

Characterization & Treatment of Hg-Contaminated Soils & Sediments of the South River

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&

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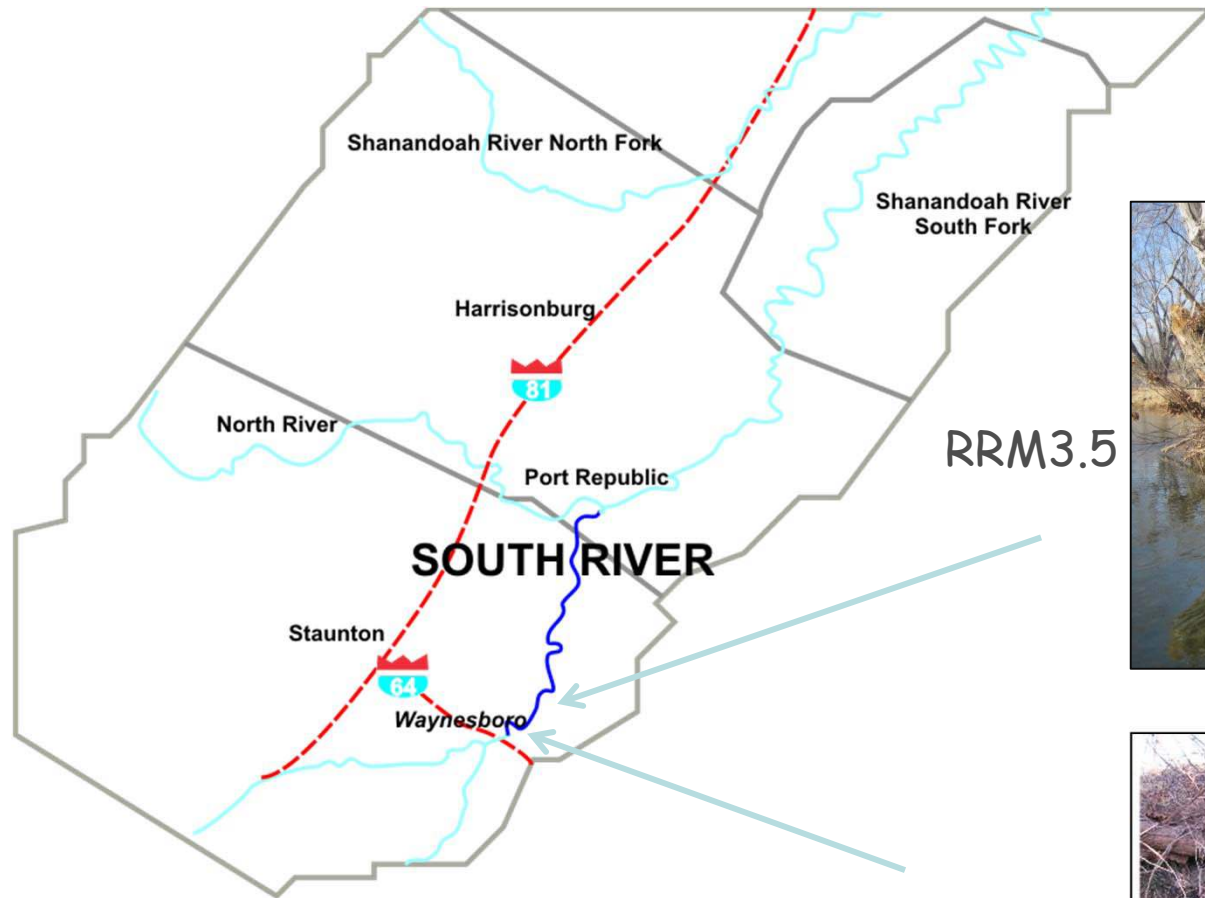
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River Bank Soils & Sediment Characterization

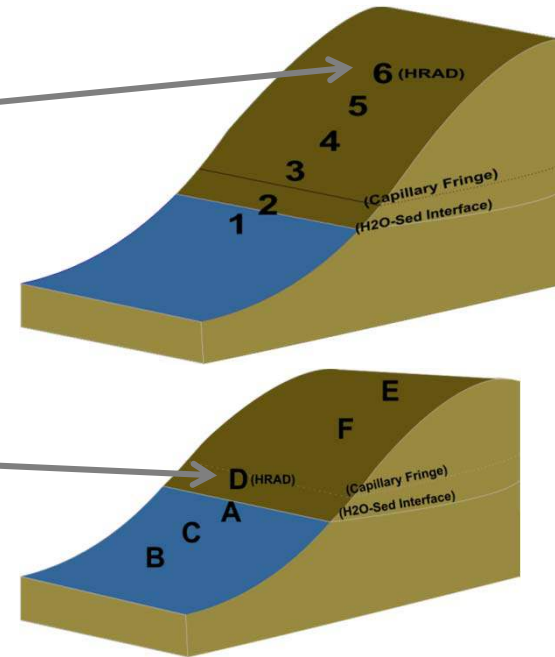
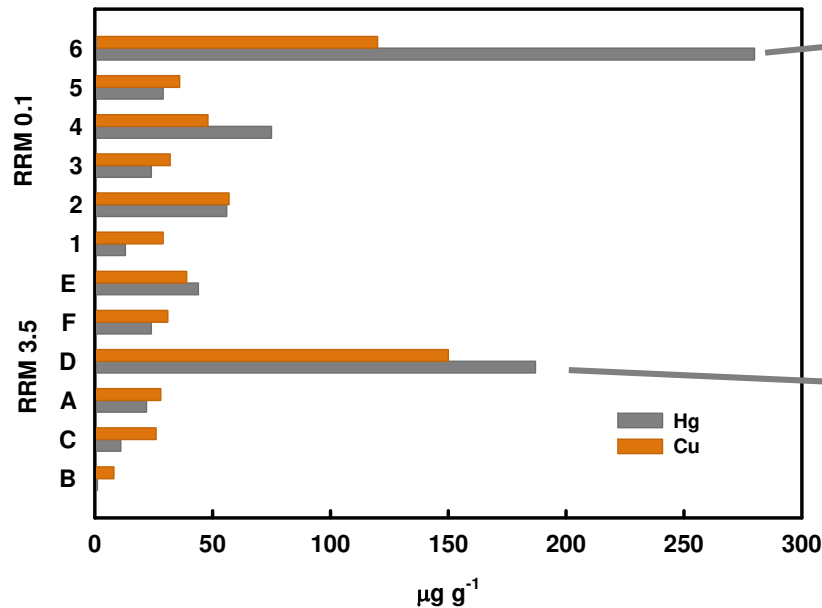


