



A Low-Cost “Green” Remediation Technology for Metals in Shipyard Stormwater and Wastewater

SBIR Topic N06-133 (Phase I + Phase II)

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Green Solutions for a Sustainable Future



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- New low cost and highly efficient adsorbent material -- SIROSORB.
- “Green” technology makes use of a waste product to remove metals and other contaminants from aqueous streams.
- SIROSORB can be incorporated in standard treatment units such as packed bed filters, continuous and batch reactors, etc. depending on treatment objectives and constraints.



SIROSORB



- SIROSORB incorporates a waste by-product of municipal drinking water treatment process
- Primarily amorphous masses of aluminum and iron hydroxides as well as some humic substances and activated carbons
- More than 2 million tons of source material (water treatment by-product) generated each year in US, typically stored in lagoons or disposed in landfills
- Source material can often be obtained for low cost
- SIROSORB can be utilized in a variety of configurations, such as batch reactors, large retention vaults, or smaller units for stormwater manholes
- Current filter based stormwater treatment systems can be retrofitted by replacing their filtering media (or mixing it) with SIROSORB



SIROSORB Advantages



Comparison with Other Approaches			
		Chemical	SIROM
	Sedimentation	Precipitation	SIROSORB
Chromium Removal	High	Very High	Very High
Copper, Lead, Zinc Removal	Varies	Very High	Very High
Organics Removal	Varies	High	Very High
Cost	Low	High	Low

- US Navy shipyards and Private shipyards,
- Commercial developments,
- Metal finishing industries,
- Firing ranges with lead contaminated soil,
- Abandoned mines (AMD treatment and soil reclamation)
- Aircraft engine servicing plants (MRO facilities)





