Secaucus High School Marsh Sediment Study

April 2011
(Revised to include April 2010 sampling results)

1.- Executive summary

This study measures if the Secaucus High School Marsh (SHS) -which was restored in 2007- when opened to the tides of the Hackensack River will or will not accumulate metals and organics contaminating the clean engineered sediments used in the restoration. The restoration was completed by removing approximately 1.5 foot of surface sediments (mainly the *Phragmites australis* rhizosphere) and replacing them with clean engineered sediments. Two high marsh areas totaling eight acres received different engineered sediments. The Northeast (NE) high marsh area received fresh water pond dredge and a 6” cap of sand. The Southeast (SE) high marsh received marine dredge, 6” of fresh water pond dredge and a cap of sand and compost mix. Plantings in both areas included *Spartina patens*, *Distichlis spicata* and others. Points at three different terrain elevations in each area have been sampled each year since 2007 and this report presents the findings up to 2010. Results indicate that 2010 metal concentrations have decreased significantly compared to the previous years. The higher terrain elevation sampling points (3.5 and 3 feet) have lower metal concentrations than the lower elevation sampling points (2.5 feet) also, the SE area amended with compost mix on the surface had significantly lower metal concentration than the NE area over a three year period. In terms of the organics, 2010 showed lower concentrations of PCB’s and OCP’s compared to the previous three years and the higher terrain elevations (3.5 and 3 feet) had lower PCB and OCP concentrations compared to the 2.5 feet elevation points over the same period. Since the opening of the site to the tides (2008) the concentrations of Cr, Cu, Hg, Ni and Zn have decreased significantly and steadily from the sediments. Similarly, the concentrations of PCB and OCP’s have also decreased.

