BrightFields, Inc.

Appendix 25

WILMINGTON COAL GAS SITE - NORTH
WILMINGTON, DELAWARE

SIRB ID: DE-1377 (FORMERLY DE-1046)

BrightFields, Inc.

GENERAL SITE INFORMATION

Site Name: Wilmington Coal Gas Site - North

SIRB ID Number: DE-1377 (formerly DE-1046)

Site Location and Description: The Former Wilmington Coal Gas Site – North (WCGS-N) is located at 301 and 401 South Madison Street. The WCGS-N is currently made up of two tax parcels (26-042.00-003 & 26-042.00-005) comprising an area of approximately 8.4 acres. The original WCGS-N parcel was known as DE-1046 and bound by South Madison Street to the east, Beech Street to the south, Linden Street to the north, and Interstate 95 and the Norfolk Southern Railway to the west (Figure 2). In 2006 the property was sold to Delaware Department of Transportation (Del DOT) and combined with the former City of Wilmington Public Works Yard Triangle Parcel (area north of Lower Linden Street, west of South Madison Street, and south and east of the elevated rail line) and both parcels make up a portion of a new DE-#, DE-1377 for Justison Redevelopment. However, for the purposes of this evaluation the site will be referred to as WCGS-N and only encompass the area between Linden Street and Beech Street.

Previous Site Uses: A carbureted water Manufactured Gas Plant (MGP) was built at the WCGS-N in 1889. Records indicate that prior to 1889 the site consisted of an undeveloped, marshy area. Operation of the MGP facility was delayed and the facility was acquired by the Wilmington Gas and Electric Company in 1904. Records indicate that manufactured gas production began on May 22, 1905 and continued through 1961. From 1949 through the mid-1950s, the site was also used for the storage of liquefied petroleum gas in four aboveground storage tanks.

From 1956 to the present, the site has been used for a variety of activities, including liquefied petroleum gas storage, material storage, natural gas operations, and maintenance activities. During this period of time, aboveground equipment and structures associated with the gas manufacturing were removed or demolished and portions of the site were paved. Delmarva Power operated the majority of the site most recently as a maintenance facility and storage yard. The property was purchased by DelDOT in 2006.

Site Regulatory Status: This section briefly summarizes previous investigations performed on the site through the SIRB program. A current SIRB regulatory status is also included.

A number of investigations have been conducted at the WCGS-N since 1986. Table 1 lists a chronology of investigations, reports, remedial actions, and regulatory actions. These investigations supported the initial Final Plan of Remedial Action for the WCGS-N issued by DNREC in September 2004.

Chronology of Investigations and Regulatory Actions

Investigation or Regulatory Action	Dates	Description
Preliminary Investigation (PI)	Oct. 86 – Jan.87	Investigation included Northern and Southern parcels of WCGS; soil gas sampling at 67 locations, background air sampling at 10 locations, 6 surface soil samples, one surface water/sediment sample, 11 shallow soil borings (B-1 through 9, 11 and 14); 2 deep borings (B-10 and B-15). All borings located on WCGS-N; B-1 through 4, 6,7,10, 14 and 15 were converted to monitoring wells (Atlantic, 1987).
Madison Street Widening Investigation	July 93	WIK well was installed on WCGS-N and sampled for various parameters as part of widening of South Madison Street and Beech Street (Earth Tech, 1994).
Facility Evaluation (FE)	April – May 94	FE primarily focused on the southern parcel. Monitoring wells installed during PI on the northern parcel and the WIK well was sampled as part of the FE (Earth Tech, 1994).
CSO #30 Investigation	Dec. 98	Two soil borings to 16 ft, two surface soil samples, 8 subsurface soil samples and 1 groundwater sample collected by the City of Wilmington (FWENC, 2002). Several metals and organics detected in soil and groundwater.
DelDOT Soil Investigation	Aug. 99	Delaware Department of Transportation (DelDOT) conducted 12 soil borings to 16 ft below ground surface (bgs) in the West Street Connector extension area. Arsenic and several organics detected (FWENC, 2002).
Remedial Investigation	Apr. – Jun. 97	Investigation included: 17 shallow soil borings (SB-16 through 32), conversion of 8 of these borings to temporary wells to monitor for free NAPL, abandonment of temporary wells after NAPL monitoring, 3 subsurface soil samples and 7 groundwater samples, UV fluorescence to screen for residual NAPL (Ruth, 2001).

