

Preliminary Investigation of the Potential for River Sediment Transport of
PCBs from the Horton Iron & Metal NPL Site to areas within a 3.9 mile
Cape Fear River Study Area near Wilmington, NC

By

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Abstract

Daniel, Shawna. Master of Environmental Assessment. *Preliminary Investigation of the Potential for River Sediment Transport of PCBs from the Horton Iron & Metal NPL Site to areas within a 3.9 mile Cape Fear River Study Area near Wilmington, NC.*

A preliminary investigation of polychlorinated biphenyl (PCB) congener concentrations in the Cape Fear River near the Horton Iron & Metal National Priorities List (NPL) site was conducted in the spring of 2014; both sediment and water samples were collected for chemical analysis. The investigation was prompted by previous studies which indicated the presence of PCBs, polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and several metals in the sediments of the boat slips associated with the NPL site, as well as the presence of PCBs and metals in the sediments and water of the nearby Cape Fear Community College (CFCC) boat operations basin. PCB congeners were detected throughout the 3.9 mile stretch of the Cape Fear River that comprised the study area with PCB congeners 206 and 209 being both the most prevalent (detected in 9 of the 20 sediment samples) and in the highest per-sample concentrations. Of the 21 PCB congeners tested for in the samples, 11 congeners were detected (IUPAC 52, 101, 105, 118, 128, 138, 153, 180, 187, 206, and 209) with individual congener concentrations ranging from 0 to 15.77 ng/g in single sediment sample analysis. Maximum concentrations for the two most prevalent PCBs, 206 and 209, were found in sediment samples from the Horton boat slips (15.77 ng/g and 5.10 ng/g, respectively). Maximum summed PCB concentrations (Σ PCBs) for individual sediment samples were found to be 29.64 ng/g at a sample site located approximately 1250 feet from the Horton site, 22.72 ng/g at the Horton site, and 28.87 ng/g at the CFCC operations basin. Maximum Σ PCBs for individual water samples were found to be 3.91 ng/g in the CFCC basin (PCBs 105, 138, and 153). Concentrations of individual PCB congeners 52, 101, 187, 206, and 209 do appear to show a possible gradient effect in the sediments between the Horton basin and CFCC basin that may be indicative of PCB transportation; sample size for this study was too small to definitively delineate such a gradient. With PCB concentrations exceeding current no-risk thresholds (3.6×10^{-6} to 14 ng/g for total PCBs in sediment, dry weight), potential for adverse human and environmental health effects may be a concern at this site. This study warrants further investigation to examine the extent and distribution of PCB contamination as well as the existence of other contaminants with the potential to elicit adverse environmental effects.

Biography

Shawna Daniel's interest in the sciences began in high school where an Environmental Biology teacher introduced her to both the constructive and destructive impacts humans have on the environment. Shawna excelled in physical and life sciences, and soon discovered that she had a true passion for learning more about one of our greatest resources, the ocean. It seemed only logical to then pursue a career in Marine Biology.

At the age of 18, Shawna attended the University of North Carolina at Wilmington, majoring in Marine Biology with minors in Chemistry and Psychology. She was exposed to a full range of biology and chemistry courses, all of which affirmed and intensified her fascination with the sciences. After receiving her Bachelor's degree in 2003, she was excited to discover another school that would allow her to gain field experience with oceanographic instrumentation and biological sampling gear on an oceangoing vessel. Two years of extensive study, field work, and lab analysis in the Marine Technology Program at Cape Fear Community College afforded her a second degree, an Associate of Applied Science in Marine Technology with Departmental Honors.

With two reputable degrees in hand, Shawna obtained a position as a fisheries observer for the National Marine Fisheries Service in Montauk, New York. She collected data from commercial fishing vessels working at sea on the northeast coast from Maine to North Carolina. After sixteen months as a federal fisheries observer, she was contacted by her alma mater, Cape Fear Community College, with a job offer she could not refuse. Shawna was invited to be an instructional technician and teach college students in the marine sciences; she accepted immediately.

During her eight year tenure at Cape Fear Community College, Shawna has been charged with laboratory maintenance, inventory, and student direction for laboratory procedures in Marine Biology, Marine Vertebrate Zoology, Marine Invertebrate Zoology, Oceanography, and Water Analysis classes. She also facilitates field work with the students for biological collections of flora and fauna from the salt marsh, estuary, inlet, floating dock, beach, and river environments. Correspondingly, Shawna also acts as one of the chief scientists on the R/V Cape Hatteras during which she directs and supervises research activities with the students; activities include biological sampling with trawls, dredges, and bottom grabs; chemical water sampling with CTDs and Niskin bottles; and bottom surveying with a video sled, side scan sonar, and magnetometer.

Currently, Shawna is pursuing her goal of becoming a bona fide faculty member in the Marine Technology department. With the completion of her Master's Degree in Environmental Assessment at North Carolina State University, Shawna will take on the responsibility of being the lead instructor for the Water Analysis classes and labs in January of 2015. Additionally, she has been asked to design and teach a new Environmental Sampling and Analysis course set to begin in August of 2015; Shawna hopes to use this new course to continue the study of contaminant transport in the Cape Fear River.

Outside of work, Shawna enjoys spending time with family and friends and playing with her three dogs. She also spends part of her weekends as a behavioral therapist for children with autism – a part of her life that provides her with an ever-evolving perspective on the world and continues to act as a catalyst for her personal growth.

Acknowledgements

First and foremost, I would like to express my immense gratitude for the love and support I have received from my fiancé, Marty Rowe. He has given me the pep talks I needed when I was completely frazzled after an all-nighter working on an exam, taken care of the dogs when I was glued to the computer writing a paper, completed the house chores when I had my nose in a book, and brought me the gallons of coffee that were necessary to keep me up on all of those late nights. The completion of this degree simply would not have been possible without your patience and understanding.

I would also like to thank my extremely supportive colleagues and students in the Marine Technology department at Cape Fear Community College who encouraged me to pursue this degree, volunteered their time to help me complete my final project, and offered guidance when I needed it. Specifically, I would like to thank Peter Simpson for sharing his knowledge and photo collection of the history of Wilmington and for captaining the boat during the sampling portion of my project; Tim Shaw for preparing my sampling gear and sharing his knowledge of EPA sampling protocols; Joel Clem for always having the boat ready for my departures; Garrett Gertz, Zach Allred, Ritchie Carr, and Adrian Moon for being the best volunteer field technicians; and Jason Rogers and Jacqui Degan who have been graciously flexible with their schedules to accommodate my needs, always willing to read and edit my many papers, and readily available to offer professional guidance on navigating all things grad school. And a special thank you to Jason Rogers for adding a humorous slant in the moments of my highest stress; you consistently reminded me to write as though no one was going to read it, always add a few more acronyms, and supplement everything with highly confounding stats and gratuitously prodigious articulations. Thank you for always making me smile.

I would also like to acknowledge my biggest fans and support team, my mom and dad, Frances and Hoyt Daniel. It has been your loving encouragement, guidance, and support that have pushed me to work hard and achieve my goals.

Finally, I would like to convey my abundant gratitude to the faculty and staff at NC State who have helped me along my journey. To Dr. Waverly Kallestad, thank you for being such an amazing professor and advisor – your teaching style and personality made your classes highly enjoyable and enlightening, and your guidance and insights ultimately made this final project possible. To Dr. Damian Shea and Peter Lazaro, thank you for analyzing my samples and providing explanations for my many questions from start to finish of this project. To Dr. Elizabeth Nichols, thank you for giving me the tools to write a monitoring plan which ultimately led me to want to undertake this study. And, to Linda Taylor, thank you for always being available to answer questions and guide me through the Environmental Assessment program process.

Introduction

Cape Fear River Basin

As the largest watershed contained fully within North Carolina (9,164 square miles), the Cape Fear River basin includes a total tributary stream length of 6,684 miles occurring within 27 of the state's counties.^{1,2} The headwaters for the main-stem of the Cape Fear River begin in the piedmont hills near Greensboro, North Carolina as two tributaries, the Deep and the Haw rivers. The Lower Cape Fear River (LCFR) flows as a confluence of the main-stem with two other major tributaries, the Northeast Cape Fear River (NECFR) and the Black River which are sourced entirely within the coastal plain area where they drain several riverine swamp forest areas.¹ The LCFR flows southward for approximately 24 miles before emptying into the Atlantic Ocean between Fort Caswell and Baldhead Island (Figure 1).²

The main-stem of the river primarily flows over a sandy/clay bottom with patches of silt along the banks. Conversely, the coastal plain tributaries are characterized by a near absence of clay and an abundance of organic matter that leach tannins into the water causing it to appear darker in color; it is due to this composition that the NECFR and the Black river are termed "blackwater rivers".^{1,4}

Hydrography of the river has been altered by the addition of several reservoir impoundments (e.g., Jordan Reservoir just south of Durham), over 1,100 dams, and three southeastern lock and dam systems.^{5,6} The impoundments are primarily used as drinking water reservoirs and habitat protection areas. The dams have been built over the years for a multitude of reasons including the production of hydroelectric power and the storage of drinking water. Many of the dams have been abandoned and no longer serve a municipal function.⁶ The lock and dam systems were constructed in the early 1900's to pass commercial traffic up and down the river; currently, the locks and dams are rarely used to lock large vessels through, and are alternatively used to protect the water intakes for cities and industries along the river by backing up the water flow at these areas.⁷

Flow speeds of the Cape Fear River fluctuate seasonally with minimum flows occurring in the late summer and early autumn months, and peak flows arising in the winter and spring (Figure 2). Overall, this flow pattern results in an annual mean discharge of approximately 267 m³/s.^{4,8} Most of the flow in the river originates from its piedmont tributaries with the last 34 miles of the river having a tidal influence resulting in an estuarine environment in the lower reaches that includes approximately 43 square miles of essential estuarine habitat.¹

Of the fourteen watersheds in North Carolina, the Cape Fear River basin is the most highly populated and industrialized.⁴ More than two million people, approximately 20% of the state's population, reside within the Cape Fear River basin area.² In 2011, the National Land Cover Database (NLCD) reported that land within this basin was 32.6% forested land, 21% agricultural and livestock production land, 11.5% developed/urbanized land, 17.6% wetlands, and 17.3% other classifications (i.e., open waters, barren lands, grasslands).⁹ With such a high surrounding population, the Cape Fear River has become an important water source for both public water consumption and industrial usage; it has also become an area with a significant influx of both point and non-point source pollutants.⁵ The estuary region, however, does appear to be a well-flushed system, with a median flushing time of about seven days (flushing times range from 1.2 to 22 days).¹⁰

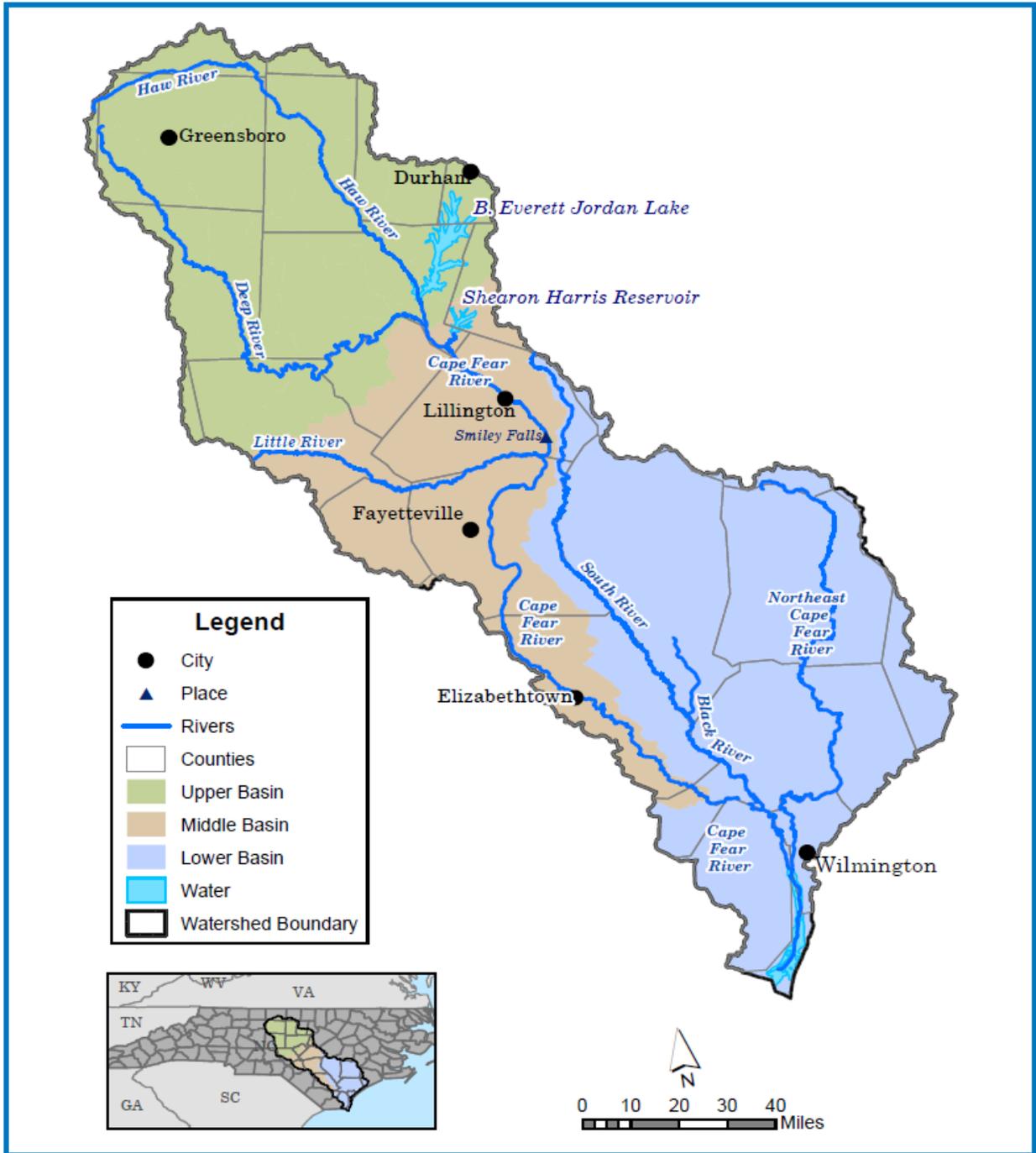


Figure 1. Cape Fear River Basin

Depiction of the main-stem and major tributaries of the Cape Fear River.

