BrightFields, Inc.

Appendix 11-B

DRAVO SHIPYARD
HARBOR ASSOCIATES
WILMINGTON, DELAWARE

SIRB ID: DE-1096

BrightFields, Inc.

GENERAL SITE INFORMATION

Site Name: Dravo Shipyard – Harbor Associates

SIRB ID Number: DE-1096

Site Location and Description: The Dravo Shipyard – Harbor Associates consists of approximately 32 acres and is located southwest of the City of Wilmington business district. This area was historically the site of shipbuilding and other heavy industrial activities. Much of the area was marshland that was filled with slag and other industrial waste products. Currently, this property is used for commercial retail space, a riverwalk, a parking lot, and open land.

The subject property is directly adjacent to The Dravo Shipyard – Amer property. The actual site extents to each property were never clearly defined. For the purposes of this assessment BrightFields utilized Figure 15 from the Preliminary Report of Field Investigation Activities Dravo Shipyard (Amer Industrial Technologies, Inc.) issued by DNREC. This report outlines the property boundary of "The Amer Property". The remainder of the area was then considered the Harbor Associated property. Because this assessment was established, different reports incorporate portions of both properties.

Previous Site Uses: The site is located in an area of Wilmington that has been in continuous industrial use since the late 1700s. The historical use of the site was investigated through a review of the following sources: aerial photographs, fire insurance maps, historic atlases, interviews with past and/or present owners and operators, and building records.

According to historical records, much of the Dravo Shipyard – Harbor Associates area to the west of the Christina River consisted of undeveloped, commercial or industrial properties, including marsh land, a bone mill, and a shipyard. The first developed use of the property, a bone mill, appeared to have occurred in 1868 or earlier. Between 1893 and 1951, the area was used as a shipyard with three buildings on the property. The buildings were removed from the property sometime between 1987 and 1993. In 2007, the property was redeveloped into a riverwalk, commercial space, a parking lot, and vacant land.

Site Regulatory Status: This section briefly summarizes previous investigations performed on the site through the SIRB program. The following reports summarize information pertaining to the established boundary of the Dravo-Harbor Associates property defined for this assessment. A current SIRB regulatory status is also included.

Previous Investigations

1979

A letter dated September 28, 1979 from DNREC addressed to Hub Marine Industrial Acres Corp. was written to inform them of DNREC's new regulation, which requires DNREC to be informed of any underground storage tanks (USTs) greater than 2,000 gallons.

On October 9, 1979, Hub Marine and Industrial Park wrote a letter to DNREC. The letter states that there is a 500 gallon UST at the extreme south end of their Madison Street property.

A letter written on October 12, 1979 from DNREC to Hub Marine and Industrial Park exempted them from regulation because their UST is below the 2,000 gallon limit.

1993

On January 12, 1993, Schranze & Associates, PC prepared a Phase II Environmental Assessment (Test Program) for the Harbor Associates, Inc. Property for Harbor Associates, Inc. Sixteen soil samples were taken from test pits excavated on a 35-acre portion of the site. Ten of the samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) and base/neutral and acid extractible organics (semi-volatiles). Nine samples were tested for TCL pesticides and PCBs. Fourteen were analyzed for priority pollutant metals. One sample was analyzed for total petroleum hydrocarbons (TPH). No evidence of significant PCB contamination was found on-site. Surficial soil samples showed localized elevated levels of zinc and lead, but the subsurface samples did not. Therefore, they concluded that metals are not migrating into the subsurface, and there is no potential for the metals to leach into the groundwater. Based on the analyses of these samples, Schranze & Associates, PC determined that the site was non-hazardous.

1998

An Underground Storage Tank Removal/Abandonment Notification Form was completed and signed on April 21, 1998 for the removal of a 1,000 gallon tank on May 4, 1998.

In June 1998, a Voluntary Cleanup Program Agreement for Facility Evaluation Remedial Investigation/Feasibility Study was signed by a representative of DNREC and of Harbor

Associates. The agreement stated that DNREC allowed Harbor Associates to conduct a Remedial Investigation and Feasibility Study with oversight by DNREC.