RRM 0.1 - Bank Stabilization Pilot Site



River Bank Soils & Sediment Characterization

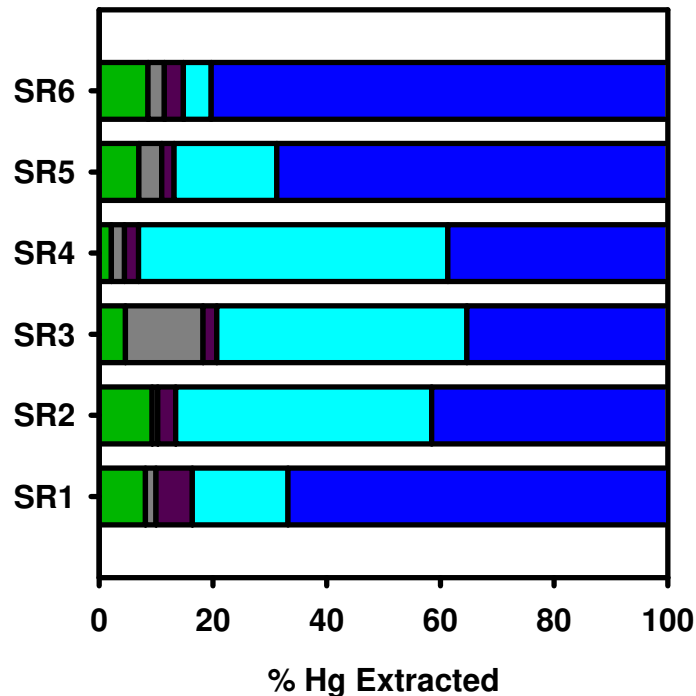
Sediment Digestions



Sample ID	Hg	Al	As	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb
mg g⁻¹, dry weight												
SR-6	280	5400	3.3	15	120	16000	820	930	300	7	8.5	23
SR-5	29	6100	3.1	14	36	20000	1300	1100	420	7	13	26
SR-4	75	5000	3.1	17	48	17000	1000	910	310	7	9	23
SR-3	24	6100	4.3	17	32	29000	2000	1200	340	7	10	13
SR-2	56	4800	3.8	21	57	20000	1000	870	320	7	14	23
SR-1	13	3200	2.5	11	29	12000	1500	710	140	7	8.8	14
mg g⁻¹, dry weight												
E	44	3700	1.7	21	39	15000	740	810	230	15	6.1	11
F	24	4600	1.6	19	31	13000	710	1100	300	24	6.5	13
D	187	5000	2.2	59	150	16000	760	1200	230	35	8.2	21
A	22	3900	1.7	18	28	18000	860	1500	130	16	5.8	6.8
C	11	6200	2.2	24	26	21000	1400	4900	290	30	9.2	12
B	1.1	4600	3	25	8.1	30000	900	3300	240	21	6.5	7.5

Chemical Sequential Extraction

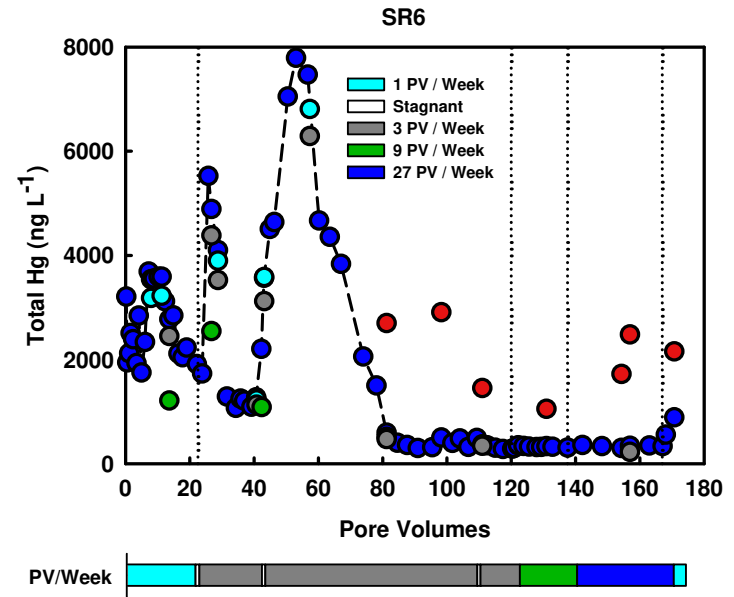
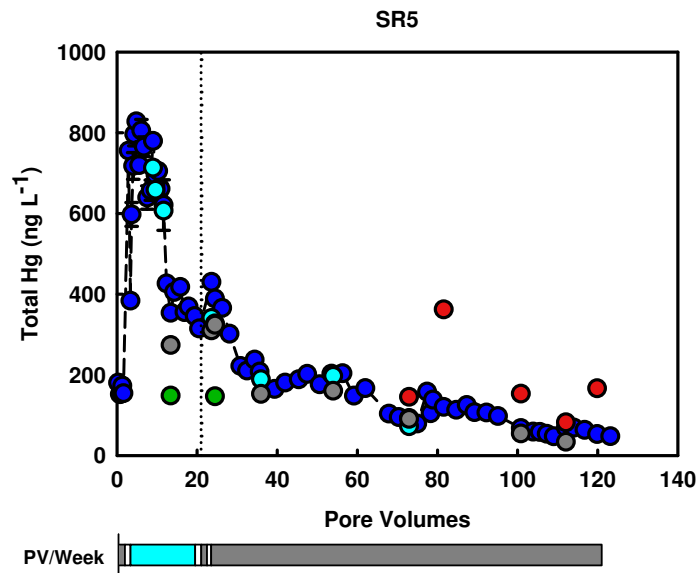
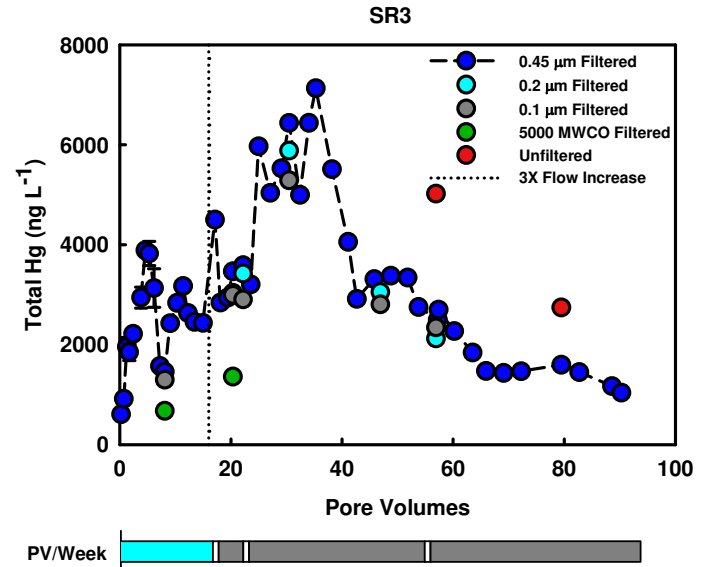
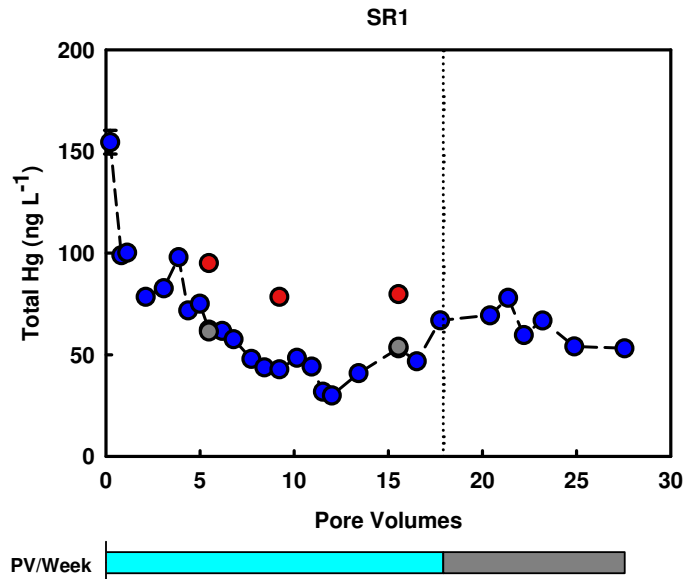
RRM 0.1