Current Applications

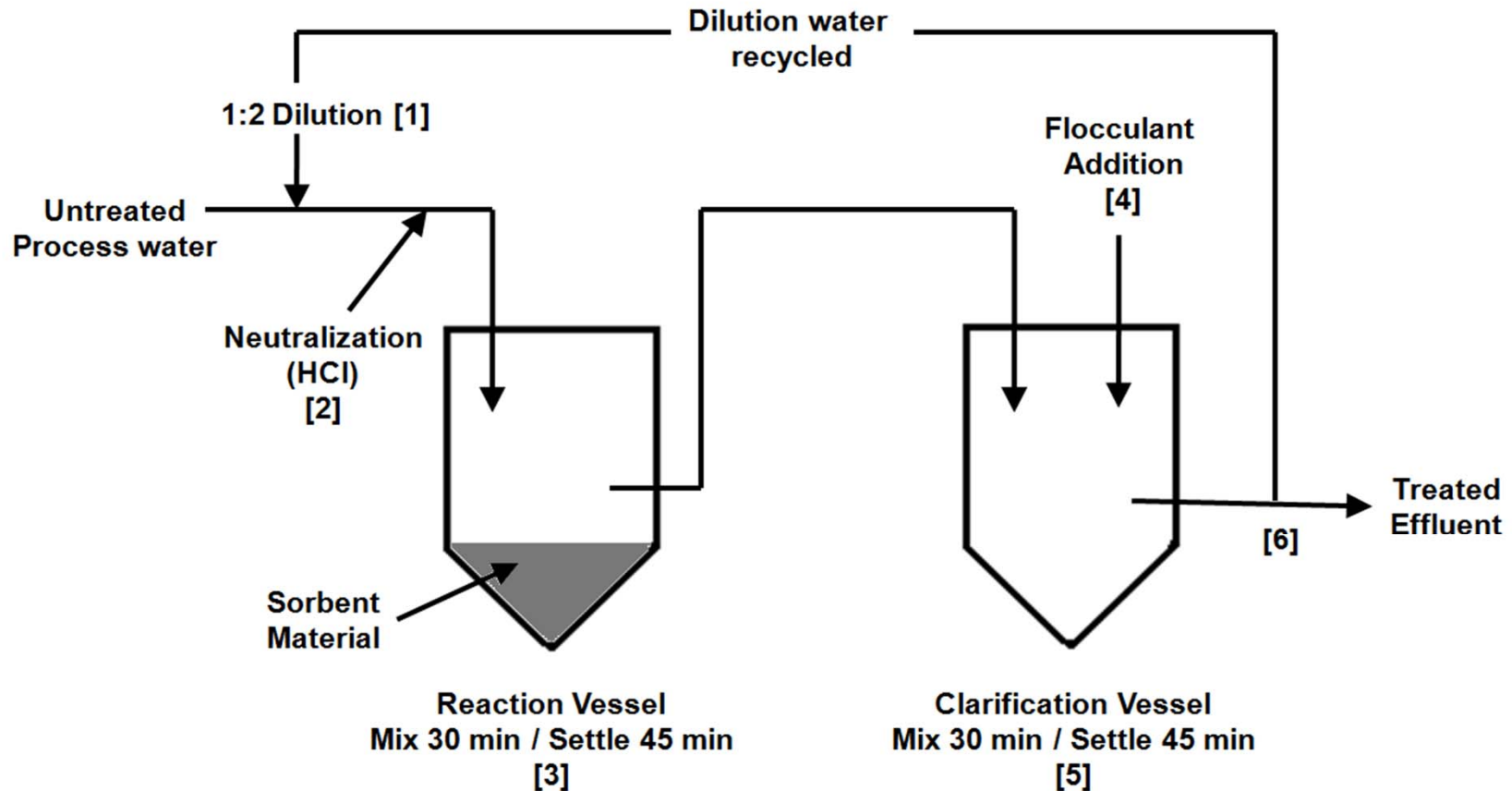


- **Industrial Process water treatment:**
 - Lab study with industrial process water from StandardAero plants in Winnipeg, CA, and Augusta, GA
 - Field-scale prototype demonstration in Augusta
- **Shipyard stormwater treatment:**
 - Lab study with Norfolk BAE stormwater
 - Lab study and onsite pilot study with Hii-Ingalls Pascagoula stormwater



Problems with StandardAero process water:

- 1. Very high pH**
- 2. Surfactants**
- 3. Very high metal concentrations**



2 stage reactor system

