

Appendix A. Supplementary Data

Diel Variation of Selenium and Arsenic in a Wetland of the Great Salt Lake, Utah.

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1. Diel Measurements of Other Metals

Diel measurements of unfiltered and filtered Ag, Al, Ba, B, Cd, Cu, Cr, Hg, Ni, Pb, and Zn were performed in May 24-25, 2006 from the wetland pond outlet (Storet Site number 4985320). Also, filtered and unfiltered Al, and Hg were collected from the same site in August 17-18, 2007. [Figure S1](#) shows the diel measurements of these trace metals. From examinations of [Figure S1](#) there is no apparent diel trend observed for Ag, Al, Ba, B, Cd, Cu, Cr, Hg, Mn, Ni, Pb, and Zn.

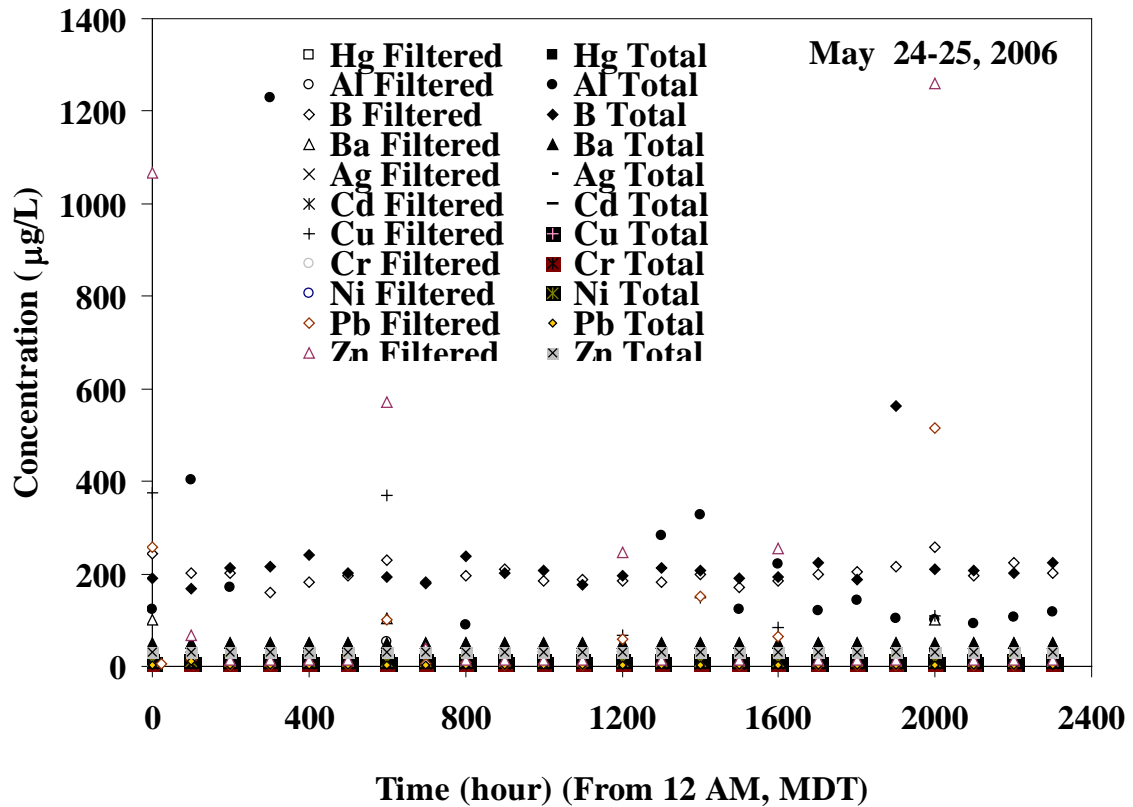
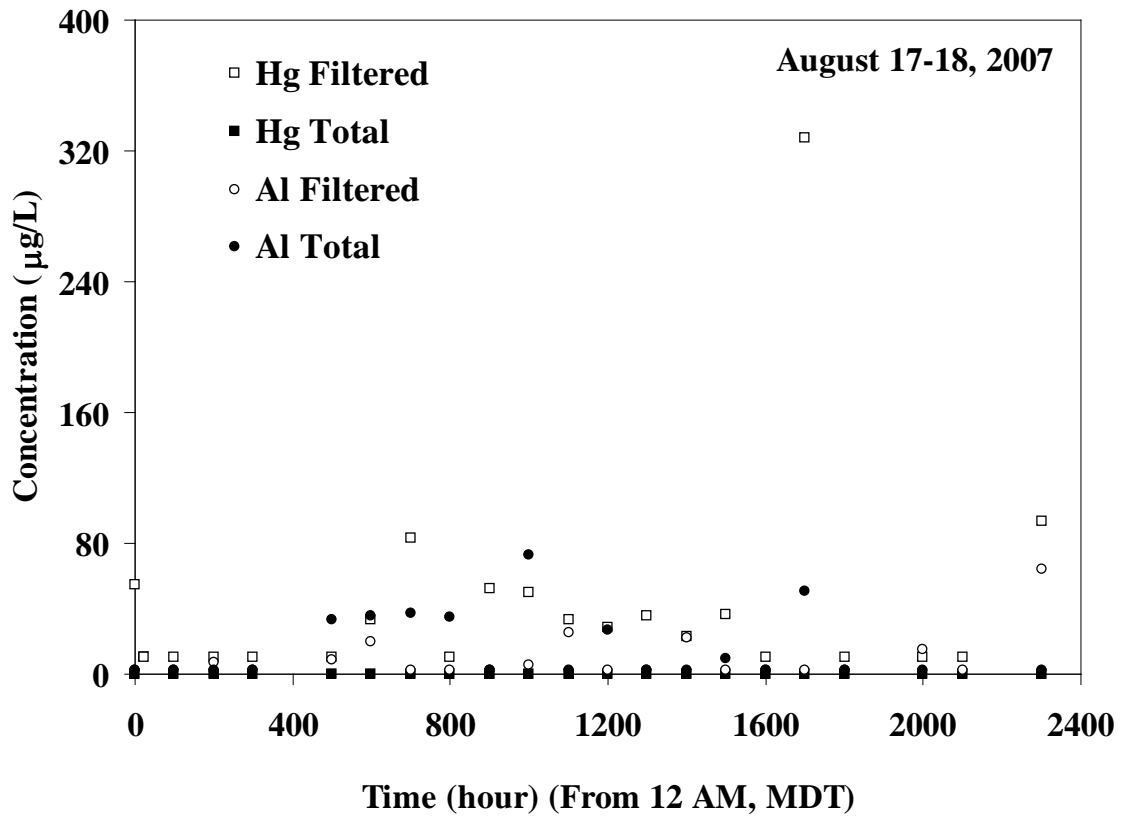