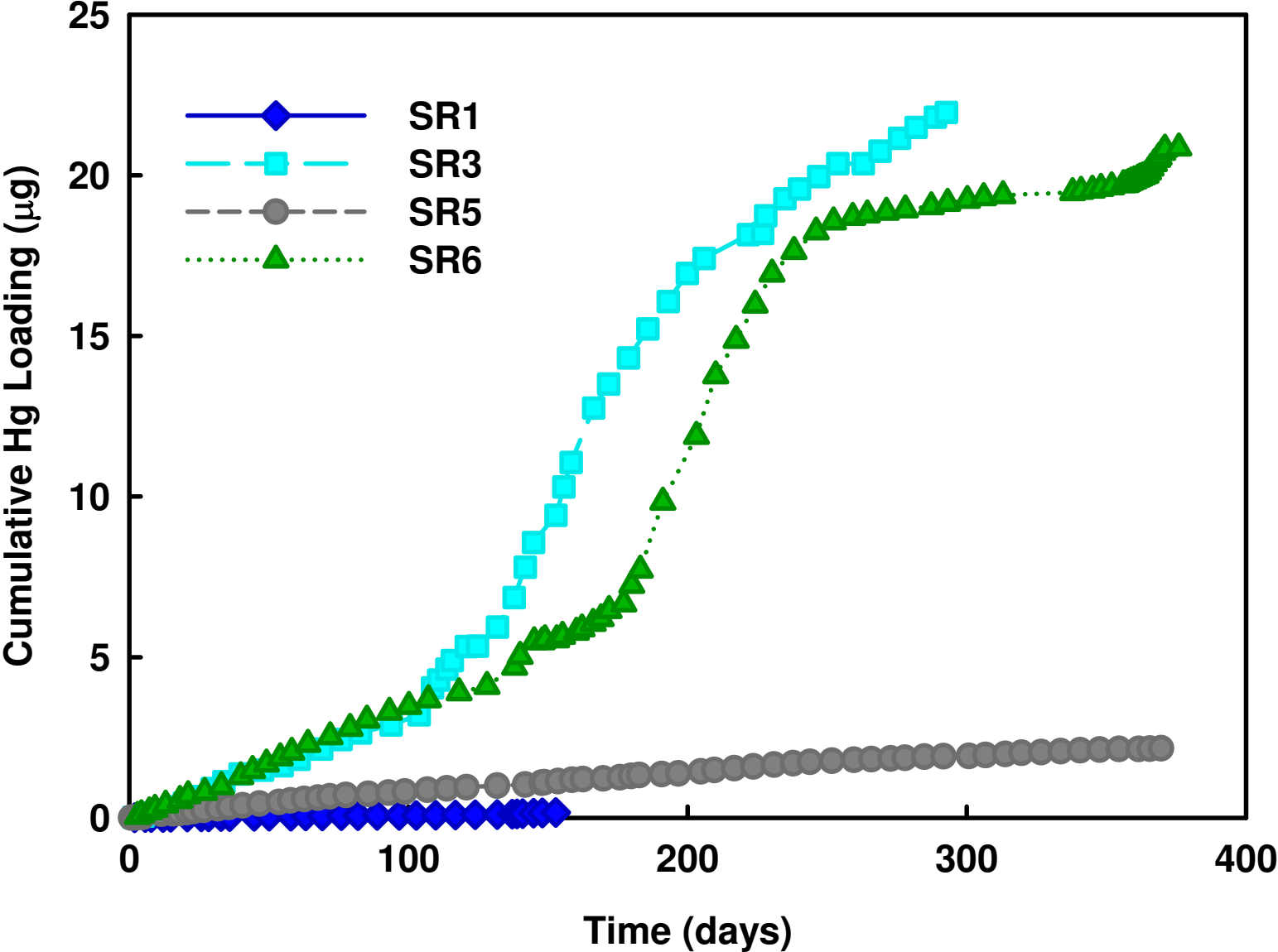
- Hg speciation highly variable in South River bank sediment
- ~2-9% of Hg mass extracted by DI water
- Largest portion extracted by F4 and F5, accounting for 79-93% of total mass

Step	Extractant	Description	Recovered Compounds	mg g ⁻¹						% Extracted					
				SR1	SR2	SR3	SR4	SR5	SR6	SR1	SR2	SR3	SR4	SR5	SR6
F1	DI	Water Soluble	HgCl ₂ , HgSO ₄	3.36	6.13	1.15	1.98	3.16	33.10	8.16	9.33	4.60	2.15	6.98	8.57
F2	0.01M HCl + 0.1M CH ₃ COOH	Stomach Acid	HgO, HgSO ₄	0.75	0.64	3.42	2.11	1.83	11.10	1.82	0.98	13.68	2.29	4.04	2.87
F3	1 M KOH	Organo-complexed	Hg ₂ Cl ₂ , CH ₃ Hg	2.64	2.06	0.60	2.27	0.98	13.00	6.41	3.14	2.41	2.46	2.16	3.37
F4	12 M HNO ₃	Elemental	Hg ₂ Cl ₂ , Hg ⁰	6.93	29.60	11.00	50.10	8.18	18.90	16.82	45.05	44.00	54.40	18.06	4.90
F5	Aqua Regia	Hg Sulfides	HgS, HgSe, HgAu	27.50	27.20	8.83	35.60	31.10	310.00	66.75	41.40	35.32	38.65	68.65	80.29
Total				41.18	65.63	25.00	92.06	45.25	386.10						

Column Tests of RRM 0.1 Bank Soils and Sediment



Cumulative Leached Hg from RRM 0.1 Columns



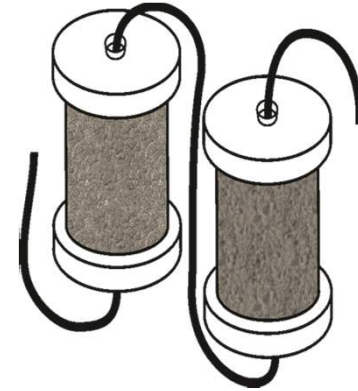
Column Leaching Estimate

- Question:
 - How long will it take for the soluble Hg (F1 fraction) to become depleted at an average flow rate of ~ 2 PV/week?

