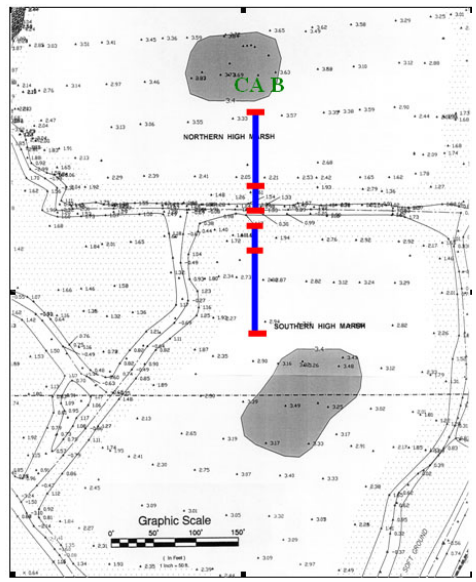
Secaucus High School Wetland Soil Study
Interim Progress Report – March 2009

Problem statement:
The enhancement of the SHS wetland included the construction of two high-marsh locations (elevation 3.0 – 3.5 ft) along the eastern side of the site totaling approximately eight acres. The northeast high marsh has an inner core of marine dredge material from off the New Jersey coast, an approximately 6” deep middle layer of freshwater pond dredge and a 6” cap of I-11 sand. The southeast high marsh has a core material of freshwater pond dredge and a six-inch cap of a 5:1 mix of sand to leaf compost. The imported material was emplaced on the surface remaining after removal of the phragmites saturated rhizosphere. The different layers of materials taper in thickness towards the periphery of the high marsh.

Objectives:
This study is designed to document the accumulation of contaminants in clean wetland soils in an engineered high marsh.



Study Design: Sampling occurred October 31, 2007 and June 27, 2008 along a transect connecting the highest elevation in each marsh. The transect was positioned perpendicular to the ditch separating the marshes. Samples were taken in six locations: at the 3.5 foot contour, at the three foot contour interval and at the two foot contour in each marsh. Elevations were determined by the vegetation that was planted; which in turn was chosen to reflect the tidal regime. These elevations correspond to the spring high water level, mean high water level and low marsh respectively. At each location, three replicate samples were taken at the surface and at depth.

High Marsh	Southeast						Northeast					
Contour Elevation (feet)	3.5		3.0		2.0		3.5		3.0		2.0	
Depth (inches)	0-10	>10	0-10	>10	0-10	>10	0-10	>10	0-10	>10	0-10	>10

In order to determine the contaminant load of the Hackensack River to the engineered marsh soils, water samples were collected from the ditch adjacent to the high marshes at the time of each sampling event.

During the first sampling, tidal access to the site was restricted. At the time of the second sampling, the site was open to the tides. Additional data collection will be necessary in order to discern variability and trends between sampling events. Only then can the contribution from the river be determined.

Results

Water

Parameter	Units	10/31/2007	6/27/2008
Cadmium	ug/L	0.566	0.777
Chromium	ug/L	47.7	17.5
Copper	ug/L	17.6	19.8
Iron	ug/L	2812	1883
Lead	ug/L	23.6	19.9
Nickel	ug/L	42.3	11.2
Zinc	ug/L	101	98.6
Fecal Coliforms	MPN/100ml	245	590
COD	mg/L	74.5	106
NH 4	mg/L	0.952	2.31
Nitrate	mg/L	4.74	0.61
TSS	mg/L	96.8	20.8
Temperature	^{o}C	15.5	33.7
Conductivity	mS/cm	14.2	12.3
Salinity	ppt	8.25	6.95
Chloride	mg/L	4639	3256
Sulfate	mg/L	586	480
pH	SU	7.21	7.83
DO	mg/L	4.87	2.30
DO%	% sat	51.6	34.0

Soil Results (Metals: mg/kg; Organics: ug/kg)

Each metal value is the average of 3 replicates; total PCBs and Pesticides (OCPs) values represent one analysis.

