	2.62E-03	131	1.23E-03	3249	1.39E-02	58101	1.05E-02	4.50E-09
LW44-5.6	4.78E+04	40	1.2E-05	5.09	9	1.001	0.020	150	3.13E-03	140	1.28E-03	2508	9.75E-03	58110	9.62E-03	2.64E-09
LW44-5.9	4.78E+04	40	1.2E-05	10.95	9	1.001	0.020	113	2.40E-03	107	7.14E-04	1268	5.01E-03	57729	8.78E-03	1.04E-09
LW44-5.12	4.78E+04	40	1.2E-05	15.85	9	1.001	0.020	ND	2.00E-03	101	6.20E-04	ND	3.91E-03	57699	8.86E-03	7.62E-10
LW44-5.14	4.78E+04	40	1.1E-05	19.05	9	1.000	0.020	ND	1.71E-03	105	6.20E-04	ND	3.10E-03	57284	6.89E-03	5.56E-10
LW44-5.15	4.78E+04	40	1.2E-05	20.85	9	1.000	0.020	ND	1.84E-03	107	7.08E-04	ND	3.42E-03	57921	9.19E-03	6.32E-10
LW44-5.16	4.78E+04	40	1.2E-05	22.13	9	1.000	0.020	ND	1.77E-03	103	6.45E-04	ND	3.21E-03	56711	5.88E-03	5.77E-10
LW44-5.17	4.78E+04	40	1.2E-05	24.27	9	1.000	0.020	ND	1.68E-03	94	4.74E-04	ND	2.88E-03	57956	9.37E-03	4.79E-10
LW44-5.18	4.78E+04	40	1.2E-05	26.07	9	1.000	0.020	ND	1.67E-03	103	6.50E-04	ND	2.74E-03	57555	8.35E-03	4.28E-10
Exp. #6																
LW44-6.0	6.89E+04	40	-	-	9	-	-	<100	-	66	-	(87)	-	73730	-	-
LW44-6.1	6.89E+04	40	-	-	9	-	-	<100	-	55	-	(21)	-	74928	-	-
LW44-6.2	6.89E+04	40	-	-	9	-	-	<100	-	55	-	(121)	-	73461	-	-
LW44-6.9	6.89E+04	40	1.2E-05	10.95	9	1.001	0.020	ND	-	89	5.60E-04	1314	4.96E-03	76963	8.34E-03	2.14E-09
LW44-6.12	6.89E+04	40	1.2E-05	15.85	9	1.001	0.020	ND	-	85	4.91E-04	979	3.71E-03	78758	1.38E-02	1.83E-09
LW44-6.14	6.89E+04	40	1.2E-05	19.05	9	1.001	0.020	ND	-	80	4.02E-04	907	3.37E-03	77082	8.79E-03	1.75E-09
LW44-6.15	6.89E+04	40	1.2E-05	20.85	9	1.001	0.020	ND	-	77	3.27E-04	807	2.91E-03	74282	6.89E-04	1.58E-09
LW44-6.16	6.89E+04	40	1.2E-05	22.13	9	1.001	0.020	ND	-	79	3.64E-04	775	2.81E-03	75959	5.50E-03	1.56E-09
LW44-6.17	6.89E+04	40	1.2E-05	24.27	9	1.001	0.020	ND	-	70	2.05E-04	711	2.53E-03	75275	3.51E-03	1.46E-09
LW44-6.18	6.89E+04	40	1.2E-05	26.07	9	1.001	0.020	ND	-	77	3.35E-04	681	2.44E-03	76507	7.09E-03	1.47E-09
Exp. #7																

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-7.0	0	23	-	-	7	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-7.1	0	23	-	-	7	-	-	<50	-	<25	-	174	-	182	-	-
LW44-7.2	0	23	-	-	7	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-7.3	0	23	8.8E-06	2.01	7	1.013	0.020	244	3.11E-03	ND	-	4586	1.34E-02	246	2.51E-04	4.11E-09
LW44-7.7	0	23	9.7E-06	9.74	7	1.013	0.020	181	2.30E-03	ND	-	1897	5.90E-03	195	1.57E-04	1.44E-09
LW44-7.10	0	23	1.1E-05	15.02	7	1.013	0.020	139	1.68E-03	ND	-	1225	4.01E-03	147	4.83E-05	9.29E-10
LW44-7.13	0	23	9.7E-06	20.76	7	1.012	0.020	123	1.29E-03	ND	-	1012	3.02E-03	137	2.36E-05	6.91E-10
LW44-7.16	0	23	9.6E-06	25.90	7	1.012	0.020	115	1.12E-03	ND	-	849	2.44E-03	122	-	5.28E-10
LW44-7.18	0	23	9.6E-06	29.92	7	1.012	0.020	102	9.06E-04	ND	-	747	2.12E-03	109	-	4.85E-10
LW44-7.19	0	23	9.8E-06	31.85	7	1.012	0.020	95	8.06E-04	ND	-	708	2.04E-03	110	-	4.93E-10
LW44-7.20	0	23	9.7E-06	34.03	7	1.012	0.020	89	6.90E-04	ND	-	675	1.90E-03	106	-	4.85E-10
LW44-7.21	0	23	9.8E-06	35.78	7	1.012	0.020	85	6.11E-04	ND	-	656	1.86E-03	101	-	4.98E-10
LW44-7.22	0	23	9.7E-06	37.78	7	1.012	0.020	86	6.29E-04	ND	-	638	1.79E-03	103	-	4.63E-10
Exp. #8																
LW44-8.0	0	23	-	-	7	-	-	<50	-	<25	-	109	-	<100	-	-
LW44-8.1	0	23	-	-	7	-	-	<50	-	<25	-	56	-	<100	-	-
LW44-8.2	0	23	-	-	7	-	-	<50	-	<25	-	61	-	<100	-	-
LW44-8.0	0	23	2.0E-06	1.06	7	1.013	0.020	ND	-	ND	-	109	-	ND	-	5.88E-11
LW44-8.1	0	23	1.8E-05	2.21	7	1.013	0.020	ND	-	ND	-	56	-	ND	-	4.33E-10
LW44-8.2	0	23	1.8E-06	5.06	7	1.013	0.020	ND	-	ND	-	61	-	ND	-	4.46E-11
LW44-8.3	0	23	8.9E-06	7.07	7	1.013	0.020	233	2.94E-03	ND	-	4797	1.40E-02	246	2.23E-04	4.42E-09
LW44-8.7	0	23	9.7E-06	14.80	7	1.013	0.020	176	2.20E-03	ND	-	2196	6.79E-03	207	1.54E-04	1.83E-09
LW44-8.10	0	23	1.1E-05	20.08	7	1.013	0.020	137	1.66E-03	ND	-	1370	4.48E-03	172	7.87E-05	1.13E-09
LW44-8.13	0	23	9.8E-06	25.82	7	1.012	0.020	117	1.18E-03	ND	-	1082	3.20E-03	142	3.09E-06	8.06E-10
LW44-8.16	0	23	9.6E-06	30.95	7	1.012	0.020	116	1.14E-03	ND	-	965	2.76E-03	142	3.14E-06	6.47E-10
LW44-8.18	0	23	9.7E-06	34.98	7	1.012	0.020	99	8.52E-04	ND	-	789	2.21E-03	121	-	5.42E-10
LW44-8.19	0	23	9.9E-06	36.91	7	1.012	0.020	94	7.90E-04	ND	-	766	2.17E-03	113	-	5.52E-10
LW44-8.20	0	23	9.8E-06	39.09	7	1.012	0.020	90	7.09E-04	ND	-	754	2.12E-03	114	-	5.61E-10
LW44-8.21	0	23	9.9E-06	40.84	7	1.012	0.020	88	6.82E-04	ND	-	723	2.03E-03	113	-	5.38E-10
LW44-8.22	0	23	9.8E-06	42.84	7	1.012	0.020	88	6.67E-04	ND	-	695	1.92E-03	116	-	4.98E-10
Exp. #9																
LW44-9.0	0	23	-	-	8	-	-	<50	-	<25	-	137	-	<100	-	-
LW44-9.1	0	23	-	-	8	-	-	<50	-	<25	-	<50	-	810	-	-
LW44-9.2	0	23	-	-	8	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-9.0	0	23	9.6E-06	1.06	8	1.016	0.020	ND	-	ND	-	137	-	ND	-	1.88E-10
LW44-9.1	0	23	1.8E-05	2.21	8	1.016	0.020	ND	-	ND	-	ND	-	810	1.79E-03	6.81E-11
LW44-9.2	0	23	6.1E-06	5.06	8	1.016	0.020	ND	-	ND	-	ND	-	ND	-	1.25E-11
LW44-9.3	0	23	9.2E-06	7.07	8	1.016	0.020	102	9.90E-04	ND	5.38E-05	3140	9.05E-03	284	-	3.22E-09
LW44-9.7	0	23	9.6E-06	14.80	8	1.016	0.020	87	7.88E-04	69	5.21E-04	1548	4.33E-03	406	1.30E-05	1.42E-09
LW44-9.10	0	23	1.1E-05	20.08	8	1.016	0.020	65	4.50E-04	68	5.51E-04	978	2.75E-03	368	-	9.17E-10

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-9.13	0	23	9.7E-06	25.82	8	1.016	0.020	59	3.03E-04	68	5.08E-04	782	1.90E-03	375	-	6.37E-10
LW44-9.16	0	23	9.6E-06	30.95	8	1.016	0.020	54	2.17E-04	57	3.38E-04	661	1.48E-03	345	-	5.04E-10
LW44-9.18	0	23	9.6E-06	34.98	8	1.016	0.020	52	1.72E-04	49	2.33E-04	583	1.23E-03	317	-	4.24E-10
LW44-9.19	0	23	7.7E-06	36.91	8	1.016	0.020	53	1.57E-04	49	1.78E-04	581	9.80E-04	318	-	3.29E-10
LW44-9.20	0	23	9.7E-06	39.09	8	1.015	0.020	54	2.07E-04	55	3.13E-04	656	1.48E-03	319	-	5.08E-10
LW44-9.21	0	23	9.8E-06	40.84	8	1.015	0.020	54	2.11E-04	54	3.05E-04	579	1.24E-03	322	-	4.12E-10
LW44-9.22	0	23	9.7E-06	42.84	8	1.015	0.020	53	2.03E-04	54	3.11E-04	552	1.14E-03	324	-	3.76E-10
Exp. #10																
LW44-10.0	0	23	-	-	8	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-10.1	0	23	-	-	8	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-10.2	0	23	-	-	8	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-10.0	0	23	9.4E-06	1.06	8	1.015	0.020	ND	5.78E-04	ND	-	ND	-	ND	-	2.97E-10
LW44-10.1	0	23	1.8E-05	2.21	8	1.015	0.020	ND	5.45E-04	ND	-	ND	-	ND	-	6.24E-10
LW44-10.2	0	23	6.3E-06	5.06	8	1.015	0.020	ND	2.03E-04	ND	-	ND	-	ND	-	1.96E-10
LW44-10.3	0	23	9.5E-06	7.07	8	1.015	0.020	84	5.65E-05	45	2.90E-04	2933	9.17E-03	236	3.08E-04	3.43E-09
LW44-10.7	0	23	9.7E-06	14.80	8	1.015	0.020	81	7.75E-05	68	6.33E-04	1505	4.75E-03	376	6.43E-04	1.68E-09
LW44-10.10	0	23	1.1E-05	20.08	8	1.015	0.020	61	8.54E-04	67	6.71E-04	972	3.26E-03	359	6.53E-04	1.22E-09
LW44-10.13	0	23	9.8E-06	25.82	8	1.015	0.020	53	8.58E-04	71	6.76E-04	775	2.38E-03	353	5.92E-04	9.27E-10
LW44-10.16	0	23	9.6E-06	30.95	8	1.015	0.020	54	8.86E-04	60	5.16E-04	676	2.02E-03	354	5.83E-04	7.74E-10
LW44-10.18	0	23	9.7E-06	34.98	8	1.015	0.020	ND	8.57E-04	53	4.06E-04	702	2.13E-03	316	5.02E-04	8.57E-10
LW44-10.19	0	23	9.8E-06	36.91	8	1.015	0.020	ND	6.95E-04	50	3.77E-04	611	1.85E-03	311	4.97E-04	7.52E-10
LW44-10.20	0	23	9.8E-06	39.09	8	1.015	0.020	50	5.49E-06	53	4.10E-04	564	1.69E-03	328	5.33E-04	6.72E-10
LW44-10.21	0	23	9.8E-06	40.84	8	1.014	0.020	ND	-	51	3.90E-04	538	1.61E-03	317	5.11E-04	6.56E-10
LW44-10.22	0	23	7.8E-06	42.84	8	1.014	0.020	ND	-	54	3.47E-04	538	1.28E-03	326	4.22E-04	5.14E-10
Exp. #11																
LW44-11.0	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-11.1	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-11.2	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-11.3	0	23	9.3E-06	2.01	9	1.005	0.020	60	1.74E-04	76	7.33E-04	1910	5.86E-03	441	7.66E-04	2.27E-09
LW44-11.7	0	23	9.7E-06	7.73	9	1.005	0.020	299	4.40E-03	341	4.72E-03	1999	6.43E-03	2140	4.79E-03	8.09E-10
LW44-11.10	0	23	1.0E-05	13.01	9	1.004	0.020	338	5.47E-03	386	5.77E-03	1941	6.68E-03	2384	5.75E-03	4.85E-10
LW44-11.13	0	23	9.8E-06	18.75	9	1.004	0.020	316	4.73E-03	363	5.06E-03	1768	5.69E-03	2251	5.07E-03	3.83E-10
LW44-11.16	0	23	9.6E-06	23.89	9	1.004	0.020	354	5.34E-03	408	5.66E-03	1948	6.21E-03	2456	5.49E-03	3.49E-10
LW44-11.18	0	23	9.7E-06	27.91	9	1.003	0.020	371	5.68E-03	427	6.00E-03	1933	6.21E-03	2577	5.82E-03	2.11E-10
LW44-11.19	0	23	9.8E-06	29.84	9	1.003	0.020	376	5.83E-03	431	6.12E-03	2027	6.59E-03	2603	5.95E-03	3.06E-10
LW44-11.20	0	23	9.7E-06	32.02	9	1.003	0.020	365	5.60E-03	419	5.91E-03	2025	6.54E-03	2524	5.72E-03	3.77E-10
LW44-11.21	0	23	9.8E-06	33.77	9	1.002	0.020	377	5.86E-03	428	6.08E-03	2063	6.73E-03	2611	5.98E-03	3.45E-10
LW44-11.22	0	23	9.7E-06	35.77	9	1.002	0.020	377	5.81E-03	429	6.05E-03	2105	6.81E-03	2618	5.95E-03	3.99E-10
Exp. #12																
LW44-12.0	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-12.1	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-12.2	0	23	-	-	9	-	-	<50	-	<25	-	<50	-	<100	-	-
LW44-12.3	0	23	9.5E-06	2.01	9	1.015	0.020	59	1.54E-04	78	7.59E-04	1974	6.15E-03	440	7.73E-04	2.39E-09
LW44-12.7	0	23	9.7E-06	9.74	9	1.015	0.020	307	4.50E-03	339	4.62E-03	2060	6.55E-03	2200	4.87E-03	8.18E-10
LW44-12.10	0	23	1.0E-05	15.02	9	1.014	0.020	304	4.79E-03	353	5.21E-03	1801	6.14E-03	2199	5.25E-03	5.41E-10
LW44-12.13	0	23	9.8E-06	20.76	9	1.014	0.020	258	3.66E-03	293	3.99E-03	1542	4.90E-03	1805	3.99E-03	4.94E-10
LW44-12.16	0	23	9.6E-06	25.90	9	1.014	0.020	344	5.11E-03	403	5.53E-03	1866	5.88E-03	2397	5.30E-03	3.08E-10
LW44-12.18	0	23	9.7E-06	29.92	9	1.014	0.020	368	5.53E-03	430	5.94E-03	1951	6.17E-03	2566	5.70E-03	2.55E-10
LW44-12.19	0	23	9.9E-06	31.85	9	1.013	0.020	383	5.94E-03	436	6.17E-03	2016	6.53E-03	2585	5.88E-03	2.39E-10
LW44-12.20	0	23	9.8E-06	34.03	9	1.013	0.020	390	6.01E-03	442	6.20E-03	2001	6.41E-03	2664	6.01E-03	1.63E-10
LW44-12.21	0	23	9.8E-06	35.78	9	1.012	0.020	378	5.80E-03	428	6.01E-03	2078	6.68E-03	2592	5.85E-03	3.51E-10
LW44-12.22	0	23	9.8E-06	37.78	9	1.012	0.020	382	5.89E-03	435	6.13E-03	2117	6.82E-03	2634	5.96E-03	3.73E-10
Exp. #13																
LW44-13.0	0	23	-	-	10	-	-	<50	-	<25	-	138	-	<100	-	-
LW44-13.1	0	23	-	-	10	-	-	<50	-	<25	-	147	-	175	-	-
LW44-13.2	0	23	-	-	10	-	-	<50	-	<25	-	110	-	159	-	-
LW44-13.3	0	23	9.3E-06	2.01	10	1.012	0.020	166	1.96E-03	295	3.85E-03	2290	6.80E-03	1706	3.51E-03	1.93E-09
LW44-13.7	0	23	1.0E-05	9.74	10	1.011	0.020	650	1.09E-02	798	1.18E-02	3922	1.28E-02	4839	1.13E-02	7.66E-10
LW44-13.10	0	23	1.1E-05	15.02	10	1.011	0.020	724	1.29E-02	880	1.38E-02	4039	1.39E-02	5479	1.35E-02	4.14E-10
LW44-13.13	0	23	9.7E-06	20.76	10	1.010	0.020	605	9.74E-03	699	9.97E-03	3222	1.01E-02	4282	9.65E-03	1.47E-10
LW44-13.16	0	23	9.6E-06	25.90	10	1.010	0.020	644	1.03E-02	752	1.06E-02	3460	1.08E-02	4521	1.01E-02	1.82E-10
LW44-13.18	0	23	9.7E-06	29.92	10	1.009	0.020	643	1.04E-02	752	1.08E-02	3426	1.08E-02	4553	1.03E-02	1.47E-10
LW44-13.19	0	23	9.9E-06	31.85	10	1.008	0.020	630	1.04E-02	738	1.07E-02	3374	1.08E-02	4496	1.03E-02	1.73E-10
LW44-13.20	0	23	9.7E-06	34.03	10	1.008	0.020	644	1.04E-02	757	1.08E-02	3351	1.05E-02	4614	1.04E-02	4.19E-11
LW44-13.21	0	23	9.9E-06	35.78	10	1.007	0.020	652	1.08E-02	767	1.12E-02	3466	1.11E-02	4698	1.08E-02	1.38E-10
LW44-13.22	0	23	9.7E-06	37.78	10	1.006	0.020	663	1.09E-02	771	1.11E-02	3545	1.13E-02	4794	1.09E-02	1.63E-10
Exp. #14																
LW44-14.0	0	23	-	-	10	-	-	<50	-	<25	-	76	-	<100	-	-
LW44-14.1	0	23	-	-	10	-	-	<50	-	<25	-	133	-	151	-	-
LW44-14.2	0	23	-	-	10	-	-	<50	-	<25	-	86	-	163	-	-
LW44-14.3	0	23	9.5E-06	2.01	10	1.015	0.020	172	2.09E-03	300	3.97E-03	2214	6.75E-03	1761	3.69E-03	1.86E-09
LW44-14.7	0	23	9.7E-06	9.74	10	1.014	0.020	643	1.03E-02	807	1.15E-02	3770	1.19E-02	4821	1.08E-02	6.34E-10
LW44-14.10	0	23	1.1E-05	15.02	10	1.014	0.020	656	1.17E-02	773	1.21E-02	3731	1.30E-02	5009	1.24E-02	5.42E-10
LW44-14.13	0	23	9.8E-06	20.76	10	1.013	0.020	494	7.88E-03	555	7.93E-03	2765	8.82E-03	3440	7.78E-03	3.72E-10
LW44-14.16	0	23	9.6E-06	25.90	10	1.013	0.020	644	1.03E-02	743	1.05E-02	3288	1.03E-02	4482	9.98E-03	-
LW44-14.18	0	23	9.7E-06	29.92	10	1.012	0.020	650	1.05E-02	755	1.07E-02	3329	1.05E-02	4598	1.03E-02	1.55E-11
LW44-14.19	0	23	9.8E-06	31.85	10	1.011	0.020	660	1.09E-02	775	1.12E-02	3417	1.10E-02	4711	1.08E-02	5.55E-11
LW44-14.20	0	23	9.8E-06	34.03	10	1.011	0.020	640	1.04E-02	760	1.09E-02	3495	1.12E-02	4579	1.04E-02	2.99E-10
LW44-14.21	0	23	9.9E-06	35.78	10	1.010	0.020	643	1.06E-02	783	1.14E-02	3454	1.12E-02	4682	1.08E-02	2.26E-10
LW44-14.22	0	23	9.8E-06	37.78	10	1.009	0.020	666	1.09E-02	789	1.14E-02	3638	1.17E-02	4862	1.11E-02	3.07E-10

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #15																
LW44-15.0	0	23	-	-	11	-	-	<50	-	<25	-	204	-	122	-	-
LW44-15.1	0	23	-	-	11	-	-	<50	-	<25	-	284	-	381	-	-
LW44-15.2	0	23	-	-	11	-	-	<50	-	<25	-	298	-	489	-	-
LW44-15.3	0	23	9.5E-06	2.01	11	1.009	0.020	763	1.22E-02	1050	1.48E-02	5913	1.81E-02	6604	1.43E-02	2.33E-09
LW44-15.7	0	23	9.6E-06	9.74	11	1.008	0.020	2442	4.18E-02	2754	4.02E-02	14683	4.69E-02	17051	3.88E-02	2.06E-09
LW44-15.10	0	23	1.0E-05	15.02	11	1.005	0.020	2869	5.37E-02	3212	5.12E-02	16583	5.80E-02	19781	4.92E-02	1.69E-09
LW44-15.13	0	23	9.7E-06	20.76	11	1.003	0.020	3078	5.36E-02	3395	5.03E-02	18941	6.16E-02	21194	4.90E-02	3.20E-09
LW44-15.16	0	23	9.6E-06	25.90	11	0.999	0.020	3202	5.53E-02	3522	5.17E-02	18710	6.03E-02	22061	5.06E-02	1.99E-09
LW44-15.18	0	23	9.6E-06	29.92	11	0.996	0.020	2776	4.83E-02	3007	4.45E-02	16009	5.19E-02	18931	4.37E-02	1.47E-09
LW44-15.19	0	23	9.8E-06	31.85	11	0.994	0.020	2314	4.09E-02	2447	3.69E-02	14100	4.66E-02	15535	3.65E-02	2.27E-09
LW44-15.20	0	23	9.7E-06	34.03	11	0.991	0.020	2691	4.72E-02	2902	4.33E-02	15788	5.16E-02	18272	4.25E-02	1.79E-09
LW44-15.21	0	23	9.9E-06	35.78	11	0.988	0.020	2630	4.71E-02	2846	4.33E-02	15319	5.12E-02	17836	4.24E-02	1.64E-09
LW44-15.22	0	23	9.7E-06	37.78	11	0.986	0.019	2637	4.66E-02	2831	4.26E-02	15795	5.21E-02	17798	4.18E-02	2.20E-09
Exp. #16																
LW44-16.0	0	23	-	-	11	-	-	<50	-	<25	-	230	-	146	-	-
LW44-16.1	0	23	-	-	11	-	-	<50	-	<25	-	389	-	581	-	-
LW44-16.2	0	23	-	-	11	-	-	<50	-	<25	-	266	-	528	-	-
LW44-16.3	0	23	9.6E-06	2.01	11	1.000	0.020	769	1.26E-02	1079	1.55E-02	5733	1.77E-02	6660	1.45E-02	2.05E-09
LW44-16.7	0	23	9.8E-06	9.74	11	0.999	0.020	2143	3.74E-02	2396	3.57E-02	12668	4.12E-02	14895	3.44E-02	1.51E-09
LW44-16.10	0	23	1.1E-05	15.02	11	0.997	0.020	2668	5.09E-02	2989	4.85E-02	15072	5.35E-02	18526	4.67E-02	1.05E-09
LW44-16.13	0	23	9.8E-06	20.76	11	0.994	0.020	3032	5.37E-02	3377	5.09E-02	17319	5.71E-02	21068	4.94E-02	1.36E-09
LW44-16.16	0	23	9.6E-06	25.90	11	0.991	0.020	3039	5.30E-02	3337	4.95E-02	17594	5.71E-02	20847	4.81E-02	1.66E-09
LW44-16.18	0	23	9.7E-06	29.92	11	0.988	0.020	2652	4.66E-02	2885	4.31E-02	15189	4.97E-02	18050	4.19E-02	1.23E-09
LW44-16.19	0	23	9.8E-06	31.85	11	0.985	0.019	2491	4.46E-02	2675	4.08E-02	14552	4.85E-02	16808	3.98E-02	1.57E-09
LW44-16.20	0	23	9.8E-06	34.03	11	0.983	0.019	2402	4.27E-02	2588	3.92E-02	14176	4.69E-02	16168	3.79E-02	1.69E-09
LW44-16.21	0	23	9.8E-06	35.78	11	0.980	0.019	2498	4.49E-02	2674	4.10E-02	14753	4.94E-02	16848	4.00E-02	1.80E-09
LW44-16.22	0	23	9.8E-06	37.78	11	0.978	0.019	2554	4.57E-02	2767	4.21E-02	14908	4.97E-02	17338	4.10E-02	1.59E-09
Exp. #17																
LW44-17A	8.67E+02	70	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LW44-17B	8.67E+02	70	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LW44-17C	8.67E+02	70	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LW44-17.3	8.67E+02	70	6.3E-05	3.07	9	1.006	0.036	519	2.98E-02	531	2.57E-02	4822	5.59E-02	(4272)	3.18E-02	1.04E-08
LW44-17.4	8.67E+02	70	5.6E-05	4.00	9	1.004	0.020	814	7.84E-02	854	6.95E-02	5090	9.54E-02	(6512)	8.19E-02	6.78E-09
LW44-17.6	8.67E+02	70	6.0E-05	5.23	9	1.002	0.020	792	8.09E-02	851	7.36E-02	4295	8.52E-02	(6457)	8.62E-02	1.73E-09
LW44-17.9	8.67E+02	70	6.1E-05	7.07	9	1.000	0.020	771	7.99E-02	827	7.25E-02	4175	8.41E-02	(6327)	8.57E-02	1.67E-09
LW44-17.10	8.67E+02	70	2.6E-05	7.92	9	0.998	0.020	700	3.11E-02	763	2.88E-02	4091	3.56E-02	(5841)	3.40E-02	1.79E-09
LW44-17.11	8.67E+02	70	6.0E-05	8.18	9	0.997	0.020	677	6.92E-02	743	6.45E-02	3847	7.71E-02	(5617)	7.50E-02	3.13E-09
LW44-17.12	8.67E+02	70	5.5E-05	8.97	9	0.996	0.020	689	6.43E-02	764	6.05E-02	3898	7.12E-02	(5873)	7.17E-02	2.74E-09
LW44-17.13	8.67E+02	70	5.3E-05	9.17	9	0.995	0.020	655	5.93E-02	723	5.56E-02	3529	6.26E-02	(5404)	6.38E-02	1.32E-09

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #18																
LW44-18A	1.00E+01	70	-	-	9	-	-	<50	-	<50	-	<100	-	(20812)	-	-
LW44-18B	1.00E+01	70	-	-	9	-	-	<50	-	<50	-	105	-	(20815)	-	-
LW44-18C	1.00E+01	70	-	-	9	-	-	<50	-	<50	-	<100	-	(21263)	-	-
LW44-18.3	1.00E+01	70	5.0E-05	3.07	9	1.007	0.036	347	1.49E-02	269	9.23E-03	3681	3.34E-02	(23238)	1.51E-02	7.39E-09
LW44-18.4	1.00E+01	70	5.7E-05	4.00	9	1.006	0.020	556	5.25E-02	462	3.60E-02	4307	8.13E-02	(24669)	5.10E-02	1.15E-08
LW44-18.6	1.00E+01	70	5.6E-05	5.23	9	1.005	0.020	529	4.91E-02	485	3.75E-02	3534	6.54E-02	(24284)	4.51E-02	6.54E-09
LW44-18.9	1.00E+01	70	6.1E-05	7.07	9	1.004	0.020	498	4.94E-02	440	3.62E-02	3317	6.61E-02	(23559)	3.80E-02	6.67E-09
LW44-18.10	1.00E+01	70	2.6E-05	7.92	9	1.003	0.020	399	1.64E-02	401	1.39E-02	2908	2.46E-02	(23340)	1.48E-02	3.26E-09
LW44-18.11	1.00E+01	70	4.7E-05	8.18	9	1.002	0.020	385	2.90E-02	400	2.55E-02	2717	4.22E-02	(23211)	2.58E-02	5.27E-09
LW44-18.12	1.00E+01	70	6.1E-05	8.97	9	1.001	0.020	368	3.56E-02	381	3.13E-02	2563	5.14E-02	(23617)	3.95E-02	6.30E-09
LW44-18.13	1.00E+01	70	6.4E-05	9.17	9	1.001	0.020	350	3.51E-02	377	3.21E-02	2448	5.10E-02	(22972)	3.11E-02	6.37E-09
Exp. #19																
LW44-19A	2.93E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(43280)	-	-
LW44-19B	2.93E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(43432)	-	-
LW44-19C	2.93E+04	70	-	-	9	-	-	<50	-	<50	-	219	-	(43191)	-	-
LW44-19.3	2.93E+04	70	5.7E-05	3.07	9	1.002	0.036	360	1.77E-02	229	8.63E-03	4345	4.48E-02	(45411)	1.60E-02	1.08E-08
LW44-19.4	2.93E+04	70	5.9E-05	4.00	9	1.001	0.020	508	4.95E-02	327	2.52E-02	3973	7.72E-02	(46727)	4.91E-02	1.10E-08
LW44-19.6	2.93E+04	70	6.1E-05	5.23	9	1.000	0.020	480	4.79E-02	326	2.60E-02	3085	6.12E-02	(46523)	4.77E-02	5.31E-09
LW44-19.9	2.93E+04	70	5.5E-05	7.07	9	0.999	0.020	495	4.48E-02	323	2.32E-02	2971	5.31E-02	(45915)	3.49E-02	3.30E-09
LW44-19.10	2.93E+04	70	2.5E-05	7.92	9	0.998	0.020	424	1.70E-02	246	7.50E-03	2863	2.30E-02	(47200)	2.35E-02	2.42E-09
LW44-19.11	2.93E+04	70	6.2E-05	8.18	9	0.997	0.020	383	3.79E-02	226	1.69E-02	2620	5.26E-02	(46492)	4.82E-02	5.85E-09
LW44-19.12	2.93E+04	70	5.8E-05	8.97	9	0.996	0.020	360	3.30E-02	222	1.54E-02	2501	4.68E-02	(47919)	6.53E-02	5.51E-09
LW44-19.13	2.93E+04	70	6.1E-05	9.17	9	0.996	0.020	338	3.23E-02	218	1.59E-02	2309	4.53E-02	(46691)	5.04E-02	5.19E-09
Exp. #20																
LW44-20A	5.83E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(85181)	-	-
LW44-20B	5.83E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(86459)	-	-
LW44-20C	5.83E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(86635)	-	-
LW44-20.3	5.83E+04	70	5.8E-05	3.07	9	1.002	0.036	286	1.38E-02	122	3.53E-03	(4456)	4.75E-02	(87685)	1.24E-02	1.34E-08
LW44-20.4	5.83E+04	70	5.4E-05	4.00	9	1.002	0.020	300	2.47E-02	142	7.69E-03	(3400)	6.07E-02	(89053)	3.88E-02	1.44E-08
LW44-20.6	5.83E+04	70	5.6E-05	5.23	9	1.001	0.020	264	2.19E-02	135	7.28E-03	(2335)	4.25E-02	(87782)	2.29E-02	8.23E-09
LW44-20.9	5.83E+04	70	5.4E-05	7.07	9	1.001	0.020	245	1.93E-02	125	6.26E-03	(2124)	3.73E-02	(85607)	-	7.19E-09
LW44-20.10	5.83E+04	70	2.4E-05	7.92	9	1.000	0.020	246	8.76E-03	124	2.79E-03	(1930)	1.53E-02	(89757)	2.18E-02	2.60E-09
LW44-20.11	5.83E+04	70	7.0E-05	8.18	9	1.000	0.020	224	2.23E-02	111	6.64E-03	(1764)	3.98E-02	(89946)	6.57E-02	6.99E-09
LW44-20.12	5.83E+04	70	5.6E-05	8.97	9	0.999	0.020	225	1.79E-02	115	5.64E-03	(1710)	3.07E-02	(89929)	5.21E-02	5.10E-09
LW44-20.13	5.83E+04	70	4.8E-05	9.17	9	0.999	0.020	214	1.45E-02	119	5.10E-03	(1685)	2.61E-02	(87735)	1.93E-02	4.62E-09
Exp. #21																
LW44-21A	8.84E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(131666)	-	-
LW44-21B	8.84E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(130926)	-	-
LW44-21C	8.84E+04	70	-	-	9	-	-	<50	-	<50	-	<100	-	(130573)	-	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-21.3	8.84E+04	70	6.4E-05	3.07	9	1.005	0.036	208	1.02E-02	78.8	1.56E-03	(3913)	4.56E-02	(131394)	2.89E-03	1.42E-08
LW44-21.4	8.84E+04	70	5.9E-05	4.00	9	1.004	0.020	189	1.50E-02	74.8	2.26E-03	(3090)	6.01E-02	(132246)	1.71E-02	1.80E-08
LW44-21.6	8.84E+04	70	5.9E-05	5.23	9	1.004	0.020	134	9.09E-03	62.8	1.17E-03	(1980)	3.79E-02	(131122)	9.61E-04	1.15E-08
LW44-21.8	8.84E+04	70	5.6E-05	7.07	9	1.003	0.020	138	9.04E-03	57.9	6.78E-04	(1813)	3.27E-02	(129994)	-	9.43E-09
LW44-21.10	8.84E+04	70	2.7E-05	7.92	9	1.003	0.020	118	3.29E-03	53.2	1.30E-04	(1397)	1.17E-02	(132240)	7.63E-03	3.37E-09
LW44-21.11	8.84E+04	70	6.3E-05	8.18	9	1.003	0.020	103	6.07E-03	ND	-	(1260)	2.48E-02	(133043)	3.02E-02	7.47E-09
LW44-21.12	8.84E+04	70	5.8E-05	8.97	9	1.003	0.020	94.7	4.77E-03	ND	-	(1212)	2.21E-02	(133665)	3.69E-02	6.91E-09
LW44-21.13	8.84E+04	70	6.1E-05	9.17	9	1.002	0.020	95.6	5.08E-03	ND	-	(1137)	2.16E-02	(132910)	2.75E-02	6.58E-09
Exp. #22																
LW44-22-A	1.14E+05	70	-	-	9	-	-	<50	-	<50	-	<100	-	(167695)	-	-
LW44-22-B	1.14E+05	70	-	-	9	-	-	<50	-	<50	-	<100	-	(159364)	-	-
LW44-22-C	1.14E+05	70	-	-	9	-	-	<50	-	<50	-	<100	-	(165406)	-	-
LW44-22.3	1.14E+05	70	6.3E-05	3.07	9	1.006	0.036	215	1.05E-02	64.2	7.61E-04	(3951)	4.56E-02	(170624)	5.46E-02	1.40E-08
LW44-22.4	1.14E+05	70	5.2E-05	4.00	9	1.005	0.020	174	1.16E-02	56.5	5.18E-04	(2989)	5.07E-02	(168823)	5.83E-02	1.56E-08
LW44-22.6	1.14E+05	70	5.9E-05	5.23	9	1.005	0.020	109	6.38E-03	ND	-	(1848)	3.50E-02	(171600)	1.06E-01	1.14E-08
LW44-22.9	1.14E+05	70	5.9E-05	7.07	9	1.005	0.020	86.2	3.86E-03	ND	-	(1653)	3.09E-02	(163795)	-	1.08E-08
LW44-22.10	1.14E+05	70	2.6E-05	7.92	9	1.004	0.020	66.2	7.61E-04	ND	-	(1275)	1.03E-02	(165619)	9.15E-03	3.81E-09
LW44-22.11	1.14E+05	70	5.8E-05	8.18	9	1.004	0.020	ND	-	ND	-	(1141)	2.06E-02	(170599)	9.11E-02	8.26E-09
LW44-22.12	1.14E+05	70	5.8E-05	8.97	9	1.004	0.020	ND	-	ND	-	(1082)	1.93E-02	(171431)	1.02E-01	7.90E-09
LW44-22.13	1.14E+05	70	6.4E-05	9.17	9	1.004	0.020	ND	-	ND	-	(1000)	1.94E-02	(165652)	2.30E-02	8.38E-09
Exp. #23																
LW44-23A	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-23B	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-23C	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-23.2	-	40	5.1E-06	1.85	9	1.010	0.020	257	2.13E-03	195	1.13E-03	5,132	8.61E-03	1,470	1.67E-03	2.59E-09
LW44-23.4	-	40	4.6E-06	4.05	9	1.010	0.020	471	3.74E-03	405	2.51E-03	6,349	9.77E-03	2,997	3.23E-03	2.40E-09
LW44-23.6	-	40	4.8E-06	6.09	9	1.010	0.020	583	4.88E-03	525	3.50E-03	6,240	1.00E-02	3,801	4.30E-03	2.04E-09
LW44-23.8	-	40	5.0E-06	8.09	9	1.010	0.020	678	5.86E-03	616	4.28E-03	6,569	1.08E-02	4,426	5.15E-03	1.98E-09
LW44-23.10	-	40	4.8E-06	11.09	9	1.009	0.020	652	5.47E-03	636	4.30E-03	5,814	9.28E-03	4,495	5.08E-03	1.52E-09
LW44-23.12	-	40	4.4E-06	14.95	9	1.009	0.020	651	5.01E-03	669	4.17E-03	5,139	7.51E-03	4,512	4.69E-03	1.00E-09
LW44-23.14	-	40	4.8E-06	18.84	9	1.009	0.020	651	5.45E-03	704	4.79E-03	4,638	7.35E-03	4,669	5.27E-03	7.60E-10
LW44-23.16	-	40	4.6E-06	22.83	9	1.008	0.020	647	5.21E-03	705	4.62E-03	4,157	6.33E-03	4,560	4.96E-03	4.48E-10
LW44-23.19	-	40	4.8E-06	29.02	9	1.008	0.020	619	5.22E-03	686	4.71E-03	3,852	6.15E-03	4,518	5.16E-03	3.67E-10
LW44-23.21	-	40	5.0E-06	33.00	9	1.008	0.020	610	5.27E-03	679	4.78E-03	3,764	6.15E-03	4,597	5.38E-03	3.52E-10
LW44-23.24	-	40	4.6E-06	39.13	9	1.007	0.020	584	4.67E-03	666	4.33E-03	3,340	5.04E-03	4,212	4.56E-03	1.48E-10
LW44-23.25	-	40	5.0E-06	40.97	9	1.007	0.020	596	5.21E-03	669	4.76E-03	3,299	5.44E-03	4,293	5.08E-03	9.03E-11
LW44-23.26	-	40	4.7E-06	43.98	9	1.007	0.020	590	4.83E-03	670	4.46E-03	3,311	5.11E-03	4,372	4.84E-03	1.12E-10
LW44-23.27	-	40	4.7E-06	48.03	9	1.006	0.020	618	5.10E-03	678	4.55E-03	3,400	5.29E-03	4,412	4.92E-03	7.64E-11
LW44-23.28	-	40	4.9E-06	52.05	9	1.005	0.020	616	5.24E-03	664	4.58E-03	3,453	5.53E-03	4,373	5.03E-03	1.17E-10
LW44-23.29	-	40	3.9E-06	55.94	9	1.005	0.020	606	4.09E-03	658	3.61E-03	3,533	4.50E-03	4,333	3.96E-03	1.64E-10

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-23.30	-	40	4.8E-06	60.32	9	1.004	0.020	574	4.80E-03	632	4.29E-03	3,392	5.37E-03	4,057	4.59E-03	2.25E-10
LW44-23.31	-	40	4.9E-06	63.88	9	1.004	0.020	542	4.65E-03	603	4.19E-03	3,211	5.21E-03	3,882	4.52E-03	2.26E-10
LW44-23.32	-	40	4.6E-06	67.95	9	1.003	0.020	504	4.05E-03	574	3.73E-03	3,108	4.73E-03	3,733	4.07E-03	2.73E-10
LW44-23.33	-	40	4.7E-06	71.86	9	1.003	0.020	483	3.90E-03	549	3.58E-03	3,037	4.66E-03	3,537	3.88E-03	3.02E-10
LW44-23.34	-	40	4.8E-06	75.08	9	1.002	0.020	473	3.96E-03	546	3.70E-03	2,945	4.69E-03	3,554	4.06E-03	2.91E-10
LW44-23.35	-	40	3.1E-06	80.03	9	1.002	0.020	553	3.04E-03	607	2.70E-03	3,661	3.81E-03	4,108	3.06E-03	3.11E-10
LW44-23.36	-	40	5.5E-06	83.42	9	1.001	0.020	491	4.70E-03	569	4.41E-03	3,243	5.90E-03	3,685	4.80E-03	4.80E-10
Exp. #24																
LW44-24A	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-24B	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-24C	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-24.2	-	40	1.0E-05	1.85	9	0.750	0.016	216	4.32E-03	195	2.77E-03	3,999	1.65E-02	1,308	3.64E-03	4.85E-09
LW44-24.4	-	40	9.5E-06	4.05	9	0.750	0.015	327	7.02E-03	313	5.15E-03	3,720	1.57E-02	2,200	6.47E-03	3.45E-09
LW44-24.6	-	40	9.8E-06	6.09	9	0.750	0.015	375	8.38E-03	387	6.79E-03	3,197	1.38E-02	2,659	8.14E-03	2.17E-09
LW44-24.8	-	40	9.5E-06	8.09	9	0.749	0.015	390	8.47E-03	423	7.29E-03	2,978	1.24E-02	2,808	8.34E-03	1.58E-09
LW44-24.10	-	40	9.7E-06	11.09	9	0.749	0.015	382	8.42E-03	447	7.89E-03	2,665	1.13E-02	2,833	8.56E-03	1.14E-09
LW44-24.12	-	40	9.4E-06	14.95	9	0.749	0.015	382	8.17E-03	450	7.70E-03	2,368	9.67E-03	2,885	8.46E-03	5.99E-10
LW44-24.14	-	40	9.4E-06	18.84	9	0.748	0.015	395	8.53E-03	471	8.18E-03	2,223	9.12E-03	3,016	8.93E-03	2.38E-10
LW44-24.16	-	40	9.9E-06	22.83	9	0.748	0.015	395	8.97E-03	462	8.41E-03	2,139	9.20E-03	2,976	9.25E-03	9.32E-11
LW44-24.19	-	40	9.6E-06	29.02	9	0.747	0.015	381	8.36E-03	435	7.61E-03	2,161	9.01E-03	2,947	8.87E-03	2.58E-10
LW44-24.21	-	40	1.0E-05	33.00	9	0.747	0.015	365	8.36E-03	412	7.52E-03	2,117	9.25E-03	2,950	9.32E-03	3.57E-10
LW44-24.24	-	40	9.7E-06	39.13	9	0.747	0.015	366	8.12E-03	437	7.77E-03	1,874	7.88E-03	2,747	8.38E-03	-
LW44-24.25	-	40	1.0E-05	40.97	9	0.746	0.015	370	8.48E-03	422	7.71E-03	1,921	8.35E-03	2,724	8.57E-03	-
Exp. #25																
LW44-25A	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-25B	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-25C	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-25.2	-	40	1.9E-05	1.85	9	0.502	0.012	152	7.09E-03	149	4.63E-03	2,705	2.71E-02	950	6.29E-03	7.97E-09
LW44-25.4	-	40	1.9E-05	4.05	9	0.502	0.010	177	1.05E-02	194	8.38E-03	1,631	1.98E-02	1,287	1.09E-02	3.69E-09
LW44-25.6	-	40	1.9E-05	6.09	9	0.502	0.010	190	1.13E-02	221	9.87E-03	1,359	1.60E-02	1,422	1.20E-02	1.91E-09
LW44-25.8	-	40	1.9E-05	8.09	9	0.501	0.010	183	1.12E-02	218	9.99E-03	1,197	1.44E-02	1,408	1.23E-02	1.30E-09
LW44-25.10	-	40	1.8E-05	11.09	9	0.501	0.010	189	1.10E-02	221	9.65E-03	1,110	1.26E-02	1,522	1.26E-02	6.51E-10
LW44-25.12	-	40	1.9E-05	14.95	9	0.501	0.010	175	1.05E-02	210	9.40E-03	1,039	1.22E-02	1,436	1.24E-02	6.92E-10
LW44-25.14	-	40	1.9E-05	18.84	9	0.500	0.010	197	1.23E-02	209	9.50E-03	1,040	1.25E-02	1,761	1.57E-02	7.93E-11
Exp. #26																
LW44-26A	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-26B	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-26C	-	40	-	-	9	-	-	<25	-	<50	-	<100	-	<100	-	-
LW44-26.2	-	40	3.8E-05	1.85	9	0.251	0.008	56	5.53E-03	52	2.90E-04	971	2.86E-02	633	1.25E-02	9.21E-09
LW44-26.4	-	40	3.8E-05	4.05	9	0.251	0.005	55	8.25E-03	73	5.52E-03	429	1.71E-02	428	1.21E-02	3.53E-09

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-26.6	-	40	3.9E-05	6.09	9	0.251	0.005	56	8.80E-03	75	5.81E-03	366	1.39E-02	448	1.30E-02	2.04E-09
LW44-26.8	-	40	3.8E-05	8.09	9	0.251	0.005	55	8.37E-03	67	4.02E-03	340	1.25E-02	559	1.71E-02	1.65E-09
LW44-26.10	-	40	3.8E-05	11.09	9	0.250	0.005	57	9.07E-03	75	5.85E-03	319	1.14E-02	509	1.52E-02	9.47E-10
Exp. #27																
LW44-27.A	8.79E+02	90	-	-	9	-	-	<50	-	<50	-	<100	-	<100	-	-
LW44-27.B	8.79E+02	90	-	-		-	-	<50	-	<50	-	728	-	<100	-	-
LW44-27.C	8.79E+02	90	-	-		-	-	<50	-	<50	-	<100	-	<100	-	-
LW44-27.2	8.79E+02	90	8.8E-05	2.11	9	0.995	0.020	1162	1.80E-01	1200	1.56E-01	7606	2.19E-01	7664	1.62E-01	1.59E-08
LW44-27.3	8.79E+02	90	8.2E-05	3.01	9	0.990	0.020	1133	1.65E-01	1190	1.46E-01	6496	1.75E-01	7467	1.49E-01	4.22E-09
LW44-27.4	8.79E+02	90	8.6E-05	4.07	9	0.985	0.020	1124	1.70E-01	1206	1.55E-01	6128	1.72E-01	7457	1.55E-01	6.29E-10
LW44-27.5	8.79E+02	90	8.7E-05	4.93	9	0.980	0.019	1167	1.81E-01	1209	1.58E-01	5908	1.69E-01	7726	1.64E-01	-4.81E-09
Exp. #28																
LW44-28A	10	90	-	-	9	-	-	<50	-	<50	-	72	-	21574	-	-
LW44-28B	10	90	-	-	9	-	-	<50	-	<50	-	50	-	21891	-	-
LW44-28C	10	90	-	-	9	-	-	<50	-	<50	-	54	-	21449	-	-
LW44-28.2	10	90	8.4E-05	2.11	9	0.999	0.020	804	1.16E-01	706	8.50E-02	6562	1.87E-01	25882	8.67E-02	2.81E-08
LW44-28.3	10	90	8.1E-05	3.01	9	0.996	0.020	784	1.10E-01	727	8.51E-02	5636	1.55E-01	26179	8.99E-02	1.81E-08
LW44-28.4	10	90	8.5E-05	4.07	9	0.993	0.020	718	1.04E-01	690	8.41E-02	4799	1.38E-01	26140	9.33E-02	1.34E-08
LW44-28.5	10	90	8.8E-05	4.93	9	0.989	0.020	707	1.06E-01	670	8.44E-02	4537	1.35E-01	25048	7.32E-02	1.14E-08
Exp. #29																
LW44-29A	3.74E+04	90	-	-	9	-	-	<50	-	<50	-	57	-	41897	-	-
LW44-29B	3.74E+04	90	-	-	9	-	-	<50	-	<50	-	50	-	42042	-	-
LW44-29C	3.74E+04	90	-	-	9	-	-	<50	-	<50	-	96	-	41179	-	-
LW44-29.2	3.74E+04	90	8.8E-05	2.11	9	0.994	0.020	741	1.12E-01	463	5.63E-02	6227	1.86E-01	45584	8.34E-02	2.95E-08
LW44-29.3	3.74E+04	90	8.1E-05	3.01	9	0.991	0.020	677	9.38E-02	470	5.29E-02	5110	1.40E-01	45455	7.44E-02	1.87E-08
LW44-29.4	3.74E+04	90	9.0E-05	4.07	9	0.988	0.020	592	9.00E-02	441	5.47E-02	4256	1.29E-01	45331	7.98E-02	1.58E-08
LW44-29.5	3.74E+04	90	7.4E-05	4.93	9	0.986	0.020	602	7.59E-02	459	4.74E-02	4231	1.07E-01	45279	6.51E-02	1.22E-08
Exp. #30																
LW44-30A	7.39E+04	90	-	-	9	-	-	<50	-	<50	-	66	-	84873	-	-
LW44-30B	7.39E+04	90	-	-	9	-	-	<50	-	<50	-	65	-	81999	-	-
LW44-30C	7.39E+04	90	-	-	9	-	-	<50	-	<50	-	85	-	83677	-	-
LW44-30.2	7.39E+04	90	7.8E-05	2.11	9	0.998	0.020	508	6.58E-02	201	1.83E-02	5659	1.49E-01	87205	7.03E-02	3.34E-08
LW44-30.3	7.39E+04	90	8.7E-05	3.01	9	0.996	0.020	495	7.08E-02	198	1.98E-02	4558	1.33E-01	88947	1.15E-01	2.48E-08
LW44-30.4	7.39E+04	90	7.9E-05	4.07	9	0.994	0.020	474	6.18E-02	184	1.65E-02	4034	1.08E-01	91585	1.56E-01	1.83E-08
LW44-30.5	7.39E+04	90	9.4E-05	4.93	9	0.992	0.020	468	7.23E-02	176	1.84E-02	3792	1.20E-01	88498	1.14E-01	1.90E-08
Exp. #31																
LW44-31A	1.06E+05	90	-	-	9	-	-	<50	-	<50	-	122	-	116232	-	-
LW44-31B	1.06E+05	90	-	-	9	-	-	<50	-	<50	-	104	-	120112	-	-
LW44-31C	1.06E+05	90	-	-	9	-	-	<50	-	<50	-	116	-	119886	-	-
LW44-31.2	1.06E+05	90	7.5E-05	2.11	9	1.001	0.020	333	3.88E-02	54	5.20E-04	4653	1.16E-01	121467	4.97E-02	3.09E-08