Figure S1. Diel measurements of total (unfiltered) and filtered Ag, Al, Ba, B, Cd, Cu, Cr, Hg, Ni, Pb, and Zn in May 2006 and August 2007.

2. PHREEQC Speciation Simulations of Se, Mn, and Se

Results of aqueous speciation simulations in PHREEQC are shown in Tables S1 through S3 below. Selenite alternated with selenate species, whereas manganese Mn(2) and arsenate predominated the August 17-18 speciation.

Table S1. Percent of Dissolved Se Species Simulated by PHREEQC (Parkhurst and Appelo, 1999) (August 17-18, 2007).

Time (h)	% Se(4)	%Se(6)	%Se(-2)	SeO3-2 mol/Kg	SeO4-2 mol/Kg	HSeO3- mol/Kg	HSeO4- mol/Kg	HSe- mol/Kg
0	100%	0%	0%	3.51E-09	2.24E-13	6.89E-09	8.50E-20	1.25E-36
1	100%	0%	0%	3.31E-09	2.89E-14	7.98E-09	1.34E-20	4.81E-34
2	100%	0%	0%	3.13E-09	6.20E-15	7.90E-09	2.98E-21	3.45E-32
3	100%	0%	0%	2.93E-09	1.10E-15	9.37E-09	6.51E-22	2.97E-30
5	100%	0%	0%	1.83E-09	1.24E-16	9.07E-09	1.13E-22	4.77E-28
6	100%	0%	0%	2.59E-09	5.50E-16	8.06E-09	3.16E-22	1.34E-29
7	100%	0%	0%	4.16E-09	5.60E-15	7.63E-09	1.93E-21	7.64E-32
8	100%	0%	0%	7.97E-09	9.54E-14	8.51E-09	1.98E-20	2.24E-34
9	100%	0%	0%	1.05E-08	1.99E-12	5.86E-09	2.22E-19	6.74E-38
10	100%	0%	0%	1.25E-08	5.07E-11	3.56E-09	2.96E-18	0.00E+00
11	97%	3%	0%	1.20E-08	4.55E-10	2.64E-09	2.09E-17	0.00E+00
12	68%	32%	0%	8.44E-09	4.55E-09	1.34E-09	1.59E-16	0.00E+00
13	19%	81%	0%	2.69E-09	1.29E-08	3.51E-10	3.91E-16	0.00E+00
14	8%	92%	0%	9.73E-10	1.28E-08	1.43E-10	4.33E-16	0.00E+00
15	3%	97%	0%	3.53E-10	1.44E-08	4.86E-11	4.55E-16	0.00E+00
16	5%	95%	0%	5.89E-10	1.35E-08	1.47E-10	7.66E-16	0.00E+00
17	2%	98%	0%	2.36E-10	1.32E-08	4.19E-11	5.29E-16	0.00E+00
18	2%	98%	0%	2.46E-10	1.40E-08	3.79E-11	4.90E-16	0.00E+00
20	39%	61%	0%	3.82E-09	7.77E-09	1.21E-09	5.32E-16	0.00E+00
21	91%	9%	0%	7.44E-09	1.21E-09	4.29E-09	1.49E-16	0.00E+00
23	100%	0%	0%	4.09E-09	2.86E-12	6.44E-09	9.24E-19	3.08E-39

Table S2. Dissolved Mn Species Simulated by PHREEQC (Parkhurst and Appelo, 1999) (August 17-18, 2007).

Time (h)	%Mn(2)	%Mn(3)	%Mn(6)	%Mn(7)	Mn(2) mol/Kg	Mn(3) mol/Kg	Mn(6) mol/Kg	Mn(7) mol/Kg
0	100%	0%	0%	0%	1.31E-06	8.14E-28	0.00E+00	0.00E+00
1	100%	0%	0%	0%	1.35E-06	3.81E-28	0.00E+00	0.00E+00
2	100%	0%	0%	0%	1.40E-06	1.98E-28	0.00E+00	0.00E+00
3	100%	0%	0%	0%	1.37E-06	1.05E-28	0.00E+00	0.00E+00
5	100%	0%	0%	0%	1.40E-06	7.06E-29	0.00E+00	0.00E+00
6	100%	0%	0%	0%	1.42E-06	8.01E-29	0.00E+00	0.00E+00
7	100%	0%	0%	0%	1.37E-06	1.14E-28	0.00E+00	0.00E+00
8	100%	0%	0%	0%	1.48E-06	2.21E-28	0.00E+00	0.00E+00
9	100%	0%	0%	0%	1.48E-06	4.65E-28	0.00E+00	0.00E+00
10	100%	0%	0%	0%	1.48E-06	1.11E-27	1.70E-39	0.00E+00
11	100%	0%	0%	0%	1.53E-06	2.76E-27	5.14E-37	0.00E+00
12	100%	0%	0%	0%	1.46E-06	7.23E-27	6.79E-34	1.40E-38
13	100%	0%	0%	0%	1.49E-06	1.87E-26	2.01E-31	1.06E-35
14	100%	0%	0%	0%	1.44E-06	3.33E-26	8.48E-31	8.27E-35
15	100%	0%	0%	0%	1.40E-06	5.30E-26	1.01E-29	1.62E-33
16	100%	0%	0%	0%	1.48E-06	7.67E-26	2.92E-31	6.34E-35
17	100%	0%	0%	0%	1.44E-06	8.21E-26	6.37E-30	1.53E-33
18	100%	0%	0%	0%	1.48E-06	7.42E-26	1.15E-29	2.43E-33
20	100%	0%	0%	0%	1.48E-06	2.83E-26	4.87E-34	3.86E-38
21	100%	0%	0%	0%	1.46E-06	1.44E-26	2.63E-37	0.00E+00
23	100%	0%	0%	0%	1.31E-06	2.24E-27	0.00E+00	0.00E+00

Table S3. Dissolved As Species Simulated by PHREEQC (Parkhurst and Appelo, 1999) (May 24-25, 2006).