Image Source: Cape Fear River Partnership ³

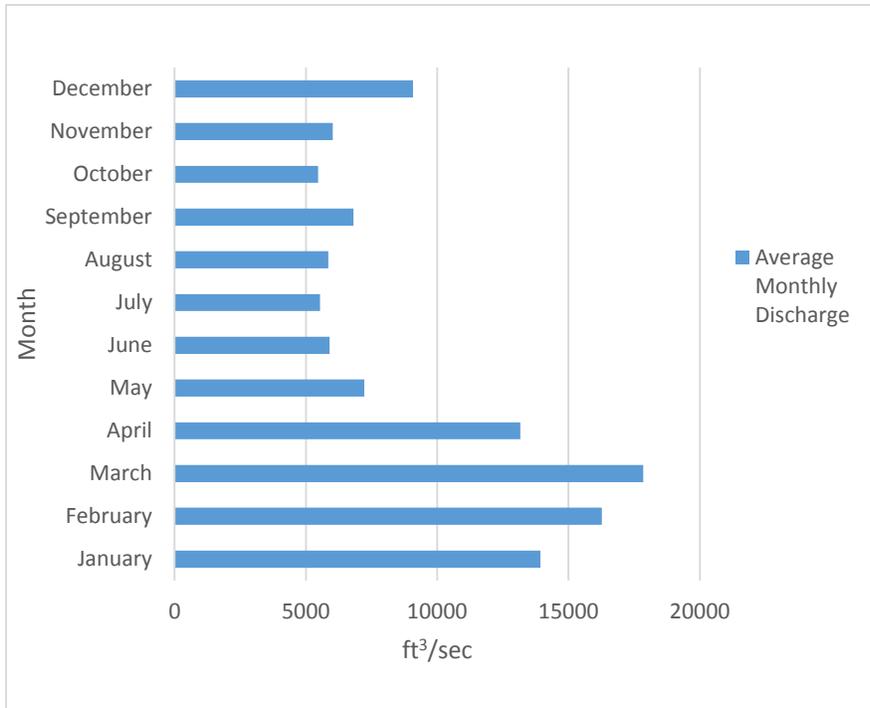


Figure 2.
Cape Fear River Monthly Average Discharge.

Average discharge calculated based on CORMP streamflow data collected from four monitoring stations: (1) Black River near Tomahawk, (2) NECFR near Chinquapin, (3) Lock and Dam #1 near Kelly, NC, and (4) Cape Fear River Discharge at mouth. This dataset was averaged from daily averages available on the CORMP website from September 1, 1969 through October 26, 2014.⁸

Site Description

The Cape Fear River study site (hereinafter referred to as “the site”) comprises approximately 3.9 miles of the Cape Fear River near downtown Wilmington, North Carolina. The site is inclusive of one of the major confluences of the Cape Fear River system in which the main-stem of the Cape Fear River intersects one of its largest tributaries, the NECFR, to flow southward as the LCFR.

The site covers approximately 0.9 miles of the LCFR and 3 miles of the NECFR that lie within the boundary lines of the Cape Fear Memorial Bridge to the south, the mouth of Ness Creek to the north, and the banks of the Cape Fear River to the east and west (Figure 3). The Cape Fear River and its associated wetlands run approximately north to south over the extent of the site.

The land area surrounding the site boundaries is a mixed-use area. In the NECFR portion of the site, the west banks are predominantly comprised of industrial and commercial use properties, while the east banks are primarily wetlands and marinas. At the confluence of the main-stem of the Cape Fear River and the NECFR (known as “Point Peter”), Downtown Wilmington can be found on the east bank and Eagle Island on the west bank. Downtown Wilmington includes both commercial and residential lands, while much of the 3,100 acres of Eagle Island consists of wetlands that have been set aside as a nature preserve. Eagle Island has additionally berthed the battleship USS North Carolina as a memorial park since 1961, and the southern portion of the island is used by the U.S. Army Corps of Engineers (USACE) and the NC Division of Soil and Water Conservation as the locations for their Wilmington and New Hanover District offices, respectively.¹² The USACE also uses 1,473 acres of the island for dredge material disposal during channel dredging activities; some dredge materials are later relocated offshore or repurposed as a component in manufactured topsoils.¹³



Figure 3. Site Locations and Surrounding Areas

(A) Cape Fear Memorial Bridge; (B) Battleship USS North Carolina; (C) CFCC Dock and Basin - sampling sub-site; (D) Confluence of the Cape Fear River and the NECFR, called "Point Peter"; (E) Isabel Holmes Bridge; (F) Hilton Railroad Bridge; (G) Horton Iron & Metal – NPL site.

Base Orthophoto Source: GoogleEarth ¹¹

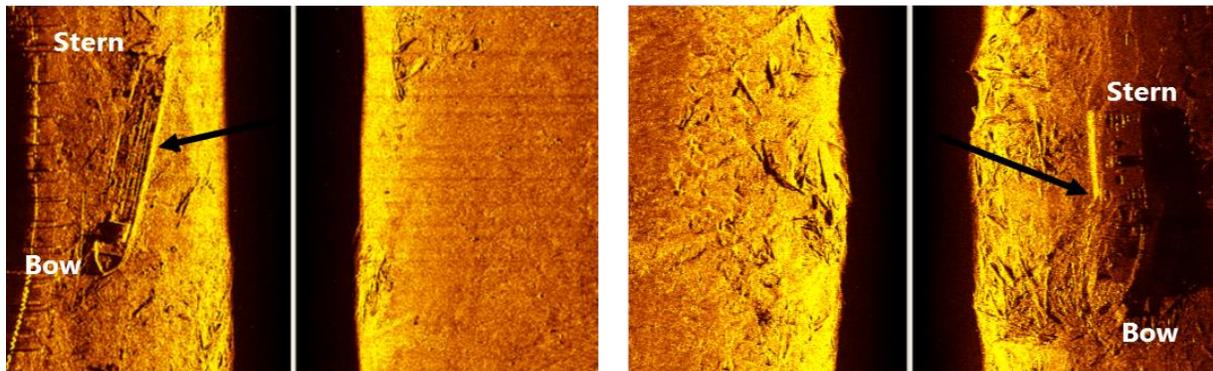
The 3.9 mile site is purposefully situated wholly over the river and its immediate embankment areas, because the main goal of this study was to investigate sediments. Water depths at the site are maintained at navigable depths by the USACE; the channel is regularly dredged to 38 feet deep from the Cape Fear Memorial Bridge to a point 750 feet above the Hilton Railroad Bridge, and to 34 feet for approximately 1.3 miles north of the Hilton Railroad Bridge. The authorized width of the channel over this same area is 250 feet. Outside of the channel, depths vary widely, but quickly become shallow (0 to 20 feet) forming steep embankments on either side of the river.¹⁴ In addition to the steepening of the river's banks, there are also several partially or wholly submerged historical artifacts such as three paddlewheel steamboats, several tugboats,

parts of at least 14 barges, one ferry, and the remains of abandoned docks and railways that litter the edges of the river (Figure 4).¹⁶ Other obstructions that are common along the edges of the river in this area include pipes, cables, and natural debris (e.g., logs, branches, rocks). The presence of these objects is especially prevalent on the west bank from the Cape Fear Memorial Bridge to the Isabel Holmes Bridge.

Figure 4. Examples of Submerged Vessels within the Site Area.

(A) The *A.P. Hurt* is a submerged 135-ft, iron steamboat located in 20-ft of water on the east bank of the LCFR, just north of the Cape Fear Memorial Bridge. The *A.P. Hurt* sank on March 26, 1923 and its remains, as seen here, are nearly fully intact. (B) The *John Knox* is a submerged 80-ft, diesel powered ferry boat located in 15-ft of water on the Eagle Island side (west bank) of the LCFR, directly across the river from the *A.P. Hurt*. The *John Knox* sank in June of 1937; although its superstructure and decking are gone, the hull remains mostly intact. See Appendix A for historical photos of both vessels when they were operable.

(Images were shot using side scan sonar in the spring of 2014 by Tim Shaw (CFCC Marine Technology Department))



(a) *A.P. Hurt*

(b) *John Knox*

Problem Statement & Study Objective

Cape Fear Community College (CFCC), in Wilmington, North Carolina, operates a fleet of training research vessels as part of their Marine Technology Program's curriculum. All vessel operations are initiated at the CFCC dock, and movement of many of the vessels to and from this dock is dependent on having a sufficient water depth in the adjacent operations basin (Figure 5).

Over time, the CFCC operations basin has filled in with sediment; the Cape Fear River has a tidal influence in this region and experiences both ebb and flow currents which transport sediments from nearby areas. As the basin has filled in, water depths have decreased drastically; at low tide, several areas in this basin may see water depths of less than one foot. At such shallow depths, boat operations are impractical. It was determined that approximately 10,000 cubic yards of sediment needed to be removed to restore full functionality to the basin. Funds were procured by the college to dredge the basin, and in 2008 a sediment evaluation was conducted by CATLIN Engineers and Scientists to assess the sediment and determine disposal options for potential dredge material. Unfortunately, the evaluation noted that the sediments in the basin are contaminated with several hazardous chemicals including metals (arsenic, lead, mercury, cadmium, chromium, barium, and silver), polychlorinated

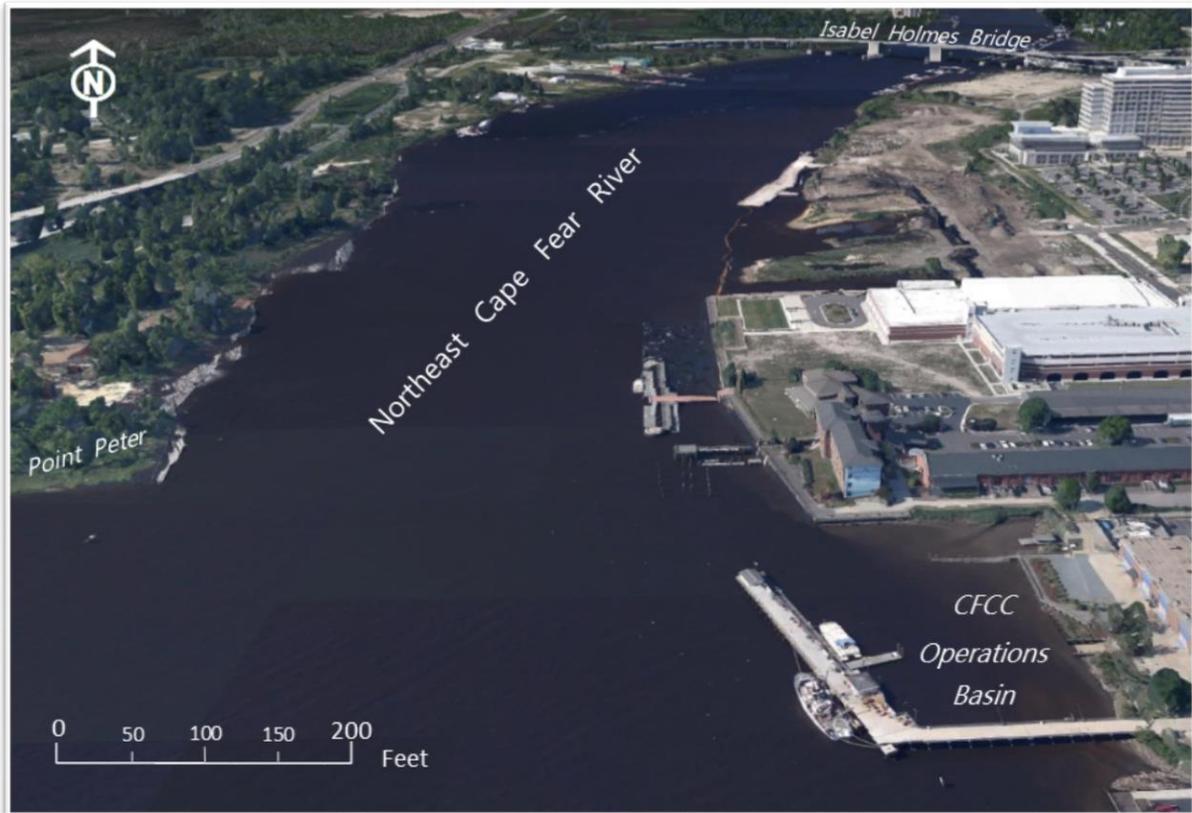


Figure 5. Location of CFCC Operations Basin.

The CFCC Operations Basin is located on the east bank of the Cape Fear River at the confluence of the main-stem of the Cape Fear River and the Northeast Cape Fear River.

Base Orthophoto Source: GoogleEarth ¹⁵

biphenyls (PCBs) (Aroclor-1254 and Aroclor-1260), and pesticides (4, 4'-DDT, Dieldrin, and Toxaphene). Due to these contaminants, the expense for removal/disposal of dredge material proved to be more than the budget permitted. As of the date of this report, no dredging has been conducted and no dredging is currently planned.

There may be a variety of scenarios, both historical and current, that could have led to this contamination; however, the two most immediately apparent, potential sources of contamination in the basin are as follows:

- 1) The City of Wilmington has two stormwater discharge outfalls located in the basin. The stormwater was tested in 2008 by CATLIN, and arsenic, lead, chromium, barium, silver, and mercury were detected; however, the findings were deemed inconclusive due to issues with sampling methods, and further testing was recommended. However, additional testing was never conducted to clarify CATLIN's report.
- 2) In 2011, the Horton Iron and Metal site was listed by the U.S. Environmental Protection Agency (EPA) on the National Priorities List (NPL). This NPL site (site "G" in Figure 3) is located

approximately 1.8 miles up the Northeast Cape Fear River from the CFCC basin (site “C” in Figure 3). All of the contaminants previously detected in the CFCC basin have also been detected at the Horton Iron and Metal NPL site.

The main objective of this study was to conduct a preliminary survey of the sediments found at and around both the CFCC operations basin and the basins associated with the Horton Iron and Metal NPL site to investigate the potential for transport of contaminants from one site to the other and to determine if any transport of PCBs could be detected. This study planned to assess the transport of PCBs via the comparison of sediment samples taken from locations progressively further away (both north and south) from the Horton and CFCC basins in an effort to detect a gradient of PCB concentrations that would demonstrate movement of the contaminant. Additionally, this study aimed to re-test the stormwater discharge to assess its potential for contributing contaminants to the CFCC basin.

CFCC Operations Basin: Description & Historical Background

The CFCC operations basin is located on the east bank of the Cape Fear River directly behind the Burnette building on CFCC’s downtown campus (34°14’24.94” N, 077°57’08.74” W). The basin covers a roughly rectangular area measuring approximately 410 feet along the shoreline and 304 feet from the shoreline to the Cape Fear River proper. Depths vary in the basin based on both tide height and location within the basin, but typically range from 0 to 6 feet. An L-shaped dock has been constructed in the basin to berth both the 135-foot *R/V Cape Hatteras* and the 53-foot *R/V Martech*. Additionally, there is a small boat ramp located near the middle of the basin’s shoreline that serves as a launch area for several of CFCC’s smaller boats, and the City of Wilmington has located stormwater runoff outfalls in both the northeast and southeast corners of the basin.