Chronology of Investigations and Regulatory Actions (continued)

Investigation or Regulatory Action	Dates	Description
DelDOT Pole Barn Investigation	May 01	Two soil borings to 5-7 ft bgs in the central portion of WCGS-N. Several semivolatile organics (SVOCs) and arsenic detected (FWENC, 2002).
Supplemental Remedial Investigation (SRI)	Nov. 01 – May 02	SRI included 7 test pits to 2.5 ft bgs, on-site and off-site residual NAPL delineation borings (NDB-1 through NDB-53), 25 soil borings (B-33 through B-57), and 12 temporary wells (TPW-1 through 5 and 7 through 13). Arsenic and PAHs in soil, free & residual NAPL in 6 areas at 3-9 ft bgs (FWENC, 2002).
Supplemental Groundwater Investigation (SGI)	Sept. – Nov. 02	Six new temporary wells (TPW-14 through 17; 19, 20, and 21) installed; these along with 3 existing wells were sampled for various organics and metals; groundwater modeling performed to determine potential off-site migration of groundwater constituents (NTH, 2003).
Draft Focused Feasibility Study (FFS)	Oct. 03	Draft FFS evaluated five alternatives. Recommended alternative included a combination of on-site and off-site containment walls, free NAPL recovery system and capping (FWENC, 2003).
Supplemental Data Acquisition (SDA)	Mar. 04	Conducted in support of the draft Focused Feasibility Study; included 4 soil borings (E-1 through E-4), residual NAPL characterization, and free NAPL measurements; TPW-17 and WIK well contained 6.23 ft and 0.1 ft, respectively, of free DNAPL; free measurable DNAPL not detected in other wells (ENSR, 2004b).
Revised FFS	May 04	The draft FFS was revised by expanding the number of alternatives evaluated to 25 and revising the recommended alternative. The revised recommendations include moving the off-site containment wall on site, and added excavation of NAPL hotspot around TPW-17, and phytoremediation (ENSR, 2004c).
Pre-design Investigation	July 04	A pre-design investigation was conducted to support the development of remedial design for TPW-17 area excavation (ENSR, 2004).
Final FFS	July 04	The Revised FFS was finalized to address comments from DNREC. Significant changes included expansions of the discussions on the presence of arsenic in soil, groundwater modeling issues, and remedial timeframes. The Final FFS served as the technical basis for Proposed and Final Plans of Remedial Action (ENSR, 2004).

Chronology of Investigations and Regulatory Actions (continued)

Investigation or Regulatory Action	Dates	Description
Plan of Remedial Action	Sept. 04	The public comment period for the initial proposed plan began on August 23, 2004, and concluded at the close of business September 13, 2004. DNREC finalized the Plan of Remedial Action on September 29, 2004 (DNREC, 2004a).
TPW-17 Remedial Design and Work Plan	Nov. 04	TPW-17 Area Excavation design and work plan were submitted to DNREC in October 2004. DNREC's review comments were addressed in an Addendum dated November 17, 2004 (ENSR, 2004).
TPW-17 Area Excavation	Oct. 04	The excavation of the TPW-17 area was completed (ENSR, 2004).
Containment Wall, Phytoremediation and Cap Design and Work Plan	Feb. 05	A remedial design was proposed for the WCGS-N including a Containment Wall, Phytoremediation, and Cap design and an associated work plan (PHI Service Company, 2005).
Off-site Sampling and Risk Analysis	Mar. 05	Sampling and analysis was conducted for off-site Operable Unit 2 and was used to complete a risk analysis (ENSR, 2005).
WCGS-N North of CSO Investigation	Nov. 05	A subsurface soil investigation was conducted at the north end of the WCGS-N (ENSR, 2005).
Purchase of the Property by DelDOT	March 15, 2006	
In-situ Stabilization Treatability Study	April 06	Tests were conducted on soil collected from WCGS-N &-S to assess the feasibility of the ISS process (ENSR, 2006). Concluded it was feasible.
Additional Delineation Summary Report	June 06	Investigation included: 24 shallow soil borings, 17 shallow (0 to 2 feet bgs) soil samples for PCB characterization, 10 soil samples for disposal characterization, 9 of these samples were analyzed for PAHs and phenols. The investigation led to a new estimate of the spatial extent of residual NAPL based on historical and new NAPL data (BrightFields, 2006).
Geotechnical Investigation Environmental Summary	June 06	A total of 18 geotechnical borings were drilled and 23 test pits were excavated for evaluating the structural suitability of soil and to evaluate the subsurface conditions. Observations were made on the presence of contaminant impacted soil and 14 soil samples were collected for waste characterization analysis (BrightFields, 2006).