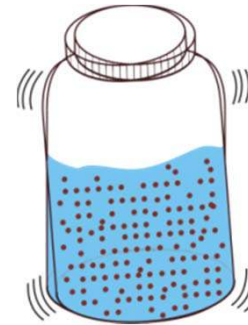
		SR6	SR5	SR3	SR1
Soluble Hg in Column	(μg)	7132	625	265	672
Pore Volumes	#	168.0	114.0	90.0	26
Run Time	(days)	375.0	375.0	290.0	153
Total Hg Flushed to Date	(mg)	20.9	2.16	22.0	1837
Average Rate of Leaching	(ng/PV)	124	19	244	71
	(ng/day)	56	6	76	12
Total Leaching Estimate	PV	57328	32972	1083	9511
	years	351	297	10	153

Banks Soils & Sediment Treatment

- Treatment column connected in series with Hg-leaching sediment column
- 2 week batch reactor experiments



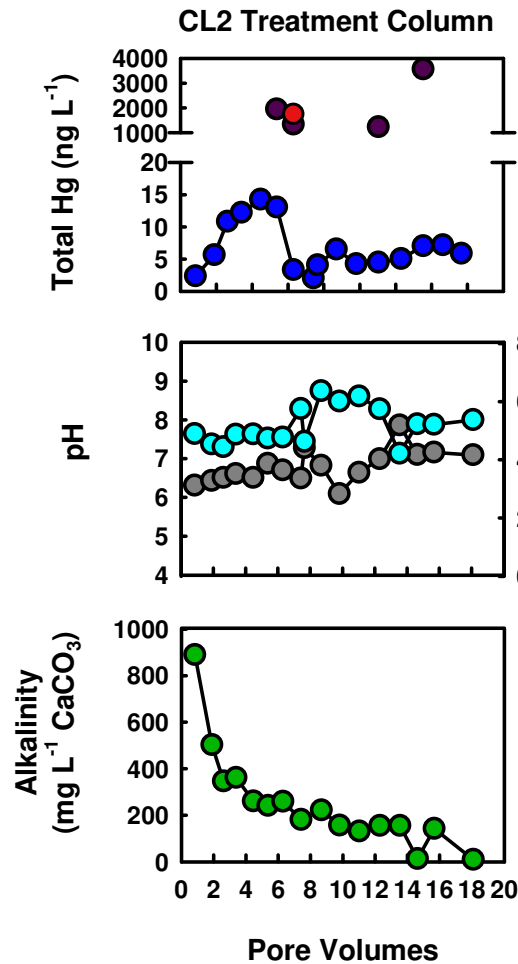
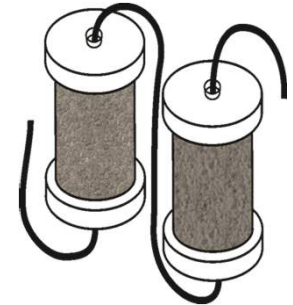
Cowboy Lump Charcoal



Biochars Being Screened

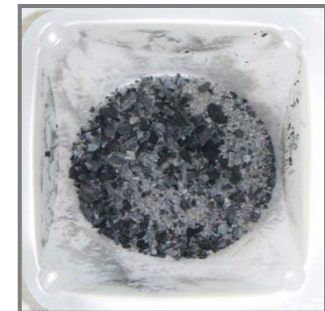
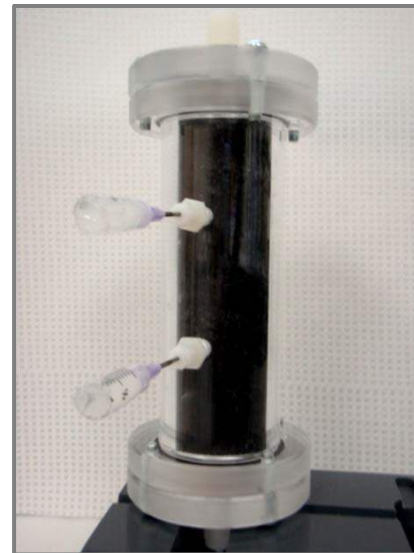
Abbrev.	Name	Charred Temp	Abbrev.	Name	Charred Temp
CA1H	Cocoa Husk	600 °C	GR3H	Iron High Brewery Spent Hops	600 °C
CA1L	Cocoa Husk	300 °C	GR3L	Iron High Brewery Spent Hops	300 °C
CC1H	Pioneer Cobs	600 °C	GR4H	Switchgrass	600 °C
CC1L	Pioneer Cobs	300 °C	GR4L	Switchgrass	300 °C
CC2H	Stinson's Ground Corn Cobs	600 °C	HW1H	Timberline Hardwood Mulch	600 °C
CC2L	Stinson's Ground Corn Cobs	300 °C	HW1L	Timberline Hardwood Mulch	300 °C
CL1	Wicked Good Charcoal	NI	HW2H	Timberline Pine Bark Nuggets	600 °C
CL2	Cowboy Charcoal	NI	HW2L	Timberline Pine Bark Nuggets	300 °C
CL3	Sigma Activated Carbon	NI	MB1H	Hurff's Cow Manure	600 °C
CL4	Sigma Activated Carbon	NI	MB1L	Hurff's Cow Manure	300 °C
CS1H	Hurff's Corn Stovers	600 °C	MP1H	Hurff's Chicken Manure	600 °C
CS1L	Hurff's Corn Stovers	300 °C	MP1L	Hurff's Chicken Manure	300 °C
CS2H	Pioneer Stovers	600 °C	MP2L	Stinson's Chicken Manure	300 °C
CS2L	Pioneer Stovers	300 °C	MP3H	Stinson's Chicken Manure	600 °C
CT1H	Cotton Seed Husk	600 °C	MU1H	Stinson's Spent Mushroom Soil	600 °C
CT1L	Cotton Seed Husk	300 °C	MU1L	Stinson's Spent Mushroom Soil	300 °C
GR1H	Hurff's Hay Mixed Grasses	600 °C	MU1L	Stinson's Spent Mushroom Soil	300 °C
GR1L	Hurff's Hay Mixed Grasses	300 °C	MU2H	Nutrasoils Fresh Mushroom Soil	600 °C
GR2H	Hurff's Straw w/ Wheat Shaft	600 °C	MU2L	Nutrasoils Fresh Compost	300 °C
GR2L	Hurff's Straw w/ Wheat Shaft	300 °C	MU3H	Stinson's Fresh Steamed Mushroom Compost	600 °C