Date	Time	As	As(3)	As(5)	As(3)	As(5)
	(hour)	mol/Kg	mol/Kg	mol/Kg	% of As	% of As
5/25/2006	000	1.38E-07	6.53E-23	1.38E-07	0%	100%
5/25/2006	100	1.51E-07	4.64E-20	1.51E-07	0%	100%
5/25/2006	200	1.56E-07	5.40E-19	1.56E-07	0%	100%
5/25/2006	300	1.60E-07	2.95E-18	1.60E-07	0%	100%
5/25/2006	400	1.62E-07	7.05E-18	1.62E-07	0%	100%
5/25/2006	500	1.92E-07	1.08E-17	1.92E-07	0%	100%
5/25/2006	600	1.86E-07	6.57E-18	1.86E-07	0%	100%
5/25/2006	700	1.82E-07	2.59E-18	1.82E-07	0%	100%
5/25/2006	800	1.82E-07	3.84E-19	1.82E-07	0%	100%
5/25/2006	900	1.64E-07	1.76E-20	1.64E-07	0%	100%
5/25/2006	1000	1.55E-07	9.32E-23	1.55E-07	0%	100%
5/25/2006	1100	1.46E-07	9.94E-25	1.46E-07	0%	100%
5/25/2006	1200	1.28E-07	8.46E-27	1.28E-07	0%	100%
5/25/2006	1300	1.18E-07	3.17E-28	1.18E-07	0%	100%
5/25/2006	1400	1.12E-07	1.85E-29	1.12E-07	0%	100%
5/25/2006	1500	1.07E-07	1.74E-30	1.07E-07	0%	100%
5/25/2006	1600	1.06E-07	1.39E-30	1.06E-07	0%	100%
5/24/2006	1700	1.29E-07	2.37E-30	1.29E-07	0%	100%
5/24/2006	1800	1.19E-07	1.85E-30	1.19E-07	0%	100%
5/24/2006	1900	1.23E-07	1.22E-29	1.23E-07	0%	100%
5/24/2006	2000	1.25E-07	8.92E-29	1.25E-07	0%	100%
5/24/2006	2100	1.33E-07	3.78E-28	1.33E-07	0%	100%
5/24/2006	2200	1.26E-07	4.82E-27	1.26E-07	0%	100%
5/24/2006	2300	1.40E-07	5.04E-26	1.40E-07	0%	100%

Ammonia and nitrate concentrations (Table S4) were used in PHREEQC to constrain the redox conditions in May 24-25, 2006.

Table S4. Nitrate (NO₃⁻) and Ammonia (NH₄⁺) measured during the diel cycle on May 2006.

Date	Time	NO3- (mg L ⁻¹)	NH4+ (mg L ⁻¹)
5/25/2006	0	0.05	0.08
5/25/2006	1	0.05	1.5
5/25/2006	2	0.05	0.93
5/25/2006	3	0.05	2.54
5/25/2006	4	0.05	0.24
5/25/2006	5	0.05	2.33
5/25/2006	6	0.05	0.96
5/25/2006	7	0.05	0.14
5/25/2006	8	0.05	0.19
5/25/2006	9	0.05	0.23
5/25/2006	10	0.05	0.18
5/25/2006	11	0.05	0.11
5/25/2006	12	0.05	0.06
5/25/2006	13	0.05	0.08
5/25/2006	14	0.05	0.09
5/25/2006	15	0.05	0.08
5/25/2006	16	0.05	0.06
5/24/2006	17	0.05	0.1
5/24/2006	18	0.05	0.13
5/24/2006	19	0.05	0.11
5/24/2006	20	0.05	0.05
5/24/2006	21	0.05	0.27
5/24/2006	22	0.05	0.1
5/24/2006	23	0.05	0.43

3. Conversion of Non-Standard Oxidation Reduction Potential (ORP) to Standard Eh and pe.

Field measurements of ORP were performed using a Silver/Silver Chloride ORP electrode (Table S5). These measurements were converted to the standard hydrogen electrode (SHE) Eh using the following equation (Lim and Chu, 2006):

$$Eh_{SHE} = Eh_{measured} + 206 - 0.7(T_w - 25) \quad (S1)$$

Where, $Eh_{SHE} = Eh$ measured with a standard hydrogen electrode [mV]; $Eh_{measured} = Eh$ measured with a non standard electrode (e.g., Silver/Silver Chloride) [mV]; and T_w = water temperature [$^{\circ}C$].