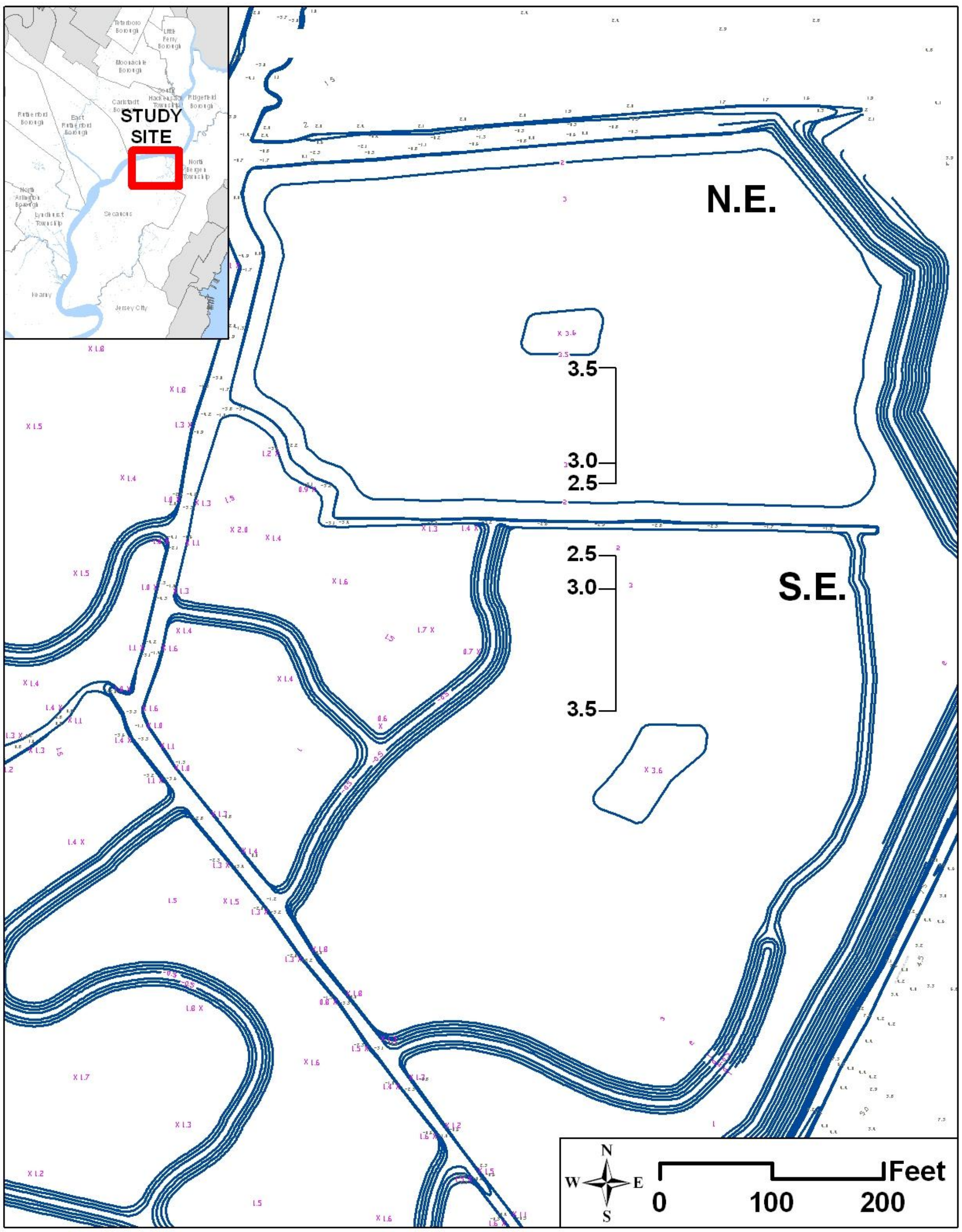
2.- Background

This study is designed to document the accumulation of contaminants in clean wetland sediments in an engineered high marsh. April 2010 represents the third sampling after the marshes were open to the tides and it occurred 12 months after the 2009 sampling period.

The enhancement of the SHS wetland included the construction of two high-marsh areas (NE and SE) along the eastern side of the site totaling approximately eight acres. The imported sediment material was emplaced on the surface remaining after removal of the *Phragmites* saturated rhizosphere. The NE high marsh surface has a core of freshwater pond dredge, and a 6” cap of I-11 sand. The SE high marsh has a small inner core of marine dredge material from off the New Jersey coast, an approximately 6” deep middle layer of freshwater pond dredge, and about a 6" cap of 5:1 mix of sand to leaf compost. The different layers of materials taper towards the periphery of the high marsh areas. High marsh plantings include *Spartina patens* (saltmeadow hay), *Distichlis spicata* (saltgrass), *Spartina cynosuroides* (big cordgrass) and *Juncus gerardii* (saltmeadow rush).

This first sampling took place October 31, 2007, after the site work was completed with plantings, but prior to the restoration of tidal flow. Subsequent sampling had taken place June 27, 2008; April 23, 2009; April 29, 2010. A transect was established perpendicular to the ditch separating the NE and SE high marsh areas and connecting the highest elevation in each marsh (Figure 1). Samples are taken at three points in each area: at 3.5, 3.0 and 2.5 foot contours where elevations coincide with the spring high water level, mean high water level, and low marsh respectively. At each point, three replicate sediment samples were taken at the surface (0-10") and at depth (>10"). In addition, each time the sediments were sampled, grab samples of water from the drainage ditches was also sampled.

Figure 1: Secaucus High School Marsh Sediment Study Site



3.- Methods

A total of 36 sediment samples are collected every year since 2007. Three replicates for each depth, contour interval and high marsh area are collected each year (Table 1).

Table 1.- Sediment samples

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

The parameters Conductivity, DO, pH, Salinity and Temperature are measured directly from waters in the ditch using a YSI Model 6820 multi-parameter water quality sensor. In addition, surface grab samples are obtained for analysis in the MERI laboratory for metals and conventional parameters (NJDEP #02437).

Each metal value is the average of 3 replicates; total PCBs and Pesticides (OCPs) values represent one analysis. 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. Statistically significant results are presented at the 5% level (i.e., $p<0.05$). .

4.- Results

4.1.- Water quality results from ditch

The average water quality measurements for nine metals and thirteen additional water parameters from waters in the ditch are shown in Table 2.