Cowboy Charcoal (CL2) Treatment Column



- 50% by volume CL2 (crushed to < 0.444 cm)
- 50% by volume Ottawa silica sand
- Dry packed into 180 cm³ column
- Flushed w/ CO₂ two hours prior to wetting with SRW
- First saturated w/ SRW, then adjoined to sediment column SR3

- THg Post-treatment 0.45 μm
- THg Pre-treatment 0.45 μm
- THg Pre-treatment Unfiltered
- pH
- Eh (mv)

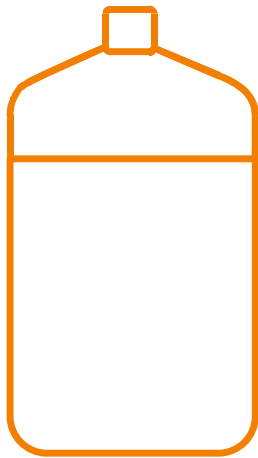


PV / Week

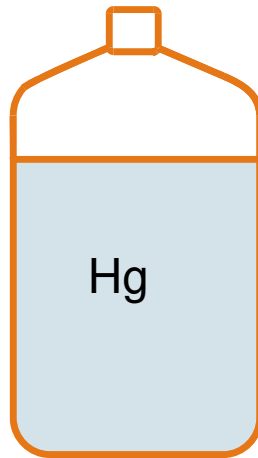
• Occasionally collecting SR3 column effluent for THg, cation, anion, pH, Eh, alkalinity, DOC

Hg-Spiked SRW Batch Biochar Screening Methodology

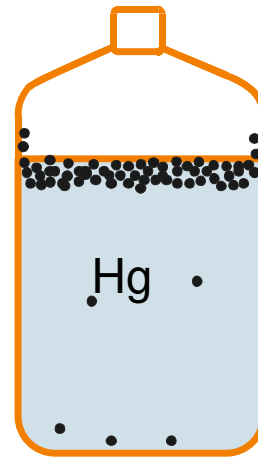
- Spiked Hg Experiments
 - $10 \mu\text{g L}^{-1} \text{HgCl}_2$
 - 2 g biochar
 - 150 ml SRW