The Eh_{SHE} was converted to pe using the following relationship (Stumm and Morgan, 1996):

$$pe = \frac{Eh_{SHE}(V)F}{2.303RT} \quad (S2)$$

Where, F = Faraday constant (96.42 KJ/V); R=universal gas constant (8.314×10^{-3} KJ/mol $^{\circ}K$); and T = water temperature ($^{\circ}K$).

Table S5. Observed ORP (millivolts (mV)), Temperature (Celsius) (August 17-18, 2007).

Time (h)	ORP (mV)	Temperature ($^{\circ}C$)
0	36.8	21.25
1	17.2	21.05
2	0.0	20.85
3	-13.4	20.00
5	-23.9	19.96
6	-21.1	19.94
7	-12.2	20.45
8	0.50	21.21
9	17.9	21.89
10	38.4	22.65
11	59.6	23.09
12	82.7	24.57
13	103.8	25.87
14	120.1	25.68
15	133.0	25.60
16	141.1	25.50
17	143.9	25.38
18	140.7	25.30
20	118.3	24.02
21	101.5	23.87
23	59.1	22.78

4. Samples Quality Assurance/ Quality Control (QA/QC)

4.1 UPH Laboratory September 2005 Se Water Samples

Selenium concentrations in September were calibrated using a multi-point linear regression ($R^2 \geq 0.998$) based on a series of Se standards varying from $0.5 \mu\text{g L}^{-1}$ to $10 \mu\text{g L}^{-1}$ (Figure S2). The method detection limit (MDL) was $0.18 \mu\text{g L}^{-1}$. Laboratory blanks and duplicates were analyzed for quality control. The average relative standard deviation (RSD) for duplicate samples of dissolved selenium concentration in September was 13% (Table S6).

4.2 Other Water Trace Metals, Nutrients, and Major Ions (2005 – 2007).

QA/QC performed on other trace metals, nutrients, and major ions and analyzed during the 2005 – 2007 are available upon request at the UPH laboratory. QA/QC were conducted in accordance to the Quality Assurance Program Plan,