Table 2: Average water quality results from ditch samples between 2007 and 2010

Parameter	Units	10/31/2007	6/27/2008	4/23/2009	4/29/2010
Cadmium	µg /L	0.566	0.777	0.197	0.264
Chromium	µg /L	47.7	17.5	10.3	11.0
Copper	µg /L	17.6	19.8	18.1	15.5
Iron	µg /L	2812	1883	992	739
Lead	µg /L	23.6	19.9	2.42	4.50
Manganese	µg /L	n/a	n/a	n/a	203
Mercury	µg /L	<0.5	<0.5	<0.5	<0.5
Nickel	µg /L	42.3	11.2	4.62	3.30
Zinc	µg /L	101	98.6	37.0	21.2

Fecal Coliforms	Col/100ml	245	590	98	156
COD	mg/L	74.5	106	65.7	62.7
NH 4	mg/L	0.952	2.31	2.80	3.36
Nitrate	mg/L	4.74	0.61	4.38	2.62
TSS	mg/L	96.8	20.8	22.3	52.0
Temperature	^{o}C	15.5	33.7	22.5	15.3
Conductivity	mS/cm	14.2	12.3	16.9	4.22
Salinity	ppt	8.25	6.95	9.96	2.25
Chloride	mg/L	4639	3256	2816	1098
Sulfate	mg/L	586	480	338	152
pH	SU	7.21	7.83	7.04	7.83
DO	mg/L	4.87	2.30	6.09	11.4
DO%	% sat	51.6	34.0	74.4	114

4.2.- Sediment contaminate and elevation differences

The Average and Standard Deviation of the two areas (NE and SE) for each constituent (i.e. nine metals, two organics and three chemical-physical properties) at the different terrain elevations and over time are shown in Table 3.

Table 3: Summary of metal and organic contaminant concentrations at different elevations (2.0, 3.0 and 3.5 feet) overall summary and by date

	2.0 feet		3.0 feet		3.5 feet	
	Avg.	SD	Avg.	SD	Avg.	SD
Cd	4.01	1.20	1.44	0.503	1.24	0.281
Cr	43.3	219	46.2	29.8	17.7	4.62
Cu	132	52.0	36.6	4.93	27.8	8.07
Fe	29126	2859	10550	1566	9176	987
Hg	5.41	3.40	1.02	0.796	0.605	0.503
Mn	951	552	497	396	96.8	16.4
Ni	90.2	25.7	25.5	8.68	13.3	1.42
Pb	193	52.6	96.1	17.1	87.5	19.1
Zn	343	103	108	19.8	88.9	25.7
PCBs	348	138	53.9	19.2	33.2	13.8
OCPs	33.3	9.78	28.1	13.5	17.3	81.4
pH	5.91	1.03	6.97	0.513	6.78	0.763
% Moist	65.6	1.86	26.4	5.15	22.0	3.45
% OM	24.6	2.81	7.83	2.00	4.99	0.953
% Fines	27.1	10.8	11.4	5.47	14.7	1.97

Parameter	Sample Date											
	October 31, 2007			June 27, 2008			April 23, 2009			April 29, 2010		
	Elevation (feet)											
	2.0	3.0	3.5	2.0	3.0	3.5	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	5.39	1.99	1.47	2.60	1.72	1.50
Cr	642	59.2	19.3	518	80.3	23.0	443	33.0	16.3	128	12.1	12.1
Cu	177	34.7	30.3	146	43.8	34.6	148	32.6	16.1	57.0	35.4	30.2
Fe	28552	8276	7829	28946	11829	9977	32958	11214	9050	26048	10883	9849
Hg	9.60	1.63	0.22	3.48	1.78	1.27	6.62	0.42	0.21	1.95	0.25	0.72
Mn	679	809	105	1433	865	116	1387	213	83.0	305	101	83.3
Ni	87.8	32.2	12.1	95.2	33.7	14.1	120	19.6	12.0	57.6	16.6	14.8
Pb	224	80.3	93.1	199	85.1	98.6	232	101	59.1	117	118	99.0
Zn	379	88.1	82.9	409	131	114	395	95.7	55.5	189	118	103
PCBs	475	44.3	32.3	347	64.8	51.3	414	74.4	17.7	157	32.0	31.5
OCPs	39.9	31.1	24.0	43.1	22.3	24.3	27.4	45.3	13.1	22.7	13.8	7.95
pH	4.78	6.95	6.87	6.01	6.85	6.92	5.58	6.41	5.75	7.25	7.65	7.59
% Moist	63.1	21.8	19.1	66.9	33.4	22.6	67.1	23.4	19.6	65.2	27.0	26.6
% OM	21.1	6.91	4.80	25.4	10.8	5.98	27.8	7.06	3.76	23.9	6.53	5.43
% Fines	29.5	9.00	12.4	23.2	10.9	13.6	15.0	6.57	16.3	40.7	19.2	16.3

With the exceptions of Mn (October ‘07), OCP (April’ 09) and Pb (April ‘10) elevation 2.0 feet yields the highest results for all constituents. For PCBs, this result is statistically significant ($p<0.05$). For most constituents, elevation 3.0 feet is higher than elevation 3.5 feet; the exceptions are Pb (October ‘07), Pb, Cd and OCPs (June ‘08).