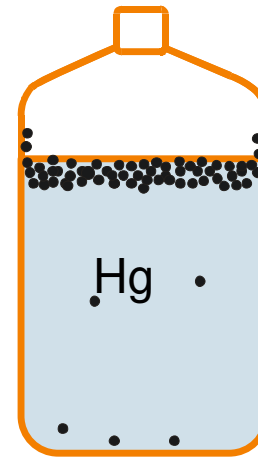
DI



SRW

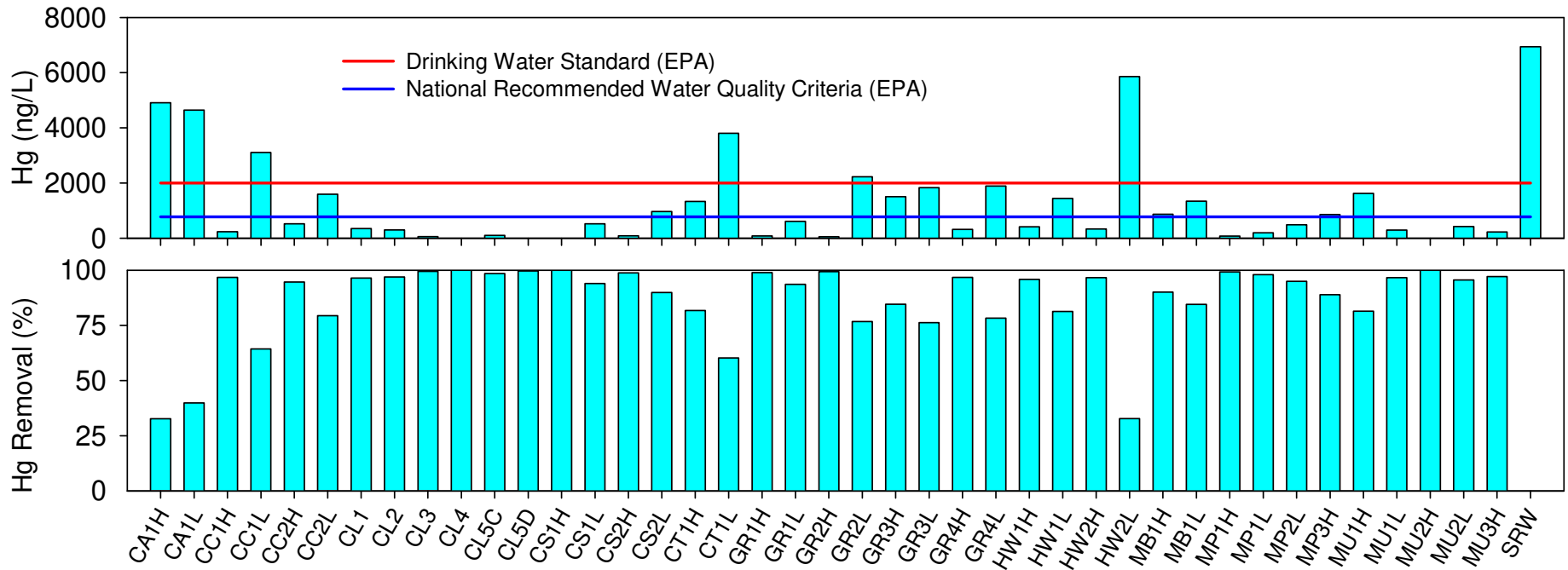


GAC

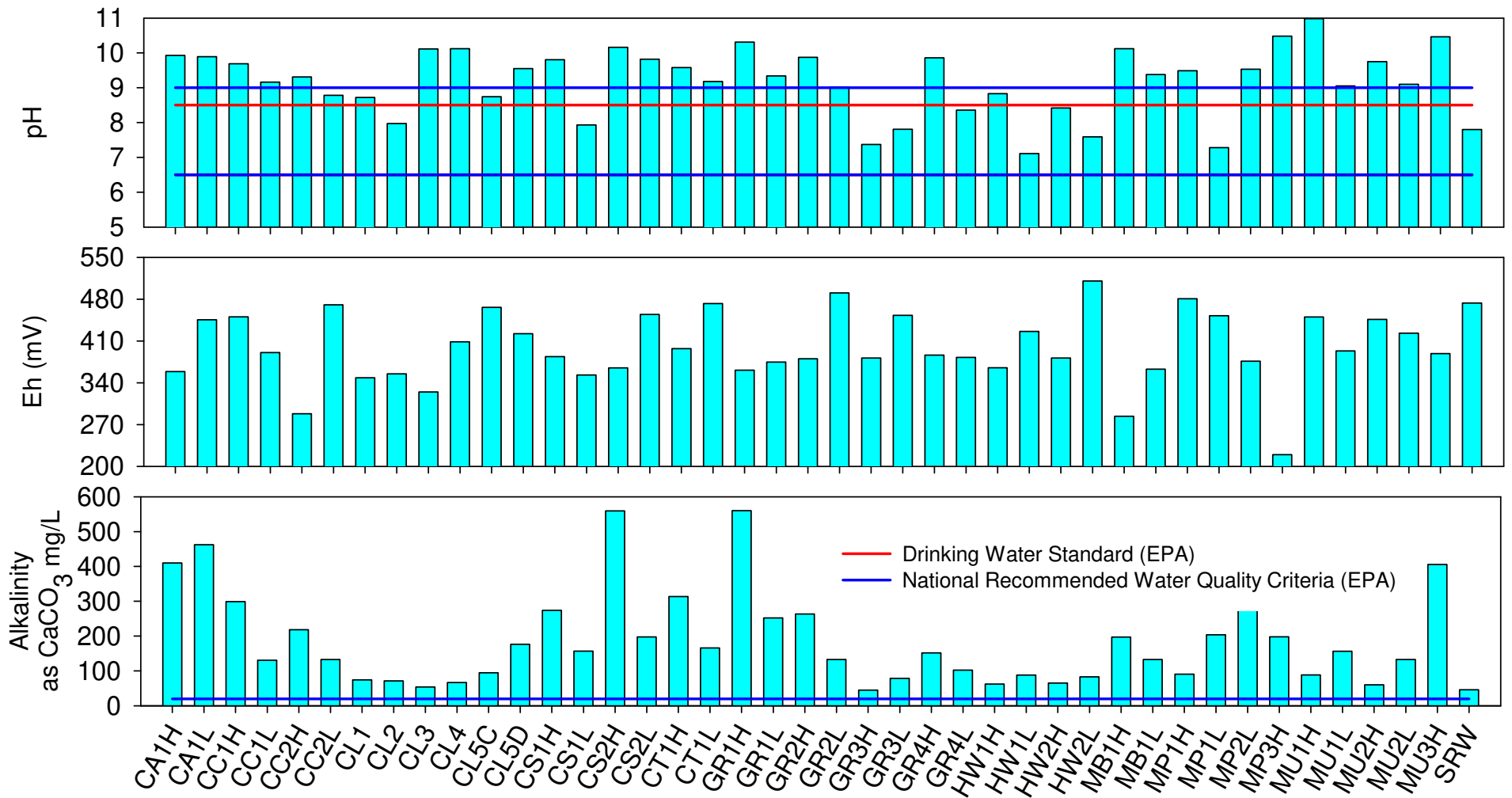


BC (20)

Hg Spiked SRW Batch Screening (THg Removed After 48 hrs)



Hg Spiked SEW Batch Screening (Treatment H₂O Chemistry After 48 hrs)



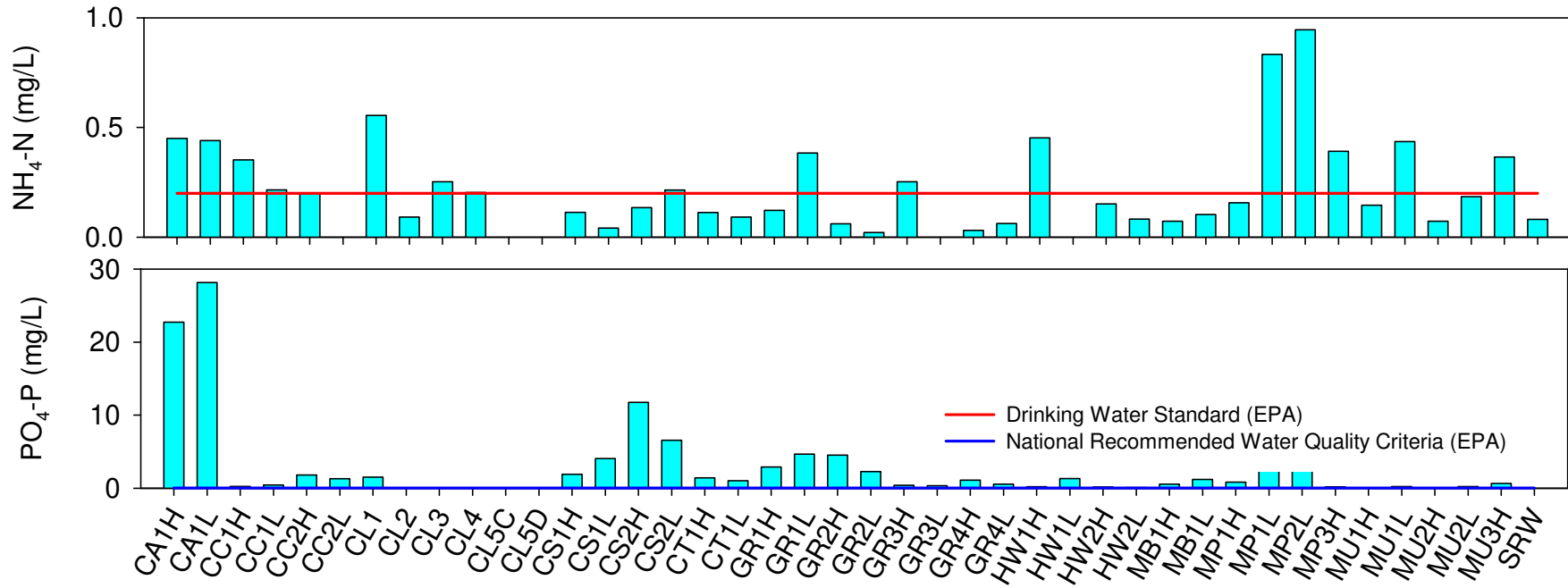
Hg Spiked SRW Batch Screening

(Nutrients After 48 hrs)