Chronology of Investigations and Regulatory Actions (continued)

Investigation or Regulatory Action	Dates	Description
Proposed and Final Plan of Remedial Action	Aug. through Oct. 06	DNREC developed a Proposed Plan of Remedial Action for the Justison Redevelopment Phase II Project. The following combination of remedial actions was proposed: 1) Hot Spot Removal and Stabilization, 2) Environmental Management During Construction, 3) Barrier Cap, 4) Vapor Barriers, 5) Groundwater Monitoring, and 6) Institutional Controls. The Final Plan of Remedial Action was issued in October 2006.
Additional Sampling Summary Report	Nov. 06	Investigation included: 10 soil borings to confirm the extent of residual NAPL in a few areas and 16 test pits to locate underground structures in proposed stabilization areas.

The Remedial Investigation (RI) conducted in April and June of 1997 outlined six areas of Non-Aqueous Phase Liquid (NAPL) contamination on the site including areas of coal tar wastes as well as petroleum hydrocarbon contamination. Since that time, additional delineation assessments have been completed to gain a better understanding of the limits of the residual NAPL areas.

Current Regulatory Status:

Following the purchase of the property by DelDOT and the change in future use of the site from industrial to commercial/residential, the selected remedial actions were re-evaluated and revised to select an option that allows future redevelopment of the site as a mixed use, commercial and residential area. In 2006, an In-Situ Stabilization (ISS) Bench-Scale Treatability Study (ENSR, 2006) was undertaken to evaluate whether ISS would be a viable remedial option for the site and several additional soil sampling events were performed to further delineate site contamination. A new Final Plan of Remedial Action was issued by DNREC in October 2006.

SUMMARY OF SITE PCB INFORMATION

Site Investigation PCB Findings:

PCBs (Aroclor-1254 and Aroclor-1260) were detected in 14 surface soil samples at concentrations ranging from 0.0098 mg/kg to 32.8 mg/kg. Reported concentrations of PCBs in the subsurface non-saturated soils ranged from 0.015 mg/kg to 20 mg/kg. The subsurface saturated soils had six detections ranging from 0.1 mg/kg to 10 mg/kg.

Due to the large spatial extent of the site, individual areas were assessed rather than comparing the site as a whole. This was done to incorporate the different overland flow pathways and to assess the different types of surface cover management factors more appropriately. Maximum concentrations observed within the individual areas were used in the overland flow calculations.

Three distinct areas were identified in the groundwater mass loading evaluation; the area in the vicinity of GP03, the northern section of the property, and the area in the vicinity of PC-5 and PC-19. The 95% UCL of the mean was calculated for the subsurface saturated soil in the northern area of concern on the property, but because the calculated value was higher than the maximum observed value, the maximum observed detection in the subsurface saturated soils was used in the partitioning equation to estimate pore water concentration. For the other two areas identified used the maximum reported concentrations associated with that area were used in the calculations.

Concentrations of PCBs on Site			
Sample Matrix	**Corresponding Figure**	**Analytical Methods**	**Range of Total PCBs**
Surface Soil	Figure 2	Method 8082	Not detected to 32.8 mg/kg
Subsurface Soil (unsaturated)	Figure 3	Method 8082	Not detected to 20.0 mg/kg
Subsurface Soil (saturated)	Figure 4	Method 8082	Not detected to 10.0 mg/kg
Ground Water	Figure 5	Method 8082	Not detected

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

Acreage where PCBs detected:

The total area associated with surface soils impacted by PCBs is 2.91 acres of which only 1.04 acres may be still contributing to via overland flow. The other 1.69 acres has been determined through the site cover evaluation to be under a temporary stockpile area or an impervious surface. Five areas of concern were identified during the evaluation of the surface concentrations. The total area of subsurface non-saturated soils impacted by PCBs is 1.59 acres. The subsurface saturated soils have been impacted by PCBs in three areas that are a total of 1.89 acres in size.

PCB Remediation Status:

The Final Plan of Remedial Action (DNREC, 2006) required hot spot removal of two PCB areas that contained total PCBs above 3 mg/kg and In-situ stabilization (ISS) of NAPL impacted areas. The first phase of this remediation was completed in August 2007 and included PCB soil removal around GP21 and excavation and ISS of NAPL impacted material.