The waterfront at this site originally operated in the 1800s and early 1900s as commercial docks that were ideally situated directly in front of both the terminus of the Atlantic Coast Line Railroad and the Cotton Exchange buildings. See Appendix A for historical photos of the Cape Fear River area. With this prime location, this area was a hotspot for barges and other river vessels to move goods up and down the river; downtown Wilmington soon became the city’s main commercial sector. In 1955, however, the Atlantic Coast Line Railroad announced that it would leave the area for a new home in Florida. This was a major blow to Wilmington’s downtown area as many of the commercial operations that relied on the railway soon followed suit and moved as well.¹⁷

In 1957, the North Carolina General Assembly passed a bill to fund the creation of a system of Industrial Education Centers around the state. Wilmington was one of seven cities selected as a site for the construction of one of these education centers, and in 1959, the Wilmington Industrial Education Center (WIEC) opened at a 32,000 square foot facility on the corner of Thirteenth and Market streets near downtown Wilmington. The demand for classes was high, and the school quickly outgrew its facilities.¹⁷

In 1963, the North Carolina State Legislature approved the Community College Act, and WIEC became Cape Fear Technical Institute (CFTI) in 1964. As the demand for classes continued to grow, a need for new facilities became imperative. It was decided that the institute’s new facilities would be located on the waterfront of downtown Wilmington and would be constructed using part of the \$58.8 million city project funds to reestablish the riverfront. The new facilities opened in 1967 and allowed CFTI to enroll

more students. With its new location on the riverfront CFTI was also able to expand its program offerings to include a Marine Technology program. The Marine Technology program was the first of its kind in the state and the second in the nation. The program's training included hands-on experience in commercial fishing, aquaculture, boat building, marine salvage and engineering, diving, sailing, and environmental protection. The students even attended their classes on a 120 foot long, 62 foot high World War II barge, the *Alton A. Lennon* which was moored on the waterfront (in the eventual location of the CFCC operations basin). The waterfront was also used from 1965 to 1981 to dock the Marine Technology program's research vessel, the S.S. Advance II.¹⁷

In 1982, CFTI procured the *R/V Dan Moore* to replace the S.S. Advance and a new dock was constructed around the operations basin and the *Alton A. Lennon*. In September of 1987, the barge-turned-schoolhouse was taken offshore and detonated to become part of the State Artificial Reef 386. The removal of the barge from the waterfront opened up the basin and made it more suitable for small boat operations.¹⁷

In 1988, CFTI changed its name again to Cape Fear Community College (CFCC). As the college grew, so did the Marine Technology department. Since then, the department has added more vessels to its training fleet including the *R/V Martech* (a 53 foot diesel powered aluminum catamaran) and several skiffs and jon-boats. In 2013, the department replaced the *R/V Dan Moore* with the larger *R/V Cape Hatteras* which docks on the river side of the CFCC operations basin where depths are sufficient for its draft.¹⁷

Horton Iron & Metal NPL Site: Description & Historical Background

The property currently owned by Horton Iron and Metal Company (hereinafter referred to as the Horton property) has operated as some form of an industrial facility since the early 1900's. Located at 2216 U.S. 421 North, Wilmington, NC, the site is bounded by U.S. Highway 421 to the west, the NECFR to the east, a fertilizer manufacturing plant (VCC-Almont Works/Agrium, Inc.) to the north, and an abandoned ship breaking facility to the south (Wilmington Resources and Sigma Recycling) (Figure 6).

The Horton property currently encompasses approximately 37 acres with nearly 1200 feet of shoreline on the NECFR which includes two large boat slips; there is a concrete pad and remnants of a railroad line located between the two boat slips. Additionally, large fragments of ships and barges are still present in the boat slips which are overgrown with coastal shrubs and grasses, and remnants of buildings from former operations can be seen on the property in the areas of previous fertilizer manufacturing and ship breaking.

The Horton property was owned by American Agricultural Chemical Company from 1911 to 1949, Naco Fertilizer Company from 1949 to 1954, and W.R. Grace from 1954 to 1959. All three companies operated as phosphate fertilizer manufacturing plants which may have potentially contributed contaminants to the surrounding area such as arsenic, cadmium, copper, lead, mercury, vanadium, zinc, platinum, asbestos, PCBs, and polycyclic aromatic hydrocarbons (PAHs). The fertilizer manufacturing facilities were located on approximately 7.4 acres of the easternmost portion of the property (between the railroad and the NECFR). During American Agricultural Chemical Company's occupancy of the

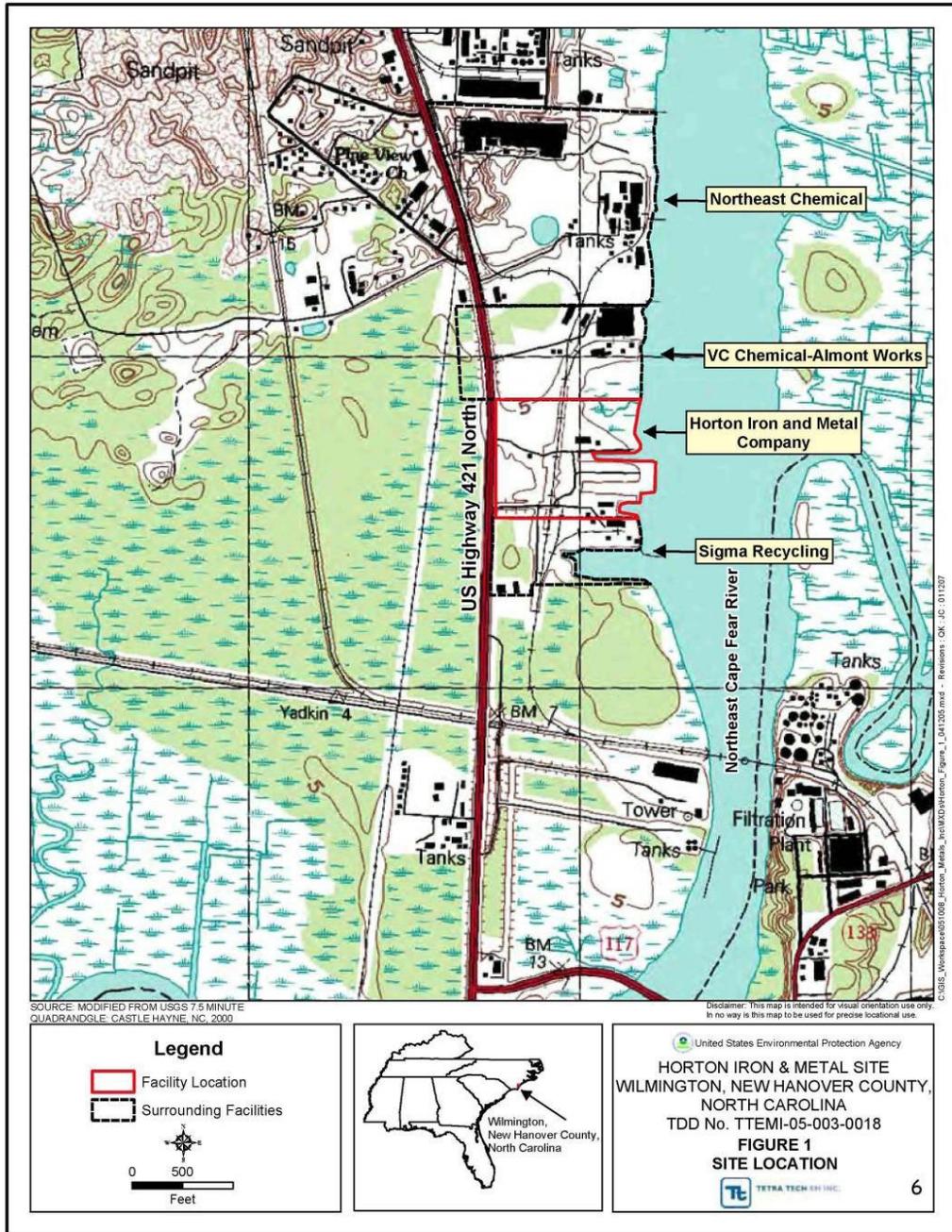


Figure 6. Horton Iron & Metal NPL Site and Surrounding Facilities.

The Horton Iron & Metal Site is located in Wilmington, NC on the west banks of the NE Cape Fear River. It is immediately bordered to the north by VCC-Almont Works (former phosphate fertilizer manufacturing that currently operates as Agrium, Inc. manufacturing nitrogen fertilizers), and by Sigma Recycling (former ship-breaking operations) to the south. Additionally, the Northeast Chemical Company can be found just north of VCC-Almont Works. The Northeast Chemical property previously operated as a phosphate fertilizer facility (1906-1980s) and a portion of that property has been functioning as a sulfuric acid manufacturing facility since 1982.

Image Source: ATSDR¹⁸

property, a lead-lined sulfuric acid chamber building was constructed near the northernmost boat slip on the property. The acid chamber was disassembled and partially removed from the site in 1921. Remnants of this chamber are still present today.^{18, 19}

W.R. Grace sold the property to Horton Iron & Metal Company in 1959, and in 1962 Horton Iron & Metal Company leased the property to Horton Industries for ship breaking and recycling operations. Horton Industries functioned as a salvage yard for World War II ships from 1962 to 1972; as such, operations were primarily conducted in the two boat slips located along the NECFR. Potential contaminants associated with ship breaking operations include asbestos, PCBs, PAHs, barium, cadmium, chromium, copper, lead, nickel, and zinc. Horton Industries dredged the two boat slips sometime in the 1960's, and the dredge material was placed around the northern, western, and southern edges of the slips.¹⁸

After the conclusion of ship breaking operations in 1972, Horton Iron & Metal Company reclaimed the property and began operating a scrap iron and metal recycling facility in the central portion of the Horton property. Horton Iron & Metal Company is still in ownership of the property today and continues to operate as an iron and metal recycling facility. These operations also have potential for contributing contaminants, such as heavy metals, to the surrounding area.^{18, 19, 20}

In 1988, the U.S. Coast Guard found extensive oil staining around the equipment used for metal crushing on the Horton Property. A Notice of Violation was issued to Horton in 1989, and Horton Iron & Metal Company was ordered to clean up the contaminated soils. Additionally, the violation mandated that groundwater at the facility be tested for contaminants that may have seeped through the soil to the watertable.^{18, 21}

Between 1989 and 1996, the oil-stained soils and an underground storage tank were removed from the Horton property. For two years during this same period, from 1994 to 1996, a new ship breaking facility operated to salvage U.S. Naval ships in an adjacent basin just south of the Horton property (Wilmington Resources and Sigma Recycling).²¹ In July of 2002, Pre- Comprehensive Environmental Response, Compensation, and Liability Information Systems (CERCLIS) screening was conducted at the Horton property to determine if the site should be entered into the CERCLIS active site inventory for further evaluation. Based on the recommendation from the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Waste Management Superfund Section, the site was added to the CERCLIS inventory in 2002.^{18, 22}

From August 2002 through September 2003, NCDENR conducted a Preliminary Assessment followed by an Expanded Site Inspection (ESI). During these evaluations, surface and subsurface soils, groundwater, and sediment samples were collected throughout the Horton property and in the adjacent NECFR. Metals and pesticides were detected in surface soils, groundwater, and sediments. Additionally, PAHs, PCBs, and asbestos were detected in the surface soils; and PAHs were detected in the sediments. Based on these findings, the Horton property was recommended for Hazardous Ranking System (HRS) scoring.^{18, 22, 23}

The EPA conducted a Non-National Priorities List Potentially Responsible Party Search from 2004 through 2010. In the meantime, from June 2005 to March 2006, the EPA contracted Tetrattech to conduct a Removal Assessment to determine whether or not a removal needed to be performed. During this assessment, soil samples were collected in a focused area around the boat slips. PCBs, Aroclors 1254 and 1262, arsenic, and lead were detected in all samples.^{22, 23}

In 2009, the EPA requested that the current owner of the Horton property take immediate (voluntary) action to reduce worker exposure and prevent the migration of contaminants off-site during storm events. In response, Horton Iron & Metal Company installed a gate to prevent any unauthorized entry into the contaminated area. Horton also installed a silt fence around the boat slips to preclude further migration of contaminated soils into the boat slips and, subsequently, the NECFR. During this same time, the EPA also required that administrative records for the site be compiled for all potential responsible parties (PRPs).^{18, 23}

The EPA also began an EPA-funded ESI in 2009 at the Horton property. This ESI focused specifically on the portion of the site that had formerly been the fertilizer manufacturing and ship breaking areas (7.4 acre area). Fourteen groundwater samples, eighteen sediment samples, and nineteen surface and subsurface soil samples were collected. PCBs, metals, PAHs, SVOCs, VOCs, and pesticides were detected in the soil and sediment samples; and metals were detected in the groundwater. The ESI concluded in March of 2010 with a second recommendation for HRS scoring.²³

The Horton property was scored in 2010 and received an HRS score of 48.03. After a comment period and EPA review, this score was accepted as the final HRS score in October 2010. This HRS score, along with the ESI data, triggered the EPA's proposal of the Horton property to the National Priorities List. From October 2010 to December 2011, a National Priorities List Responsible Party Search was conducted, and the EPA made a final listing of the Horton property to the National Priorities List (NPL) on September 16, 2011.^{18, 22, 23} For additional information regarding the background and development of the NPL, see Appendix B.

From March 2011 to July 2012, the EPA conducted a combined Remedial Investigation/Feasibility Study (RI/FS) which was followed by RI/FS negotiations between the EPA and the PRPs to decide liability. An Administrative Order on Consent was signed by the EPA and responsible parties in September of 2012 to delegate site clean-up responsibilities. The responsible parties began a Potentially Responsible Party RI/FS immediately following this signing; this RI/FS is still ongoing.²² On March 4, 2014, the Agency for Toxic Substances and Disease Registry (ATSDR) released its Final Public Health Assessment for the Horton Iron & Metal NPL site. Appendix C presents a table of the above described historical timeline (1911 – 2014) for the Horton Iron & Metal NPL site.

Table 1 summarizes the PCB, metal, and pesticide soil concentrations reported in the ATSDR Final Public Health Assessment as being greater than established ATSDR health-effect screening values. This assessment concluded that none of the data suggest that the asbestos documented in the former fertilizer manufacturing and ship-breaking area surface soil is expected to be released to the air and become an inhalation hazard; contaminants other than asbestos that were identified in the soils, sediments, and groundwater do not present a human health hazard because people do not currently have contact with the source areas at a frequency adequate enough to cause harm; no data exist to determine if workers of the former fertilizer plant or ship breaking facility may have been harmed by contaminants during their employment; and, no data exist to determine if human health may be harmed by eating finfish or shellfish from the areas downstream of the Horton property.¹⁸

Further, the assessment made the following recommendations: (1) signs and physical barriers should be placed around the perimeter of the contaminated areas to discourage access; (2) increased communication to the facility employees of potential hazards associated with working at the site, including hazards to unborn and young children associated with carrying contaminants home on soiled

clothing; (3) further investigations to determine if asbestos-containing fill material was deposited beyond the known areas of contamination; (4) further investigations to determine if an airborne asbestos hazard exists; (5) removal or capping of contaminated soils to prevent release; (6) land-use restrictions; (7) groundwater wells on the Horton property should continue to not be used as a drinking water source; (8) North Carolina Division of Public Health (NCDPH) should work with NCDENR to enable the collection and analysis of tissue samples from both shellfish and finfish collected downstream of this area; and (9) NCDPH should work with local and state agencies to increase awareness of potential hazards associated with consuming fish from this area.¹⁸

Table 1. Horton Iron & Metal NPL Site: Detected PCBs, Metals, and Pesticides

Surface soil measurements were reported in the 2014 ATSDR Final Public Health Assessment for concentrations greater than established ATSDR health-effect screening values.¹⁸ Cape Fear River Sediment concentrations were collected as part of this paper’s study; they are included here for reference.