The PCBs concentration also decreases as the elevation increases; the data shows a concentration of 348 µg /kg at elevation 2.0 feet, 53.2 µg/kg at elevation 3.0 feet and 33.2 µg /kg at elevation 3.5 feet. The same occurred with OCP’s where concentration of 33.3 µg /kg, 28.1 µg /kg, 17.3 µg /kg for elevations 2.0, 3.0, 3.5 feet respectively.

The pH values for elevation 2.0 feet during all samplings are lower than for elevations 3.0 and 3.5 feet. Other soil physical parameters (% Moisture, % Organic Matter, and % Fines) have opposite trend – their values are decreasing with elevation increase which are similar to metal concentrations behavior.

4.3.- Surface contaminants (0-10”) versus contaminants found at depths greater than 10”

The overall concentrations measured at the surface of the engineered soil (0-10 inches in depth) is less than at the horizon below (>10 inches) for all metals and organic compounds (Table 4).

Table 4.- Average constituent concentration at the surface and below 10" for NE and SE samples, overall and by date

Parameter	Overall				Sample Date							
	Surface		Deep		October 31, 2007		June 27, 2008		April 23, 2009		April 29, 2010	
	Avg.	SD	Avg.	SD	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Cd	2.08	2.17	2.57	1.82	2.13	2.32	1.44	2.18	2.55	3.34	1.82	2.07
Cr	175	349	232	379	203	273	211	204	158	170	69.9	31.7
Cu	62.8	82.7	84.5	65.8	69.8	92.6	61.0	88.5	61.8	69.2	35.9	46.2
Fe	14559	13413	18482	10209	11848	18030	13640	20195	16209	19272	12446	18741
Hg	2.67	3.61	3.07	5.31	4.38	4.59	2.21	2.14	2.51	2.33	1.16	0.79
Mn	629	1606	636	1300	261	800	800	809	765	357	136	190
Ni	34.6	41.8	60.1	57.5	37.0	50.9	34.9	60.4	36.0	64.8	26.5	32.9
Pb	97.6	115	163	89.1	99.4	165	90.3	165	110	151	86.7	136
Zn	144	206	245	185	153	214	156	280	127	237	109	164
PCBs	136	37.1	154	73.5	128	239	154	155	173	164	87.3	59.8
OCPs	16.1	3.58	36.4	15.3	12.4	50.9	20.9	39.0	16.3	40.9	14.8	14.8
pH	6.69	0.767	6.42	0.705	6.40	5.99	6.68	6.51	6.04	5.79	7.62	7.37
% Moist	34.4	4.79	41.5	1.64	27.9	41.4	38.3	43.6	33.8	39.6	37.7	41.4
% OM	8.06	2.07	16.0	2.36	7.24	14.6	5.52	19.2	9.49	16.2	9.97	13.9
% Fines	11.3	3.39	19.9	11.2	10.7	14.6	12.7	19.1	7.01	10.1	15.0	35.8

4.4.- Differences in constituent concentration between the NE and SE marsh areas

The concentrations of Cd, Cr, Cu, Hg, Pb, PCBs and OCPs measured at the SE marsh are lower than the NE marsh (a few exceptions were Mn in 2008, Fe and Ni 2009). The chemical-physical parameters did not show differences depending on marsh location (Table 5).