The Brownfield Preliminary Assessment II Dravo Shipyard – Harbor Associates (DE-1096) was completed by DNREC in June 1998. The purpose of the assessment was to generally characterize the environmental conditions of the 33-acre Harbor Associates portion of Dravo Shipyard.

- Fifty-nine soil and sediment samples were taken and screened on site by DNREC's mobile laboratory. Eighteen soil/sediment samples, 4 surface water samples, and 4 groundwater samples were selected for confirmatory laboratory analysis. The sediment screening results found an absence of PCBs and low levels of DDT. Of the samples selected for PCB laboratory analysis, the data received from the lab was unusable, so confirmatory data was not available for these samples. (BrightFields Note: No additional information was given.) Arsenic and lead as well as other inorganic compounds were elevated in all sediment samples analyzed by the laboratory. SED-11, located in a sediment filled storm sewer beneath the site, had elevated levels of organic compounds.

- The two soil samples that were analyzed for TAL metals contained levels of arsenic of (29.5 mg/kg in TP-2s and 4.1 mg/kg in TP-16d) above the carcinogenic Industrial Soil Benchmark (3.8 mg/kg). Five of the eleven soil samples that were analyzed for SVOCs by the laboratory contained concentrations of benzo(a)pyrene above the industrial risk-based concentration criteria. Several other SVOCs were also detected above the RBC criteria.

- Of the 4 surface water samples analyzed for confirmation of TAL inorganics and the semivolatile and pesticide/PCB components of the TCL organics package, SW-1 and SW-2 exceeded acceptable levels of aluminum, and SW-2 and SW-5 exceeded acceptable levels of lead. The groundwater samples contained elevated metals. Elevated levels of iron were detected in MW-1/4 and MW-3 in filtered and unfiltered samples. MW-2 had elevated levels of lead in filtered and unfiltered samples, and manganese was elevated in MW-1/4 in a filtered groundwater sample. DNREC concluded that water was likely to be impacted by contamination from the site.

In August 1998, EA Engineering, Science, and Technology, Inc. submitted an Interim Action Summary Report and Remedial Investigation/Feasibility Study to Harbor Associates and Riverfront Development Corporation. One hundred-sixty soil and sediment samples were collected from excavated soil from utility trenches and test pits throughout the area. Contaminants of concern identified were PAHs, arsenic, lead, and PCBs. Approximately 3,900 tons of soil from utility trench excavations were disposed off site. The soil remaining on site was

not expected to pose a threat to human health or the environment if it is not disturbed and is capped by a concrete or asphalt barrier.

On August 31, 1998, DNREC wrote a letter to Mr. Michael R. Walsh regarding the soil samples obtained from the 1,000-gallon UST excavation. This UST was removed on May 4, 1998. The results indicated that the low levels of contamination pose no threat to human health or the environment. No further action was required at that time.

1999

In August 1999, EA Engineering, Science, and Technology completed the OU II Remedial Investigation/Feasibility Study Dravo Shipyard – Harbor Associates and Former Amer (RDC) Properties for Harbor Associates and Riverfront Development Corporation. Seventy-five composite soil samples were collected from test pits excavated every 100 feet to the depth where groundwater was encountered. Instead of comparing site soil data to the URS, EA utilized the soil disposition criteria (ex: Level A, B, C, Z) used for this project: "The RI/FS plan states that the plan serves as the disposition plan for subsurface material during the redevelopment construction. The soil reuse decision plan was based on the DNREC-SIRB Remediation Standards document with respect to the Uniform Risk-Based Standards (URS) for unrestricted and restricted reuse classification. The decision plan is intended to protect human health by limiting reuse options of material dependent on the concentration of constituents of concern (COC) detected."