Contaminant	Frequency of Contaminant Detections in Horton Surface Soils	Number of Horton Surface Soil Detections greater than ATSDR Screening Value	Horton Surface Soil Concentration Ranges greater than ATSDR Screening Value (mg/kg)	ATSDR Screening Value (mg/kg)	Per Sample Concentration ranges of Cape Fear River Sediments at or near Horton site (mg/kg) ^b
PCBs					
Aroclor-1242	1/14	1	1.4	0.4	N/A
Aroclor-1248	2/22	2	0.550 – 1.6		
Aroclor-1254	19/32	9	0.078 – 3.8		
Aroclor-1260	8/14	3	0.89 – 1.2		
Aroclor-1262	8/10	4	0.040 – 1.90		
Aroclor-1268	3/14	1	0.55		
Total PCBs ^a	N/A	N/A	0.023 – 5.40		
∑PCB for this study ^b	N/A	N/A	N/A		0.0051 – 0.02964
Metals					
Antimony	22/25	11	20 – 420	20 (child); 300 (adult)	N/A
Arsenic	35/35	35	1.5 – 240	0.5	
Iron	25/25	4	62,000 – 190,000	72,000	
Lead	35/35	24	800 – 23,000	800	
Mercury	23/25	0	0.15 – 97	310	
Pesticides					
4,4'-DDT	21/27	1	7.0	2.0	0
Dieldrin	6/27	1	0.36	0.040	0
Toxaphene	1/27	1	19	0.60	N/A

^a Individual Aroclor concentrations for all detections were summed for each sample and reported as “Total PCBs”

^b ∑PCB = summed PCBs (inclusive of 21 PCB congeners) analyzed per Cape Fear River sediment sample (20 samples total) over 3.9 mile area of this paper’s study site near Horton Iron & Metal property.

Polychlorinated Biphenyls (PCBs)

The EPA lists PCBs amongst the top 29 most prevalent chemicals detected at NPL sites (Appendix B).³⁰ According to data presented by the ATSDR, PCBs have been identified in nearly a third of the hazardous waste sites that have been proposed for inclusion on the NPL.³¹ PCBs are important environmental pollutants that belong to a large family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs have been manufactured for a multitude of industrial and commercial applications ranging from plasticizers, dyes, and adhesives to fluids and lubricants in transformers, capacitors, and hydraulic equipment.^{32, 33} In the United States, PCBs were first produced commercially in 1929, and approximately 600,000 tons were manufactured before North American production was banned in 1977.³² The U.S. Congress officially banned most uses of PCBs in 1979.³³

Chemically, PCBs are compounds in which two to ten chlorine atoms are attached to a biphenyl molecule. With a variety of potential chemical structures, there are 209 possible PCB compounds, called congeners.³¹ The general chemical structure of the chlorinated biphenyls, as well as a few examples of PCB congeners can be seen in Table 2.

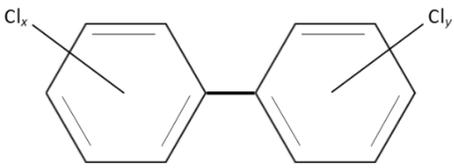
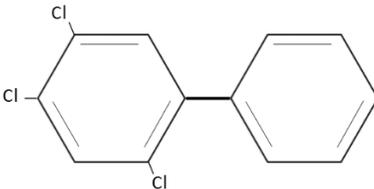
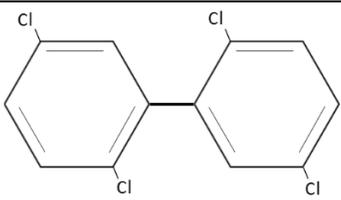
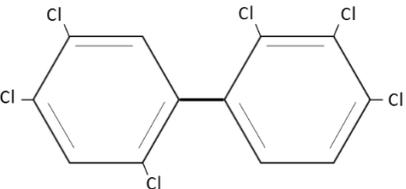
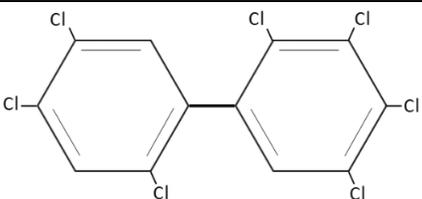
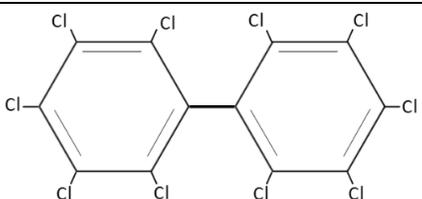
The “lighter”, less chlorinated PCB congeners receive lower IUPAC numbering, while the “heavier”, more chlorinated PCB congeners receive higher numbering (e.g., PCB 52 is less chlorinated than PCB 209). PCB manufacture usually involved creating mixtures of several PCB congeners; these mixtures have been marketed globally under several trade names including Chlophen (Germany), Fenclor (Italy), Phenochlor (France), and Kanechlor (Japan). The major U.S. producer of PCBs, the Monsanto Corporation, marketed their PCB mixtures under the trade name Aroclor from 1930 to 1977. The different formulations of Aroclor mixtures are identified by a four-digit numbering system in which the first two digits generally indicate the number of carbon atoms in the phenyl rings and the last two digits represent the approximate content of chlorine by weight percent (e.g., Aroclor 1254 mixture contains 12 carbon atoms and has an average chlorine content of 54%).³¹

PCBs tend to be relatively insoluble in water with solubility decreasing with the more highly chlorinated congeners. Also, PCBs are freely soluble in nonpolar organic solvents and biological lipids. These characteristics make PCB mixtures unlikely to dissolve in aqueous soil systems or water columns, and more likely to adhere to soils, sediments, suspended matter, and biota in the environment. PCBs also degrade slowly in the environment with more highly chlorinated congeners resisting degradation for longer periods; photolysis appears to be the dominant degradation process. PCBs are therefore relatively persistent environmental pollutants that demonstrate an increase in persistence with an increase in the degree of chlorination (i.e., higher-end PCBs, such as PCB 206 will tend to persist in the environment longer than lower-end PCBs, like PCB 53).³¹ Additionally, with average bioconcentration factors (BCFs) ranging from 3.26 to 5.27, PCBs have been shown to bioconcentrate significantly in aquatic organisms; as with the other characteristics, bioconcentration capabilities also increase with an increase in chlorination.^{31, 34}

As PCBs are no longer manufactured nor imported in large quantities in the U.S., the current major source of PCBs to environmental media is environmental cycling of PCBs that were previously introduced into the environment. The major PCB exposure routes to humans are through the consumption of contaminated food and drinking water, as well as by the inhalation of contaminated air. Once exposed to PCBs, humans and animals have been shown to experience a variety of adverse health

effects including both carcinogenic and non-carcinogenic responses. The EPA has listed PCBs as probable human carcinogens.³⁵ Some studies have shown that ingestion of soils or fish contaminated with PCBs may cause lower birth weights and IQs in children as well as cardiovascular, hepatic, and neurological problems.³⁶

Table 2. Representative examples of PCB Congener Chemical Structures.

PCB Name	IUPAC Number	Empirical Formula	Molecular Structure
Generic Chlorinated Biphenyl	N/A	$C_{12}H_{10-n}Cl_n$	
2,4,5-Trichlorobiphenyl	29	$C_{12}H_7Cl_3$	
2,2',5,5'-Tetrachlorobiphenyl	52	$C_{12}H_6Cl_4$	
2,2',3,4,4',5'-Hexachlorobiphenyl	138	$C_{12}H_4Cl_6$	
2,2',3,4,4',5,5'-Heptachlorobiphenyl	180	$C_{12}H_3Cl_7$	
Decachlorobiphenyl	209	$C_{12}Cl_{10}$	

Materials & Methods

Selection of Sample Locations

Due to budget constraints for the analysis of samples, it was decided that 20 sediment samples and 2 water samples would be sufficient for this preliminary study. In an effort to collect samples from random locations across the entire 3.9 mile study site that would adequately portray the presence or absence of a PCB gradient in the sediments, the site was divided into five subsampling grids – Upriver, Horton, Mid-river, CFCC basin, and Downriver (Figure 7).

The subsampling grids consisted of grid blocks measuring 10-meters by 10-meters. All grid blocks were numbered, and Microsoft Excel’s random number generator was used to generate five grid locations (four sampling sites and one alternate site) within each of the five subsampling sites.



Figure 7. Subsampling Sites.

The gridded subsections are color-coded: Pink = Upriver subsection (“Upriver”); Yellow = Horton Iron & Metal subsection (“Horton”); Red = transition between Horton and CFCC subsections (“Mid-river”); Blue = CFCC operations basin subsection (“CFCC Basin”); and, Green = Downriver subsection (“Downriver”).

Base Orthophoto Source: GoogleEarth³⁷

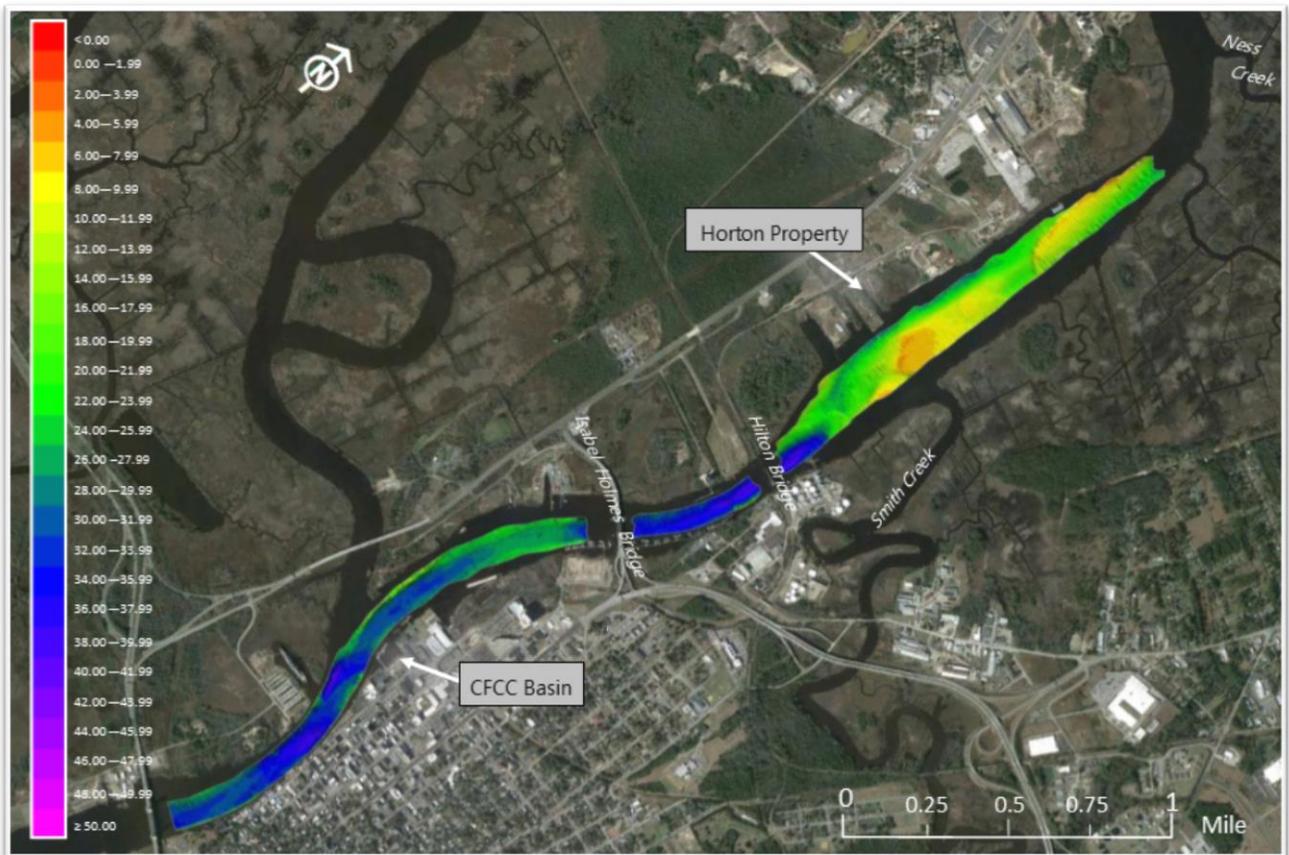
Sample Locations

Before sampling events commenced, an attempt to ascertain potentially poor sampling locations (e.g., obstacles that might prohibit the deployment of sampling gear and collection of sample(s)) was made. Satellite imagery was used (GoogleEarth) to locate river banks, docks, and other large obstructions. A site inspection was conducted to mark areas that had less conspicuous obstructions that would need to be avoided. During the site inspection, exploratory grabs were taken using a petite ponar to locate areas with large deposits of sand; sand was avoided during this study because it is a poor material for contaminant adhesion.

Following the site inspection, a singlebeam survey of the entire site was completed using an Odom CVM Echotrac echosounder to create a depth profile of the study site (Figure 8). Due to shallow depths which precluded the boat from passing over the bottom and the presence of low density, partially suspended sediments (“fluff”), depth measurements near the banks of the river and in the basins (CFCC and Horton) were incomplete or inaccurate; these data points were removed from the survey data and thus are not depicted in the final depth profile image shown in Figure 8. However, precise depth data from these ancillary areas was initially considered unnecessary because the depth profile was primarily used to locate and avoid selecting sample sites within the main channel (depths for each sample location were later measured using a lead line at the time of sample collection). It was deemed important to avoid placing sample locations in the main channel because it is dredged every one to five years (depending on location in the river) which could result in erroneous measurements of accumulated contaminant concentrations in this area (i.e., dredging in the main channel has likely removed contaminants associated with the sediments and sampling this area could result in an under-reporting of contaminant concentrations). Additionally, the main channel was avoided due to excessive current flow which has resulted in highly flushed bottom sediments that are higher in sand and rock deposits.

Figure 8. Depth Profile of the Study Site.