The portions of the ISS that were completed in 2007 have been identified as remediation areas for the surface soils because the process of ISS mixes the soil in both the vertical and horizontal direction with a grout mixture. Once completed a layer of 6 to 12 inches of stone was placed on top to cover the area. As of the July 2008 site inspection, other areas of the site were being used as temporary staging areas, which helps minimize any surface erosion from original soils.

The second phase of the remediation, including excavation of the second PCB hot spot began in March 2009 and was completed in June 2009. However, this mass loading evaluation was performed prior to the initiation of the 2009 work and assumes conditions after the 2007 remediation.

PCB MASS LOADING SUMMARY

The PCB mass loading rate to surface water via overland flow is discussed below. The PCB mass loading rate to surface water via overland flow and via groundwater transport were estimated for the WCGS-N site. 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 specific factors are site specific and rely on local information of the site. A breakdown of the individual factors is presented below with a brief explanation of their choice.

Ground Cover and Canopy:

A site inspection was performed on July 30, 2008 to estimate the current site ground cover and canopy. Due to the size of the site and the different cover systems, BrightFields identified five separate areas of concern. The cover/management factor (C) assigned to the site and associated flow path is 0.011 to 0.45, which corresponds to areas of bare ground to areas that currently have a vegetative cover consisting of 75% groundcover of tall weeds or short brush, with the cover at the surface being grass, grass-like plants, decaying compacted duff, or litter at least 2 inches deep. Photographs of the site ground cover and canopy are attached.

Site Sediment and Erosion Control Practices:

Currently portions of the site that have not yet been developed (90%) are maintaining silt fence around the perimeter of the property. Areas that have been developed (Area 5) are not instituting any sediment and erosion techniques. Photographs of these sediment and erosion control techniques in use at the site are attached.

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 site

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)	0.365	The soil erodibility factor was chosen based on the information provided by the boring log represented for EX-08 in the Remedial Investigation Report-West Street Connector Extension (WIK 1999).
ls = topographic factor (dimensionless)	1.040	The slope length was estimated to 128 feet, which is the distance between the site and the closest storm water discharge location along the overland flow path. The assumed slope (1.1%) and slope length were used to calculate a topographic factor of 1.040 from the USGS windows based application.
C = cover/management factor (dimensionless)	0.332	The cover/management factor C assigned to the area by the USGS windows based application was 0.332, which corresponds to approximately a 25% cover with tall weeds and short brush.
P = support practice factor (dimensionless)	0.09	Silt fence is in place around the vicinity of this location.

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

The total PCB loading via overland flow for Area 1 is 0.01 grams per year. Please see attached table for specific variables.

Area 2: Southern 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)	0.237	The soil erodibility factor was chosen based on the information provided by the boring log represented for GP-16 and GP-17 in the Additional Delineation Summary Report (BrightFields 2006).
ls = topographic factor (dimensionless)	0.077	The slope length was estimated to 246 feet, which is the distance between the site and the closest storm water discharge location along the overland flow path. The assumed slope (0.4 %) and slope length were used to calculate a topographic factor of 0.077 from the USGS windows based application.

RUSLE Factors	Values Provided	Explanation of Selection
C = cover/management factor (dimensionless)	0.45	The cover/management factor C assigned to the site by the USGS windows based application was 0.45, which corresponds to bare ground.
P = support practice factor (dimensionless)	0.57	Silt fence is in place around the vicinity of this location.

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

The total PCB loading via overland flow for Area 2 is 0.05 grams per year. Please see attached table for specific variables.

Area 3: Center of the property adjacent to Hollingsworth Avenue

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)	0.276	The soil erodibility factor was chosen based on the information provided by the boring log represented for GP22 in the Additional Delineation Summary Report (BrightFields 2006).
ls = topographic factor (dimensionless)	0.107	The slope length was estimated to 89 feet, which is the distance between the site and the closest storm water discharge location along the overland flow path. The assumed slope (0.7 %) and slope length were used to calculate a topographic factor of 0.107 from the USGS windows based application.
C = cover/management factor (dimensionless)	0.45	The cover/management factor C assigned to the site by the USGS windows based application was 0.45, which corresponds to bare ground.
P = support practice factor (dimensionless)	0.13	Silt fence is in place around the vicinity of this location.

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

The total PCB loading via overland flow for Area 3 is 0.1 grams per year. Please see attached table for specific variables.