Table 5.- Difference in constituent concentration between NE and SE areas and over time

Parameter	Overall				Sample Date							
	North		South		October 31, 2007		June 27, 2008		April 23, 2009		April 29, 2010	
	Avg.	SD	Avg.	SD	North	South	North	South	North	South	North	South
Cd	2.61	2.13	2.04	1.84	2.75	1.70	2.01	1.61	3.09	2.81	1.89	1.99
Cr	272	470	135	190	327	149	303	111	182	146	40.4	61.2
Cu	87.3	87.0	60.1	58.7	105	57.9	86.3	63.2	72.3	58.7	36.0	46.0
Fe	16629	11898	16411	12206	15470	14408	17096	16739	17360	18121	15390	15797
Hg	3.89	5.79	1.88	2.53	6.68	2.30	2.54	1.81	3.00	1.84	0.88	1.07
Mn	625	1390	639	1517	708	352	592	1016	575	548	163	162
Ni	51.1	57.2	43.6	45.4	54.6	33.4	50.1	45.2	48.8	52.0	26.2	33.2
Pb	157	123	103	82	173	91.6	152	104	147	114	106	117
Zn	219	228	170	168	205	161	261	175	191	173	141	132

PCBs	163	69.7	127	60.4	259	109	159	150	141	196	93.2	53.9
OCPs	30.9	9.84	21.7	7.12	35.8	27.6	39.9	20.0	30.4	26.8	17.3	12.3
pH	6.62	0.763	6.48	0.624	6.34	6.06	6.66	6.52	5.84	5.98	7.65	7.34
% Moist	36.9	0.455	39.0	5.48	36.3	33.0	36.8	45.1	37.3	36.1	37.2	41.9
% OM	12.5	1.31	12.5	1.59	10.7	11.2	13.3	14.8	13.6	12.1	12.2	11.8
% Fines	17.6	6.96	15.8	7.12	19.7	14.2	17.1	14.7	8.41	8.71	25.1	25.7

4.5.- Constituent concentration over time.

Chromium, copper and OCPs concentrations diminish with time. Mercury concentration decreased significantly between 2007 and 2008 ($p<0.05$) and again showed a significant decreasing trend between 2009 and 2010 (Table 6).

Table 6: Summary of Temporal Effects

Parameter	Overall		Sample Date			
	Avg.	SD	10/31/2007	6/27/2008	4/23/2009	4/29/2010
Cd	2.23	2.00	2.21	1.81	2.95	1.95
Cr	165	362	240	207	164	50.8
Cu	65.4	75.1	80.8	74.8	65.5	40.6
Fe	16215	12000	14886	16917	17741	15314
Hg	2.45	4.53	4.21	2.18	2.42	0.98
Mn	516	1449	531	804	561	166
Ni	42.9	51.5	44.0	47.6	50.4	29.7
Pb	126	107	132	128	131	111
Zn	178	201	183	218	182	129
PCBs	145	49.30	184	154	169	73.5
OCPs	26.3	7.74	31.7	29.9	28.6	14.8
pH	6.55	0.89	6.20	6.59	5.91	7.50
% Moist	38.0	21.4	34.7	40.9	36.7	39.6
% OM	12.4	9.93	10.9	14.0	12.9	12.0
% Fines	16.7	12.8	17.0	15.9	8.56	25.4

In 2010, five metals show significantly lower concentrations compared to previous three years: PCBs and OCPs concentrations also showed a decreasing trend.

5.- Discussion

During construction, the surface soils were removed to eradicate Phragmites rhizomes and to achieve engineered elevations of high and low marsh. This left a subsurface horizon that contained a legacy reservoir of metals and organic pollutants of the industrial uses of the lower Hackensack River. The porous nature of the clean sand deposited during construction is unlikely to stop the metals from migrating upward and incoming tides if they contain contaminants should deposit some on the surface sediments. The fact that surface sediments remain cleaner than the subsurface ones leads us to conclude, so far, that recontamination by legacy subsurface sediments and the tide is not occurring at SHS.

The two engineered high marshes differ slightly in their composition: the SE marsh contains marine dredge material and compost on the surface while the NE marsh does not. For most of the parameters measured, the SE marsh amended with leaf compost contains significantly lower contaminant concentrations.