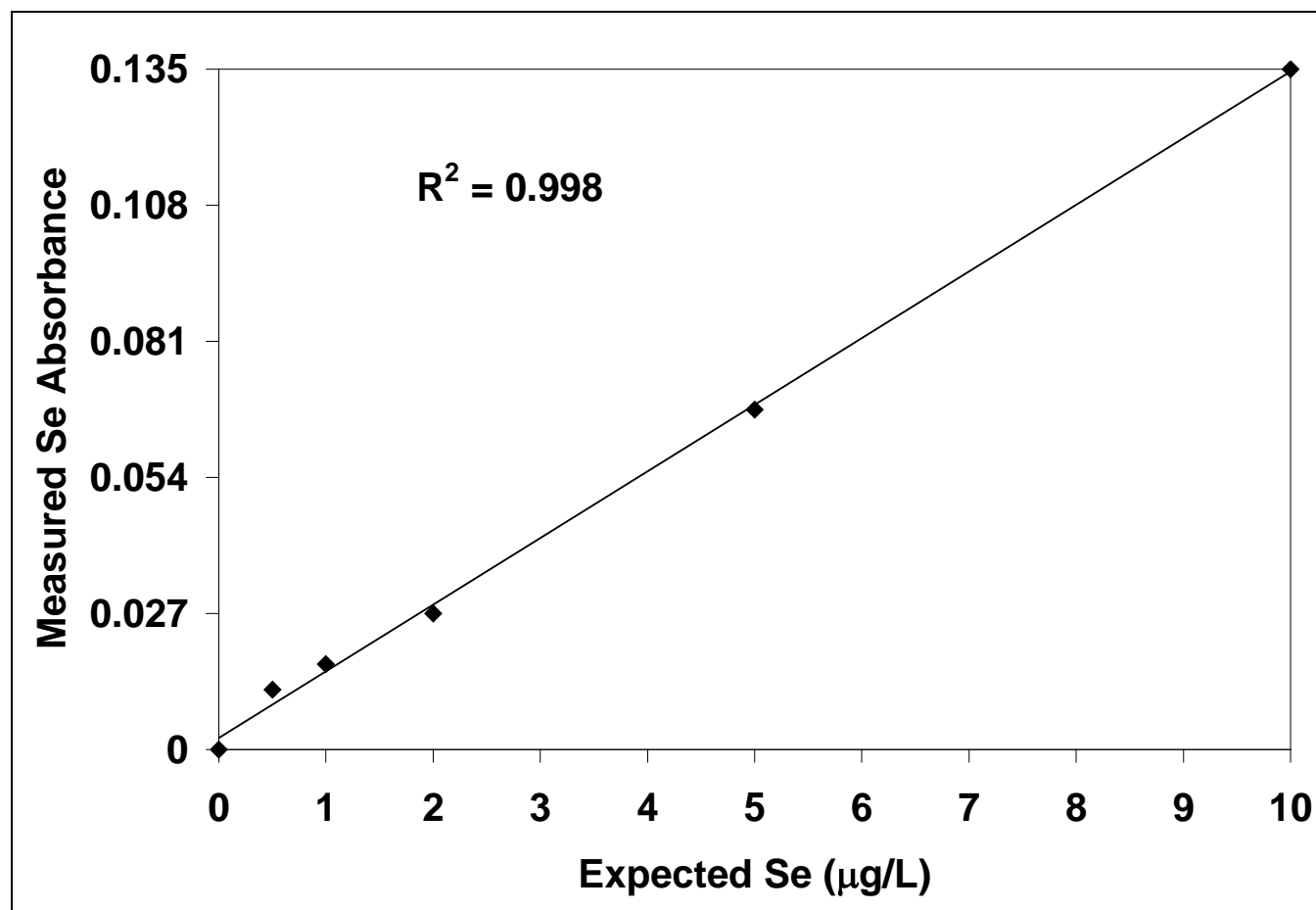


Figure S2. HGAAS multipoint calibration for dissolved selenium samples measured in September 2005 at UT Storet no. 4985320.

revision 7.003, revised November 2006, chapter 7.0 “Sampling, Documentation, and Sample Acceptance” published by the UPH laboratory.

Table S6. Dissolved Selenium in Duplicate Samples Concentrations Measured in September 2005. NA = Not Available.

Time (h)	Unit	Analysis #1	Duplicate	Mean	SD	%RSD
Blank	µg L ⁻¹	0.004	0.006	0.005	0.0014	28.28
0000	µg L ⁻¹	0.877	1.033	0.955	0.111	11.58
0100	µg L ⁻¹	1.172	0.838	1.005	0.236	23.53
0200	µg L ⁻¹	1.004	1.104	1.054	0.070	6.667
0300	µg L ⁻¹	1.093	1.345	1.219	0.178	14.59
0400	µg L ⁻¹	1.046	1.157	1.101	0.078	7.071
0500	µg L ⁻¹	1.308	1.343	1.326	0.025	1.858
0600	µg L ⁻¹	NA	NA	NA	NA	NA
0700	µg L ⁻¹	1.196	0.777	0.986	0.297	30.09
0800	µg L ⁻¹	1.234	1.445	1.339	0.149	11.13
0900	µg L ⁻¹	1.201	1.400	1.300	0.141	10.84
1000	µg L ⁻¹	1.320	1.273	1.297	0.033	2.538