Area 4: Center of the property adjacent to Harlan Boulevard

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)	0.148	The soil erodibility factor was chosen based on the information provided by the boring log represented for GP04 in the Additional Delineation Summary Report (BrightFields 2006).
ls = topographic factor (dimensionless)	0.066	The slope length was estimated to 300 feet, which is the distance between the site and the closest storm water discharge location along the overland flow path. The assumed slope (0.3 %) and slope length were used to calculate a topographic factor of 0.066 from the USGS windows based application.
C = cover/management factor (dimensionless)	0.45	The cover/management factor C assigned to the site by the USGS windows based application was 0.45, which corresponds to bare ground.
P = support practice factor (dimensionless)	0.019	Silt fence is in place around the vicinity of this location.

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

The total PCB loading via overland flow for Area 4 is 0.002 grams per year. Please see attached table for specific variables.

Area 5: Northeast 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)	0.276	The soil erodibility factor was chosen based on the information provided by the boring log represented for GP22 in the Additional Delineation Summary Report (BrightFields 2006).
ls = topographic factor (dimensionless)	0.085	The slope length was estimated to 275 feet, which is the distance between the site and the closest storm water discharge location along the overland flow path. The assumed slope (0.5 ft/ft) and slope length were used to calculate a topographic factor of 0.085 from the USGS windows based application.

RUSLE Factors	Values Provided	Explanation of Selection
C = cover/management factor (dimensionless)	0.011	The cover/management factor C assigned to the site by the USGS windows based application was 0.011, which corresponds to 80% ground cover composed of grass, grass-like plants, decaying compacted duff, or litter at least 2 inches thick.
P = support practice factor (dimensionless)	0.13	Silt fence is in place around the vicinity of this location.

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

The total PCB loading via overland flow for Area 5 is 0.001 grams per year. Please see attached table for specific variables.

Uncertainty Analysis Associated with Overland Flow:

Specific Areas and Degree of Uncertainty for the WCGS-N

	Samples Per Acre (site)	Samples Per Acre (hot spot)	Chemical Data Quality*	Topography	Soil Type	Site Coverage	Map Quality	Distance to Discharge Points
Site Specific Information	3.8	~ 86	Method 8082	Estimated using topography	Detailed logs that are located within the area of concern	Based on a thorough site assessment	Scaled Map	128 feet 246 feet 89 feet 300 feet 275 feet
Degree of Uncertainty	Moderate	Low	Low to Moderate	Moderate	Low	Low	Medium	Moderate

* Primary analysis used in the historical samples

Sources of uncertainty for the WCGS-N include the following: topography has been well documented in the area, but it changes quite frequently due to the ongoing redevelopment activities. Groundwater depths were also not found for all sample locations. In these instances BrightFields inferred groundwater depths from sample locations in the vicinity of missing data or determination of subsurface saturated vs. subsurface non-saturated was based on sample moisture description (wet, saturated, etc…). The redevelopment activities that have taken place on the site have changed surface cover. BrightFields segregated areas of concern to evaluate the individual site surface conditions. In some instances the surface cover did not look like native soil, but because there was no documented, fill BrightFields evaluated the surface "as is". Based on these evaluations the overall level of uncertainty associated with PCB mass loading via overland flow from the WCGS-N site is **low to 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. The calculated PCB concentration in the pore water ranges from 100 to 10,000 µg/L. 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: Area in the vicinity of GP03

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	4.20	38.0	An examination of the drilling logs shows that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit ranges in composition from coarse-grained sandy silt to fine sand. The hydraulic conductivity for coarse-grained sandy silt to fine sand ranges from approximately 1 x 10^{-3} to 1 x 10^{-2} cm/sec (Cernica, 1995).
I = Horizontal Groundwater Gradient	0.0083	0.021	Calculations of the horizontal gradient were based on groundwater measurements from surveyed elevations in the shallow wells at the WCGS-N. The gradient is toward the Christina River.
Saturated Thickness (ft)	5	7	Based on the borings logs, the saturated zone above the marsh deposits averages approximately 5 to 7 feet thick.
Lateral Discharge Distance (ft)	40	40	The lateral discharge distance was chosen to be equal to the length of the PCB impacted area measured perpendicular to the Christina River.
A= Cross-Sectional Area (ft2)	200	280	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	2.19	11.0	The maximum concentration observed in the saturated subsurface soil in this area (10 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	620		Approximate distance from property boundary to closest surface water location.