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-31.3	1.06E+05	90	9.2E-05	3.01	9	1.000	0.020	296	4.13E-02	ND	-	3752	1.14E-01	121459	6.06E-02	2.90E-08
LW44-31.4	1.06E+05	90	7.6E-05	4.07	9	0.998	0.020	255	2.83E-02	ND	-	2989	7.42E-02	119895	2.12E-02	1.83E-08
LW44-31.5	1.06E+05	90	8.8E-05	4.93	9	0.997	0.020	244	3.15E-02	ND	-	2731	7.90E-02	120027	2.76E-02	1.90E-08
Exp. #32																
LW44-32.A	1.22E+05	90	-	-	9	-	-	<50	-	<50	-	53	-	129824	-	-
LW44-32.C	1.22E+05	90	-	-	9	-	-	<50	-	<50	-	101	-	145751	-	-
LW44-32.2	1.22E+05	90	9.2E-05	2.11	9	1.002	0.020	395	5.79E-02	ND	-	4924	1.52E-01	131308.1	-	3.75E-08
LW44-32.3	1.22E+05	90	7.1E-05	3.01	9	1.000	0.020	329	3.60E-02	ND	-	3838	9.04E-02	137194.7	-	2.17E-08
LW44-32.4	1.22E+05	90	9.1E-05	4.07	9	0.999	0.020	303	4.23E-02	ND	-	3288	1.00E-01	140705.6	6.49E-02	2.31E-08
LW44-32.5	1.22E+05	90	4.7E-05	4.93	9	0.998	0.020	289	2.06E-02	ND	-	3243	5.08E-02	140491.1	3.09E-02	1.21E-08
Exp. #33																
LW44-33A	8.97E+02	23	-	-		-	-	<50	-	<10	-	<100	-	(16)	-	-
LW44-33B	8.97E+02	23	-	-	9	-	-	<50	-	<10	-	<100	-	(18)	-	-
LW44-33C	8.97E+02	23	-	-	9	-	-	<50	-	<10	-	<100	-	(22)	-	-
LW44-33.4	8.97E+02	23	9.7E-06	7.12	9	4.014	0.050	321	1.91E-03	362	2.09E-03	4,046	5.18E-03	2,255	2.09E-03	1.31E-09
LW44-33.8	8.97E+02	23	9.7E-06	14.25	9	4.013	0.079	311	1.15E-03	300	1.08E-03	2,755	2.19E-03	2,098	1.22E-03	4.13E-10
LW44-33.12	8.97E+02	23	9.6E-06	22.22	9	4.013	0.079	467	1.82E-03	531	1.91E-03	2,470	1.92E-03	3,367	1.94E-03	4.30E-11
LW44-33.16	8.97E+02	23	9.5E-06	33.09	9	4.012	0.079	498	1.95E-03	515	1.85E-03	2,514	1.96E-03	3,336	1.92E-03	2.54E-12
LW44-33.20	8.97E+02	23	9.6E-06	42.48	9	4.012	0.079	447	1.73E-03	440	1.58E-03	2,448	1.91E-03	2,944	1.70E-03	7.03E-11
LW44-33.24	8.97E+02	23	1.1E-05	52.10	9	4.011	0.079	362	1.54E-03	380	1.54E-03	2,054	1.80E-03	2,457	1.60E-03	1.03E-10
LW44-33.28	8.97E+02	23	9.4E-06	68.08	9	4.011	0.079	311	1.11E-03	388	1.36E-03	1,658	1.24E-03	2,292	1.29E-03	5.06E-11
LW44-33.32	8.97E+02	23	9.3E-06	86.08	9	4.010	0.079	368	1.36E-03	403	1.41E-03	1,827	1.37E-03	2,570	1.44E-03	5.87E-12
LW44-33.34	8.97E+02	23	9.5E-06	93.15	9	4.009	0.079	330	1.21E-03	364	1.29E-03	1,855	1.41E-03	2,303	1.31E-03	8.08E-11
LW44-33.35	8.97E+02	23	9.7E-06	96.01	9	4.009	0.079	369	1.41E-03	474	1.73E-03	1,821	1.42E-03	2,773	1.61E-03	3.55E-12
Exp. #34																
LW44-34A	1.51E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	16,543	-	-
LW44-34B	1.51E+04	23	-	-	9	-	-	<50	-	12	-	<100	-	16,797	-	-
LW44-34C	1.51E+04	23	-	-	9	-	-	<50	-	13	-	<100	-	16,703	-	-
LW44-34.4	1.51E+04	23	9.7E-06	7.12	9	4.018	0.050	231	1.27E-03	139	7.51E-04	3,800	4.82E-03	17,244	5.22E-04	1.42E-09
LW44-34.8	1.51E+04	23	9.6E-06	14.25	9	4.018	0.079	177	5.56E-04	124	4.13E-04	2,440	1.91E-03	17,357	3.93E-04	5.40E-10
LW44-34.12	1.51E+04	23	9.4E-06	22.22	9	4.017	0.079	263	9.13E-04	267	9.24E-04	1,913	1.45E-03	19,006	1.33E-03	2.15E-10
LW44-34.16	1.51E+04	23	9.4E-06	33.09	9	4.017	0.079	355	1.31E-03	287	9.91E-04	1,903	1.44E-03	18,935	1.28E-03	5.24E-11
LW44-34.20	1.51E+04	23	9.5E-06	42.48	9	4.017	0.079	298	1.07E-03	197	6.75E-04	1,589	1.20E-03	17,798	6.42E-04	5.09E-11
LW44-34.24	1.51E+04	23	1.1E-05	52.10	9	4.016	0.079	239	9.24E-04	152	5.79E-04	1,354	1.14E-03	17,040	2.33E-04	8.74E-11
LW44-34.28	1.51E+04	23	9.4E-06	68.08	9	4.016	0.079	204	6.61E-04	133	4.41E-04	1,285	9.50E-04	17,061	2.17E-04	1.16E-10
LW44-34.32	1.51E+04	23	9.4E-06	86.08	9	4.015	0.079	216	7.15E-04	118	3.85E-04	1,295	9.58E-04	17,240	3.20E-04	9.71E-11
LW44-34.34	1.51E+04	23	9.5E-06	93.15	9	4.015	0.079	182	5.71E-04	100	3.21E-04	1,377	1.03E-03	25,439	5.02E-03	1.82E-10
LW44-34.35	1.51E+04	23	9.5E-06	96.01	9	4.015	0.079	189	6.01E-04	137	4.57E-04	1,252	9.26E-04	21,709	2.88E-03	1.30E-10
Exp. #35																
LW44-35A	3.01E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	32,764	-	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-35B	3.01E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	33,786	-	-
LW44-35C	3.01E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	33,228	-	-
LW44-35.4	3.01E+04	23	9.9E-06	7.12	9	4.020	0.050	216	1.19E-03	107	5.80E-04	3,797	4.90E-03	34,511	1.18E-03	1.49E-09
LW44-35.8	3.01E+04	23	9.6E-06	14.25	9	4.020	0.079	144	4.11E-04	83	2.71E-04	2,434	1.91E-03	34,675	8.24E-04	5.97E-10
LW44-35.12	3.01E+04	23	9.6E-06	22.22	9	4.019	0.079	197	6.43E-04	172	5.95E-04	1,855	1.43E-03	35,721	1.43E-03	3.13E-10
LW44-35.16	3.01E+04	23	9.4E-06	33.09	9	4.019	0.079	276	9.68E-04	195	6.68E-04	1,722	1.30E-03	34,627	7.78E-04	1.31E-10
LW44-35.20	3.01E+04	23	9.5E-06	42.48	9	4.019	0.079	213	7.04E-04	116	3.87E-04	1,287	9.55E-04	34,038	4.47E-04	1.00E-10
LW44-35.24	3.01E+04	23	1.1E-05	52.10	9	4.019	0.079	153	5.08E-04	85	3.13E-04	1,051	8.77E-04	33,488	1.51E-04	1.47E-10
LW44-35.28	3.01E+04	23	9.4E-06	68.08	9	4.019	0.079	112	2.66E-04	68	2.10E-04	903	6.41E-04	34,274	5.77E-04	1.50E-10
LW44-35.32	3.01E+04	23	9.4E-06	86.08	9	4.018	0.079	125	3.22E-04	73	2.27E-04	909	6.48E-04	34,203	5.38E-04	1.30E-10
LW44-35.34	3.01E+04	23	9.3E-06	93.15	9	4.018	0.079	108	2.46E-04	62	1.87E-04	1,072	7.70E-04	43,846	5.98E-03	2.09E-10
LW44-35.35	3.01E+04	23	9.3E-06	96.01	9	4.018	0.079	110	2.56E-04	77	2.39E-04	987	7.03E-04	37,698	2.51E-03	1.78E-10
Exp. #36																
LW44-36A	4.60E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	49,478	-	-
LW44-36B	4.60E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	50,662	-	-
LW44-36C	4.60E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	51,502	-	-
LW44-36.4	4.60E+04	23	9.4E-06	7.12	9	4.015	0.050	203	1.04E-03	74	3.67E-04	3,931	4.88E-03	50,467	-	1.53E-09
LW44-36.8	4.60E+04	23	9.6E-06	14.25	9	4.015	0.079	124	3.24E-04	64	1.99E-04	2,829	2.22E-03	58,295	4.49E-03	7.56E-10
LW44-36.12	4.60E+04	23	9.4E-06	22.22	9	4.015	0.079	108	2.49E-04	83	2.63E-04	1,782	1.34E-03	53,038	1.41E-03	4.34E-10
LW44-36.16	4.60E+04	23	9.3E-06	33.09	9	4.014	0.079	137	3.70E-04	96	3.08E-04	1,315	9.58E-04	50,161	-	2.35E-10
LW44-36.20	4.60E+04	23	9.3E-06	42.48	9	4.014	0.079	110	2.53E-04	65	1.96E-04	949	6.68E-04	48,718	-	1.66E-10
LW44-36.24	4.60E+04	23	1.1E-05	52.10	9	4.014	0.079	71	9.95E-05	40	1.24E-04	699	5.42E-04	49,744	-	1.76E-10
LW44-36.28	4.60E+04	23	9.0E-06	68.08	9	4.014	0.079	51	5.15E-06	48	1.32E-04	670	4.37E-04	47,362	-	1.72E-10
LW44-36.32	4.60E+04	23	9.1E-06	86.08	9	4.014	0.079	ND	-6.74E-06	33	7.96E-05	656	4.31E-04	51,939	7.69E-04	1.75E-10
LW44-36.34	4.60E+04	23	9.2E-06	93.15	9	4.014	0.079	ND	-2.76E-05	26	5.51E-05	840	5.76E-04	43,225	-	2.41E-10
LW44-36.35	4.60E+04	23	9.2E-06	96.01	9	4.014	0.079	53	1.21E-05	28	6.36E-05	904	6.28E-04	46,505	-	2.46E-10
Exp. #37																
LW44-36A	6.04E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	65,880	-	-
LW44-36B	6.04E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	69,250	-	-
LW44-36C	6.04E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	67,086	-	-
LW44-37.4	6.04E+04	23	9.8E-06	7.12	9	4.021	0.050	183	9.44E-04	54	2.61E-04	3,801	4.89E-03	65,178	-	1.57E-09
LW44-37.8	6.04E+04	23	9.7E-06	14.25	9	4.021	0.079	97	2.09E-04	39	1.07E-04	2,373	1.87E-03	66,618	-	6.64E-10
LW44-37.12	6.04E+04	23	9.5E-06	22.22	9	4.021	0.079	73	1.01E-04	50	1.46E-04	1,680	1.27E-03	67,027	-	4.66E-10
LW44-37.16	6.04E+04	23	9.5E-06	33.09	9	4.021	0.079	74	1.04E-04	60	1.83E-04	1,150	8.46E-04	67,098	-	2.96E-10
LW44-37.20	6.04E+04	23	9.5E-06	42.48	9	4.020	0.079	61	4.83E-05	40	1.09E-04	749	5.25E-04	63,845	-	1.90E-10
LW44-37.24	6.04E+04	23	1.1E-05	52.10	9	4.020	0.079	(35)	-	23	5.50E-05	534	3.95E-04	70,172	1.79E-03	1.86E-10
LW44-37.28	6.04E+04	23	9.3E-06	68.08	9	4.020	0.079	(26)	-	17	2.67E-05	754	5.17E-04	64,244	-	2.48E-10
LW44-37.32	6.04E+04	23	9.4E-06	86.08	9	4.020	0.079	(19)	-	23	4.68E-05	519	3.32E-04	63,348	-	1.86E-10
LW44-37.34	6.04E+04	23	9.1E-06	93.15	9	4.020	0.079	(20)	-	18	2.96E-05	532	3.35E-04	57,809	-	1.84E-10
LW44-37.35	6.04E+04	23	9.0E-06	96.01	9	4.020	0.079	(21)	-	24	4.92E-05	544	3.37E-04	62,078	-	1.83E-10

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #38																
LW44-38A	5.24E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	52,022	-	-
LW44-38B	5.24E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	57,400	-	-
LW44-38C	5.24E+04	23	-	-	9	-	-	<50	-	<10	-	<100	-	61,722	-	-
LW44-38.4	5.24E+04	23	9.7E-06	7.12	9	4.006	0.050	181	9.25E-04	46	2.14E-04	3,696	4.72E-03	76,634	1.83E-02	1.51E-09
LW44-38.8	5.24E+04	23	9.7E-06	14.25	9	4.006	0.079	101	2.26E-04	37	1.01E-04	2,735	2.16E-03	86,867	1.75E-02	7.74E-10
LW44-38.12	5.24E+04	23	9.5E-06	22.22	9	4.006	0.079	65	6.71E-05	35	9.15E-05	1,697	1.29E-03	82,731	1.48E-02	4.89E-10
LW44-38.16	5.24E+04	23	9.4E-06	33.09	9	4.006	0.079	(44)	-	36	9.36E-05	1,073	7.79E-04	82,997	1.48E-02	3.22E-10
LW44-38.20	5.24E+04	23	9.5E-06	42.48	9	4.006	0.079	(30)	-	26	5.88E-05	743	5.21E-04	81,033	1.38E-02	2.43E-10
LW44-38.24	5.24E+04	23	1.1E-05	52.10	9	4.006	0.079	(16)	-	17	3.05E-05	559	4.20E-04	80,956	1.56E-02	2.34E-10
LW44-38.28	5.24E+04	23	9.2E-06	68.08	9	4.006	0.079	(9)	-	13	1.04E-05	509	3.21E-04	74,205	9.58E-03	1.97E-10
LW44-38.32	5.24E+04	23	9.3E-06	86.08	9	4.005	0.079	(6)	-	14	1.30E-05	433	2.64E-04	83,475	1.49E-02	1.80E-10
LW44-38.34	5.24E+04	23	9.4E-06	93.15	9	4.005	0.079	(7)	-	10	-	428	2.62E-04	73,591	9.41E-03	1.78E-10
LW44-38.35	5.24E+04	23	9.0E-06	96.01	9	4.005	0.079	(7)	-	12	8.42E-06	448	2.67E-04	77,411	1.11E-02	1.78E-10
Exp. #39																
LW44-47A	0	40	-	-	7	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-47B	0	40	-	-	7	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-47C	0	40	-	-	7	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-47.1	0	40	1.0E-05	1.98	7	1.005	0.020	480	7.92E-03	25	2.35E-04	6,014	2.03E-02	569	1.68E-04	4.94E-09
LW44-47.2	0	40	8.6E-06	5.03	7	1.004	0.020	682	9.93E-03	ND	-	6,999	2.02E-02	1,134	1.32E-03	4.10E-09
LW44-47.4	0	40	8.8E-06	9.10	7	1.003	0.020	590	8.69E-03	24	1.91E-04	5,038	1.48E-02	611	2.38E-04	2.44E-09
LW44-47.6	0	40	8.7E-06	13.96	7	1.003	0.020	484	6.88E-03	28	2.38E-04	3,789	1.09E-02	ND	-	1.60E-09
LW44-47.9	0	40	9.5E-06	23.09	7	1.002	0.020	389	5.91E-03	30	2.92E-04	2,631	8.21E-03	ND	-	9.19E-10
LW44-47.12	0	40	1.1E-05	33.15	7	1.002	0.020	345	6.08E-03	29	3.32E-04	2,187	8.02E-03	ND	-	7.76E-10
LW44-47.14	0	40	9.3E-06	37.18	7	1.001	0.020	320	4.57E-03	31	2.95E-04	2,036	6.10E-03	ND	-	6.14E-10
Exp. #40																
LW44-48A	0	40	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-48B	0	40	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-48C	0	40	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-48.1	0	40	1.1E-05	1.98	8	1.009	0.020	286	4.54E-03	82	1.17E-03	4,871	1.71E-02	744	6.22E-04	5.01E-09
LW44-48.2	0	40	9.1E-06	5.03	8	1.008	0.020	302	4.16E-03	92	1.13E-03	4,918	1.48E-02	1,049	1.20E-03	4.26E-09
LW44-48.4	0	40	9.4E-06	9.10	8	1.008	0.020	200	2.57E-03	131	1.74E-03	3,086	9.53E-03	817	7.21E-04	2.78E-09
LW44-48.6	0	40	9.0E-06	13.96	8	1.008	0.020	152	1.68E-03	129	1.64E-03	2,161	6.30E-03	691	4.16E-04	1.85E-09
LW44-48.9	0	40	9.9E-06	23.09	8	1.008	0.020	119	1.24E-03	118	1.64E-03	1,439	4.49E-03	587	2.08E-04	1.30E-09
LW44-48.12	0	40	1.3E-05	33.15	8	1.008	0.020	112	1.44E-03	109	1.94E-03	1,216	4.82E-03	594	2.89E-04	1.35E-09
LW44-48.14	0	40	9.8E-06	37.18	8	1.007	0.020	108	1.03E-03	108	1.47E-03	1,104	3.33E-03	603	2.44E-04	9.17E-10
Exp. #41																
LW44-49A	0	40	-	-	9	-	-	<50	-	<10	-	104	-	<500	-	-
LW44-49B	0	40	-	-	9	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-49C	0	40	-	-	9	-	-	<50	-	<10	-	<100	-	<500	-	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-49.1	0	40	1.0E-05	1.98	9	1.008	0.020	238	3.58E-03	232	3.56E-03	3,663	1.26E-02	1,368	2.19E-03	3.62E-09
LW44-49.2	0	40	9.8E-06	5.03	9	1.007	0.020	420	6.61E-03	480	7.06E-03	4,090	1.33E-02	2,923	5.74E-03	2.65E-09
LW44-49.4	0	40	8.6E-06	9.10	9	1.007	0.020	485	6.80E-03	597	7.72E-03	3,436	9.69E-03	3,550	6.32E-03	1.16E-09
LW44-49.6	0	40	9.2E-06	13.96	9	1.006	0.020	496	7.44E-03	635	8.78E-03	3,142	9.45E-03	3,669	7.02E-03	8.05E-10
LW44-49.9	0	40	9.9E-06	23.09	9	1.006	0.020	468	7.51E-03	619	9.22E-03	2,803	9.05E-03	3,425	6.98E-03	6.16E-10
LW44-49.12	0	40	1.3E-05	33.15	9	1.005	0.020	483	1.01E-02	583	1.12E-02	2,687	1.12E-02	3,562	9.44E-03	4.48E-10
LW44-49.14	0	40	9.0E-06	37.18	9	1.004	0.020	460	6.73E-03	578	7.85E-03	2,575	7.56E-03	3,375	6.26E-03	3.33E-10
Exp. #42																
LW44-50A	0	40	-	-	10	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-50B	0	40	-	-	10	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-50C	0	40	-	-	10	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-50.1	0	40	1.1E-05	1.98	10	1.005	0.020	467	8.15E-03	623	1.01E-02	4,387	1.56E-02	3,600	8.04E-03	2.98E-09
LW44-50.2	0	40	9.2E-06	5.03	10	1.004	0.020	824	1.29E-02	1,028	1.43E-02	5,837	1.78E-02	5,995	1.22E-02	1.96E-09
LW44-50.4	0	40	9.4E-06	9.10	10	1.003	0.020	844	1.37E-02	1,055	1.52E-02	5,164	1.63E-02	6,019	1.26E-02	1.02E-09
LW44-50.6	0	40	8.9E-06	13.96	10	1.002	0.020	832	1.28E-02	1,019	1.39E-02	4,883	1.46E-02	5,866	1.16E-02	7.12E-10
LW44-50.9	0	40	9.9E-06	23.09	10	1.001	0.020	825	1.41E-02	1,003	1.52E-02	4,462	1.48E-02	5,828	1.28E-02	2.76E-10
LW44-50.12	0	40	1.3E-05	33.15	10	1.000	0.020	779	1.70E-02	964	1.88E-02	4,180	1.78E-02	5,519	1.56E-02	2.94E-10
LW44-50.14	0	40	9.8E-06	37.18	10	0.999	0.020	736	1.24E-02	927	1.39E-02	3,993	1.31E-02	5,228	1.13E-02	2.81E-10
Exp. #43																
LW44-51A	0	40	-	-	11	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-51B	0	40	-	-	11	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-51C	0	40	-	-	11	-	-	<50	-	<10	-	<100	-	<500	-	-
LW44-51.1	0	40	1.0E-05	1.98	11	1.003	0.020	1,213	2.14E-02	1,611	2.48E-02	7,859	2.66E-02	9,270	2.14E-02	2.07E-09
LW44-51.2	0	40	9.7E-06	5.03	11	1.000	0.020	2,563	4.45E-02	2,982	4.43E-02	14,807	4.85E-02	17,238	3.93E-02	1.60E-09
LW44-51.4	0	40	9.4E-06	9.10	11	0.996	0.020	3,568	6.06E-02	4,052	5.86E-02	19,083	6.09E-02	23,146	5.18E-02	1.25E-10
LW44-51.6	0	40	8.8E-06	13.96	11	0.994	0.020	3,282	5.26E-02	3,500	4.78E-02	17,399	5.24E-02	20,542	4.33E-02	-
LW44-51.9	0	40	9.8E-06	23.09	11	0.990	0.020	4,011	7.20E-02	4,390	6.71E-02	20,961	7.07E-02	25,643	6.07E-02	-
LW44-51.12	0	40	1.3E-05	33.15	11	0.984	0.019	3,449	8.03E-02	3,384	6.71E-02	18,553	8.12E-02	21,187	6.48E-02	3.62E-10
LW44-51.14	0	40	9.7E-06	37.18	11	0.979	0.019	3,498	6.24E-02	3,352	5.09E-02	18,364	6.16E-02	21,417	5.02E-02	-
Exp. #44																
LW44-52A	0	40	-	-	12	-	-	<50	-	12	-	<100	-	<500	-	-
LW44-52B	0	40	-	-	12	-	-	<50	-	11	-	<100	-	<500	-	-
LW44-52C	0	40	-	-	12	-	-	<50	-	16	-	<100	-	<500	-	-
LW44-52.1	0	40	1.0E-05	1.98	12	1.001	0.020	2,107	3.80E-02	2,824	4.37E-02	13,009	4.44E-02	15,343	3.64E-02	2.56E-09
LW44-52.2	0	40	9.3E-06	5.03	12	0.994	0.020	6,400	1.09E-01	7,689	1.11E-01	34,393	1.09E-01	44,219	9.93E-02	2.64E-10
LW44-52.4	0	40	9.1E-06	9.10	12	0.985	0.020	8,859	1.49E-01	10,398	1.48E-01	45,333	1.43E-01	57,223	1.27E-01	-
LW44-52.6	0	40	8.9E-06	13.96	12	0.979	0.019	8,682	1.43E-01	9,989	1.39E-01	45,610	1.40E-01	55,013	1.20E-01	-
LW44-52.9	0	40	9.9E-06	23.09	12	0.971	0.019	8,826	1.63E-01	9,784	1.53E-01	45,657	1.58E-01	55,803	1.36E-01	-
LW44-52.12	0	40	1.3E-05	33.15	12	0.955	0.019	9,071	2.18E-01	9,652	1.96E-01	50,007	2.24E-01	57,314	1.82E-01	2.67E-09
LW44-52.14	0	40	9.7E-06	37.18	12	0.942	0.019	8,391	1.57E-01	9,078	1.44E-01	46,504	1.63E-01	52,556	1.30E-01	2.29E-09

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #45																
LW44-53.A	0	90	-	-	7	-	-	50	-	10	-	100	-	500	-	-
LW44-53.1	0	90	7.2E-05	0.94	7	0.998	0.020	4,083	5.34E-01	51	4.62E-03	26,604	6.53E-01	1,939	2.53E-02	4.78E-08
LW44-53.2	0	90	8.5E-05	1.17	7	0.989	0.020	6,224	9.64E-01	91	1.07E-02	34,929	1.01E+00	2,095	3.30E-02	1.96E-08
LW44-53.4	0	90	5.9E-05	2.19	7	0.983	0.019	4,891	5.34E-01	89	7.32E-03	26,724	5.47E-01	1,194	1.02E-02	5.22E-09
LW44-53.6	0	90	7.3E-05	5.18	7	0.973	0.019	3,399	4.59E-01	82	8.26E-03	18,703	4.75E-01	934	7.89E-03	6.37E-09
LW44-53.8	0	90	8.0E-05	7.02	7	0.960	0.019	3,077	4.62E-01	79	8.84E-03	16,491	4.66E-01	945	9.01E-03	1.60E-09
LW44-53.9	0	90	7.5E-05	8.05	7	0.948	0.019	2,929	4.13E-01	74	7.78E-03	15,967	4.24E-01	906	7.74E-03	4.43E-09
Exp. #46																
LW44-54.A	0	90	-	-	8	-	-	50	-	10	-	100	-	500	-	-
LW44-54.1	0	90	7.4E-05	0.94	8	0.998	0.020	1,481	1.93E-01	260	2.84E-02	14,465	3.61E-01	2,258	3.15E-02	6.70E-08
LW44-54.2	0	90	7.1E-05	1.17	8	0.995	0.020	1,943	2.47E-01	404	4.33E-02	15,706	3.80E-01	2,821	4.02E-02	5.29E-08
LW44-54.4	0	90	3.3E-05	2.19	8	0.994	0.020	1,509	8.83E-02	367	1.82E-02	10,496	1.17E-01	2,303	1.45E-02	1.15E-08
LW44-54.6	0	90	7.5E-05	5.18	8	0.991	0.020	941	1.24E-01	337	3.82E-02	5,612	1.43E-01	2,121	2.99E-02	7.55E-09
LW44-54.8	0	90	7.8E-05	7.02	8	0.988	0.020	817	1.10E-01	319	3.74E-02	5,047	1.33E-01	2,071	3.00E-02	8.89E-09
LW44-54.9	0	90	7.2E-05	8.05	8	0.985	0.019	812	1.01E-01	326	3.53E-02	4,821	1.17E-01	2,013	2.67E-02	6.23E-09
Exp. #47																
LW44-55.A	0	9	-	-	9	-	-	50	-	10	-	100	-	500	-	-
LW44-55.1	0	90	7.1E-05	0.94	9	1.000	0.020	846	1.03E-01	928	9.99E-02	8,155	1.94E-01	5,795	9.08E-02	3.63E-08
LW44-55.2	0	90	5.2E-05	1.17	9	0.998	0.020	1,284	1.18E-01	1,458	1.17E-01	10,400	1.84E-01	8,913	1.07E-01	2.62E-08
LW44-55.4	0	90	4.8E-05	2.19	9	0.998	0.020	1,204	1.02E-01	1,391	1.03E-01	7,755	1.26E-01	8,423	9.32E-02	9.64E-09
LW44-55.6	0	90	7.2E-05	5.18	9	0.994	0.020	1,313	1.67E-01	1,518	1.68E-01	6,704	1.63E-01	8,916	1.48E-01	-
LW44-55.8	0	90	7.6E-05	7.02	9	0.989	0.020	1,300	1.77E-01	1,497	1.77E-01	6,938	1.80E-01	8,960	1.59E-01	1.33E-09
LW44-55.9	0	90	7.5E-05	8.05	9	0.984	0.019	1,234	1.65E-01	1,419	1.65E-01	6,783	1.73E-01	8,574	1.49E-01	3.40E-09
Exp. #48																
LW44-56.A	0	90	-	-	10	-	-	50	-	10	-	100	5.00E+02	500	-	
LW44-56.1	0	90	7.5E-05	0.94	10	0.499	0.010	1,040	2.72E-01	1,182	2.72E-01	6,681	3.37E-01	6,757	2.28E-01	2.59E-08
LW44-56.2	0	90	8.2E-05	1.17	10	0.497	0.010	1,788	5.25E-01	2,006	5.08E-01	10,184	5.67E-01	11,300	4.33E-01	1.70E-08
LW44-56.4	0	90	5.5E-05	2.19	10	0.495	0.010	1,910	3.79E-01	2,030	3.47E-01	10,101	3.80E-01	11,975	3.11E-01	2.73E-10
LW44-56.6	0	90	7.7E-05	5.18	10	0.488	0.010	2,390	6.72E-01	2,514	6.06E-01	12,424	6.60E-01	14,986	5.53E-01	-
LW44-56.8	0	90	7.1E-05	7.02	10	0.479	0.010	2,319	6.11E-01	2,283	5.16E-01	12,391	6.17E-01	14,469	4.99E-01	2.27E-09
LW44-56.9	0	90	4.5E-05	8.05	10	0.473	0.009	2,270	3.82E-01	2,244	3.24E-01	12,155	3.86E-01	14,133	3.11E-01	1.77E-09
Exp. #49																
LW44.57.A	0	90	-	-	11	-	-	50	-	10	-	100	-	500	-	-
LW44-57.1	0	90	7.2E-05	0.94	11	0.494	0.010	3,527	9.17E-01	3,545	7.85E-01	19,269	9.42E-01	22,054	7.55E-01	9.90E-09
LW44-57.2	0	90	5.1E-05	1.17	11	0.487	0.010	6,346	1.19E+00	5,825	9.25E-01	33,830	1.19E+00	37,710	9.32E-01	-
LW44-57.4	0	90	5.7E-05	2.19	11	0.482	0.010	6,615	1.43E+00	5,244	9.58E-01	34,345	1.39E+00	37,940	1.08E+00	-
LW44-57.6	0	90	7.5E-05	5.18	11	0.462	0.009	6,486	1.89E+00	4,896	1.21E+00	33,638	1.84E+00	38,207	1.47E+00	-
LW44-57.8	0	90	8.0E-05	7.02	11	0.441	0.009	4,852	1.57E+00	3,670	1.01E+00	24,805	1.50E+00	28,786	1.23E+00	-
LW44-57.9	0	90	7.5E-05	8.05	11	0.423	0.008	4,197	1.33E+00	3,050	8.19E-01	21,594	1.28E+00	24,863	1.03E+00	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #50																
LW44-58.A	0	90	-	-	12	-	-	50	-	10	-	100	-	500	-	-
LW44-58.1	0	90	7.0E-05	0.94	12	0.484	0.010	9,098	2.37E+00	9,720	2.14E+00	47,454	2.31E+00	57,168	1.97E+00	-
LW44-58.2	0	90	8.2E-05	1.17	12	0.462	0.009	16,900	5.36E+00	15,460	4.14E+00	83,899	4.97E+00	98,609	4.15E+00	-
LW44-58.4	0	90	6.3E-05	2.19	12	0.446	0.009	15,178	3.85E+00	12,693	2.72E+00	75,478	3.58E+00	87,323	2.94E+00	-
LW44-58.6	0	90	7.2E-05	5.18	12	0.407	0.008	13,067	4.08E+00	9,970	2.63E+00	64,959	3.78E+00	72,152	2.98E+00	-
LW44-58.8	0	90	7.5E-05	7.02	12	0.362	0.007	11,338	4.10E+00	8,524	2.61E+00	52,648	3.56E+00	62,210	2.98E+00	-
LW44-58.9	0	90	7.5E-05	8.05	12	0.315	0.007	11,773	4.87E+00	8,911	3.11E+00	54,671	4.22E+00	64,730	3.54E+00	-
Exp. #51																
LW44-59A	0	70	-	-	7	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-59.1	0	70	-	-	7	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-59.2	0	70	6.1E-05	0.85	7	1.008	0.036	864	4.94E-02	ND	-	6,682	7.44E-02	568	5.51E-04	9.99E-09
LW44-59.4	0	70	5.7E-05	2.99	7	1.004	0.020	1,449	1.46E-01	29	3.77E-04	8,602	1.65E-01	562	8.59E-04	7.69E-09
LW44-59.6	0	70	9.4E-05	4.85	7	0.999	0.020	1,168	1.91E-01	41	2.31E-03	6,596	2.07E-01	ND	-	6.30E-09
LW44-59.8	0	70	5.1E-05	6.86	7	0.996	0.020	1,062	9.53E-02	43	1.43E-03	5,966	1.03E-01	ND	-	3.03E-09
LW44-59.9	0	70	5.8E-05	7.77	7	0.993	0.020	1,011	1.02E-01	44	1.71E-03	5,467	1.07E-01	ND	-	1.64E-09
LW44-59.10	0	70	5.8E-05	8.07	7	0.991	0.020	1,056	1.08E-01	50	2.28E-03	6,051	1.19E-01	ND	-	4.41E-09
LW44-59.11	0	70	1.3E-04	8.36	7	0.989	0.020	962	2.14E-01	47	4.33E-03	5,122	2.19E-01	ND	-	2.20E-09
Exp. #52																
LW44-60A	0	70	-	-	8	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-60.1	0	70	-	-	8	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-60.2	0	70	5.7E-05	0.85	8	1.008	0.036	279	1.31E-02	93	3.30E-03	3,914	4.07E-02	766	2.02E-03	1.10E-08
LW44-60.4	0	70	5.7E-05	2.99	8	1.006	0.020	407	3.73E-02	178	1.35E-02	3,876	7.34E-02	1,096	8.25E-03	1.44E-08
LW44-60.6	0	70	9.0E-05	4.85	8	1.005	0.020	369	5.23E-02	154	1.78E-02	2,862	8.44E-02	921	9.15E-03	1.28E-08
LW44-60.8	0	70	5.1E-05	6.86	8	1.004	0.020	357	2.87E-02	152	9.97E-03	2,470	4.13E-02	886	4.79E-03	5.03E-09
LW44-60.9	0	70	5.8E-05	7.77	8	1.003	0.020	324	2.90E-02	134	9.68E-03	2,133	4.00E-02	819	4.47E-03	4.43E-09
LW44-60.10	0	70	5.8E-05	8.07	8	1.002	0.020	310	2.75E-02	133	9.63E-03	2,051	3.85E-02	792	4.11E-03	4.37E-09
LW44-60.11	0	70	1.3E-04	8.36	8	1.002	0.020	305	5.91E-02	131	2.07E-02	1,991	8.16E-02	779	8.58E-03	8.99E-09
Exp. #53																
LW44-61A	0	70	-	-	9	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-61.1	0	70	-	-	9	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-61.2	0	70	5.7E-05	0.85	9	1.005	0.036	308	1.47E-02	428	1.94E-02	3,197	3.29E-02	2,217	1.30E-02	7.25E-09
LW44-61.4	0	70	5.7E-05	2.99	9	1.004	0.020	624	5.95E-02	706	5.94E-02	4,071	7.67E-02	4,457	5.44E-02	6.84E-09
LW44-61.6	0	70	8.9E-05	4.85	9	1.001	0.020	630	9.48E-02	739	9.82E-02	3,460	1.02E-01	4,437	8.53E-02	2.98E-09
LW44-61.8	0	70	5.1E-05	6.86	9	0.999	0.020	742	6.44E-02	864	6.57E-02	3,949	6.67E-02	5,099	5.68E-02	9.21E-10
LW44-61.9	0	70	5.8E-05	7.77	9	0.997	0.020	750	7.39E-02	871	7.52E-02	3,931	7.53E-02	5,066	6.39E-02	5.71E-10
LW44-61.10	0	70	5.8E-05	8.07	9	0.996	0.020	725	7.15E-02	846	7.33E-02	3,894	7.48E-02	5,068	6.42E-02	1.32E-09
LW44-61.11	0	70	1.2E-04	8.36	9	0.995	0.020	721	1.52E-01	838	1.55E-01	3,850	1.58E-01	4,910	1.33E-01	2.47E-09
Exp. #54																
LW44-62A	0	70	-	-	10	-	-	<50	-	<25	-	<100	-	<500	-	-

Table A1. SPFT Results for LAWA44 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LW44-62.1	0	70	-	-	10	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-62.2	0	70	5.6E-05	0.85	10	0.501	0.023	389	3.01E-02	476	3.36E-02	2,562	4.06E-02	2,677	2.56E-02	4.22E-09
LW44-62.4	0	70	5.7E-05	2.99	10	0.499	0.010	956	1.89E-01	1,148	1.97E-01	5,184	1.98E-01	6,507	1.66E-01	3.39E-09
LW44-62.6	0	70	9.0E-05	4.85	10	0.495	0.010	908	2.84E-01	1,069	2.92E-01	4,791	2.90E-01	6,148	2.49E-01	2.13E-09
LW44-62.8	0	70	5.1E-05	6.86	10	0.492	0.010	828	1.47E-01	996	1.55E-01	4,342	1.50E-01	5,670	1.30E-01	9.07E-10
LW44-62.9	0	70	5.8E-05	7.77	10	0.490	0.010	814	1.64E-01	980	1.73E-01	4,208	1.64E-01	5,512	1.43E-01	1.20E-10
LW44-62.10	0	70	5.8E-05	8.07	10	0.489	0.010	802	1.62E-01	974	1.72E-01	4,158	1.63E-01	5,490	1.43E-01	3.83E-10
LW44-62.11	0	70	1.3E-04	8.36	10	0.487	0.010	803	3.55E-01	951	3.68E-01	4,202	3.60E-01	5,462	3.11E-01	2.02E-09
Exp. #55																
LW44-63A	0	70	-	-	11	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-63.1	0	70	-	-	11	-	-	<50	-	<25	-	<100	-	<500	-	-
LW44-63.2	0	70	6.6E-05	0.85	11	0.502	0.023	1,066	1.07E-01	1,252	1.08E-01	6,162	1.19E-01	7,137	9.24E-02	4.76E-09
LW44-63.4	0	70	5.7E-05	2.99	11	0.493	0.010	2,942	6.06E-01	2,910	5.10E-01	15,083	5.85E-01	17,977	4.86E-01	-
LW44-63.6	0	70	8.9E-05	4.85	11	0.482	0.010	3,372	1.11E+00	3,432	9.63E-01	17,537	1.09E+00	20,380	8.86E-01	-
LW44-63.8	0	70	5.1E-05	6.86	11	0.470	0.009	3,678	7.12E-01	3,221	5.28E-01	19,165	6.97E-01	21,821	5.55E-01	-
LW44-63.9	0	70	5.7E-05	7.77	11	0.460	0.009	3,546	7.91E-01	3,054	5.77E-01	18,096	7.59E-01	21,037	6.17E-01	-
LW44-63.10	0	70	5.9E-05	8.07	11	0.454	0.009	3,518	8.23E-01	3,054	6.06E-01	19,709	8.67E-01	20,763	6.38E-01	1.76E-08
LW44-63.11	0	70	1.1E-04	8.36	11	0.449	0.009	3,394	1.54E+00	2,871	1.10E+00	17,585	1.50E+00	19,942	1.19E+00	-
Exp. #56																
LW44-64A	0	70	-	-	12	-	-	<50	-	32	-	<100	-	<500	-	-
LW44-64.1	0	70	-	-	12	-	-	<50	-	50	-	<100	-	<500	-	-
LW44-64.2	0	70	5.7E-05	0.85	12	0.505	0.023	2,496	2.21E-01	3,033	2.28E-01	13,523	2.26E-01	16,699	1.95E-01	1.97E-09
LW44-64.4	0	70	5.7E-05	2.99	12	0.483	0.010	7,728	1.63E+00	8,355	1.49E+00	40,528	1.60E+00	47,843	1.34E+00	-
LW44-64.6	0	70	9.1E-05	4.85	12	0.451	0.009	9,100	3.28E+00	8,908	2.70E+00	47,491	3.20E+00	54,462	2.59E+00	-
LW44-64.8	0	70	4.6E-05	6.86	12	0.416	0.008	12,794	2.50E+00	10,711	1.76E+00	65,487	2.39E+00	73,531	1.90E+00	-
LW44-64.9	0	70	5.9E-05	7.77	12	0.387	0.008	9,167	2.47E+00	8,344	1.90E+00	47,554	2.40E+00	53,386	1.90E+00	-
LW44-64.10	0	70	5.3E-05	8.07	12	0.373	0.007	8,519	2.19E+00	8,003	1.74E+00	43,527	2.09E+00	50,790	1.73E+00	-
LW44-64.11	0	70	1.2E-04	8.36	12	0.360	0.007	8,350	5.13E+00	7,645	3.96E+00	43,298	4.97E+00	48,693	3.95E+00	-