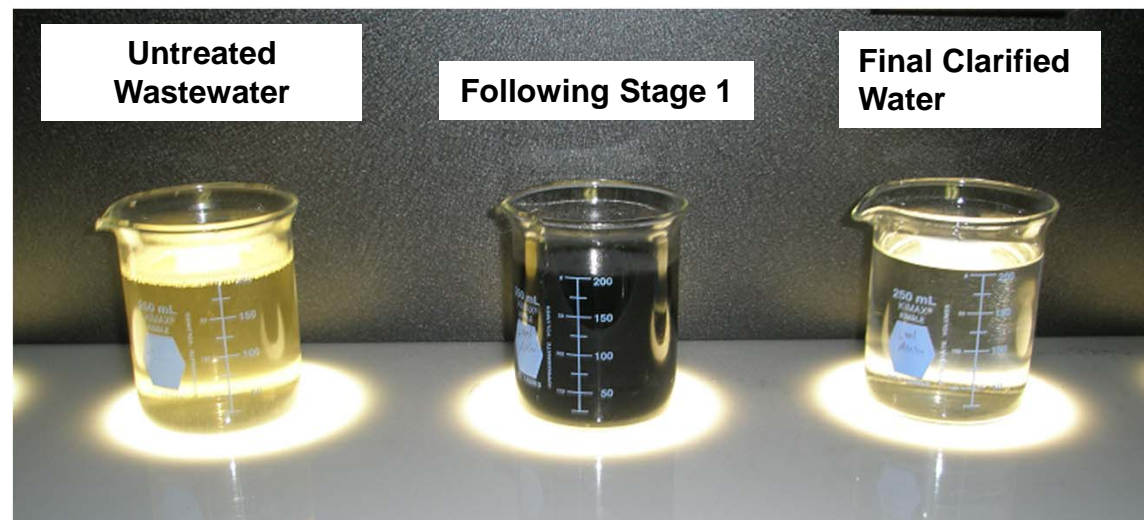
- Neutralization + Sorbent Treatment
- Clarification



Augusta Prototype Demonstration



- **Prototype demo conducted Aug 9 -13 at StandardAero in Augusta, GA (Aircraft maintenance, repair, and overhaul facility).**
- **Hurdles overcome**
 - The high pH of the process water required a neutralization step prior to sorbent treatment
 - Due to the high concentrations of surfactants, sorbent media had to be fortified with additional activated carbon





Concentration of metals in StandardAero process water before and after treatment using SIROSORB