Samples were screened by DNREC for PCBs and carcinogenic polycyclic aromatic hydrocarbons (PAHs) using immunoassay analysis and for metals using X-ray Fluorescence (XRF). Screening results indicated that the maximum concentration for carcinogenic PAHs was 229 ppm (TP-32). No samples exceeded the DNREC onsite reuse criteria (Level Z) concentration of 300 ppm. The PCB screening results ranged from 0.14 ppm (TP-34 and TP-35) to below the detection limit. Arsenic ranged from 31.1 ppm (TP-34) to below the detection limit. The maximum detected lead concentration was 403 ppm (TP-4), which is above the DNREC unlimited reuse criteria (Level A) concentration of 400 ppm. BTEX was not detected.

- From the 75 screened samples, 11 were sent for PAH confirmatory analysis, 5 for PCB confirmatory analysis, and 6 for metals confirmatory analysis. PAHs ranged from 15.4 mg/kg (TP-32) to 0.2 mg/kg (TP-73). No PCBs were detected in the confirmatory analyses. Arsenic ranged from 7.5 mg/kg (TP-14) to 2.4 mg/kg (TP-32), and lead ranged from 130 mg/kg (TP-4) to 4.4 mg/kg (TP-52).

- An additional 17 soil samples were collected from within the proposed bioswale area. DNREC screening results indicated the concentration of carcinogenic PAHs ranged from 126.6 ppm (BS-13d) to below the detection limit. Eight of the samples were over 50 ppm. PCBs ranged from 0.44 ppm (BS-1d) to below the detection limit. Arsenic (26 mg/kg (BS-2d) to not detected) and lead (399 ppm (BS-2d)) were below the unlimited reuse criteria (Level A).

- Based on the screening results for the bioswale samples, 7 samples were sent for confirmatory analysis for SVOCs, 3 samples for PCBs, and 5 samples for metals. The SVOC results ranged from 39.9 mg/kg (BS-7d) to 0.39 (BS-9d). The PCB confirmatory results were below the detection limit. Arsenic ranged from 8.2 mg/kg (BS-2d) to 1.3 mg/kg (BS-11s), and lead ranged from 126 mg/kg (BS-7s) to 60.1 mg/kg (BS-5s). It was determined that the soil excavated from the bioswale area could be used on site if it was placed under an impermeable cap.

- Six groundwater monitoring wells were installed. Groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, and dissolved TAL metals. SVOCs and VOCs were below the detection limits. Aluminum, iron, and manganese were above the URS. The maximum concentration of arsenic (23.1 µg/L) was found at MW-6. Lead concentrations were not above the detection limit.

The RI/FS concluded that contaminants on the property could be transported to the river by surface water, groundwater, or sediment transport and/or as particulates in the air, and could present a risk to the public, future construction worker, and the environment. The recommended remedial action was to contain contaminated soil under an impermeable cap, which would remove the exposure routes.

2000

In April 2000, EA Engineering, Science, and Technology prepared an OUIV Analytical Sediment Summary Report for the Riverfront Development Corporation. OUIV consists of the sediments of the Christina River directly adjacent to the former Dravo Shipyard. Sediment samples were collected in February 1999 to assess sediment quality and the presence or absence of contaminants along the Harbor Associates Property. Eleven sediment samples (SD-1 through SD10) (including one duplicate) were collected using a Ponar sampler from locations approximately 5 feet from the edge of the property into the river and 300 feet apart. Sediment samples were analyzed for TCL VOCs, PCBs, TCL SVOCs, and TAL metals at the former EA Laboratories a DNREC HSCA-approved laboratory and were validated by Meridian Science & Technology, Inc. of Annapolis Maryland. VOCs including methylene chloride (SD-1 and SD-6), benzene (SD-6), and toluene (SD-6, SD-7, SD-9, and SD-10) were detected at concentrations

exceeding their respective URS standards. Several PAHs were detected at concentrations exceeding their respective URS for Protection of the Environment. Other SVOCs detected at concentrations exceeding their respective URS include butyl benzyl phthalate (SD-8) and bis(2-ethylhexyl)phthalate (SD-8). PCBs were not detected at a concentration above their respective URS. Numerous metals including arsenic, lead, chromium, and zinc were detected at concentrations exceeding the URS criteria. No conclusions or recommendations were presented in this report.