Base Orthophoto Source: GoogleEarth³⁷



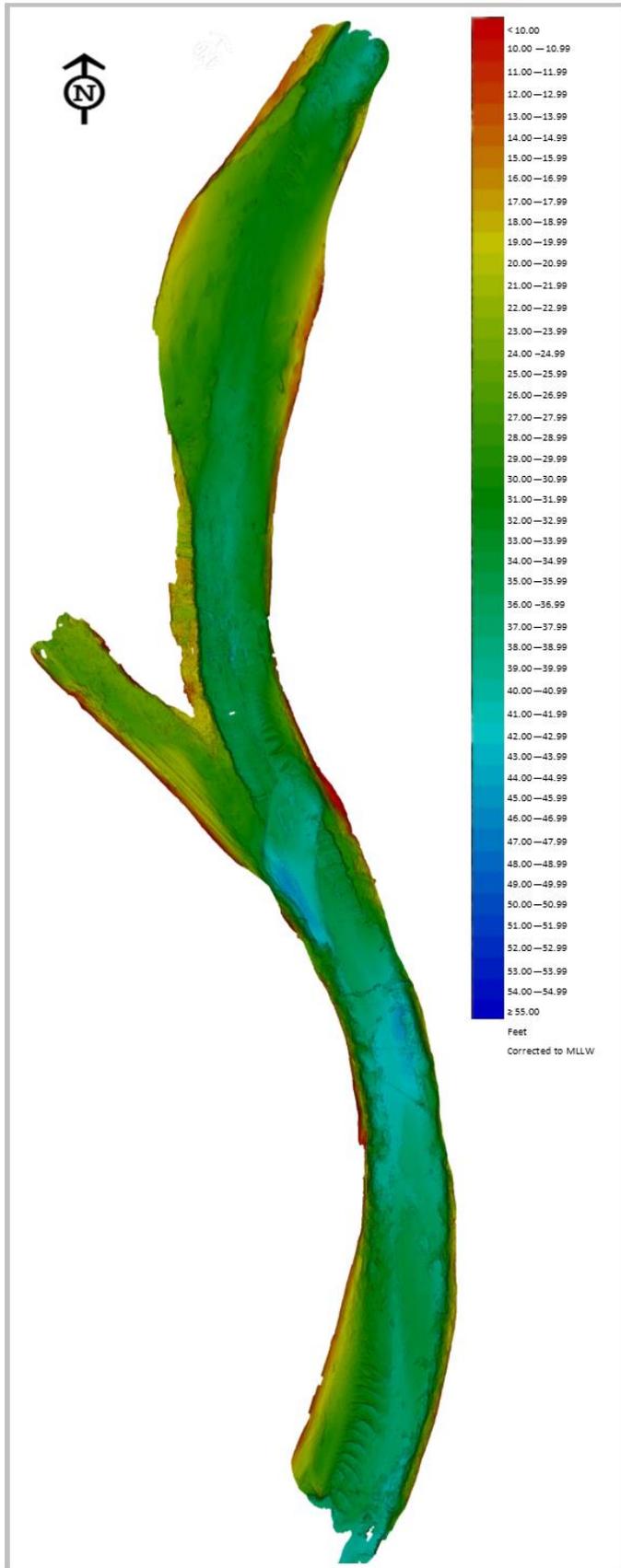


Figure 9. Multibeam Survey.

Multibeam survey conducted over part of the study area – from the Cape Fear Memorial Bridge (most southern location) to the Isabel Holmes Bridge (most northern location). A small portion of the main-stem of the Cape Fear River was also surveyed to view the bottom profile at the bifurcation. Depth measurements have been corrected to Mean Lower Low Water (MLLW) and range from < 10.00 feet (red) to ≥ 55.00 feet (dark blue).

Prior knowledge of the area and its many submerged obstructions, prompted a side scan sonar (SSS) survey to be conducted in the Downriver subsampling area. Figure 4 depicts a couple of the larger items that were located using an EdgeTech 4125. The SSS survey also revealed a large underwater cable and several logs. Further SSS surveying was planned for the other subsampling areas, but due to scheduling conflicts, was never completed.

A multibeam survey was also conducted over part of the study site using an R2Sonic 2022 multibeam system (Figure 9). This data was used to locate areas with observable sand waves which would indicate the presence of large deposits of sand that would need to be avoided. Again, a multibeam survey over the entire extent of the study site had been planned, but scheduling conflicts prohibited its completion; the completed multibeam survey covered the area between the Cape Fear Memorial Bridge and the Isabel Holmes Bridge.

After a careful examination of all of the site inspection data, the sediment sampling sites that were originally generated by Microsoft Excel were moved to the closest grid block (either east or west) that would avoid sampling in areas that were located in the

channel, in heavily sandy areas, near docks (where boat traffic often stirs up bottom sediments), and/or over known obstructions. Table 3 shows the locations of planned sampling. Five locations were pre-selected for each subsampling grid; four planned locations and one alternate (to be used if one of the first four was found unsuitable due an obstruction or high sand content).

Water sample locations were based on the locations of the two stormwater outfalls located in the CFCC basin.

Sampling Equipment & Procedures

Sediment Samples

Sampling gear and techniques were based on methods outlined by the EPA.^{38, 39} Sediment samples were collected during four separate sampling events on April 30th, and May 1st, 5th, and 6th of 2014. All sediment samples were collected from the deck of an 18-ft SeaArc jon-boat with a 30 horsepower E-tech Evinrude motor. Sediment sampling was conducted starting at the pre-selected location located furthest from the Horton subsampling site (Downriver E) and proceeded toward the Horton site.

Once on site of a sampling location, a common lead line was used to ascertain depth, a YSI-ProPlus multiparameter meter was used to collect water parameters (temperature, salinity, conductivity, pH, and DO), a Kestrel weather meter was used to ascertain weather data (air temperature, barometric pressure, and wind speed), and a Garmin GPS was used to record the precise location of the sample as well as accurate tide/current data (Figure 10a). After ambient conditions were recorded, a digital field camera was used for photo documentation of the site (Figure 10b).

The samples were then collected using a Wildco stainless steel petite ponar grab attached to a polypropylene rope. The grab and a Teflon-coated, stainless steel sample spoon were cleaned prior to the commencement of any field work each day by soaking in a large Teflon tub filled with a Liquinox solution for several minutes, followed by a thorough scrubbing with a cleaning brush. The grab, Teflon spoon, and Teflon tub were then rinsed with deionized water and allowed to air dry. During field collections, when not in use, the grab and Teflon spoon were placed in the Teflon tub to maintain a barrier between the sampling equipment and the boat in order to prevent contamination (Figure 10c). Sediment sampling was performed using a “live-boat” sampling technique in which the boat captain attempted to maintain a static position in the water, but no anchor was set (Figure 10d).

When the boat was in position, the gear technician rinsed the pre-cleaned sediment grab, Teflon spoon, and Teflon tub in site water (Figure 10e). The grab was then lowered slowly over the edge of the boat to the bottom ensuring that the grab did not cause a wash-out of the surficial sediment layer (Figure 10f). Once lifted to the boat, the grab was placed into the Teflon tub.

Photos were taken of the undisturbed sediment surface before removal from the grab. Sediment was scooped from the grab by a second technician wearing clean nitrile gloves using the pre-cleaned Teflon spoon (Figure 10g). Approximately 300-350mL of sample were scooped from the center of the grab, representing the top 5-13 centimeters of surficial sediments. Samples were kept in certified, pre-cleaned, 500mL, amber glass jars with PTFE-lined polypropylene caps. Care was taken not to touch the

Table 3. Pre-selected sampling locations.

Five sampling locations were pre-selected for each sub-sampling grid with A, B, C, and D being the planned locations, and E being an alternate. Note: All A through D locations that are crossed through were not used during sample collection because they were found to be unsuitable during sampling events (e.g., grab pulled up only large rocks or mostly sand); All alternate (E) locations that are crossed through were not used during sample collection because locations A through D were suitable; and the word (moved) appears next to sites that were relocated from locations selected by Excel based on site inspection, singlebeam, SSS, and multibeam data collected prior to sampling events.

Name	Latitude	Longitude
Upriver		
Upriver - D	34°16'53.42"N	77°56'58.75"W
Upriver - B (moved)	34°16'45.94"N	77°57'5.05"W
Upriver - A (moved)	34°16'38.95"N	77°56'54.50"W
Upriver - E (moved)	34°16'25.36"N	77°57'6.32"W
Upriver - C	34°16'17.52"N	77°57'2.75"W
Horton		
Horton - D	34°16'0.83"N	77°57'6.27"W
Horton - E	34°15'56.55"N	77°57'7.14"W
Horton - B	34°15'51.65"N	77°57'11.83"W
Horton - A	34°15'51.33"N	77°57'11.82"W
Horton - C	34°15'49.26"N	77°57'9.06"W
Mid-river		
Mid - A (moved)	34°15'51.56"N	77°56'50.18"W
Mid - B (moved)	34°15'35.08"N	77°56'58.92"W
Mid - C (moved)	34°15'11.52"N	77°57'4.11"W
Mid - D (moved)	34°14'49.19"N	77°57'7.67"W
Mid - E (moved)	34°14'31.45"N	77°57'18.36"W
CCFC Basin		
CFCC Basin - A	34°14'25.93"N	77°57'8.53"W
CFCC Basin - E	34°14'25.62"N	77°57'8.10"W
CFCC Basin - D	34°14'25.28"N	77°57'6.57"W
CFCC Basin - C	34°14'24.97"N	77°57'7.73"W
CFCC Basin - B	34°14'23.68"N	77°57'6.96"W
Downriver		
Downriver - B	34°14'19.16"N	77°57'15.97"W
Downriver - D (moved)	34°14'15.86"N	77°57'11.75"W
Downriver - A (moved)	34°14'10.08"N	77°57'7.02"W
Downriver - C (moved)	34°14'0.38"N	77°57'5.09"W
Downriver - E (moved)	34°13'51.01"N	77°57'7.05"W

grab or the mouth of the jars with the spoon during transfer (Figure 10h). Once the jars were sealed and labeled, they were wiped clean with a lint-free paper towel and placed immediately in a cooler with wet ice. After the completion of each sample collection, the nitrile gloves were discarded.

Between grab stations within the same subsampling grid, the grab, Teflon tub, and Teflon-coated spoon were scrubbed with a disposable cleaning brush and rinsed with site water; new cleaning brushes were used for each subsampling grid. Before moving to a new subsampling grid, the grab, tub, and spoon were decontaminated with Liquinox, scrubbed clean with a cleaning brush, and followed by a deionized water rinse (Figure 10i). Once sampling was complete for the day, the grab, tub, and spoon were again cleaned with Liquinox and deionized water, and samples were immediately taken to the CFCC lab for preservation and storage.

Sediment samples were stored in a lab freezer for 3 to 9 days (depending on collection date) in CFCC's Water Analysis lab before transport to the Toxicology Lab at North Carolina State University (NCSU) in Raleigh, North Carolina. Sediment samples remained in freezer storage at NCSU for approximately two months before analysis.

Water Samples

Water samples were collected from the shore at the stormwater outfall locations on May 7th, 2014 at low tide in order to exclude as much basin water from the samples as possible in an effort to reduce the dilution factor (i.e., an attempt to provide a possible contamination "source" measure). The same instrumentation was used to collect ambient environmental conditions and precise GPS locations as was used for the sediment sampling.

Water was collected in the same type of 500mL amber glass jars as the sediment. With gloved hands, the jars were submerged beneath the surface of the water and filled to the mouth with sample water. Caps were placed on the jars while they were still under water to prevent contamination of the sample. Water samples were directly taken to the CFCC lab for preservation and storage.

Water samples were stored in a lab refrigerator for one day in CFCC's Water Analysis lab before transport to the Toxicology Lab at NCSU. Water samples remained in refrigerator storage at NCSU for approximately 3-4 days before analysis.

Laboratory Analysis

Samples were analyzed in the Shea Lab at NCSU using methods modified from EPA 8270.⁴⁰ Twenty-one PCB congeners of interest were selected based on the PCB list used by the NOAA National Benthic Surveillance and Mussel Watch Project (IUPAC numbers 8, 18, 28, 44, 52, 66, 77, 101, 105, 118, 126, 128, 138, 153, 170, 180, 187, 195, 201, 206, and 209).⁴¹

Sediment samples were individually thawed, removed from jars, and homogenized. An aliquot was centrifuged to separate the majority of the water from the sediment. Between 4-5 grams (wet weight) of centrifuged sediment was mixed with approximately 10 grams of diatomaceous earth until the mixture was a free flowing powder. The samples were then extracted via pressurized solvent extraction using a Buchi Speed Extractor E-916 (temp.: 80°C; pressure: 150 bar; solvent: dichloromethane; total time: 50 mins).

Figure 10. Representative Field Sampling Photos.

(a) Ambient environmental data being collected with Kestrel (near-field, yellow instrument in photo); (b) site photo at Mid-river B subsampling site – notice a portion of the railroad bridge on the shore; (c) petite ponar grab in Teflon tub; (d) boat captain using GPS to maintain positioning over subsampling site; (e) site water rinse of Teflon tub; (f) deployment of ponar grab off bow of boat; (g) sediment sample being scooped from ponar into jar; (h) sediment sample on pre-cleaned Teflon coated spoon being transferred into jar; (i) Liquinox cleaning of ponar.

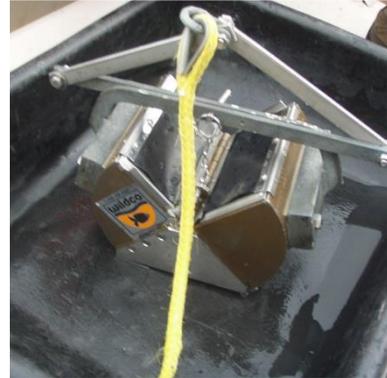
(a)



(b)



(c)



(d)



(e)



(f)



(g)



(h)



(i)



The sediment extract was then cleaned-up using a Shimadzu HPLC with an OI Analytical Optima GPC column. To determine what fraction of the eluate to collect, a sample containing all of the PCBs of interest was run through the column and fractions of the eluate were collected at regular time intervals. Those fractions were then analyzed to see when the compounds elute, denoting which fraction to collect from samples. A sample containing a lipid and sulfur (representing large and small molecules) was then analyzed by the same technique to determine what fraction to discard.

The cleaned-up extracts were then concentrated to approximately 0.5mL, and 2 μ L of each extract were separately injected into an Agilent 6890 gas chromatograph (GC) connected to an Agilent 5973 mass selective detector (MSD) and operated in Select Ion Monitoring (SIM) mode (inlet temp.: 300°C ; pressure pulsed splitless injection; column flow: 1.2 mL/min, He). Analytes were separated on a Restek Rtx-5MS column (30m x 250 μ m dia. x 0.25 μ m film thickness) with a 5m integrated guard column.

Water samples were extracted using liquid-liquid extraction with dichloromethane solvent. The extracts were then filtered through a sodium sulfate column to remove any residual water. Filtered extracts were concentrated and analyzed by the GC/MS using the same methods as the sediment extracts.

For quality control, five procedural blanks were analyzed to determine the levels of target analytes in reagents, glassware, and/or solvents that were used in the analysis. Surrogate spikes of 4,4'-dibromooctofluorobiphenyl (DBOFB), PCB 112, and PCB 197 were also added for quality control of the analysis procedures.

Detection and quantitation limits varied depending on the sample matrix and compound analyzed. The quantitation limits for this method were cited by the laboratory as being between 10-50 ng/L and ng/g for the water and sediment matrices, respectively. Several analytes could be reliably detected and identified at concentrations below these limits, but quantification may be unreliable because the sample concentrations are so close to the detection limits. Additionally, limits for the sediment detection and quantitation would be on the higher end of the cited range due to its more complex matrix.

The lab also analyzed the samples for the presence of 28 organochlorine pesticides (OCPs). Two sediment samples were found to contain detectable amounts of either chlordane and nonachlor, or dichlorodiphenyldichloroethylene (4,4'-DDE); neither water sample had detectable OCPs. However, for the purposes of this paper, the OCP analysis and results will not be discussed further. Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) analysis of the samples had been planned to detect and quantify any metals that were present in the samples, however, the lab was unable to complete this analysis before the writing of this report and as such, no metals data are presented here.