Sample Nomenclature: High Marsh [Northeast/Southeast] Elevation [3.5/3.0/2.0] Depth [Shallow/Deep]

Sampled October 31, 2007											
Sample Name	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn	PCBs	OCPs
Average	**2.21**	**240**	**80.8**	**14886**	**4.21**	**531**	**44.0**	**132**	**183**	**184**	**31.7**
Std Dev	2.23	428	87.8	13122	6.70	1374	53.5	122	201	258	27.5
N 3.5 S	1.11	23.6	32.0	6550	0.30	94.1	15.2	79.4	72.3	1.29	7.33
N 3.5 D	1.09	17.3	33.3	8570	0.17	98.8	11.9	106	95.1	87.1	62.0
N 3.0 S	0.60	10.4	3.26	4102	0.07	30.8	3.62	5.96	12.0	0.75	0.38
N 3.0 D	2.47	166	101	16953	3.61	2951	105	240	267	129	39.2
N 2.0 S	5.37	383	198	31455	8.72	575	81.4	280	287	494	44.8
N 2.0 D	5.70	1385	252	24955	20.1	504	110	326	499	839	61.2
S 3.5 S	0.53	7.45	3.74	5106	0.08	51.8	3.17	7.27	14.6	1.57	1.00
S 3.5 D	1.41	28.8	52.3	11088	0.30	174	18.2	180	150	39.4	25.8
S 3.0 S	0.50	4.34	3.54	3694	0.32	37.0	2.06	6.51	13.7	4.43	1.55
S 3.0 D	0.87	55.6	30.4	8355	0.61	217	18.1	69.3	59.2	43.0	83.3
S 2.0 S	5.36	520	154	31856	6.94	1137	91.9	173	498	267	19.6
S 2.0 D	1.48	280	106	25942	2.63	500	67.6	117	232	299	34.1
Sampled June 27,2008											
Sample Name	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn	PCBs	OCPs
Average	**1.81**	**207**	**74.8**	**16917**	**2.18**	**804**	**47.6**	**128**	**218**	**154**	**29.9**
Std Dev	1.61	399	70.3	11140	2.43	1914	46.2	100	209	157	23.4
N 3.5 S	0.10	13.4	2.27	5697	0.87	31.7	5.32	7.59	13.1	11.6	4.45
N 3.5 D	1.85	29.1	55.7	13313	1.53	171	20.7	175	197	75.0	43.9
N 3.0 S	0.26	6.98	1.93	4692	1.51	28.1	3.88	6.36	13.1	6.72	2.76
N 3.0 D	1.75	155	69.2	17986	1.51	1991	57.6	192	287	138	68.2
N 2.0 S	4.40	981	221	32124	6.40	716	104	303	539	483	63.1
N 2.0 D	3.72	633	168	28765	3.41	616	109	225	517	240	56.9
S 3.5 S	0.65	18.3	35.6	8995	1.52	93.8	11.0	66.7	85.3	46.1	20.2
S 3.5 D	1.27	31.4	44.9	11902	1.16	167	19.2	145	160	72.5	28.7
S 3.0 S	0.13	11.3	4.61	6191	0.92	124	6.15	11.6	23.6	11.2	2.62
S 3.0 D	1.54	149	99.5	18449	3.16	1316	67.0	130	200	104	15.7
S 2.0 S	3.08	233	101	24141	2.05	3804	78.9	147	259	364	32.2
S 2.0 D	2.98	225	93.8	30755	2.05	594	88.9	122	320	300	20.4

Summary of the Results

In addition to the compilation of the summary statistics for each variable, the entire data set was analyzed to estimate the effect of each variable - elevation, marsh, depth, and time period – by fitting a generalized linear regression model. Indicator variables were used in the regression model to estimate the effects of different levels of these variables. The statistically significant results at the 5% level (i.e., $p < 0.05$) are indicated below.

1. There is a consistent difference in contaminants between soil samples collected at 3 elevations on the constructed high marsh. With one exception (Mn in October), elevation 2.0 yields the highest results. For most constituents, elevation 3.0 is higher then elevation 3.5; the exceptions are Pb in October and Pb, Cd and OCPs in June. Statistical analysis confirms that elevation 3.0/3.5 has statistically significantly lower concentration than elevation 2.0 for all metals except Mn as well as for PCB. Each tabulated metal value is the average of 12 samples; PCBs and OCPs values are derived from 4 samples.

Parameter	Sample Date					
	October 31, 2007			June 27, 2008		
	Elevation					
	2.0	3.0	3.5	2.0	3.0	3.5
Cd	4.48	1.11	1.03	3.55	0.92	0.97
Cr	642	59.2	19.3	518	80.3	23.0
Cu	177	34.7	30.3	146	43.8	34.6
Fe	28552	8276	7829	28946	11829	9977
Hg	9.60	1.63	0.22	3.48	1.78	1.27
Mn	679	809	105	1433	865	116
Ni	87.8	32.2	12.1	95.2	33.7	14.1
Pb	224	80.3	93.1	199	85.1	98.6
Zn	379	88.1	82.9	409	131	114
PCBs	475	44.3	32.3	347	64.8	51.3
OCPs	39.9	31.1	24.0	43.1	22.3	24.3

2. The concentration measurement at the surface of the engineered soil (0-10 inches in depth) is lower than that at horizon below (>10 inches) for all metals during October '07. Concentrations are enriched in the deep layer relative to the surface; exceptions are Cr and Hg in June. However, this effect was statistically significant ($p < 0.05$) only for Cd. Each tabulated metal value is the average of 18 samples; PCBs and OCPs values are derived from 6 samples.