1100	µg L ⁻¹	1.279	1.366	1.322	0.061	4.645
1200	µg L ⁻¹	1.347	1.214	1.281	0.094	7.328
1300	µg L ⁻¹	0.932	1.078	1.005	0.103	10.28
1400	µg L ⁻¹	0.839	0.935	0.887	0.068	7.672
1500	µg L ⁻¹	1.070	1.164	1.117	0.066	5.954
1600	µg L ⁻¹	1.159	1.053	1.106	0.074	6.719
1700	µg L ⁻¹	1.056	1.216	1.136	0.113	9.964
1800	µg L ⁻¹	1.074	1.357	1.216	0.200	16.47
1900	µg L ⁻¹	1.041	0.810	0.925	0.163	17.67
2000	µg L ⁻¹	0.652	1.233	0.943	0.411	43.60
2100	µg L ⁻¹	0.790	1.014	0.902	0.159	17.61
2200	µg L ⁻¹	1.103	1.298	1.200	0.138	11.49
2300	µg L ⁻¹	1.392	0.941	1.167	0.319	27.35

4.3 CWECs Laboratory August 2007 Water Samples

The QA/QC for the August 2007 samples of total and dissolved Se including laboratory calibration (blank, low, mid, and high), continuing calibration verification standards (CCV), continuing calibration blank (CCB), and initial calibration blank (ICB) are shown in [Table S7](#). The selenium Minimum Detection Limit (MDL) was $0.007\mu\text{g L}^{-1}$.