[] – μg L^{-1}
Rate – g m^{-2} d^{-1}
IEX Rate – mol m^{-2} s^{-1}

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
<u>LAWB45</u>																
Exp. #1																
LB45-1B	0	40	-	-	7	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-1C	0	40	-	-	7	-	-	<100	-	10	-	<500	-	<500	-	-
LB45-1.1	0	40	4.2E-05	0.73	7	1.004	0.020	531	2.33E-02	14	2.27E-04	1,121	2.67E-02	698	1.83E-03	1.35E-09
LB45-1.2	0	40	4.0E-05	2.08	7	1.003	0.020	285	9.54E-03	11	7.03E-05	536	1.47E-03	(497)	-	-
LB45-1.3	0	40	4.0E-05	2.74	7	1.003	0.020	157	2.95E-03	10	1.13E-05	(292)	-	(357)	-	-
LB45-1.4	0	40	4.0E-05	3.77	7	1.002	0.020	110	5.12E-04	13	1.61E-04	(202)	-	(241)	-	-
LB45-1.5	0	40	3.9E-05	4.91	7	1.002	0.020	ND	5.03E-03	10	-	(162)	-	(235)	-	-
LB45-1.6	0	40	4.0E-05	5.82	7	1.002	0.020	ND	5.23E-03	13	2.08E-04	(120)	-	(163)	-	-
LB45-1.7	0	40	4.0E-05	6.81	7	1.002	0.020	ND	5.18E-03	14	2.12E-04	(116)	-	(145)	-	-
LB45-1.8	0	40	4.0E-05	7.80	7	1.002	0.020	ND	5.20E-03	19	5.19E-04	(110)	-	(125)	-	-
LB45-1.9	0	40	4.0E-05	9.06	7	1.002	0.020	ND	5.21E-03	16	3.79E-04	(92)	-	(124)	-	-
LB45-1.10	0	40	4.0E-05	9.94	7	1.002	0.020	ND	5.22E-03	15	3.25E-04	(77)	-	(114)	-	-
LB45-1.11	0	40	4.0E-05	10.86	7	1.001	0.020	ND	5.15E-03	18	4.55E-04	(80)	-	(116)	-	-
Exp. #2						-										
LB45-2A	0	40	-	-	8	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-2B	0	40	-	-	8	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-2C	0	40	-	-	8	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-2.1	0	40	4.1E-05	0.73	8	1.005	0.020	389	1.53E-02	43	2.07E-03	718	9.16E-03	950	4.07E-03	-
LB45-2.2	0	40	4.0E-05	2.08	8	1.004	0.020	255	7.97E-03	87	4.66E-03	ND	-	873	3.29E-03	-
LB45-2.3	0	40	4.0E-05	2.74	8	1.004	0.020	166	3.46E-03	85	4.64E-03	ND	-	664	1.47E-03	-
LB45-2.4	0	40	4.0E-05	3.77	8	1.004	0.020	136	1.87E-03	79	4.20E-03	ND	-	589	7.90E-04	-
LB45-2.5	0	40	4.0E-05	4.91	8	1.003	0.020	115	7.72E-04	77	4.15E-03	ND	-	501	1.01E-05	-
LB45-2.6	0	40	4.0E-05	5.82	8	1.003	0.020	101	4.12E-05	70	3.68E-03	ND	-	ND	-	-
LB45-2.7	0	40	4.0E-05	6.81	8	1.003	0.020	ND	5.23E-03	70	3.73E-03	ND	-	ND	-	-
LB45-2.8	0	40	4.0E-05	7.80	8	1.003	0.020	ND	5.20E-03	60	3.08E-03	ND	-	ND	-	-
LB45-2.9	0	40	4.0E-05	9.06	8	1.003	0.020	ND	5.16E-03	65	3.38E-03	ND	-	ND	-	-
LB45-2.10	0	40	3.9E-05	9.94	8	1.003	0.020	ND	5.11E-03	61	3.11E-03	ND	-	ND	-	-
LB45-2.11	0	40	3.8E-05	10.86	8	1.003	0.020	ND	4.96E-03	65	3.24E-03	ND	-	ND	-	-
Exp. #3																
LB45-3A	0	40	-	-	9	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-3B	0	40	-	-	9	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-3C	0	40	-	-	9	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-3.1	0	40	3.5E-05	0.73	9	1.007	0.020	206	4.87E-03	109	5.35E-03	ND	-	1,527	8.08E-03	-
LB45-3.2	0	40	3.6E-05	2.08	9	1.006	0.020	267	7.92E-03	197	1.05E-02	ND	-	1,391	7.22E-03	-
LB45-3.3	0	40	3.6E-05	2.74	9	1.006	0.020	285	8.74E-03	223	1.19E-02	ND	-	1,504	8.11E-03	-
LB45-3.4	0	40	3.7E-05	3.77	9	1.006	0.020	285	8.79E-03	235	1.27E-02	ND	-	1,525	8.36E-03	-
LB45-3.5	0	40	3.7E-05	4.91	9	1.005	0.020	272	8.30E-03	229	1.24E-02	ND	-	1,475	8.04E-03	-
LB45-3.6	0	40	3.7E-05	5.82	9	1.005	0.020	264	7.83E-03	216	1.16E-02	ND	-	1,461	7.85E-03	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-3.7	0	40	3.7E-05	6.81	9	1.005	0.020	243	6.83E-03	208	1.12E-02	ND	-	1,333	6.81E-03	-
LB45-3.8	0	40	3.7E-05	7.80	9	1.004	0.020	247	6.96E-03	202	1.08E-02	ND	-	1,376	7.13E-03	-
LB45-3.9	0	40	2.9E-05	9.06	9	1.004	0.020	260	6.03E-03	226	9.61E-03	ND	-	1,445	6.10E-03	-
LB45-3.10	0	40	6.2E-06	9.94	9	1.004	0.020	314	1.72E-03	262	2.40E-03	ND	-	1,720	1.68E-03	-
LB45-3.11	0	40	3.9E-05	10.86	9	1.003	0.020	356	1.28E-02	289	1.66E-02	614	4.55E-03	1,952	1.25E-02	-
Exp. #4																
LB45-4A	0	40	-	-	10	-	-	<100	-	10	-	<500	-	<500	-	-
LB45-4B	0	40	-	-	10	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-4C	0	40	-	-	10	-	-	<100	-	<10	-	<500	-	<500	-	-
LB45-4.1	0	40	4.0E-05	0.73	10	0.509	0.013	228	1.06E-02	221	2.06E-02	ND	-	1,494	1.40E-02	-
LB45-4.2	0	40	3.9E-05	2.08	10	0.508	0.010	346	2.49E-02	319	3.69E-02	ND	-	1,935	2.48E-02	-
LB45-4.3	0	40	4.0E-05	2.74	10	0.508	0.010	345	2.49E-02	289	3.36E-02	ND	-	2,026	2.66E-02	-
LB45-4.4	0	40	3.9E-05	3.77	10	0.507	0.010	343	2.45E-02	291	3.35E-02	ND	-	1,986	2.56E-02	-
LB45-4.5	0	40	4.0E-05	4.91	10	0.507	0.010	344	2.50E-02	298	3.49E-02	ND	-	1,985	2.61E-02	-
LB45-4.6	0	40	3.9E-05	5.82	10	0.506	0.010	338	2.39E-02	294	3.37E-02	ND	-	1,898	2.41E-02	-
LB45-4.7	0	40	3.9E-05	6.81	10	0.506	0.010	338	2.39E-02	291	3.34E-02	ND	-	1,901	2.41E-02	-
LB45-4.8	0	40	4.0E-05	7.80	10	0.505	0.010	342	2.47E-02	303	3.55E-02	ND	-	1,899	2.45E-02	-
LB45-4.9	0	40	3.9E-05	9.06	10	0.505	0.010	336	2.40E-02	297	3.44E-02	ND	-	1,874	2.39E-02	-
LB45-4.10	0	40	4.0E-05	9.94	10	0.504	0.010	328	2.35E-02	283	3.32E-02	ND	-	1,837	2.36E-02	-
LB45-4.11	0	40	3.9E-05	10.86	10	0.504	0.010	308	2.09E-02	278	3.17E-02	1,210	5.65E-02	1,721	2.10E-02	-
Exp. #5																
LB45-5A	0	40	-	-	11	-	-	<100	-	12	-	<500	-	<500	-	-
LB45-5B	0	40	-	-	11	-	-	<100	-	11	-	<500	-	<500	-	-
LB45-5C	0	40	-	-	11	-	-	<100	-	13	-	<500	-	<500	-	-
LB45-5.1	0	40	3.8E-05	0.73	11	0.504	0.013	330	1.80E-02	366	3.29E-02	626	7.85E-03	2,210	2.30E-02	-
LB45-5.2	0	40	3.8E-05	2.08	11	0.503	0.010	784	6.68E-02	762	8.65E-02	1,127	4.87E-02	4,539	6.76E-02	-
LB45-5.3	0	40	4.0E-05	2.74	11	0.501	0.010	875	8.13E-02	807	9.85E-02	1,213	5.94E-02	4,969	8.03E-02	-
LB45-5.4	0	40	4.0E-05	3.77	11	0.500	0.010	917	8.53E-02	832	1.01E-01	1,235	6.10E-02	5,093	8.21E-02	-
LB45-5.5	0	40	4.0E-05	4.91	11	0.499	0.010	909	8.55E-02	826	1.02E-01	1,213	5.98E-02	5,073	8.27E-02	-
LB45-5.6	0	40	4.0E-05	5.82	11	0.497	0.010	899	8.43E-02	813	9.98E-02	1,231	6.13E-02	5,223	8.54E-02	-
LB45-5.7	0	40	4.0E-05	6.81	11	0.496	0.010	895	8.40E-02	809	9.94E-02	1,222	6.06E-02	4,991	8.12E-02	-
LB45-5.8	0	40	4.0E-05	7.80	11	0.494	0.010	898	8.41E-02	815	9.99E-02	1,233	6.13E-02	5,001	8.12E-02	-
LB45-5.9	0	40	2.1E-05	9.06	11	0.493	0.010	916	4.57E-02	830	5.42E-02	1,249	3.34E-02	5,098	4.41E-02	-
LB45-5.10	0	40	4.0E-05	9.94	11	0.492	0.010	919	8.65E-02	840	1.03E-01	1,274	6.50E-02	5,744	9.49E-02	-
LB45-5.11	0	40	4.0E-05	10.86	11	0.491	0.010	899	8.43E-02	802	9.85E-02	1,237	6.18E-02	5,456	8.95E-02	-
Exp. #6																
LB45-6A	0	40	-	-	12	-	-	<100	-	<10	-	<500	-	516	-	-
LB45-6B	0	40	-	-	12	-	-	<100	-	<10	-	<500	-	529	-	-
LB45-6C	0	40	-	-	12	-	-	<100	-	<10	-	<500	-	524	-	-
LB45-6.1	0	40	3.9E-05	0.73	12	0.509	0.013	503	3.19E-02	560	5.13E-02	976	2.99E-02	3,388	3.88E-02	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-6.2	0	40	4.0E-05	2.08	12	0.507	0.010	922	8.47E-02	897	1.08E-01	1,426	7.59E-02	5,292	8.42E-02	-
LB45-6.3	0	40	4.0E-05	2.74	12	0.506	0.010	978	9.03E-02	931	1.12E-01	1,438	7.67E-02	5,599	8.94E-02	-
LB45-6.4	0	40	3.9E-05	3.77	12	0.504	0.010	966	8.81E-02	906	1.08E-01	1,447	7.66E-02	5,420	8.54E-02	-
LB45-6.5	0	40	4.0E-05	4.91	12	0.503	0.010	962	8.95E-02	898	1.09E-01	1,511	8.34E-02	5,418	8.71E-02	-
LB45-6.6	0	40	4.0E-05	5.82	12	0.501	0.010	963	8.97E-02	913	1.11E-01	1,454	7.88E-02	5,419	8.72E-02	-
LB45-6.7	0	40	3.9E-05	6.81	12	0.500	0.010	944	8.68E-02	884	1.06E-01	1,517	8.31E-02	5,572	8.89E-02	-
LB45-6.8	0	40	4.0E-05	7.80	12	0.498	0.010	912	8.42E-02	858	1.04E-01	1,451	7.83E-02	5,149	8.22E-02	-
LB45-6.9	0	40	4.0E-05	9.06	12	0.497	0.010	898	8.28E-02	849	1.03E-01	1,466	7.97E-02	5,132	8.19E-02	-
LB45-6.10	0	40	3.9E-05	9.94	12	0.495	0.010	932	8.55E-02	883	1.06E-01	1,464	7.87E-02	5,282	8.37E-02	-
LB45-6.11	0	40	3.8E-05	10.86	12	0.494	0.010	988	8.81E-02	952	1.10E-01	1,514	8.00E-02	5,896	9.13E-02	-
Exp. #7																
LB45-7.0	0	90	-	-	7	-	-	<100	-	23	-	<5000	-	<5000	-	-
LB45-7.1	0	90	-	-	7	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-7.2	0	90	-	-	7	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-7.3	0	90	1.6E-05	2.05	7	0.754	0.015	2,404	6.51E-02	290	9.20E-03	ND	-	ND	-	-
LB45-7.4	0	90	4.5E-05	2.87	7	0.749	0.015	4,369	3.32E-01	104	8.25E-03	5,947	-	ND	-	-
LB45-7.5	0	90	5.4E-05	3.92	7	0.743	0.015	2,629	2.39E-01	101	9.69E-03	ND	-	ND	-	-
LB45-7.6	0	90	5.7E-05	4.89	7	0.738	0.015	2,043	1.95E-01	103	1.05E-02	ND	-	ND	-	-
LB45-7.7	0	90	5.3E-05	5.90	7	0.734	0.015	1,915	1.70E-01	85	7.80E-03	ND	-	ND	-	-
LB45-7.8	0	90	5.5E-05	6.90	7	0.730	0.015	1,704	1.58E-01	99	9.85E-03	ND	-	ND	-	-
LB45-7.9	0	90	5.5E-05	8.16	7	0.726	0.015	1,638	1.50E-01	72	6.65E-03	ND	-	ND	-	-
LB45-7.10	0	90	5.0E-05	9.10	7	0.722	0.014	1,794	1.51E-01	87	7.67E-03	ND	-	ND	-	-
Exp. #8																
LB45-8.0	0	90	-	-	8	-	-	<100	-	10	-	<5000	-	<5000	-	-
LB45-8.1	0	90	-	-	8	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-8.2	0	90	-	-	8	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-8.3	0	90	4.3E-05	2.05	8	0.749	0.015	1,135	7.72E-02	553	4.79E-02	ND	-	5,344	4.39E-03	-
LB45-8.4	0	90	4.4E-05	2.87	8	0.747	0.015	1,214	8.47E-02	764	6.77E-02	ND	-	6,413	1.84E-02	-
LB45-8.5	0	90	3.9E-05	3.92	8	0.745	0.015	1,153	7.26E-02	791	6.37E-02	ND	-	6,249	1.48E-02	-
LB45-8.6	0	90	5.2E-05	4.89	8	0.743	0.015	1,081	9.00E-02	728	7.78E-02	ND	-	5,887	1.39E-02	-
LB45-8.7	0	90	5.8E-05	5.90	8	0.741	0.015	1,003	9.22E-02	657	7.81E-02	ND	-	5,468	8.18E-03	-
LB45-8.8	0	90	5.1E-05	6.90	8	0.738	0.015	964	7.78E-02	674	7.07E-02	ND	-	5,285	4.39E-03	-
LB45-8.9	0	90	5.4E-05	8.16	8	0.736	0.015	922	7.88E-02	648	7.23E-02	ND	-	5,088	1.44E-03	-
LB45-8.10	0	90	5.0E-05	9.10	8	0.734	0.015	903	7.11E-02	615	6.33E-02	ND	-	ND	-	-
Exp. #9																
LB45-9.0	0	90	-	-	9	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-9.1	0	90	-	-	9	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-9.2	0	90	-	-	9	-	-	<100	-	17	-	<5000	-	<5000	-	-
LB45-9.3	0	90	5.6E-05	2.05	9	0.500	-	1,409	1.92E-01	1,057	1.82E-01	ND	-	7,720	6.85E-02	-
LB45-9.4	0	90	5.0E-05	2.87	9	0.497	0.010	1,708	2.09E-01	1,278	1.94E-01	ND	-	8,916	8.71E-02	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-9.5	0	90	5.7E-05	3.92	9	0.493	0.010	1,773	2.53E-01	1,349	2.39E-01	ND	-	9,256	1.10E-01	-
LB45-9.6	0	90	5.5E-05	4.89	9	0.489	0.010	1,762	2.42E-01	1,322	2.25E-01	ND	-	9,238	1.06E-01	-
LB45-9.7	0	90	5.1E-05	5.90	9	0.486	0.010	1,669	2.15E-01	1,278	2.04E-01	ND	-	8,902	9.14E-02	-
LB45-9.8	0	90	5.3E-05	6.90	9	0.482	0.010	1,586	2.14E-01	1,225	2.07E-01	ND	-	8,481	8.60E-02	-
LB45-9.9	0	90	5.5E-05	8.16	9	0.478	0.010	1,619	2.29E-01	1,232	2.17E-01	ND	-	8,692	9.54E-02	-
LB45-9.10	0	90	4.8E-05	9.10	9	0.475	0.010	1,675	2.09E-01	1,312	2.03E-01	ND	-	8,996	9.06E-02	-
Exp. #10																
LB45-10.0	0	90	-	-	10	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-10.1	0	90	-	-	10	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-10.2	0	90	-	-	10	-	-	<100	-	<10	-	<5000	-	<5000	-	-
LB45-10.3	0	90	5.4E-05	2.05	10	0.497	0.010	2,487	3.38E-01	1,504	2.50E-01	(3,271)	-	11,068	1.47E-01	-
LB45-10.4	0	90	5.3E-05	2.87	10	0.490	0.010	3,922	5.41E-01	1,946	3.24E-01	5,113	1.27E-02	15,991	2.66E-01	-
LB45-10.5	0	90	2.0E-05	3.92	10	0.486	0.010	4,550	2.41E-01	1,991	1.27E-01	6,040	4.48E-02	18,034	1.21E-01	-
LB45-10.6	0	90	5.1E-05	4.89	10	0.478	0.010	4,908	6.60E-01	1,913	3.09E-01	6,513	1.65E-01	18,769	3.24E-01	-
LB45-10.7	0	90	5.5E-05	5.90	10	0.469	0.009	4,066	6.00E-01	1,750	3.11E-01	5,422	5.07E-02	16,471	2.97E-01	-
LB45-10.8	0	90	5.6E-05	6.90	10	0.461	0.009	3,677	5.64E-01	1,644	3.04E-01	(4,628)	-	15,209	2.76E-01	-
LB45-10.9	0	90	5.5E-05	8.16	10	0.451	0.009	3,627	5.59E-01	1,535	2.85E-01	(4,722)	-	14,851	2.67E-01	-
LB45-10.10	0	90	4.9E-05	9.10	10	0.444	0.009	3,616	5.03E-01	1,708	2.87E-01	(4,584)	-	15,551	2.59E-01	-
Exp. #11																
LB45-11.0	0	90	-	-	11	-	-	<100	-	37	-	<5000	-	<5000	-	-
LB45-11.1	0	90	-	-	11	-	-	<100	-	75	-	<5000	-	<5000	-	-
LB45-11.2	0	90	-	-	11	-	-	<100	-	45	-	<5000	-	<5000	-	-
LB45-11.3	0	90	5.3E-05	2.05	11	0.495	0.010	4,670	6.31E-01	2,541	4.06E-01	6,009	1.11E-01	21,378	3.87E-01	-
LB45-11.4	0	90	5.6E-05	2.87	11	0.484	0.010	6,639	9.82E-01	2,915	5.08E-01	8,672	4.38E-01	27,660	5.83E-01	-
LB45-11.5	0	90	5.7E-05	3.92	11	0.469	0.009	6,813	1.06E+00	2,703	4.93E-01	8,546	4.44E-01	27,245	6.00E-01	-
LB45-11.6	0	90	5.4E-05	4.89	11	0.455	0.009	6,456	9.68E-01	2,448	4.31E-01	8,291	3.98E-01	26,007	5.48E-01	-
LB45-11.7	0	90	5.6E-05	5.90	11	0.442	0.009	5,788	9.33E-01	2,107	3.98E-01	7,367	3.08E-01	23,146	5.10E-01	-
LB45-11.8	0	90	5.3E-05	6.90	11	0.430	0.009	5,455	8.52E-01	1,997	3.65E-01	6,790	2.26E-01	21,945	4.62E-01	-
LB45-11.9	0	90	5.1E-05	8.16	11	0.417	0.008	5,359	8.38E-01	1,934	3.54E-01	6,968	2.49E-01	21,534	4.51E-01	-
LB45-11.10	0	90	5.2E-05	9.10	11	0.406	0.008	5,086	8.32E-01	1,965	3.77E-01	6,407	1.87E-01	20,733	4.50E-01	-
Exp. #12																
LB45-12.0	0	90	-	-	12	-	-	<100	-	139	-	<5000	-	<5000	-	-
LB45-12.1	0	90	-	-	12	-	-	<100	-	278	-	<5000	-	<5000	-	-
LB45-12.2	0	90	-	-	12	-	-	<100	-	296	-	<5000	-	<5000	-	-
LB45-12.3	0	90	5.6E-05	2.05	12	0.496	0.010	3,502	4.95E-01	2,918	4.61E-01	5,324	3.75E-02	18,782	3.44E-01	-
LB45-12.4	0	90	5.5E-05	2.87	12	0.488	0.010	4,583	6.56E-01	3,523	5.68E-01	6,709	1.99E-01	22,616	4.41E-01	-
LB45-12.5	0	90	2.5E-05	3.92	12	0.480	0.010	7,274	4.92E-01	5,036	3.89E-01	9,993	2.72E-01	33,834	3.39E-01	-
LB45-12.6	0	90	5.2E-05	4.89	12	0.468	0.009	6,937	9.75E-01	4,305	6.85E-01	9,494	5.09E-01	30,979	6.35E-01	-
LB45-12.7	0	90	5.3E-05	5.90	12	0.454	0.009	6,977	1.04E+00	3,858	6.50E-01	9,227	5.10E-01	29,953	6.49E-01	-
LB45-12.8	0	90	5.8E-05	6.90	12	0.438	0.009	7,522	1.26E+00	3,902	7.34E-01	9,830	6.51E-01	31,350	7.65E-01	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-12.9	0	90	5.1E-05	8.16	12	0.420	0.009	7,384	1.13E+00	3,795	6.54E-01	9,533	5.61E-01	30,855	6.89E-01	-
LB45-12.10	0	90	5.0E-05	9.10	12	0.405	0.008	7,280	1.15E+00	3,735	6.60E-01	9,116	5.23E-01	30,271	6.92E-01	-
Exp. #13																
LB45-13A	8.97E+02	23	-	-	9	-	-	<25	-	<75	-	<300	-	<1500	-	-
LB45-13B	8.97E+02	23	-	-	9	-	-	<25	-	<75	-	<300	-	<1500	-	-
LB45-13C	8.97E+02	23	-	-	9	-	-	<25	-	<75	-	<300	-	<1500	-	-
LB45-13.4	8.97E+02	23	9.8E-06	7.12	9	2.006	0.032	515	3.93E-03	325	2.37E-03	720	2.68E-03	2,506	1.38E-03	-
LB45-13.8	8.97E+02	23	9.6E-06	14.25	9	2.005	0.040	465	2.75E-03	323	1.83E-03	596	1.47E-03	2,306	8.62E-04	-
LB45-13.12	8.97E+02	23	9.5E-06	22.22	9	2.005	0.040	532	3.14E-03	472	2.90E-03	641	1.68E-03	2,921	1.51E-03	-
LB45-13.16	8.97E+02	23	9.5E-06	33.09	9	2.005	0.040	523	3.07E-03	439	2.65E-03	694	1.93E-03	2,864	1.44E-03	-
LB45-13.20	8.97E+02	23	9.5E-06	42.48	9	2.004	0.040	461	2.69E-03	355	2.03E-03	607	1.50E-03	2,430	9.81E-04	-
LB45-13.24	8.97E+02	23	1.1E-05	52.10	9	2.004	0.040	392	2.61E-03	311	1.98E-03	492	1.08E-03	2,061	6.82E-04	-
LB45-13.28	8.97E+02	23	9.7E-06	68.08	9	2.003	0.040	341	2.00E-03	316	1.79E-03	419	5.95E-04	1,970	5.08E-04	-
LB45-13.32	8.97E+02	23	9.9E-06	86.08	9	2.003	0.040	369	2.21E-03	307	1.76E-03	438	7.05E-04	2,010	5.61E-04	-
LB45-13.34	8.97E+02	23	1.0E-05	93.15	9	2.002	0.040	351	2.12E-03	292	1.66E-03	440	7.25E-04	1,948	4.99E-04	-
LB45-13.35	8.97E+02	23	9.7E-06	96.01	9	2.002	0.040	374	2.22E-03	360	2.13E-03	464	8.26E-04	2,196	7.57E-04	-
Exp. #14																
LB45-14A	1.51E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	16,485	-	-
LB45-14B	1.51E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	16,890	-	-
LB45-14C	1.51E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	17,003	-	-
LB45-14.4	1.51E+04	23	9.8E-06	7.12	9	2.002	0.032	377	2.84E-03	96	1.96E-04	515	1.38E-03	17,725	1.29E-03	-
LB45-14.8	1.51E+04	23	9.6E-06	14.25	9	2.002	0.040	332	1.91E-03	87	8.73E-05	434	6.66E-04	17,717	9.88E-04	-
LB45-14.12	1.51E+04	23	9.4E-06	22.22	9	2.001	0.040	362	2.07E-03	192	8.48E-04	465	8.06E-04	19,086	2.41E-03	-
LB45-14.16	1.51E+04	23	9.5E-06	33.09	9	2.001	0.040	340	1.95E-03	190	8.41E-04	466	8.14E-04	18,936	2.27E-03	-
LB45-14.20	1.51E+04	23	9.4E-06	42.48	9	2.001	0.040	330	1.88E-03	131	4.07E-04	368	3.32E-04	17,956	1.23E-03	-
LB45-14.24	1.51E+04	23	1.1E-05	52.10	9	2.000	0.040	294	1.88E-03	110	2.86E-04	354	2.99E-04	16,837	5.34E-05	-
LB45-14.28	1.51E+04	23	9.5E-06	68.08	9	2.000	0.040	260	1.46E-03	94	1.41E-04	374	3.68E-04	17,407	6.55E-04	-
LB45-14.32	1.51E+04	23	9.9E-06	86.08	9	2.000	0.040	269	1.57E-03	98	1.74E-04	361	3.13E-04	17,408	6.81E-04	-
LB45-14.34	1.51E+04	23	9.7E-06	93.15	9	1.999	0.040	223	1.25E-03	ND	-	323	1.16E-04	25,967	9.92E-03	-
LB45-14.35	1.51E+04	23	9.7E-06	96.01	9	1.999	0.040	229	1.29E-03	94	1.43E-04	323	1.17E-04	21,097	4.66E-03	-
Exp. #15																
LB45-15A	3.01E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	33,259	-	-
LB45-15B	3.01E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	33,415	-	-
LB45-15C	3.01E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	33,339	-	-
LB45-15.4	3.01E+04	23	9.8E-06	7.12	9	2.003	0.032	296	2.17E-03	ND	-	415	7.32E-04	33,599	3.60E-04	-
LB45-15.8	3.01E+04	23	9.6E-06	14.25	9	2.003	0.040	222	1.24E-03	ND	-	332	1.57E-04	34,277	1.01E-03	-
LB45-15.12	3.01E+04	23	9.4E-06	22.22	9	2.002	0.040	259	1.44E-03	101	1.89E-04	359	2.87E-04	35,368	2.14E-03	-
LB45-15.16	3.01E+04	23	9.4E-06	33.09	9	2.002	0.040	273	1.53E-03	106	2.25E-04	390	4.42E-04	34,034	7.34E-04	-
LB45-15.20	3.01E+04	23	9.5E-06	42.48	9	2.002	0.040	232	1.29E-03	ND	-	ND	-	33,969	6.72E-04	-
LB45-15.24	3.01E+04	23	6.2E-06	52.10	9	2.002	0.040	188	6.54E-04	ND	-	ND	-	33,837	3.44E-04	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-15.28	3.01E+04	23	9.5E-06	68.08	9	2.002	0.040	132	6.61E-04	ND	-	ND	-	34,562	1.29E-03	-
LB45-15.32	3.01E+04	23	9.8E-06	86.08	9	2.001	0.040	136	7.09E-04	ND	-	ND	-	35,083	1.91E-03	-
LB45-15.34	3.01E+04	23	9.7E-06	93.15	9	2.001	0.040	95	4.39E-04	ND	-	ND	-	44,644	1.22E-02	-
LB45-15.35	3.01E+04	23	9.7E-06	96.01	9	2.001	0.040	104	5.00E-04	ND	-	ND	-	37,721	4.75E-03	-
Exp. #16																
LB45-16A	4.60E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	50,267	-	-
LB45-16B	4.60E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	50,834	-	-
LB45-16C	4.60E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	51,232	-	-
LB45-16.4	4.60E+04	23	9.8E-06	7.12	9	1.999	0.032	229	1.64E-03	ND	-	376	-	53,035	3.12E-03	-
LB45-16.8	4.60E+04	23	9.6E-06	14.25	9	1.999	0.040	138	7.06E-04	ND	-	ND	-	51,930	1.23E-03	-
LB45-16.12	4.60E+04	23	9.4E-06	22.22	9	1.999	0.040	129	6.43E-04	ND	-	ND	-	53,608	2.99E-03	-
LB45-16.16	4.60E+04	23	9.4E-06	33.09	9	1.999	0.040	140	7.04E-04	ND	-	ND	-	51,552	8.13E-04	-
LB45-16.20	4.60E+04	23	9.5E-06	42.48	9	1.998	0.040	118	5.80E-04	ND	-	ND	-	50,058	-	-
LB45-16.24	4.60E+04	23	1.1E-05	52.10	9	1.998	0.040	71	3.21E-04	ND	-	ND	-	51,174	4.75E-04	-
LB45-16.28	4.60E+04	23	9.4E-06	68.08	9	1.998	0.040	46	1.30E-04	ND	-	ND	-	48,606	-	-
LB45-16.32	4.60E+04	23	9.8E-06	86.08	9	1.998	0.040	35	6.42E-05	ND	-	ND	-	52,713	2.11E-03	-
LB45-16.34	4.60E+04	23	9.6E-06	93.15	9	1.998	0.040	30	3.17E-05	ND	-	ND	-	42,823	-	-
LB45-16.35	4.60E+04	23	9.8E-06	96.01	9	1.998	0.040	38	8.17E-05	ND	-	ND	-	47,424	-	-
Exp. #17																
LB45-17A	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	66,580	-	-
LB45-17B	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	67,154	-	-
LB45-17C	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	72,215	-	-
LB45-17.4	6.04E+04	23	9.7E-06	7.12	9	2.005	0.032	179	1.23E-03	ND	-	302	-	67,752	-	-
LB45-17.8	6.04E+04	23	9.8E-06	14.25	9	2.005	0.040	99	4.73E-04	ND	-	ND	-	66,233	-	-
LB45-17.12	6.04E+04	23	9.7E-06	22.22	9	2.005	0.040	87	3.92E-04	ND	-	ND	-	73,018	4.72E-03	-
LB45-17.16	6.04E+04	23	9.5E-06	33.09	9	2.005	0.040	82	3.54E-04	ND	-	ND	-	68,361	-	-
LB45-17.20	6.04E+04	23	9.6E-06	42.48	9	2.005	0.040	62	2.29E-04	ND	-	ND	-	64,796	-	-
LB45-17.24	6.04E+04	23	1.1E-05	52.10	9	2.005	0.040	35	6.80E-05	ND	-	ND	-	72,839	5.10E-03	-
LB45-17.28	6.04E+04	23	9.5E-06	68.08	9	2.005	0.040	ND	1.49E-04	ND	-	ND	-	65,809	-	-
LB45-17.32	6.04E+04	23	9.8E-06	86.08	9	2.004	0.040	ND	1.59E-04	ND	-	ND	-	65,110	-	-
LB45-17.34	6.04E+04	23	9.7E-06	93.15	9	2.004	0.040	ND	1.58E-04	ND	-	ND	-	59,263	-	-
LB45-17.35	6.04E+04	23	9.7E-06	96.01	9	2.004	0.040	ND	1.58E-04	ND	-	ND	-	64,366	-	-
Exp. #18																
LB45-18A	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	52,429	-	-
LB45-18B	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	59,118	-	-
LB45-18C	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	67,153	-	-
LB45-18.4	5.24E+04	23	9.9E-06	7.12	9	2.014	0.032	169	1.16E-03	ND	-	302	1.07E-05	80,462	2.89E-02	-
LB45-18.8	5.24E+04	23	9.7E-06	14.25	9	2.014	0.040	95	4.40E-04	ND	-	ND	-	82,510	2.47E-02	-
LB45-18.12	5.24E+04	23	9.5E-06	22.22	9	2.014	0.040	69	2.74E-04	ND	-	ND	-	87,955	3.00E-02	-
LB45-18.16	5.24E+04	23	9.6E-06	33.09	9	2.014	0.040	48	1.44E-04	ND	-	ND	-	84,683	2.68E-02	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-18.20	5.24E+04	23	9.6E-06	42.48	9	2.014	0.040	34	5.54E-05	ND	-	ND	-	83,648	2.55E-02	-
LB45-18.24	5.24E+04	23	1.1E-05	52.10	9	2.014	0.040	ND	1.78E-04	ND	-	ND	-	83,189	2.88E-02	-
LB45-18.28	5.24E+04	23	9.7E-06	68.08	9	2.014	0.040	ND	1.57E-04	ND	-	ND	-	77,066	1.89E-02	-
LB45-18.32	5.24E+04	23	9.9E-06	86.08	9	2.014	0.040	ND	1.60E-04	ND	-	ND	-	85,851	2.87E-02	-
LB45-18.34	5.24E+04	23	9.7E-06	93.15	9	2.014	0.040	ND	1.56E-04	ND	-	ND	-	76,518	1.82E-02	-
LB45-18.35	5.24E+04	23	9.8E-06	96.01	9	2.013	0.040	ND	1.59E-04	ND	-	ND	-	80,466	2.27E-02	-
Exp. #19																
LB45-19.0	0	23	-	-	7	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-19.1	0	23	-	-	7	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-19.4	0	23	8.8E-06	7.07	7	1.007	0.020	325	3.16E-03	ND	-	673	5.22E-03	ND	-	8.23E-10
LB45-19.5	0	23	9.0E-06	9.03	7	1.006	0.020	231	2.10E-03	ND	-	464	3.36E-03	ND	-	5.02E-10
LB45-19.7	0	23	9.2E-06	16.97	7	1.006	0.020	114	7.56E-04	ND	-	210	1.04E-03	ND	-	1.12E-10
LB45-19.9	0	23	1.0E-05	28.88	7	1.006	0.020	83	4.39E-04	ND	-	174	7.86E-04	ND	-	1.38E-10
LB45-19.10	0	23	8.2E-06	33.88	7	1.006	0.020	68	1.87E-04	ND	-	133	2.83E-04	ND	-	3.81E-11
LB45-19.11	0	23	5.1E-07	37.99	7	1.006	0.020	ND	2.37E-05	ND	-	ND	3.58E-05	ND	-	4.87E-12
LB45-19.12	0	23	9.6E-06	40.86	7	1.006	0.020	96	5.70E-04	ND	-	195	9.41E-04	ND	-	1.48E-10
LB45-19.13	0	23	8.9E-06	41.90	7	1.006	0.020	77	3.06E-04	ND	-	167	6.12E-04	ND	-	1.22E-10
Exp. #20																
LB45-20.0	0	23	-	-	8	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-20.1	0	23	-	-	8	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-20.4	0	23	9.8E-06	7.07	8	1.003	0.020	192	1.81E-03	ND	-	442	3.48E-03	ND	-	6.66E-10
LB45-20.5	0	23	9.6E-06	9.03	8	1.003	0.020	141	1.13E-03	ND	-	302	2.00E-03	ND	-	3.50E-10
LB45-20.7	0	23	9.8E-06	16.97	8	1.003	0.020	76	3.31E-04	ND	-	152	5.28E-04	ND	-	7.86E-11
LB45-20.9	0	23	1.1E-05	28.88	8	1.003	0.020	ND	6.83E-04	ND	-	ND	-	ND	-	-
LB45-20.10	0	23	9.7E-06	33.88	8	1.002	0.020	ND	6.29E-04	ND	-	ND	-	ND	-	-
LB45-20.11	0	23	1.0E-05	37.99	8	1.002	0.020	ND	6.68E-04	ND	-	ND	-	ND	-	-
LB45-20.12	0	23	1.0E-05	40.86	8	1.002	0.020	ND	6.49E-04	ND	-	ND	-	ND	-	-
LB45-20.13	0	23	9.3E-06	41.90	8	1.002	0.020	ND	6.05E-04	ND	-	ND	-	ND	-	-
Exp. #21																
LB45-21.0	0	23	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-21.1	0	23	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-21.4	0	23	9.6E-06	7.07	9	1.004	0.020	227	2.21E-03	140	1.33E-03	438	3.36E-03	1,073	1.23E-03	4.60E-10
LB45-21.5	0	23	9.8E-06	9.03	9	1.004	0.020	249	2.53E-03	164	1.71E-03	419	3.23E-03	1,210	1.55E-03	2.80E-10
LB45-21.7	0	23	9.9E-06	16.97	9	1.003	0.020	242	2.48E-03	167	1.78E-03	364	2.71E-03	1,224	1.60E-03	9.26E-11
LB45-21.9	0	23	1.0E-05	28.88	9	1.003	0.020	178	1.72E-03	196	2.33E-03	269	1.81E-03	1,083	1.35E-03	3.66E-11
LB45-21.10	0	23	9.6E-06	33.88	9	1.003	0.020	260	2.63E-03	265	3.17E-03	388	2.87E-03	1,575	2.30E-03	9.46E-11
LB45-21.11	0	23	6.9E-06	37.99	9	1.002	0.020	271	1.99E-03	253	2.16E-03	404	2.17E-03	1,573	1.65E-03	7.45E-11
LB45-21.12	0	23	6.5E-06	40.86	9	1.002	0.020	287	2.02E-03	232	1.83E-03	428	2.22E-03	1,665	1.70E-03	8.04E-11
LB45-21.13	0	23	1.4E-05	41.90	9	1.002	0.020	281	4.20E-03	251	4.31E-03	425	4.70E-03	1,610	3.45E-03	1.97E-10
Exp. #22																

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-22.0	0	23	-	-	10	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-22.1	0	23	-	-	10	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-22.4	0	23	9.7E-06	7.07	10	0.508	0.013	249	3.93E-03	257	4.83E-03	410	4.88E-03	1,534	3.50E-03	3.79E-10
LB45-22.5	0	23	9.8E-06	9.03	10	0.507	0.010	292	6.08E-03	273	6.62E-03	462	7.22E-03	1,694	5.14E-03	4.56E-10
LB45-22.7	0	23	9.9E-06	16.97	10	0.507	0.010	239	4.79E-03	205	4.66E-03	365	5.35E-03	1,296	3.46E-03	2.24E-10
LB45-22.9	0	23	1.0E-05	28.88	10	0.507	0.010	266	5.79E-03	283	7.40E-03	379	5.96E-03	1,753	5.77E-03	6.58E-11
LB45-22.10	0	23	9.0E-06	33.88	10	0.507	0.010	331	6.52E-03	310	7.15E-03	453	6.51E-03	2,064	6.23E-03	-
LB45-22.11	0	23	1.0E-05	37.99	10	0.506	0.010	314	6.93E-03	303	7.84E-03	471	7.76E-03	1,844	6.05E-03	3.32E-10
LB45-22.12	0	23	1.0E-05	40.86	10	0.506	0.010	292	6.21E-03	256	6.27E-03	431	6.76E-03	1,656	5.09E-03	2.20E-10
LB45-22.13	0	23	9.1E-06	41.90	10	0.506	0.010	271	5.19E-03	231	5.04E-03	390	5.42E-03	1,516	4.10E-03	9.16E-11
Exp. #23																
LB45-23.0	0	23	-	-	11	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-23.1	0	23	-	-	11	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-23.4	0	23	9.6E-06	7.07	11	0.505	0.013	452	7.90E-03	478	9.94E-03	724	9.74E-03	2,943	8.22E-03	7.38E-10
LB45-23.5	0	23	9.8E-06	9.03	11	0.504	0.010	588	1.37E-02	574	1.58E-02	869	1.56E-02	3,623	1.36E-02	7.42E-10
LB45-23.7	0	23	9.9E-06	16.97	11	0.504	0.010	515	1.19E-02	466	1.26E-02	804	1.43E-02	2,848	1.03E-02	9.61E-10
LB45-23.9	0	23	1.0E-05	28.88	11	0.503	0.010	602	1.48E-02	588	1.70E-02	885	1.67E-02	3,783	1.51E-02	7.68E-10
LB45-23.10	0	23	9.6E-06	33.88	11	0.502	0.010	908	2.14E-02	823	2.28E-02	1,217	2.21E-02	5,587	2.17E-02	2.95E-10
LB45-23.11	0	23	1.0E-05	37.99	11	0.500	0.010	901	2.25E-02	798	2.34E-02	1,376	2.69E-02	5,521	2.28E-02	1.73E-09
LB45-23.12	0	23	9.9E-06	40.86	11	0.499	0.010	848	2.06E-02	750	2.14E-02	1,275	2.42E-02	5,094	2.04E-02	1.41E-09
LB45-23.13	0	23	9.1E-06	41.90	11	0.499	0.010	800	1.79E-02	720	1.89E-02	1,151	2.00E-02	4,746	1.74E-02	8.13E-10
Exp. #24																
LB45-24.0	0	23	-	-	12	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-24.1	0	23	-	-	12	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-24.4	0	23	1.0E-05	7.07	12	0.503	0.013	746	1.45E-02	791	1.82E-02	1,157	1.75E-02	5,323	1.72E-02	1.20E-09
LB45-24.5	0	23	1.1E-05	9.03	12	0.502	0.010	966	2.52E-02	967	2.98E-02	1,466	2.99E-02	5,958	2.57E-02	1.86E-09
LB45-24.7	0	23	9.9E-06	16.97	12	0.501	0.010	1,262	3.13E-02	1,240	3.63E-02	1,864	3.62E-02	7,681	3.18E-02	1.95E-09
LB45-24.9	0	23	6.4E-06	28.88	12	0.501	0.010	1,181	1.89E-02	1,192	2.25E-02	1,815	2.27E-02	7,176	1.91E-02	1.54E-09
LB45-24.10	0	23	9.7E-06	33.88	12	0.499	0.010	1,318	3.20E-02	1,271	3.64E-02	1,954	3.72E-02	8,363	3.40E-02	2.07E-09
LB45-24.11	0	23	1.0E-05	37.99	12	0.496	0.010	1,306	3.38E-02	1,236	3.77E-02	1,902	3.85E-02	8,373	3.63E-02	1.89E-09
LB45-24.12	0	23	1.0E-05	40.86	12	0.495	0.010	1,396	3.55E-02	1,309	3.93E-02	1,995	3.98E-02	9,031	3.86E-02	1.69E-09
LB45-24.13	0	23	9.3E-06	41.90	12	0.494	0.010	1,411	3.34E-02	1,348	3.76E-02	2,048	3.80E-02	9,015	3.58E-02	1.83E-09
Exp. #25																
LB45-25A	0	70	-	-	7	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-25.1	0	70	-	-	7	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-25.2	0	70	5.6E-05	2.02	7	1.002	0.036	1,602	6.20E-02	ND	-	2,673	8.17E-02	1,243	5.09E-03	7.86E-09
LB45-25.4	0	70	5.7E-05	4.16	7	0.998	0.020	1,850	1.34E-01	ND	-	2,698	1.53E-01	729	2.92E-03	7.86E-09
LB45-25.6	0	70	5.5E-05	6.02	7	0.994	0.020	1,400	9.71E-02	ND	-	2,016	1.10E-01	ND	-	4.95E-09
LB45-25.8	0	70	5.2E-05	8.03	7	0.990	0.020	1,249	8.23E-02	52	1.44E-04	1,806	9.31E-02	ND	-	4.31E-09
LB45-25.9	0	70	6.1E-05	8.91	7	0.988	0.020	1,202	9.25E-02	ND	-	1,752	1.05E-01	ND	-	5.18E-09

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-25.10	0	70	5.4E-05	9.24	7	0.986	0.020	1,120	7.61E-02	51	7.74E-05	1,665	8.85E-02	ND	-	4.95E-09
LB45-25.11	0	70	5.9E-05	9.88	7	0.985	0.020	1,157	8.67E-02	52	2.02E-04	1,850	1.09E-01	ND	-	8.90E-09
Exp. #26																
LB45-26A	0	70	-	-	8	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-26.1	0	70	-	-	8	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-26.2	0	70	5.6E-05	2.02	8	1.004	0.036	618	2.29E-02	128	3.71E-03	1,253	3.69E-02	1,789	8.89E-03	5.61E-09
LB45-26.4	0	70	5.7E-05	4.16	8	1.003	0.020	423	2.76E-02	210	1.40E-02	684	3.43E-02	1,433	1.18E-02	2.69E-09
LB45-26.6	0	70	5.4E-05	6.02	8	1.002	0.020	366	2.24E-02	185	1.13E-02	535	2.45E-02	1,160	8.02E-03	8.37E-10
LB45-26.8	0	70	5.5E-05	8.03	8	1.001	0.020	376	2.32E-02	173	1.03E-02	628	2.98E-02	1,180	8.28E-03	2.63E-09
LB45-26.9	0	70	6.1E-05	8.91	8	1.000	0.020	351	2.39E-02	168	1.10E-02	503	2.54E-02	1,097	8.11E-03	6.01E-10
LB45-26.10	0	70	4.2E-05	9.24	8	1.000	0.020	342	1.61E-02	167	7.64E-03	510	1.79E-02	1,077	5.44E-03	7.30E-10
LB45-26.11	0	70	5.9E-05	9.88	8	1.000	0.020	332	2.18E-02	159	9.95E-03	463	2.22E-02	1,051	7.29E-03	1.79E-10
Exp. #27																
LB45-27A	0	70	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-27.1	0	70	-	-	9	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-27.2	0	70	5.7E-05	2.02	9	1.006	0.037	750	2.86E-02	493	2.13E-02	1,377	4.14E-02	3,876	2.36E-02	5.13E-09
LB45-27.4	0	70	5.7E-05	4.16	9	1.004	0.020	788	5.41E-02	706	5.69E-02	1,159	6.17E-02	4,488	5.01E-02	3.03E-09
LB45-27.6	0	70	5.5E-05	6.02	9	1.002	0.020	854	5.75E-02	825	6.55E-02	1,280	6.71E-02	4,729	5.18E-02	3.83E-09
LB45-27.8	0	70	5.5E-05	8.03	9	1.000	0.020	920	6.19E-02	840	6.64E-02	1,342	7.02E-02	5,023	5.51E-02	3.32E-09
LB45-27.9	0	70	6.1E-05	8.91	9	0.998	0.020	914	6.86E-02	825	7.27E-02	1,317	7.67E-02	4,925	6.01E-02	3.26E-09
LB45-27.10	0	70	4.3E-05	9.24	9	0.997	0.020	866	4.59E-02	807	5.03E-02	1,308	5.40E-02	4,817	4.16E-02	3.23E-09
LB45-27.11	0	70	5.7E-05	9.88	9	0.996	0.020	894	6.35E-02	802	6.69E-02	1,296	7.15E-02	4,877	5.64E-02	3.21E-09
Exp. #28																
LB45-28A	0	70	-	-	10	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-28.1	0	70	-	-	10	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-28.2	0	70	5.7E-05	2.02	10	0.508	0.023	698	4.16E-02	634	4.43E-02	1,143	5.32E-02	3,770	3.60E-02	4.63E-09
LB45-28.4	0	70	5.8E-05	4.16	10	0.506	0.010	1,148	1.64E-01	999	1.67E-01	1,688	1.88E-01	5,979	1.40E-01	9.74E-09
LB45-28.6	0	70	5.5E-05	6.02	10	0.503	0.010	1,056	1.44E-01	931	1.49E-01	1,504	1.59E-01	5,550	1.23E-01	6.25E-09
LB45-28.8	0	70	5.4E-05	8.03	10	0.500	0.010	960	1.29E-01	900	1.42E-01	1,375	1.44E-01	5,162	1.13E-01	5.85E-09
LB45-28.9	0	70	6.1E-05	8.91	10	0.498	0.010	959	1.45E-01	910	1.62E-01	1,415	1.67E-01	5,127	1.26E-01	8.67E-09
LB45-28.10	0	70	4.8E-05	9.24	10	0.497	0.010	956	1.14E-01	875	1.22E-01	1,394	1.29E-01	5,078	9.84E-02	6.14E-09
LB45-28.11	0	70	5.6E-05	9.88	10	0.496	0.010	968	1.35E-01	826	1.35E-01	1,408	1.53E-01	5,229	1.19E-01	7.14E-09
Exp. #29																
LB45-29A	0	70	-	-	11	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-29.1	0	70	-	-	11	-	-	<50	-	<50	-	<100	-	<500	-	-
LB45-29.2	0	70	7.2E-05	2.02	11	0.502	0.023	1,256	9.86E-02	1,116	1.03E-01	2,037	1.26E-01	6,624	8.58E-02	1.09E-08
LB45-29.4	0	70	5.8E-05	4.16	11	0.495	0.010	3,319	4.95E-01	2,298	4.02E-01	5,045	5.95E-01	15,550	3.90E-01	4.00E-08
LB45-29.6	0	70	5.4E-05	6.02	11	0.486	0.010	3,348	4.77E-01	2,073	3.45E-01	5,140	5.79E-01	15,132	3.62E-01	4.09E-08
LB45-29.8	0	70	5.1E-05	8.03	11	0.477	0.010	3,997	5.49E-01	2,322	3.73E-01	6,047	6.57E-01	18,037	4.18E-01	4.33E-08
LB45-29.9	0	70	5.7E-05	8.91	11	0.469	0.009	3,735	5.83E-01	2,204	4.03E-01	5,674	7.01E-01	16,971	4.46E-01	4.71E-08

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-29.10	0	70	5.4E-05	9.24	11	0.465	0.009	3,706	5.54E-01	2,172	3.80E-01	5,587	6.61E-01	16,733	4.21E-01	4.26E-08
LB45-29.11	0	70	5.9E-05	9.88	11	0.461	0.009	3,677	6.00E-01	2,117	4.04E-01	5,579	7.21E-01	16,508	4.54E-01	4.81E-08
Exp. #30																
LB45-30A	0	70	-	-	12	-	-	<50	-	53	-	<100	-	<500	-	-
LB45-30.1	0	70	-	-	12	-	-	<50	-	58	-	<100	-	510	-	-
LB45-30.2	0	70	5.8E-05	2.02	12	0.507	0.023	1,786	1.13E-01	1,866	1.39E-01	2,983	1.49E-01	10,156	1.08E-01	1.44E-08
LB45-30.4	0	70	5.9E-05	4.16	12	0.500	0.010	2,991	4.48E-01	2,911	5.13E-01	4,932	5.84E-01	16,041	4.05E-01	5.46E-08
LB45-30.6	0	70	5.4E-05	6.02	12	0.492	0.010	3,191	4.45E-01	3,240	5.33E-01	5,161	5.69E-01	16,891	3.97E-01	4.98E-08
LB45-30.8	0	70	4.7E-05	8.03	12	0.483	0.010	4,195	5.22E-01	3,976	5.84E-01	6,699	6.61E-01	21,360	4.50E-01	5.53E-08
LB45-30.9	0	70	6.2E-05	8.91	12	0.476	0.010	3,310	5.51E-01	3,207	6.29E-01	5,416	7.14E-01	17,338	4.87E-01	6.51E-08
LB45-30.10	0	70	4.9E-05	9.24	12	0.472	0.009	3,265	4.30E-01	3,154	4.89E-01	5,329	5.56E-01	17,194	3.82E-01	5.02E-08
LB45-30.11	0	70	6.0E-05	9.88	12	0.468	0.009	3,423	5.64E-01	3,311	6.43E-01	5,289	6.89E-01	17,925	4.99E-01	5.01E-08
Exp. #31																
LB45-31.A	8.82E+02	40	-	-	9	-	-	<25	-	<10	-	<50	-	<1000	-	-
LB45-31.2	8.82E+02	40	1.8E-05	3.02	9	0.508	0.013	401	1.37E-02	313	1.31E-02	641	1.72E-02	2,114	6.98E-03	1.37E-09
LB45-31.4	8.82E+02	40	1.8E-05	5.48	9	0.507	0.010	413	1.75E-02	353	1.83E-02	606	1.99E-02	2,302	1.01E-02	9.62E-10
LB45-31.7	8.82E+02	40	1.7E-05	8.14	9	0.507	0.010	407	1.71E-02	356	1.83E-02	592	1.93E-02	2,292	9.92E-03	8.76E-10
LB45-31.13	8.82E+02	40	1.7E-05	16.27	9	0.507	0.010	373	1.54E-02	333	1.68E-02	549	1.75E-02	2,134	8.58E-03	8.56E-10
LB45-31.16	8.82E+02	40	1.4E-05	21.94	9	0.507	0.010	370	1.26E-02	326	1.37E-02	546	1.44E-02	2,105	6.93E-03	7.21E-10
LB45-31.20	8.82E+02	40	1.7E-05	29.05	9	0.506	0.010	359	1.42E-02	315	1.53E-02	525	1.61E-02	2,040	7.59E-03	7.46E-10
LB45-31.21	8.82E+02	40	1.3E-05	30.17	9	0.506	0.010	359	1.12E-02	317	1.21E-02	550	1.33E-02	2,025	5.86E-03	8.41E-10
LB45-31.22	8.82E+02	40	1.7E-05	31.08	9	0.506	0.010	403	1.66E-02	342	1.73E-02	573	1.83E-02	2,227	9.25E-03	6.73E-10
LB45-31.23	8.82E+02	40	1.8E-05	34.07	9	0.505	0.010	350	1.51E-02	305	1.62E-02	527	1.76E-02	2,010	8.05E-03	1.01E-09
Exp. #32																
LB45-32.A	1.61E+04	40	-	-	9	-	-	<25	-	25	-	<50	-	19,567	-	-
LB45-32.2	1.61E+04	40	1.9E-05	3.02	9	0.504	0.013	321	1.19E-02	183	7.46E-03	525	1.52E-02	20,525	6.58E-03	1.31E-09
LB45-32.4	1.61E+04	40	1.9E-05	5.48	9	0.504	0.010	321	1.44E-02	208	1.04E-02	501	1.74E-02	20,857	1.07E-02	1.21E-09
LB45-32.7	1.61E+04	40	1.9E-05	8.14	9	0.503	0.010	306	1.38E-02	218	1.12E-02	457	1.59E-02	21,110	1.30E-02	8.34E-10
LB45-32.13	1.61E+04	40	1.9E-05	16.27	9	0.503	0.010	286	1.30E-02	227	1.19E-02	435	1.53E-02	21,264	1.45E-02	8.93E-10
LB45-32.16	1.61E+04	40	1.4E-05	21.94	9	0.503	0.010	275	9.34E-03	219	8.55E-03	432	1.13E-02	21,178	1.03E-02	7.93E-10
LB45-32.19	1.61E+04	40	2.9E-05	29.05	9	0.502	0.010	274	1.90E-02	215	1.70E-02	436	2.33E-02	21,829	2.94E-02	1.75E-09
LB45-32.21	1.61E+04	40	1.9E-05	30.17	9	0.502	0.010	268	1.20E-02	210	1.07E-02	398	1.36E-02	21,463	1.60E-02	6.57E-10
LB45-32.22	1.61E+04	40	1.9E-05	31.08	9	0.502	0.010	265	1.16E-02	209	1.05E-02	399	1.34E-02	20,928	1.13E-02	7.24E-10
LB45-32.23	1.61E+04	40	1.9E-05	34.07	9	0.501	0.010	263	1.18E-02	204	1.04E-02	397	1.37E-02	21,621	1.74E-02	7.59E-10
Exp. #33																
LB45-33.A	3.21E+04	40	-	-	9	-	-	<25	-	<10	-	<50	-	37,385	-	-
LB45-33.2	3.21E+04	40	1.9E-05	3.02	9	1.007	0.020	486	1.15E-02	228	6.42E-03	894	1.67E-02	40,040	1.13E-02	2.09E-09
LB45-33.4	3.21E+04	40	1.8E-05	5.48	9	1.006	0.020	484	1.10E-02	225	6.07E-03	780	1.38E-02	38,995	6.59E-03	1.15E-09
LB45-33.7	3.21E+04	40	1.9E-05	8.14	9	1.006	0.020	444	1.02E-02	219	6.01E-03	684	1.22E-02	38,531	4.77E-03	8.23E-10
LB45-33.13	3.21E+04	40	1.9E-05	16.27	9	1.006	0.020	405	9.36E-03	205	5.68E-03	636	1.15E-02	38,528	4.82E-03	8.36E-10

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-33.16	3.21E+04	40	1.4E-05	21.94	9	1.005	0.020	412	7.14E-03	218	4.54E-03	662	8.97E-03	39,231	5.83E-03	7.33E-10
LB45-33.20	3.21E+04	40	1.9E-05	29.05	9	1.005	0.020	397	9.37E-03	203	5.73E-03	634	1.17E-02	39,829	1.05E-02	9.24E-10
LB45-33.21	3.21E+04	40	1.8E-05	30.17	9	1.004	0.020	383	8.14E-03	186	4.73E-03	604	1.00E-02	40,119	1.06E-02	7.43E-10
LB45-33.22	3.21E+04	40	1.8E-05	31.08	9	1.004	0.020	377	8.44E-03	181	4.85E-03	579	1.01E-02	39,319	7.96E-03	6.61E-10
LB45-33.23	3.21E+04	40	1.9E-05	34.07	9	1.003	0.020	365	8.37E-03	170	4.66E-03	547	9.74E-03	39,359	8.34E-03	5.45E-10
Exp. #34																
LB45-34.A	4.78E+04	40	-	-	9	-	-	<25	-	<10	-	<50	-	55,203	-	-
LB45-34.2	4.78E+04	40	2.0E-05	3.02	9	1.006	0.020	357	8.46E-03	125	3.45E-03	679	1.27E-02	56,183	4.27E-03	1.70E-09
LB45-34.4	4.78E+04	40	1.9E-05	5.48	9	1.006	0.020	318	7.09E-03	116	3.01E-03	546	9.53E-03	55,813	2.53E-03	9.73E-10
LB45-34.7	4.78E+04	40	1.9E-05	8.14	9	1.005	0.020	273	6.05E-03	108	2.82E-03	446	7.70E-03	56,397	5.00E-03	6.57E-10
LB45-34.13	4.78E+04	40	1.9E-05	16.27	9	1.005	0.020	235	5.20E-03	105	2.78E-03	381	6.51E-03	58,283	1.31E-02	5.23E-10
LB45-34.16	4.78E+04	40	1.5E-05	21.94	9	1.005	0.020	219	3.68E-03	105	2.12E-03	367	4.77E-03	58,188	9.68E-03	4.34E-10
LB45-34.20	4.78E+04	40	1.9E-05	29.05	9	1.005	0.020	193	4.22E-03	96	2.54E-03	323	5.45E-03	57,639	1.05E-02	4.95E-10
LB45-34.21	4.78E+04	40	1.9E-05	30.17	9	1.004	0.020	189	4.07E-03	91	2.39E-03	309	5.13E-03	57,617	1.03E-02	4.23E-10
LB45-34.22	4.78E+04	40	1.9E-05	31.08	9	1.004	0.020	182	3.79E-03	93	2.37E-03	308	4.95E-03	57,349	8.87E-03	4.62E-10
LB45-34.23	4.78E+04	40	1.9E-05	34.07	9	1.004	0.020	170	3.59E-03	87	2.26E-03	293	4.79E-03	58,702	1.49E-02	4.78E-10
Exp. #35																
LB45-35.A	6.89E+04	40	-	-	9	-	-	<25	-	<10	-	<50	-	73,953	-	-
LB45-35.2	6.89E+04	40	1.9E-05	3.02	9	2.004	0.032	473	7.09E-03	114	1.94E-03	979	1.17E-02	66,656	-	1.83E-09
LB45-35.4	6.89E+04	40	1.9E-05	5.48	9	2.003	0.040	352	3.96E-03	91	1.16E-03	651	5.77E-03	66,216	-	7.24E-10
LB45-35.7	6.89E+04	40	1.9E-05	8.14	9	2.003	0.040	270	3.00E-03	84	1.07E-03	493	4.32E-03	66,765	-	5.25E-10
LB45-35.13	6.89E+04	40	1.8E-05	16.27	9	2.003	0.040	189	1.93E-03	65	7.60E-04	330	2.61E-03	69,520	-	2.74E-10
LB45-35.16	6.89E+04	40	1.4E-05	21.94	9	2.003	0.040	158	1.23E-03	57	5.13E-04	300	1.85E-03	68,273	-	2.46E-10
LB45-35.20	6.89E+04	40	1.9E-05	29.05	9	2.003	0.040	139	1.42E-03	54	6.54E-04	259	2.07E-03	70,899	-	2.59E-10
LB45-35.21	6.89E+04	40	1.7E-05	30.17	9	2.003	0.040	178	1.73E-03	110	1.34E-03	428	3.38E-03	70,636	-	6.61E-10
LB45-35.22	6.89E+04	40	1.8E-05	31.08	9	2.002	0.040	123	1.17E-03	51	5.83E-04	232	1.73E-03	69,358	-	2.24E-10
LB45-35.23	6.89E+04	40	1.9E-05	34.07	9	2.002	0.040	116	1.12E-03	48	5.48E-04	224	1.70E-03	71,428	-	2.33E-10
Exp. #36																
LB45-36.A	7.64E+04	40	-	-	9	-	-	<25	-	<10	-	<50	-	82,270	-	-
LB45-36.2	7.64E+04	40	1.9E-05	3.02	9	2.002	0.032	494	7.48E-03	53	8.02E-04	950	1.14E-02	74,004	-	1.57E-09
LB45-36.4	7.64E+04	40	1.9E-05	5.48	9	2.001	0.040	361	4.12E-03	61	7.38E-04	649	5.84E-03	68,044	-	6.88E-10
LB45-36.7	7.64E+04	40	1.9E-05	8.14	9	2.001	0.040	284	3.20E-03	65	7.95E-04	491	4.33E-03	68,998	-	4.51E-10
LB45-36.13	7.64E+04	40	1.9E-05	16.27	9	2.001	0.040	171	1.77E-03	56	6.54E-04	314	2.54E-03	72,008	-	3.09E-10
LB45-36.16	7.64E+04	40	1.4E-05	21.94	9	2.001	0.040	131	9.75E-04	54	4.79E-04	261	1.55E-03	74,845	-	2.28E-10
LB45-36.20	7.64E+04	40	1.9E-05	29.05	9	2.001	0.040	102	9.66E-04	42	4.72E-04	206	1.56E-03	77,243	-	2.38E-10
LB45-36.21	7.64E+04	40	1.7E-05	30.17	9	2.001	0.040	98	8.30E-04	42	4.35E-04	200	1.35E-03	81,183	-	2.09E-10
LB45-36.22	7.64E+04	40	1.9E-05	31.08	9	2.001	0.040	90	7.85E-04	39	4.21E-04	189	1.34E-03	77,979	-	2.22E-10
LB45-36.23	7.64E+04	40	1.9E-05	34.07	9	2.000	0.040	79	6.75E-04	39	4.37E-04	179	1.29E-03	78,933	-	2.46E-10
Exp. #37																
LB45-43.A	8.79E+02	90	-	-	9	-	-	<25	-	<10	-	<50	-	<1000	-	-