	Total Metals (ppb)									
	Ag	Al	As	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Before	242	11000	23	2260	12800	1890	13500	2210	2820	172
After	<10	<10	<10	<10	<10	120	80	<10	<10	<10



Concentration of metals in Norfolk Shipyard stormwater before and after treatment using SIROSORB

Stormwater characterized by high Cu and Zn concentration that were reduced to below detection level after SIROSORB treatment

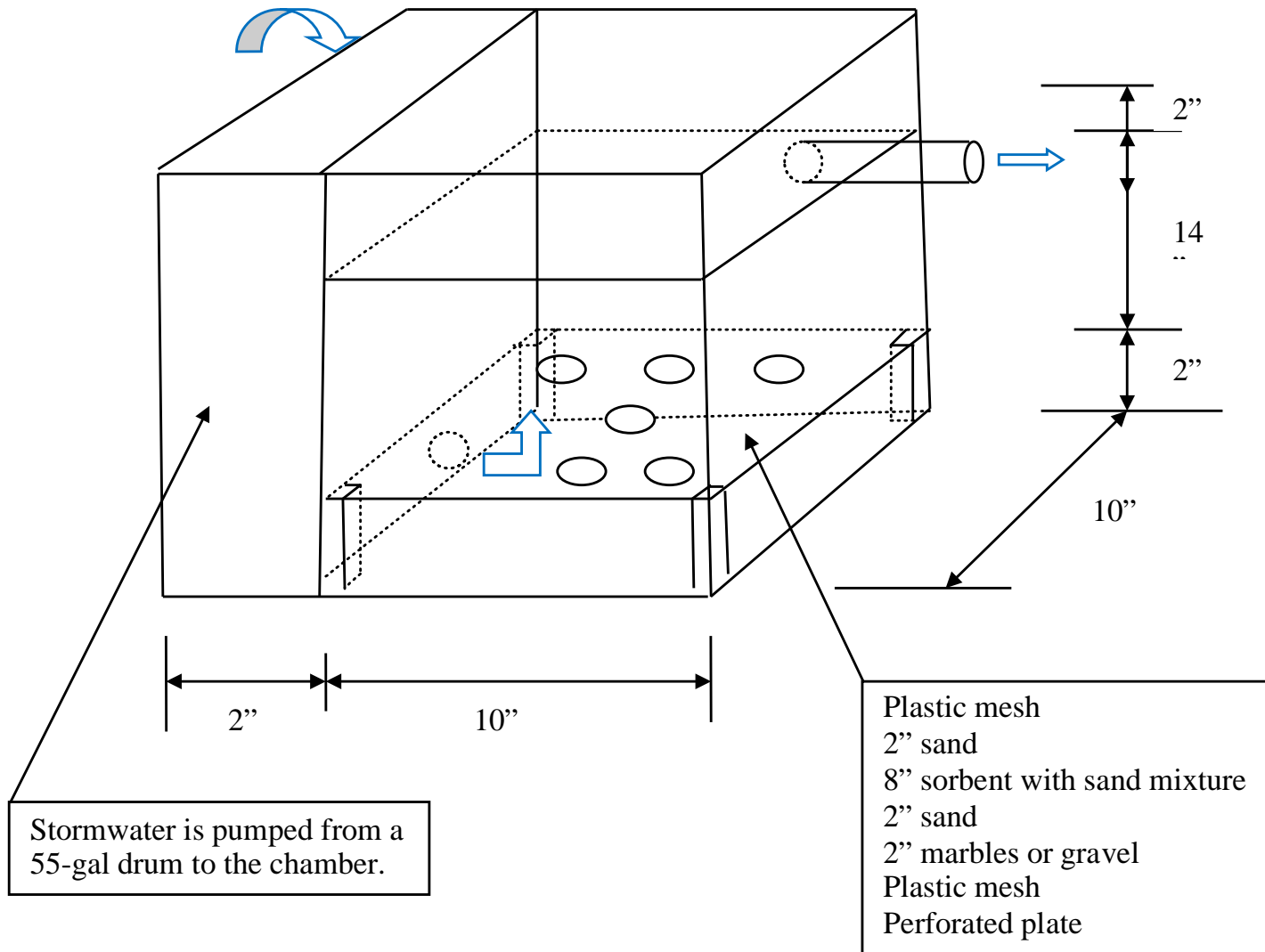
	Total Metals (ppb)									
	Ag	Al	As	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Before	<10	136	30.3	10.2	46.4	1330	8642	77.6	55.8	1913
After	<10	132	<10	<10	<10	16.2	88.5	<10	<10	<10