An April 26, 2000 EA Engineering, Science, and Technology Letter to DNREC-SIRB was written to inform them that approximately 800 yards of classified B-soil was to be moved from the Riverwalk Phase III and IV stockpile along West Street to this area. It was to be spread in low lying areas along the entire area of the proposed parking lots and future buildings (Shipyard Shops) on the Dravo Shipyard Site.

2001

A Final Plan of Remedial Action was written by DNREC in February 2001 to address the soil and subsoil for Operable Unit (OU) II and groundwater for OUs I, II, and III at the Dravo Shipyard Site. Three remedial alternatives were evaluated. Remedial Alternative 2, consisting of containment of impacted soil was chosen as the most appropriate remedial action because it is cost effective, meets the remedial objectives, and satisfies the evaluation criteria.

2002

DNREC wrote a letter on May 7, 2002 addressed to Pettinaro Construction Company regarding stockpiling and disposal of any soils excavated from the OU II DE-1096 property, and that DNREC must be informed prior to activity.

On December 30, 2002, Pennoni Associates, Inc. prepared a Closure Report for the Pettinaro Property for DNREC. This closure report documented the removal and disposal of six truck loads of SVOC contaminated soils located on the DE-1096 property. The letter states that the remaining B Type soil has been re-graded on site.

Current Regulatory Status:

The Final Plan of Remedial Action was issued in February 2001, and the site was redeveloped into commercial space, open space, a riverwalk, and a parking lot.

SUMMARY OF SITE PCB INFORMATION

Site Investigation PCB Findings:

Total PCBs were detected in multiple surface soil sample locations at a concentrations ranging from 0.027 mg/kg to 10.8 mg/kg. One subsurface unsaturated sample was reported to have total PCBs of 5.64 mg/kg. There were a total of four subsurface saturated samples reported to have total PCBs concentrations ranging from 0.60 mg/kg to 0.70 mg/kg.

After further evaluation of the sample locations and current site coverage, BrightFields determined that there are two areas that could still be potentially contributing to mass loading via overland flow. Due to this evaluation the maximum concentration observed in each area was used in the overland flow calculations instead of calculating a 95% UCL of the mean of total PCBs for the site. PCBs were detected in the subsurface saturated zone in two distinct areas. These areas were evaluated separately to determine the loading of each area.

Concentrations of PCBs on Site			
Sample Matrix	**Corresponding Figure**	**Analytical Methods**	**Range of Total PCBs**
Surface Soil	Figure 2	Method 8082 and Immunoassay	Not detected to 27.3 mg/kg
Subsurface Soil (unsaturated)	Figure 3	Method 8082 and Immunoassay	Not detected
Subsurface Soil (saturated)	Figure 4	Method 8082 and Immunoassay	Not detected to 0.70 mg/kg
Ground Water	Figure 5	No Criteria Available	No Criteria Available

A summary of all samples collected for PCBs are presented in the attached Tables 1 through 2

Acreage where PCBs detected:

The estimated surface soil area impacted by PCBs is 12 acres (Figure 2) of which only 3.71 acres (Figure 6) may still be contributing to mass loading via overland flow. The other 8.29 acres is currently under an impervious surface. Estimated subsurface unsaturated soil that is impacted by PCBs is 0.41 acres (Figure 3). Estimated subsurface saturated soil impacted by PCBs is 1.95 acres.

PCB Remediation Status:

There have been no specific remedial activities required for PCBs on the Dravo Shipyard – Harbor Associates Property.

PCB MASS LOADING SUMMARY

The PCB mass loading rate to surface water via overland flow and via groundwater transport are discussed below. A summary of the results is included below and the details of the calculations are included as attachments to this Appendix.