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-43.1	8.79E+02	90	1.7E-05	0.79	9	0.506	0.010	529	2.25E-02	378	1.94E-02	899	3.01E-02	2,735	1.33E-02	3.05E-09
LB45-43.2	8.79E+02	90	8.1E-05	1.89	9	0.503	0.010	1,201	2.47E-01	916	2.25E-01	1,755	2.85E-01	6,224	1.88E-01	1.50E-08
LB45-43.3	8.79E+02	90	1.9E-05	2.90	9	0.501	0.010	1,180	5.85E-02	916	5.42E-02	1,586	6.18E-02	6,100	4.42E-02	1.34E-09
LB45-43.6	8.79E+02	90	7.6E-05	5.84	9	0.498	0.010	1,494	2.93E-01	865	2.02E-01	1,965	3.04E-01	7,120	2.09E-01	4.26E-09
LB45-43.8	8.79E+02	90	4.1E-05	7.74	9	0.494	0.010	1,337	1.43E-01	791	1.01E-01	1,749	1.47E-01	6,562	1.04E-01	1.68E-09
LB45-43.9	8.79E+02	90	8.0E-05	9.06	9	0.489	0.010	1,079	2.25E-01	686	1.70E-01	1,432	2.34E-01	5,574	1.67E-01	3.74E-09
LB45-43.10	8.79E+02	90	7.7E-05	9.79	9	0.486	0.010	1,148	2.30E-01	754	1.80E-01	1,516	2.39E-01	5,884	1.72E-01	3.47E-09
LB45-43.11	8.79E+02	90	7.7E-05	10.83	9	0.483	0.010	1,183	2.42E-01	782	1.90E-01	1,530	2.45E-01	6,014	1.79E-01	1.50E-09
LB45-43.12	8.79E+02	90	1.4E-04	10.93	9	0.481	0.010	1,179	4.45E-01	794	3.57E-01	1,565	4.64E-01	5,973	3.29E-01	7.69E-09
Exp. #38																
LB45-44.A	3.74E+04	90	-	-	9	-	-	<25	-	<10	-	<50	-	39,061	-	-
LB45-44.1	3.74E+04	90	5.9E-05	0.79	9	0.501	0.010	647	9.60E-02	299	5.28E-02	1,083	1.27E-01	43,706	1.23E-01	1.23E-08
LB45-44.2	3.74E+04	90	8.3E-05	1.89	9	0.498	0.010	1,221	2.60E-01	391	9.78E-02	1,847	3.10E-01	45,423	2.37E-01	2.01E-08
LB45-44.3	3.74E+04	90	4.6E-05	2.90	9	0.495	0.010	1,542	1.85E-01	379	5.32E-02	2,072	1.96E-01	46,400	1.54E-01	4.41E-09
LB45-44.6	3.74E+04	90	7.3E-05	5.84	9	0.491	0.010	1,882	3.57E-01	360	7.95E-02	2,575	3.86E-01	45,688	2.18E-01	1.14E-08
LB45-44.8	3.74E+04	90	3.9E-05	7.74	9	0.487	0.010	1,119	1.14E-01	232	2.73E-02	1,604	1.29E-01	46,251	1.28E-01	5.85E-09
LB45-44.9	3.74E+04	90	8.1E-05	9.06	9	0.484	0.010	574	1.20E-01	262	6.51E-02	815	1.33E-01	41,443	8.92E-02	5.10E-09
LB45-44.10	3.74E+04	90	7.1E-05	9.79	9	0.482	0.010	716	1.32E-01	359	7.92E-02	1,015	1.47E-01	41,865	9.22E-02	5.86E-09
LB45-44.11	3.74E+04	90	8.1E-05	10.83	9	0.480	0.010	963	2.06E-01	390	9.83E-02	1,311	2.20E-01	44,296	1.97E-01	5.63E-09
LB45-44.12	3.74E+04	90	1.4E-04	10.93	9	0.478	0.010	1,269	4.63E-01	418	1.80E-01	1,694	4.87E-01	47,414	5.33E-01	9.31E-09
Exp. #39																
LB45-45.A	7.39E+04	90	-	-	9	-	-	<25	-	<10	-	<50	-	80,560	-	-
LB45-45.1	7.39E+04	90	6.4E-05	0.79	9	1.000	0.020	446	3.51E-02	141	1.29E-02	1,159	7.36E-02	88,206	1.09E-01	1.54E-08
LB45-45.2	7.39E+04	90	6.7E-05	1.89	9	0.999	0.020	672	5.65E-02	169	1.64E-02	1,300	8.68E-02	87,791	1.08E-01	1.21E-08
LB45-45.3	7.39E+04	90	3.8E-05	2.90	9	0.997	0.020	1,125	5.48E-02	198	1.10E-02	1,844	7.10E-02	87,409	5.84E-02	6.48E-09
LB45-45.6	7.39E+04	90	7.6E-05	5.84	9	0.992	0.020	2,754	2.74E-01	303	3.47E-02	4,242	3.34E-01	82,533	3.39E-02	2.41E-08
LB45-45.8	7.39E+04	90	4.0E-05	7.74	9	0.987	0.020	1,159	5.92E-02	161	9.30E-03	1,868	7.54E-02	82,926	2.12E-02	6.47E-09
LB45-45.9	7.39E+04	90	8.2E-05	9.06	9	0.984	0.020	436	4.48E-02	123	1.46E-02	759	6.13E-02	81,691	2.11E-02	6.62E-09
LB45-45.10	7.39E+04	90	6.9E-05	9.79	9	0.983	0.020	334	2.81E-02	150	1.50E-02	560	3.68E-02	82,391	2.85E-02	3.47E-09
LB45-45.11	7.39E+04	90	7.8E-05	10.83	9	0.982	0.020	330	3.17E-02	161	1.85E-02	541	4.05E-02	81,142	1.04E-02	3.53E-09
LB45-45.12	7.39E+04	90	2.1E-04	10.93	9	0.982	0.020	381	9.81E-02	173	5.29E-02	704	1.43E-01	81,160	2.83E-02	1.80E-08
Exp. #40																
LB45-46.A	1.06E+05	90	-	-	9	-	-	<25	-	<10	-	<50	-	108,234	-	-
LB45-46.1	1.06E+05	90	4.7E-05	0.79	9	1.002	0.020	337	1.89E-02	78	4.86E-03	992	4.54E-02	131,385	2.40E-01	1.06E-08
LB45-46.2	1.06E+05	90	6.8E-05	1.89	9	1.001	0.020	418	3.49E-02	81	7.44E-03	980	6.56E-02	127,829	2.98E-01	1.23E-08
LB45-46.3	1.06E+05	90	2.2E-05	2.90	9	1.000	0.020	457	1.25E-02	85	2.57E-03	891	1.94E-02	135,397	1.35E-01	2.74E-09
LB45-46.6	1.06E+05	90	7.6E-05	5.84	9	0.999	0.020	352	3.24E-02	82	8.43E-03	664	4.84E-02	133,190	4.24E-01	6.38E-09
LB45-46.8	1.06E+05	90	3.8E-05	7.74	9	0.998	0.020	238	1.06E-02	49	2.33E-03	428	1.50E-02	136,781	2.45E-01	1.75E-09
LB45-46.9	1.06E+05	90	8.4E-05	9.06	9	0.998	0.020	233	2.28E-02	48	4.91E-03	402	3.07E-02	118,565	1.94E-01	3.17E-09
LB45-46.10	1.06E+05	90	7.9E-05	9.79	9	0.997	0.020	321	3.05E-02	73	7.67E-03	546	4.07E-02	122,243	2.47E-01	4.03E-09

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-46.11	1.06E+05	90	7.3E-05	10.83	9	0.996	0.020	277	2.42E-02	69	6.64E-03	499	3.43E-02	131,522	3.83E-01	4.03E-09
LB45-46.12	1.06E+05	90	1.4E-04	10.93	9	0.996	0.020	231	3.78E-02	62	1.13E-02	436	5.62E-02	131,499	7.31E-01	7.36E-09
Exp. #41																
LB45-47.A	1.22E+05	90	-	-	9	-	-	<25	-	<10	-	<50	-	125,733	-	-
LB45-47.1	1.22E+05	90	7.6E-05	0.79	9	2.003	0.040	601	2.84E-02	58	2.79E-03	1,988	7.59E-02	150,975	2.13E-01	1.90E-08
LB45-47.2	1.22E+05	90	7.0E-05	1.89	9	2.001	0.040	711	3.12E-02	64	2.90E-03	1,450	5.06E-02	152,385	2.08E-01	7.74E-09
LB45-47.3	1.22E+05	90	4.6E-05	2.90	9	2.000	0.040	742	2.15E-02	66	1.98E-03	1,320	3.03E-02	150,681	1.28E-01	3.49E-09
LB45-47.6	1.22E+05	90	7.2E-05	5.84	9	1.998	0.040	530	2.38E-02	31	1.14E-03	942	3.34E-02	160,668	2.82E-01	3.83E-09
LB45-47.8	1.22E+05	90	4.4E-05	7.74	9	1.997	0.040	424	1.15E-02	20	3.43E-04	712	1.52E-02	144,520	9.28E-02	1.46E-09
LB45-47.9	1.22E+05	90	8.1E-05	9.06	9	1.995	0.040	386	1.91E-02	17	4.54E-04	626	2.42E-02	143,230	1.59E-01	2.04E-09
LB45-47.10	1.22E+05	90	7.6E-05	9.79	9	1.994	0.040	414	1.94E-02	26	9.54E-04	687	2.52E-02	150,162	2.08E-01	2.33E-09
LB45-47.11	1.22E+05	90	7.1E-05	10.83	9	1.993	0.040	373	1.61E-02	20	5.47E-04	658	2.23E-02	161,611	2.84E-01	2.50E-09
LB45-47.12	1.22E+05	90	2.1E-04	10.93	9	1.993	0.040	341	4.26E-02	20	1.53E-03	592	5.79E-02	159,822	7.86E-01	6.13E-09
Exp. #42																
LB45-48.A	1.39E+05	90	-	-	9	-	-	<25	-	<10	-	<50	-	137,926	-	-
LB45-48.1	1.39E+05	90	4.4E-05	0.79	9	2.008	0.040	637	1.76E-02	117	3.62E-03	6,684	1.51E-01	160,320	1.10E-01	5.33E-08
LB45-48.2	1.39E+05	90	1.9E-06	1.89	9	2.008	0.040	801	9.73E-04	151	2.09E-04	9,183	9.10E-03	171,368	7.18E-03	3.24E-09
LB45-48.3	1.39E+05	90	7.2E-05	2.90	9	2.007	0.040	688	3.08E-02	91	4.47E-03	7,193	2.64E-01	167,591	2.36E-01	9.31E-08
LB45-48.6	1.39E+05	90	7.3E-05	5.84	9	2.006	0.040	320	1.39E-02	53	2.41E-03	2,183	8.00E-02	171,882	2.75E-01	2.64E-08
LB45-48.8	1.39E+05	90	3.7E-05	7.74	9	2.005	0.040	290	6.45E-03	40	8.67E-04	1,784	3.36E-02	163,466	1.07E-01	1.08E-08
LB45-48.9	1.39E+05	90	8.0E-05	9.06	9	2.004	0.040	260	1.22E-02	44	2.07E-03	1,618	6.47E-02	155,100	1.53E-01	2.10E-08
LB45-48.10	1.39E+05	90	6.5E-05	9.79	9	2.003	0.040	273	1.06E-02	60	2.52E-03	1,759	5.78E-02	157,371	1.42E-01	1.89E-08
LB45-48.11	1.39E+05	90	6.8E-05	10.83	9	2.002	0.040	234	9.23E-03	42	1.67E-03	1,552	5.28E-02	165,768	2.11E-01	1.74E-08
Exp. #43																
LB45-49.A	8.67E+02	70	-	-	9	-	-	<100	-	<50	-	<50	-	<500	-	-
LB45-49.1	8.67E+02	70	6.4E-05	0.90	9	0.501	0.023	528	3.12E-02	399	3.00E-02	866	4.73E-02	2,763	2.83E-02	6.43E-09
LB45-49.3	8.67E+02	70	6.6E-05	1.83	9	0.500	0.010	718	1.07E-01	603	1.13E-01	1,038	1.36E-01	3,851	9.95E-02	1.16E-08
LB45-49.4	8.67E+02	70	6.6E-05	2.87	9	0.498	0.010	703	1.03E-01	587	1.09E-01	978	1.27E-01	3,719	9.46E-02	9.19E-09
LB45-49.7	8.67E+02	70	6.3E-05	5.18	9	0.496	0.010	602	8.31E-02	514	9.06E-02	834	1.03E-01	3,295	7.92E-02	7.96E-09
LB45-49.9	8.67E+02	70	6.4E-05	7.95	9	0.494	0.010	556	7.69E-02	478	8.53E-02	774	9.71E-02	3,063	7.41E-02	8.06E-09
LB45-49.10	8.67E+02	70	6.6E-05	8.89	9	0.492	0.010	537	7.58E-02	435	7.88E-02	759	9.77E-02	3,000	7.43E-02	8.74E-09
LB45-49.11	8.67E+02	70	5.6E-05	10.11	9	0.491	0.010	561	6.80E-02	533	8.42E-02	834	9.20E-02	3,074	6.51E-02	9.59E-09
LB45-49.12	8.67E+02	70	6.6E-05	10.98	9	0.490	0.010	623	9.24E-02	573	1.09E-01	930	1.23E-01	3,341	8.59E-02	1.24E-08
Exp. #44																
LB45-50.A	2.93E+04	70	-	-	9	-	-	<100	-	<50	-	<50	-	33,080	-	-
LB45-50.1	2.93E+04	70	7.2E-05	0.90	9	0.498	0.023	260	1.32E-02	96	4.52E-03	469	2.75E-02	33,763	9.67E-03	5.70E-09
LB45-50.3	2.93E+04	70	6.6E-05	1.83	9	0.497	0.010	475	6.52E-02	172	2.50E-02	773	9.99E-02	34,488	4.20E-02	1.38E-08
LB45-50.4	2.93E+04	70	6.6E-05	2.87	9	0.496	0.010	477	6.57E-02	176	2.60E-02	729	9.39E-02	34,284	3.59E-02	1.13E-08
LB45-50.7	2.93E+04	70	6.4E-05	5.18	9	0.494	0.010	454	5.96E-02	203	3.05E-02	652	8.06E-02	34,593	4.37E-02	8.39E-09
LB45-50.9	2.93E+04	70	6.6E-05	7.95	9	0.492	0.010	449	6.13E-02	202	3.15E-02	640	8.25E-02	34,515	4.32E-02	8.45E-09

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-50.10	2.93E+04	70	6.6E-05	8.89	9	0.491	0.010	437	5.90E-02	193	2.96E-02	633	8.11E-02	34,189	3.33E-02	8.84E-09
LB45-50.11	2.93E+04	70	5.6E-05	10.11	9	0.490	0.010	433	4.97E-02	209	2.81E-02	627	6.85E-02	34,386	3.34E-02	7.50E-09
LB45-50.12	2.93E+04	70	6.6E-05	10.98	9	0.489	0.010	452	6.22E-02	232	3.80E-02	647	8.39E-02	34,702	4.91E-02	8.66E-09
Exp. #45																
LB45-51.A	5.83E+04	70	-	-	9	-	-	<100	-	<50	-	57	-	66,179	-	-
LB45-51.1	5.83E+04	70	6.6E-05	0.90	9	0.998	0.036	251	7.15E-03	57	3.80E-04	568	1.92E-02	65,652	-	4.80E-09
LB45-51.3	5.83E+04	70	6.6E-05	1.83	9	0.997	0.020	257	1.36E-02	58	8.61E-04	503	3.06E-02	65,750	-	6.82E-09
LB45-51.4	5.83E+04	70	6.6E-05	2.87	9	0.997	0.020	232	1.14E-02	59	8.86E-04	463	2.78E-02	65,864	-	6.56E-09
LB45-51.7	5.83E+04	70	6.2E-05	5.18	9	0.996	0.020	191	7.40E-03	61	1.04E-03	329	1.75E-02	66,742	7.82E-03	4.04E-09
LB45-51.9	5.83E+04	70	2.4E-05	7.95	9	0.995	0.020	275	5.59E-03	70	7.64E-04	460	1.02E-02	66,843	3.63E-03	1.86E-09
LB45-51.10	5.83E+04	70	6.6E-05	8.89	9	0.995	0.020	156	4.82E-03	51	1.25E-04	287	1.58E-02	66,052	-	4.38E-09
LB45-51.11	5.83E+04	70	5.6E-05	10.11	9	0.995	0.020	134	2.50E-03	53	2.88E-04	232	1.02E-02	66,096	-	3.09E-09
LB45-51.12	5.83E+04	70	6.6E-05	10.98	9	0.994	0.020	146	4.00E-03	62	1.18E-03	292	1.62E-02	65,968	-	4.86E-09
Exp. #46																
LB45-52.A	8.84E+04	70	-	-	9	-	-	<25	-	<50	-	<50	-	97,505	-	-
LB45-52.1	8.84E+04	70	6.6E-05	0.90	9	1.004	0.036	217	9.06E-03	ND	-	538	1.83E-02	96,536	-	3.67E-09
LB45-52.3	8.84E+04	70	6.6E-05	1.83	9	1.003	0.020	188	1.40E-02	ND	-	417	2.50E-02	96,756	-	4.41E-09
LB45-52.4	8.84E+04	70	6.6E-05	2.87	9	1.003	0.020	138	9.70E-03	ND	-	293	1.65E-02	97,212	-	2.73E-09
LB45-52.7	8.84E+04	70	6.3E-05	5.18	9	1.003	0.020	75	4.15E-03	ND	-	180	8.51E-03	95,890	-	1.74E-09
LB45-52.9	8.84E+04	70	6.6E-05	7.95	9	1.002	0.020	60	2.98E-03	ND	-	151	6.91E-03	98,611	1.63E-02	1.57E-09
LB45-52.10	8.84E+04	70	6.6E-05	8.89	9	1.002	0.020	62	3.15E-03	ND	-	160	7.48E-03	97,131	-	1.73E-09
LB45-52.11	8.84E+04	70	5.6E-05	10.11	9	1.002	0.020	55	2.17E-03	ND	-	127	4.42E-03	90,515	-	8.99E-10
LB45-52.12	8.84E+04	70	6.6E-05	10.98	9	1.002	0.020	68	3.73E-03	ND	-	149	6.76E-03	89,611	-	1.21E-09
Exp. #47																
LB45-53.A	1.14E+05	70	-	-	9	-	-	<25	-	<50	-	<50	-	114,657	-	-
LB45-53.1	1.14E+05	70	6.7E-05	0.90	9	2.004	0.058	353	9.88E-03	ND	-	869	1.96E-02	116,163	7.76E-03	3.88E-09
LB45-53.3	1.14E+05	70	6.6E-05	1.83	9	2.004	0.040	321	1.26E-02	ND	-	681	2.14E-02	114,534	-	3.51E-09
LB45-53.4	1.14E+05	70	6.6E-05	2.87	9	2.003	0.040	235	8.98E-03	ND	-	504	1.54E-02	114,075	-	2.56E-09
LB45-53.7	1.14E+05	70	6.3E-05	5.18	9	2.003	0.040	138	4.67E-03	ND	-	307	8.43E-03	123,428	6.19E-02	1.50E-09
LB45-53.9	1.14E+05	70	6.7E-05	7.95	9	2.002	0.040	93	2.93E-03	ND	-	212	5.57E-03	124,089	7.01E-02	1.05E-09
LB45-53.10	1.14E+05	70	6.6E-05	8.89	9	2.002	0.040	87	2.64E-03	ND	-	205	5.27E-03	125,525	7.96E-02	1.05E-09
LB45-53.11	1.14E+05	70	5.6E-05	10.11	9	2.002	0.040	83	2.13E-03	ND	-	209	4.63E-03	120,926	3.95E-02	1.00E-09
LB45-53.12	1.14E+05	70	6.6E-05	10.98	9	2.002	0.040	75	2.13E-03	ND	-	191	4.80E-03	116,554	1.39E-02	1.06E-09
Exp. #48																
LB45-54.A	1.37E+05	70	-	-	9	-	-	<25	-	<50	-	58	-	120,313	-	-
LB45-54.1	1.37E+05	70	6.8E-05	0.90	9	2.002	0.058	395	1.14E-02	ND	-	1,019	2.35E-02	121,984	8.81E-03	4.83E-09
LB45-54.3	1.37E+05	70	6.7E-05	1.83	9	2.002	0.040	323	1.30E-02	ND	-	704	2.23E-02	120,405	6.86E-04	3.73E-09
LB45-54.4	1.37E+05	70	6.6E-05	2.87	9	2.001	0.040	231	8.88E-03	ND	-	490	1.48E-02	121,411	8.12E-03	2.36E-09
LB45-54.7	1.37E+05	70	6.4E-05	5.18	9	2.001	0.040	138	4.66E-03	ND	-	831	2.54E-02	136,064	1.12E-01	8.29E-09
LB45-54.9	1.37E+05	70	6.5E-05	7.95	9	2.000	0.040	103	3.30E-03	ND	-	222	5.49E-03	134,735	1.04E-01	8.75E-10

Table A2. SPFT Results for LAWB45 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LB45-54.10	1.37E+05	70	6.5E-05	8.89	9	2.000	0.040	95	2.96E-03	ND	-	216	5.33E-03	135,545	1.11E-01	9.45E-10
LB45-54.11	1.37E+05	70	5.6E-05	10.11	9	2.000	0.040	84	2.15E-03	ND	-	201	4.16E-03	128,716	5.28E-02	8.01E-10
LB45-54.12	1.37E+05	70	6.2E-05	10.98	9	1.999	0.040	79	2.21E-03	ND	-	199	4.54E-03	122,769	1.71E-02	9.29E-10

[] – $\mu g\ L^{-1}$
Rate – $g\ m^{-2}\ d^{-1}$
IEX Rate – $mol\ m^{-2}\ s^{-1}$

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LAWC22																
Exp. #1																
LC22-1A	0	40	-	-	7	-	-	<10	-	<25	-	106	-	<100	-	-
LC22-1B	0	40	-	-	7	-	-	<10	-	<25	-	107	-	<100	-	-
LC22-1C	0	40	-	-	7	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-1.1	0	40	4.3E-05	0.73	7	1.002	0.020	346	2.22E-02	<25	-	2,337	4.51E-02	406	3.02E-03	9.15E-09
LC22-1.2	0	40	4.1E-05	2.08	7	1.001	0.020	248	1.48E-02	<25	-	1,539	2.77E-02	552	4.28E-03	5.18E-09
LC22-1.3	0	40	4.1E-05	2.74	7	1.001	0.020	155	8.64E-03	11	9.39E-05	951	1.65E-02	505	3.86E-03	3.14E-09
LC22-1.4	0	40	4.1E-05	3.77	7	1.001	0.020	124	6.52E-03	12	1.40E-04	688	1.13E-02	245	1.37E-03	1.89E-09
LC22-1.5	0	40	4.1E-05	4.91	7	1.000	0.020	104	5.24E-03	41	1.98E-03	524	8.17E-03	197	9.26E-04	1.17E-09
LC22-1.6	0	40	4.1E-05	5.82	7	1.000	0.020	90	4.38E-03	17	4.52E-04	438	6.53E-03	160	5.77E-04	8.58E-10
LC22-1.7	0	40	4.1E-05	6.81	7	1.000	0.020	86	4.01E-03	15	3.06E-04	416	6.03E-03	154	5.13E-04	8.05E-10
LC22-1.8	0	40	4.1E-05	7.80	7	1.000	0.020	79	3.60E-03	21	6.83E-04	378	5.32E-03	123	2.22E-04	6.86E-10
LC22-1.9	0	40	4.1E-05	9.06	7	1.000	0.020	77	3.46E-03	17	4.63E-04	350	4.79E-03	112	1.18E-04	5.31E-10
LC22-1.10	0	40	4.1E-05	9.94	7	0.999	0.020	75	3.31E-03	18	5.24E-04	331	4.42E-03	108	7.71E-05	4.42E-10
LC22-1.11	0	40	4.1E-05	10.86	7	0.999	0.020	72	3.12E-03	16	3.76E-04	317	4.12E-03	<100	-	3.96E-10
Exp. #2																
LC22-2A	0	40	-	-	8	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-2B	0	40	-	-	8	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-2C	0	40	-	-	8	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-2.1	0	40	3.7E-05	0.73	8	1.006	0.020	416	2.33E-02	83	4.20E-03	2,863	4.82E-02	1,187	9.28E-03	9.92E-09
LC22-2.2	0	40	3.8E-05	2.08	8	1.005	0.020	183	9.79E-03	67	3.45E-03	1,259	2.10E-02	659	4.97E-03	4.49E-09
LC22-2.3	0	40	4.1E-05	2.74	8	1.005	0.020	108	5.48E-03	67	3.65E-03	712	1.18E-02	544	4.19E-03	2.52E-09
LC22-2.4	0	40	4.0E-05	3.77	8	1.005	0.020	85	3.92E-03	68	3.71E-03	538	8.36E-03	456	3.33E-03	1.77E-09
LC22-2.5	0	40	4.1E-05	4.91	8	1.005	0.020	71	3.04E-03	59	3.17E-03	411	6.03E-03	431	3.15E-03	1.20E-09
LC22-2.6	0	40	4.1E-05	5.82	8	1.005	0.020	63	2.52E-03	58	3.07E-03	347	4.79E-03	388	2.73E-03	9.06E-10
LC22-2.7	0	40	3.6E-05	6.81	8	1.004	0.020	61	2.11E-03	66	3.19E-03	342	4.16E-03	351	2.11E-03	8.16E-10
LC22-2.8	0	40	4.1E-05	7.80	8	1.004	0.020	56	2.03E-03	56	2.94E-03	322	4.27E-03	331	2.18E-03	8.92E-10
LC22-2.9	0	40	3.3E-05	9.06	8	1.004	0.020	55	1.60E-03	52	2.16E-03	274	2.70E-03	317	1.66E-03	4.38E-10
LC22-2.10	0	40	4.1E-05	9.94	8	1.004	0.020	52	1.79E-03	55	2.91E-03	252	2.94E-03	313	2.02E-03	4.58E-10
LC22-2.11	0	40	4.1E-05	10.86	8	1.004	0.020	47	1.48E-03	32	1.42E-03	217	2.25E-03	354	2.39E-03	3.08E-10
Exp. #3																
LC22-3A	0	40	-	-	9	-	-	<10	-	<25	-	<100	-	121	-	-
LC22-3B	0	40	-	-	9	-	-	<10	-	<25	-	<100	-	108	-	-
LC22-3C	0	40	-	-	9	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-3.1	0	40	4.3E-05	0.73	9	0.503	0.013	139	1.25E-02	100	9.52E-03	886	2.52E-02	772	1.04E-02	5.05E-09
LC22-3.2	0	40	4.1E-05	2.08	9	0.502	0.010	219	2.56E-02	204	2.48E-02	943	3.25E-02	1,477	2.58E-02	2.75E-09
LC22-3.3	0	40	4.1E-05	2.74	9	0.502	0.010	222	2.60E-02	228	2.80E-02	850	2.89E-02	1,448	2.53E-02	1.16E-09
LC22-3.4	0	40	4.1E-05	3.77	9	0.502	0.010	219	2.56E-02	222	2.71E-02	816	2.76E-02	1,427	2.49E-02	8.08E-10
LC22-3.5	0	40	4.1E-05	4.91	9	0.501	0.010	217	2.55E-02	206	2.53E-02	811	2.77E-02	1,459	2.57E-02	8.62E-10

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-3.6	0	40	4.1E-05	5.82	9	0.501	0.010	205	2.40E-02	204	2.51E-02	739	2.49E-02	1,353	2.37E-02	3.38E-10
LC22-3.7	0	40	4.1E-05	6.81	9	0.500	0.010	194	2.23E-02	193	2.35E-02	723	2.41E-02	1,282	2.22E-02	7.06E-10
LC22-3.8	0	40	4.1E-05	7.80	9	0.500	0.010	190	2.18E-02	192	2.33E-02	726	2.41E-02	1,247	2.15E-02	9.47E-10
LC22-3.9	0	40	4.1E-05	9.06	9	0.500	0.010	193	2.23E-02	192	2.35E-02	725	2.43E-02	1,300	2.27E-02	7.79E-10
LC22-3.10	0	40	3.8E-05	9.94	9	0.499	0.010	187	2.03E-02	181	2.07E-02	737	2.33E-02	1,224	2.00E-02	1.21E-09
LC22-3.11	0	40	4.0E-05	10.86	9	0.499	0.010	184	2.09E-02	175	2.10E-02	701	2.31E-02	1,205	2.06E-02	8.72E-10
Exp. #4																
LC22-4A	0	40	-	-	10	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-4B	0	40	-	-	10	-	-	<10	-	<25	-	299	-	<100	-	-
LC22-4C	0	40	-	-	10	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-4.1	0	40	4.0E-05	0.73	10	0.503	0.013	204	1.82E-02	256	2.43E-02	1,065	2.67E-02	1,657	2.27E-02	3.42E-09
LC22-4.2	0	40	4.1E-05	2.08	10	0.502	0.010	348	4.25E-02	378	4.70E-02	1,352	4.56E-02	2,365	4.27E-02	1.24E-09
LC22-4.3	0	40	4.1E-05	2.74	10	0.502	0.010	341	4.17E-02	366	4.58E-02	1,277	4.30E-02	2,243	4.06E-02	4.88E-10
LC22-4.4	0	40	4.1E-05	3.77	10	0.501	0.010	347	4.23E-02	366	4.54E-02	1,293	4.33E-02	2,290	4.12E-02	3.65E-10
LC22-4.5	0	40	4.1E-05	4.91	10	0.500	0.010	362	4.47E-02	384	4.82E-02	1,320	4.48E-02	2,361	4.30E-02	3.88E-11
LC22-4.6	0	40	4.1E-05	5.82	10	0.499	0.010	342	4.18E-02	359	4.46E-02	1,263	4.22E-02	2,242	4.04E-02	1.67E-10
LC22-4.7	0	40	4.0E-05	6.81	10	0.499	0.010	337	4.05E-02	340	4.16E-02	1,243	4.09E-02	2,332	4.15E-02	1.51E-10
LC22-4.8	0	40	3.9E-05	7.80	10	0.498	0.010	350	4.16E-02	369	4.45E-02	1,304	4.25E-02	2,303	4.03E-02	3.93E-10
LC22-4.9	0	40	4.2E-05	9.06	10	0.497	0.010	339	4.30E-02	366	4.73E-02	1,268	4.41E-02	2,242	4.19E-02	4.39E-10
LC22-4.10	0	40	4.0E-05	9.94	10	0.497	0.010	350	4.21E-02	336	4.10E-02	1,290	4.26E-02	2,309	4.10E-02	1.86E-10
LC22-4.11	0	40	3.8E-05	10.86	10	0.496	0.010	328	3.73E-02	339	3.94E-02	1,222	3.80E-02	2,180	3.67E-02	3.10E-10
Exp. #5																
LC22-5A	0	40	-	-	11	-	-	14	-	<25	-	138	-	<100	-	-
LC22-5B	0	40	-	-	11	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-5C	0	40	-	-	11	-	-	<10	-	<25	-	<100	-	<100	-	-
LC22-5.1	0	40	4.2E-05	0.73	11	0.507	0.013	407	4.06E-02	510	5.14E-02	1,928	5.63E-02	2,939	4.31E-02	6.29E-09
LC22-5.2	0	40	4.1E-05	2.08	11	0.505	0.010	640	8.00E-02	703	8.74E-02	2,451	8.90E-02	4,338	7.90E-02	3.58E-09
LC22-5.3	0	40	4.1E-05	2.74	11	0.504	0.010	818	1.04E-01	898	1.13E-01	3,005	1.11E-01	5,385	9.97E-02	2.80E-09
LC22-5.4	0	40	4.1E-05	3.77	11	0.503	0.010	727	9.18E-02	791	9.90E-02	2,695	9.88E-02	4,750	8.71E-02	2.79E-09
LC22-5.5	0	40	4.1E-05	4.91	11	0.501	0.010	721	9.34E-02	779	1.00E-01	2,650	9.96E-02	5,119	9.65E-02	2.46E-09
LC22-5.6	0	40	4.1E-05	5.82	11	0.500	0.010	674	8.66E-02	731	9.32E-02	2,482	9.24E-02	4,336	8.09E-02	2.34E-09
LC22-5.7	0	40	4.1E-05	6.81	11	0.499	0.010	647	8.30E-02	698	8.89E-02	2,431	9.04E-02	4,149	7.73E-02	2.95E-09
LC22-5.8	0	40	4.1E-05	7.80	11	0.497	0.010	625	7.99E-02	669	8.49E-02	2,378	8.81E-02	4,267	7.94E-02	3.30E-09
LC22-5.9	0	40	3.9E-05	9.06	11	0.496	0.010	796	9.85E-02	872	1.07E-01	2,865	1.03E-01	5,188	9.32E-02	1.75E-09
LC22-5.10	0	40	4.1E-05	9.94	11	0.494	0.010	834	1.08E-01	907	1.16E-01	2,977	1.11E-01	5,385	1.01E-01	1.54E-09
LC22-5.11	0	40	4.0E-05	10.86	11	0.493	0.010	837	1.08E-01	908	1.16E-01	3,004	1.12E-01	5,420	1.01E-01	1.77E-09
Exp. #6																
LC22-6A	0	40	-	-	12	-	-	<10	-	<25	-	116	-	128	-	-
LC22-6B	0	40	-	-	12	-	-	<10	-	<25	-	122	-	126	-	-
LC22-6C	0	40	-	-	12	-	-	<10	-	<25	-	139	-	132	-	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-6.1	0	40	4.0E-05	0.73	12	0.506	0.013	629	6.23E-02	831	8.22E-02	2,736	7.87E-02	5,143	7.41E-02	6.56E-09
LC22-6.2	0	40	4.0E-05	2.08	12	0.504	0.010	1,092	1.37E-01	1,247	1.54E-01	4,264	1.55E-01	7,417	1.34E-01	7.33E-09
LC22-6.3	0	40	4.2E-05	2.74	12	0.502	0.010	1,183	1.57E-01	1,345	1.75E-01	4,480	1.72E-01	8,067	1.54E-01	6.25E-09
LC22-6.4	0	40	4.0E-05	3.77	12	0.500	0.010	1,065	1.36E-01	1,210	1.53E-01	4,133	1.54E-01	7,032	1.30E-01	6.90E-09
LC22-6.5	0	40	4.1E-05	4.91	12	0.498	0.010	1,076	1.40E-01	1,233	1.58E-01	4,136	1.56E-01	7,140	1.34E-01	6.47E-09
LC22-6.6	0	40	4.1E-05	5.82	12	0.496	0.010	1,056	1.37E-01	1,201	1.54E-01	4,115	1.55E-01	6,946	1.30E-01	7.21E-09
LC22-6.7	0	40	3.8E-05	6.81	12	0.494	0.010	1,084	1.34E-01	1,248	1.52E-01	4,185	1.50E-01	7,202	1.28E-01	6.44E-09
LC22-6.8	0	40	4.1E-05	7.80	12	0.492	0.010	987	1.29E-01	1,116	1.44E-01	3,762	1.42E-01	6,949	1.31E-01	5.38E-09
LC22-6.9	0	40	4.1E-05	9.06	12	0.489	0.010	1,220	1.60E-01	1,386	1.79E-01	4,548	1.73E-01	8,126	1.54E-01	5.23E-09
LC22-6.10	0	40	4.1E-05	9.94	12	0.487	0.010	1,223	1.62E-01	1,381	1.80E-01	4,607	1.77E-01	8,116	1.54E-01	6.02E-09
LC22-6.11	0	40	4.0E-05	10.86	12	0.485	0.010	1,215	1.61E-01	1,414	1.84E-01	4,580	1.76E-01	8,096	1.54E-01	6.04E-09
Exp. #7																
LC22-7.0	0	90	-	-	7	-	-	13	-	<50	-	<5000	-	<5000	-	-
LC22-7.1	0	90	-	-	7	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-7.2	0	90	-	-	7	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-7.3	0	90	1.7E-05	2.05	7	0.751	0.015	2,785	9.82E-02	223	7.40E-03	11,878	7.22E-02	ND	-	-
LC22-7.4	0	90	4.6E-05	2.87	7	0.742	0.015	6,696	6.72E-01	158	1.44E-02	24,997	5.91E-01	ND	-	-
LC22-7.5	0	90	5.4E-05	3.92	7	0.731	0.015	4,141	4.84E-01	110	1.13E-02	15,027	3.47E-01	ND	-	-
LC22-7.6	0	90	5.9E-05	4.89	7	0.721	0.014	3,415	4.45E-01	119	1.38E-02	12,224	2.79E-01	ND	-	-
LC22-7.7	0	90	5.2E-05	5.90	7	0.712	0.014	3,147	3.65E-01	121	1.26E-02	11,221	2.15E-01	ND	-	-
LC22-7.8	0	90	5.3E-05	6.90	7	0.705	0.014	2,989	3.58E-01	126	1.37E-02	10,942	2.12E-01	ND	-	-
LC22-7.9	0	90	5.3E-05	8.16	7	0.696	0.014	2,843	3.47E-01	118	1.29E-02	10,153	1.87E-01	ND	-	-
LC22-7.10	0	90	4.8E-05	9.10	7	0.688	0.014	3,083	3.42E-01	97	9.44E-03	11,001	1.98E-01	ND	-	-
Exp. #8																
LC22-8.0	0	90	-	-	8	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-8.1	0	90	-	-	8	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-8.2	0	90	-	-	8	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-8.3	0	90	5.7E-05	2.05	8	0.750	0.015	779	8.91E-02	459	5.32E-02	ND	-	ND	-	-
LC22-8.4	0	90	4.8E-05	2.87	8	0.748	0.015	869	8.60E-02	679	6.82E-02	ND	-	ND	-	-
LC22-8.5	0	90	5.2E-05	3.92	8	0.746	0.015	825	8.83E-02	695	7.57E-02	ND	-	ND	-	-
LC22-8.6	0	90	5.7E-05	4.89	8	0.744	0.015	803	9.39E-02	687	8.19E-02	ND	-	ND	-	-
LC22-8.7	0	90	5.3E-05	5.90	8	0.742	0.015	713	7.73E-02	595	6.63E-02	ND	-	ND	-	-
LC22-8.8	0	90	5.4E-05	6.90	8	0.740	0.015	736	8.12E-02	638	7.21E-02	ND	-	ND	-	-
LC22-8.9	0	90	5.4E-05	8.16	8	0.738	0.015	720	8.02E-02	627	7.17E-02	ND	-	ND	-	-
LC22-8.10	0	90	6.0E-05	9.10	8	0.736	0.015	705	8.64E-02	627	7.90E-02	ND	-	ND	-	-
Exp. #9																
LC22-9.0	0	90	-	-	9	-	-	10	-	<50	-	<5000	-	<5000	-	-
LC22-9.1	0	90	-	-	9	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-9.2	0	90	-	-	9	-	-	<10	-	<50	-	<5000	-	<5000	-	-
LC22-9.3	0	90	5.6E-05	2.05	9	0.500	0.010	1,268	2.21E-01	1,138	1.98E-01	5,455	2.41E-02	8,076	7.98E-02	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-9.4	0	90	5.8E-05	2.87	9	0.497	0.010	1,631	3.00E-01	1,457	2.67E-01	6,130	6.28E-02	10,094	1.39E-01	-
LC22-9.5	0	90	5.4E-05	3.92	9	0.492	0.010	1,632	2.79E-01	1,493	2.54E-01	5,787	4.06E-02	10,141	1.30E-01	-
LC22-9.6	0	90	5.3E-05	4.89	9	0.488	0.010	1,716	2.94E-01	1,584	2.70E-01	6,112	5.74E-02	10,771	1.46E-01	-
LC22-9.7	0	90	5.7E-05	5.90	9	0.484	0.010	1,532	2.83E-01	1,391	2.56E-01	5,524	2.92E-02	9,740	1.30E-01	-
LC22-9.8	0	90	5.3E-05	6.90	9	0.480	0.009	1,500	2.59E-01	1,420	2.44E-01	5,303	1.58E-02	9,696	1.20E-01	-
LC22-9.9	0	90	5.3E-05	8.16	9	0.476	0.009	1,383	2.41E-01	1,286	2.24E-01	ND	-	8,837	9.95E-02	-
LC22-9.10	0	90	4.7E-05	9.10	9	0.472	0.009	1,558	2.42E-01	1,471	2.28E-01	5,629	2.95E-02	10,129	1.18E-01	-
Exp. #10																
LC22-10.0	0	90	-	-	10	-	-	115	-	<50	-	<5000	-	<5000	-	-
LC22-10.1	0	90	-	-	10	-	-	80	-	<50	-	<5000	-	<5000	-	-
LC22-10.2	0	90	-	-	10	-	-	40	-	<50	-	<5000	-	<5000	-	-
LC22-10.3	0	90	5.3E-05	2.05	10	0.498	0.010	2,938	5.01E-01	2,308	3.76E-01	11,478	3.29E-01	15,556	2.62E-01	-
LC22-10.4	0	90	5.6E-05	2.87	10	0.490	0.010	3,606	6.59E-01	2,539	4.42E-01	12,632	4.13E-01	18,406	3.55E-01	-
LC22-10.5	0	90	1.8E-05	3.92	10	0.484	0.010	4,426	2.69E-01	2,625	1.52E-01	15,235	1.84E-01	21,214	1.43E-01	-
LC22-10.6	0	90	5.1E-05	4.89	10	0.477	0.009	3,868	6.59E-01	2,391	3.87E-01	13,419	4.25E-01	19,311	3.54E-01	-
LC22-10.7	0	90	5.2E-05	5.90	10	0.470	0.009	2,117	3.70E-01	1,768	2.93E-01	ND	-	11,478	1.66E-01	-
LC22-10.8	0	90	5.6E-05	6.90	10	0.463	0.009	3,089	5.95E-01	2,158	3.95E-01	10,677	3.25E-01	16,591	3.25E-01	-
LC22-10.9	0	90	5.4E-05	8.16	10	0.454	0.009	2,907	5.53E-01	2,023	3.66E-01	10,196	2.94E-01	15,836	3.00E-01	-
LC22-10.10	0	90	5.6E-05	9.10	10	0.445	0.009	3,180	6.30E-01	2,598	4.92E-01	11,047	3.56E-01	17,975	3.74E-01	-
Exp. #11																
LC22-11.0	0	90	-	-	11	-	-	21	-	<50	-	<5000	-	<5000	-	-
LC22-11.1	0	90	-	-	11	-	-	40	-	<50	-	<5000	-	<5000	-	-
LC22-11.2	0	90	-	-	11	-	-	56	-	<50	-	<5000	-	<5000	-	-
LC22-11.3	0	90	5.6E-05	2.05	11	0.495	0.010	4,233	7.67E-01	3,015	5.29E-01	15,088	5.41E-01	23,231	4.78E-01	-
LC22-11.4	0	90	5.4E-05	2.87	11	0.483	0.010	5,623	1.01E+00	3,325	5.76E-01	19,758	7.80E-01	28,473	6.07E-01	-
LC22-11.5	0	90	5.4E-05	3.92	11	0.467	0.009	6,064	1.13E+00	3,305	5.94E-01	20,605	8.54E-01	30,337	6.79E-01	-
LC22-11.6	0	90	5.1E-05	4.89	11	0.452	0.009	6,313	1.13E+00	3,287	5.67E-01	21,449	8.65E-01	31,500	6.82E-01	-
LC22-11.7	0	90	5.7E-05	5.90	11	0.436	0.009	6,140	1.28E+00	3,003	6.07E-01	21,133	9.94E-01	29,990	7.54E-01	-
LC22-11.8	0	90	5.3E-05	6.90	11	0.419	0.008	6,241	1.26E+00	2,933	5.74E-01	22,141	1.02E+00	29,885	7.28E-01	-
LC22-11.9	0	90	5.5E-05	8.16	11	0.401	0.008	5,840	1.27E+00	2,638	5.51E-01	19,936	9.54E-01	28,022	7.20E-01	-
LC22-11.10	0	90	5.7E-05	9.10	11	0.385	0.008	5,842	1.37E+00	2,699	6.13E-01	20,207	1.05E+00	28,282	7.91E-01	-
Exp. #12																
LC22-12.0	0	90	-	-	12	-	-	89	-	<50	-	<5000	-	<5000	-	-
LC22-12.1	0	90	-	-	12	-	-	116	-	<50	-	<5000	-	<5000	-	-
LC22-12.2	0	90	-	-	12	-	-	144	-	<50	-	<5000	-	<5000	-	-
LC22-12.3	0	90	5.3E-05	2.05	12	0.491	0.010	6,231	1.08E+00	5,242	8.69E-01	25,151	1.03E+00	35,259	7.57E-01	-
LC22-12.4	0	90	5.4E-05	2.87	12	0.464	0.009	14,544	2.68E+00	8,926	1.58E+00	51,960	2.54E+00	70,659	1.74E+00	-
LC22-12.5	0	90	2.4E-05	3.92	12	0.442	0.009	14,927	1.27E+00	8,462	6.93E-01	52,193	1.18E+00	70,376	8.01E-01	-
LC22-12.6	0	90	5.6E-05	4.89	12	0.405	0.008	17,559	3.82E+00	9,084	1.90E+00	60,967	3.57E+00	80,760	2.37E+00	-
LC22-12.7	0	90	5.4E-05	5.90	12	0.370	0.008	11,283	2.58E+00	6,332	1.38E+00	38,804	2.27E+00	54,004	1.61E+00	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-12.8	0	90	5.3E-05	6.90	12	0.344	0.007	9,825	2.38E+00	5,843	1.36E+00	33,779	2.05E+00	48,938	1.53E+00	-
LC22-12.9	0	90	5.5E-05	8.16	12	0.316	0.006	8,767	2.42E+00	5,259	1.38E+00	29,844	2.01E+00	43,639	1.53E+00	-
LC22-12.10	0	90	4.4E-05	9.10	12	0.294	0.006	9,275	2.18E+00	5,597	1.26E+00	31,357	1.82E+00	46,167	1.39E+00	-
Exp. #13																
LC22-13A	8.97E+02	23	-	-	9	-	-	<75	-	<25	-	<300	-	<1500	-	-
LC22-13B	8.97E+02	23	-	-	9	-	-	<75	-	<25	-	<300	-	<1500	-	-
LC22-13C	8.97E+02	23	-	-	9	-	-	<75	-	<25	-	<300	-	<1500	-	-
LC22-13.4	8.97E+02	23	9.9E-06	7.12	9	4.019	0.050	583	3.53E-03	343	1.64E-03	2,857	4.73E-03	3,169	1.51E-03	4.79E-10
LC22-13.8	8.97E+02	23	9.7E-06	14.25	9	4.018	0.079	550	2.06E-03	376	1.15E-03	2,187	2.16E-03	3,120	9.09E-04	4.79E-10
LC22-13.12	8.97E+02	23	9.5E-06	22.22	9	4.018	0.079	615	2.27E-03	563	1.82E-03	1,962	1.87E-03	3,930	1.34E-03	4.79E-10
LC22-13.16	8.97E+02	23	9.5E-06	33.09	9	4.017	0.079	635	2.34E-03	542	1.74E-03	2,041	1.95E-03	3,888	1.31E-03	4.79E-10
LC22-13.20	8.97E+02	23	9.6E-06	42.48	9	4.016	0.079	561	2.07E-03	458	1.44E-03	1,923	1.84E-03	3,368	1.04E-03	4.79E-10
LC22-13.24	8.97E+02	23	1.1E-05	52.10	9	4.016	0.079	463	1.93E-03	408	1.43E-03	1,527	1.58E-03	2,948	9.15E-04	4.79E-10
LC22-13.28	8.97E+02	23	9.6E-06	68.08	9	4.015	0.079	419	1.54E-03	417	1.30E-03	ND	1.05E-03	2,734	6.89E-04	4.79E-10
LC22-13.32	8.97E+02	23	9.8E-06	86.08	9	4.014	0.079	440	1.65E-03	414	1.30E-03	ND	1.26E-03	2,844	7.63E-04	4.79E-10
LC22-13.34	8.97E+02	23	9.7E-06	93.15	9	4.013	0.079	429	1.59E-03	391	1.21E-03	ND	1.25E-03	2,757	7.07E-04	4.79E-10
LC22-13.35	8.97E+02	23	9.6E-06	96.01	9	4.012	0.079	470	1.73E-03	496	1.59E-03	ND	1.18E-03	3,105	8.92E-04	4.79E-10
Exp. #14														16,562		
LC22-14A	1.51E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	16,737	-	-
LC22-14B	1.51E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	16,820	-	-
LC22-14C	1.51E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-		-	-
LC22-14.4	1.51E+04	23	9.8E-06	7.12	9	4.019	0.050	403	2.38E-03	112	2.27E-04	2,306	3.70E-03	18,118	1.27E-03	5.25E-10
LC22-14.8	1.51E+04	23	9.7E-06	14.25	9	4.018	0.079	366	1.34E-03	99	9.27E-05	1,674	1.57E-03	18,102	7.83E-04	9.43E-11
LC22-14.12	1.51E+04	23	9.4E-06	22.22	9	4.018	0.079	456	1.64E-03	237	5.97E-04	1,534	1.37E-03	19,608	1.58E-03	-
LC22-14.16	1.51E+04	23	9.5E-06	33.09	9	4.018	0.079	475	1.73E-03	226	5.66E-04	1,580	1.44E-03	19,591	1.59E-03	-
LC22-14.20	1.51E+04	23	9.6E-06	42.48	9	4.017	0.079	409	1.49E-03	154	2.99E-04	ND	1.16E-03	18,310	8.94E-04	-
LC22-14.24	1.51E+04	23	1.1E-05	52.10	9	4.017	0.079	367	1.52E-03	126	2.18E-04	ND	1.12E-03	17,791	6.89E-04	-
LC22-14.28	1.51E+04	23	9.7E-06	68.08	9	4.016	0.079	315	1.13E-03	109	1.29E-04	ND	8.31E-04	17,828	6.28E-04	-
LC22-14.32	1.51E+04	23	9.9E-06	86.08	9	4.015	0.079	335	1.23E-03	107	1.25E-04	ND	8.25E-04	17,813	6.31E-04	-
LC22-14.34	1.51E+04	23	9.9E-06	93.15	9	4.015	0.079	263	9.54E-04	ND	-	ND	7.94E-04	26,008	5.33E-03	-
LC22-14.35	1.51E+04	23	9.8E-06	96.01	9	4.014	0.079	266	9.51E-04	113	1.46E-04	ND	6.41E-04	21,511	2.72E-03	-
Exp. #15																
LC22-15A	3.01E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	34,050	-	-
LC22-15B	3.01E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	33,267	-	-
LC22-15C	3.01E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	33,880	-	-
LC22-15.4	3.01E+04	23	9.8E-06	7.12	9	4.029	0.050	319	1.84E-03	75	3.00E-06	2,002	3.12E-03	34,851	1.00E-03	5.10E-10
LC22-15.8	3.01E+04	23	9.7E-06	14.25	9	4.029	0.079	257	9.05E-04	ND	-	ND	1.22E-03	35,190	8.16E-04	1.27E-10
LC22-15.12	3.01E+04	23	9.4E-06	22.22	9	4.028	0.079	310	1.08E-03	120	1.66E-04	ND	1.02E-03	36,441	1.47E-03	-
LC22-15.16	3.01E+04	23	9.5E-06	33.09	9	4.028	0.079	367	1.31E-03	130	2.04E-04	ND	1.09E-03	35,755	1.11E-03	-
LC22-15.20	3.01E+04	23	9.5E-06	42.48	9	4.028	0.079	283	9.90E-04	78	1.04E-05	ND	7.19E-04	34,858	6.19E-04	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-15.24	3.01E+04	23	1.1E-05	52.10	9	4.027	0.079	197	7.52E-04	ND	-	ND	4.68E-04	34,285	3.46E-04	-
LC22-15.28	3.01E+04	23	9.6E-06	68.08	9	4.027	0.079	143	4.54E-04	ND	-	ND	1.80E-04	34,928	6.60E-04	-
LC22-15.32	3.01E+04	23	9.7E-06	86.08	9	4.027	0.079	146	4.70E-04	ND	-	ND	1.21E-04	35,765	1.13E-03	-
LC22-15.34	3.01E+04	23	9.6E-06	93.15	9	4.027	0.079	114	3.48E-04	ND	-	ND	2.32E-04	44,486	5.99E-03	-
LC22-15.35	3.01E+04	23	9.5E-06	96.01	9	4.026	0.079	117	3.54E-04	ND	-	ND	1.19E-04	38,972	2.89E-03	-
Exp. #16																
LC22-16A	4.60E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	50,494	-	-
LC22-16B	4.60E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	51,318	-	-
LC22-16C	4.60E+04	23	-	-	9	-	-	<75	-	<25	-	<300	-	50,956	-	-
LC22-16.4	4.60E+04	23	9.9E-06	7.12	9	4.043	0.050	252	1.43E-03	ND	-	1,869	2.89E-03	52,219	1.17E-03	5.84E-10
LC22-16.8	4.60E+04	23	9.9E-06	14.25	9	4.043	0.080	172	5.81E-04	ND	-	ND	8.76E-04	52,641	9.76E-04	1.17E-10
LC22-16.12	4.60E+04	23	9.4E-06	22.22	9	4.043	0.080	155	4.92E-04	ND	-	ND	5.53E-04	52,679	9.54E-04	2.45E-11
LC22-16.16	4.60E+04	23	9.6E-06	33.09	9	4.042	0.080	179	5.98E-04	ND	-	ND	4.62E-04	52,155	6.83E-04	-
LC22-16.20	4.60E+04	23	9.7E-06	42.48	9	4.042	0.080	133	4.20E-04	ND	-	ND	1.55E-04	50,432	-	-
LC22-16.24	4.60E+04	23	1.1E-05	52.10	9	4.042	0.080	85	2.65E-04	ND	-	ND	ND	51,732	5.12E-04	-
LC22-16.28	4.60E+04	23	9.7E-06	68.08	9	4.042	0.080	57	1.25E-04	ND	-	ND	ND	49,389	-	-
LC22-16.32	4.60E+04	23	9.7E-06	86.08	9	4.042	0.080	45	7.95E-05	ND	-	ND	ND	53,499	1.44E-03	-
LC22-16.34	4.60E+04	23	9.8E-06	93.15	9	4.042	0.080	41	6.11E-05	ND	-	ND	ND	45,589	-	-
LC22-16.35	4.60E+04	23	9.6E-06	96.01	9	4.042	0.080	47	8.53E-05	ND	-	ND	ND	47,787	-	-
Exp. #17																
LC22-17A	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	66,537	-	-
LC22-17B	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	67,719	-	-
LC22-17C	6.04E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	68,493	-	-
LC22-17.4	6.04E+04	23	9.9E-06	7.12	9	4.024	0.050	219	1.23E-03	ND	-	1,652	2.51E-03	67,528	-	5.10E-10
LC22-17.8	6.04E+04	23	9.7E-06	14.25	9	4.024	0.079	129	4.07E-04	ND	-	ND	6.95E-04	67,729	8.21E-05	1.15E-10
LC22-17.12	6.04E+04	23	9.7E-06	22.22	9	4.024	0.079	110	3.33E-04	ND	-	ND	4.20E-04	69,279	9.50E-04	3.47E-11
LC22-17.16	6.04E+04	23	9.5E-06	33.09	9	4.024	0.079	108	3.16E-04	ND	-	ND	1.91E-04	69,906	1.27E-03	-
LC22-17.20	6.04E+04	23	9.6E-06	42.48	9	4.023	0.079	79	2.10E-04	ND	-	ND	-	65,455	-	-
LC22-17.24	6.04E+04	23	1.1E-05	52.10	9	4.023	0.079	49	1.08E-04	ND	-	ND	-	73,149	3.54E-03	-
LC22-17.28	6.04E+04	23	9.5E-06	68.08	9	4.023	0.079	32	2.84E-05	ND	-	ND	-	66,828	-	-
LC22-17.32	6.04E+04	23	9.7E-06	86.08	9	4.023	0.079	25	-	ND	-	ND	-	66,252	-	-
LC22-17.34	6.04E+04	23	9.7E-06	93.15	9	4.023	0.079	ND	-	ND	-	ND	-	60,505	-	-
LC22-17.35	6.04E+04	23	1.1E-05	96.01	9	4.023	0.079	27	7.59E-06	ND	-	ND	-	65,206	-	-
Exp. #18																
LC22-18A	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	52,478	-	-
LC22-18B	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	58,366	-	-
LC22-18C	5.24E+04	23	-	-	9	-	-	<25	-	<75	-	<300	-	64,021	-	-
LC22-18.4	5.24E+04	23	9.8E-06	7.12	9	4.006	0.050	219	1.22E-03	ND	-	1,709	2.59E-03	80,716	2.02E-02	5.49E-10
LC22-18.8	5.24E+04	23	9.7E-06	14.25	9	4.006	0.079	126	3.96E-04	ND	-	ND	7.72E-04	83,342	1.41E-02	1.50E-10
LC22-18.12	5.24E+04	23	9.5E-06	22.22	9	4.006	0.079	94	2.64E-04	ND	-	ND	4.09E-04	87,968	1.64E-02	5.76E-11