Results

PCBs were detected in 12 of the 20 sediment samples, and 1 of the 2 water samples (Figure 11), with the detection of PCBs in at least one sample taken from each sub-sampling grid. Of the 21 PCB congeners of interest, 11 were detected, with PCBs 206 and 209 being both the most prevalent (detected in 9 of the sediment samples) and in the highest per-sample concentrations (PCB 206 maximum concentration = 15.77 ng/g; PCB 209 maximum concentration = 5.10 ng/g) (Figure 12). Maximum concentrations of PCBs 206 and 209 were found within the Horton (Max. PCB 206 = 15.77 ng/g; Max. PCB 209 = 5.10 ng/g) and CFCC (Max. PCB 206 = 4.88 ng/g; Max. PCB 209 = 0.96 ng/g) basins as well as at the Mid-river-A sampling

Figure 11. Detect/Non-Detect of PCBs at the 22 Sample Locations.

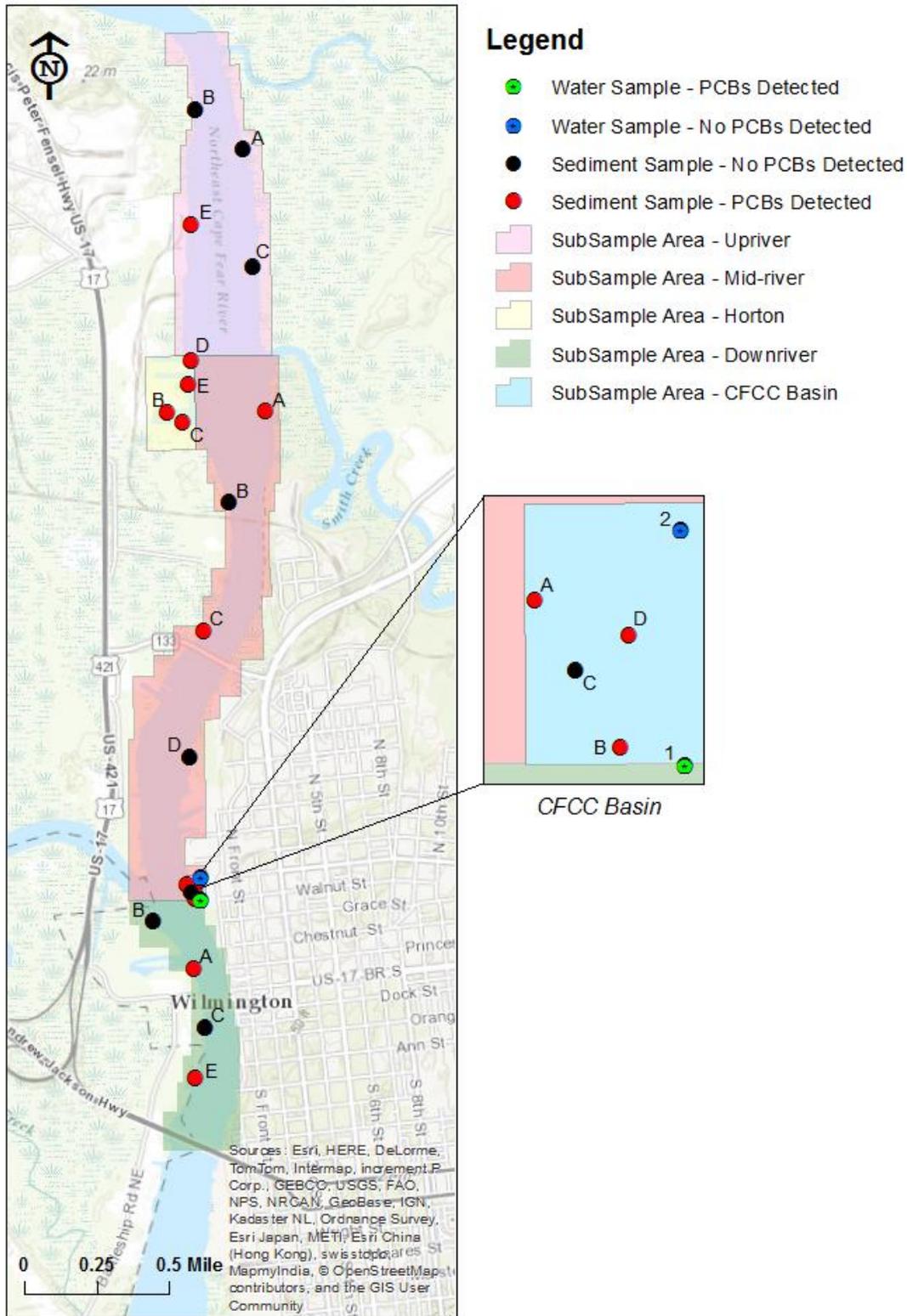
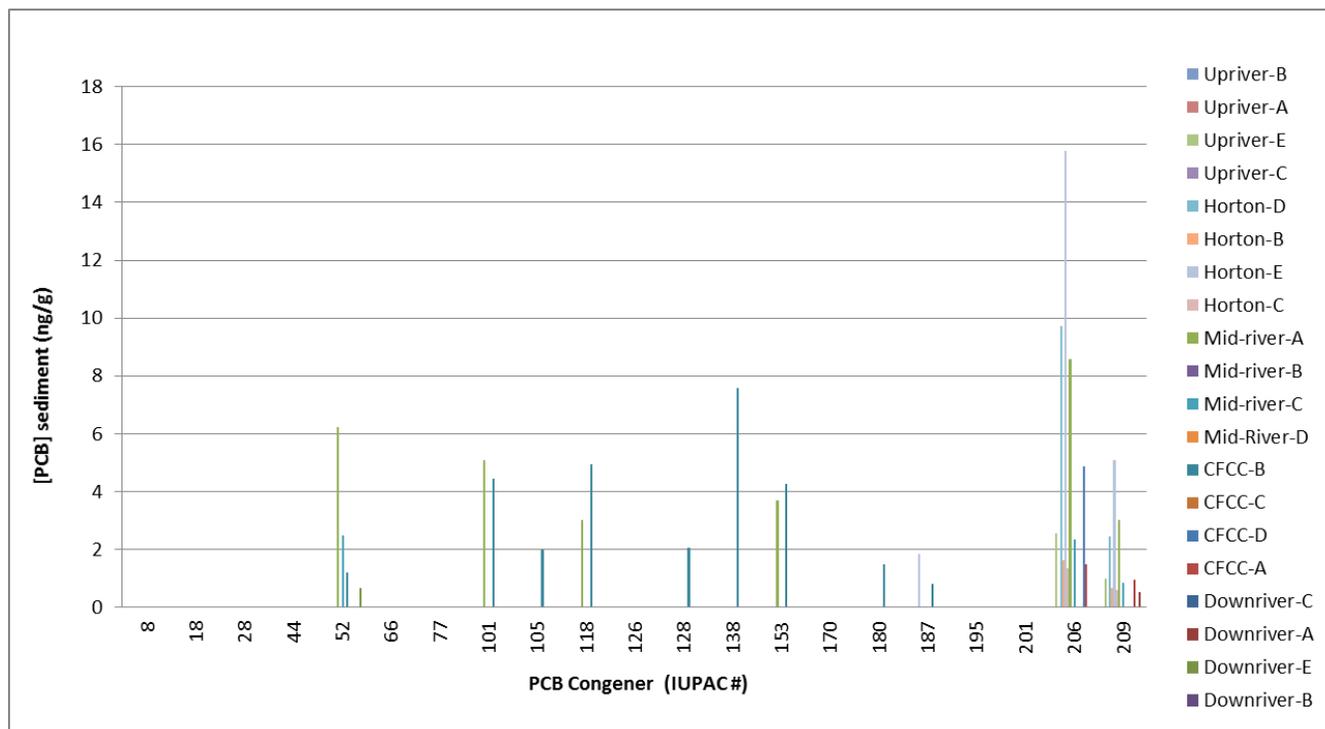


Figure 12. Individual PCB Congener Concentrations (ng/g) in 20 Sediment Samples.



site (PCB 206 = 8.57 ng/g; PCB 209 = 3.04 ng/g) located approximately 1250 feet across the river from the Horton basin (Table 4).

Concentrations of the 21 PCB congeners of interest were summed for each of the 20 sediment samples, as well as for each sediment sub-sampling grid; calculations summed the reported concentrations and used 0 ng/g or 0 ng/L for the non-detect values. It should be noted here that comparison of Σ PCB concentrations from this study to the Σ PCB concentrations of other studies may be difficult due to differences in analyzed PCB congeners; furthermore, a comparison of Σ PCB concentrations to Aroclor concentrations may prove even more problematic due to the varying mixtures of PCBs found in different Aroclor compounds.

Σ PCB concentrations were found in excess of 10 ng/g for two sediment samples in the Horton basin (Horton-D and Horton-E), one sediment sample in the mid-river grid (Mid-river-A), and one sediment sample in the CFCC basin (CFCC basin-B) (Figure 13). Furthermore, Σ PCB concentrations were found to be the highest within the approximately 34-acre area of the Horton basin sub-sampling grid (39.15 ng/g). The next two highest Σ PCB concentrations were found within the approximately 300-acre Mid-river (37.53 ng/g) and the approximately 3-acre CFCC basin (36.20 ng/g) sub-sampling grids. Only one sample from the Upriver grid (approx. 187-acre area) and two samples from the Downriver grid (approx.

100-acre area) had PCBs detected; accordingly, the Upriver grid and the Downriver grid had the lowest Σ PCBs, at 3.56 and 1.18 ng/g respectively.

Three PCB congeners (IUPAC 105, 138, and 153) were detected in the water sample taken from the stormwater outfall area in the southern region of the CFCC basin; none of the PCBs of interest were detected in the water sample collected at the outfall in the northeastern region of the CFCC basin. The three PCBs detected in the southern water sample (Water-1) were also detected in one of the sediment samples collected from the CFCC basin (CFCC basin-B); CFCC basin-B is the closest collected sediment sample to the southern outfall.

Higher-chlorinated PCB congeners were the only PCBs detected in samples collected from the Horton and Upriver sub-sampling grids (IUPAC 187, 206, and 209), while both higher- and lower-chlorinated PCBs were detected in samples collected from the other three grids. Individual PCB congener concentrations for PCBs 52, 101, 187, 206, and 209 were detected at the highest levels in samples from the Horton grid or the most northern Mid-river sample site (nearest to the Horton grid). Concentrations of these PCBs were detected at progressively lower levels with movement either north or south of this area.

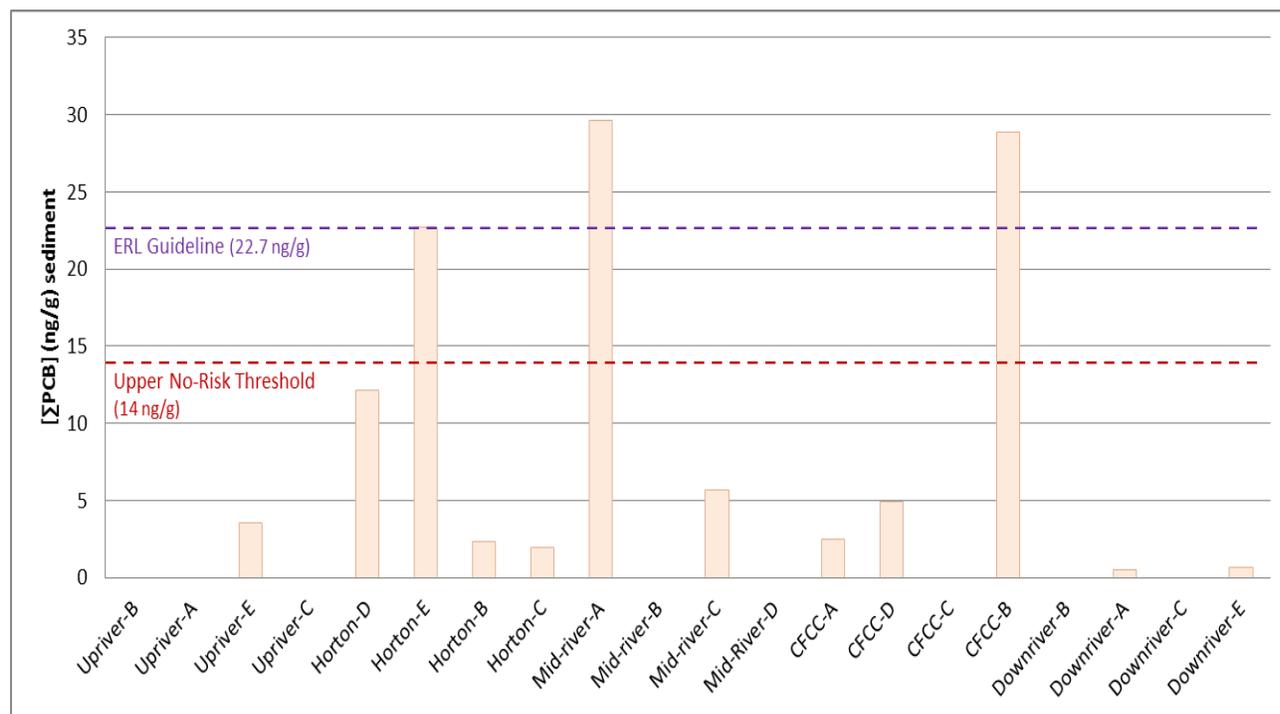
Table 4. Concentrations of 11 Detected PCB Congeners in 20 Sediment (ng/g; dry weight) and 2 Water Samples (ng/L).

Sampling Sites	PCB Congener (IUPAC#)											Sum PCBs	
	52	101	105	118	128	138	153	180	187	206	209	Per sample	Per sub-site
<i>Sediment Samples^a (ng/g)</i>													
Upriver-B	0	0	0	0	0	0	0	0	0	0	0	0	3.56
Upriver-A	0	0	0	0	0	0	0	0	0	0	0	0	
Upriver-E	0	0	0	0	0	0	0	0	0	2.56	1.00	3.56	
Upriver-C	0	0	0	0	0	0	0	0	0	0	0	0	
Horton-D	0	0	0	0	0	0	0	0	0	9.70	2.45	12.15	39.15
Horton-E	0	0	0	0	0	0	0	0	1.85	15.77	5.10	22.72	
Horton-B	0	0	0	0	0	0	0	0	0	1.65	0.68	2.33	
Horton-C	0	0	0	0	0	0	0	0	0	1.36	0.59	1.95	
Mid-river-A	6.21	5.09	0	3.02	0	0	3.71	0	0	8.57	3.04	29.64	37.53
Mid-river-B	0	0	0	0	0	0	0	0	0	0	0	0	
Mid-river-C	2.51	0	0	0	0	0	0	0	0	2.34	3.04	7.89	
Mid-river-D	0	0	0	0	0	0	0	0	0	0	0	0	
CFCC basin-A	0	0	0	0	0	0	0	0	0	1.49	0.96	2.45	36.20
CFCC basin-D	0	0	0	0	0	0	0	0	0	4.88	0	4.88	
CFCC basin-C	0	0	0	0	0	0	0	0	0	0	0	0	
CFCC basin-B	1.21	4.45	2.01	4.96	2.06	7.60	4.29	1.48	0.81	0	0	28.87	
Downriver-B	0	0	0	0	0	0	0	0	0	0	0	0	1.18
Downriver-A	0	0	0	0	0	0	0	0	0	0	0.51	0.51	
Downriver-C	0	0	0	0	0	0	0	0	0	0	0	0	
Downriver-E	0.67	0	0	0	0	0	0	0	0	0	0	0.67	
<i>Water Samples – from stormwater outfalls in CFCC basin^a (ng/L)</i>													
Water-1	0	0	1.17	0	0	1.61	1.13	0	0	0	0	3.91	3.91
Water-2	0	0	0	0	0	0	0	0	0	0	0	0	0

^a Non-detect values are reported as 0 ng/g for sediment samples and 0 ng/L for water samples.

