APPENDIX A

Details of Glass Property Constraints

NOTATION

C_1	Bound for Crystal1 – 3.0
C_2	Bound for Crystal2 – 0.08
C_3	Bound for Crystal3 – 0.225
C_4	Bound for Crystal4 – 0.18
C_5	Bound for Crystal5 – 0.18
$k_{\min}$	Lower limit for conductivity – 18
$k_{\max}$	Upper limit for conductivity – 50
$\mu_{\min}$	Lower limit for viscosity (PaS) – 2.0
$\mu_{\max}$	Upper limit for viscosity (PaS) – 10.0
$D_{\max}^{\text{PCT}}$	Max release rate (product consistency test) (g per m_2) – 10.0
$D_{\max}^{\text{MCC}}$	Max release rate (materials characterization center) (g per m^2) – 28.0
μ_a^i	Linear coefficients of viscosity model
μ_b^{ij}	Cross term coefficients of viscosity model
k_a^i	Linear coefficients of electrical conductivity model
k_b^{ij}	Cross term coefficients of electrical conductivity model
Dp_a^i	Linear coefficients of durability (PCT) model (for Boron)
Dp_b^{ij}	Cross term coefficients of durability (PCT) model for Boron
Dm_a^i	Linear coefficients of durability (MCC) model (for Boron)
Dm_b^{ij}	Cross term coefficients of durability (MCC) model (for Boron)

1. Component Bounds:

   a) $0.42 \leq p^{(\text{SiO}_2)} \leq 0.57$
   b) $0.05 \leq p^{(\text{B}_2\text{O}_3)} \leq 0.20$
   c) $0.05 \leq p^{(\text{Na}_2\text{O})} \leq 0.20$
   d) $0.01 \leq p^{(\text{Li}_2\text{O})} \leq 0.07$
   e) $0.0 \leq p^{(\text{CaO})} \leq 0.10$
   f) $0.0 \leq p^{(\text{MgO})} \leq 0.08$

g) $0.02 \leq p^{(\mathrm{Fe_2O_3})} \leq 0.15$
h) $0.0 \leq p^{(\mathrm{Al_2O_3})} \leq 0.15$
i) $0.0 \leq p^{(\mathrm{ZrO_2})} \leq 0.13$
j) $0.01 \leq p^{(\mathrm{other})} \leq 0.10$

2. Five glass crystallinity constraints:

a) $p^{(\mathrm{SiO_2})} > p^{(\mathrm{Al_2O_3})} * C_1$
b) $p^{(\mathrm{MgO})} + p^{(\mathrm{CaO})} < C_2$
c) $p^{(\mathrm{Fe_2O_3})} + p^{(\mathrm{Al_2O_3})} + p^{(\mathrm{ZrO_2})} + p^{('\mathrm{Other'})} < C_3$
d) $p^{(\mathrm{Al_2O_3})} + p^{(\mathrm{ZrO_2})} < C_4$
d) $p^{(\mathrm{MgO})} + p^{(\mathrm{CaO})} + p^{(\mathrm{ZrO_2})} < C_5$

3. Solubility Constraints:

a) $p^{(\mathrm{Cr_2O_3})} < 0.005$
b) $p^{(\mathrm{F})} < 0.017$
c) $p^{(\mathrm{P_2O_5})} < 0.01$
d) $p^{(\mathrm{SO_3})} < 0.005$
e) $p^{(\mathrm{Rh_2O_3+PdO+Ru_2O_3})} < 0.025$

4. Viscosity Constraints:

a) $\sum_{i=1}^{n} \mu_a^i * p^{(i)} + \sum_{j=1}^{n} \sum_{i=1}^{n} \mu_b^{ij} * p^{(i)} * p^{(j)} > \log(\mu_{\min})$
b) $\sum_{i=1}^{n} \mu_a^i * p^{(i)} + \sum_{j=1}^{n} \sum_{i=1}^{n} \mu_b^{ij} * p^{(i)} * p^{(j)} < \log(\mu_{\max})$

5. Conductivity Constraints:

a) $\sum_{i=1}^{n} k_a^i * p^{(i)} + \sum_{j=1}^{n} \sum_{i=1}^{n} k_b^{ij} * p^{(i)} * p^{(j)} > \log(k_{\min})$
b) $\sum_{i=1}^{n} k_a^i * p^{(i)} + \sum_{j=1}^{n} \sum_{i=1}^{n} k_b^{ij} * p^{(i)} * p^{(j)} < \log(k_{\max})$