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-18.16	5.24E+04	23	9.6E-06	33.09	9	4.006	0.079	67	1.63E-04	ND	-	ND	1.05E-04	86,660	1.57E-02	-
LC22-18.20	5.24E+04	23	9.6E-06	42.48	9	4.006	0.079	47	8.68E-05	ND	-	ND	-	84,554	1.47E-02	-
LC22-18.24	5.24E+04	23	1.1E-05	52.10	9	4.005	0.079	28	1.51E-05	ND	-	ND	-	83,996	1.65E-02	-
LC22-18.28	5.24E+04	23	9.6E-06	68.08	9	4.005	0.079	ND	-	ND	-	ND	-	79,439	1.17E-02	-
LC22-18.32	5.24E+04	23	9.8E-06	86.08	9	4.005	0.079	ND	-	ND	-	ND	-	87,437	1.65E-02	-
LC22-18.34	5.24E+04	23	9.8E-06	93.15	9	4.005	0.079	ND	-	ND	-	ND	-	77,134	1.07E-02	-
LC22-18.35	5.24E+04	23	9.7E-06	96.01	9	4.005	0.079	ND	-	ND	-	ND	-	80,981	1.28E-02	-
Exp. #19																
LC22-19A	0	23	-	-	7	-	-	<50	-	<10	-	<100	-	<500	-	-
LC22-19B	0	23	-	-	7	-	-	<50	-	<10	-	<100	-	<500	-	-
LC22-19C	0	23	-	-	7	-	-	<50	-	11	-	<100	-	<500	-	-
LC22-19.1	0	23	7.4E-06	2.05	7	1.004	0.020	261	2.51E-03	42	3.71E-04	1,956	6.47E-03	ND	-	1.58E-09
LC22-19.2	0	23	8.8E-06	3.84	7	1.004	0.020	245	2.78E-03	ND	-	1,760	6.90E-03	ND	-	1.65E-09
LC22-19.4	0	23	9.2E-06	8.85	7	1.004	0.020	160	1.63E-03	10	-	1,044	4.12E-03	ND	-	9.92E-10
LC22-19.6	0	23	7.9E-06	15.82	7	1.003	0.020	ND	-	41	3.81E-04	372	1.01E-03	ND	-	4.32E-10
LC22-19.9	0	23	9.6E-06	22.81	7	1.003	0.020	ND	-	40	4.42E-04	204	4.75E-04	ND	-	3.15E-10
LC22-19.12	0	23	9.7E-06	30.98	7	1.003	0.020	ND	-	34	3.57E-04	159	2.72E-04	ND	-	2.88E-10
LC22-19.14	0	23	9.8E-06	38.92	7	1.003	0.020	ND	-	32	3.36E-04	146	2.11E-04	ND	-	2.64E-10
Exp. #20																
LC22-20A	0	23	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LC22-20B	0	23	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LC22-20C	0	23	-	-	8	-	-	<50	-	<10	-	<100	-	<500	-	-
LC22-20.1	0	23	9.2E-06	2.05	8	1.005	0.020	153	1.53E-03	21	1.58E-04	1,359	1.36E+03	ND	-	1.58E-09
LC22-20.2	0	23	9.6E-06	3.84	8	1.005	0.020	133	1.28E-03	34	3.59E-04	1,099	1.10E+03	ND	-	1.30E-09
LC22-20.4	0	23	1.0E-05	8.85	8	1.005	0.020	79	4.74E-04	43	5.19E-04	611	6.11E+02	ND	-	7.70E-10
LC22-20.6	0	23	4.7E-06	15.82	8	1.005	0.020	83	2.56E-04	ND	-	543	5.43E+02	ND	-	2.94E-10
LC22-20.9	0	23	8.6E-06	22.81	8	1.005	0.020	ND	-	ND	-	287	2.87E+02	ND	-	3.31E-10
LC22-20.12	0	23	9.1E-06	30.98	8	1.005	0.020	ND	-	ND	-	220	2.20E+02	ND	-	2.99E-10
LC22-20.14	0	23	8.9E-06	38.92	8	1.005	0.020	ND	-	ND	4.60E-06	185	1.85E+02	ND	-	2.51E-10
Exp. #21																
LC22-21A	0	23	-	-	9	-	-	<50	-	14	-	<100	-	<500	-	-
LC22-21B	0	23	-	-	9	-	-	<50	-	152	-	<100	-	<500	-	-
LC22-21C	0	23	-	-	9	-	-	<50	-	14	-	<100	-	<500	-	-
LC22-21.1	0	23	9.0E-06	2.05	9	1.004	0.020	132	1.20E-03	64	5.54E-05	1,231	4.82E-03	500	8.13E-07	1.45E-09
LC22-21.2	0	23	9.7E-06	3.84	9	1.004	0.020	157	1.67E-03	112	7.92E-04	1,116	4.66E-03	830	7.42E-04	1.19E-09
LC22-21.4	0	23	9.9E-06	8.85	9	1.004	0.020	171	1.95E-03	167	1.68E-03	799	3.28E-03	1,114	1.41E-03	5.32E-10
LC22-21.6	0	23	7.7E-06	15.82	9	1.003	0.020	154	1.29E-03	166	1.28E-03	610	1.85E-03	1,082	1.03E-03	2.25E-10
LC22-21.9	0	23	9.6E-06	22.81	9	1.003	0.020	131	1.25E-03	171	1.67E-03	447	1.57E-03	1,007	1.12E-03	1.27E-10
LC22-21.12	0	23	9.1E-06	30.98	9	1.003	0.020	158	1.59E-03	184	1.78E-03	530	1.85E-03	1,156	1.38E-03	1.03E-10
LC22-21.14	0	23	9.2E-06	38.92	9	1.003	0.020	168	1.75E-03	176	1.67E-03	601	2.18E-03	1,186	1.46E-03	1.71E-10

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
Exp. #22																
LC22-22A	0	23	-	-	10	-	-	<50	-	14	-	<100	-	<500	-	-
LC22-22B	0	23	-	-	10	-	-	<50	-	12	-	<100	-	<500	-	-
LC22-22C	0	23	-	-	10	-	-	<50	-	12	-	<100	-	<500	-	-
LC22-22.1	0	23	9.6E-06	2.05	10	0.506	0.013	140	2.20E-03	191	4.24E-03	752	4.66E-03	1,111	2.14E-03	9.83E-10
LC22-22.2	0	23	9.6E-06	3.84	10	0.506	0.010	235	5.68E-03	300	8.59E-03	939	7.55E-03	1,846	5.92E-03	7.45E-10
LC22-22.4	0	23	9.7E-06	8.85	10	0.506	0.010	288	7.42E-03	330	9.60E-03	1,021	8.40E-03	2,084	7.07E-03	3.91E-10
LC22-22.6	0	23	7.8E-06	15.82	10	0.505	0.010	261	5.30E-03	285	6.65E-03	910	5.96E-03	1,826	4.78E-03	2.61E-10
LC22-22.9	0	23	9.5E-06	22.81	10	0.505	0.010	229	5.49E-03	265	7.50E-03	756	5.87E-03	1,685	5.19E-03	1.52E-10
LC22-22.12	0	23	9.9E-06	30.98	10	0.505	0.010	226	5.62E-03	245	7.19E-03	776	6.29E-03	1,605	5.04E-03	2.68E-10
LC22-22.14	0	23	9.9E-06	38.92	10	0.504	0.010	173	3.95E-03	180	5.18E-03	645	5.09E-03	1,174	3.08E-03	4.57E-10
Exp. #23																
LC22-23A	0	23	-	-	11	-	-	<50	-	24	-	<100	-	747	-	-
LC22-23B	0	23	-	-	11	-	-	<50	-	179	-	<100	-	820	-	-
LC22-23C	0	23	-	-	11	-	-	<50	-	27	-	<100	-	789	-	-
LC22-23.1	0	23	9.2E-06	2.05	11	0.503	0.013	285	5.56E-03	355	6.38E-03	1,065	6.67E-03	2,916	7.22E-03	4.43E-10
LC22-23.2	0	23	9.8E-06	3.84	11	0.502	0.010	595	1.72E-02	689	1.88E-02	1,928	1.69E-02	4,941	1.88E-02	-
LC22-23.4	0	23	9.7E-06	8.85	11	0.502	0.010	760	2.23E-02	830	2.30E-02	2,441	2.15E-02	5,699	2.21E-02	-
LC22-23.6	0	23	7.9E-06	15.82	11	0.501	0.010	729	1.74E-02	784	1.76E-02	2,369	1.70E-02	5,349	1.68E-02	-
LC22-23.9	0	23	9.3E-06	22.81	11	0.500	0.010	727	2.05E-02	777	2.06E-02	2,351	2.00E-02	5,302	1.96E-02	-
LC22-23.12	0	23	9.2E-06	30.98	11	0.499	0.010	663	1.84E-02	704	1.83E-02	2,115	1.77E-02	4,836	1.74E-02	-
LC22-23.14	0	23	9.1E-06	38.92	11	0.499	0.010	502	1.34E-02	485	1.18E-02	1,742	1.43E-02	3,403	1.11E-02	-
Exp. #24																
LC22-24A	0	23	-	-	12	-	-	53	-	24	-	<100	-	1,141	-	-
LC22-24B	0	23	-	-	12	-	-	<50	-	26	-	<100	-	1,135	-	-
LC22-24C	0	23	-	-	12	-	-	54	-	40	-	<100	-	1,215	-	-
LC22-24.1	0	23	9.5E-06	2.05	12	0.503	0.013	501	1.10E-02	630	1.42E-02	1,735	1.17E-02	4,882	1.30E-02	-
LC22-24.2	0	23	9.4E-06	3.84	12	0.502	0.010	983	2.84E-02	1,155	3.33E-02	3,304	2.86E-02	8,146	3.05E-02	-
LC22-24.4	0	23	9.9E-06	8.85	12	0.501	0.010	1,226	3.75E-02	1,380	4.19E-02	4,017	3.66E-02	9,420	3.78E-02	-
LC22-24.6	0	23	7.9E-06	15.82	12	0.499	0.010	1,171	2.89E-02	1,319	3.23E-02	3,763	2.76E-02	8,927	2.87E-02	-
LC22-24.9	0	23	9.1E-06	22.81	12	0.498	0.010	1,282	3.66E-02	1,404	3.96E-02	4,102	3.48E-02	9,616	3.60E-02	-
LC22-24.12	0	23	7.8E-06	30.98	12	0.497	0.010	1,340	3.28E-02	1,465	3.55E-02	4,192	3.05E-02	10,084	3.26E-02	-
LC22-24.14	0	23	9.1E-06	38.92	12	0.495	0.010	1,428	4.08E-02	1,564	4.42E-02	4,545	3.85E-02	10,650	4.03E-02	-
Exp. #25																
LC22-25A	0	70	-	-	7	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-25.1	0	70	-	-	7	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-25.2	0	70	5.7E-05	2.02	7	1.004	0.036	1,158	5.61E-02	ND	-	5,392	7.83E-02	1,137	4.62E-03	8.87E-09
LC22-25.4	0	70	5.7E-05	4.16	7	1.001	0.020	1,259	1.13E-01	ND	-	4,667	1.24E-01	603	1.37E-03	4.69E-09
LC22-25.6	0	70	5.5E-05	6.02	7	0.997	0.020	1,009	8.52E-02	49	2.08E-03	3,434	8.66E-02	ND	-	5.73E-10
LC22-25.8	0	70	4.8E-05	8.03	7	0.994	0.020	992	7.35E-02	50	1.88E-03	3,393	7.51E-02	ND	-	6.47E-10

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-25.9	0	70	6.1E-05	8.91	7	0.992	0.020	875	8.25E-02	41	1.54E-03	2,983	8.43E-02	ND	-	7.07E-10
LC22-25.10	0	70	5.3E-05	9.24	7	0.991	0.020	859	6.97E-02	36	9.18E-04	2,992	7.28E-02	ND	-	1.26E-09
LC22-25.11	0	70	5.9E-05	9.88	7	0.989	0.020	852	7.76E-02	66	3.81E-03	2,967	8.12E-02	ND	-	1.42E-09
Exp. #26																
LC22-26A	0	70	-	-	8	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-26.1	0	70	-	-	8	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-26.2	0	70	6.0E-05	2.02	8	1.001	0.036	481	2.29E-02	159	6.92E-03	3,298	4.97E-02	1,825	1.01E-02	1.07E-08
LC22-26.4	0	70	5.7E-05	4.16	8	1.000	0.020	308	2.40E-02	228	1.83E-02	1,557	3.97E-02	1,512	1.35E-02	6.25E-09
LC22-26.6	0	70	5.3E-05	6.02	8	0.992	0.020	3,760	3.22E-01	4,109	3.45E-01	13,706	3.46E-01	23,638	2.88E-01	9.33E-09
LC22-26.8	0	70	5.1E-05	8.03	8	0.987	0.020	263	1.78E-02	200	1.42E-02	988	2.17E-02	1,328	9.93E-03	1.57E-09
LC22-26.9	0	70	6.1E-05	8.91	8	0.987	0.020	234	1.84E-02	187	1.58E-02	896	2.33E-02	1,251	1.08E-02	1.95E-09
LC22-26.10	0	70	4.1E-05	9.24	8	0.986	0.019	216	1.12E-02	179	1.01E-02	827	1.44E-02	1,167	6.48E-03	1.27E-09
LC22-26.11	0	70	5.9E-05	9.88	8	0.986	0.019	219	1.63E-02	186	1.51E-02	831	2.07E-02	1,196	9.63E-03	1.72E-09
Exp. #27																
LC22-27A	0	70	-	-	9	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-27.1	0	70	-	-	9	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-27.2	0	70	5.5E-05	2.02	9	1.001	0.036	639	2.88E-02	503	2.27E-02	503	4.60E-02	4,049	2.49E-02	6.87E-09
LC22-27.4	0	70	5.7E-05	4.16	9	0.999	0.020	762	6.60E-02	754	6.56E-02	754	7.65E-02	5,109	6.12E-02	4.19E-09
LC22-27.6	0	70	5.4E-05	6.02	9	0.996	0.020	830	6.86E-02	868	7.19E-02	868	7.14E-02	5,427	6.20E-02	1.11E-09
LC22-27.8	0	70	5.1E-05	8.03	9	0.994	0.020	884	6.95E-02	888	6.98E-02	888	6.94E-02	5,584	6.07E-02	-
LC22-27.9	0	70	6.0E-05	8.91	9	0.992	0.020	835	7.77E-02	862	8.04E-02	862	7.88E-02	5,367	6.89E-02	4.34E-10
LC22-27.10	0	70	5.2E-05	9.24	9	0.990	0.020	827	6.61E-02	832	6.67E-02	832	6.69E-02	5,269	5.82E-02	3.17E-10
LC22-27.11	0	70	5.6E-05	9.88	9	0.989	0.020	808	7.00E-02	825	7.17E-02	825	7.20E-02	5,265	6.30E-02	7.77E-10
Exp. #28																
LC22-28A	0	70	-	-	10	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-28.1	0	70	-	-	10	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-28.2	0	70	5.6E-05	2.02	10	0.506	0.023	730	5.35E-02	768	5.67E-02	2,958	6.57E-02	4,675	4.70E-02	4.89E-09
LC22-28.4	0	70	5.7E-05	4.16	10	0.503	0.010	1,106	1.95E-01	1,115	1.95E-01	3,845	2.02E-01	6,842	1.68E-01	2.88E-09
LC22-28.6	0	70	5.4E-05	6.02	10	0.499	0.010	1,015	1.70E-01	1,030	1.72E-01	3,415	1.71E-01	6,386	1.49E-01	3.06E-10
LC22-28.8	0	70	5.3E-05	8.03	10	0.497	0.010	944	1.54E-01	1,005	1.63E-01	3,135	1.53E-01	6,001	1.35E-01	-
LC22-28.9	0	70	5.6E-05	8.91	10	0.494	0.010	965	1.69E-01	1,026	1.80E-01	3,205	1.68E-01	6,088	1.48E-01	-
LC22-28.10	0	70	5.2E-05	9.24	10	0.493	0.010	914	1.47E-01	941	1.51E-01	3,050	1.46E-01	5,725	1.27E-01	-
LC22-28.11	0	70	5.9E-05	9.88	10	0.492	0.010	922	1.70E-01	936	1.72E-01	3,127	1.72E-01	5,822	1.48E-01	9.86E-10
Exp. #29																
LC22-29A	0	70	-	-	11	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-29.1	0	70	-	-	11	-	-	<50	-	<25	-	<100	-	<500	-	-
LC22-29.2	0	70	6.6E-05	2.02	11	0.502	0.023	1,266	1.14E-01	1,323	1.18E-01	4,588	1.23E-01	7,923	9.94E-02	3.60E-09
LC22-29.4	0	70	5.7E-05	4.16	11	0.494	0.010	2,856	5.20E-01	2,525	4.50E-01	9,740	5.22E-01	16,275	4.19E-01	9.64E-10
LC22-29.6	0	70	5.5E-05	6.02	11	0.485	0.010	2,958	5.35E-01	2,619	4.63E-01	9,861	5.25E-01	16,829	4.30E-01	-
LC22-29.8	0	70	5.2E-05	8.03	11	0.475	0.009	3,320	5.75E-01	2,673	4.52E-01	11,230	5.73E-01	18,525	4.54E-01	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-29.9	0	70	5.6E-05	8.91	11	0.467	0.009	3,162	6.05E-01	2,564	4.79E-01	10,546	5.94E-01	17,717	4.79E-01	-
LC22-29.10	0	70	5.2E-05	9.24	11	0.463	0.009	3,122	5.59E-01	2,469	4.32E-01	10,515	5.54E-01	17,365	4.40E-01	-
LC22-29.11	0	70	5.8E-05	9.88	11	0.459	0.009	3,104	6.30E-01	2,361	4.68E-01	10,343	6.18E-01	17,042	4.89E-01	-
Exp. #30																
LC22-30A	0	70	-	-	12	-	-	<50	-	39	-	<100	-	<500	-	-
LC22-30.1	0	70	-	-	12	-	-	<50	-	50	-	<100	-	<500	-	-
LC22-30.2	0	70	5.7E-05	2.02	12	0.505	0.023	2,299	1.80E-01	2,620	2.01E-01	8,323	1.93E-01	15,137	1.68E-01	4.99E-09
LC22-30.4	0	70	5.7E-05	4.16	12	0.496	0.010	3,581	6.57E-01	3,824	6.82E-01	13,278	7.17E-01	22,492	5.86E-01	2.39E-08
LC22-30.6	0	70	5.5E-05	6.02	12	0.484	0.010	3,718	6.68E-01	4,067	7.11E-01	13,599	7.18E-01	23,374	5.96E-01	2.03E-08
LC22-30.8	0	70	4.5E-05	8.03	12	0.471	0.009	5,591	8.53E-01	5,905	8.75E-01	20,830	9.33E-01	33,414	7.25E-01	3.20E-08
LC22-30.9	0	70	6.1E-05	8.91	12	0.459	0.009	4,272	9.10E-01	4,609	9.55E-01	15,764	9.88E-01	26,340	7.98E-01	3.08E-08
LC22-30.10	0	70	5.3E-05	9.24	12	0.453	0.009	4,344	8.06E-01	4,639	8.38E-01	16,082	8.78E-01	26,395	6.96E-01	2.84E-08
LC22-30.11	0	70	5.2E-05	9.88	12	0.447	0.009	4,400	8.25E-01	4,727	8.62E-01	16,115	8.88E-01	27,155	7.24E-01	2.52E-08
Exp. #31																
LC22-31.A	8.82E+02	40	-	-	9	-	-	<50	-	<10	-	<50	-	<1000	-	-
LC22-31.2	8.82E+02	40	1.9E-05	0.89	9	0.504	0.013	218	8.22E-03	206	9.32E-03	944	1.28E-02	1,399	2.79E-03	1.82E-09
LC22-31.4	8.82E+02	40	1.9E-05	3.34	9	0.504	0.010	260	1.26E-02	261	1.46E-02	923	1.53E-02	1,761	6.53E-03	1.08E-09
LC22-31.7	8.82E+02	40	1.8E-05	6.01	9	0.503	0.010	278	1.36E-02	293	1.63E-02	930	1.53E-02	1,905	7.71E-03	7.00E-10
LC22-31.13	8.82E+02	40	1.8E-05	14.14	9	0.503	0.010	279	1.35E-02	293	1.62E-02	965	1.57E-02	1,929	7.82E-03	8.98E-10
LC22-31.16	8.82E+02	40	1.2E-05	19.80	9	0.503	0.010	332	1.12E-02	344	1.29E-02	1,124	1.25E-02	2,288	7.32E-03	5.05E-10
LC22-31.20	8.82E+02	40	1.8E-05	26.92	9	0.502	0.010	293	1.39E-02	306	1.64E-02	976	1.55E-02	2,011	8.28E-03	6.40E-10
LC22-31.21	8.82E+02	40	1.8E-05	28.03	9	0.502	0.010	296	1.47E-02	307	1.72E-02	985	1.63E-02	2,012	8.67E-03	6.58E-10
LC22-31.22	8.82E+02	40	1.8E-05	28.95	9	0.502	0.010	293	1.43E-02	307	1.70E-02	984	1.61E-02	2,026	8.68E-03	7.19E-10
LC22-31.23	8.82E+02	40	1.8E-05	31.94	9	0.501	0.010	269	1.30E-02	280	1.56E-02	911	1.50E-02	1,864	7.37E-03	7.77E-10
Exp. #32																
LC22-32.A	1.61E+04	40	-	-	9	-	-	<50	-	<10	-	<50	-	16,581	-	-
LC22-32.2	1.61E+04	40	1.7E-05	0.89	9	0.507	0.013	207	6.64E-03	164	6.34E-03	891	1.04E-02	17,475	5.41E-03	1.50E-09
LC22-32.4	1.61E+04	40	1.9E-05	3.34	9	0.507	0.010	220	1.02E-02	201	1.11E-02	803	1.32E-02	18,087	1.29E-02	1.19E-09
LC22-32.7	1.61E+04	40	1.9E-05	6.01	9	0.507	0.010	208	9.51E-03	194	1.08E-02	717	1.18E-02	17,868	1.11E-02	8.94E-10
LC22-32.13	1.61E+04	40	1.9E-05	14.14	9	0.506	0.010	212	9.69E-03	211	1.17E-02	726	1.18E-02	18,201	1.39E-02	8.54E-10
LC22-32.16	1.61E+04	40	1.5E-05	19.80	9	0.506	0.010	216	7.75E-03	211	9.12E-03	733	9.34E-03	18,548	1.32E-02	6.35E-10
LC22-32.20	1.61E+04	40	1.9E-05	26.92	9	0.506	0.010	206	9.52E-03	203	1.14E-02	725	1.21E-02	18,156	1.38E-02	1.01E-09
LC22-32.21	1.61E+04	40	1.9E-05	28.03	9	0.505	0.010	201	9.03E-03	200	1.11E-02	692	1.13E-02	18,196	1.39E-02	8.88E-10
LC22-32.22	1.61E+04	40	1.8E-05	28.95	9	0.505	0.010	202	8.91E-03	204	1.11E-02	705	1.13E-02	18,135	1.31E-02	9.38E-10
LC22-32.23	1.61E+04	40	1.9E-05	31.94	9	0.505	0.010	196	8.78E-03	199	1.10E-02	678	1.11E-02	18,301	1.48E-02	9.11E-10
Exp. #33																
LC22-33.A	3.21E+04	40	-	-	9	-	-	<50	-	<10	-	<50	-	37,072	-	-
LC22-33.2	3.21E+04	40	1.9E-05	0.89	9	1.006	0.020	264	6.73E-03	148	4.20E-03	1,402	1.24E-02	38,024	4.28E-03	2.27E-09
LC22-33.4	3.21E+04	40	1.9E-05	3.34	9	1.006	0.020	252	6.16E-03	153	4.22E-03	1,109	9.44E-03	38,096	4.47E-03	1.31E-09
LC22-33.7	3.21E+04	40	1.9E-05	6.01	9	1.005	0.020	228	5.36E-03	153	4.19E-03	916	7.64E-03	38,397	5.73E-03	9.08E-10

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-33.13	3.21E+04	40	1.9E-05	14.14	9	1.005	0.020	229	5.36E-03	164	4.48E-03	871	7.19E-03	38,504	6.14E-03	7.30E-10
LC22-33.16	3.21E+04	40	1.5E-05	19.80	9	1.005	0.020	213	3.81E-03	152	3.24E-03	812	5.23E-03	38,439	4.59E-03	5.64E-10
LC22-33.20	3.21E+04	40	1.9E-05	26.92	9	1.004	0.020	256	6.37E-03	167	4.70E-03	977	8.37E-03	38,121	4.64E-03	7.97E-10
LC22-33.21	3.21E+04	40	1.9E-05	28.03	9	1.004	0.020	241	5.89E-03	172	4.85E-03	894	7.60E-03	38,394	5.82E-03	6.81E-10
LC22-33.22	3.21E+04	40	1.8E-05	28.95	9	1.004	0.020	224	5.16E-03	152	4.11E-03	868	7.11E-03	38,404	5.67E-03	7.78E-10
LC22-33.23	3.21E+04	40	1.9E-05	31.94	9	1.004	0.020	204	4.71E-03	141	3.87E-03	784	6.55E-03	38,449	6.02E-03	7.35E-10
Exp. #34																
LC22-34.A	4.78E+04	40	-	-	9	-	-	<50	-	<10	-	<50	-	55,922	-	-
LC22-34.2	4.78E+04	40	1.7E-05	0.89	9	1.006	0.020	246	5.37E-03	136	3.35E-03	1,452	1.12E-02	51,344	-	2.34E-09
LC22-34.4	4.78E+04	40	1.8E-05	3.34	9	1.006	0.020	231	5.40E-03	139	3.74E-03	1,147	9.55E-03	54,958	-	1.66E-09
LC22-34.7	4.78E+04	40	1.8E-05	6.01	9	1.005	0.020	198	4.39E-03	128	3.41E-03	918	7.54E-03	54,642	-	1.26E-09
LC22-34.13	4.78E+04	40	1.9E-05	14.14	9	1.005	0.020	172	3.65E-03	134	3.60E-03	733	5.98E-03	55,362	-	9.30E-10
LC22-34.16	4.78E+04	40	1.4E-05	19.80	9	1.005	0.020	178	2.99E-03	133	2.79E-03	746	4.75E-03	55,586	-	6.99E-10
LC22-34.20	4.78E+04	40	1.9E-05	26.92	9	1.005	0.020	160	3.35E-03	118	3.21E-03	670	5.52E-03	55,678	-	8.65E-10
LC22-34.21	4.78E+04	40	1.8E-05	28.03	9	1.005	0.020	159	3.25E-03	125	3.32E-03	684	5.50E-03	55,776	-	8.98E-10
LC22-34.22	4.78E+04	40	1.8E-05	28.95	9	1.004	0.020	156	3.11E-03	119	3.10E-03	656	5.19E-03	55,935	5.73E-05	8.30E-10
LC22-34.23	4.78E+04	40	1.9E-05	31.94	9	1.004	0.020	151	3.05E-03	115	3.06E-03	633	5.12E-03	57,610	7.27E-03	8.28E-10
Exp. #35																
LC22-35.A	6.89E+04	40	-	-	9	-	-	<50	-	<10	-	<50	-	73,508	-	-
LC22-35.2	6.89E+04	40	-6.5E-05	0.89	9	2.004	0.031	334	-	129	-	2,275	-	71,175	2.23E-02	-
LC22-35.4	6.89E+04	40	1.9E-05	3.34	9	2.004	0.040	272	3.36E-03	206	2.89E-03	1,562	6.70E-03	72,088	-	1.33E-09
LC22-35.7	6.89E+04	40	1.9E-05	6.01	9	2.004	0.040	225	2.64E-03	104	1.38E-03	1,189	5.03E-03	73,844	7.27E-04	9.55E-10
LC22-35.13	6.89E+04	40	1.9E-05	14.14	9	2.003	0.040	161	1.67E-03	83	1.07E-03	823	3.41E-03	76,453	6.37E-03	6.95E-10
LC22-35.16	6.89E+04	40	1.4E-05	19.80	9	2.003	0.040	158	1.27E-03	84	8.49E-04	832	2.69E-03	76,413	4.89E-03	5.65E-10
LC22-35.20	6.89E+04	40	1.8E-05	26.92	9	2.003	0.040	99	7.15E-04	62	7.45E-04	596	2.34E-03	76,073	5.39E-03	6.50E-10
LC22-35.21	6.89E+04	40	1.9E-05	28.03	9	2.003	0.040	97	7.04E-04	62	7.69E-04	582	2.36E-03	76,011	5.42E-03	6.60E-10
LC22-35.22	6.89E+04	40	1.8E-05	28.95	9	2.003	0.040	90	6.00E-04	59	7.04E-04	549	2.16E-03	76,268	5.86E-03	6.24E-10
LC22-35.23	6.89E+04	40	1.9E-05	31.94	9	2.003	0.040	84	5.22E-04	55	6.59E-04	536	2.15E-03	77,351	8.34E-03	6.51E-10
Exp. #36																
LC22-36.A	7.64E+04	40	-	-	9	-	-	<50	-	<10	-	<50	-	88,085	-	-
LC22-36.2	7.64E+04	40	1.9E-05	0.89	9	2.005	0.031	418	7.13E-03	36	4.83E-04	2,585	1.43E-02	79,782	-	2.88E-09
LC22-36.4	7.64E+04	40	1.9E-05	3.34	9	2.004	0.040	341	4.40E-03	67	8.38E-04	1,885	8.11E-03	74,783	-	1.48E-09
LC22-36.7	7.64E+04	40	1.8E-05	6.01	9	2.004	0.040	259	3.11E-03	89	1.15E-03	1,371	5.76E-03	72,786	-	1.06E-09
LC22-36.13	7.64E+04	40	1.8E-05	14.14	9	2.004	0.040	172	1.78E-03	90	1.13E-03	927	3.74E-03	78,454	-	7.85E-10
LC22-36.16	7.64E+04	40	1.4E-05	19.80	9	2.004	0.040	139	1.04E-03	78	7.73E-04	771	2.45E-03	79,265	-	5.65E-10
LC22-36.20	7.64E+04	40	1.2E-05	26.92	9	2.004	0.040	112	6.03E-04	70	5.63E-04	705	1.85E-03	86,193	-	4.99E-10
LC22-36.21	7.64E+04	40	1.9E-05	28.03	9	2.003	0.040	131	1.22E-03	74	9.42E-04	762	3.14E-03	81,897	-	7.68E-10
LC22-36.22	7.64E+04	40	1.8E-05	28.95	9	2.003	0.040	109	8.65E-04	64	7.68E-04	649	2.58E-03	80,436	-	6.85E-10
LC22-36.23	7.64E+04	40	1.3E-06	31.94	9	2.003	0.040	100	5.42E-05	61	5.34E-05	655	1.93E-04	79,823	-	5.53E-11
Exp. #37																

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
SS030804B1-A	8.79E+02	90	-	-	9	-	-	<50	-	<10	-	<50	-	<1000	-	-
SS030804B1-B	8.79E+02	90	-	-	9	-	-	<50	-	<10	-	<50	-	<1000	-	-
LC22-43.1	8.79E+02	90	3.7E-05	0.79	9	0.501	0.010	818	9.27E-02	846	9.80E-02	3,736	1.30E-01	6,448	9.41E-02	1.49E-08
LC22-43.2	8.79E+02	90	7.6E-05	1.89	9	0.497	0.010	1,473	3.54E-01	1,538	3.69E-01	5,555	4.00E-01	9,347	2.97E-01	1.85E-08
LC22-43.3	8.79E+02	90	2.2E-05	2.90	9	0.494	0.010	1,318	8.95E-02	1,358	9.24E-02	4,511	9.21E-02	8,398	7.48E-02	1.04E-09
LC22-43.6	8.79E+02	90	7.8E-05	5.84	9	0.491	0.010	1,322	3.26E-01	1,254	3.10E-01	4,319	3.20E-01	8,405	2.72E-01	-
LC22-43.8	8.79E+02	90	4.2E-05	7.74	9	0.486	0.010	1,294	1.76E-01	1,179	1.60E-01	4,320	1.76E-01	8,219	1.46E-01	2.32E-10
LC22-43.9	8.79E+02	90	8.0E-05	9.06	9	0.480	0.010	1,219	3.14E-01	1,146	2.96E-01	4,014	3.11E-01	7,997	2.69E-01	-
LC22-43.10	8.79E+02	90	8.1E-05	9.79	9	0.476	0.009	1,220	3.22E-01	1,198	3.18E-01	4,064	3.23E-01	7,902	2.72E-01	4.40E-10
LC22-43.11	8.79E+02	90	7.6E-05	10.83	9	0.471	0.009	1,244	3.13E-01	1,199	3.03E-01	4,075	3.09E-01	8,003	2.63E-01	-
LC22-43.12	8.79E+02	90	1.8E-04	10.93	9	0.469	0.009	1,280	7.52E-01	1,217	7.16E-01	4,177	7.38E-01	8,149	6.26E-01	-
Exp. #38																
SS030804B2-A	3.74E+04	90	-	-	9	-	-	<50	-	<10	-	<50	-	46,369	-	-
SS030804B2-B	3.74E+04	90	-	-	9	-	-	<50	-	<10	-	<50	-	38,308	-	-
LC22-44.1	3.74E+04	90	7.0E-05	0.79	9	0.504	0.010	617	1.27E-01	402	8.55E-02	2,980	1.92E-01	44,944	8.38E-02	2.60E-08
LC22-44.2	3.74E+04	90	8.3E-05	1.89	9	0.501	0.010	888	2.25E-01	486	1.24E-01	3,493	2.71E-01	46,317	1.53E-01	1.82E-08
LC22-44.3	3.74E+04	90	4.4E-05	2.90	9	0.498	0.010	830	1.11E-01	436	5.86E-02	3,078	1.25E-01	46,204	7.84E-02	5.94E-09
LC22-44.6	3.74E+04	90	7.6E-05	5.84	9	0.496	0.010	839	1.95E-01	504	1.19E-01	2,846	2.02E-01	46,181	1.36E-01	2.83E-09
LC22-44.8	3.74E+04	90	4.0E-05	7.74	9	0.494	0.010	589	7.05E-02	275	3.36E-02	2,145	8.00E-02	45,001	4.98E-02	3.82E-09
LC22-44.9	3.74E+04	90	7.8E-05	9.06	9	0.491	0.010	498	1.15E-01	334	8.05E-02	1,769	1.29E-01	42,231	-	5.63E-09
LC22-44.10	3.74E+04	90	7.1E-05	9.79	9	0.489	0.010	566	1.22E-01	456	1.02E-01	1,941	1.31E-01	42,078	-	3.46E-09
LC22-44.11	3.74E+04	90	8.5E-05	10.83	9	0.487	0.010	577	1.49E-01	490	1.32E-01	2,022	1.63E-01	45,154	1.14E-01	5.65E-09
LC22-44.12	3.74E+04	90	1.2E-04	10.93	9	0.486	0.010	599	2.28E-01	566	2.24E-01	2,178	2.58E-01	47,445	3.04E-01	1.22E-08
Exp. #39																
SS030804B3-A	7.39E+04	90	-	-	9	-	-	<50	-	<10	-	<50	-	83,074	-	-
SS030804B3-B	7.39E+04	90	-	-	9	-	-	<50	-	<10	-	<50	-	74,762	-	-
LC22-45.1	7.39E+04	90	5.8E-05	0.79	9	0.998	0.020	494	4.21E-02	213	1.87E-02	3,746	1.02E-01	86,976	1.09E-01	2.41E-08
LC22-45.2	7.39E+04	90	7.2E-05	1.89	9	0.996	0.020	641	6.92E-02	246	2.68E-02	3,896	1.32E-01	85,728	1.14E-01	2.49E-08
LC22-45.3	7.39E+04	90	4.3E-05	2.90	9	0.995	0.020	600	3.89E-02	239	1.57E-02	3,223	6.57E-02	85,684	6.86E-02	1.07E-08
LC22-45.6	7.39E+04	90	7.3E-05	5.84	9	0.993	0.020	736	8.15E-02	314	3.51E-02	3,300	1.13E-01	82,351	5.84E-02	1.25E-08
LC22-45.8	7.39E+04	90	4.0E-05	7.74	9	0.991	0.020	444	2.58E-02	165	9.83E-03	2,135	3.99E-02	80,554	1.53E-02	5.62E-09
LC22-45.9	7.39E+04	90	8.2E-05	9.06	9	0.989	0.020	344	3.97E-02	126	1.51E-02	1,699	6.50E-02	80,997	4.01E-02	1.01E-08
LC22-45.10	7.39E+04	90	7.6E-05	9.79	9	0.988	0.020	394	4.28E-02	148	1.67E-02	1,777	6.28E-02	80,205	2.29E-02	7.99E-09
LC22-45.11	7.39E+04	90	7.7E-05	10.83	9	0.986	0.020	415	4.66E-02	164	1.91E-02	1,786	6.47E-02	79,068	2.74E-03	7.24E-09
LC22-45.12	7.39E+04	90	1.3E-04	10.93	9	0.986	0.019	458	8.61E-02	197	3.82E-02	1,930	1.16E-01	76,956	-	1.20E-08
Exp. #40																
SS030804B4-A	1.06E+05	90	-	-	9	-	-	<50	-	11	-	<50	-	113,351	-	-
SS030804B4-B	1.06E+05	90	-	-	9	-	-	<50	-	<10	-	<50	-	101,114	-	-
LC22-46.1	1.06E+05	90	4.5E-05	0.79	9	0.995	0.020	279	1.66E-02	91	5.72E-03	3,008	6.29E-02	131,009	2.48E-01	1.85E-08
LC22-46.2	1.06E+05	90	6.9E-05	1.89	9	0.994	0.020	245	2.19E-02	80	7.60E-03	2,764	8.91E-02	126,600	3.11E-01	2.68E-08

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-46.3	1.06E+05	90	2.1E-05	2.90	9	0.994	0.020	228	6.18E-03	93	2.79E-03	2,164	2.15E-02	127,261	9.96E-02	6.10E-09
LC22-46.6	1.06E+05	90	7.4E-05	5.84	9	0.993	0.020	167	1.41E-02	72	7.24E-03	1,307	4.42E-02	128,446	3.65E-01	1.20E-08
LC22-46.8	1.06E+05	90	4.1E-05	7.74	9	0.993	0.020	130	5.34E-03	50	2.57E-03	957	1.76E-02	125,074	1.70E-01	4.89E-09
LC22-46.9	1.06E+05	90	8.1E-05	9.06	9	0.992	0.020	135	1.13E-02	51	5.25E-03	861	3.15E-02	121,302	2.68E-01	8.09E-09
LC22-46.10	1.06E+05	90	6.4E-05	9.79	9	0.991	0.020	207	1.65E-02	77	6.84E-03	1,130	3.32E-02	119,039	1.77E-01	6.65E-09
LC22-46.11	1.06E+05	90	8.3E-05	10.83	9	0.991	0.020	181	1.78E-02	73	8.24E-03	1,069	4.04E-02	123,737	3.20E-01	9.03E-09
LC22-46.12	1.06E+05	90	1.5E-04	10.93	9	0.990	0.020	154	2.55E-02	70	1.42E-02	993	6.78E-02	127,881	7.28E-01	1.69E-08
Exp. #41																
SS030804B5-A	1.22E+05	90	-	-	9	-	-	<50	-	<10	-	<50	-	123,534	-	-
SS030804B5-B	1.22E+05	90	-	-	9	-	-	<50	-	<10	-	<50	-	103,000	-	-
LC22-47.1	1.22E+05	90	6.8E-05	0.79	9	2.002	0.040	481	2.38E-02	73	3.38E-03	5,368	8.59E-02	151,639	3.04E-01	2.48E-08
LC22-47.2	1.22E+05	90	7.5E-05	1.89	9	2.001	0.040	306	1.56E-02	54	2.62E-03	4,060	7.15E-02	150,048	3.21E-01	2.23E-08
LC22-47.3	1.22E+05	90	5.2E-05	2.90	9	2.000	0.039	224	7.31E-03	59	1.98E-03	3,041	3.68E-02	155,807	2.56E-01	1.18E-08
LC22-47.6	1.22E+05	90	7.3E-05	5.84	9	2.000	0.039	232	1.08E-02	46	2.09E-03	1,818	3.08E-02	157,657	3.78E-01	7.95E-09
LC22-47.8	1.22E+05	90	4.0E-05	7.74	9	1.999	0.039	206	5.07E-03	40	9.40E-04	1,445	1.33E-02	145,069	1.48E-01	3.28E-09
LC22-47.9	1.22E+05	90	8.1E-05	9.06	9	1.998	0.039	193	9.40E-03	46	2.28E-03	1,347	2.49E-02	140,813	2.59E-01	6.19E-09
LC22-47.10	1.22E+05	90	7.5E-05	9.79	9	1.997	0.039	183	8.13E-03	47	2.20E-03	1,401	2.41E-02	149,069	3.13E-01	6.38E-09
LC22-47.11	1.22E+05	90	7.7E-05	10.83	9	1.997	0.039	177	7.91E-03	51	2.47E-03	1,331	2.33E-02	153,754	3.61E-01	6.16E-09
LC22-47.12	1.22E+05	90	9.1E-05	10.93	9	1.996	0.039	163	8.39E-03	41	2.22E-03	1,214	2.53E-02	151,487	4.07E-01	6.76E-09
Exp. #42																
SS030804B6-A	1.39E+05	90	-	-	9	-	-	<50	-	<10	-	<50	-	129,572	-	-
SS030804B6-B	1.39E+05	90	-	-	9	-	-	<50	-	<10	-	<50	-	97,300	-	-
LC22-48.1	1.39E+05	90	4.7E-05	0.79	9	1.993	0.039	489	1.68E-02	60	1.85E-03	1,686	1.83E-02	155,190	2.29E-01	6.05E-10
LC22-48.2	1.39E+05	90	1.1E-06	1.89	9	1.993	0.039	975	8.51E-04	120	9.83E-05	2,521	6.64E-04	143,025	3.89E-03	-
LC22-48.3	1.39E+05	90	6.7E-05	2.90	9	1.990	0.039	1,528	8.05E-02	96	4.56E-03	2,795	4.37E-02	157,120	3.41E-01	-
LC22-48.6	1.39E+05	90	7.4E-05	5.84	9	1.987	0.039	521	2.84E-02	21	6.53E-04	947	1.58E-02	166,825	4.61E-01	-
LC22-48.8	1.39E+05	90	4.0E-05	7.74	9	1.985	0.039	440	1.28E-02	17	2.13E-04	758	6.80E-03	155,252	1.97E-01	-
LC22-48.9	1.39E+05	90	7.9E-05	9.06	9	1.984	0.039	383	2.14E-02	16	3.71E-04	672	1.17E-02	148,936	3.27E-01	-
LC22-48.10	1.39E+05	90	7.5E-05	9.79	9	1.982	0.039	415	2.24E-02	25	8.97E-04	709	1.19E-02	151,889	3.39E-01	-
LC22-48.11	1.39E+05	90	7.3E-05	10.83	9	1.981	0.039	380	1.99E-02	18	4.67E-04	674	1.10E-02	158,612	3.90E-01	-
LC22-48.12	1.39E+05	90	1.3E-04	10.93	9	1.980	0.039	335	2.94E-02	17	7.42E-04	607	1.68E-02	166,449	7.83E-01	-
Exp. #43																
LC22-49.A	8.67E+02	70	-	-	9	-	-	<25	-	<10	-	<100	-	<500	-	-
LC22-49.1	8.67E+02	70	6.2E-05	0.90	9	0.506	0.023	359	2.92E-02	360	2.97E-02	1,403	3.33E-02	2,416	2.40E-02	1.63E-09
LC22-49.3	8.67E+02	70	6.6E-05	1.83	9	0.505	0.010	566	1.15E-01	565	1.15E-01	1,838	1.08E-01	3,771	9.98E-02	-
LC22-49.4	8.67E+02	70	6.6E-05	2.87	9	0.504	0.010	556	1.12E-01	565	1.14E-01	1,798	1.05E-01	3,704	9.69E-02	-
LC22-49.7	8.67E+02	70	6.3E-05	5.18	9	0.502	0.010	472	9.13E-02	481	9.34E-02	1,548	8.66E-02	3,155	7.77E-02	-
LC22-49.9	8.67E+02	70	6.6E-05	7.95	9	0.500	0.010	450	9.11E-02	462	9.39E-02	1,416	8.24E-02	3,013	7.70E-02	-
LC22-49.10	8.67E+02	70	6.2E-05	8.89	9	0.498	0.010	433	8.30E-02	438	8.46E-02	1,395	7.71E-02	2,936	7.10E-02	-
LC22-49.11	8.67E+02	70	5.8E-05	10.11	9	0.496	0.010	483	8.70E-02	522	9.44E-02	1,626	8.47E-02	3,257	7.49E-02	-

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-49.12	8.67E+02	70	6.3E-05	10.98	9	0.495	0.010	553	1.09E-01	770	1.53E-01	1,872	1.07E-01	3,657	9.35E-02	-
Exp. #44																
LC22-50.A	2.93E+04	70	-	-	9	-	-	<25	-	<10	-	<100	-	32,850	-	-
LC22-50.1	2.93E+04	70	6.3E-05	0.90	9	0.507	0.023	171	1.29E-02	101	7.85E-03	783	1.77E-02	33,449	7.59E-03	1.89E-09
LC22-50.3	2.93E+04	70	6.6E-05	1.83	9	0.506	0.010	321	6.22E-02	201	3.90E-02	1,206	6.80E-02	34,340	4.49E-02	2.32E-09
LC22-50.4	2.93E+04	70	6.6E-05	2.87	9	0.505	0.010	316	6.12E-02	201	3.89E-02	1,137	6.38E-02	33,729	2.65E-02	1.05E-09
LC22-50.7	2.93E+04	70	6.3E-05	5.18	9	0.504	0.010	316	5.90E-02	232	4.37E-02	1,048	5.61E-02	34,179	3.85E-02	-
LC22-50.9	2.93E+04	70	6.5E-05	7.95	9	0.502	0.010	316	6.12E-02	235	4.59E-02	1,048	5.83E-02	34,697	5.57E-02	-
LC22-50.10	2.93E+04	70	6.5E-05	8.89	9	0.501	0.010	314	6.11E-02	230	4.51E-02	1,030	5.75E-02	34,478	4.93E-02	-
LC22-50.11	2.93E+04	70	5.6E-05	10.11	9	0.500	0.010	314	5.24E-02	237	4.00E-02	1,015	4.85E-02	33,947	2.85E-02	-
LC22-50.12	2.93E+04	70	6.6E-05	10.98	9	0.499	0.010	318	6.25E-02	251	4.99E-02	1,029	5.80E-02	34,495	5.03E-02	-
Exp. #45																
LC22-51.A	5.83E+04	70	-	-	9	-	-	<25	-	10	-	<100	-	66,285	-	-
LC22-51.1	5.83E+04	70	6.6E-05	0.90	9	1.006	0.036	155	7.60E-03	62	2.96E-03	1,012	1.55E-02	64,690	-	3.17E-09
LC22-51.3	5.83E+04	70	6.5E-05	1.83	9	1.005	0.020	217	2.03E-02	86	7.90E-03	1,105	3.11E-02	65,107	-	4.32E-09
LC22-51.4	5.83E+04	70	6.6E-05	2.87	9	1.005	0.020	209	1.95E-02	84	7.63E-03	978	2.72E-02	65,143	-	3.06E-09
LC22-51.7	5.83E+04	70	6.3E-05	5.18	9	1.004	0.020	189	1.67E-02	86	7.52E-03	800	2.08E-02	66,681	5.77E-03	1.66E-09
LC22-51.9	5.83E+04	70	2.4E-05	7.95	9	1.003	0.020	295	1.06E-02	114	3.99E-03	1,209	1.28E-02	67,861	8.88E-03	8.61E-10
LC22-51.10	5.83E+04	70	6.5E-05	8.89	9	1.003	0.020	184	1.67E-02	81	7.25E-03	787	2.11E-02	67,495	1.82E-02	1.75E-09
LC22-51.11	5.83E+04	70	5.6E-05	10.11	9	1.002	0.020	151	1.15E-02	80	6.27E-03	622	1.39E-02	66,541	3.33E-03	9.69E-10
LC22-51.12	5.83E+04	70	6.6E-05	10.98	9	1.002	0.020	151	1.34E-02	82	7.53E-03	606	1.57E-02	65,858	-	9.42E-10
Exp. #46																
LC22-52.A	8.84E+04	70	-	-	9	-	-	<25	-	<10	-	<100	-	96,748	-	-
LC22-52.1	8.84E+04	70	6.6E-05	0.90	9	1.005	0.036	113	5.16E-03	35	1.42E-03	863	1.30E-02	96,200	-	3.15E-09
LC22-52.3	8.84E+04	70	6.6E-05	1.83	9	1.005	0.020	104	8.45E-03	35	2.56E-03	747	2.02E-02	97,171	6.45E-03	4.67E-09
LC22-52.4	8.84E+04	70	6.5E-05	2.87	9	1.004	0.020	78	5.60E-03	28	1.87E-03	594	1.53E-02	95,799	-	3.86E-09
LC22-52.7	8.84E+04	70	6.3E-05	5.18	9	1.004	0.020	56	3.13E-03	32	2.17E-03	373	8.16E-03	94,898	-	2.01E-09
LC22-52.9	8.84E+04	70	6.6E-05	7.95	9	1.004	0.020	59	3.59E-03	33	2.34E-03	325	7.04E-03	96,380	-	1.38E-09
LC22-52.10	8.84E+04	70	6.5E-05	8.89	9	1.004	0.020	52	2.89E-03	29	1.97E-03	296	6.04E-03	96,603	-	1.26E-09
LC22-52.11	8.84E+04	70	5.7E-05	10.11	9	1.003	0.020	48	2.08E-03	28	1.58E-03	295	5.23E-03	91,341	-	1.26E-09
LC22-52.12	8.84E+04	70	6.6E-05	10.98	9	1.003	0.020	65	4.28E-03	36	2.66E-03	292	5.98E-03	86,958	-	6.78E-10
Exp. #47																
LC22-53.A	1.14E+05	70	-	-	9	-	-	<25	-	12	-	<100	-	115,042	-	-
LC22-53.1	1.14E+05	70	6.5E-05	0.90	9	2.006	0.057	200	6.42E-03	30	6.49E-04	1,667	1.68E-02	115,633	3.10E-03	4.14E-09
LC22-53.3	1.14E+05	70	6.7E-05	1.83	9	2.005	0.040	172	7.98E-03	24	6.41E-04	1,397	2.05E-02	115,685	4.98E-03	5.01E-09
LC22-53.4	1.14E+05	70	6.6E-05	2.87	9	2.005	0.040	121	5.10E-03	19	3.93E-04	1,014	1.42E-02	116,053	7.70E-03	3.64E-09
LC22-53.7	1.14E+05	70	6.4E-05	5.18	9	2.005	0.040	66	2.11E-03	13	7.74E-05	598	7.49E-03	125,049	7.37E-02	2.15E-09
LC22-53.9	1.14E+05	70	6.6E-05	7.95	9	2.004	0.040	49	1.30E-03	11	-	414	4.93E-03	124,853	7.55E-02	1.45E-09
LC22-53.10	1.14E+05	70	6.6E-05	8.89	9	2.004	0.040	45	1.06E-03	14	1.40E-04	385	4.43E-03	125,303	7.81E-02	1.34E-09
LC22-53.11	1.14E+05	70	5.5E-05	10.11	9	2.004	0.040	40	6.66E-04	15	1.34E-04	373	3.58E-03	119,790	3.05E-02	1.16E-09

Table A3. SPFT Results for LAWC22 Glasses.