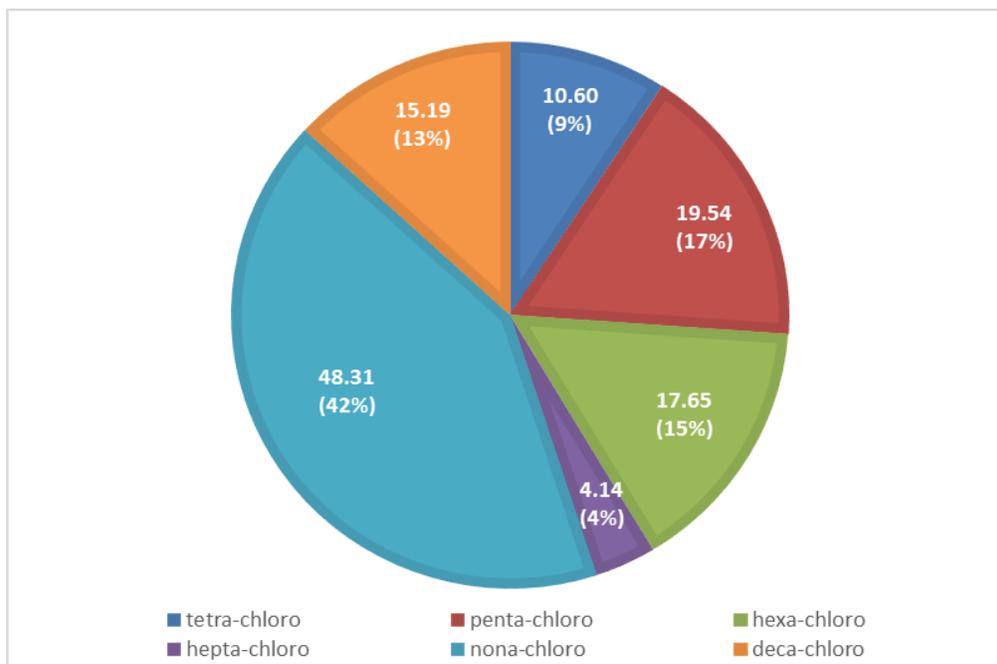
Figure 13. Σ PCB (ng/g) by Sample for 20 Sediment Samples.

Upstream data are shown on the far left and downstream data on the far right (downstream gradient from left to right). As described in the text, concentrations below the Effects Range-Low (ERL) guideline value (shown in purple) for total PCBs have been shown to rarely be associated with harmful effects in aquatic organisms. The No-Risk Threshold used for this study ranged from 3.6×10^{-6} to 14 ng/g for total PCBs in sediment (dry weight). The upper limit of that no-risk threshold is shown in red.



PCB homolog group concentrations over the entire study area were also summed. 42% (48.31 ng/g) of the total summed homolog concentrations were comprised of the single nonachlorobiphenyl homolog, PCB 206. The remainder of the study area was found to contain 10.6 ng/g tetrachloro- (PCB 52), 19.54 ng/g pentachloro- (PCBs 101, 105, and 118), 17.65 ng/g hexachloro- (PCBs 128, 138, and 153), and 15.19 ng/g decachlorobiphenyls (PCB 209). There was no detection of any dichloro-, trichloro-, or octachlorobiphenyls (Figure 14). Although it is difficult to compare individual congener concentrations to concentrations of commercial PCB mixtures (i.e., Aroclors), it is worth mentioning that the homologs found at the study site are the major components of Aroclors 1254 and 1260 which were both detected in previous sediment sampling events conducted at the CFCC basin by CATLIN Engineers and Scientists in 2008 as well as in soil samples collected by Tetratech at the Horton Iron and Metal NPL site during their 2005 Removal Assessment.^{23,31}

Figure 14. Σ PCB Homolog Group Concentrations (ng/g) for combined Sediment Samples.



Discussion

As a preliminary investigation, this study was able to confirm the presence of PCBs in sediments throughout the study area, with concentrations being highest in the Horton and CFCC basins. These data corroborate, to some degree, the previous work conducted at the site by CATLIN Engineers and Scientists in the CFCC basin and by the state and federal agencies at the Horton property. Concentrations of individual PCB congeners 52, 101, 187, 206, and 209 do appear to show a possible gradient effect in the sediments between the Horton basin and CFCC basin that may be indicative of PCB transportation. However, the sample size for this study was too small to confidently assert the presence of such a gradient; additional sampling would allow for further delineation.

One of the water samples also showed a presence of PCBs in the surface waters associated with the stormwater outfall located in the CFCC basin. The specific PCB congeners detected in the water sample (PCBs 105, 138, and 153) were not amongst the congeners detected at the Horton basin; however, these three PCB congeners were detected, along with six other congeners (PCBs 52, 101, 118, 128, 180, and 187) in a single sediment sample collected in the CFCC basin near the stormwater outfall. This may be evidence that the outfall could be contributing to the overall contamination of the CFCC basin. However, the other three sediment samples taken from the CFCC basin did not show any of the PCB congeners found in the water sample. Furthermore, the second water sample taken from the stormwater outfall located only about 400 feet north of the first outfall did not show the presence of any PCBs. Additionally, it should be noted that the water samples were collected at low tide which increases the potential for bottom sediments to become suspended enough to be in the shallow water column from which the samples were collected; this could mean that the PCBs detected in the water

sample were actually from very fine sediment particles in the water. This reasoning aligns with the physical-chemical characteristics of PCBs (especially higher-chlorinated PCBs) which are far more likely to adhere to sediments and organic matter than to dissolve in water.

PCBs are nearly ubiquitous in the environment today and would be expected to be found in several environmental compartments, so it is no surprise that PCBs were detected in sediments at the site.³¹ Rather, it is the concentration levels of some of the congeners that may be of significance. PCB concentrations detected in this study site were not found to be nearly as high as those found in heavily contaminated riverine sediments downstream from other Superfund sites such as those in the St. Lawrence River and the Raquette River in New York which were found to have total PCB concentrations of 5.7×10^6 and 3.6×10^4 ng/g, respectively. However, the concentration levels were within the lower range of concentrations found in sediments of several streams in the moderately contaminated Potomac River Basin in 1976 (10 to 1200 ng/g), as well as in range of concentrations found in sediments collected from the heavily populated San Francisco Bay in 1992 (1.3 to 8.1 ng/g).^{42, 43}

Although it is not apparent which PCB congeners were analyzed, a study conducted by Hewitt *et al* reported that total PCB concentrations (inclusive of 20 undeclared PCB congeners) were detected in the sediments of the Cape Fear River headwater tributaries of the Haw River and the Deep River between 0.1 and 0.7 ng/g (dry weight) in 2006.⁴⁴ Additionally, Mallin *et al* conducted a study in 2004 that reported total PCB concentrations of 6.4 ng/g in sediments of Rockfish Creek, which drains directly into the NECFR approximately 55 miles upriver of the study site, and 4.9 ng/g in sediments of Livingston Creek which drains into the main-stem of the Cape Fear River approximately 25 miles upriver of the study site.⁴⁵ While specific PCB congeners were not described in either of these studies, the reported concentrations may be an appropriate representation of total background PCB levels in the Cape Fear River. As such, further evaluation of the Σ PCB concentrations described in this paper is possible. Both the Upriver and Downriver sub-sampling grids had Σ PCB concentrations within these background levels; however, five of the twelve samples collected from the other three sub-sampling grids had Σ PCB concentrations above these background levels (ranging from 7.89 ng/g in the Mid-river grid to 28.87 ng/g in the CFCC basin grid; this is approximately 1.6 to nearly 6 times greater than the mid-range Livingston Creek “background level” (4.9 ng/g) in sediment). This evidence may be indicative of a nearby source of PCB contamination to the study site, such as the Horton Iron & Metal NPL site.

Due to the varying methods for analyzing PCBs in sediments (e.g., different PCB congeners or mixtures analyzed per study) and the various toxicity levels associated with individual PCB congeners, a definitive no-risk threshold in sediments is difficult to find. It does appear that an approximation of a no-risk threshold has been attempted by several states and agencies and tends to range between 3.6×10^{-6} to 14 ng/g for total PCBs in sediment (dry weight).^{31, 46, 47} Additionally, Long *et al* compiled numerous marine and estuarine sediment studies in 1995 to determine guideline values (an effects range-low (ERL) and an effects range-median (ERM)) for concentration ranges of several environmental contaminants, including total PCBs, that are associated with adverse biological effects in aquatic communities. For total PCBs in sediment, the ERL was reported as 22.7 ng/g and the ERM as 180 ng/g. Concentrations below the ERL were rarely observed to elicit harmful effects on aquatic organisms; concentrations above the ERM frequently demonstrated harmful effects; and concentrations between the ERL and ERM were occasionally associated with harmful effects.⁴⁸ Moreover, the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (SQGPAL) has set a total PCB sediment threshold for the protection of

aquatic life at 34.1 ng/g (dry weight) with a probable effects level estimated as high as 277 ng/g (dry weight).⁴⁹

∑PCB concentrations for all five sub-sample grids exceed the lower end of the cited no-risk threshold range; moreover, three of the grids (Horton, Mid-river, and CFCC) demonstrated ∑PCB concentrations between the ERL and ERM and were also in excess of the SQGPAL threshold for the protection of aquatic organisms. These results show that PCB concentrations within the study site are elevated enough to pose a potential risk to the health of the associated aquatic communities.

PCBs have been classified by the EPA as Probable Human Carcinogens. It should be noted that potential for human exposure to PCBs in the sediments found at the study site is low due primarily to the absence of recreational swimming in this portion of the river; the high velocity of the river current precludes most recreational activities that could lead to interaction with the sediments. However, human exposure to these sediments may be a potential occupational hazard for any individuals that work on the annual dredge projects in this area. Additionally, PCBs may pose a risk to human health through consumption of finfish and shellfish. Even with lower concentrations in the sediments, bioconcentration of PCBs in the tissues of aquatic organisms could lead to more toxic levels being accumulated and potentially consumed. The ATSDR lists an upper-bound cancer slope of 2 per mg/kg-d for human ingestion of fish.³¹ This may be especially important for the blue crabs, flounder, and shrimp which all live on the bottom of the river and are all regularly captured within the bounds of the study site for human consumption. Additionally, even in the absence of human consumption, high bioconcentration of PCBs may be further affecting the health of aquatic animals in the study area (e.g., potential chronic adverse effects).

The ATSDR lists PCB congeners 77, 87, 99, 101, 105, 118, 126, 128, 138, 153, 156, 169, 170, 180, 183, and 194 as the PCBs of highest concern in the environment due to their high toxicity and high abundance.³¹ Ten of these “high-concern” PCBs were tested for during this analysis, and seven of them were detected in samples. The presence of these congeners may increase the potential risk of toxic health responses in the aquatic organisms at the study site. Interestingly, none of these “high-concern” congeners were detected in the Upriver or Downriver sub-sampling grids. The lack of these congeners in the area upriver of the Horton NPL site may suggest that the Horton site is the source of these contaminants; likewise, a lack of these congeners in the area downriver of the CFCC basin may suggest that the CFCC site may be an area of high sediment deposition and, therefore, a repository for transported contaminants from the Horton site. The CFCC basin is uniquely situated at the western edge of the confluence of two rivers; the current of the main-stem of the Cape Fear River meets the eastern boundary of the southward flowing NECFR at a nearly 45° angle which may be creating a shift in the water movement towards the CFCC basin where sediments are then deposited in the slower moving waters.

It is also important to note that the samples for this study were collected during the peak flow season for the Cape Fear River which could have contributed to higher flushing potential of the surficial sediments. PCB levels could actually be higher in deeper sediments, and may be higher in surficial sediments during lower flow seasons (late summer and early fall). The deeper sediments may retain historical PCB contamination, while the presence of PCBs in the surficial layers may denote a continued release of PCBs from runoff which may be more likely to be affected by river flow velocities. Future

investigations at this study site may warrant an examination of the potential for seasonal effects on chemical concentrations.

Conclusion

This study was able to provide precursory confirmation of earlier data that already exist for the site; as such, it confirms the existence of contaminants in the sediments, specifically PCBs, at potentially hazardous levels within the CFCC basin. This new evidence reaffirms the prior conclusion that dredge material removed from the CFCC basin would likely need to be treated as hazardous waste during disposal which is currently cost prohibitive for the college.

Based on this preliminary study, further investigation of this site is warranted to better understand the extent and distribution of PCB contamination as well as to further delineate the potential role of the Horton basin as a contaminant source to the CFCC basin. Additionally, other contaminants that were previously identified at the Horton Iron & Metal NPL site, such as metals and PAHs, should be added to the analysis.

Future plans for this site are already being devised. A new course, Environmental Sampling and Analysis, is currently being developed by the author of this report. The course is set to begin in the fall of 2015 at Cape Fear Community College. As a major component of the new course, this study will be continued through student sampling events. Over the course of the next five years, it is hoped that an additional 100-200 samples will be taken from this study area for analysis in the Chemical Technology lab on campus. In addition to sediment samples, the new study will also attempt to investigate PCB levels in tissues samples taken from finfish in the study area. Additional water sampling will also be conducted focusing on the two stormwater outfalls in the CFCC basin as well as three other known outfalls in the study area. Completion of the SSS and multibeam surveys of the entire site are also planned. Furthermore, once this site is thoroughly investigated, the course will plan to continue the investigation into further reaches of the river to investigate the extent of transport of contaminants.

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Appendix A

Relevant Historic Photographs from Cape Fear River area in Wilmington, NC

Photos were compiled from research conducted in the North Carolina Archives Room at the New Hanover County Public Library (NHCPL) in Wilmington, NC.