Table S7. ICPMS results including QC of total and dissolved selenium concentrations in August 2007.

Sample#	Description	Date	Time	Se ($\mu\text{g L}^{-1}$)
Cal_Blnk	Calibration			0.00
Lo_Cal_Stnd	Calibration			0.40
Mid_Cal_Stnd	Calibration			2.00
Hi_Cal_Stnd	Calibration			20.0
ICB	blank			0.00
CCV	10 ppb			9.84
CCB	blank			0.02
CCB	blank			0.00
1	not filtered	8/17/07	8:00 AM	1.49
2	filtered	8/17/07	8:00 AM	1.30
3	not filtered	8/17/07	9:00 AM	1.38
4	filtered	8/17/07	9:00 AM	1.29
5	not filtered	8/17/07	10:00 AM	1.27
CCV	10 ppb			10.0
CCB	blank			0.01
CCB	blank			0.00
6	filtered	8/17/07	10:00 AM	1.27
7	not filtered	8/17/07	11:00 AM	1.30
8	filtered	8/17/07	11:00 AM	1.19
9	not filtered	8/17/07	12:00 noon	1.25
10	filtered	8/17/07	12:00 noon	1.13
CCV	10 ppb			10.0
CCB	blank			0.01
CCB	blank			0.00
11	not filtered	8/17/07	13:00 h:m	1.32
12	filtered	8/17/07	13:00 h:m	1.26
13	not filtered	8/17/07	14:00 h:m	1.28
14	filtered	8/17/07	14:00 h:m	1.10
15	not filtered	8/17/07	15:00 h:m	1.21
CCV	10 ppb			9.80
CCB	blank			0.01
CCB	blank			0.00
16	filtered	8/17/07	15:00 h:m	1.17
17	not filtered	8/17/07	16:00 h:m	1.23

Table S7. Continued

Sample#	Description	Date	Time	Se ($\mu\text{g L}^{-1}$)
18	filtered	8/17/07	16:00 h:m	1.12
19	not filtered	8/17/07	17:00 h:m	1.19
20	filtered	8/17/07	17:00 h:m	1.06
CCV	10 ppb			9.59
CCB	blank			0.01
CCB	blank			0.00
21	not filtered	8/17/07	18:00 h:m	1.21
22	filtered	8/17/07	18:00 h:m	1.13
23	not filtered	8/17/07	20:00 h:m	1.08
24	filtered	8/17/07	20:00 h:m	1.01
25	not filtered	8/17/07	21:00 h:m	1.07
CCV	10 ppb			9.80
CCB	blank			0.01
CCB	blank			0.00
26	filtered	8/17/07	21:00 h:m	1.02
27	not filtered	8/17/07	23:00 h:m	1.02
28	filtered	8/17/07	23:00 h:m	0.83
29	not filtered	8/18/07	24:00 h:m	1.01
30	filtered	8/18/07	24:00 h:m	0.82
CCV	10 ppb			10
CCB	blank			0.01
CCB	blank			0.00
31	not filtered	8/18/07	1:00 AM	1.03
32	filtered	8/18/07	1:00 AM	0.89
33	not filtered	8/18/07	2:00 AM	1.00
34	filtered	8/18/07	2:00 AM	0.87
35	not filtered	8/18/07	3:00 AM	0.92
CCV	10 ppb			9.5
CCB	blank			0.01
CCB	blank			0.00
36	filtered	8/18/07	3:00 AM	0.97
37	not filtered	8/18/07	5:00 AM	0.96
38	filtered	8/18/07	5:00 AM	0.86
39	not filtered	8/18/07	6:00 AM	0.94
40	filtered	8/18/07	6:00 AM	0.84
CCV	10 ppb			9.58
CCB	blank			0.01
CCB	blank			0.00
41	not filtered	8/18/07	7:00 AM	0.99
42	filtered	8/18/07	7:00 AM	0.93
CCV	10 ppb			9.63
CCB	blank			0.01
CCB	blank			0.00

Selenium concentrations in August were calibrated using a multi-point linear regression ($R^2 \geq 0.99998$) based on a series of three Se standards varying from $0 \mu\text{g L}^{-1}$ to $20 \mu\text{g L}^{-1}$ (Figure S3).