Sample ID	Influent [Si]	T (°C)	Flow Rate (m^3/d)	Time, days	pH (23°C)	Glass Mass (g)	SA (m^2)	[B]	B Rate	[Al]	Al Rate	[Na]	Na Rate	[Si]	Si Rate	IEX Rate
LC22-53.12	1.14E+05	70	6.6E-05	10.98	9	2.004	0.040	40	8.12E-04	24	6.48E-04	375	4.30E-03	116,901	1.43E-02	1.39E-09
Exp. #48																
LC22-54.A	1.37E+05	70	-	-	9	-	-	<25	-	<10	-	<100	-	120,577	-	-
LC22-54.1	1.37E+05	70	7.1E-05	0.90	9	2.005	0.057	187	6.47E-03	28	7.05E-04	1,620	1.77E-02	122,530	1.12E-02	4.50E-09
LC22-54.3	1.37E+05	70	6.6E-05	1.83	9	2.004	0.040	151	6.73E-03	23	6.59E-04	1,329	1.92E-02	123,281	2.07E-02	4.99E-09
LC22-54.4	1.37E+05	70	6.5E-05	2.87	9	2.004	0.040	100	3.99E-03	15	2.33E-04	909	1.25E-02	122,903	1.76E-02	3.40E-09
LC22-54.7	1.37E+05	70	6.4E-05	5.18	9	2.004	0.040	60	1.82E-03	ND	-	1,045	1.43E-02	135,455	1.10E-01	4.97E-09
LC22-54.9	1.37E+05	70	6.5E-05	7.95	9	2.003	0.040	52	1.42E-03	12	1.01E-04	449	5.36E-03	134,901	1.08E-01	1.57E-09
LC22-54.10	1.37E+05	70	6.5E-05	8.89	9	2.003	0.040	41	8.60E-04	ND	-	378	4.30E-03	135,775	1.15E-01	1.37E-09
LC22-54.11	1.37E+05	70	5.6E-05	10.11	9	2.003	0.040	38	6.10E-04	10	-	358	3.42E-03	128,951	5.43E-02	1.12E-09
LC22-54.12	1.37E+05	70	6.6E-05	10.98	9	2.003	0.040	35	5.64E-04	16	3.31E-04	340	3.77E-03	121,693	8.59E-03	1.28E-09

[] – μg L^{-1}
Rate – g m^{-2} d^{-1}
IEX Rate – mol m^{-2} s^{-1}

Appendix B
Pressurized Unsaturated Flow Test Results

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-01	1	0.07	0.31	0.12	-	6.0E+03	1.1E-03	3.1E+04	6.6E-03	-	-	2.1E+02	1.1E-04
LAWA44-02	2	0.18	0.07	0.05	-	7.1E+03	5.6E-03	4.7E+04	4.4E-02	-	-	7.9E+02	1.7E-03
LAWA44-03	3	1.19	0.05	0.01	-	4.6E+03	5.3E-03	9.1E+04	1.2E-01	-	-	1.5E+02	4.6E-04
LAWA44-04	4	3.41	0.04	0.01	-	6.2E+03	8.2E-03	1.6E+05	2.6E-01	-	-	6.3E+00	2.3E-05
LAWA44-05	5	5.74	0.03	0.01	-	6.2E+03	1.1E-02	1.2E+05	2.5E-01	-	-	6.5E+00	3.1E-05
LAWA44-06	6	7.91	0.02	0.00	-	6.1E+03	1.4E-02	1.1E+05	3.0E-01	-	-	4.3E+00	2.7E-05
LAWA44-07	7	10.37	0.03	0.01	-	6.2E+03	1.3E-02	1.0E+05	2.6E-01	-	-	9.0E+00	5.2E-05
LAWA44-08	8	12.78	0.03	0.01	-	5.4E+03	9.0E-03	1.0E+05	2.0E-01	-	-	5.9E+00	2.7E-05
LAWA44-09	9	15.39	0.03	0.01	-	5.2E+03	8.7E-03	9.0E+04	1.8E-01	-	-	5.2E+00	2.3E-05
LAWA44-10	10	17.90	0.03	0.00	-	5.2E+03	1.0E-02	8.6E+04	2.1E-01	-	-	3.5E+00	1.9E-05
LAWA44-11	11	20.05	0.03	0.01	-	5.2E+03	9.2E-03	8.6E+04	1.8E-01	-	-	8.6E+00	4.1E-05
LAWA44-12	12	22.50	0.03	0.01	-	4.9E+03	8.0E-03	7.8E+04	1.5E-01	-	-	2.5E+01	1.1E-04
LAWA44-13	13	24.75	0.02	0.01	-	5.3E+03	1.6E-02	7.5E+04	2.8E-01	-	-	7.0E+00	6.0E-05
LAWA44-14	14	26.82	0.04	0.01	-	4.6E+03	5.8E-03	7.9E+04	1.2E-01	-	-	1.2E+01	4.2E-05
LAWA44-15	15	29.01	0.05	0.01	-	4.4E+03	5.5E-03	8.0E+04	1.2E-01	-	-	5.1E+00	1.7E-05
LAWA44-16	16	31.40	0.04	0.01	-	4.5E+03	6.3E-03	7.1E+04	1.2E-01	-	-	3.8E+00	1.4E-05
LAWA44-17	17	34.27	0.05	0.01	-	4.3E+03	4.8E-03	6.6E+04	8.8E-02	-	-	3.9E+00	1.2E-05
LAWA44-18	18	36.80	0.05	0.00	-	4.4E+03	5.4E-03	7.0E+04	1.0E-01	-	-	5.1E+00	1.7E-05
LAWA44-19	19	38.76	0.05	0.00	-	3.8E+03	4.3E-03	7.4E+04	1.0E-01	-	-	8.7E+00	2.7E-05
LAWA44-20	20	40.87	0.05	0.01	-	4.1E+03	4.2E-03	7.1E+04	8.8E-02	-	-	2.4E+00	6.9E-06
LAWA44-21	21	43.02	0.05	0.00	-	4.1E+03	4.8E-03	6.9E+04	9.6E-02	-	-	8.8E+00	2.8E-05
LAWA44-22	22	45.38	0.05	0.01	-	4.1E+03	4.3E-03	6.7E+04	8.3E-02	-	-	6.4E+00	1.8E-05
LAWA44-23	23	48.28	0.05	0.01	-	3.9E+03	4.0E-03	6.7E+04	8.3E-02	-	-	6.0E+00	1.7E-05
LAWA44-24	24	50.83	0.05	0.01	-	4.3E+03	4.7E-03	5.5E+04	7.1E-02	-	-	5.0E+00	1.5E-05
LAWA44-25	25	53.26	0.06	0.01	-	4.1E+03	3.8E-03	6.2E+04	6.9E-02	-	-	6.4E+00	1.6E-05
LAWA44-26	26	56.38	0.06	0.01	-	3.9E+03	3.6E-03	6.5E+04	7.2E-02	-	-	6.1E+00	1.6E-05
LAWA44-27	27	59.42	0.06	0.01	-	3.6E+03	3.6E-03	6.1E+04	7.1E-02	-	-	4.1E+00	1.1E-05
LAWA44-28	28	61.76	0.06	0.01	-	3.7E+03	3.8E-03	6.0E+04	7.3E-02	-	-	3.9E+00	1.1E-05
LAWA44-29	29	63.91	0.06	0.01	-	3.5E+03	3.5E-03	5.6E+04	6.5E-02	-	-	5.0E+00	1.4E-05
LAWA44-30	30	66.40	0.06	0.01	-	3.6E+03	3.2E-03	6.0E+04	6.4E-02	-	-	1.5E+01	3.7E-05
LAWA44-31	31	68.76	0.07	0.01	-	3.7E+03	3.2E-03	6.1E+04	6.2E-02	-	-	5.5E+00	1.3E-05
LAWA44-32	32	70.93	0.06	0.01	-	3.4E+03	3.0E-03	5.3E+04	5.6E-02	-	-	3.8E+00	9.3E-06
LAWA44-33	33	73.41	0.06	0.01	-	3.4E+03	3.5E-03	5.3E+04	6.4E-02	-	-	3.9E+00	1.1E-05
LAWA44-34	34	75.83	0.07	0.01	-	3.6E+03	3.1E-03	6.0E+04	6.1E-02	-	-	5.0E+00	1.2E-05
LAWA44-35	35	77.99	0.05	0.01	-	3.6E+03	3.9E-03	5.5E+04	7.1E-02	-	-	-	-
LAWA44-36	36	80.40	0.05	0.01	-	3.2E+03	3.6E-03	5.2E+04	7.0E-02	-	-	-	-
LAWA44-37	37	82.77	0.05	0.01	-	3.4E+03	3.6E-03	5.6E+04	7.0E-02	-	-	-	-

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-38	38	84.78	0.06	0.01	-	3.7E+03	3.8E-03	6.0E+04	7.3E-02	-	-	-	-
LAWA44-39	39	87.92	0.06	0.01	-	3.4E+03	3.4E-03	5.2E+04	6.2E-02	-	-	-	-
LAWA44-40	40	91.56	0.07	0.01	-	3.3E+03	2.8E-03	5.7E+04	5.8E-02	-	-	-	-
LAWA44-41	41	94.49	0.05	0.01	-	3.3E+03	3.7E-03	4.7E+04	6.4E-02	-	-	-	-
LAWA44-42	42	96.99	0.05	0.01	-	3.0E+03	3.5E-03	5.3E+04	7.2E-02	-	-	-	-
LAWA44-43	43	98.95	0.07	0.00	-	3.2E+03	2.7E-03	6.7E+04	6.6E-02	-	-	-	-
LAWA44-44	44	102.33	0.07	0.01	-	3.6E+03	3.1E-03	5.4E+04	5.6E-02	-	-	-	-
LAWA44-45	45	105.95	0.07	0.00	-	3.6E+03	3.0E-03	5.1E+04	5.0E-02	-	-	-	-
LAWA44-46	46	108.41	0.07	0.01	-	3.3E+03	2.8E-03	5.6E+04	5.7E-02	-	-	-	-
LAWA44-47	47	110.82	0.07	0.01	-	3.8E+03	3.3E-03	5.2E+04	5.3E-02	-	-	-	-
LAWA44-48	48	112.98	0.07	0.01	-	3.5E+03	2.9E-03	5.4E+04	5.3E-02	-	-	-	-
LAWA44-49	49	115.44	0.06	0.01	-	3.4E+03	3.0E-03	4.4E+04	4.6E-02	-	-	-	-
LAWA44-50	50	117.82	0.07	0.01	-	2.9E+03	2.3E-03	5.9E+04	5.5E-02	-	-	-	-
LAWA44-51	51	119.93	0.07	0.01	-	3.4E+03	2.8E-03	5.1E+04	4.9E-02	-	-	-	-
LAWA44-52	52	122.35	0.07	0.01	-	3.7E+03	2.8E-03	4.3E+04	4.0E-02	-	-	-	-
LAWA44-53	53	124.75	0.10	0.01	-	3.1E+03	1.8E-03	5.1E+04	3.4E-02	-	-	-	-
LAWA44-54	54	126.90	0.09	0.01	-	3.7E+03	2.4E-03	4.9E+04	3.7E-02	-	-	-	-
LAWA44-55	55	129.36	0.08	0.00	-	3.7E+03	2.5E-03	4.1E+04	3.4E-02	-	-	-	-
LAWA44-56	56	131.75	0.09	0.01	-	2.7E+03	1.7E-03	4.7E+04	3.5E-02	-	-	-	-
LAWA44-57	57	133.86	0.08	0.01	-	2.6E+03	1.8E-03	5.3E+04	4.2E-02	-	-	-	-
LAWA44-58	58	136.34	0.08	0.00	-	2.6E+03	1.9E-03	4.7E+04	4.0E-02	-	-	-	-
LAWA44-59	59	139.20	0.08	0.00	-	2.3E+03	1.6E-03	4.9E+04	4.0E-02	-	-	-	-
LAWA44-60	60	141.26	0.08	0.00	-	2.2E+03	1.6E-03	4.5E+04	3.7E-02	-	-	-	-
LAWA44-61	61	143.82	0.08	0.00	-	2.1E+03	1.5E-03	4.7E+04	3.9E-02	-	-	-	-
LAWA44-62	62	147.44	0.08	0.01	-	1.9E+03	1.3E-03	4.9E+04	3.9E-02	-	-	2.4E+01	4.5E-05
LAWA44-63	63	150.33	0.07	0.00	-	1.7E+03	1.3E-03	4.6E+04	4.2E-02	-	-	2.9E+01	6.1E-05
LAWA44-64	64	152.73	0.08	0.00	-	1.6E+03	1.2E-03	4.6E+04	4.0E-02	-	-	3.1E+01	6.3E-05
LAWA44-65	65	154.98	0.08	0.01	-	1.5E+03	1.0E-03	4.8E+04	3.9E-02	-	-	3.8E+00	7.1E-06
LAWA44-66	66	157.41	0.07	0.00	-	2.1E+03	1.7E-03	4.6E+04	4.3E-02	-	-	6.3E+02	1.3E-03
LAWA44-67	67	159.82	0.08	0.01	-	2.7E+03	2.0E-03	5.2E+04	4.6E-02	-	-	1.8E+01	3.7E-05
LAWA44-68	68	161.96	0.08	0.01	-	2.6E+03	2.0E-03	4.7E+04	4.2E-02	-	-	1.5E+01	3.1E-05
LAWA44-69	69	164.35	0.07	0.01	-	2.6E+03	2.0E-03	4.9E+04	4.7E-02	-	-	1.4E+01	3.1E-05
LAWA44-70	70	166.86	0.07	0.01	-	2.7E+03	2.1E-03	4.4E+04	4.1E-02	-	-	6.3E+02	1.3E-03
LAWA44-71	71	169.03	0.08	0.01	-	2.3E+03	1.6E-03	5.4E+04	4.4E-02	-	-	1.1E+01	2.1E-05
LAWA44-72	72	171.35	0.09	0.00	-	2.2E+03	1.4E-03	4.7E+04	3.7E-02	-	-	2.5E+01	4.4E-05
LAWA44-73	73	173.85	0.08	0.01	-	2.2E+03	1.5E-03	4.9E+04	3.9E-02	-	-	6.3E+02	1.2E-03
LAWA44-74	74	176.00	0.06	0.01	-	2.2E+03	2.0E-03	4.2E+04	4.6E-02	-	-	6.3E+02	1.6E-03

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-75	75	178.33	0.06	0.01	-	2.8E+03	2.8E-03	4.9E+04	5.8E-02	-	-	3.4E+01	9.4E-05
LAWA44-76	76	180.80	0.06	0.02	-	2.6E+03	2.5E-03	4.8E+04	5.4E-02	-	-	1.8E+00	4.6E-06
LAWA44-77	77	183.45	0.08	0.01	-	2.4E+03	1.8E-03	4.9E+04	4.4E-02	-	-	5.0E+02	1.0E-03
LAWA44-78	78	186.47	0.05	0.02	-	2.1E+03	2.6E-03	5.1E+04	7.5E-02	-	-	1.3E+01	4.4E-05
LAWA44-79	79	189.53	0.04	0.01	-	2.3E+03	3.1E-03	5.3E+04	8.3E-02	-	-	3.8E+01	1.4E-04
LAWA44-80	80	192.41	0.05	0.01	-	2.8E+03	3.2E-03	4.8E+04	6.4E-02	-	-	4.7E+01	1.5E-04
LAWA44-81	81	194.83	0.04	0.02	-	9.3E+03	1.3E-02	5.1E+04	8.5E-02	-	-	3.3E+01	1.2E-04
LAWA44-82	82	197.50	0.03	0.00	-	3.3E+03	6.3E-03	2.9E+04	6.4E-02	-	-	5.9E+01	3.0E-04
LAWA44-83	83	199.86	0.02	0.00	-	3.6E+03	8.7E-03	3.9E+04	1.1E-01	-	-	3.9E+01	2.6E-04
LAWA44-84	84	201.73	0.04	0.01	-	3.7E+03	5.6E-03	4.5E+04	8.1E-02	-	-	2.3E+01	9.6E-05
LAWA44-85	85	203.92	0.03	0.00	-	3.3E+03	6.2E-03	4.5E+04	9.9E-02	-	-	1.6E+01	8.3E-05
LAWA44-86	86	206.37	0.02	0.00	-	3.2E+03	8.0E-03	4.3E+04	1.3E-01	-	-	8.7E+00	6.0E-05
LAWA44-87	87	208.77	0.02	0.00	-	3.1E+03	7.6E-03	4.4E+04	1.3E-01	-	-	5.0E+02	3.4E-03
LAWA44-88	88	210.97	0.03	0.01	-	3.1E+03	6.4E-03	4.6E+04	1.1E-01	-	-	2.9E+01	1.6E-04
LAWA44-89	89	213.40	0.02	0.01	-	3.0E+03	7.1E-03	4.8E+04	1.3E-01	-	-	2.7E+01	1.7E-04
LAWA44-90	90	215.80	0.02	0.01	-	2.9E+03	7.2E-03	4.7E+04	1.4E-01	-	-	3.5E+01	2.4E-04
LAWA44-91	91	217.93	0.02	0.01	-	3.0E+03	9.4E-03	4.3E+04	1.6E-01	-	-	4.5E+01	3.9E-04
LAWA44-92	92	220.36	0.02	0.00	-	3.0E+03	7.2E-03	4.2E+04	1.2E-01	-	-	2.7E+01	1.8E-04
LAWA44-93	93	222.84	0.03	0.00	-	3.0E+03	6.1E-03	4.5E+04	1.1E-01	-	-	5.0E+02	2.8E-03
LAWA44-94	94	225.00	0.04	0.02	-	2.8E+03	3.5E-03	4.4E+04	6.6E-02	-	-	5.0E+02	1.7E-03
LAWA44-95	95	227.50	0.07	0.00	-	2.5E+03	2.0E-03	5.6E+04	5.1E-02	-	-	5.0E+02	1.1E-03
LAWA44-96	96	230.01	0.04	0.00	-	4.2E+03	5.6E-03	3.8E+04	6.1E-02	-	-	4.1E+00	1.5E-05
LAWA44-97	97	232.10	0.04	0.01	-	4.1E+03	6.0E-03	3.5E+04	6.0E-02	-	-	3.0E+01	1.2E-04
LAWA44-98	98	234.46	0.03	0.02	-	3.1E+03	5.0E-03	3.1E+04	6.0E-02	-	-	8.0E+00	3.6E-05
LAWA44-99	99	236.86	0.09	0.00	-	2.6E+03	1.7E-03	4.7E+04	3.6E-02	-	-	3.3E+01	5.9E-05
LAWA44-100	100	238.96	0.10	0.00	-	2.9E+03	1.7E-03	4.9E+04	3.4E-02	-	-	3.7E+01	6.0E-05
LAWA44-101	101	241.37	0.10	0.00	-	3.2E+03	1.7E-03	4.8E+04	3.1E-02	-	-	1.8E+01	2.6E-05
LAWA44-102	102	243.81	0.06	0.02	-	3.0E+03	2.7E-03	4.0E+04	4.2E-02	-	-	9.3E+00	2.3E-05
LAWA44-103	103	245.97	0.06	0.00	-	2.9E+03	2.6E-03	3.3E+04	3.5E-02	-	-	2.3E+01	5.6E-05
LAWA44-104	104	248.43	0.07	0.00	-	3.1E+03	2.4E-03	4.9E+04	4.6E-02	-	-	9.4E-01	2.0E-06
LAWA44-105	105	250.91	0.07	0.00	-	3.4E+03	2.6E-03	4.3E+04	3.9E-02	7.9E+00	1.5E-03	-	-
LAWA44-106	106	253.43	0.07	0.01	-	-	-	-	-	8.8E+00	1.8E-03	-	-
LAWA44-107	107	255.80	0.07	0.00	-	-	-	-	-	7.5E+00	1.5E-03	-	-
LAWA44-108	108	257.88	0.06	0.03	-	3.7E+03	3.5E-03	6.1E+04	6.9E-02	9.1E+00	2.1E-03	-	-
LAWA44-109	109	260.34	0.05	0.01	-	-	-	-	-	8.5E+00	2.4E-03	-	-
LAWA44-110	110	262.74	0.05	0.01	-	-	-	-	-	9.0E+00	2.6E-03	-	-
LAWA44-111	111	264.82	0.05	0.01	-	4.2E+03	4.7E-03	4.5E+04	5.9E-02	7.9E+00	2.1E-03	-	-

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-112	112	266.94	0.05	0.01	-	-	-	-	-	1.7E+01	4.5E-03	-	-
LAWA44-113	113	273.90	0.04	0.01	-	-	-	-	-	7.6E+00	2.4E-03	-	-
LAWA44-114	114	280.95	0.04	0.01	-	3.8E+03	5.4E-03	4.8E+04	8.2E-02	7.5E+00	2.6E-03	-	-
LAWA44-115	115	283.39	0.03	0.00	-	-	-	-	-	6.2E+00	3.1E-03	-	-
LAWA44-116	116	285.88	0.05	0.01	-	-	-	-	-	8.9E+00	2.5E-03	-	-
LAWA44-117	117	288.04	0.04	0.01	-	3.6E+03	5.1E-03	4.3E+04	7.2E-02	6.9E+00	2.3E-03	-	-
LAWA44-118	118	290.44	0.05	0.01	-	-	-	-	-	7.4E+00	1.9E-03	-	-
LAWA44-119	119	292.95	0.05	0.01	-	-	-	-	-	8.8E+00	2.2E-03	-	-
LAWA44-120	120	295.50	0.05	0.01	-	4.3E+03	4.9E-03	4.1E+04	5.6E-02	6.8E+00	1.9E-03	-	-
LAWA44-121	121	297.94	0.05	0.01	-	-	-	-	-	7.2E+00	2.1E-03	-	-
LAWA44-122	122	300.00	0.05	0.01	-	-	-	-	-	7.8E+00	2.2E-03	-	-
LAWA44-123	123	302.12	0.04	0.00	-	8.1E+03	1.1E-02	5.3E+04	8.7E-02	9.7E+00	3.2E-03	-	-
LAWA44-124	124	304.50	0.08	0.03	-	-	-	-	-	1.1E+01	1.9E-03	-	-
LAWA44-125	125	307.77	0.27	0.08	-	-	-	-	-	3.2E+01	1.6E-03	-	-
LAWA44-126	126	311.25	0.16	0.01	-	5.4E+03	1.9E-03	4.0E+04	1.7E-02	1.4E+01	1.2E-03	-	-
LAWA44-127	127	313.84	0.17	0.01	-	-	-	-	-	1.0E+01	8.1E-04	-	-
LAWA44-128	128	316.01	0.17	0.00	-	-	-	-	-	1.1E+01	8.3E-04	-	-
LAWA44-129	129	318.42	0.18	0.00	-	5.8E+03	1.9E-03	4.3E+04	1.6E-02	9.7E+00	7.5E-04	-	-
LAWA44-130	130	321.28	0.17	0.01	-	-	-	-	-	1.5E+01	1.2E-03	-	-
LAWA44-131	131	327.97	0.15	0.02	-	-	-	-	-	1.3E+01	1.2E-03	-	-
LAWA44-132	132	334.43	0.16	0.01	-	1.2E+04	4.2E-03	4.9E+04	2.0E-02	1.2E+01	9.8E-04	-	-
LAWA44-133	133	336.84	0.18	0.01	-	-	-	-	-	9.9E+00	7.3E-04	-	-
LAWA44-134	134	339.33	0.19	0.01	-	-	-	-	-	1.0E+01	7.4E-04	-	-
LAWA44-135	135	341.79	0.21	0.01	-	1.4E+04	3.8E-03	4.3E+04	1.4E-02	1.0E+01	6.7E-04	-	-
LAWA44-136	136	343.91	0.22	0.02	-	-	-	-	-	9.3E+00	5.7E-04	-	-
LAWA44-137	137	346.87	0.13	1.28	-	-	-	-	-	1.0E+01	1.1E-03	-	-
LAWA44-138	138	349.78	0.05	0.03	-	1.2E+04	1.2E-02	3.0E+04	3.7E-02	6.4E+00	1.6E-03	-	-
LAWA44-139	139	351.44	0.05	0.01	-	-	-	-	-	6.0E+00	1.8E-03	-	-
LAWA44-140	140	353.42	0.08	0.02	-	-	-	-	-	7.0E+00	1.3E-03	-	-
LAWA44-141	141	355.80	0.08	0.01	-	8.6E+03	5.9E-03	4.3E+04	3.5E-02	8.6E+00	1.4E-03	-	-
LAWA44-142	142	357.95	0.09	0.01	-	-	-	-	-	8.1E+00	1.2E-03	-	-
LAWA44-143	143	360.38	0.11	0.01	-	-	-	-	-	8.3E+00	9.9E-04	-	-
LAWA44-144	144	362.76	0.13	0.01	-	7.2E+03	3.3E-03	4.0E+04	2.2E-02	8.0E+00	8.7E-04	-	-
LAWA44-145	145	364.97	0.13	0.01	-	-	-	-	-	7.8E+00	8.5E-04	-	-
LAWA44-146	146	367.40	0.13	0.01	-	-	-	-	-	8.2E+00	8.9E-04	-	-
LAWA44-147	147	369.89	0.13	0.01	-	5.9E+03	2.7E-03	3.9E+04	2.1E-02	6.9E+00	7.5E-04	-	-
LAWA44-148	148	372.46	0.13	0.01	-	-	-	-	-	7.5E+00	8.1E-04	-	-

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-149	149	375.29	0.11	0.01	-	-	-	-	-	7.8E+00	9.3E-04	-	-
LAWA44-150	150	378.26	0.13	0.00	-	5.5E+03	2.4E-03	4.0E+04	2.1E-02	7.1E+00	7.4E-04	-	-
LAWA44-151	151	381.25	0.13	0.00	-	-	-	-	-	7.3E+00	7.6E-04	-	-
LAWA44-152	152	383.85	0.13	0.01	-	-	-	-	-	7.3E+00	7.4E-04	-	-
LAWA44-153	153	386.04	0.15	0.00	-	4.8E+03	1.8E-03	3.8E+04	1.7E-02	1.0E+01	9.3E-04	-	-
LAWA44-154	154	388.38	0.15	0.00	-	-	-	-	-	6.9E+00	6.2E-04	-	-
LAWA44-155	155	390.82	0.15	0.01	-	-	-	-	-	7.2E+00	6.5E-04	-	-
LAWA44-156	156	393.51	0.15	0.01	-	5.2E+03	2.0E-03	3.1E+04	1.4E-02	5.7E+00	5.2E-04	-	-
LAWA44-157	157	395.88	0.13	0.01	-	-	-	-	-	6.9E+00	7.2E-04	-	-
LAWA44-158	158	397.90	0.15	0.01	-	-	-	-	-	7.8E+00	7.0E-04	-	-
LAWA44-159	159	400.08	0.13	0.02	-	6.8E+03	3.0E-03	3.2E+04	1.6E-02	5.5E+00	5.7E-04	-	-
LAWA44-160	160	402.33	0.12	0.01	-	-	-	-	-	6.8E+00	7.7E-04	-	-
LAWA44-161	161	404.71	0.15	0.02	-	-	-	-	-	7.8E+00	7.3E-04	-	-
LAWA44-162	162	406.95	0.15	0.01	-	5.0E+03	1.9E-03	4.1E+04	1.8E-02	7.7E+00	6.8E-04	-	-
LAWA44-163	163	409.39	0.17	0.01	-	-	-	-	-	7.1E+00	5.6E-04	-	-
LAWA44-164	164	411.87	0.18	0.01	-	4.3E+03	1.4E-03	3.7E+04	1.4E-02	6.8E+00	5.2E-04	-	-
LAWA44-165	165	414.49	0.18	0.01	-	3.4E+03	1.1E-03	3.6E+04	1.3E-02	7.0E+00	5.3E-04	-	-
LAWA44-166	166	417.31	0.18	0.01	-	3.8E+03	1.2E-03	3.7E+04	1.4E-02	9.1E+00	6.8E-04	-	-
LAWA44-167	167	420.27	0.19	0.01	-	4.3E+03	1.3E-03	3.8E+04	1.3E-02	7.5E+00	5.3E-04	-	-
LAWA44-168	168	424.29	0.19	0.01	-	3.7E+03	1.1E-03	3.2E+04	1.2E-02	3.8E+00	2.7E-04	-	-
LAWA44-169	169	427.89	0.20	0.01	-	3.8E+03	1.1E-03	3.4E+04	1.1E-02	4.4E+00	3.0E-04	-	-
LAWA44-170	170	430.36	0.18	0.01	-	3.7E+03	1.2E-03	3.3E+04	1.2E-02	6.8E+00	5.1E-04	-	-
LAWA44-171	171	432.76	0.20	0.01	-	4.0E+03	1.1E-03	3.6E+04	1.2E-02	1.5E+00	1.0E-04	-	-
LAWA44-172	172	434.93	0.20	0.01	-	4.1E+03	1.2E-03	3.6E+04	1.2E-02	1.0E+01	7.1E-04	-	-
LAWA44-173	173	437.36	0.19	0.01	-	3.7E+03	1.1E-03	3.2E+04	1.1E-02	2.5E+00	1.8E-04	-	-
LAWA44-174	174	439.88	0.19	0.01	-	3.4E+03	1.0E-03	3.3E+04	1.2E-02	3.0E+00	2.2E-04	-	-
LAWA44-175	175	443.38	0.19	0.01	-	3.9E+03	1.2E-03	4.8E+04	1.7E-02	7.7E+00	5.5E-04	-	-
LAWA44-176	176	446.76	0.19	0.02	-	4.8E+03	1.5E-03	3.6E+04	1.3E-02	7.0E+00	5.1E-04	-	-
LAWA44-177	177	448.95	0.20	0.01	-	3.8E+03	1.1E-03	3.1E+04	1.0E-02	4.2E+00	2.8E-04	-	-
LAWA44-178	178	451.40	0.21	0.01	-	3.6E+03	9.9E-04	3.7E+04	1.2E-02	5.7E+00	3.7E-04	-	-
LAWA44-179	179	453.86	0.22	0.01	-	3.5E+03	9.1E-04	3.4E+04	1.0E-02	4.0E+00	2.4E-04	-	-
LAWA44-180	180	456.06	0.23	0.01	-	3.7E+03	9.2E-04	3.4E+04	1.0E-02	5.0E+00	3.0E-04	-	-
LAWA44-181	181	458.41	0.23	0.01	-	3.7E+03	9.1E-04	3.6E+04	1.0E-02	8.8E+00	5.2E-04	-	-
LAWA44-182	182	460.82	0.24	0.01	-	3.5E+03	8.3E-04	3.5E+04	9.8E-03	9.0E+00	5.1E-04	-	-
LAWA44-183	183	463.01	0.24	0.01	-	3.3E+03	7.7E-04	3.4E+04	9.6E-03	4.5E+00	2.6E-04	-	-
LAWA44-184	184	465.40	0.22	0.01	-	4.4E+03	1.1E-03	3.2E+04	1.0E-02	1.7E+00	1.1E-04	-	-
LAWA44-185	185	468.27	0.23	0.01	-	3.9E+03	9.8E-04	3.3E+04	9.8E-03	5.0E-01	3.0E-05	-	-

Table B1. LAWA44 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Cr]	Cr Rate	[Mg]	Mg Rate
LAWA44-186	186	475.25	0.10	0.10	-	3.2E+03	1.8E-03	3.5E+04	2.3E-02	4.9E+00	6.5E-04	-	-
LAWA44-187	187	481.81	0.07	0.07	-	3.3E+03	2.7E-03	3.5E+04	3.4E-02	6.9E+00	1.4E-03	-	-
LAWA44-188	188	484.04	0.22	0.01	-	4.6E+03	1.2E-03	3.3E+04	1.0E-02	1.3E+01	8.0E-04	-	-
LAWA44-189	189	486.42	0.23	0.01	-	3.5E+03	8.7E-04	3.3E+04	9.9E-03	4.9E+00	3.0E-04	-	-
LAWA44-190	190	488.80	0.25	0.00	-	3.1E+03	7.1E-04	3.4E+04	9.2E-03	2.1E+00	1.1E-04	-	-
LAWA44-191	191	491.31	0.22	0.01	-	4.4E+03	1.2E-03	5.5E+04	1.7E-02	9.1E+00	5.7E-04	-	-
LAWA44-192	192	494.69	0.18	0.18	-	2.9E+03	9.2E-04	3.5E+04	1.3E-02	6.1E+00	4.7E-04	-	-
LAWA44-193	193	497.85	0.26	0.01	-	3.2E+03	7.0E-04	3.3E+04	8.6E-03	4.2E+00	2.2E-04	-	-
LAWA44-194	194	500.39	0.26	0.00	-	3.7E+03	8.1E-04	3.2E+04	8.3E-03	8.2E+00	4.3E-04	-	-
LAWA44-195	195	497.85	0.26	0.00	-	4.4E+03	9.6E-04	2.7E+04	7.0E-03	6.3E+00	3.3E-04	-	-
LAWA44-196	196	500.47	0.26	0.00	-	3.7E+03	8.1E-04	3.2E+04	8.2E-03	3.5E+00	1.8E-04	-	-
LAWA44-197	197	508.37	0.26	0.00	-	4.0E+03	8.8E-04	3.2E+04	8.3E-03	2.1E+01	1.1E-03	-	-
LAWA44-198	198	514.75	0.26	0.00	-	4.2E+03	9.0E-04	3.3E+04	8.6E-03	7.1E+00	3.7E-04	-	-

θ – volumetric water content
σθ –volumetric water content error
[] – concentration in ug L^{-1}
Rate – in g m^{-2} d^{-1}

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-01	1	0.07	0.31	0.12	-	1.9E+05	7.7E-03	8.9E+04	2.6E-03	6.4E+01	3.2E-05	4.0E+02	1.0E-04	7.3E+01	2.0E-05
LWA44-02	2	0.18	0.07	0.05	-	3.4E+05	5.9E-02	9.5E+04	1.2E-02	6.7E+01	1.5E-04	3.4E+02	3.7E-04	4.8E+01	5.6E-05
LWA44-03	3	1.19	0.05	0.01	-	4.6E+05	1.2E-01	1.4E+05	2.6E-02	4.8E+01	1.5E-04	1.8E+02	2.9E-04	4.6E+01	7.9E-05
LWA44-04	4	3.41	0.04	0.01	-	8.7E+05	2.6E-01	2.1E+05	4.3E-02	6.4E+00	2.3E-05	6.5E+01	1.2E-04	1.2E+01	2.3E-05
LWA44-05	5	5.74	0.03	0.01	-	6.3E+05	2.4E-01	1.7E+05	4.7E-02	2.5E+01	1.2E-04	3.3E+01	7.8E-05	6.3E+01	1.6E-04
LWA44-06	6	7.91	0.02	0.00	-	5.5E+05	2.9E-01	1.7E+05	6.3E-02	4.5E+01	2.9E-04	5.8E+01	1.9E-04	1.1E+02	3.8E-04
LWA44-07	7	10.37	0.03	0.01	-	5.2E+05	2.4E-01	1.7E+05	5.6E-02	7.3E+01	4.3E-04	6.6E+01	1.9E-04	1.6E+02	5.2E-04
LWA44-08	8	12.78	0.03	0.01	-	4.9E+05	1.8E-01	1.6E+05	4.2E-02	8.0E+01	3.6E-04	3.3E+01	7.5E-05	1.9E+02	4.6E-04
LWA44-09	9	15.39	0.03	0.01	-	4.3E+05	1.6E-01	1.5E+05	3.8E-02	9.8E+01	4.5E-04	8.4E+01	1.9E-04	2.3E+02	5.7E-04
LWA44-10	10	17.90	0.03	0.00	-	4.2E+05	1.8E-01	1.5E+05	4.8E-02	1.1E+02	6.2E-04	5.9E+01	1.6E-04	2.5E+02	7.6E-04
LWA44-11	11	20.05	0.03	0.01	-	4.1E+05	1.6E-01	1.5E+05	4.2E-02	1.3E+02	6.5E-04	6.7E+01	1.6E-04	3.0E+02	7.7E-04
LWA44-12	12	22.50	0.03	0.01	-	3.7E+05	1.3E-01	1.4E+05	3.7E-02	1.4E+02	6.2E-04	6.3E+01	1.4E-04	3.1E+02	7.5E-04
LWA44-13	13	24.75	0.02	0.01	-	3.6E+05	2.5E-01	1.4E+05	7.0E-02	1.6E+02	1.4E-03	4.0E+01	1.7E-04	3.8E+02	1.7E-03
LWA44-14	14	26.82	0.04	0.01	-	3.7E+05	1.1E-01	1.4E+05	2.8E-02	1.4E+02	4.8E-04	6.1E+01	1.1E-04	3.1E+02	5.9E-04
LWA44-15	15	29.01	0.05	0.01	-	3.8E+05	1.0E-01	1.4E+05	2.7E-02	1.6E+02	5.5E-04	6.4E+01	1.1E-04	3.5E+02	6.4E-04
LWA44-16	16	31.40	0.04	0.01	-	3.4E+05	1.1E-01	1.3E+05	3.0E-02	1.7E+02	6.6E-04	6.5E+01	1.3E-04	3.7E+02	7.6E-04
LWA44-17	17	34.27	0.05	0.01	-	3.2E+05	7.9E-02	1.2E+05	2.2E-02	1.8E+02	5.5E-04	7.5E+01	1.2E-04	3.9E+02	6.5E-04
LWA44-18	18	36.80	0.05	0.00	-	3.3E+05	9.0E-02	1.4E+05	2.6E-02	1.8E+02	6.2E-04	7.4E+01	1.2E-04	4.1E+02	7.4E-04
LWA44-19	19	38.76	0.05	0.00	-	3.5E+05	9.0E-02	1.4E+05	2.6E-02	1.6E+02	5.0E-04	7.4E+01	1.2E-04	3.6E+02	6.0E-04
LWA44-20	20	40.87	0.05	0.01	-	3.5E+05	8.0E-02	1.4E+05	2.4E-02	1.6E+02	4.7E-04	6.7E+01	9.7E-05	3.7E+02	5.7E-04
LWA44-21	21	43.02	0.05	0.00	-	3.3E+05	8.5E-02	1.4E+05	2.6E-02	1.7E+02	5.5E-04	7.6E+01	1.2E-04	3.8E+02	6.7E-04
LWA44-22	22	45.38	0.05	0.01	-	3.2E+05	7.3E-02	1.4E+05	2.3E-02	1.8E+02	5.1E-04	5.4E+01	7.9E-05	4.0E+02	6.3E-04
LWA44-23	23	48.28	0.05	0.01	-	3.2E+05	7.4E-02	1.4E+05	2.2E-02	1.8E+02	5.1E-04	7.6E+01	1.1E-04	3.9E+02	6.0E-04
LWA44-24	24	50.83	0.05	0.01	-	2.6E+05	6.2E-02	1.1E+05	1.9E-02	2.0E+02	6.0E-04	6.5E+01	9.9E-05	4.7E+02	7.6E-04
LWA44-25	25	53.26	0.06	0.01	-	2.9E+05	6.0E-02	1.3E+05	1.9E-02	2.2E+02	5.6E-04	7.0E+01	9.1E-05	5.0E+02	7.0E-04
LWA44-26	26	56.38	0.06	0.01	-	3.1E+05	6.4E-02	1.4E+05	2.0E-02	1.8E+02	4.7E-04	9.0E+01	1.2E-04	4.4E+02	6.1E-04
LWA44-27	27	59.42	0.06	0.01	-	2.9E+05	6.4E-02	1.3E+05	2.0E-02	1.8E+02	4.9E-04	7.3E+01	1.0E-04	4.1E+02	6.0E-04
LWA44-28	28	61.76	0.06	0.01	-	2.8E+05	6.4E-02	1.3E+05	2.0E-02	1.9E+02	5.2E-04	6.8E+01	9.6E-05	4.4E+02	6.7E-04
LWA44-29	29	63.91	0.06	0.01	-	2.7E+05	5.8E-02	1.2E+05	1.8E-02	1.8E+02	4.8E-04	6.8E+01	9.2E-05	4.2E+02	6.2E-04
LWA44-30	30	66.40	0.06	0.01	-	2.8E+05	5.6E-02	1.3E+05	1.8E-02	1.9E+02	4.5E-04	7.3E+01	9.0E-05	4.8E+02	6.3E-04
LWA44-31	31	68.76	0.07	0.01	-	2.9E+05	5.5E-02	1.3E+05	1.8E-02	2.0E+02	4.6E-04	6.5E+01	7.7E-05	4.9E+02	6.2E-04
LWA44-32	32	70.93	0.06	0.01	-	2.5E+05	4.9E-02	1.1E+05	1.6E-02	1.8E+02	4.4E-04	6.6E+01	8.0E-05	4.4E+02	5.8E-04
LWA44-33	33	73.41	0.06	0.01	-	2.5E+05	5.7E-02	1.1E+05	1.8E-02	1.8E+02	5.0E-04	8.8E+01	1.2E-04	4.4E+02	6.7E-04
LWA44-34	34	75.83	0.07	0.01	-	2.8E+05	5.3E-02	1.3E+05	1.8E-02	2.0E+02	4.8E-04	1.1E+02	1.3E-04	5.2E+02	6.6E-04
LWA44-35	35	77.99	0.05	0.01	-	2.6E+05	6.3E-02	1.2E+05	2.0E-02	1.9E+02	5.6E-04	5.0E+01	7.5E-05	5.2E+02	8.3E-04
LWA44-36	36	80.40	0.05	0.01	-	2.5E+05	6.3E-02	1.1E+05	1.9E-02	1.7E+02	5.3E-04	3.6E+01	5.7E-05	4.8E+02	8.1E-04
LWA44-37	37	82.77	0.05	0.01	-	2.6E+05	6.1E-02	1.1E+05	1.9E-02	1.8E+02	5.2E-04	3.0E+01	4.4E-05	5.1E+02	7.9E-04
LWA44-38	38	84.78	0.06	0.01	-	2.8E+05	6.4E-02	1.3E+05	2.1E-02	2.0E+02	5.7E-04	3.5E+01	5.0E-05	5.6E+02	8.5E-04
LWA44-39	39	87.92	0.06	0.01	-	2.5E+05	5.5E-02	1.1E+05	1.7E-02	1.9E+02	5.3E-04	4.4E+01	6.1E-05	5.5E+02	8.1E-04

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-40	40	91.56	0.07	0.01	-	2.7E+05	5.1E-02	1.2E+05	1.6E-02	1.9E+02	4.5E-04	3.6E+01	4.3E-05	5.4E+02	6.8E-04
LWA44-41	41	94.49	0.05	0.01	-	2.3E+05	5.8E-02	1.0E+05	1.8E-02	1.8E+02	5.6E-04	3.3E+01	5.2E-05	5.1E+02	8.7E-04
LWA44-42	42	96.99	0.05	0.01	-	2.6E+05	6.5E-02	1.1E+05	2.0E-02	1.6E+02	5.2E-04	3.6E+01	5.7E-05	4.8E+02	8.2E-04
LWA44-43	43	98.95	0.07	0.00	-	3.1E+05	5.8E-02	1.4E+05	1.8E-02	2.0E+02	4.7E-04	4.7E+01	5.4E-05	5.8E+02	7.2E-04
LWA44-44	44	102.33	0.07	0.01	-	2.7E+05	5.3E-02	1.3E+05	1.7E-02	2.1E+02	5.1E-04	4.1E+01	4.9E-05	6.1E+02	7.8E-04
LWA44-45	45	105.95	0.07	0.00	-	2.4E+05	4.4E-02	1.1E+05	1.4E-02	2.0E+02	4.7E-04	4.6E+01	5.3E-05	5.9E+02	7.3E-04
LWA44-46	46	108.41	0.07	0.01	-	2.7E+05	5.1E-02	1.2E+05	1.7E-02	1.9E+02	4.5E-04	5.3E+01	6.3E-05	5.6E+02	7.1E-04
LWA44-47	47	110.82	0.07	0.01	-	2.6E+05	4.8E-02	1.2E+05	1.6E-02	2.1E+02	5.0E-04	4.6E+01	5.4E-05	6.2E+02	7.9E-04
LWA44-48	48	112.98	0.07	0.01	-	2.7E+05	4.8E-02	1.2E+05	1.6E-02	2.2E+02	4.9E-04	4.9E+01	5.6E-05	6.4E+02	7.9E-04
LWA44-49	49	115.44	0.06	0.01	-	2.1E+05	4.1E-02	9.5E+04	1.3E-02	1.8E+02	4.4E-04	3.5E+01	4.3E-05	5.4E+02	7.1E-04
LWA44-50	50	117.82	0.07	0.01	-	2.8E+05	4.8E-02	1.3E+05	1.6E-02	1.9E+02	4.1E-04	4.3E+01	4.7E-05	5.6E+02	6.6E-04
LWA44-51	51	119.93	0.07	0.01	-	2.6E+05	4.6E-02	1.3E+05	1.6E-02	2.0E+02	4.4E-04	4.1E+01	4.5E-05	5.9E+02	7.1E-04
LWA44-52	52	122.35	0.07	0.01	-	2.1E+05	3.6E-02	9.8E+04	1.2E-02	2.0E+02	4.3E-04	4.6E+01	4.9E-05	6.0E+02	6.9E-04
LWA44-53	53	124.75	0.10	0.01	-	2.4E+05	3.0E-02	1.1E+05	1.0E-02	1.9E+02	3.0E-04	4.9E+01	3.8E-05	5.7E+02	4.8E-04
LWA44-54	54	126.90	0.09	0.01	-	2.4E+05	3.5E-02	1.1E+05	1.2E-02	2.0E+02	3.6E-04	5.4E+01	4.8E-05	6.0E+02	5.8E-04
LWA44-55	55	129.36	0.08	0.00	-	2.0E+05	3.0E-02	9.1E+04	1.0E-02	2.0E+02	3.8E-04	4.3E+01	4.1E-05	5.8E+02	6.0E-04
LWA44-56	56	131.75	0.09	0.01	-	2.2E+05	3.0E-02	1.0E+05	9.9E-03	1.9E+02	3.2E-04	4.3E+01	3.7E-05	5.6E+02	5.2E-04
LWA44-57	57	133.86	0.08	0.01	-	2.6E+05	3.8E-02	1.2E+05	1.3E-02	1.7E+02	3.2E-04	4.2E+01	3.9E-05	4.9E+02	5.0E-04
LWA44-58	58	136.34	0.08	0.00	-	2.9E+05	4.6E-02	1.0E+05	1.1E-02	1.7E+02	3.4E-04	5.1E+01	5.1E-05	5.0E+02	5.3E-04
LWA44-59	59	139.20	0.08	0.00	-	3.6E+05	5.5E-02	1.1E+05	1.2E-02	1.4E+02	2.7E-04	6.9E+01	6.7E-05	4.2E+02	4.4E-04
LWA44-60	60	141.26	0.08	0.00	-	3.4E+05	5.2E-02	9.7E+04	1.1E-02	1.4E+02	2.7E-04	6.6E+01	6.4E-05	4.1E+02	4.3E-04
LWA44-61	61	143.82	0.08	0.00	-	3.4E+05	5.4E-02	9.2E+04	1.0E-02	1.4E+02	2.7E-04	6.1E+01	6.0E-05	4.2E+02	4.4E-04
LWA44-62	62	147.44	0.08	0.01	-	3.7E+05	5.5E-02	8.8E+04	9.5E-03	1.4E+02	2.7E-04	3.5E+01	3.3E-05	4.0E+02	4.0E-04
LWA44-63	63	150.33	0.07	0.00	-	3.2E+05	5.5E-02	7.7E+04	9.4E-03	1.3E+02	2.8E-04	3.2E+01	3.4E-05	3.8E+02	4.4E-04
LWA44-64	64	152.73	0.08	0.00	-	3.2E+05	5.1E-02	7.3E+04	8.4E-03	1.2E+02	2.4E-04	2.9E+01	3.0E-05	3.3E+02	3.6E-04
LWA44-65	65	154.98	0.08	0.01	-	3.0E+05	4.6E-02	7.1E+04	7.8E-03	1.2E+02	2.3E-04	2.7E+01	2.6E-05	3.5E+02	3.6E-04
LWA44-66	66	157.41	0.07	0.00	-	2.2E+05	3.8E-02	7.5E+04	9.3E-03	1.4E+02	3.1E-04	2.7E+01	2.9E-05	4.2E+02	4.8E-04
LWA44-67	67	159.82	0.08	0.01	-	2.1E+05	3.5E-02	7.8E+04	9.2E-03	1.7E+02	3.5E-04	3.1E+01	3.2E-05	5.1E+02	5.7E-04
LWA44-68	68	161.96	0.08	0.01	-	1.8E+05	3.1E-02	6.9E+04	8.2E-03	1.5E+02	3.1E-04	2.7E+01	2.8E-05	4.6E+02	5.1E-04
LWA44-69	69	164.35	0.07	0.01	-	1.8E+05	3.2E-02	7.2E+04	9.1E-03	1.6E+02	3.5E-04	2.8E+01	3.1E-05	4.8E+02	5.7E-04
LWA44-70	70	166.86	0.07	0.01	-	1.6E+05	2.8E-02	6.6E+04	8.2E-03	1.5E+02	3.2E-04	2.5E+01	2.7E-05	4.5E+02	5.3E-04
LWA44-71	71	169.03	0.08	0.01	-	2.0E+05	3.0E-02	8.3E+04	8.9E-03	1.5E+02	2.8E-04	2.9E+01	2.7E-05	4.5E+02	4.6E-04
LWA44-72	72	171.35	0.09	0.00	-	1.8E+05	2.6E-02	7.6E+04	7.9E-03	1.3E+02	2.3E-04	2.5E+01	2.2E-05	3.9E+02	3.8E-04
LWA44-73	73	173.85	0.08	0.01	-	2.0E+05	3.0E-02	8.9E+04	9.4E-03	1.2E+02	2.3E-04	2.5E+01	2.3E-05	3.8E+02	3.8E-04
LWA44-74	74	176.00	0.06	0.01	-	1.8E+05	3.6E-02	7.9E+04	1.1E-02	1.2E+02	3.0E-04	2.8E+01	3.5E-05	3.6E+02	5.0E-04
LWA44-75	75	178.33	0.06	0.01	-	2.0E+05	4.5E-02	8.9E+04	1.4E-02	1.6E+02	4.3E-04	7.1E+01	9.7E-05	4.9E+02	7.2E-04
LWA44-76	76	180.80	0.06	0.02	-	2.0E+05	4.1E-02	9.0E+04	1.3E-02	1.4E+02	3.5E-04	3.4E+01	4.4E-05	4.4E+02	6.2E-04
LWA44-77	77	183.45	0.08	0.01	-	2.1E+05	3.5E-02	9.7E+04	1.1E-02	1.3E+02	2.7E-04	3.9E+01	4.0E-05	4.1E+02	4.6E-04
LWA44-78	78	186.47	0.05	0.02	-	2.1E+05	5.9E-02	1.0E+05	2.1E-02	1.4E+02	4.9E-04	4.4E+01	7.5E-05	4.2E+02	7.7E-04
LWA44-79	79	189.53	0.04	0.01	-	2.4E+05	7.1E-02	1.3E+05	2.8E-02	1.3E+02	4.9E-04	4.5E+01	8.2E-05	3.9E+02	7.7E-04