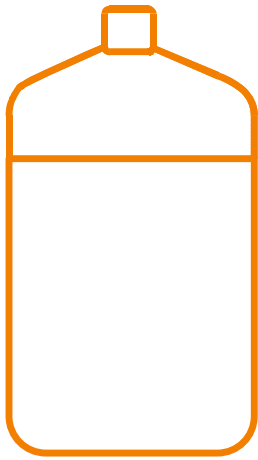


Hg Spiked SEW Batch Screening

(Nutrients Cont'd After 48 hrs)



Soil & Sediment Batch Treatment Methodology

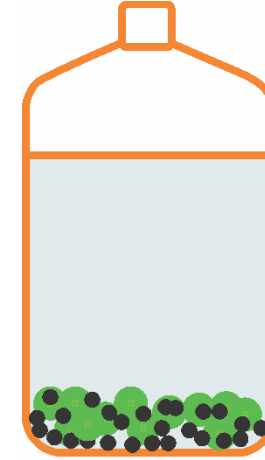


DI



● Sediment

80 mL SRW +
20 g sediment



● BC

● Sediment

2 g BC +
80 mL SRW +
20 g sediment

Soils & Sediment Batch Treatment

- Applied to 2 riverbank sediment samples:

RRM 0.1 **SR4** & SR6

- Wicked Good Charcoal (CL1)
- Cowboy Charcoal (CL2) - and DUST (CL2d)
- Colorado Charcoal (CL5)
- Colorado Charcoal Dust (CL5d)
- GAC

- Variable % Dry Weight Reactive Material

• ~ 0.7%

SR4

• ~ 1.3%

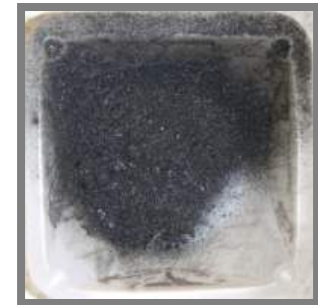
• ~ 2.6%

• ~ 5.0%

SR6

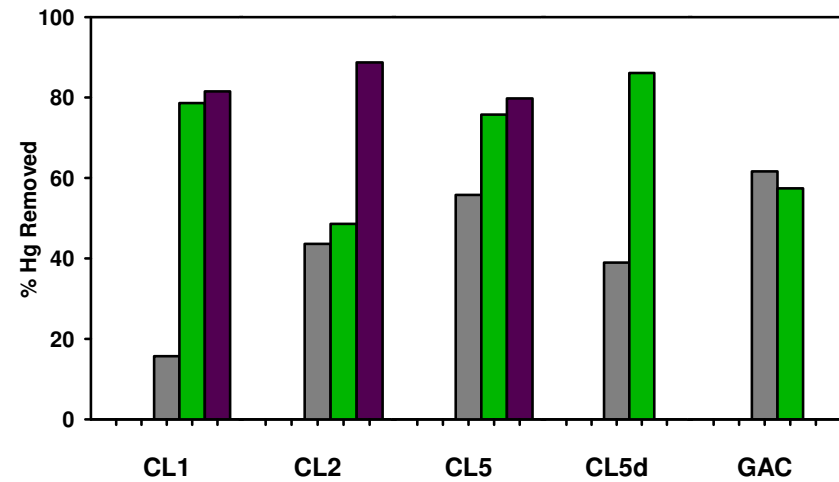
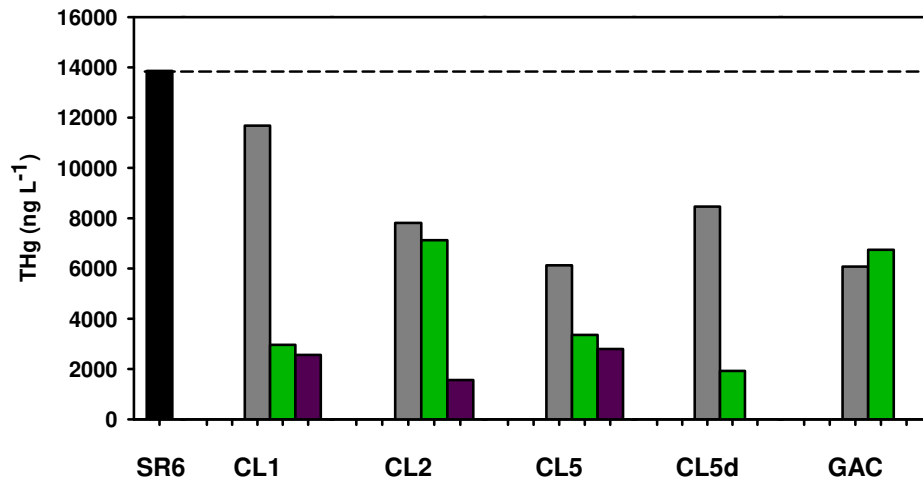
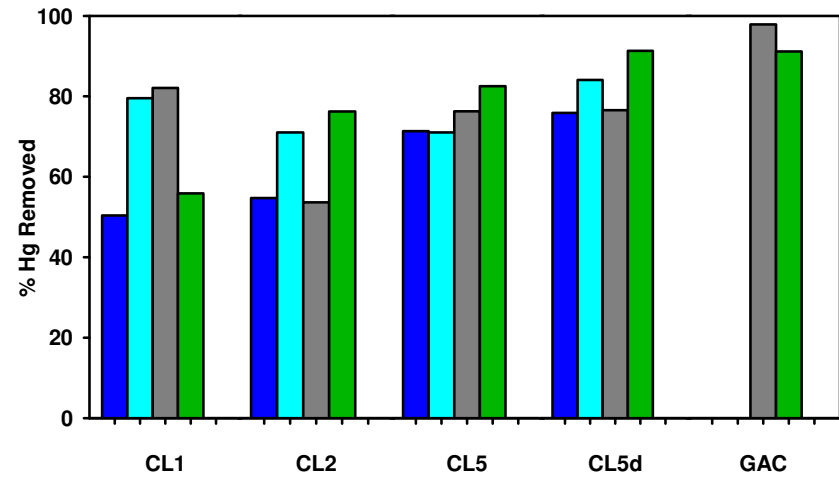
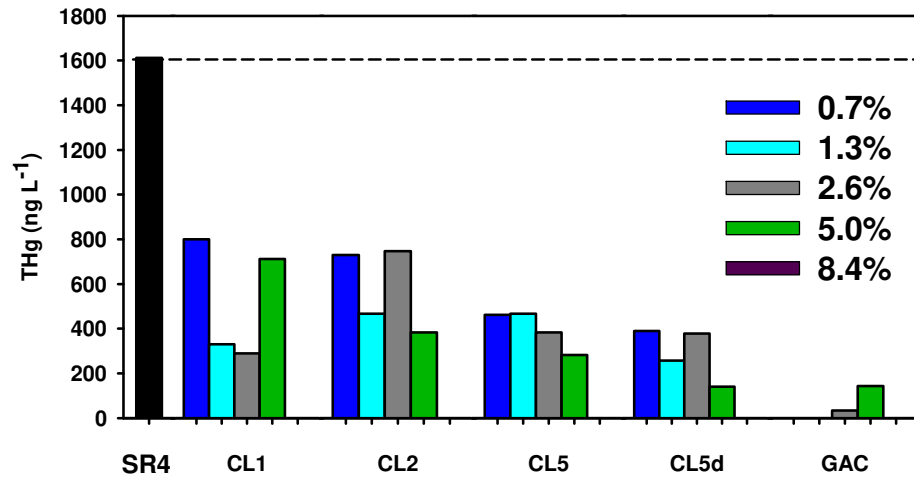
• ~ 8.4%