6. Dissolution rate for boron by PCT test (DissPCTbor):
$\sum_{i=1}^{n} Dp_a^i * p^i + \sum_{j=1}^{n} \sum_{i=1}^{n} Dp_b^{ij} * p^{(i)} * p^{(j)} < \log(D_{\max}^{\mathrm{PCT}})$
7. Dissolution rate for boron by MCC test (DissMCCbor):
$\sum_{i=1}^{n} Dm_a^i * p^i + \sum_{j=1}^{n} \sum_{i=1}^{n} Dm_b^{ij} * p^{(i)} * p^{(j)} < \log(D_{\max}^{\mathrm{MCC}})$

Waste Composition Data

	Fractional Composition of Wastes						
Comp.	AY-102	AZ-101	AZ-102	SY-102	SY-101	SY-103	B-103
SiO_2	0.072	0.092	0.022	0.020	0.000	0.019	0.011
B_2O_3	0.026	0.000	0.006	0.003	0.000	0.000	0.000
Na_2O	0.105	0.264	0.120	0.154	0.300	0.230	0.100
Li_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CaO	0.061	0.012	0.010	0.030	0.007	0.006	0.000
MgO	0.040	0.000	0.003	0.012	0.000	0.001	0.000
Fe_2O_3	0.328	0.323	0.392	0.133	0.000	0.039	0.155

	Fractional Composition of Wastes						
Comp.	AY-102	AZ-101	AZ-102	SY-102	SY-101	SY-103	B-103
Al_2O_3	0.148	0.157	0.212	0.318	0.659	0.546	0.214
ZrO_2	0.002	0.057	0.063	0.002	0.000	0.001	0.000
Other	0.217	0.096	0.173	0.328	0.034	0.159	0.520
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cr_2O_3	0.016	0.007	0.005	0.089	0.002	0.116	0.000
F	0.006	0.001	0.001	0.005	0.002	0.001	0.000
P_2O_5	0.042	0.001	0.021	0.088	0.013	0.005	0.037
SO_3	0.001	0.018	0.009	0.027	0.005	0.002	0.007
NobMet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mass	59772	40409	143747	359609	167510	185990	6170

	Fractional Composition of Wastes $w^{(i)}/g^{(i)}$						
Comp.	BY-104	BY-110	C-103	C-105	C-106	C-108	C-109
SiO_2	0.030	0.040	0.412	0.359	0.437	0.001	0.001
B_2O_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na_2O	0.082	0.089	0.006	0.012	0.014	0.010	0.007
Li_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CaO	0.141	0.046	0.041	0.044	0.046	0.000	0.737
MgO	0.000	0.000	0.028	0.026	0.031	0.000	0.000
Fe_2O_3	0.067	0.051	0.338	0.064	0.214	0.206	0.003
Al_2O_3	0.344	0.462	0.057	0.372	0.168	0.693	0.013
ZrO_2	0.007	0.003	0.043	0.004	0.008	0.032	0.000
Other	0.330	0.309	0.075	0.119	0.082	0.058	0.238
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cr_2O_3	0.000	0.000	0.002	0.005	0.004	0.002	0.000
F	0.001	0.001	0.000	0.000	0.000	0.000	0.000
$P_2O_50.016$	0.022	0.013	0.012	0.031	0.047	0.003	0.000
SO_3	0.002	0.003	0.000	0.002	0.000	0.000	0.000
NobMet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mass	155473	103492	85211	207127	367165	46919	53271

	Fractional Composition of Wastes						
	C-111	C-112	S-102	SX-106	TX-105	TX-118	U-107
SiO_2	0.002	0.001	0.000	0.033	0.010	0.060	0.008
B_2O_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na_2O	0.011	0.005	0.337	0.280	0.168	0.425	0.038

	Fractional Composition of Wastes						
	C-111	C-112	S-102	SX-106	TX-105	TX-118	U-107
Li_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CaO	0.426	0.593	0.000	0.000	0.000	0.000	0.000
MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe_2O_3	0.042	0.002	0.023	0.102	0.167	0.026	0.077
Al_2O_3	0.256	0.097	0.582	0.388	0.595	0.240	0.650
ZrO_2	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.256	0.302	0.058	0.197	0.060	0.250	0.228
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cr_2O3	0.000	0.000	0.024	0.020	0.000	0.000	0.000
F	0.000	0.000	0.000	0.001	0.000	0.004	0.001
P_2O_5	0.012	0.005	0.006	0.038	0.002	0.159	0.020
SO_3	0.000	0.000	0.000	0.003	0.001	0.009	0.001
NobMet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mass	24485	65673	36537	45273	42200	412495	11504

Index