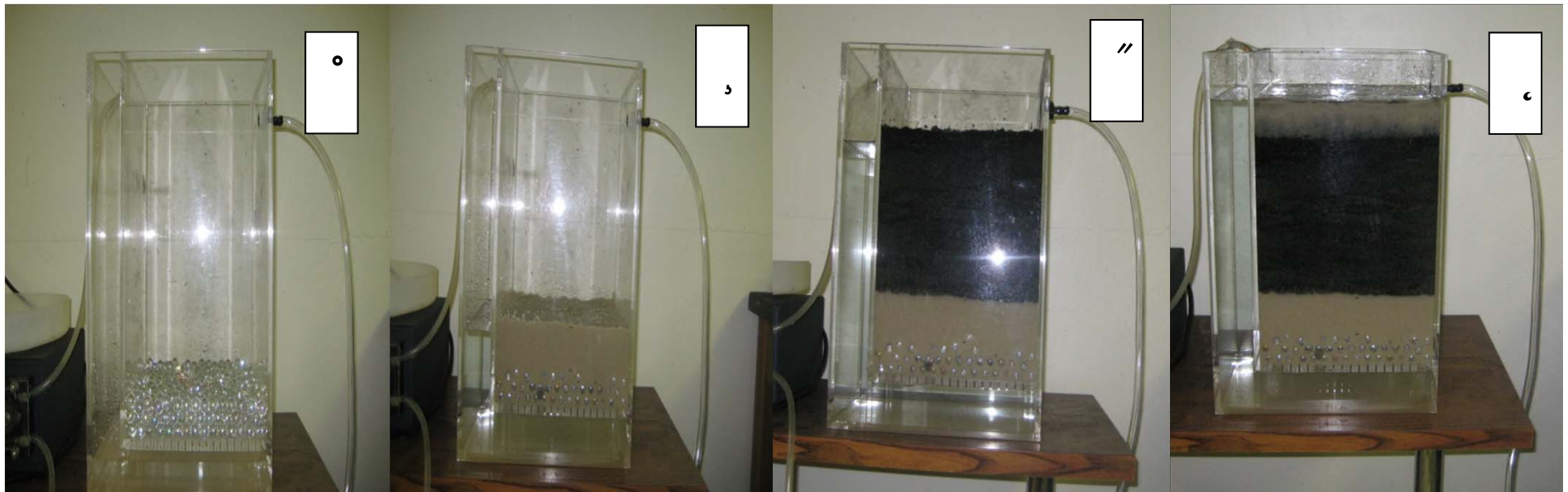


On-site Pilot Study - Pascagoula



- **SIROM is working with the Pascagoula shipyard of Hii-Ingalls to pilot test a small prototype reactor for metal removal of shipyard stormwater.**
- **Currently the shipyard discharges stormwater directly to surface waters without any treatment.**
- **Out of 36 stormwater outfalls, 4 compliance outfalls currently exceed upcoming regulatory limits for copper (34 ppb) and zinc (63 ppb).**





Packing of the reactor in various stages of filter media: marbles (a), marbles and sand(b), marbles, sand and mixture of sand and SIROSORB (c), marbles and sand(b), marbles, sand plus mixture of sand and SIROSORB, and sand (d).

- Sampling device and treatment prototype installed in March 2011.



• Ongoing Study

- First sampling event occurred in the week of March 28, 2011, followed by onsite treatment. Second sampling + treatment in the week of April 18.
- Influent and effluent samples were analyzed for pH, turbidity, and metals. Results demonstrate very high efficiency of the SIROM system in reducing turbidity and metals concentrations, and in maintaining the solution pH.
- Sampling and treatment will continue until total sorbent saturation is obtained for optimization purposes.



Fig. 1a. Stormwater- before (Influent) and after treatment (Effluent).