OVERLAND FLOW:

Overland flow has been determined on this site by using the Revised Universal Soil Loss Equation (RUSLE). The RUSLE predicts the long term average annual rate of erosion on an area based on rainfall patterns, soil type, topography, cover/canopy factors and support management practices. These factors are site-specific and require information pertaining directly to the site. A breakdown of the individual factors is presented below with a brief explanation of their selection.

Ground Cover and Canopy:

A site inspection was performed on June 23, 2008 to estimate the current site ground cover and canopy. The cover/management factor (C) assigned to the site and associated flow path ranges from 0.072 to 0.077, which corresponds to tall weeds and short brush with the cover at the surface consisting of mostly broadleaf herbaceous plants or undecayed residues or both.

Site Sediment and Erosion Control Practices:

As of July 2009 there is a bio-swale along the perimeter of the property parallel to the river, which prevents sediment from entering into Christina River.

Input Factors and Results:

A breakdown of the individual factors is presented below with a brief explanation of their choice.

Area 1: Southwest portion of the property.

RUSLE Factors	Values Provided	Explanation of Selection
R = rainfall-runoff erosivity index (10^2 ft-tonf-in/ac-hr)	170	An appropriate value for R for the site was determined from plots of Rainfall patterns for the Eastern U.S. (Wischmeier and Smith, 1978).
K = soil erodibility (0.01 tonf acre hr/acre ft-ton in)	0.28	The soil erodibility factor was chosen based on the information provided by the boring log for TP-18 in the Brownfield Preliminary Assessment (DNREC 1997a).

RUSLE Factors	Values Provided	Explanation of Selection
LS = topographic factor (dimensionless)	0.210	The slope length was estimated to 449 feet, which is the distance between the sample detection centroid and the discharge location along the overland flow path. Estimated slope (1.41 ft/ft) and slope length were used to calculate a topographic factor of 0.210.
C = cover/management factor (dimensionless)	0.077	The cover/management factor C assigned to this area and associated flow path was 0.077, which corresponds to vegetation consisting of short brush and weeds.
P = support practice factor (dimensionless)	1.0	There are currently no sediment and erosion controls in place at the Dravo Shipyard – Harbor Associates Property.

The average annual erosion rate is based on the windows based RUSLE2 program (RUSLE2 License, version 2006-Jul-24).

Based on the calculations performed, the total PCB loading from Area 1 of the Dravo Shipyard – Harbor Associates Property to the discharge location via erosion under current site conditions is 2 grams per year.

Area 2: Southeast portion of the property.

RUSLE Factors	Values Provided	Explanation of Selection
R = rainfall-runoff erosivity index (10^2 ft-tonf-in/ac-hr)	170	An appropriate value for R for the site was determined from plots of Rainfall patterns for the Eastern U.S. (Wischmeier and Smith, 1978).
K = soil erodibility (0.01 tonf acre hr/acre ft-ton in)	0.28	The soil erodibility factor was chosen based on the information provided by the boring log for TP-16 in the Brownfield Preliminary Assessment (DNREC 1997a).
LS = topographic factor (dimensionless)	0.670	The slope length was estimated to 131 feet, which is the distance between the sample detection centroid and the bio-swale along the overland flow path. Estimated slope (4.05 ft/ft) and slope length were used to calculate a topographic factor of 0.670.
C = cover/management factor (dimensionless)	0.072	The cover/management factor C assigned to this area and associated flow path was 0.072, which corresponds to vegetation consisting of short brush and weeds.
P = support practice factor (dimensionless)	1.0	There are currently no sediment and erosion controls in place at the Dravo Shipyard – Harbor Associates Property.

The average annual erosion rate is based on the windows based RUSLE2 program (RUSLE2 License, version 2006-Jul-24).

Based on the calculations performed, the total PCB loading from Area 2 of the Dravo Shipyard – Harbor Associates Property to the bio-swale via erosion under current site conditions is 20 grams per year.