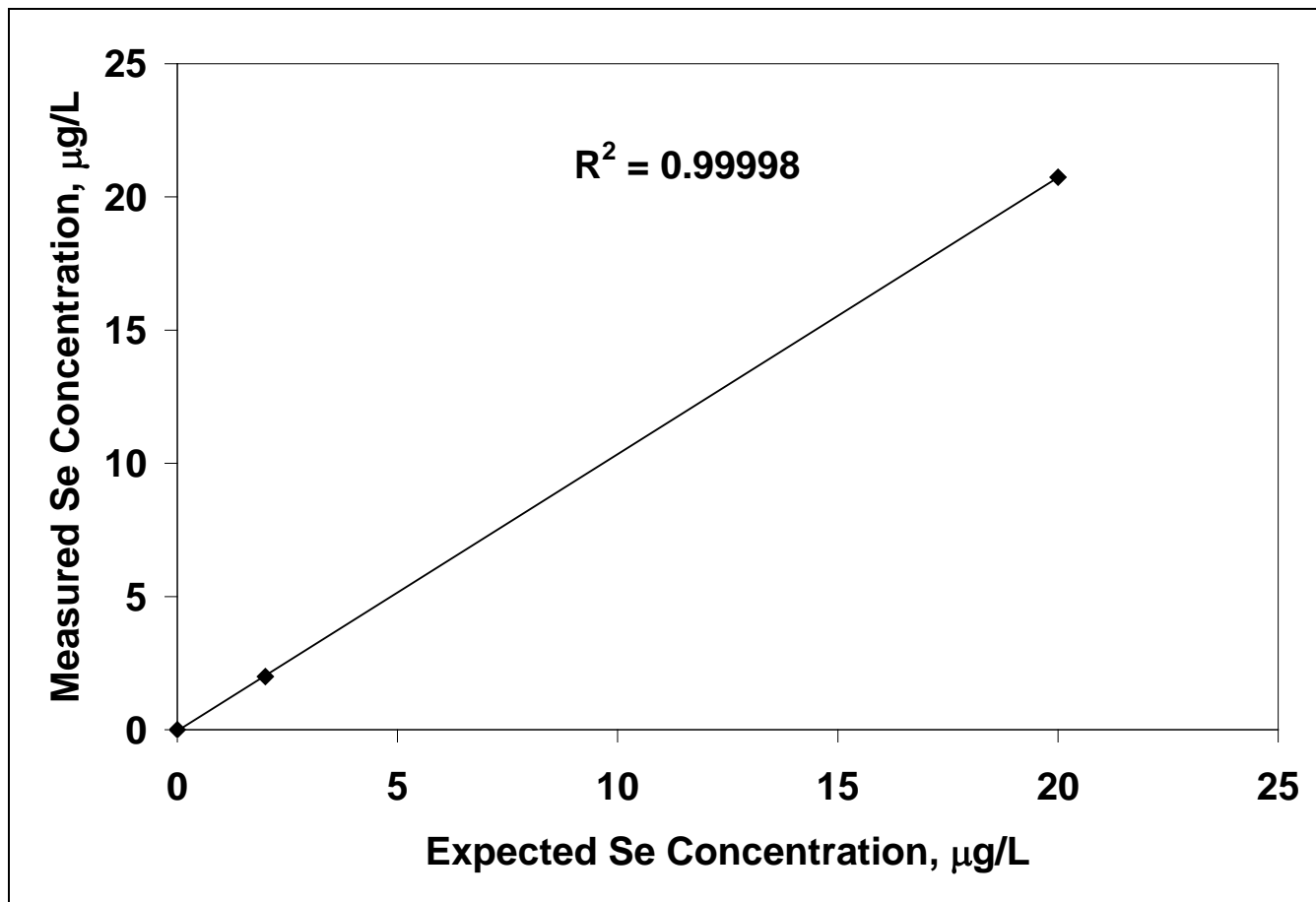


Figure S3. ICPMS multipoint calibration for dissolved selenium samples measured in August 2007 at UT Storet no. 4985320.

References

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