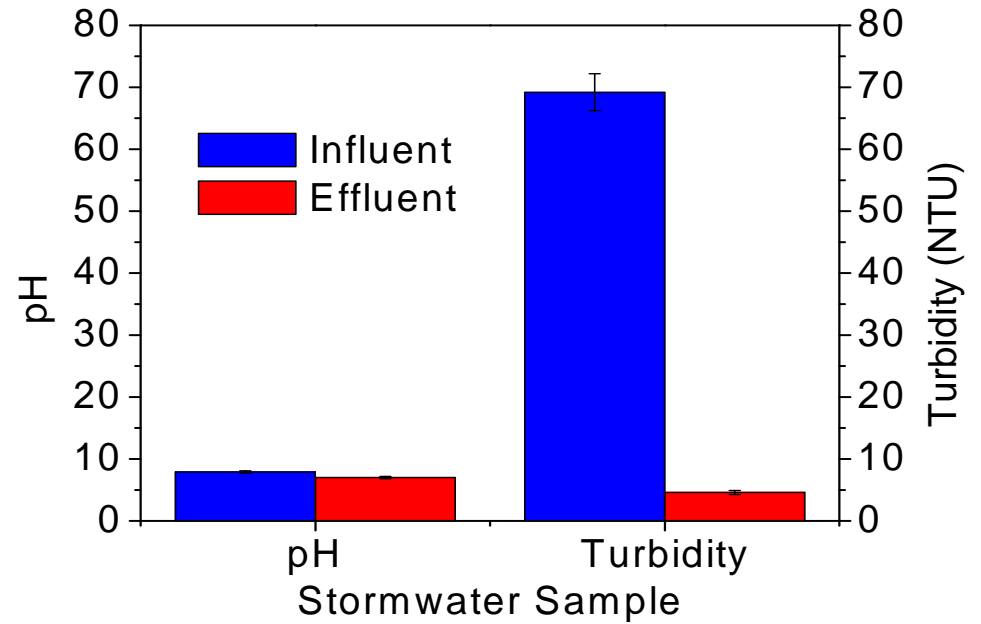


Fig. 1b. Stormwater pH and Turbidity (mean +/- std. dev. of 3 replicate samples)

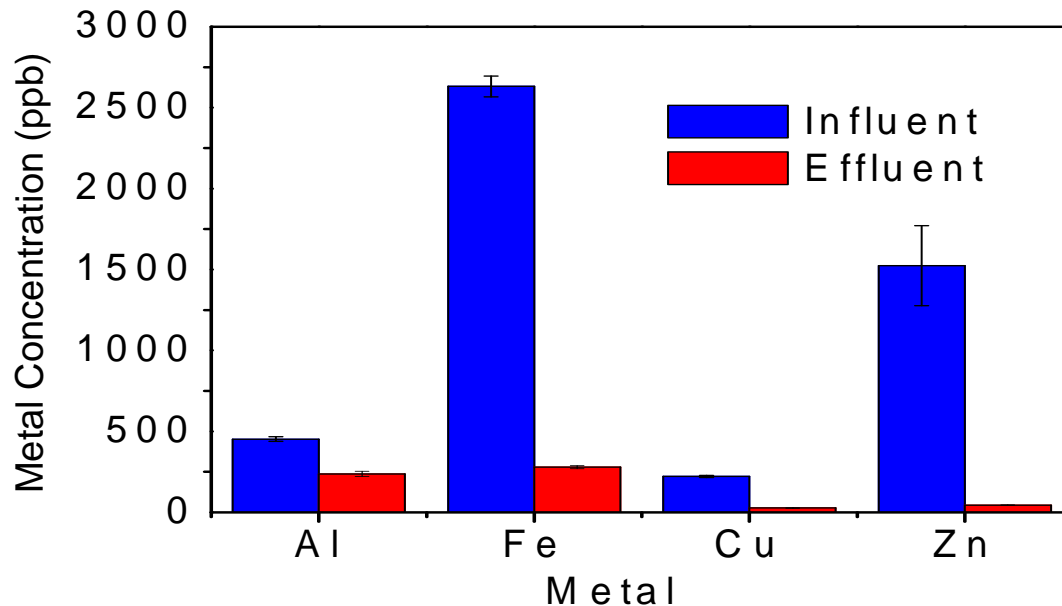


Fig. 2. Concentration of dominant metals in stormwater sample. Bars represent mean +/- std. dev. for 3 replicate samples



Fig. 1. Stormwater- before (Influent) and after treatment (Effluent).

Turbidity (NTU)	Turbidity (NTU)
Influent	Effluent
84.39	6.12
89.92	5.38
86.58	5.84

Table 1. Turbidity values of stormwater influent and effluent samples.