Uncertainty Analysis Associated with Overland Flow:

Specific Areas and Degree of Uncertainty for the Dravo Shipyard – Harbor Associates Property

	Samples Per Acre (site)	Chemical Data Quality*	Topography	Soil Type	Site Coverage	Map Quality	Distance to Discharge Points
Site Specific Information	6.84	Immunoassay	Estimated using topography	Detailed logs that are located within the area of concern	Based on a thorough site assessment	Scaled Map	449 feet 131 feet
Degree of Uncertainty	Low	High	Moderate	Low	Low	Moderate	Moderate to High

* Primary analysis used in the historical samples

Sources of uncertainty for the Dravo Shipyard – Harbor Associates Property include the following: the majority of the samples were analyzed using screening methods, which present a higher uncertainty. A large proportion of the samples collected were large composite samples, which characterized more than five feet below ground surface (bgs). This can cause concentrations reported in the surface soil to be either higher or lower depending on the actual zone of contamination. In addition, a few samples were not found on any figures and could not be included in this assessment. During the site visit, BrightFields personnel noticed that the majority of the site had already undergone extensive redevelopment. During site activities for redevelopment original surface and subsurface soil could have been disturbed, relocated, removed, etc… from the site. BrightFields made the assumption that all reported concentrations have remained on the property. The mass loading calculation of the contribution of PCBs from surface soil in Area 2 assumes that all of the PCB-impacted material would be discharged to the bio-swale. Assuming that the bio-swale is 100 percent effective at retaining the sediment from overland flow then none of the PCB mass calculated would actually enter the river. Based on this evaluation the overall level of uncertainty associated with PCB mass loading via overland flow from the Shipyard – Harbor Associates Property is moderate.

GROUNDWATER DISCHARGE ANALYSIS

Groundwater discharge is based on the hydraulic conductivity of the soil, the groundwater gradient, and the cross-sectional area of the aquifer. A breakdown of the individual factors used in the Darcy equation is presented below.

Because PCBs were detected in saturated soil, but not in groundwater, the calculated concentration of PCBs in pore water, based on partitioning, was used to calculate the mass loading. An examination of the PCB data in the saturated zone indicates that there are three areas of PCBs

The calculated PCB concentration in the pore water ranges from 0.15 to 0.82 µg/L for Area 1 (TP6D/TP7D), 0.16 to 0.77 µg/L for Area 2 (TP32/33), and 0.006 to 0.03 µg/L for Area 3 (TP103B). The calculations are presented in Table B in the groundwater transport calculations attachment.

Input Factors:
A breakdown of the individual factors is presented below with a brief explanation of their choice.

Area A: Vicinity of TP6D/TP7D

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	14.2	42.5	Drilling logs from split-spoon samples from the BPA and test pit logs from the RI/FS were used to evaluate the lithology beneath the site. The logs show that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit lithology is predominantly a fine-grained sand. The hydraulic conductivity for fine-grained sand ranges from approximately 5×10^{-3} to 1.5×10^{-2} cm/sec (Cernica, 1995).
I = Horizontal Groundwater Gradient	0.007	0.009	In January 1999, EA measured depth to groundwater in 6 wells on the Harbor Associates property. The data from the 4 wells closest to the Christina River were used to assess the groundwater flow direction and horizontal gradient at the site. Calculations of the horizontal gradient from these measurements showed that the gradient of groundwater flows toward the Christina River (Table A).
Saturated Thickness (ft)	2	4	Based on the logs, the saturated thickness was approximately 2 to 4 feet
Lateral Discharge Distance (ft)	265	265	The lateral discharge distance was estimated to be equal to the length of the PCB impacted area measured parallel to the Christina River.
A= Cross-Sectional Area (ft2)	530	1,100	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	0.16	0.82	The maximum concentration observed in the saturated subsurface soil (0.75 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	580		Approximate distance from cross sectional area to the closest surface water location.

The PCB loading via groundwater discharge for Area A is between 0.45 to 3.6 milligrams per year. Please see attached table for specific variables.