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-80	80	192.41	0.05	0.01	-	2.2E+05	5.6E-02	1.2E+05	2.2E-02	1.4E+02	4.2E-04	4.5E+01	7.0E-05	4.0E+02	6.7E-04
LWA44-81	81	194.83	0.04	0.02	-	2.6E+05	8.0E-02	1.6E+05	3.5E-02	5.2E+02	2.0E-03	1.2E+02	2.3E-04	1.3E+03	2.8E-03
LWA44-82	82	197.50	0.03	0.00	-	1.5E+05	6.1E-02	6.8E+04	2.0E-02	1.8E+02	9.4E-04	3.7E+01	9.6E-05	5.6E+02	1.6E-03
LWA44-83	83	199.86	0.02	0.00	-	1.9E+05	9.9E-02	8.6E+04	3.3E-02	1.8E+02	1.2E-03	3.5E+01	1.1E-04	5.7E+02	2.0E-03
LWA44-84	84	201.73	0.04	0.01	-	2.1E+05	7.1E-02	9.7E+04	2.3E-02	1.8E+02	7.7E-04	3.6E+01	7.4E-05	7.4E+02	1.6E-03
LWA44-85	85	203.92	0.03	0.00	-	2.0E+05	8.4E-02	9.8E+04	2.9E-02	1.8E+02	9.3E-04	4.3E+01	1.1E-04	5.6E+02	1.6E-03
LWA44-86	86	206.37	0.02	0.00	-	2.0E+05	1.1E-01	9.5E+04	3.8E-02	1.7E+02	1.2E-03	4.1E+01	1.4E-04	5.4E+02	2.0E-03
LWA44-87	87	208.77	0.02	0.00	-	2.0E+05	1.1E-01	9.7E+04	3.8E-02	1.8E+02	1.2E-03	4.4E+01	1.5E-04	5.6E+02	2.0E-03
LWA44-88	88	210.97	0.03	0.01	-	2.2E+05	9.8E-02	1.0E+05	3.3E-02	1.9E+02	1.1E-03	4.3E+01	1.2E-04	5.8E+02	1.7E-03
LWA44-89	89	213.40	0.02	0.01	-	2.2E+05	1.2E-01	1.1E+05	4.0E-02	1.9E+02	1.2E-03	4.2E+01	1.4E-04	5.9E+02	2.0E-03
LWA44-90	90	215.80	0.02	0.01	-	2.2E+05	1.2E-01	1.1E+05	4.2E-02	1.9E+02	1.3E-03	3.6E+01	1.2E-04	5.9E+02	2.1E-03
LWA44-91	91	217.93	0.02	0.01	-	2.1E+05	1.5E-01	1.0E+05	5.1E-02	1.9E+02	1.7E-03	4.6E+01	2.0E-04	5.7E+02	2.7E-03
LWA44-92	92	220.36	0.02	0.00	-	2.0E+05	1.1E-01	9.8E+04	3.7E-02	1.9E+02	1.2E-03	5.0E+01	1.7E-04	5.8E+02	2.1E-03
LWA44-93	93	222.84	0.03	0.00	-	2.2E+05	9.6E-02	1.1E+05	3.4E-02	2.0E+02	1.1E-03	4.3E+01	1.2E-04	6.0E+02	1.8E-03
LWA44-94	94	225.00	0.04	0.02	-	2.1E+05	5.9E-02	1.0E+05	2.1E-02	1.9E+02	6.6E-04	4.8E+01	8.5E-05	5.8E+02	1.1E-03
LWA44-95	95	227.50	0.07	0.00	-	2.9E+05	4.9E-02	1.5E+05	1.9E-02	2.2E+02	4.8E-04	5.3E+01	5.7E-05	6.3E+02	7.2E-04
LWA44-96	96	230.01	0.04	0.00	-	2.1E+05	6.2E-02	1.2E+05	2.5E-02	2.9E+02	1.1E-03	5.2E+01	9.6E-05	8.6E+02	1.7E-03
LWA44-97	97	232.10	0.04	0.01	-	1.8E+05	5.9E-02	9.0E+04	2.1E-02	2.6E+02	1.1E-03	4.9E+01	9.9E-05	7.9E+02	1.7E-03
LWA44-98	98	234.46	0.03	0.02	-	1.5E+05	5.3E-02	7.1E+04	1.8E-02	2.0E+02	9.2E-04	5.0E+01	1.1E-04	5.9E+02	1.4E-03
LWA44-99	99	236.86	0.09	0.00	-	2.1E+05	3.0E-02	9.9E+04	1.0E-02	2.1E+02	3.8E-04	7.3E+01	6.6E-05	6.4E+02	6.2E-04
LWA44-100	100	238.96	0.10	0.00	-	2.4E+05	3.1E-02	1.2E+05	1.1E-02	2.0E+02	3.3E-04	4.5E+01	3.6E-05	6.0E+02	5.2E-04
LWA44-101	101	241.37	0.10	0.00	-	2.4E+05	2.9E-02	1.2E+05	1.1E-02	2.0E+02	3.0E-04	5.1E+01	3.8E-05	6.1E+02	5.0E-04
LWA44-102	102	243.81	0.06	0.02	-	2.1E+05	4.1E-02	1.1E+05	1.5E-02	1.9E+02	4.6E-04	4.9E+01	6.0E-05	5.8E+02	7.6E-04
LWA44-103	103	245.97	0.06	0.00	-	1.6E+05	3.2E-02	8.1E+04	1.1E-02	1.7E+02	4.2E-04	4.4E+01	5.4E-05	5.4E+02	7.1E-04
LWA44-104	104	248.43	0.07	0.00	-	2.4E+05	4.1E-02	1.2E+05	1.5E-02	2.2E+02	4.8E-04	4.6E+01	5.0E-05	6.7E+02	7.8E-04
LWA44-105	105	250.91	0.07	0.00	-	2.0E+05	3.4E-02	1.2E+05	1.5E-02	2.0E+02	4.2E-04	3.0E+01	3.3E-05	5.9E+02	6.8E-04
LWA44-106	106	253.43	0.07	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-107	107	255.80	0.07	0.00	-	-	-	-	-	-	-	-	-	-	-
LWA44-108	108	257.88	0.06	0.03	-	2.7E+05	5.7E-02	1.6E+05	2.3E-02	2.8E+02	7.2E-04	4.6E+01	6.1E-05	8.1E+02	1.1E-03
LWA44-109	109	260.34	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-110	110	262.74	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-111	111	264.82	0.05	0.01	-	2.1E+05	5.1E-02	1.3E+05	2.2E-02	2.2E+02	6.7E-04	3.6E+01	5.6E-05	6.7E+02	1.1E-03
LWA44-112	112	266.94	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-113	113	273.90	0.04	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-114	114	280.95	0.04	0.01	-	2.2E+05	6.9E-02	1.3E+05	2.9E-02	2.3E+02	9.0E-04	2.3E+01	4.6E-05	7.0E+02	1.5E-03
LWA44-115	115	283.39	0.03	0.00	-	-	-	-	-	-	-	-	-	-	-
LWA44-116	116	285.88	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-117	117	288.04	0.04	0.01	-	1.9E+05	6.1E-02	1.1E+05	2.5E-02	2.1E+02	7.9E-04	2.6E+01	5.1E-05	6.1E+02	1.3E-03
LWA44-118	118	290.44	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-119	119	292.95	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-120	120	295.50	0.05	0.01	-	1.9E+05	4.9E-02	1.2E+05	2.1E-02	2.2E+02	6.9E-04	6.4E+01	1.0E-04	6.9E+02	1.2E-03
LWA44-121	121	297.94	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-122	122	300.00	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-123	123	302.12	0.04	0.00	-	2.4E+05	7.4E-02	1.4E+05	3.1E-02	3.6E+02	1.4E-03	5.4E+01	1.0E-04	1.2E+03	2.4E-03
LWA44-124	124	304.50	0.08	0.03	-	-	-	-	-	-	-	-	-	-	-
LWA44-125	125	307.77	0.27	0.08	-	-	-	-	-	-	-	-	-	-	-
LWA44-126	126	311.25	0.16	0.01	-	2.2E+05	1.7E-02	1.6E+05	9.0E-03	8.4E+02	8.1E-04	6.1E+01	2.9E-05	2.4E+03	1.2E-03
LWA44-127	127	313.84	0.17	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-128	128	316.01	0.17	0.00	-	-	-	-	-	-	-	-	-	-	-
LWA44-129	129	318.42	0.18	0.00	-	2.3E+05	1.6E-02	1.6E+05	8.0E-03	2.5E+02	2.2E-04	2.5E+01	1.1E-05	7.2E+02	3.4E-04
LWA44-130	130	321.28	0.17	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-131	131	327.97	0.15	0.02	-	-	-	-	-	-	-	-	-	-	-
LWA44-132	132	334.43	0.16	0.01	-	2.2E+05	1.7E-02	1.5E+05	8.1E-03	5.7E+02	5.5E-04	4.8E+01	2.3E-05	1.7E+03	8.5E-04
LWA44-133	133	336.84	0.18	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-134	134	339.33	0.19	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-135	135	341.79	0.21	0.01	-	2.0E+05	1.2E-02	1.4E+05	6.0E-03	4.4E+02	3.3E-04	8.1E+01	3.1E-05	1.3E+03	5.2E-04
LWA44-136	136	343.91	0.22	0.02	-	-	-	-	-	-	-	-	-	-	-
LWA44-137	137	346.87	0.13	1.28	-	-	-	-	-	-	-	-	-	-	-
LWA44-138	138	349.78	0.05	0.03	-	1.5E+05	3.4E-02	1.0E+05	1.7E-02	2.6E+02	7.3E-04	2.5E+01	3.6E-05	7.7E+02	1.2E-03
LWA44-139	139	351.44	0.05	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-140	140	353.42	0.08	0.02	-	-	-	-	-	-	-	-	-	-	-
LWA44-141	141	355.80	0.08	0.01	-	1.6E+05	2.4E-02	8.7E+04	9.5E-03	3.3E+02	6.2E-04	2.6E+01	2.4E-05	9.5E+02	9.7E-04
LWA44-142	142	357.95	0.09	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-143	143	360.38	0.11	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-144	144	362.76	0.13	0.01	-	1.7E+05	1.7E-02	9.9E+04	7.1E-03	2.8E+02	3.5E-04	4.6E+01	2.8E-05	8.2E+02	5.5E-04
LWA44-145	145	364.97	0.13	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-146	146	367.40	0.13	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-147	147	369.89	0.13	0.01	-	1.8E+05	1.8E-02	1.0E+05	7.3E-03	2.7E+02	3.3E-04	1.4E+01	8.5E-06	7.7E+02	5.1E-04
LWA44-148	148	372.46	0.13	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-149	149	375.29	0.11	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-150	150	378.26	0.13	0.00	-	1.8E+05	1.8E-02	1.1E+05	7.3E-03	2.7E+02	3.2E-04	2.4E+01	1.5E-05	7.7E+02	4.9E-04
LWA44-151	151	381.25	0.13	0.00	-	-	-	-	-	-	-	-	-	-	-
LWA44-152	152	383.85	0.13	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-153	153	386.04	0.15	0.00	-	1.8E+05	1.5E-02	1.1E+05	6.3E-03	2.3E+02	2.4E-04	1.4E+01	7.0E-06	6.8E+02	3.7E-04
LWA44-154	154	388.38	0.15	0.00	-	-	-	-	-	-	-	-	-	-	-
LWA44-155	155	390.82	0.15	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-156	156	393.51	0.15	0.01	-	1.4E+05	1.1E-02	8.0E+04	4.7E-03	2.1E+02	2.1E-04	2.0E+01	1.1E-05	6.2E+02	3.4E-04

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-157	157	395.88	0.13	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-158	158	397.90	0.15	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-159	159	400.08	0.13	0.02	-	1.7E+05	1.6E-02	1.0E+05	7.1E-03	2.5E+02	3.0E-04	4.6E+01	2.8E-05	7.5E+02	4.9E-04
LWA44-160	160	402.33	0.12	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-161	161	404.71	0.15	0.02	-	-	-	-	-	-	-	-	-	-	-
LWA44-162	162	406.95	0.15	0.01	-	1.8E+05	1.5E-02	1.1E+05	6.4E-03	2.6E+02	2.7E-04	7.4E+01	3.8E-05	7.8E+02	4.3E-04
LWA44-163	163	409.39	0.17	0.01	-	-	-	-	-	-	-	-	-	-	-
LWA44-164	164	411.87	0.18	0.01	-	1.7E+05	1.2E-02	9.9E+04	5.0E-03	2.2E+02	1.9E-04	5.1E+01	2.2E-05	6.3E+02	3.0E-04
LWA44-165	165	414.49	0.18	0.01	-	1.8E+05	1.2E-02	9.4E+04	4.6E-03	1.8E+02	1.6E-04	-	0.0E+00	4.7E+02	2.2E-04
LWA44-166	166	417.31	0.18	0.01	-	1.9E+05	1.3E-02	1.0E+05	5.0E-03	2.0E+02	1.7E-04	-	0.0E+00	5.4E+02	2.5E-04
LWA44-167	167	420.27	0.19	0.01	-	2.0E+05	1.3E-02	1.1E+05	5.0E-03	2.6E+02	2.1E-04	-	0.0E+00	5.5E+02	2.4E-04
LWA44-168	168	424.29	0.19	0.01	-	1.7E+05	1.1E-02	8.6E+04	4.1E-03	1.6E+02	1.4E-04	-	0.0E+00	4.6E+02	2.1E-04
LWA44-169	169	427.89	0.20	0.01	-	1.8E+05	1.1E-02	8.9E+04	4.0E-03	1.7E+02	1.3E-04	-	0.0E+00	4.9E+02	2.1E-04
LWA44-170	170	430.36	0.18	0.01	-	1.7E+05	1.1E-02	8.8E+04	4.3E-03	2.0E+02	1.7E-04	-	0.0E+00	4.6E+02	2.1E-04
LWA44-171	171	432.76	0.20	0.01	-	1.8E+05	1.2E-02	9.2E+04	4.2E-03	1.8E+02	1.4E-04	-	0.0E+00	5.0E+02	2.1E-04
LWA44-172	172	434.93	0.20	0.01	-	2.0E+05	1.2E-02	9.6E+04	4.3E-03	1.8E+02	1.4E-04	7.6E+00	3.0E-06	5.3E+02	2.2E-04
LWA44-173	173	437.36	0.19	0.01	-	1.7E+05	1.1E-02	8.5E+04	4.1E-03	1.7E+02	1.4E-04	-	0.0E+00	4.3E+02	1.9E-04
LWA44-174	174	439.88	0.19	0.01	-	1.7E+05	1.1E-02	8.7E+04	4.1E-03	1.6E+02	1.3E-04	-	0.0E+00	4.2E+02	1.9E-04
LWA44-175	175	443.38	0.19	0.01	-	2.7E+05	1.8E-02	1.2E+05	5.4E-03	1.9E+02	1.6E-04	-	0.0E+00	5.4E+02	2.4E-04
LWA44-176	176	446.76	0.19	0.02	-	2.1E+05	1.4E-02	1.1E+05	5.3E-03	1.8E+02	1.5E-04	-	0.0E+00	5.1E+02	2.3E-04
LWA44-177	177	448.95	0.20	0.01	-	1.7E+05	1.0E-02	8.4E+04	3.7E-03	1.5E+02	1.1E-04	-	0.0E+00	4.1E+02	1.7E-04
LWA44-178	178	451.40	0.21	0.01	-	1.9E+05	1.2E-02	9.8E+04	4.2E-03	1.6E+02	1.2E-04	-	0.0E+00	4.6E+02	1.9E-04
LWA44-179	179	453.86	0.22	0.01	-	1.8E+05	1.0E-02	9.6E+04	3.9E-03	1.4E+02	1.0E-04	-	0.0E+00	4.1E+02	1.6E-04
LWA44-180	180	456.06	0.23	0.01	-	1.9E+05	1.0E-02	9.9E+04	3.9E-03	1.6E+02	1.1E-04	-	0.0E+00	4.6E+02	1.7E-04
LWA44-181	181	458.41	0.23	0.01	-	1.9E+05	1.0E-02	9.9E+04	3.9E-03	1.6E+02	1.1E-04	-	0.0E+00	4.5E+02	1.6E-04
LWA44-182	182	460.82	0.24	0.01	-	1.9E+05	1.0E-02	9.9E+04	3.7E-03	1.6E+02	1.0E-04	-	0.0E+00	4.1E+02	1.4E-04
LWA44-183	183	463.01	0.24	0.01	-	1.8E+05	9.2E-03	9.7E+04	3.6E-03	1.5E+02	9.5E-05	-	0.0E+00	3.7E+02	1.3E-04
LWA44-184	184	465.40	0.22	0.01	-	1.8E+05	1.1E-02	1.0E+05	4.1E-03	1.7E+02	1.2E-04	-	0.0E+00	4.6E+02	1.8E-04
LWA44-185	185	468.27	0.23	0.01	-	1.7E+05	9.7E-03	8.8E+04	3.5E-03	1.4E+02	1.0E-04	-	0.0E+00	4.3E+02	1.6E-04
LWA44-186	186	475.25	0.10	0.10	-	1.8E+05	2.2E-02	9.8E+04	8.5E-03	1.5E+02	2.3E-04	-	0.0E+00	4.2E+02	3.5E-04
LWA44-187	187	481.81	0.07	0.07	-	1.8E+05	3.3E-02	1.0E+05	1.3E-02	1.6E+02	3.6E-04	-	0.0E+00	4.6E+02	5.6E-04
LWA44-188	188	484.04	0.22	0.01	-	1.8E+05	1.1E-02	1.1E+05	4.4E-03	2.2E+02	1.6E-04	-	0.0E+00	6.2E+02	2.4E-04
LWA44-189	189	486.42	0.23	0.01	-	1.8E+05	9.9E-03	9.3E+04	3.7E-03	1.4E+02	9.8E-05	-	0.0E+00	4.2E+02	1.6E-04
LWA44-190	190	488.80	0.25	0.00	-	1.8E+05	9.0E-03	9.5E+04	3.5E-03	1.5E+02	9.2E-05	-	0.0E+00	4.2E+02	1.4E-04
LWA44-191	191	491.31	0.22	0.01	-	3.1E+05	1.8E-02	1.1E+05	4.4E-03	2.2E+02	1.6E-04	-	0.0E+00	6.3E+02	2.4E-04
LWA44-192	192	494.69	0.18	0.18	-	1.7E+05	1.2E-02	9.1E+04	4.6E-03	1.5E+02	1.3E-04	-	0.0E+00	4.1E+02	1.9E-04
LWA44-193	193	497.85	0.26	0.01	-	1.8E+05	8.6E-03	1.0E+05	3.5E-03	2.3E+02	1.4E-04	-	0.0E+00	5.5E+02	1.8E-04

Table B1. LAWA44 PUF Test Results

Sample ID	Vial	Time	θ	σθ	pH	[Na]	Na Rate	[Si]	Si Rate	[Ti]	Ti Rate	[Zn]	Zn Rate	[Zr]	Zr Rate
LWA44-194	194	500.39	0.26	0.00	-	1.9E+05	8.9E-03	1.1E+05	3.7E-03	3.0E+02	1.8E-04	6.1E+00	1.8E-06	7.9E+02	2.6E-04
LWA44-195	195	497.85	0.26	0.00	-	1.7E+05	8.2E-03	9.9E+04	3.4E-03	2.7E+02	1.6E-04	2.4E+00	7.1E-07	7.2E+02	2.3E-04
LWA44-196	196	500.47	0.26	0.00	-	1.7E+05	8.1E-03	9.4E+04	3.2E-03	2.1E+02	1.2E-04	-	0.0E+00	5.8E+02	1.9E-04
LWA44-197	197	508.37	0.26	0.00	-	1.7E+05	8.0E-03	9.7E+04	3.3E-03	2.3E+02	1.4E-04	-	0.0E+00	6.3E+02	2.0E-04
LWA44-198	198	514.75	0.26	0.00	-	1.8E+05	8.5E-03	9.9E+04	3.4E-03	2.5E+02	1.5E-04	3.6E+00	1.1E-06	7.1E+02	2.3E-04

θ – volumetric water content
σθ –volumetric water content error
[] – concentration in ug L^{-1}
Rate – in g m^{-2} d^{-1}

Table B2. LAWB45 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[Fe]	[Li]	Li Rate	[Mg]	[Na]	Na Rate	[Si]	Si Rate	[S]	S Rate	[Zn]	[Zr]
LAW B45-1	1	0.08	2.6E-01	1.3E-01	7.976	1.0E+02	3.5E-07	1.1E+03	3.9E-04	(159.7)	-	(34.9)	9.2E+02	3.3E-04	(58.17)	(1896.8)	-	(2964.75)	-	(477.73)	-	(39.6)	(22.3)
LAW B45-2	2	0.97	1.1E-01	1.6E-02	8.656	1.1E+03	1.3E-03	1.2E+04	1.2E-02	(228.7)	-	(43.0)	9.4E+03	1.7E-02	146.84	1.5E+04	4.3E-03	3.8E+04	5.1E-03	1.3E+03	9.5E-03	(19.3)	(11.0)
LAW B45-3	3	2.46	1.3E-01	5.2E-03	9.462	1.4E+03	1.4E-03	7.6E+04	6.6E-02	(213.1)	-	(61.4)	4.3E+04	6.6E-02	(45.30)	8.1E+04	4.9E-02	9.8E+04	1.3E-02	7.6E+03	7.1E-02	(18.1)	(9.8)
LAW B45-4	4	5.09	1.3E-01	8.0E-03	9.460	1.1E+03	1.0E-03	1.1E+05	9.4E-02	(221.6)	-	(29.3)	6.5E+04	1.0E-01	(13.95)	1.2E+05	7.5E-02	1.1E+05	1.5E-02	9.9E+03	9.4E-02	(4.0)	(7.5)
LAW B45-5	5	7.26	1.2E-01	8.6E-03	9.628	9.9E+02	9.6E-04	9.3E+04	8.5E-02	(383.0)	9.9E-05	(26.0)	5.8E+04	9.5E-02	(12.91)	1.1E+05	6.9E-02	1.2E+05	1.7E-02	8.0E+03	7.8E-02	(8.7)	(6.3)
LAW B45-6	6	10.62	1.2E-01	6.7E-03	9.599	8.3E+02	7.9E-04	8.6E+04	8.0E-02	(262.7)	9.5E-06	(15.3)	5.3E+04	8.7E-02	(4.93)	9.9E+04	6.5E-02	1.1E+05	1.6E-02	6.9E+03	6.7E-02	(2.7)	(3.8)
LAW B45-7	7	13.15	1.2E-01	2.6E-03	9.571	8.3E+02	7.9E-04	9.8E+04	9.0E-02	(230.7)	-	(20.1)	5.9E+04	9.7E-02	(4.88)	1.1E+05	7.4E-02	1.1E+05	1.6E-02	7.7E+03	7.5E-02	(3.1)	(3.4)
LAW B45-8	8	14.69	1.2E-01	6.1E-03	9.478	7.7E+02	7.4E-04	8.4E+04	7.9E-02	2.7E+02	1.8E-05	(9.9)	4.8E+04	8.0E-02	(3.40)	9.6E+04	6.5E-02	1.1E+05	1.7E-02	6.5E+03	6.4E-02	(0.3)	(1.9)
LAW B45-9	9	17.52	1.3E-01	6.4E-03	9.332	7.4E+02	6.9E-04	7.8E+04	7.0E-02	4.2E+02	1.2E-04	(8.1)	4.3E+04	6.8E-02	(4.61)	9.2E+04	5.9E-02	1.0E+05	1.4E-02	6.1E+03	5.7E-02	(1.9)	(4.1)
LAW B45-10	10	20.09	1.3E-01	5.3E-03	9.469	7.4E+02	6.4E-04	8.4E+04	7.1E-02	6.2E+02	2.6E-04	(10.4)	4.6E+04	6.9E-02	(3.40)	1.0E+05	6.1E-02	1.1E+05	1.5E-02	6.6E+03	5.9E-02	<100	(3.4)
LAW B45-11	11	22.23	1.5E-01	2.9E-03	9.440	6.3E+02	4.7E-04	7.6E+04	5.7E-02	6.8E+02	2.6E-04	(4.2)	4.2E+04	5.6E-02	(5.47)	9.1E+04	4.8E-02	1.0E+05	1.2E-02	6.0E+03	4.6E-02	<100	(6.5)
LAW B45-12	12	24.63	1.5E-01	7.1E-03	9.355	6.8E+02	5.3E-04	7.6E+04	5.8E-02	3.8E+02	7.8E-05	(11.8)	4.1E+04	5.6E-02	(3.00)	8.8E+04	4.8E-02	1.1E+05	1.2E-02	5.8E+03	4.6E-02	(0.86)	(4.6)
LAW B45-13	13	27.59	1.5E-01	5.5E-03	9.432	6.5E+02	5.0E-04	8.1E+04	6.2E-02	3.5E+02	6.2E-05	(6.5)	4.4E+04	6.0E-02	(3.82)	9.4E+04	5.1E-02	9.5E+04	1.1E-02	6.1E+03	4.9E-02	<100	(4.0)
LAW B45-14	14	30.55	1.4E-01	3.8E-03	9.537	6.1E+02	4.8E-04	7.9E+04	6.2E-02	5.1E+02	1.7E-04	(6.2)	4.3E+04	6.1E-02	(1.89)	9.3E+04	5.3E-02	1.1E+05	1.3E-02	6.2E+03	5.1E-02	<100	(2.8)
LAW B45-15	15	33.13	1.5E-01	3.6E-03	9.537	6.9E+02	5.3E-04	8.0E+04	6.0E-02	4.5E+02	1.3E-04	(6.2)	4.3E+04	5.8E-02	(4.60)	9.4E+04	5.0E-02	1.0E+05	1.2E-02	6.1E+03	4.8E-02	<100	(3.3)
LAW B45-16	16	35.31	1.4E-01	3.6E-03	9.383	7.8E+02	6.4E-04	7.8E+04	6.1E-02	5.6E+02	2.0E-04	(3.9)	4.0E+04	5.6E-02	(2.51)	9.3E+04	5.2E-02	9.9E+04	1.2E-02	5.7E+03	4.7E-02	<100	(2.3)
LAW B45-17	17	37.64	1.4E-01	5.9E-03	9.435	8.2E+02	7.1E-04	7.4E+04	6.1E-02	5.8E+02	2.2E-04	(3.6)	3.8E+04	5.6E-02	(2.88)	8.3E+04	4.8E-02	8.9E+04	1.1E-02	5.5E+03	4.8E-02	<100	(63.5)
LAW B45-18	18	40.14	1.3E-01	6.2E-03	9.401	7.1E+02	6.1E-04	8.6E+04	7.3E-02	8.2E+02	3.9E-04	(13.5)	4.5E+04	6.8E-02	(4.02)	9.9E+04	6.0E-02	1.0E+05	1.3E-02	6.7E+03	6.0E-02	(2.5)	(4.6)
LAW B45-19	19	42.77	1.2E-01	1.7E-03	9.455	6.6E+02	6.1E-04	9.2E+04	8.5E-02	7.4E+02	3.6E-04	(4.0)	4.9E+04	8.1E-02	(2.33)	1.1E+05	7.2E-02	1.1E+05	1.5E-02	7.1E+03	6.9E-02	<100	(1.6)
LAW B45-20	20	45.67	1.4E-01	2.2E-03	9.402	6.3E+02	5.2E-04	8.7E+04	7.1E-02	7.0E+02	3.0E-04	(23.6)	4.7E+04	6.8E-02	(3.76)	1.0E+05	6.0E-02	1.1E+05	1.4E-02	6.7E+03	5.8E-02	(6.2)	(3.0)
LAW B45-21	21	49.60	1.3E-01	5.0E-03	9.176	9.8E+02	8.9E-04	1.2E+05	1.0E-01	8.1E+02	3.9E-04	(9.8)	6.0E+04	9.1E-02	18.52	1.4E+05	8.7E-02	1.2E+05	1.6E-02	9.2E+03	8.4E-02	(54.9)	(10.2)
LAW B45-22	22	53.65	1.3E-01	4.1E-03	9.321	6.2E+02	5.1E-04	8.3E+04	6.9E-02	6.0E+02	2.4E-04	(6.9)	4.2E+04	6.3E-02	(4.23)	9.6E+04	5.8E-02	1.0E+05	1.3E-02	6.3E+03	5.5E-02	(0.9)	(8.2)
LAW B45-23	23	56.71	1.5E-01	4.4E-03	9.310	5.8E+02	4.3E-04	8.3E+04	6.2E-02	7.4E+02	3.0E-04	(7.3)	4.3E+04	5.6E-02	(3.75)	1.0E+05	5.3E-02	1.1E+05	1.2E-02	6.3E+03	4.9E-02	(2.0)	(3.4)
LAW B45-24	24	63.64	1.5E-01	6.2E-03	9.290	5.9E+02	4.3E-04	9.9E+04	7.2E-02	7.9E+02	3.2E-04	(6.1)	5.3E+04	6.9E-02	(3.74)	1.2E+05	6.5E-02	1.3E+05	1.5E-02	8.0E+03	6.3E-02	<100	(4.7)
LAW B45-25	25	64.09	1.6E-01	9.9E-04	9.325	5.7E+02	4.0E-04	9.1E+04	6.5E-02	1.2E+03	5.3E-04	(200.5)	4.9E+04	6.3E-02	(18.55)	1.1E+05	5.9E-02	1.1E+05	1.3E-02	7.1E+03	5.3E-02	(5.0)	(3.4)
LAW B45-26	26B	67.48	1.5E-01	4.6E-03	9.055	6.1E+02	4.4E-04	8.2E+04	6.0E-02	6.9E+02	2.6E-04	(10.2)	4.3E+04	5.5E-02	(4.49)	1.0E+05	5.4E-02	1.1E+05	1.2E-02	6.1E+03	4.6E-02	(10.7)	(2.7)
LAW B45-27	27B	74.50	1.6E-01	4.7E-03	8.799	5.7E+02	3.9E-04	8.3E+04	5.8E-02	7.4E+02	2.8E-04	(3.1)	4.2E+04	5.2E-02	(4.52)	1.0E+05	5.1E-02	1.0E+05	1.1E-02	6.1E+03	4.5E-02	<100	(2.0)
LAW B45-28	28B	81.07	1.6E-01	5.3E-03	8.929	5.4E+02	3.8E-04	8.6E+04	6.2E-02	7.2E+02	2.8E-04	(1.0)	4.4E+04	5.7E-02	(2.42)	1.1E+05	5.7E-02	9.7E+04	1.1E-02	6.3E+03	4.8E-02	<100	(0.0)
LAW B45-29	29B	87.54	1.5E-01	4.3E-03	8.934	5.4E+02	3.9E-04	8.6E+04	6.4E-02	7.4E+02	3.0E-04	(3.7)	4.3E+04	5.6E-02	(1.74)	1.1E+05	5.8E-02	9.5E+04	1.1E-02	6.3E+03	4.8E-02	<100	(3.2)
LAW B45-30	30B	94.67	1.5E-01	1.6E-02	9.182	5.5E+02	4.1E-04	8.6E+04	6.7E-02	7.8E+02	3.3E-04	(1.6)	4.4E+04	6.0E-02	(1.79)	1.1E+05	6.0E-02	9.7E+04	1.2E-02	6.2E+03	5.0E-02	<100	(0.0)
LAW B45-31	31B	103.48	1.5E-01	1.2E-02	9.368	5.6E+02	4.1E-04	9.2E+04	6.9E-02	8.3E+02	3.5E-04	(4.1)	4.6E+04	6.1E-02	(4.72)	1.2E+05	6.3E-02	1.1E+05	1.3E-02	7.0E+03	5.6E-02	<100	(13.6)
LAW B45-32	32B	108.48	1.5E-01	1.5E-02	9.273	5.8E+02	4.3E-04	8.3E+04	6.2E-02	7.0E+02	2.8E-04	(6.2)	4.0E+04	5.3E-02	(3.86)	1.0E+05	5.5E-02	1.0E+05	1.2E-02	6.1E+03	4.8E-02	(0.3)	(7.6)
LAW B45-33	33B	115.12	1.6E-01	5.1E-03	9.270	5.7E+02	4.0E-04	9.0E+04	6.5E-02	8.4E+02	3.5E-04	(5.1)	4.4E+04	5.6E-02	(3.19)	1.1E+05	5.9E-02	1.0E+05	1.1E-02	6.7E+03	5.0E-02	<100	(6.8)
LAW B45-34	34B	121.76	1.5E-01	5.5E-03	9.231	6.1E+02	4.5E-04	8.3E+04	6.2E-02	7.3E+02	2.9E-04	<500	3.8E+04	5.1E-02	(0.91)	1.0E+05	5.4E-02	9.3E+04	1.1E-02	6.1E+03	4.8E-02	<100	(3.1)
LAW B45-35	35B	129.18	1.5E-01	6.8E-03	9.250	6.1E+02	4.4E-04	9.2E+04	6.7E-02	8.5E+02	3.6E-04	(1.8)	4.2E+04	5.5E-02	(2.29)	1.2E+05	6.2E-02	1.0E+05	1.2E-02	6.9E+03	5.3E-02	<100	(2.5)
LAW B45-36	36B	134.50	1.5E-01	6.8E-03	9.213	6.5E+02	4.8E-04	8.9E+04	6.5E-02	7.5E+02	3.0E-04	(6.4)	4.0E+04	5.2E-02	(2.88)	1.1E+05	5.8E-02	9.8E+04	1.1E-02	6.5E+03	5.0E-02	<100	(2.6)
LAW B45-37	37B	144.62	1.6E-01	5.4E-03	9.176	6.4E+02	4.4E-04	9.4E+04	6.5E-02	8.2E+02	3.2E-04	(3.4)	4.2E+04	5.1E-02	(5.14)	1.1E+05	5.4E-02	9.8E+04	1.0E-02	6.9E+03	5.0E-02	<100	(3.1)
LAW B45-38	38B	148.73	1.7E-01	5.4E-03	9.118	6.3E+02	4.1E-04	8.8E+04	5.9E-02	6.3E+02	2.1E-04	(0.1)	3.8E+04	4.4E-02	(1.31)	1.0E+05	5.0E-02	9.2E+04	9.4E-03	6.5E+03	4.5E-02	<100	(2.0)

Table B2. LAWB45 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[Fe]	[Li]	Li Rate	[Mg]	[Na]	Na Rate	[Si]	Si Rate	[S]	S Rate	[Zn]	[Zr]
LAW B45-41	41B	169.87	1.7E-01	6.0E-03	9.039	6.9E+02	4.7E-04	9.4E+04	6.2E-02	6.6E+02	2.2E-04	(49.2)	3.7E+04	4.3E-02	90.34	1.1E+05	5.4E-02	9.4E+04	9.6E-03	7.2E+03	5.1E-02	(12.4)	(20.0)
LAW B45-44	44B	192.17	1.7E-01	7.3E-03	9.125	8.2E+02	5.8E-04	1.0E+05	6.9E-02	5.8E+02	1.8E-04	(62.7)	4.0E+04	4.8E-02	49.01	1.2E+05	6.0E-02	9.8E+04	1.0E-02	7.5E+03	5.4E-02	(12.8)	(12.2)
LAW B45-47	47B	212.55	1.3E-01	1.0E-02	8.664	8.7E+02	7.9E-04	6.8E+04	5.9E-02	5.8E+02	2.3E-04	(119.1)	2.6E+04	4.0E-02	39.58	6.9E+04	4.1E-02	7.6E+04	9.9E-03	5.0E+03	4.4E-02	(24.5)	(37.6)
LAW B45-50	50B	232.90	1.6E-01	8.5E-03	8.950	7.5E+02	5.3E-04	8.8E+04	6.1E-02	8.5E+02	3.4E-04	(52.2)	3.1E+04	3.8E-02	25.95	9.6E+04	4.8E-02	7.3E+04	7.5E-03	6.9E+03	5.0E-02	(6.5)	(8.3)
LAW B45-53	53B	253.42	1.8E-01	9.5E-03	8.825	8.3E+02	5.5E-04	9.7E+04	6.1E-02	9.5E+02	3.6E-04	(32.9)	3.4E+04	3.8E-02	18.04	1.1E+05	5.0E-02	7.7E+04	7.3E-03	7.4E+03	4.9E-02	(5.5)	(9.6)
LAW B45-56	56B	274.63	1.7E-01	9.6E-03	8.978	8.1E+02	5.6E-04	9.5E+04	6.3E-02	9.6E+02	3.9E-04	-	3.2E+04	3.8E-02	14.49	1.0E+05	5.0E-02	7.5E+04	7.5E-03	7.4E+03	5.2E-02	(4.6)	(4.9)
LAW B45-59	59B	295.71	1.5E-01	7.7E-03	8.765	8.8E+02	7.1E-04	9.8E+04	7.5E-02	1.2E+03	6.2E-04	(61.6)	3.4E+04	4.6E-02	15.40	1.1E+05	6.2E-02	7.7E+04	8.8E-03	7.8E+03	6.4E-02	(1.5)	(6.7)
LAW B45-62	62B	316.66	1.2E-01	5.8E-01	8.715	7.8E+02	7.3E-04	2.3E+05	2.1E-01	2.0E+03	1.3E-03	(76.9)	1.7E+05	2.7E-01	26.25	3.2E+05	2.2E-01	4.4E+05	6.7E-02	1.7E+04	1.7E-01	(33.9)	(19.2)
LAW B45-65	65B	342.25	2.1E-01	9.4E-02	8.715	7.3E+02	4.1E-04	8.5E+04	4.7E-02	9.4E+02	3.1E-04	(35.8)	3.6E+04	3.5E-02	9.35	1.0E+05	4.1E-02	8.7E+04	7.3E-03	5.9E+03	3.4E-02	(17.3)	(3.6)
LAW B45-68	68B	368.25	1.5E-01	9.5E-03	8.615	9.6E+02	7.7E-04	7.7E+04	5.7E-02	6.6E+02	2.5E-04	(33.6)	3.0E+04	3.9E-02	29.12	7.9E+04	4.1E-02	7.3E+04	8.1E-03	4.3E+03	3.3E-02	(12.9)	(9.1)
LAW B45-70	70B	381.71	1.3E-01	4.8E-03	8.634	9.0E+02	8.3E-04	7.2E+04	6.3E-02	7.8E+02	3.7E-04	(17.2)	2.7E+04	4.1E-02	(34)	7.6E+04	4.6E-02	7.5E+04	9.7E-03	4.2E+03	3.7E-02	(15.4)	(2.5)
LAW B45-75	75B	415.60	1.6E-01	2.6E-03	8.536	9.1E+02	6.9E-04	7.8E+04	5.6E-02	5.2E+02	1.6E-04	(12.2)	2.8E+04	3.6E-02	(30)	8.1E+04	4.0E-02	6.8E+04	7.1E-03	3.9E+03	2.8E-02	(7.1)	(3.2)
LAW B45-77	77B	432.06	1.3E-01	4.9E-02	8.606	4.1E+02	3.3E-04	1.8E+05	1.6E-01	1.8E+03	1.1E-03	(12.9)	1.1E+05	1.7E-01	(33)	2.6E+05	1.8E-01	1.8E+05	2.7E-02	1.3E+04	1.3E-01	(9.4)	(2.6)
LAW B45-78	78B	469.66	1.8E-01	1.2E-01	8.660	6.6E+02	4.2E-04	1.2E+05	7.4E-02	1.2E+03	4.7E-04	(18.9)	5.2E+04	5.9E-02	(38)	1.4E+05	6.4E-02	9.9E+04	9.8E-03	8.7E+03	5.9E-02	(22.5)	(3.5)
LAW B45-79	79B	474.13	1.9E-01	4.4E-03	9.062	5.6E+02	3.2E-04	1.1E+05	6.5E-02	8.8E+02	3.0E-04	(11.7)	4.6E+04	4.7E-02	(40)	1.3E+05	5.4E-02	8.5E+04	7.5E-03	6.3E+03	3.8E-02	(22.3)	(1.9)
LAW B45-80	80B	482.33	1.9E-01	5.8E-03	8.939	7.5E+02	4.6E-04	9.5E+04	5.6E-02	5.1E+02	1.3E-04	(8.8)	3.5E+04	3.6E-02	(34)	9.8E+04	4.2E-02	8.4E+04	7.5E-03	4.7E+03	2.8E-02	(4.6)	(3.4)
LAW B45-85	85B	530.16	3.3E-01	1.1E-01	8.976	3.7E+02	1.1E-04	4.7E+05	1.6E-01	6.4E+03	1.7E-03	(7.2)	1.9E+05	1.2E-01	(25)	5.0E+05	1.3E-01	1.2E+05	6.7E-03	5.0E+04	1.9E-01	(3.7)	(4.8)

θ – volumetric water content
σθ –volumetric water content error
[] – concentration in ug L^{-1}
Rate – in g m^{-2} d^{-1}

Table B3. LAWC22 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[Fe]	[Li]	Li Rate	[Mg]	[Na]	Na Rate	[Si]	Si Rate	[S]	S Rate	[Zn]	[Zr]
LAW C22-1	1	0.07	2.5E-01	1.5E-01	8.485	(68.7)	-	7.8E+02	2.6E-04	(56.6)	-	(4.4)	(320.2)	-	(1.1)	(6089.5)	-	(2564.36)	-	(65.27)	-	(5.0)	<125
LAW C22-2	2	1.48	8.6E-02	1.2E-02	9.710	1.4E+03	1.9E-03	8.6E+03	1.2E-02	(64.9)	-	(80.6)	3.9E+03	1.3E-02	(20.5)	3.8E+04	1.2E-02	2.4E+04	2.8E-03	9.5E+02	1.5E-02	(20.7)	(9.5)
LAW C22-3	3	3.47	6.8E-02	3.7E-02	9.828	3.0E+03	5.0E-03	1.0E+05	1.8E-01	(55.8)	-	(74.9)	3.2E+04	1.5E-01	(20.4)	3.9E+05	2.0E-01	2.0E+05	4.9E-02	1.5E+04	6.1E-01	(32.4)	(15.6)
LAW C22-4	4	5.61	6.5E-02	4.4E-02	8.086	1.9E+03	3.3E-03	1.0E+05	1.9E-01	(48.3)	-	(39.7)	3.0E+04	1.5E-01	(8.3)	3.6E+05	1.9E-01	1.9E+05	4.7E-02	1.4E+04	5.6E-01	(16.8)	(7.2)
LAW C22-5	5	7.78	1.8E-02	1.8E-02	9.651	2.0E+03	1.2E-02	6.0E+04	4.1E-01	4.9E+02	1.4E-03	(17.3)	1.9E+04	3.4E-01	(10.2)	2.1E+05	4.0E-01	1.1E+05	9.8E-02	9.9E+03	1.5E+00	(69.6)	(5.5)
LAW C22-6	6	11.01	3.5E-02	3.2E-02	7.692	1.9E+03	6.3E-03	1.2E+05	4.3E-01	(72.4)	-	(56.8)	3.5E+04	3.3E-01	(6.4)	4.0E+05	4.0E-01	1.7E+05	8.0E-02	1.5E+04	1.1E+00	(16.0)	(4.9)
LAW C22-7	7	12.17	5.0E-03	1.1E-02	8.935	2.2E+03	5.0E-02	4.8E+04	1.1E+00	(94.4)	-	(26.1)	1.5E+04	9.3E-01	(9.8)	1.8E+05	1.2E+00	1.1E+05	3.3E-01	5.2E+03	2.6E+00	(6.5)	(5.7)
LAW C22-8	8	14.71	2.7E-03	4.5E-03	8.294	1.6E+03	6.5E-02	3.6E+04	1.6E+00	5.7E+02	1.2E-02	(13.3)	9.4E+03	1.1E+00	(9.7)	1.2E+05	1.5E+00	6.9E+04	3.8E-01	4.4E+03	4.0E+00	(99.7)	(3.0)
LAW C22-9	9	19.58	1.1E-01	8.3E-02	8.845	1.1E+03	1.0E-03	1.5E+05	1.6E-01	1.3E+03	9.2E-04	(43.0)	4.6E+04	1.3E-01	(10.1)	5.0E+05	1.5E-01	2.0E+05	2.9E-02	1.4E+04	3.2E-01	(57.3)	(7.6)
LAW C22-10	10	20.59	4.0E-02	1.3E-02	10.312	1.4E+03	3.9E-03	6.7E+04	2.0E-01	(137.8)	-	(26.1)	2.5E+04	2.0E-01	(17.4)	2.8E+05	2.4E-01	1.5E+05	6.1E-02	1.4E+04	9.6E-01	(49.0)	(2.4)
LAW C22-11	11	22.24	3.9E-02	8.5E-03	8.316	9.1E+02	2.4E-03	1.4E+04	4.4E-02	(148.0)	-	(19.0)	3.6E+03	2.6E-02	(7.8)	4.7E+04	3.4E-02	3.4E+04	1.1E-02	7.4E+03	4.9E-01	(13.9)	(4.3)
LAW C22-12	12	24.64	7.6E-02	1.2E-02	9.245	2.2E+03	3.3E-03	7.0E+04	1.1E-01	(82.5)	-	(38.2)	1.7E+04	7.0E-02	(12.8)	2.3E+05	1.0E-01	1.1E+05	2.2E-02	1.4E+04	4.8E-01	(14.2)	(11.3)
LAW C22-13	13	27.61	8.4E-02	7.7E-03	9.932	2.2E+03	3.0E-03	7.4E+04	1.1E-01	(104.6)	-	(29.6)	2.1E+04	8.1E-02	(9.1)	2.6E+05	1.1E-01	1.2E+05	2.4E-02	1.0E+04	3.2E-01	(17.4)	(17.6)
LAW C22-14	14	30.56	8.1E-02	5.7E-03	9.636	1.9E+03	2.6E-03	6.5E+04	9.7E-02	(49.6)	-	(26.8)	1.9E+04	7.6E-02	(5.1)	2.4E+05	1.0E-01	1.2E+05	2.4E-02	7.9E+03	2.5E-01	(13.0)	(8.2)
LAW C22-15	15	33.14	9.3E-02	4.8E-03	9.821	2.0E+03	2.4E-03	7.1E+04	9.3E-02	(44.8)	-	(15.2)	2.3E+04	7.8E-02	(4.1)	2.5E+05	9.2E-02	1.3E+05	2.3E-02	7.1E+03	2.0E-01	(37.2)	(6.4)
LAW C22-16	16	35.32	8.6E-02	3.4E-03	9.885	2.0E+03	2.7E-03	6.1E+04	8.6E-02	(20.9)	-	(11.8)	2.0E+04	7.3E-02	(4.7)	2.1E+05	8.3E-02	1.3E+05	2.3E-02	5.4E+03	1.6E-01	(7.9)	(3.2)
LAW C22-17	17	37.65	9.5E-02	6.5E-03	9.863	1.6E+03	1.8E-03	5.9E+04	7.6E-02	(20.5)	-	(10.4)	1.9E+04	6.2E-02	(2.4)	2.0E+05	7.2E-02	1.2E+05	1.9E-02	5.1E+03	1.3E-01	<100	(4.2)
LAW C22-18	18	40.15	9.3E-02	6.1E-03	9.765	1.7E+03	2.1E-03	6.5E+04	8.5E-02	(12.3)	-	(11.6)	2.2E+04	7.7E-02	(3.7)	2.3E+05	8.3E-02	1.4E+05	2.5E-02	5.0E+03	1.4E-01	(2.3)	(3.5)
LAW C22-19	19	42.78	8.3E-02	4.6E-03	9.772	1.4E+03	1.9E-03	7.3E+04	1.1E-01	(18.5)	-	(14.6)	2.5E+04	9.8E-02	(2.4)	2.5E+05	1.0E-01	1.6E+05	3.1E-02	5.6E+03	1.7E-01	(5.7)	(3.8)
LAW C22-20	20	45.68	7.7E-02	1.3E-02	9.719	2.2E+03	3.2E-03	5.5E+04	8.8E-02	(42.2)	-	(7.0)	1.9E+04	7.9E-02	(2.2)	2.0E+05	8.9E-02	1.2E+05	2.6E-02	4.5E+03	1.5E-01	(6.5)	(3.5)
LAW C22-21	21	49.62	8.0E-02	6.2E-03	9.391	2.0E+03	2.8E-03	7.8E+04	1.2E-01	(138.3)	-	(9.6)	2.4E+04	9.8E-02	(6.7)	2.6E+05	1.1E-01	1.4E+05	2.9E-02	6.4E+03	2.1E-01	(17.8)	(3.3)
LAW C22-22	22	53.67	8.7E-02	5.1E-03	9.606	1.3E+03	1.6E-03	5.9E+04	8.2E-02	(26.1)	-	(5.2)	1.9E+04	7.0E-02	(1.1)	2.0E+05	7.8E-02	1.2E+05	2.3E-02	4.5E+03	1.3E-01	<100	(2.9)
LAW C22-23	23	56.72	9.1E-02	8.8E-03	9.434	1.2E+03	1.4E-03	5.0E+04	6.7E-02	(42.7)	-	(6.3)	1.5E+04	5.1E-02	(5.3)	1.6E+05	5.9E-02	1.0E+05	1.7E-02	3.8E+03	1.0E-01	(9.5)	(17.6)
LAW C22-24	24	60.09	6.8E-02	1.2E-02	8.754	9.6E+02	1.5E-03	4.5E+04	8.0E-02	(120.5)	-	(15.5)	1.1E+04	5.2E-02	(6.5)	1.3E+05	6.6E-02	7.3E+04	1.6E-02	4.5E+03	1.7E-01	(0.8)	(8.1)
LAW C22-25	25	64.11	7.5E-02	1.1E-02	9.698	1.9E+03	2.9E-03	8.6E+04	1.4E-01	(47.9)	-	(17.3)	2.1E+04	8.9E-02	(6.5)	2.6E+05	1.2E-01	1.3E+05	2.8E-02	5.6E+03	1.9E-01	(9.2)	(6.4)
LAW C22-26	26B	67.49	1.0E-01	1.7E-02	9.452	1.2E+03	1.3E-03	8.1E+04	9.4E-02	(19.5)	-	(9.6)	2.7E+04	8.4E-02	(3.9)	2.8E+05	9.2E-02	1.8E+05	2.8E-02	4.7E+03	1.1E-01	(16.1)	(6.1)
LAW C22-27	27B	74.51	9.2E-02	1.0E-02	9.267	1.1E+03	1.3E-03	5.8E+04	7.7E-02	(39.1)	-	(8.7)	2.2E+04	7.7E-02	(9.7)	2.1E+05	7.7E-02	1.5E+05	2.7E-02	3.3E+03	8.4E-02	(9.3)	(8.2)
LAW C22-28	28B	81.08	1.1E-01	3.3E-03	9.543	1.3E+03	1.3E-03	5.3E+04	6.0E-02	(15.6)	-	(8.7)	2.1E+04	6.1E-02	(4.6)	2.0E+05	6.3E-02	1.4E+05	2.2E-02	3.0E+03	6.5E-02	(4.7)	(100.1)
LAW C22-29	29B	87.55	1.1E-01	6.9E-03	9.398	1.3E+03	1.3E-03	4.8E+04	5.3E-02	(10.7)	-	(7.8)	1.8E+04	5.2E-02	(2.6)	1.8E+05	5.4E-02	1.4E+05	2.0E-02	2.5E+03	5.1E-02	(2.6)	(12.0)
LAW C22-30	30B	94.68	1.0E-01	2.4E-02	9.051	1.4E+03	1.5E-03	4.4E+04	5.3E-02	(14.4)	-	(6.6)	1.6E+04	5.0E-02	(3.6)	1.6E+05	5.4E-02	1.3E+05	2.0E-02	2.3E+03	5.1E-02	(4.1)	(7.2)
LAW C22-31	31B	103.49	8.2E-02	1.4E-02	9.151	1.3E+03	1.8E-03	4.6E+04	6.9E-02	(17.9)	-	(4.1)	1.6E+04	6.3E-02	(2.4)	1.6E+05	6.8E-02	1.3E+05	2.5E-02	2.5E+03	6.8E-02	(2.6)	(6.5)
LAW C22-32	32B	108.49	1.0E-01	1.3E-02	8.528	1.4E+03	1.5E-03	4.5E+04	5.4E-02	(13.5)	-	(66.9)	1.6E+04	4.9E-02	(3.6)	1.6E+05	5.1E-02	1.3E+05	2.0E-02	2.6E+03	5.6E-02	(8.3)	(14.4)
LAW C22-33	33B	115.14	1.0E-01	1.5E-02	9.307	1.6E+03	1.8E-03	4.7E+04	5.7E-02	(10.6)	-	(4.3)	1.7E+04	5.4E-02	(3.3)	1.7E+05	5.7E-02	1.3E+05	2.1E-02	2.5E+03	5.6E-02	<100	(21.7)
LAW C22-34	34B	121.77	6.0E-02	6.4E-03	9.066	1.4E+03	2.5E-03	4.8E+04	9.8E-02	(49.7)	-	(2.9)	1.6E+04	8.6E-02	(7.5)	1.5E+05	8.6E-02	1.2E+05	3.3E-02	2.6E+03	9.8E-02	(9.3)	(11.7)
LAW C22-35	35B	129.19	6.8E-02	2.1E-02	9.104	1.5E+03	2.5E-03	4.9E+04	8.8E-02	(45.6)	-	(10.4)	1.6E+04	7.3E-02	(3.4)	1.7E+05	8.2E-02	1.2E+05	2.9E-02	2.3E+03	7.5E-02	(6.8)	(10.5)
LAW C22-36	36B	134.51	6.1E-02	7.4E-03	8.917	1.7E+03	3.1E-03	5.4E+04	1.1E-01	(28.0)	-	(6.2)	1.4E+04	7.2E-02	(3.7)	1.6E+05	8.8E-02	9.2E+04	2.4E-02	2.7E+03	9.9E-02	(3.3)	(6.1)
LAW C22-37	37B	144.63	8.5E-02	1.8E-02	9.218	1.4E+03	1.9E-03	6.2E+04	8.8E-02	(64.8)	-	(22.2)	1.9E+04	7.3E-02	(3.6)	2.0E+05	8.0E-02	1.4E+05	2.7E-02	3.0E+03	8.3E-02	(17.4)	(6.3)
LAW C22-38	38B	148.75	7.4E-02	1.5E-02	8.835	1.5E+03	2.3E-03	4.0E+04	6.6E-02	(76.7)	-	(18.0)	8.9E+03	3.7E-02	(3.8)	1.1E+05	4.7E-02	6.1E+04	1.2E-02	2.0E+03	5.8E-02	(45.6)	(3.8)