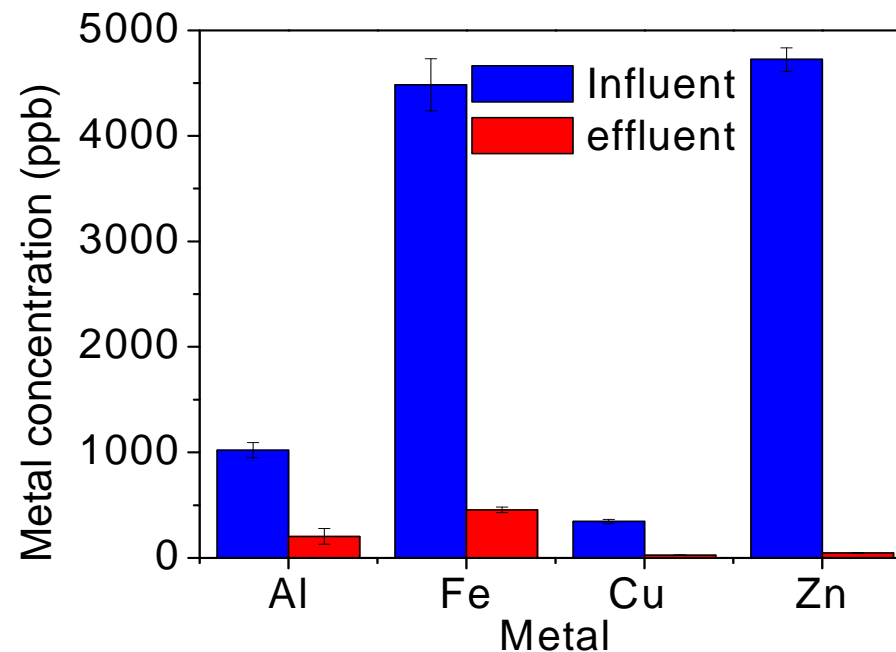


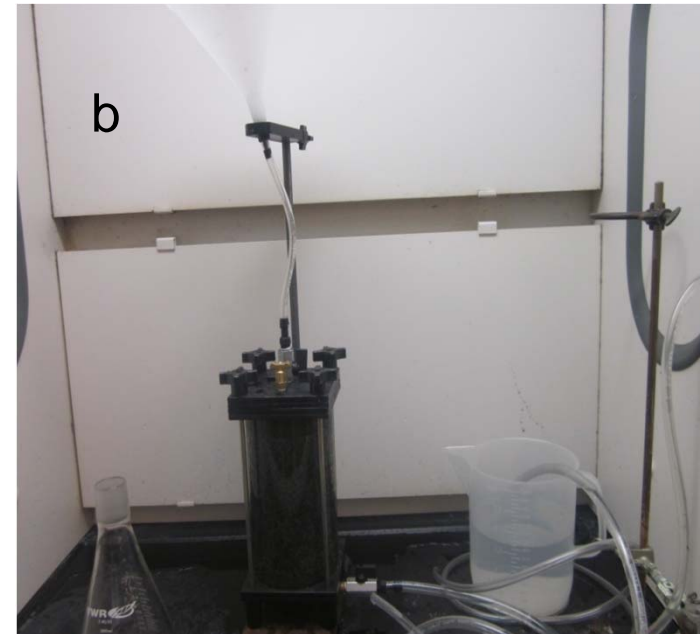
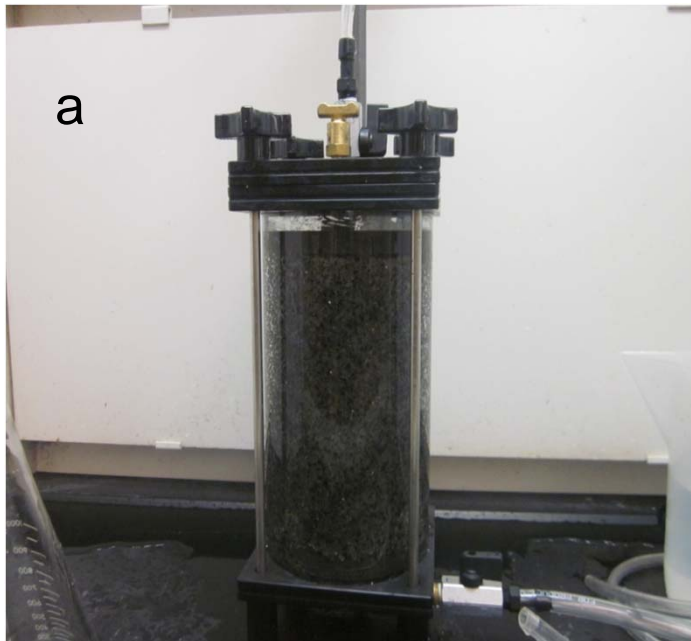
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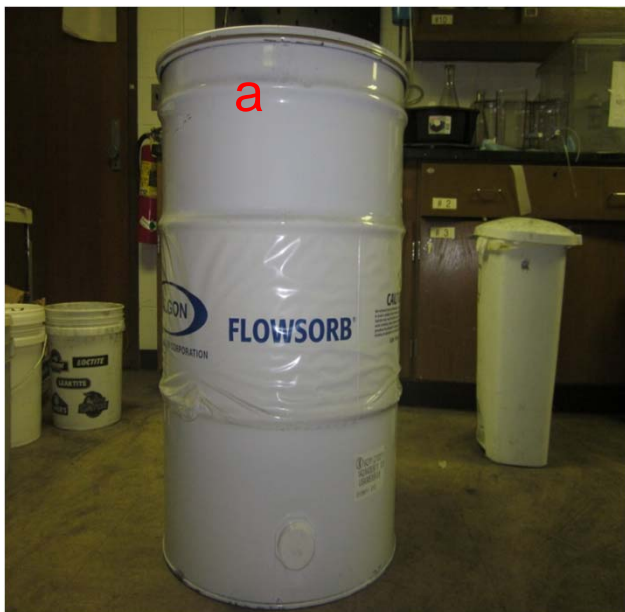
Sorbent Optimization