Area B: Vicinity of TP32/33

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	14.2	42.5	Drilling logs from split-spoon samples from the BPA and test pit logs from the RI/FS were used to evaluate the lithology beneath the site. The logs show that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit lithology is predominantly a fine-grained sand. The hydraulic conductivity for fine-grained sand ranges from approximately 5×10^{-3} to 1.5×10^{-2} cm/sec (Cernica, 1995).
I = Horizontal Groundwater Gradient	0.007	0.009	In January 1999, EA measured depth to groundwater in 6 wells on the Harbor Associates property. The data from the 4 wells closest to the Christina River were used to assess the groundwater flow direction and horizontal gradient at the site. Calculations of the horizontal gradient from these measurements showed that the gradient of groundwater flows toward the Christina River (Table A).
Saturated Thickness (ft)	2	4	Based on the logs, the saturated thickness was approximately 2 to 4 feet.
Lateral Discharge Distance (ft)	160	160	The lateral discharge distance was estimated to be equal to the length of the PCB impacted area measured parallel to the Christina River.
A= Cross-Sectional Area (ft2)	320	640	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	0.15	0.77	The maximum concentration observed in the saturated subsurface soil (0.70 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	Directly adjacent		Approximate distance from property boundary to closest surface water location.

The PCB loading via groundwater discharge for Area B is between 0.25 to 1.9 milligrams per year. Please see attached table for specific variables.

Area C: Vicinity of TP103B

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	14.2	42.5	Drilling logs from split-spoon samples from the BPA and test pit logs from the RI/FS were used to evaluate the lithology beneath the site. The logs show that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit lithology is predominantly a fine-grained sand. The hydraulic conductivity for fine-grained sand ranges from approximately 5×10^{-3} to 1.5×10^{-2} cm/sec (Cernica, 1995).

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
I = Horizontal Groundwater Gradient	0.007	0.009	In January 1999, EA measured depth to groundwater in 6 wells on the Harbor Associates property. The data from the 4 wells closest to the Christina River were used to assess the groundwater flow direction and horizontal gradient at the site. Calculations of the horizontal gradient from these measurements showed that the gradient of groundwater flows toward the Christina River (Table A).
Saturated Thickness (ft)	2	4	Based on the logs, the saturated thickness was approximately 2 to 4 feet.
Lateral Discharge Distance (ft)	70	70	The lateral discharge distance was estimated to be equal to the length of the PCB impacted area measured parallel to the Christina River.
A= Cross-Sectional Area (ft2)	140	280	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	0.006	0.03	The maximum concentration observed in the saturated subsurface soil (0.027 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	Directly adjacent		Approximate distance from property boundary to closest surface water location.

Mass Loading Via Groundwater Transport Result:

The maximum detected soil concentrations from each sub-area were used to calculate the groundwater concentrations for the loading estimate. The estimated minimum and maximum contaminant mass loading contributions are shown in the Table C in the groundwater transport calculations attachment. As previously described, these calculations are highly conservative (protective), and they overestimate the actual mass loading because they assume that there are no contaminant losses due to degradation, dispersion, sorption, volatilization, etc.

The total PCB loading via groundwater discharge is between 0.7 and 5.6 milligrams per year (attached Table C).

Uncertainty Analysis Associated with Groundwater Transport:

Specific Areas and Degree of Uncertainty for the Dravo Shipyard – Harbor Associates Property

	Groundwater PCB Concentration	Hydraulic Conductivity	Horizontal Groundwater Gradient	Saturated Thickness	Lateral Discharge Distance	Distance to Discharge point
Site Specific Information	Partitioning based on maximum concentration observed in saturated soil (screening)	Conductivity based on good quality logs or geotechnical logs	Gradient based on few professionally surveyed wells and/or tidal influenced wells	High quality logs with saturated thickness	Laboratory sample data, acceptable ground-water flow data	Directly adjacent to 580 feet
Degree of Uncertainty	High	Moderate	Low to Moderate	Low to Moderate	Moderate	Low to Moderate

Based on this evaluation the overall uncertainty associated with the Dravo Shipyard – Harbor Associates Property is **moderate**.

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Figures