6.- Conclusions

1. Year 2010 metal concentration was significantly lower than those in previous years for 5 metals: Cr, Cu, Hg, Ni, and Zn. This is a continuation of the trend started in year 2009, when Hg and Cd had lower concentrations compared to previous years.
2. Elevations of 3.0 ft and 3.5 ft had significantly lower metal concentration than that for Elevation of 2.0 ft for all metals except Mn, when the elevation effects are averaged over deep and surface. In case of Mn, Elevations of 3.0 ft and 3.5 ft had significantly lower metal concentration than that for Elevation of 2.0 ft for Surface only.
3. The south marsh had significantly lower metal concentration than north marsh for 5 metals: Cd, Cr, Cu, Hg, and Pb.
4. The surface at Elevation of 3.0 ft and 3.5 ft had significantly lower metal concentration than other combinations of surface-elevation for 6 metals: Cd, Cu, Fe, Mn, Pb, and Zn.
5. The south marsh at Elevation of 3.0 ft and 3.5 ft had significantly lower metal concentration than other combinations of marsh-elevation for 4 metals: Cr, Cu, Hg, and Pb.
6. Year 2010 had significantly lower concentration of PCB and OCP compared to the previous 3 years. PCB and OCP concentrations were reduced by 95 µg/Kg and 15 µg/Kg, respectively.
7. Elevations of 3.0 ft and 3.5 ft had significantly lower concentration of PCB by about 300 µg /Kg compared to Elevation of 2.0.
8. The surface at Elevation of 3.0 ft and 3.5 ft had significantly lower concentration of OCP than other combinations of surface-elevation by about 20 µg /Kg.

Appendix I: Soil Results

Each metal value is the average of 3 replicates. PCBs and OCPs (Pesticides) are sampled once at each location. Sample Nomenclature: High Marsh [Northeast/Southeast] Elevation [3.5/3.0/2.0] Depth [Surface/Deep]

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

Sampled October 31, 2007											
Sample	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	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

Sampled April 23, 2009											
Sample	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn	PCBs	OCPs
Average	**2.96**	**164**	**65.5**	**17757**	**2.42**	**561**	**50.4**	**131**	**182**	**169**	**28.6**
Std Dev	2.01	241	67.2	11889	3.68	931	56.1	101	198	211	34.9
N 3.5 S	1.41	9.85	2.94	7251	0.24	34.7	7.99	28.6	18.5	0.47	0.12
N 3.5 D	1.79	18.6	24.8	9991	0.25	79.4	14.6	90.2	88.5	0.23	0.00
N 3.0 S	1.26	14.8	4.3	7056	0.15	251	6.41	29.7	20.6	1.00	0.22
N 3.0 D	2.98	36.0	68.9	15946	0.54	200	28.7	212	204	118	122
N 2.0 S	4.76	422	169	35102	7.58	2475	85.9	251	324	304	23.6
N 2.0 D	6.33	593	164	28812	9.23	407	149.1	271	491	420	35.7
S 3.5 S	1.48	13.9	12.5	8560	0.19	81.4	11.4	50.7	44.8	57.2	42.4
S 3.5 D	1.19	23.0	24.0	10397	0.18	137	13.9	67.0	70.3	12.9	9.64
S 3.0 S	1.46	10.6	12.9	7304	0.08	75.3	10.6	38.5	31.4	8.14	1.87
S 3.0 D	2.34	70.7	44.2	14751	0.90	326	32.9	124	128	170	56.5
S 2.0 S	5.03	474	169	32182	6.81	1675	94.1	263	325	669	29.3
S 2.0 D	5.44	281	89.7	35736	2.87	992	149	143	441	261	21.2

Sampled April 29, 2010											
Sample	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn	PCBs	OCPs
Average	**1.95**	**50.8**	**40.6**	**15314**	**0.98**	**163**	**29.7**	**111**	**129**	**73.5**	**14.8**
Std Dev	0.92	73.6	28.8	8699	1.23	115	23.1	64.1	105	105	14.0
N 3.5 S	0.71	3.47	3.08	6908	0.073	21.2	5.78	21.7	13.5	2.18	0.24
N 3.5 D	2.13	18.2	56.6	9011	2.27	122	22.2	168	208	55.0	20.3
N 3.0 S	1.19	4.74	5.29	6264	0.096	25.2	6.82	32.6	20.6	4.45	0.82
N 3.0 D	1.98	18.4	59.5	13964	0.30	135	21.7	193	212	47.3	25.6
N 2.0 S	4.09	180	73.5	24829	2.36	355	65.6	177	316	386	45.6
N 2.0 D	1.24	18.6	17.1	27866	0.19	320	35.1	42.7	77.4	64.6	11.5
S 3.5 S	1.17	7.90	14.0	7425	0.26	72.9	10.3	57.7	50.2	0.99	0.29
S 3.5 D	2.11	17.8	39.9	12099	0.36	119	20.4	142	129	67.8	11.0
S 3.0 S	1.27	9.77	23.1	9735	0.28	111	14.1	74.8	72.3	73.9	28.3
S 3.0 D	2.47	15.5	53.5	13658	0.32	132	23.9	171	168	2.42	0.37
S 2.0 S	2.63	216	95.3	19669	3.90	230	57.2	162	184	53.7	13.3
S 2.0 D	2.46	98.7	46.3	31828	1.36	315	72.7	84.7	176	122	20.3