Parameter	Sample Date					
	October 31, 2007			June 27, 2008		
	Surface	Deep	Difference	Surface	Deep	Difference
Cd	2.13	2.32	8%	1.44	2.18	52%
Cr	203	273	26%	211	204	-3%
Cu	69.8	92.6	25%	61.0	88.5	45%
Fe	11848	18030	34%	13640	20195	48%
Hg	4.38	4.59	5%	2.21	2.14	-3%
Mn	261	800	67%	800	809	1%
Ni	37.0	50.9	27%	34.9	60.4	73%
Pb	99.4	165	40%	90.3	165	83%
Zn	153	214	29%	156	280	80%
PCBs	128	239	46%	154	155	1%
OCPs	12.4	50.9	76%	20.9	39.0	46%

3. The concentrations measured at the southeast marsh are lower than at the northeast marsh, with the exception of Mn in June. The statistical significance of this effect ($p < 0.05$) was found for all metals except Fe, Mn and Ni. Each tabulated metal value is the average of 18 samples; PCBs and OCPs values are derived from 6 samples.

Parameter	Sample Date					
	October 31, 2007			June 27, 2008		
	Northeast	Southeast	Difference	Northeast	Southeast	Difference
Cd	2.75	1.70	62%	2.01	1.61	20%
Cr	327	149	119%	303	111	63%
Cu	105	57.9	80%	86.3	63.2	27%
Fe	15470	14408	7%	17096	16739	2%
Hg	6.68	2.30	190%	2.54	1.81	29%
Mn	708	352	101%	592	1016	-72%
Ni	54.6	33.4	63%	50.1	45.2	10%
Pb	173	91.6	89%	152	104	32%
Zn	205	161	27%	261	175	33%
PCBs	259	109	58%	159	150	6%
OCPs	35.8	27.6	23%	39.9	20.0	50%

4. There is no clear difference in concentrations between the two time periods for 8 metals, PCBs and OCPs. The only statistically significant ($p < 0.05$) change (reduction) was for Hg. Each tabulated metal value is the average of 36 samples; PCBs and OCPs values are derived from 12 samples.

Parameter	Sample Date		Change
	10/31/2007	6/27/2008	
Cd	2.21	1.81	-18%
Cr	240	207	-14%
Cu	80.8	74.8	-7%
Fe	14886	16917	14%
Hg	4.21	2.18	-48%
Mn	531	804	52%
Ni	44.0	47.6	8%
Pb	132	128	-4%
Zn	183	218	19%
PCBs	184	154	-16%
OCPs	31.7	29.9	-6%

Discussion

During construction, the surface soils were removed to eradicate phragmites rhizomes and to achieve engineered elevations. This left a substrate that contained a reservoir of metals and organic pollutants that represent a legacy of the industrial uses of the lower Hackensack River. The porous nature of the clean sand that was deposited during construction is unlikely to stop the metals from migrating upward into the developing soil profile. The first hypothesis confirms that the cover material is clean relative to the base.

The second question addresses the differences between the concentrations found at the surface and in the material below. As time elapses we anticipate documenting the development of distinct horizons as the imported material matures into a wetland soil. Present concentrations do not reveal a significant difference between horizons, with the exception of cadmium (higher in the subsurface).

The two engineered high marshes differ in their composition: the northeast marsh contains marine dredge material, while the southeast marsh does not. For most of the constituents measured, the northeast marsh contains significantly higher concentrations. The southeast marsh is amended with leaf compost; we expect to be able to record whether this additional organic matter effects the distribution of contaminants as time elapses.

The two sampling events, separated by the opening of the site to the tides, did not exhibit a significant difference in contaminant concentrations. The one exception was mercury which diminished. We expect there will be changes within the soil profile as the site is exposed to tidal river water. But this effect is not yet discernable.

Anticipated sampling this spring should yield additional information that will illuminate trends that were anticipated in the study thus far.