- **Although the prototype system cleaned the metals and turbidity in the stormwater, flow rate was limited (0.5 - 1 gpm).**
- **To improve the flow rate, SIROSORB was mixed with various ratios of Granular Activated Carbon (GAC) and the mixture was lab tested for flow using a permeameter.**
- **Stormwater metal concentrations were studied with the various ratios of SIROSORB and GAC in the permeameter.**
- **Permeameter flow rates were converted to equivalent of a 55 gallon, commercially-available Flowsorb drums.**



Packed permeameter (a); permeameter setup in the hood (b).



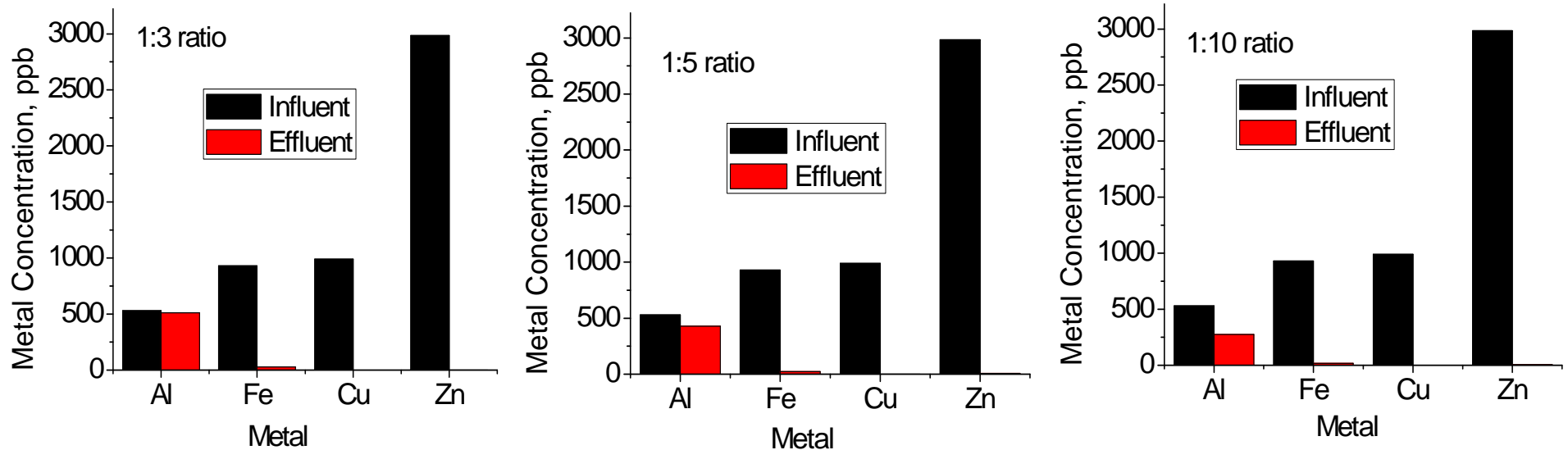
(a) Profile view, (b) inlet, (c) outlet



Sorbent Optimization: Flow Rates



SIROSORB-GAC	Actual flow rate in permeameter (gpm)	Calculated flow rate in Flowsorb (gpm)
GAC alone	0.55	14.51
1:3 ratio	0.32	8.43
1:5 ratio	0.38	9.45
1:10 ratio	0.48	12.44



- ❖ Even the 1:10 ratio of SIROSORB:GAC completely removed the problem metals (Cu, Zn) in the Pascagoula stormwater.
- ❖ Scaled-up technology demonstration has been planned in 2012 at the Pascagoula site.



For more information and complete product literature contact:

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Augusta Demonstration Results



Batch	Ag		Al		As		Cd		Cr	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	205.8	7.91	258.6	837.8	16.6	7.55	603.9	20.35	799.5	7.38
2	215.1	7.33	338.8	1097.7	48.7	4.88	638.5	21.45	696.2	6.52
3	222.0	7.92	337.2	1092.5	47.3	6.06	671.9	24.44	796.3	9.07
4	204.0	9.09	307.8	997.2	64.0	5.76	611.1	19.96	708.9	10.03
5	159.5	5.24	263.1	852.4	50.2	9.20	581.1	22.92	698.8	10.76
6	205.3	4.11	367.2	1189.7	27.1	6.07	578.3	19.94	757.4	7.35
7	207.2	7.61	290.5	941.2	15.5	4.86	633.8	17.97	709.7	10.91
8	171.8	7.16	204.3	761.9	74.4	4.70	612.2	23.82	711.6	7.28
9	184.6	5.65	209.9	680.0	36.4	6.10	615.5	17.51	767.1	8.40
10	198.1	8.97	289.1	936.6	54.5	8.68	631.1	24.04	761.4	10.36

Batch	Cu		Fe		Ni		Pb		Zn	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	1807.0	10.37	2435.6	226.0	2979.0	3.59	1715.8	10.77	755.3	3.66
2	1934.1	10.62	2443.2	242.8	2964.0	10.52	1799.8	11.72	675.6	6.00
3	1907.8	8.79	2424.2	250.9	2915.3	13.08	1621.4	5.77	721.8	7.05
4	1835.5	28.14	2482.1	245.0	2888.6	3.87	1710.1	3.65	682.0	6.79
5	1840.0	9.84	2447.1	254.8	2813.0	3.13	1769.7	10.16	715.7	13.94
6	1812.6	9.88	2279.6	268.2	2998.6	11.02	1656.8	3.22	748.2	5.36
7	1971.9	19.03	2210.2	357.8	2812.0	7.33	1718.2	6.87	722.7	29.61
8	2018.5	46.59	2436.8	327.8	2988.7	5.33	1741.5	13.91	747.9	31.59
9	1934.9	77.05	2317.9	342.9	2868.4	11.46	1674.5	3.02	722.6	43.91
10	1984.8	58.79	2208.6	356.3	2839.6	7.77	1745.5	5.12	764.0	26.02



Concentration of metals in Pascagoula Shipyard stormwater before and after treatment using SIROSORB

Stormwater characterized by high Cu and Zn concentration that were reduced to below detection level after SIROSORB treatment

	Total Metals (ppb)									
	Ag	Al	As	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Before	14.90	12.49	<5	<5	<5	28.90	23.75	<5	<5	190.8
After	14.92	41.32	<5	<5	<5	<5	<5	<5	<5	<5



Stormwater System



- The standard in stormwater treatment is a cartridge system packed with sorbent media. These commercially available systems can be easily modified to use SIROM as its reactive media.
- Sorbent material had to be reoptimized since the small particle size distribution of sorbent media would cause compaction and channeling issues which would inhibit flow through the system.
- Optimized sorbent accounted for increased permeability by mixing with sand and/or GAC.