The PCB loading via groundwater discharge for Area A is between 0.8 to 25 grams per year. Please see attached table for specific variables.

Area B: Northern Portion of the Property

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	4.20	38.0	An examination of the drilling logs shows that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit ranges in composition from coarse-grained sandy silt to fine sand. The hydraulic conductivity for coarse-grained sandy silt to fine sand ranges from approximately 1 x 10^{-3} to 1 x 10^{-2} cm/sec (Cernica, 1995).
I = Horizontal Groundwater Gradient	0.0083	0.021	Calculations of the horizontal gradient were based on groundwater measurements from surveyed elevations in the shallow wells at the WCGS-N. The gradient is toward the Christina River.
Saturated Thickness (ft)	5	7	Based on the borings logs, the saturated zone above the marsh deposits averages approximately 5 to 7 feet thick.
Lateral Discharge Distance (ft)	300	300	The lateral discharge distance was chosen to be equal to the length of the PCB impacted area measured perpendicular to the Christina River.
A= Cross-Sectional Area (ft2)	1,500	2,100	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	0.10	0.51	The average concentration observed in the saturated subsurface soil in this area (0.468 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	620		Approximate distance from property boundary to closest surface water location.

The PCB loading via groundwater discharge for Area B is between 0.28 to 8.9 grams per year. Please see attached table for specific variables.

Area C: Area in the vicinity of EX09

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
K = Hydraulic Conductivity (ft/day)	4.20	38.0	An examination of the drilling logs shows that the groundwater being monitored is within a moderately coarse-grained fill unit that overlies the marsh deposit clay. The fill unit ranges in composition from coarse-grained sandy silt to fine sand. The hydraulic conductivity for coarse-grained sandy silt to fine sand ranges from approximately 1 x 10^{-3} to 1 x 10^{-2} cm/sec (Cernica, 1995).
I = Horizontal Groundwater Gradient	0.0083	0.021	Calculations of the horizontal gradient were based on groundwater measurements from surveyed elevations in the shallow wells at the WCGS-N. The gradient is toward the Christina River.
Saturated Thickness (ft)	5	7	Based on the borings logs, the saturated zone above the marsh deposits averages approximately 5 to 7 feet thick.

Groundwater Transport Factors	Value Used		Justification/Derivation of Value Used
	min	max	
Lateral Discharge Distance (ft)	95	95	The lateral discharge distance was chosen to be equal to the length of the PCB impacted area measured perpendicular to the Christina River.
A= Cross-Sectional Area (ft2)	475	665	Calculated from the saturated thickness and lateral discharge distance.
Groundwater PCB Concentration (ug/L)	0.022	0.11	The maximum concentration observed in the saturated subsurface soil in this area (0.1 mg/kg) was used to determine the estimated concentration in groundwater.
Distance to Discharge point (ft)	620		Approximate distance from property boundary to closest surface water location.

The PCB loading via groundwater discharge for Area C is between 0.02 to 0.60 grams per year. Please see attached table for specific variables.

Mass Loading Via Groundwater Transport Result:

The groundwater discharge is 2,150 to 68,800 L/day (attached Table A). 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 1 and 35 grams per year (attached Table C). However, the area around GP03 which is estimated to contribute between 0.8 and 25 grams per year was not excavated at the time this evaluation was initially performed in April 2009, but has since been excavated.

Uncertainty Analysis Associated with Groundwater Transport:

Specific Areas and Degree of Uncertainty for the WCGS-N

	Groundwater PCB Concentration	Sample Density	Hydraulic Conductivity	Horizontal Groundwater Gradient	Saturated Thickness	Lateral Discharge Distance	Distance to Discharge point
Site Specific Information	Partitioning based on maximum concentration	Moderate number of samples	Based on detailed site logs.	Few points with groundwater measurements.	Multiple good quality	Good groundwater gradient defined and a moderate	620 feet

	observed in saturated soil				logs	number of samples collected on-site.	
Degree of Uncertainty	Moderate - High	Low to Moderate	Moderate	Moderate	Low to Moderate	Moderate	High

Based on this evaluation the overall uncertainty associated with PCB mass loading via groundwater transport from the WCGS-N is **moderate**.

Site References:

Atlantic Environmental Services (Atlantic), February 1987, Preliminary Investigation Wilmington Manufactured Gas Plant, February 4, 1987.

BrightFields (2006). Additional Delineation Sampling Wilmington Coal Gas Site – Northern Parcel. June 19, 2006.

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