Photo 1: *River steamer, A.P. Hurt (ca. 1890); NHCPL Collection: Dr. Robert M. Fales*

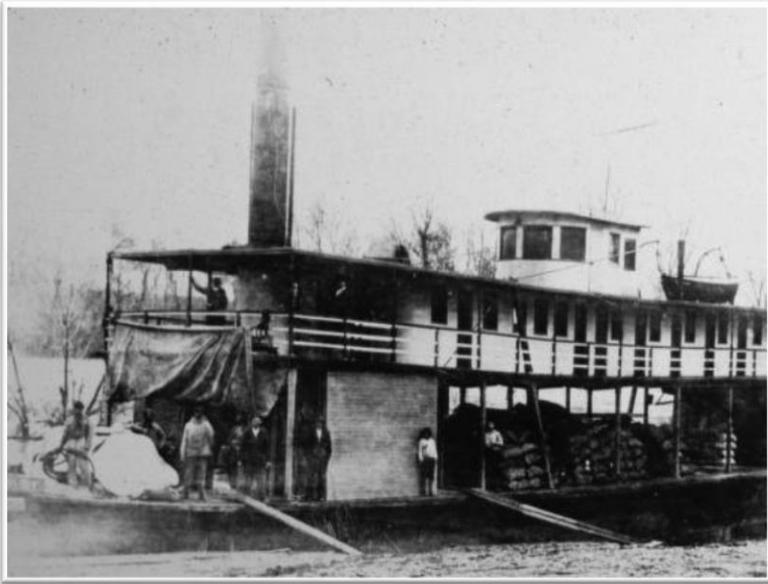


Photo 2: *Ferry boat, John Knox (1918); NHCPL Collection: Dr. Robert M. Fales*

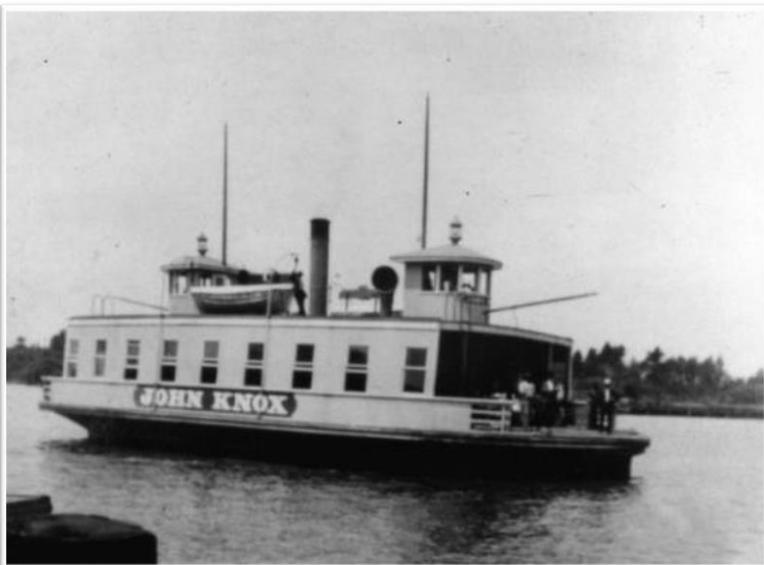


Photo 3: 1911 postcard depicting a scene of downtown Wilmington buildings overlooking the Cape Fear River. The spit of land seen across the river on the far right of image is Point Peter; the larger landmass across the river (on left) is Eagles Island. The near-field buildings would be situated just south of the eventual location of Cape Fear Community College. Postcard publisher: J.H. Rehder & Co.



Photo 4: Hilton Railroad Bridge over the Northeast Cape Fear River (date unknown). The Hilton Railroad Bridge is located less than a mile downriver from the Horton Iron & Metal site. NHCPL collection: Louis T. Moore, 908



Photo 5: Aerial view of U.S. Liberty ships that had been “mothballed” after World War II on the Brunswick River adjacent to the Cape Fear River (1949). The Cape Fear River (visible along the top of the photo) and the Brunswick River form a V-shape around Eagles Island (large landmass in center of photo). It is this storage location that eventually required a nearby location for shipbreaking and salvage; Horton Industries would fit the bill for this task with a location only about five miles north on the Northeast Cape Fear River. (Southward flow of Cape Fear River is from left to right in this image.) Photo publisher: U.S. Navy



Photo 6: Aerial view of Cape Fear River (1962). This photo was taken five years prior to the building of Cape Fear Technical Institute's first waterfront facility. The Battleship USS North Carolina is visible on the west bank of the river (mid-right in photo), and the eventual location of the CFCC operations basin can be seen on the east bank directly across the river from Point Peter (mid-left in photo). Photographer: Chiles Larson



Appendix B

Background and Development of the NPL

On December 11, 1980, the U.S. Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or the Superfund Act). This law brought active federal government involvement to uncontrolled hazardous waste sites. CERCLA was intended to be all-inclusive in its scope, comprising both preventative and response measures at both potential release sites and known release sites of uncontrolled hazardous substances that may endanger human or environmental health. On October 17, 1986, CERCLA was amended and strengthened by the Superfund Amendment and Reauthorization Act (SARA) to reflect the EPA's experience in administering the Superfund program.^{24, 25, 26}

CERCLA instituted protocols for closed and abandoned hazardous waste sites, established strict liability guidelines for parties responsible for the releases of hazardous waste, and created a trust fund to afford clean-up actions in the absence of an identifiable responsible party (the Superfund). SARA emphasized the importance of conducting clean-up activities with permanent results, provided new enforcement authorities, improved state and citizen involvement, and increased the size of the trust fund from \$1.6 billion to \$8.5 billion.^{24, 27}

Additionally, under section 105 (a)(8)(B) of CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) was required to establish a list of known or threatened releases of hazardous substances that are deemed national priorities. This list, the National Priorities List (NPL), largely serves as an information and management tool to guide the EPA in determining which sites warrant further investigation and/or immediate removal action. The NPL, therefore, permits the EPA to prioritize sites based on the nature and extent of public health and environmental risks that may be posed by the sites and to determine what remedial actions, if any, may be appropriate. CERCLA requires that this list be revised at least once per year.^{26, 28}

Sites may be placed on the NPL if at least one of the following criteria are met: (1) If, after the evaluation of air, ground water, surface soil, and soil exposure, a site scores 28.50 or greater on the HRS; (2) if a state designates a site as its single top priority to be listed on the NPL, even if an HRS score has not been acquired; and (3) if the ATSDR has issued a health advisory recommending humans be restricted access to the site, the EPA determines that the site poses a significant threat to public health, and the EPA deduces that remedial actions will be more cost effective than removal actions in the future. The NPL does not assign liability to any party, and the placement of a site on the NPL does not mean that any remedial or removal action will necessarily be required.^{26, 29}

Sites may be deleted from the NPL by the EPA when it is determined that no further response is appropriate to protect human health or the environment. Partial deletions of NPL sites can also be conducted when portions of a site have completed clean-up actions. Even after the deletion of a site from the NPL, the site remains eligible for further CERCLA-funded remedial and/or removal action(s) in the event that such actions are again necessary.²⁸

While there are a plethora of hazardous substances that can be detected at sites that are placed on the NPL, the EPA has derived a list of chemicals that are most commonly found. These 29 most prevalent chemicals are as follows (in alphabetical order): acetone, Aldrin/Dieldrin, arsenic, barium, benzene, 2-butanone, cadmium, carbon tetrachloride, Chlordane, chloroform, chromium, cyanide, DDT, DDE, DDD, 1,1-dichloroethene, 1,2-dichloroethane, lead, mercury, methylene chloride, naphthalene, nickel, pentachlorophenol, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, xylene, and zinc.³⁰

Appendix C

Horton Iron & Metal NPL Site, Wilmington, NC: Historical Information

Unless otherwise noted, the following timeline chronicles the property currently known as the Horton Iron & Metal NPL site (EPA ID: NCN000407480). Some ancillary information has been included for the parcels of land directly bordering the Horton site to the north and south; this information is pertinent because these adjacent properties were used for operations similar to that which were conducted at the Horton site. The adjacent properties have been assessed for contaminants and Removal Actions have been conducted; however, neither property has been proposed for the National Priorities List. For clarification of locations, see Figure 6 in the main text of this document.

Dates	Property Owners/Operators	Operations/Activities	Potential/Detected Contaminants	Other Notes
1906-1943	<p style="text-align: center;">Virginia Carolina Chemical (VCC)- Almont Works</p> <p style="text-align: center;">(EPA ID 110009261690)</p> <p style="text-align: center;">(Presently owned by Agrium, Inc.)</p> <p>NOT ON HORTON SITE; <i>This company operated along the northern border of the Horton Site.</i></p>	<p style="text-align: center;">Phosphate fertilizer manufacturing</p> <p style="text-align: center;">(Agrium, Inc. currently operates a nitrogen fertilizer manufacturing facility on the property.)</p>	<p style="text-align: center;"><u>Potential Contaminants:</u></p> <ul style="list-style-type: none"> • Arsenic, cadmium, copper, lead, mercury, vanadium, zinc, platinum, asbestos, PAHs, PCBs 	<p>Exxon-Mobil (merged with VCC-Almont in 1999) conducted a Removal Action at the VCC Almont site from October 2012 to February 2013 to address soil and sediment contamination associated with the former fertilizer manufacturing operations; 125,426 tons of soil and sediment were excavated and treated</p>
1911-1949	<p style="text-align: center;">American Agricultural Chemical Company (AACC); AACC's successor corporation name was Conoco Phillips Co. which is now Phillips 66.</p>	<p style="text-align: center;">Phosphate fertilizer manufacturing; Fertilizer operations appear to have begun in 1915</p>	<p style="text-align: center;"><u>Potential Contaminants:</u></p> <ul style="list-style-type: none"> • Arsenic, cadmium, copper, lead, mercury, vanadium, zinc, platinum, asbestos, PAHs, PCBs 	<p>Lead-lined sulfuric acid chamber building constructed by AACC on the northeast portion of the site</p>

1921	American Agricultural Chemical Company (AACC)	Lead-lined acid chamber disassembled	<u>Potential Contaminant:</u> <ul style="list-style-type: none"> Lead 	
1949-1954	Naco Fertilizer Company, a subsidiary of W.R. Grace	Continued fertilizer manufacturing	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Arsenic, cadmium, copper, lead, mercury, vanadium, zinc, platinum, asbestos, PAHs, PCBs 	
1954-1959	W.R. Grace	Continued fertilizer manufacturing	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Arsenic, cadmium, copper, lead, mercury, vanadium, zinc, platinum, asbestos, PAHs, PCBs 	
1959	W.R. Grace sold the property to Horton Iron & Metal			
1962	Horton Iron & Metal leased the property to Horton Industries			
1962-1972	Horton Industries	Ship breaking and recycling (salvage) of World War II ships	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Asbestos, PCBs, PAHs, barium, cadmium, chromium, copper, lead, nickel, zinc 	Operations took place in the boat slips located on the eastern-most side of the property along the west bank of the NE Cape Fear River
Sometime in the 1960's	Horton Industries	Horton dredged the boat slips; dredge material was placed on the property along the northern, western, and southern edges of the slips	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Asbestos, PCBs, PAHs, barium, cadmium, chromium, copper, lead, nickel, zinc 	

1970's to present	Horton Iron & Metal	Scrap iron and metal recycling	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Metals and petroleum products 	
↓ Contamination Detected on Horton Site & Remedial Actions Begin				
1988	Horton Iron & Metal	U.S. Coast Guard found extensive oil staining around metal crushing equipment on the Horton property		
1989	Horton Iron & Metal	A Notice of Violation was issued to Horton ordering clean-up of the contaminated soils and a determination of whether groundwater at the facility was contaminated		
1989-1996	Horton Iron & Metal	Oil-stained soils & an underground storage tank were removed from site		
1994-1996	<p>Wilmington Resources and Sigma Recycling ^a</p> <p>(EPA ID 11006828148)</p> <p>NOT ON HORTON SITE; <i>This company operated along the southeastern border of the Horton Site (See Footnote).</i></p>	Ship-breaking of U.S. Naval ships	<u>Potential Contaminants:</u> <ul style="list-style-type: none"> Asbestos, PCBs, PAHs, barium, cadmium, chromium, copper, lead, nickel, zinc 	Multiple worker safety violations & at least 12 environmental violations during this time including asbestos on old ship parts scattered around salvage yard & higher than normal levels of fuel, lead, chrome, and PCBs on site.
2002	Horton Iron & Metal	Pre-CERCLIS screening conducted		
2002	Horton Iron & Metal	U.S. EPA initial "Discovery" of site as a potential hazardous waste site		

2002	Horton Iron & Metal	Based on the NCDENR Division of Waste Management Superfund Section recommendation, the site was added to the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)		
2002-2003	Horton Iron & Metal	The North Carolina Department of Environment and Natural Resources (NCDENR) conducted a Preliminary Assessment followed by an Expanded Site Inspection (ESI)	<u>Contaminants Detected:</u> <ul style="list-style-type: none"> • Surface soils – metals, PAHs, PCBs, pesticides, asbestos • Groundwater – metals, pesticides • Sediments – metals, PAHs, pesticides 	Surface and subsurface soil, ground water, surface water, and sediment samples throughout the Horton property and in the adjacent Northeast Cape Fear River were collected.
2004-2010	Horton Iron & Metal	Non-National Priorities List Potentially Responsible Party Search		
2005-2008	Horton Iron & Metal	U.S. EPA contractor (TetraTech) conducted a Final Removal Assessment; ten surface soil samples were collected in a focused area around the boat slips.	<u>Contaminants Detected:</u> <ul style="list-style-type: none"> • PCB Aroclors 1254 and 1262, arsenic, and lead were detected in all samples. 	
2009	Horton Iron & Metal	U.S. EPA requires that Administrative Records for the site be compiled for all potential Responsible Parties (RPs)		

2009	Horton Iron & Metal	U.S. EPA requested that the owner take immediate (voluntary) action necessary to reduce worker exposure and prevent contaminants from migrating off-site during storm events.		<p>In response, Horton installed a gate to prevent unauthorized entry into the contaminated area.</p> <p>Horton also installed a silt fence around the boat slips to prevent further migration of contaminated soils into the boat slips and the Northeast Cape Fear River.</p>
2009-2010	Horton Iron & Metal	U.S. EPA contractor conducts an Expanded Site Inspection in the portion of the site that had formerly been the fertilizer manufacturing & ship breaking areas (7.4 acre area); 14 groundwater, 18 sediment, and 19 surface soil samples were collected.	<p><u>Contaminants Detected:</u></p> <ul style="list-style-type: none"> • Surface & subsurface soils – metals, PAHs, PCBs, SVOCs, pesticides, VOCs • Groundwater – metals • Sediments – metals, PAHs, PCBs, SVOCs, pesticides, VOCs 	Based on this ESI, an HRS scoring was recommended
2010	Horton Iron & Metal	Site scored with Hazard Ranking System (HRS)		<p>HRS Site Score = 48.03</p> <p>After a comment period & U.S. EPA review, this score was accepted as the final HRS Site Score.</p>
2010	Horton Iron & Metal	U.S. EPA proposal of this site to National Priorities List		

2010-2011	Horton Iron & Metal	National Priorities List Responsible Party Search conducted		
2011	Horton Iron & Metal	U.S. EPA final listing of the site to the National Priorities List		
2011-2012	Horton Iron & Metal	U.S. EPA conducted Remedial Investigation/Feasibility Study (RI/FS)		
2012	Horton Iron & Metal	RI/FS Negotiations conducted between EPA and potentially responsible parties to decide liability; An Administrative Order on Consent signed by the EPA and responsible parties to delegate site clean-up responsibilities		
Started in 2012	Horton Iron & Metal	Potentially Responsible Party RI/FS		As of the date of this report, the PRP RI/FS is ongoing
2014	Horton Iron & Metal	Final Release of ATSDR Public Health Assessment for site		

^a Officially, Sigma Recycling (formerly Wilmington Resources) is not part of the Horton Iron & Metal Site; Sigma Recycling borders the Horton site to the south. However, for the purposes of sediment contamination, it is important to note that the Sigma boat slip and the Horton boat slips are essentially all part of the same small basin on the west bank of the NE Cape Fear River.