Appendix II: Soil Physical Parameters

% Moisture						
			2007	2008	2009	2010
			34.7	**40.9**	**36.7**	**39.6**
Sample	Average	Std Dev	23.1	21.0	22.9	21.1
N 3.5 S	**14.7**	3.03	10.3	15.0	16.7	16.7
N 3.5 D	**26.5**	4.01	32.3	25.7	23.4	24.4
N 3.0 S	**17.7**	4.33	12.3	19.6	22.4	16.4
N 3.0 D	**31.4**	7.96	42.7	30.4	28.2	24.2
N 2.0 S	**62.9**	6.26	56.2	63.9	60.4	71.0
N 2.0 D	**68.2**	3.82	64.0	66.1	72.4	70.4
S 3.5 S	**21.6**	7.89	11.8	30.0	19.2	25.5
S 3.5 D	**25.1**	9.71	22.1	19.8	19.1	39.6
S 3.0 S	**29.2**	14.5	13.9	37.9	20.1	44.8
S 3.0 D	**27.3**	12.3	18.3	45.5	22.7	22.5
S 2.0 S	**60.6**	5.75	63.1	63.1	64.1	52.0
S 2.0 D	**70.5**	3.12	68.9	74.3	71.6	67.2
Overall	**38.0**	21.4				

pH (S.U.)						
			2007	2008	2009	2010
			6.20	**6.59**	**5.91**	**7.50**
Sample	Average	Std Dev	1.11	0.51	0.52	0.31
N 3.5 S	**7.11**	1.08	7.58	7.38	5.52	7.95
N 3.5 D	**6.84**	0.72	6.82	7.05	5.89	7.62
N 3.0 S	**7.00**	0.57	7.03	6.86	6.36	7.74
N 3.0 D	**6.81**	0.63	6.73	6.66	6.17	7.68
N 2.0 S	**6.24**	0.92	5.40	5.91	6.10	7.55
N 2.0 D	**5.74**	1.29	4.48	6.11	5.00	7.38
S 3.5 S	**6.60**	0.82	6.59	6.53	5.63	7.64
S 3.5 D	**6.57**	0.50	6.47	6.72	5.95	7.14
S 3.0 S	**7.01**	0.46	7.04	6.99	6.44	7.57
S 3.0 D	**7.03**	0.41	7.00	6.87	6.65	7.61
S 2.0 S	**6.15**	1.03	4.77	6.39	6.18	7.25
S 2.0 D	**5.49**	1.00	4.46	5.63	5.05	6.80
Overall	**6.55**	0.89				

% OM						
			2007	2008	2009	2010
			10.9	**14.0**	**12.9**	**12.0**
Sample	Average	Std Dev	8.55	10.4	11.9	9.55
N 3.5 S	**0.98**	0.15	0.90	0.86	1.19	0.95
N 3.5 D	**7.93**	2.37	8.37	9.73	4.48	9.15
N 3.0 S	**1.68**	0.85	0.96	2.91	1.47	1.39
N 3.0 D	**14.4**	3.94	12.6	19.8	14.4	10.7
N 2.0 S	**23.0**	4.87	18.6	19.5	25.3	28.8
N 2.0 D	**26.6**	6.09	22.7	27.0	35.1	21.7
S 3.5 S	**3.32**	1.12	1.82	4.21	4.14	3.12
S 3.5 D	**7.73**	1.72	8.12	9.10	5.22	8.48
S 3.0 S	**3.91**	0.69	3.96	3.37	3.44	4.86
S 3.0 D	**11.4**	3.97	10.1	17.3	8.94	9.15
S 2.0 S	**20.5**	2.36	17.2	22.8	21.4	20.7
S 2.0 D	**27.9**	3.46	25.7	32.1	29.2	24.5
Overall	**12.4**	9.93				