Table B3. LAWC22 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[Fe]	[Li]	Li Rate	[Mg]	[Na]	Na Rate	[Si]	Si Rate	[S]	S Rate	[Zn]	[Zr]
LAW C22-41	41B	169.88	6.4E-02	6.5E-03	8.906	2.0E+03	3.6E-03	5.1E+04	9.7E-02	(35.5)	-	(26.9)	1.3E+04	6.3E-02	(16.1)	1.5E+05	7.7E-02	8.4E+04	2.0E-02	2.4E+03	8.2E-02	(5.5)	(11.5)
LAW C22-44	44B	192.18	1.1E-01	1.2E-02	9.094	2.2E+03	2.3E-03	5.7E+04	6.4E-02	(68.0)	-	(1.0)	1.5E+04	4.4E-02	(14.0)	1.7E+05	5.3E-02	9.9E+04	1.4E-02	2.6E+03	5.4E-02	(2.3)	(9.3)
LAW C22-47	47B	215.08	3.7E-01	2.2E-01	8.938	7.7E+02	2.2E-04	2.4E+04	8.0E-03	850.09	1.7E-04	(68.9)	1.6E+04	1.4E-02	(27.5)	1.5E+05	1.3E-02	1.3E+05	5.5E-03	1.7E+03	9.1E-03	(68.3)	(18.8)
LAW C22-50	50B	233.12	1.1E-01	3.4E-02	9.264	2.2E+03	2.2E-03	4.6E+04	5.1E-02	(135.0)	-	(8.0)	1.2E+04	3.4E-02	(12.9)	1.3E+05	3.8E-02	8.3E+04	1.2E-02	1.8E+03	3.2E-02	<100	(9.1)
LAW C22-53	53B	253.43	1.5E-01	1.1E-02	9.273	2.1E+03	1.6E-03	4.6E+04	3.8E-02	(99.0)	-	(29.4)	1.4E+04	2.9E-02	(8.9)	1.4E+05	3.2E-02	9.9E+04	1.1E-02	2.5E+03	3.9E-02	(3.5)	(8.6)
LAW C22-56	56B	274.64	1.5E-01	1.2E-02	9.265	2.0E+03	1.5E-03	5.0E+04	4.1E-02	(111.5)	-	(40.1)	1.4E+04	2.9E-02	(9.2)	1.4E+05	3.3E-02	9.6E+04	1.0E-02	2.4E+03	3.7E-02	(1.8)	(10.2)
LAW C22-59	59B	295.73	1.1E-01	1.2E-02	9.237	1.9E+03	2.0E-03	5.6E+04	6.4E-02	(157.7)	-	(38.9)	1.4E+04	4.2E-02	(12.5)	1.6E+05	4.9E-02	1.0E+05	1.5E-02	2.6E+03	5.5E-02	(10.4)	(10.3)
LAW C22-62	62B	316.67	6.8E-02	7.7E-01	9.285	2.1E+03	3.5E-03	6.4E+04	1.1E-01	(126.1)	-	(26.2)	1.6E+04	7.3E-02	(7.8)	1.7E+05	8.6E-02	9.8E+04	2.3E-02	3.0E+03	1.0E-01	(1.4)	(9.6)
LAW C22-65	65B	339.29	1.2E-01	1.1E-02	9.729	2.1E+03	1.9E-03	9.6E+04	9.8E-02	(197.2)	-	(74.8)	2.2E+04	5.8E-02	(19.7)	2.6E+05	7.4E-02	1.1E+05	1.5E-02	4.4E+03	9.0E-02	<100	(7.1)
LAW C22-68	68B	368.26	1.1E-01	1.1E-02	9.629	1.8E+03	1.8E-03	8.7E+04	9.4E-02	(215.0)	-	(58.9)	2.0E+04	5.5E-02	(19.8)	2.4E+05	7.1E-02	1.0E+05	1.4E-02	3.9E+03	8.4E-02	(4.6)	(13.6)
LAW C22-70	70B	381.72	1.1E-01	6.0E-03	9.788	1.8E+03	1.7E-03	1.4E+05	1.5E-01	333.64	7.7E-05	(8.5)	2.7E+04	7.8E-02	(29.4)	3.5E+05	1.1E-01	1.0E+05	1.5E-02	6.6E+03	1.5E-01	(20.3)	(1.3)
LAW C22-75	75B	415.61	1.2E-01	3.3E-03	10.080	1.6E+03	1.5E-03	1.8E+05	1.9E-01	353.40	9.2E-05	(9.7)	3.6E+04	9.9E-02	(21.6)	4.7E+05	1.4E-01	1.2E+05	1.6E-02	7.9E+03	1.8E-01	(8.2)	(0.6)
LAW C22-77	77B	429.63	1.1E-01	2.4E-03	10.154	1.4E+03	1.4E-03	2.0E+05	2.2E-01	309.22	5.5E-05	(75.8)	4.0E+04	1.2E-01	(36.1)	5.3E+05	1.7E-01	1.4E+05	2.1E-02	8.7E+03	2.1E-01	(51.3)	(36.9)
LAW C22-78	78B	465.14	2.5E-01	4.3E-01	9.902	8.4E+02	3.5E-04	1.9E+05	9.0E-02	278.15	1.2E-05	(15.9)	4.6E+04	5.9E-02	(27.3)	5.4E+05	7.6E-02	1.6E+05	1.0E-02	2.5E+04	2.7E-01	(28.0)	(8.9)
LAW C22-79	79B	476.14	3.2E-01	1.4E-01	9.518	6.0E+02	1.8E-04	1.6E+05	6.0E-02	(99.0)	-	(12.9)	5.0E+04	5.0E-02	(16.6)	5.5E+05	6.0E-02	2.5E+05	1.3E-02	3.1E+04	2.7E-01	(8.4)	(21.2)
LAW C22-80	80B	484.79	4.0E-01	2.0E-02	9.446	2.0E+02	2.9E-05	2.3E+05	6.9E-02	(76.4)	-	(6.5)	6.1E+04	4.9E-02	(19.2)	6.0E+05	5.2E-02	1.6E+05	6.4E-03	3.5E+04	2.4E-01	(11.2)	(15.2)

θ – volumetric water content

σθ –volumetric water content error

[] – concentration in ug L^{-1}

Rate – in g m^{-2} d^{-1}

Table B4. LAWAN102 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[K]	K Rate	[Li]	Li Rate	[Na]	Na Rate
LAW AN102-1	1	0.18	1.4E-01	9.6E-02	12.2857	1.8E+03	1.4E-03	2.2E+03	1.7E-03	(84.2)	-	-	-	1.8E+03	2.8E-03	1.2E+04	8.1E-04
LAW AN102-2	2	0.91	2.1E-01	3.1E-02	10.0623	3.2E+03	1.7E-03	1.1E+04	6.2E-03	(142.5)	-	-	-	8.7E+03	1.1E-02	4.6E+04	7.6E-03
LAW AN102-3	3	9.02	1.1E-01	1.4E-02	10.2362	1.0E+03	9.4E-04	1.9E+04	2.1E-02	(101.9)	-	-	-	8.8E+03	2.2E-02	5.6E+04	1.9E-02
LAW AN102-4	4	14.83	1.3E-01	3.2E-02	9.7519	6.1E+02	4.4E-04	6.1E+04	5.6E-02	1.3E+03	6.5E-04	-	-	2.4E+04	5.2E-02	1.5E+05	4.8E-02
LAW AN102-5	5	15.87	1.0E-01	1.3E-02	9.6756	9.9E+02	9.8E-04	8.7E+04	9.9E-02	9.2E+02	5.4E-04	-	-	3.9E+04	1.1E-01	2.3E+05	9.3E-02
LAW AN102-6	6	17.34	1.1E-01	2.4E-03	9.3195	1.2E+03	1.2E-03	5.2E+04	5.6E-02	4.1E+02	1.2E-04	-	-	2.2E+04	5.8E-02	1.4E+05	5.3E-02
LAW AN102-7	7	20.96	2.2E-01	7.7E-02	9.0207	1.6E+03	7.6E-04	6.7E+04	3.6E-02	1.8E+03	5.7E-04	-	-	3.6E+04	4.8E-02	2.0E+05	3.9E-02
LAW AN102-8	8	22.96	8.0E-02	3.3E-03	9.4324	1.9E+03	2.6E-03	4.0E+04	5.9E-02	8.7E+02	6.5E-04	-	-	2.1E+04	7.7E-02	1.3E+05	6.6E-02
LAW AN102-9	9	24.37	8.6E-02	1.5E-03	9.3851	1.7E+03	2.1E-03	4.4E+04	6.1E-02	6.2E+02	3.6E-04	-	-	2.0E+04	6.7E-02	1.2E+05	5.7E-02
LAW AN102-10	10	27.89	9.0E-02	2.2E-03	9.3035	1.7E+03	2.0E-03	4.2E+04	5.5E-02	4.7E+02	2.0E-04	-	-	1.9E+04	6.0E-02	1.1E+05	5.0E-02
LAW AN102-11	11	29.80	8.8E-02	3.1E-03	9.8567	1.7E+03	2.1E-03	4.0E+04	5.4E-02	3.5E+02	9.3E-05	-	-	1.8E+04	5.7E-02	1.1E+05	4.9E-02
LAW AN102-12	12	31.33	9.0E-02	3.0E-03	9.7612	1.5E+03	1.8E-03	3.8E+04	5.1E-02	4.1E+02	1.5E-04	-	-	1.6E+04	5.1E-02	9.7E+04	4.4E-02
LAW AN102-13	13	34.54	9.3E-02	1.5E-03	10.0051	1.6E+03	1.8E-03	4.2E+04	5.3E-02	3.9E+02	1.2E-04	-	-	1.7E+04	5.3E-02	1.0E+05	4.5E-02
LAW AN102-14	14	36.03	9.0E-02	1.9E-03	9.5103	1.6E+03	1.9E-03	3.9E+04	5.2E-02	3.8E+02	1.2E-04	-	-	1.6E+04	5.1E-02	9.9E+04	4.4E-02
LAW AN102-15	15	38.50	9.0E-02	1.7E-03	9.3221	1.5E+03	1.8E-03	3.6E+04	4.7E-02	3.0E+02	5.1E-05	-	-	1.4E+04	4.5E-02	8.7E+04	3.8E-02
LAW AN102-16	16	40.97	9.1E-02	5.7E-03	9.2449	1.4E+03	1.7E-03	4.0E+04	5.2E-02	6.3E+02	3.5E-04	-	-	1.6E+04	4.9E-02	9.7E+04	4.3E-02
LAW AN102-17	17	44.15	9.1E-02	2.5E-03	9.3812	1.6E+03	1.9E-03	3.8E+04	5.0E-02	3.8E+02	1.2E-04	-	-	1.5E+04	4.6E-02	9.0E+04	4.0E-02
LAW AN102-18	18	45.51	8.6E-02	2.7E-03	9.2364	1.5E+03	1.9E-03	3.6E+04	5.0E-02	3.6E+02	1.0E-04	-	-	1.3E+04	4.4E-02	8.5E+04	3.9E-02
LAW AN102-19	19	47.92	7.5E-02	2.6E-03	9.4950	1.5E+03	2.1E-03	3.4E+04	5.5E-02	3.8E+02	1.4E-04	-	-	1.3E+04	4.7E-02	8.1E+04	4.3E-02
LAW AN102-20	20	50.24	7.8E-02	2.1E-03	9.3853	1.5E+03	2.1E-03	3.7E+04	5.7E-02	3.6E+02	1.2E-04	-	-	1.4E+04	4.9E-02	8.8E+04	4.5E-02
LAW AN102-21	21	52.56	7.9E-02	1.4E-03	9.3077	1.5E+03	2.1E-03	3.6E+04	5.3E-02	(194.4)	-	-	-	1.3E+04	4.5E-02	8.2E+04	4.1E-02
LAW AN102-22	22	54.94	8.2E-02	1.6E-03	9.2793	1.5E+03	2.0E-03	3.4E+04	4.9E-02	3.6E+02	1.1E-04	-	-	1.2E+04	4.1E-02	7.7E+04	3.7E-02
LAW AN102-23	23	57.07	8.3E-02	1.2E-03	9.1932	1.6E+03	2.1E-03	3.4E+04	4.9E-02	3.3E+02	8.0E-05	-	-	1.2E+04	4.0E-02	8.0E+04	3.8E-02
LAW AN102-24	24	59.36	8.3E-02	1.3E-03	9.1341	1.6E+03	2.1E-03	3.4E+04	4.8E-02	3.2E+02	6.8E-05	-	-	1.1E+04	3.8E-02	7.7E+04	3.6E-02
LAW AN102-25	25	61.98	8.6E-02	2.0E-03	8.9593	1.6E+03	2.0E-03	3.2E+04	4.5E-02	4.0E+02	1.4E-04	-	-	1.1E+04	3.5E-02	7.3E+04	3.3E-02
LAW AN102-26	26	64.20	9.0E-02	3.3E-03	8.9757	1.6E+03	2.0E-03	3.2E+04	4.2E-02	3.5E+02	9.3E-05	-	-	1.0E+04	3.2E-02	7.2E+04	3.1E-02
LAW AN102-27	27	66.41	8.7E-02	2.0E-03	8.9849	1.7E+03	2.1E-03	3.2E+04	4.4E-02	3.2E+02	7.0E-05	-	-	1.0E+04	3.2E-02	7.0E+04	3.1E-02
LAW AN102-30	30	73.44	8.8E-02	2.8E-03	8.8954	5.0E+03	5.9E-03	3.4E+04	4.4E-02	(370.9)	-	3.6E+04	2.9E-01	9.2E+03	2.7E-02	6.6E+04	3.3E-02
LAW AN102-33	33B	93.31	9.0E-02	1.4E-02	8.7587	1.4E+03	1.2E-03	3.4E+04	4.2E-02	(786.8)	-	2.8E+04	6.7E-02	1.1E+04	3.2E-02	7.5E+04	3.7E-02
LAW AN102-36	36B	110.41	9.4E-02	3.4E-03	8.4247	5.6E+03	6.2E-03	3.3E+04	3.9E-02	(748.1)	-	4.5E+04	5.1E-01	8.3E+03	2.3E-02	6.1E+04	2.9E-02
LAW AN102-39	39B	129.41	9.6E-02	2.9E-03	8.5182	2.1E+03	2.0E-03	3.3E+04	3.9E-02	(895.8)	-	4.3E+04	4.4E-01	7.6E+03	2.0E-02	6.3E+04	2.9E-02
LAW AN102-42	42B	150.29	1.2E-01	7.0E-03	8.1638	2.1E+03	1.5E-03	3.5E+04	3.2E-02	(589.8)	-	4.5E+04	3.8E-01	7.8E+03	1.6E-02	6.8E+04	2.5E-02
LAW AN102-45	45B	170.31	1.3E-01	7.3E-03	8.3527	2.1E+03	1.4E-03	3.6E+04	3.1E-02	(587.3)	-	4.9E+04	4.2E-01	8.2E+03	1.6E-02	7.5E+04	2.5E-02
LAW AN102-48	48B	191.38	1.5E-01	1.0E-02	8.2165	2.7E+03	1.6E-03	3.8E+04	2.8E-02	1.2E+03	1.4E-04	5.2E+04	4.2E-01	8.2E+03	1.4E-02	7.9E+04	2.3E-02
LAW AN102-51	51B	219.48	1.7E-01	7.5E-03	8.8967	1.7E+03	8.4E-04	5.2E+04	3.5E-02	(864.6)	-	6.9E+04	6.1E-01	1.6E+04	2.5E-02	1.3E+05	3.6E-02
LAW AN102-54	54B	241.42	1.6E-01	8.1E-03	9.2160	2.2E+03	1.1E-03	3.5E+04	2.4E-02	(683.8)	-	1.5E+04	-1.4E-01	9.3E+03	1.5E-02	8.2E+04	2.2E-02
LAW AN102-56	56B	256.53	1.5E-01	7.4E-03	8.0316	2.1E+03	1.2E-03	3.3E+04	2.5E-02	(823.3)	-	5.9E+04	5.3E-01	8.1E+03	1.4E-02	6.9E+04	2.0E-02
LAW AN102-60	60B	285.04	1.9E-01	8.1E-03	8.8593	1.9E+03	8.3E-04	3.6E+04	2.1E-02	(578.6)	-	5.0E+04	3.1E-01	8.8E+03	1.2E-02	8.3E+04	1.9E-02
LAW AN102-65	65B	318.55	2.3E-01	3.1E-03	8.6663	1.7E+03	5.8E-04	4.6E+04	2.3E-02	(542.4)	-	3.7E+04	1.2E-01	9.5E+03	1.1E-02	9.7E+04	1.9E-02
LAW AN102-70	70B	362.44	2.4E-01	1.3E-02	8.8846	2.3E+03	8.4E-04	5.7E+04	2.7E-02	(865.5)	-	4.8E+04	2.3E-01	1.4E+04	1.6E-02	1.3E+05	2.4E-02
LAW AN102-73	73B	396.57	2.8E-01	6.6E-03	9.0630	2.1E+03	6.5E-04	3.6E+04	1.4E-02	(291.8)	-	1.9E+04	-5.2E-02	1.3E+04	1.2E-02	9.6E+04	1.5E-02

Table B4. LAWAN102 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	Ca Rate	[K]	K Rate	[Li]	Li Rate	[Na]	Na Rate
LAW AN102-75	75B	408.46	2.9E-01	2.9E-03	8.8762	2.0E+03	5.8E-04	2.9E+04	1.1E-02	(356.8)	-	5.0E+04	2.0E-01	1.1E+04	9.9E-03	7.7E+04	1.2E-02
LAW AN102-80	80B	444.42	2.8E-01	2.7E-03	8.9797	1.9E+03	5.8E-04	3.2E+04	1.3E-02	(367.3)	-	4.3E+04	1.5E-01	1.2E+04	1.2E-02	8.4E+04	1.3E-02
LAW AN102-84	84B	473.52	2.7E-01	2.9E-03	8.6410	2.1E+03	6.6E-04	2.5E+04	1.0E-02	(272.5)	-	3.5E+04	8.8E-02	7.3E+03	6.7E-03	5.4E+04	8.7E-03

θ – volumetric water content
σθ –volumetric water content error
[] – concentration in ug L^{-1}
Rate – in g m^{-2} d^{-1}

Table B4. LAWAN102 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Si]	Si Rate	[S]	S Rate	[^{99}Tc]	^{99}Tc Rate	[U]	U Rate
LAW AN102-1	1	0.18	1.4E-01	9.6E-02	12.2857	1.5E+04	5.8E-04	(446.5)	-	(0.015)	-	1.5E-02	-
LAW AN102-2	2	0.91	2.1E-01	3.1E-02	10.0623	4.8E+04	3.0E-03	2.5E+03	2.9E-02	1.2E-01	2.5E-03	3.5E-02	-
LAW AN102-3	3	9.02	1.1E-01	1.4E-02	10.2362	5.0E+04	6.2E-03	5.9E+03	1.5E-01	2.1E-01	1.0E-02	4.5E-02	-
LAW AN102-4	4	14.83	1.3E-01	3.2E-02	9.7519	6.2E+04	6.6E-03	1.8E+04	4.0E-01	8.0E-01	4.2E-02	1.6E-01	2.46E-04
LAW AN102-5	5	15.87	1.0E-01	1.3E-02	9.6756	1.4E+05	2.1E-02	2.4E+04	6.9E-01	9.7E-01	6.5E-02	2.9E-01	7.07E-04
LAW AN102-6	6	17.34	1.1E-01	2.4E-03	9.3195	1.1E+05	1.5E-02	1.4E+04	3.7E-01	5.7E-01	3.5E-02	2.4E-01	5.18E-04
LAW AN102-7	7	20.96	2.2E-01	7.7E-02	9.0207	1.5E+05	1.1E-02	1.8E+04	2.4E-01	7.4E-01	2.3E-02	5.4E-01	6.85E-04
LAW AN102-8	8	22.96	8.0E-02	3.3E-03	9.4324	1.1E+05	2.2E-02	8.3E+03	3.0E-01	4.7E-01	3.9E-02	3.5E-01	1.14E-03
LAW AN102-9	9	24.37	8.6E-02	1.5E-03	9.3851	1.1E+05	1.9E-02	6.0E+03	1.9E-01	5.3E-01	4.1E-02	3.8E-01	1.17E-03
LAW AN102-10	10	27.89	9.0E-02	2.2E-03	9.3035	1.0E+05	1.8E-02	4.5E+03	1.3E-01	5.0E-01	3.7E-02	3.8E-01	1.13E-03
LAW AN102-11	11	29.80	8.8E-02	3.1E-03	9.8567	1.0E+05	1.8E-02	3.4E+03	9.7E-02	4.8E-01	3.6E-02	3.9E-01	1.17E-03
LAW AN102-12	12	31.33	9.0E-02	3.0E-03	9.7612	9.3E+04	1.6E-02	3.0E+03	8.5E-02	4.4E-01	3.2E-02	3.0E-01	8.42E-04
LAW AN102-13	13	34.54	9.3E-02	1.5E-03	10.0051	9.7E+04	1.6E-02	3.0E+03	8.1E-02	4.9E-01	3.5E-02	3.2E-01	8.99E-04
LAW AN102-14	14	36.03	9.0E-02	1.9E-03	9.5103	9.5E+04	1.6E-02	2.5E+03	6.8E-02	4.9E-01	3.6E-02	3.5E-01	1.02E-03
LAW AN102-15	15	38.50	9.0E-02	1.7E-03	9.3221	8.5E+04	1.4E-02	2.5E+03	6.6E-02	4.5E-01	3.3E-02	3.0E-01	8.57E-04
LAW AN102-16	16	40.97	9.1E-02	5.7E-03	9.2449	8.9E+04	1.5E-02	2.5E+03	6.6E-02	4.9E-01	3.6E-02	3.1E-01	8.64E-04
LAW AN102-17	17	44.15	9.1E-02	2.5E-03	9.3812	8.8E+04	1.5E-02	2.2E+03	5.5E-02	4.1E-01	2.9E-02	3.0E-01	8.34E-04
LAW AN102-18	18	45.51	8.6E-02	2.7E-03	9.2364	8.2E+04	1.4E-02	2.2E+03	6.1E-02	4.5E-01	3.4E-02	3.0E-01	8.75E-04
LAW AN102-19	19	47.92	7.5E-02	2.6E-03	9.4950	7.9E+04	1.6E-02	2.1E+03	6.4E-02	4.1E-01	3.6E-02	2.7E-01	9.10E-04
LAW AN102-20	20	50.24	7.8E-02	2.1E-03	9.3853	8.2E+04	1.6E-02	2.4E+03	7.2E-02	4.4E-01	3.7E-02	3.0E-01	9.72E-04
LAW AN102-21	21	52.56	7.9E-02	1.4E-03	9.3077	8.1E+04	1.5E-02	2.1E+03	6.2E-02	4.4E-01	3.6E-02	3.0E-01	9.71E-04
LAW AN102-22	22	54.94	8.2E-02	1.6E-03	9.2793	7.4E+04	1.3E-02	2.0E+03	5.6E-02	4.2E-01	3.3E-02	3.0E-01	9.41E-04
LAW AN102-23	23	57.07	8.3E-02	1.2E-03	9.1932	7.4E+04	1.3E-02	2.1E+03	6.0E-02	4.2E-01	3.3E-02	2.8E-01	8.40E-04
LAW AN102-24	24	59.36	8.3E-02	1.3E-03	9.1341	7.3E+04	1.3E-02	2.0E+03	5.5E-02	4.1E-01	3.2E-02	2.8E-01	8.33E-04
LAW AN102-25	25	61.98	8.6E-02	2.0E-03	8.9593	7.0E+04	1.2E-02	2.1E+03	5.5E-02	4.1E-01	3.0E-02	2.5E-01	6.95E-04
LAW AN102-26	26	64.20	9.0E-02	3.3E-03	8.9757	6.7E+04	1.1E-02	1.9E+03	4.8E-02	4.0E-01	2.9E-02	2.8E-01	7.67E-04
LAW AN102-27	27	66.41	8.7E-02	2.0E-03	8.9849	6.6E+04	1.1E-02	1.9E+03	4.8E-02	4.0E-01	3.0E-02	2.7E-01	7.81E-04
LAW AN102-30	30	73.44	8.8E-02	2.8E-03	8.8954	6.2E+04	1.0E-02	(1,770)	-	4.3E-01	3.4E-02	2.9E-01	1.38E-04
LAW AN102-33	33B	93.31	9.0E-02	1.4E-02	8.7587	7.3E+04	1.2E-02	(2,034)	-	4.1E-01	3.1E-02	2.8E-01	1.14E-04
LAW AN102-36	36B	110.41	9.4E-02	3.4E-03	8.4247	5.8E+04	8.5E-03	(1,945)	-	4.3E-01	3.2E-02	2.8E-01	9.48E-05
LAW AN102-39	39B	129.41	9.6E-02	2.9E-03	8.5182	5.6E+04	8.2E-03	(1,958)	-	4.3E-01	3.2E-02	3.9E-01	4.61E-04
LAW AN102-42	42B	150.29	1.2E-01	7.0E-03	8.1638	6.0E+04	6.9E-03	(1,833)	-	4.4E-01	2.5E-02	3.3E-01	2.09E-04
LAW AN102-45	45B	170.31	1.3E-01	7.3E-03	8.3527	6.2E+04	6.6E-03	(1,955)	-	4.7E-01	2.5E-02	4.1E-01	3.59E-04
LAW AN102-48	48B	191.38	1.5E-01	1.0E-02	8.2165	6.3E+04	5.9E-03	(2,037)	-	4.9E-01	2.2E-02	4.4E-01	3.79E-04
LAW AN102-51	51B	219.48	1.7E-01	7.5E-03	8.8967	9.4E+04	8.5E-03	(2,793)	-	5.0E-01	2.1E-02	4.4E-01	3.43E-04
LAW AN102-54	54B	241.42	1.6E-01	8.1E-03	9.2160	6.5E+04	5.6E-03	(1,782)	-	4.4E-01	1.8E-02	4.7E-01	4.17E-04
LAW AN102-56	56B	256.53	1.5E-01	7.4E-03	8.0316	5.9E+04	5.4E-03	(1,530)	-	3.8E-01	1.7E-02	6.3E-01	7.60E-04
LAW AN102-60	60B	285.04	1.9E-01	8.1E-03	8.8593	6.4E+04	4.7E-03	(1,937)	-	4.3E-01	1.5E-02	6.3E-01	6.07E-04
LAW AN102-65	65B	318.55	2.3E-01	3.1E-03	8.6663	6.8E+04	4.2E-03	2,501	-	6.0E-01	1.8E-02	6.8E-01	5.75E-04
LAW AN102-70	70B	362.44	2.4E-01	1.3E-02	8.8846	7.2E+04	4.4E-03	2,513	-	5.5E-01	1.6E-02	9.3E-01	8.79E-04
LAW AN102-73	73B	396.57	2.8E-01	6.6E-03	9.0630	7.7E+04	4.0E-03	(1,510)	-	3.8E-01	9.2E-03	1.0E+00	8.52E-04

Table B4. LAWAN102 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Si]	Si Rate	[S]	S Rate	[^{99}Tc]	^{99}Tc Rate	[U]	U Rate
LAW AN102-75	75B	408.46	2.9E-01	2.9E-03	8.8762	6.8E+04	3.4E-03	(1,175)	-	3.2E-01	7.5E-03	9.6E-01	7.69E-04
LAW AN102-80	80B	444.42	2.8E-01	2.7E-03	8.9797	7.5E+04	3.9E-03	(1,544)	-	3.7E-01	8.9E-03	9.5E-01	7.56E-04
LAW AN102-84	84B	473.52	2.7E-01	2.9E-03	8.6410	5.7E+04	2.9E-03	(955)	-	2.9E-01	7.1E-03	9.1E-01	7.49E-04

θ – volumetric water content
σθ –volumetric water content error
[] – concentration in ug L^{-1}
Rate – in g m^{-2} d^{-1}

Table B5. LAWAP101 PUF Test Results

Sample ID	Vial #	Time, days	θ	σθ	pH	[Al]	Al Rate	[B]	B Rate	[Ca]	[Fe]	[K]	K Rate	[Na]	Na Rate	[Si]	Si Rate	[S]	S Rate	[Ti]	Ti Rate	[Zr]	Zr Rate
LAW AP101-1	1	0.00	0.168	0.030	8.852	(347)	-	2.5E+03	3.4E-04	(210.7)	(31.6)	1.3E+05	7.3E-02	(11514.6)	-	(4,552)	-	(682)	-	(9.4)	-	(9.9)	-
LAW AP101-2	2	0.06	0.197	0.000	8.798	(294)	-	5.0E+03	1.8E-03	(91.5)	(122.3)	3.9E+04	8.0E-03	3.4E+04	1.8E-03	(5,587)	-	(319)	-	(10.9)	-	(9.0)	-
LAW AP101-3	3	1.98	0.169	0.010	10.443	2.E+03	8.6E-04	3.1E+05	2.1E-01	(135.1)	(50.0)	5.1E+05	3.2E-01	1.3E+06	2.0E-01	1.9E+05	1.8E-02	1.7E+04	2.2E-01	(25.2)	-	(28.5)	-
LAW AP101-4	4	3.52	0.136	0.010	11.634	2.E+03	1.3E-03	3.4E+05	2.9E-01	(30.2)	(15.9)	2.2E+05	1.6E-01	1.3E+06	2.5E-01	3.0E+05	3.6E-02	1.5E+04	2.3E-01	(15.8)	-	(7.7)	-
LAW AP101-5	5	6.65	0.158	0.020	11.818	4.E+03	2.9E-03	2.4E+05	1.8E-01	ND	(40.9)	1.7E+05	1.1E-01	9.1E+05	1.5E-01	2.6E+05	2.7E-02	1.0E+04	1.1E-01	8.3E+01	6.1E-05	(63.2)	-
LAW AP101-6	6	8.61	0.133	0.033	11.682	3.E+03	2.4E-03	2.6E+05	2.3E-01	(19.1)	(23.8)	2.0E+05	1.4E-01	9.6E+05	1.8E-01	2.5E+05	3.1E-02	1.0E+04	1.3E-01	(49.3)	-	(47.7)	-
LAW AP101-7	7	10.55	0.076	0.016	11.506	3.E+03	3.9E-03	2.4E+05	3.7E-01	(180.7)	(39.1)	1.4E+05	1.8E-01	8.7E+05	2.9E-01	2.7E+05	5.9E-02	8.6E+03	1.7E-01	6.2E+01	4.5E-05	(53.6)	-
LAW AP101-8	8	13.55	0.093	0.008	11.638	5.E+03	5.7E-03	1.8E+05	2.2E-01	(56.2)	(101.2)	1.8E+05	1.8E-01	7.3E+05	2.0E-01	1.7E+05	3.0E-02	6.1E+03	6.5E-02	1.1E+02	1.8E-04	(217.9)	-
LAW AP101-9	9	15.09	0.109	0.008	11.558	4.E+03	3.8E-03	1.5E+05	1.6E-01	(6.6)	(41.9)	2.2E+05	2.0E-01	6.4E+05	1.5E-01	1.8E+05	2.8E-02	5.1E+03	2.8E-02	5.5E+01	1.4E-05	(123.0)	-
LAW AP101-10	10	17.57	0.105	0.011	11.427	4.E+03	4.3E-03	1.2E+05	1.3E-01	(4.9)	(52.2)	1.7E+05	1.5E-01	5.1E+05	1.2E-01	1.6E+05	2.4E-02	(3,870)	-	7.0E+01	5.7E-05	(158.0)	-
LAW AP101-12	12	24.05	0.125	0.010	11.275	5.E+03	4.3E-03	1.1E+05	9.8E-02	(37.9)	(152.8)	1.6E+05	1.2E-01	4.5E+05	9.0E-02	1.4E+05	1.8E-02	(3,054)	-	1.6E+02	2.7E-04	3.7E+02	1.5E-04
LAW AP101-14	14	26.97	0.130	0.009	11.420	6.E+03	5.3E-03	7.8E+04	6.8E-02	(28.9)	(141.4)	1.4E+05	9.8E-02	3.3E+05	6.3E-02	1.1E+05	1.4E-02	(1,876)	-	1.6E+02	2.6E-04	3.8E+02	1.5E-04
LAW AP101-16	16	31.62	0.136	0.012	11.360	6.E+03	5.0E-03	8.1E+04	6.8E-02	(41.0)	(212.8)	1.5E+05	1.0E-01	3.5E+05	6.3E-02	1.2E+05	1.4E-02	(1,903)	-	2.5E+02	4.4E-04	5.9E+02	4.0E-04
LAW AP101-18	18	37.16	0.118	0.013	11.275	6.E+03	5.9E-03	7.2E+04	6.9E-02	(40.3)	(180.9)	1.1E+05	8.1E-02	3.2E+05	6.6E-02	1.1E+05	1.5E-02	(1,732)	-	2.0E+02	3.7E-04	4.8E+02	3.1E-04
LAW AP101-20	20	41.00	0.130	0.011	11.163	7.E+03	5.6E-03	7.0E+04	6.1E-02	(44.2)	(211.5)	1.0E+05	6.9E-02	3.2E+05	5.9E-02	1.1E+05	1.3E-02	(1,512)	-	2.6E+02	4.7E-04	6.2E+02	4.5E-04
LAW AP101-23	23	48.05	0.122	0.015	11.007	8.E+03	7.3E-03	6.4E+04	5.9E-02	(48.3)	(248.5)	5.9E+04	3.2E-02	3.0E+05	6.0E-02	1.2E+05	1.5E-02	(1,291)	-	3.1E+02	6.2E-04	7.3E+02	6.3E-04
LAW AP101-26	26	59.60	0.122	0.025	10.227	1.E+04	8.8E-03	5.8E+04	5.3E-02	(630.6)	(243.3)	1.1E+05	7.7E-02	2.6E+05	5.2E-02	9.8E+04	1.2E-02	(1,514)	-	3.0E+02	6.1E-04	7.2E+02	6.2E-04
LAW AP101-29	29	68.18	0.090	0.022	9.870	6.E+03	7.5E-03	5.1E+04	6.3E-02	(294.1)	(254.4)	1.6E+05	1.7E-01	2.2E+05	5.7E-02	7.9E+04	1.3E-02	(1,117)	-	3.0E+02	8.3E-04	7.1E+02	8.1E-04
LAW AP101-32	32	86.43	0.076	0.021	9.868	6.E+03	9.4E-03	4.6E+04	6.7E-02	(324.9)	(298.1)	1.1E+05	1.3E-01	2.0E+05	6.2E-02	8.5E+04	1.7E-02	(1,225)	-	3.3E+02	1.1E-03	7.7E+02	1.1E-03
LAW AP101-35	35	107.51	0.068	0.028	9.710	7.E+03	1.1E-02	4.1E+04	6.6E-02	(129.4)	(309.2)	1.1E+05	1.3E-01	1.8E+05	6.1E-02	8.2E+04	1.8E-02	(1,139)	-	3.4E+02	1.2E-03	7.9E+02	1.3E-03

θ - volumetric water content

σθ –volumetric water content error

[] – concentration in ug L^{-1}

Rate – in g m^{-2} d^{-1}

Appendix C
Product Consistency Test Results

Table C1. LAWA44 PCT Test Results

Sample ID	S/V Ratio, m^{-1}	Time	Reaction Progress (mol kg^{-1})	Norm. Al (mg L^{-1})	Norm. B (mg L^{-1})	Norm. Ca (mg L^{-1})	Norm. Fe (mg L^{-1})	Norm. K (mg L^{-1})	Norm. Mg (mg L^{-1})	Norm. Na (mg L^{-1})	Norm. P (mg L^{-1})	Norm. Si (mg L^{-1})	Norm. S (mg L^{-1})	Norm. Ti (mg L^{-1})	Norm. Zr (mg L^{-1})	Norm. Zn (mg L^{-1})
PCT-2003-1	20000	7	1.0E-01	2.6E+02	6.7E+03	-	-	-	-	6.2E+03	-	1.3E+03	-	-	-	-
PCT-2003-2	20000	14	1.2E-01	3.4E+02	8.0E+03	-	-	-	-	7.9E+03	-	1.5E+03	-	-	-	-
PCT-2003-3	20000	21	1.9E-01	2.4E+02	1.3E+04	-	-	-	-	1.2E+04	-	2.2E+03	-	-	-	-
PCT-2003-4	20000	28	2.0E-01	2.2E+02	1.4E+04	-	-	-	-	1.2E+04	-	2.3E+03	-	-	-	-
PCT-2003-5	20000	35	2.0E-01	2.5E+02	1.3E+04	2.1E+02	4.1E+00	4.3E+03	7.2E+01	1.1E+04	3.0E+04	2.4E+03	1.9E+04	5.3E-01	3.5E+00	2.7E+01
PCT-2003-6	20000	42	1.8E-01	2.0E+02	1.2E+04	2.4E+02	8.6E+00	3.8E+03	4.4E+01	1.0E+04	9.0E+03	2.2E+03	2.4E+04	-	1.3E+00	2.4E+01
PCT-2003-7	20000	49	2.4E-01	1.3E+02	1.6E+04	1.8E+02	7.5E+00	4.5E+03	1.1E+02	1.2E+04	2.9E+04	2.7E+03	1.2E+04	2.7E+00	-	3.2E+01
PCT-2003-8	20000	56	2.7E-01	8.3E+01	1.8E+04	1.7E+02	7.8E+00	5.0E+03	9.6E+01	1.3E+04	-	2.7E+03	2.4E+04	1.5E-01	4.8E-01	9.4E+01

Table C2. LAWB45 PCT Test Results

Sample ID	S/V Ratio, m^{-1}	Time, days	Reaction Progress (mol kg^{-1})	Norm. Al (mg L^{-1})	Norm. B (mg L^{-1})	Norm. Ca (mg L^{-1})	Norm. Li (mg L^{-1})	Norm. Na (mg L^{-1})	Norm. Si (mg L^{-1})
LAW B45-10A-5.1F	2000	7	3.5E-02	4.3E+01	2.2E+03	4.7E+01	8.6E+02	1.9E+03	6.4E+02
LAW B45-10A-5.2F	2000	14	5.3E-02	4.3E+01	3.3E+03	6.4E+01	1.4E+03	2.9E+03	6.7E+02
LAW B45-10A-5.3F	2000	21	8.6E-02	3.5E+01	5.4E+03	4.4E+01	2.3E+03	4.6E+03	8.1E+02
LAW B45-1A-5.1F	20000	7	1.1E-01	4.4E+01	6.9E+03	3.8E+01	3.3E+03	5.5E+03	1.0E+03
LAW B45-1A-5.2F	20000	14	1.4E-01	3.5E+01	9.0E+03	8.0E+01	4.1E+03	6.9E+03	9.5E+02
LAW B45-1A-5.3F	20000	21	2.2E-01	4.3E+01	1.4E+04	9.8E+01	6.2E+03	1.1E+04	1.1E+03

Table C3. LAWC22 PCT Test Results

Sample ID	S/V Ratio, m^{-1}	Time, days	Reaction Progress (mol kg^{-1})	Norm. Al (mg L^{-1})	Norm. B (mg L^{-1})	Norm. Li (mg L^{-1})	Norm. Mg (mg L^{-1})	Norm. Na (mg L^{-1})	Norm. Si (mg L^{-1})
LAW C22-10A-5.1F	2000	7	9.1E-03	3.6E+01	5.9E+02	-	2.6E+01	5.0E+02	4.7E+02
LAW C22-10A-5.2F	2000	14	1.1E-02	5.0E+01	7.0E+02	6.6E+01	1.1E+01	6.2E+02	4.2E+02
LAW C22-10A-5.3F	2000	21	1.2E-02	6.4E+01	7.5E+02	8.7E+01	1.7E+01	6.8E+02	4.0E+02
LAW C22-1A-5.1F	20000	7	4.1E-02	8.4E+01	2.7E+03	1.6E+03	3.5E+01	2.4E+03	8.9E+02
LAW C22-1A-5.2F	20000	14	5.0E-02	8.9E+01	3.2E+03	2.1E+03	2.0E+01	3.0E+03	9.1E+02
LAW C22-1A-5.3F	20000	21	6.6E-02	1.1E+02	4.2E+03	2.9E+03	-	3.8E+03	1.0E+03

Appendix D
Microbial Experiment Test Results

Table D1. Microbial Experiment Test Conditions

Expt. ID#	Description	Glass added (g)	DIW (mL)	PBS (mL)	SPS (mL)	addtl C (mL)	culture	Temp (°C)
MBD44-1	Expt	0.5	50	0	0	0	TPM	19
MBD44-2	Expt	0.5	10	40	0	0	TPM	19
MBD44-3	Expt	0.5	10	40	0	0	TPM	19
MBD44-4	Expt	0.5	9	40	0	1	TPM	19
MBD44-5	Expt	0.5	9	40	0	1	TPM	19
MBD44-6	Expt	0.5	50	0	0	0	TPM	40
MBD44-7	Expt	0.5	10	40	0	0	TPM	40
MBD44-8	Expt	0.5	10	40	0	0	TPM	40
MBD44-9	Expt	0.5	9	40	0	1	TPM	40
MBD44-10	Expt	0.5	9	40	0	1	TPM	40
MBD44-11	Expt	0.5	50	0	0	0	HSE	19
MBD44-12	Expt	0.5	10	0	40	0	HSE	19
MBD44-13	Expt	0.5	10	0	40	0	HSE	19
MBD44-14	Expt	0.5	9	0	40	1	HSE	19
MBD44-15	Expt	0.5	9	0	40	1	HSE	19
MBD44-16	Expt	0.5	50	0	0	0	HSE	40
MBD44-17	Expt	0.5	10	0	40	0	HSE	40
MBD44-18	Expt	0.5	10	0	40	0	HSE	40
MBD44-19	Expt	0.5	9	0	40	1	HSE	40
MBD44-20	Expt	0.5	9	0	40	1	HSE	40
MBD44-21	Blank	0.5	50	0	0	0	none	19
MBD44-22	Blank	0.5	10	0	40	0	none	19
MBD44-23	Blank	0.5	10	40	0	0	none	19
MBD44-24	Blank	0.5	9	0	40	1	none	19
MBD44-25	Blank	0.5	9	40	0	1	none	19
MBD44-26	Blank	0.5	50	0	0	0	none	40
MBD44-27	Blank	0.5	10	0	40	0	none	40
MBD44-28	Blank	0.5	10	40	0	0	none	40
MBD44-29	Blank	0.5	9	0	40	1	none	40

Table D1. Microbial Experiment Test Conditions

Expt. ID#	Description	Glass added (g)	DIW (mL)	PBS (mL)	SPS (mL)	addtl C (mL)	culture	Temp (°C)
MBD44-30	Blank	0.5	9	40	0	1	none	40
MBD44-31	Control	0	50	0	0	0	none	19
MBD44-32	Control	0	10	0	40	0	none	19
MBD44-33	Control	0	10	40	0	0	none	19
MBD44-34	Control	0	9	0	40	1	none	19
MBD44-35	Control	0	9	40	0	1	none	19
MBD44-36	Control	0	50	0	0	0	none	40
MBD44-37	Control	0	10	0	40	0	none	40
MBD44-38	Control	0	10	40	0	0	none	40
MBD44-39	Control	0	9	0	40	1	none	40
MBD44-40	Control	0	9	40	0	1	none	40

Table D2. Microbial Experiment Test Results

Type	Test ID	[Al]				[B]				[Si]			
		1	3	4	5	1	3	4	5	1	3	4	5
TPM[1]	MBD44-1.1	71	(32)	20	*	421	628	850	*	3300	(3695)	4,227	*
HSE[2]	MBD44-11.1	3070	3854	1,966	*	981	1606	2,572	*	13921	16173	12,755	*
none	MBD44-21.1	113	337	309	*	580	635	871	*	4407	(3934)	4,652	*
TPM	MBD44-2.1	29	419	15	*	321	513	780	*	1255	(1912)	2,732	*
none	MBD44-23.1	28	(41)	38	*	419	553	843	*	1971	(2609)	4,032	*
HSE	MBD44-12.1	13256	9064	10,600	*	1134	1524	2,021	*	42423	27644	30,147	*
none	MBD44-22.1	970	1980	3,101	*	929	1765	2,698	*	6527	13225	18,684	*
TPM	MBD44-3.1	(19)	127	15	*	299	504	766	*	1486	(1834)	2,746	*
none	MBD44-23.1	28	(41)	38	*	419	553	843	*	1971	(2609)	4,032	*
HSE	MBD44-13.1	12572	10916	9,101	*	1143	1509	1,907	*	42200	32175	27,386	*
none	MBD44-22.1	970	1980	3,101	*	929	1765	2,698	*	6527	13225	18,684	*
TPM	MBD44-4.1	34	(32)	46	*	283	506	745	*	1178	(1279)	1,639	*
none	MBD44-25.1	47	(64)	25	*	242	281	(421)	*	1411	(1153)	1,432	*
HSE	MBD44-14.1	3331	177	216	*	836	918	1,055	*	20193	18200	15,683	*
none	MBD44-24.1	573	1509	89	*	737	1272	1,899	*	6196	9902	11,037	*
TPM	MBD44-5.1	28	(19)	39	*	282	454	684	*	(704)	(701)	982	*
none	MBD44-25.1	47	(64)	25	*	242	281	(421)	*	1411	(1153)	1,432	*
HSE	MBD44-15.1	(22)	(20)	599	*	805	952	1,277	*	19553	18313	19,932	*
none	MBD44-24.1	573	1509	89	*	737	1272	1,899	*	6196	9902	11,037	*

TPM – denotes Thiobacillus perometabolis culture
HSE – denotes Hanford Soil Extract
none – denotes blank samples
[] – denotes concentration in $\mu g\ L^{-1}$
() – denotes value is below estimated limit of quantification

Table D2. Microbial Experiment Test Results

Type	Test ID	[Al]				[B]				[Si]			
		1	3	4	5	1	3	4	5	1	3	4	5
TPM[1]	MBD44-6.1	643	3497	1,230	1,121	1513	1573	2,086	2,360	10331	10822	11,182	11,882
HSE[2]	MBD44-16.1	3427	1128	5,181	5,731	3083	5264	10,418	12,617	23997	18163	35,668	41,875
none	MBD44-26.1	1052	789	1,278	1,338	1470	1566	2,108	2,294	10101	9092	11,584	12,416
TPM	MBD44-7.1	297	789	621	571	777	1073	1,701	2,060	4497	5390	6,055	6,494
none	MBD44-28.1	66	(70)	186	134	1392	2126	3,415	3,979	5574	7382	8,893	10,095
HSE	MBD44-17.1	25181	11881	12,443	14,693	2227	2672	3,996	5,108	76565	35276	34,250	43,889
none	MBD44-27.1	3693	3556	4,031	4,053	3272	3803	5,213	6,275	24241	23657	24,311	25,938
TPM	MBD44-8.1	459	894	544	1,769	853	1098	1,683	2,109	4931	5340	5,950	7,029
none	MBD44-28.1	66	(70)	186	134	1392	2126	3,415	3,979	5574	7382	8,893	10,095
HSE	MBD44-18.1	21667	12841	10,637	13,617	2036	2514	3,897	4,772	68562	37275	31,368	40,814
none	MBD44-28.1	66	(70)	186	134	1392	2126	3,415	3,979	5574	7382	8,893	10,095
TPM	MBD44-9.1	35	2900	36	(13)	457	920	1,624	2,436	1302	(2425)	2,957	4,796
none	MBD44-30.1	54	(24)	39	896	677	1172	2,568	3,436	2197	3741	7,734	10,805
HSE	MBD44-19.1	77	(21)	158	144	2559	3424	4,817	5,209	30676	30248	29,220	28,228
none	MBD44-29.1	2120	3670	5,339	5,054	1961	3198	5,014	6,446	15884	24951	28,838	32,810
TPM	MBD44-10.1	35	(83)	23	45	473	780	1,542	2,487	1283	(1460)	2,659	4,395
none	MBD44-30.1	54	(24)	39	896	677	1172	2,568	3,436	2197	3741	7,734	10,805
HSE	MBD44-20.1	41	(97)	88	97	2116	2849	4,151	4,795	26766	27841	27,853	28,315
none	MBD44-29.1	2120	3670	5,339	5,054	1961	3198	5,014	6,446	15884	24951	28,838	32,810

TPM – denotes Thiobacillus perometabolis culture
HSE – denotes Hanford Soil Extract
none – denotes blank samples
[] – denotes concentration in $\mu g\ L^{-1}$
() – denotes value is below estimated limit of quantification

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