- Centrifuged & filtered @ 0.45 mm



Soils & Sediment Batch Treatment (%Dry Weight Treatment After 2 weeks)

SR4



SR6

Soils & Sediment Batch Treatment

(%Dry Weight Treatment After 2 weeks)

% Dry Weight Reactive Material										
	0.7%		1.3%		2.6%		5.0%		8.4%	
	THg (ngL ⁻¹)	% Removed	THg (ngL ⁻¹)	% Removed	THg (ngL ⁻¹)	% Removed	THg (ngL ⁻¹)	% Removed	THg (ngL ⁻¹)	% Removed
SR4 Untreated					1612					
CL1	800.0	50	330.0	80	289	82	711.7	56	--	--
CL2	730	55	467	71	747	54	383.4	76	--	--
CL5	462	71	467	71	383	76	282	83	--	--
CL5d	389	76	257	84	378	77	140	91	--	--
GAC	--	--	--	--	34.3	98	143	91	--	--
SR6 Untreated					13900					
CL1	--	--	--	--	11700	16	2960	79	2560	82
CL2	--	--	--	--	7810	44	7125	49	1560	89
CL5	--	--	--	--	613	56	3360	76	2800.0	80
CL5d	--	--	--	--	8460	39	1930	86	--	--
GAC	--	--	--	--	5320	62	5900.0	57	--	--

Wertman's "Cow Pond" Sediment & Floodplain Soil Characterization

Wertman
"Cow Pond" Samples

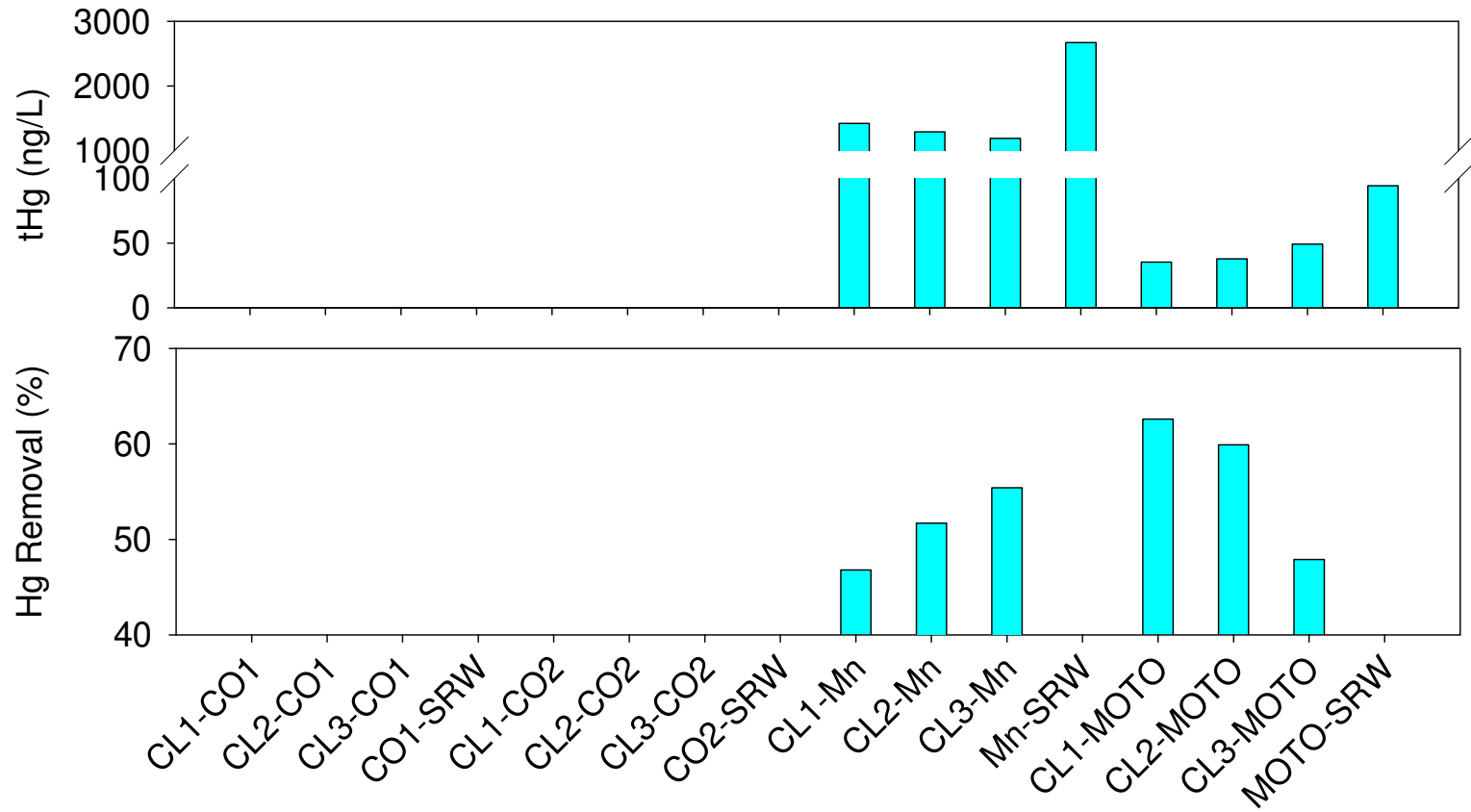


Floodplain
Samples



Sample ID	Hg	Al	As	Ca	Mn	Na	Ni	Pb	P	Cr	Cu	Fe	K	Mg	Sr
ug g ⁻¹ Dry Weight															
MOTO	5.8	4800	1.6	1600	260	6	5.5	5.7	340	11	9.5	17000	890	810	6.5
MN	132	7400	3.4	2900	460	10	10	30	430	48	76	27000	1800	1300	13
CO2	1.4	2100	1.1	550	190	10	4.6	4.6	170	9	11	7000	440	320	3.7

Wertman's "Cow Pond" Sediment & Floodplain Soil Batch Treatability



Questions?