% Fines						
			2007	2008	2009	2010
			17.0	**15.9**	**8.56**	**25.4**
Sample	Average	Std Dev	13.1	8.8	6.09	16.1
N 3.5 S	**1.17**	0.30	0.97	1.51	0.87	1.33
N 3.5 D	**20.5**	10.6	24.7	23.3	5.00	28.9
N 3.0 S	**2.88**	3.03	0.70	7.28	1.07	2.48
N 3.0 D	**23.6**	7.96	25.8	19.5	15.4	33.6
N 2.0 S	**29.6**	9.47	34.2	31.7	15.7	36.8
N 2.0 D	**27.8**	15.3	32.0	19.4	12.4	47.2
S 3.5 S	**6.00**	3.17	2.41	9.89	4.82	6.9
S 3.5 D	**18.7**	9.43	21.6	19.5	5.60	28.0
S 3.0 S	**5.59**	4.69	2.33	4.31	3.22	12.5
S 3.0 D	**13.7**	10.2	7.17	12.7	6.59	28.4
S 2.0 S	**22.8**	5.70	23.5	21.3	16.4	30.2
S 2.0 D	**28.2**	14.5	28.3	20.3	15.6	48.4
Overall	**16.7**	12.8				

Appendix III: HR3 Water Quality Data Summary

2007 - 2008

Parameters	Units	Average	Std Dev	12/07	03/08	04/08
Cd	**µg/L**	**0.465**	0.086	0.517	.366	.512
Cr	**µg/L**	**10.05**	3.99	14.4	6.55	9.21
Cu	**µg/L**	**10.95**	6.46	18.06	5.43	9.37
Fe	**µg/L**	**744**	491	1235	252	746
Ni	**µg/L**	**7.31**	2.80	5.89	5.51	10.54
Pb	**µg/L**	**8.73**	2.22	8.89	6.43	10.87
Zn	**µg/L**	**50.0**	13.5	61.1	35.0	53.8
PCBs	**ng/L**	**31.2**	8.64	22.0	39.1	32.5
OCPs	**ng/L**	**9.72**	9.28	20.4	5.17	3.59

2008 - 2009

Parameters	Units	Average	Std Dev	07/08	12/08	03/09
Cd	**µg/L**	**0.375**	0.237	0.325	0.168	0.633
Cr	**µg/L**	**9.38**	1.17	10.38	8.09	9.67
Cu	**µg/L**	**8.99**	1.28	10.21	7.66	9.10
Fe	**µg/L**	**632**	596	1320	305	272
Ni	**µg/L**	**7.05**	6.03	13.97	4.25	2.93
Pb	**µg/L**	**8.48**	4.96	14.02	4.46	6.97
Zn	**µg/L**	**62.6**	16.5	77.9	45.1	64.9
PCBs	**ng/L**	**20.9**	10.5	11.3	19.3	32.1
OCPs	**ng/L**	**9.77**	4.90	4.12	12.7	12.5

2009 - 2010

Parameters	Units	Average	Std Dev	05/09	09/09	10/09	03/10
Cd	**µg/L**	**0.261**	0.050	0.261	0.289	0.304	0.191
Cr	**µg/L**	**10.64**	1.26	12.19	9.13	10.39	10.85
Cu	**µg/L**	**9.07**	5.13	10.31	15.63	3.75	6.60
Fe	**µg/L**	**401**	126	289	564	435	315
Ni	**µg/L**	**5.08**	4.45	11.61	3.81	3.35	1.58
Pb	**µg/L**	**2.35**	0.67	2.71	3.11	1.77	1.81
Zn	**µg/L**	**32.9**	4.10	37.7	34.8	29.0	30.0
PCBs	**ng/L**	**20.8**	17.0	46.2	14.3	12.3	10.4
OCPs	**ng/L**	**6.34**	3.83	11.2	6.50	5.90	1.79

Table 7: Average Water Quality Summary

Parameter	Units	2007-2008	2008-2009	2009-2010
Cd	μg/L	0.465	0.375	0.261
Cr	μg/L	10.05	9.38	10.64
Cu	μg/L	10.95	8.99	9.07
Fe	μg/L	744	632	401
Ni	μg/L	7.31	7.05	5.08
Pb	μg/L	8.73	8.48	2.35
Zn	μg/L	50.0	62.6	32.9
PCBs	ng/L	31.2	20.9	20.8
OCPs	ng/L	9.72	9.77	6.34