February 28, 2018

Mr. Joe Ghiold, Project Manager
Facility Management Branch
Hazardous Waste Section
Division of Waste Management
NC Department of Environmental Quality
1646 Mail Service Center
Raleigh, NC 27699-1646

Re: Focused Feasibility Study Report– PFAS Remediation
Chemours Fayetteville Works
Fayetteville, North Carolina
EPA ID No. NCD 047 368 642

Dear Mr. Ghiold:

Enclosed, please find two hard copies of the *Focused Feasibility Study Report – PFAS Remediation* for the Chemours Fayetteville Works. The purpose of this FS is to analyze potential remedial options to address discharges from the site to the surface-water, groundwater and, ultimately the Cape Fear River. In addition to this hard copy of the report, an electronic submittal (PDF) has been made to you via email.

If you have any questions or need additional information, please feel free to contact me at 704-560-6435.

Respectfully submitted,

Kevin Garon
Project Director
Chemours Corporate Remediation Group

cc: Christel Compton – Chemours Fayetteville Works
File

Enclosures

PARSONS

FOCUSED FEASIBLITY STUDY REPORT – PFAS REMEDIATION

CHEMOURS FAYETTEVILLE WORKS RCRA PERMIT NO. NCD047368642-R2-M3

Prepared for:

The Chemours Company FC, LLC
Corporate Remediation Group
22828 NC Highway 87 W
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February 2018

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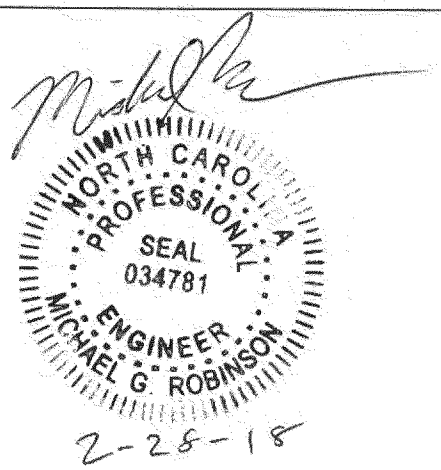
FOCUSED FEASIBLITY STUDY REPORT – PFAS REMEDIATION
CHEMOURS FAYETTEVILLE WORKS
RCRA PERMIT NO. NCD047368642-R2-M3

Seals, as applicable:



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ACRONYMS

Acronym	Definition / Description
APFO	Ammonium Perfluorooctanoate
bgs	Below ground surface
Chemours	The Chemours Company FC, LLC
CMS	Corrective Measures Study
COC	Constituent of concern
CSM	Conceptual site model
CRG	Corporate Remediation Group
DHHS	NC Department of Health and Human Services
DuPont	E. I. du Pont de Nemours and Company
FEP	Fluorinated ethylene propylene
FS	Feasibility Study
GCL	Geosynthetic Clay Liner
gpm	Gallon(s) per minute
GPR	Ground penetrating radar
HDPE	High-Density Polyethylene
HFPO-DA	Hexafluoropropylene oxide dimer acid
IXM	Ion Exchange Membrane
IM	Interim measure
IMAC	Interim maximum allowable concentrations
LF	Linear Feet
MSL	Mean sea level
NCDENR	North Carolina Department of Environmental and Natural Resources
NCDEQ	North Carolina Department of Environmental Quality
ng/L	Nanograms per liter
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and maintenance
PPA	Polymer processing aid
ppt	Parts per trillion
PMDF	Polymer Manufacturing Development Facility
PRB	Permeable reactive barrier
PVF	Polyvinyl Fluoride
PMDF	Polymer Manufacturing Development Facility
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
Site	Chemours Fayetteville Works Facility
USEPA	U. S. Environmental Protection Agency
WWTP	Wastewater treatment plant

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1.0 INTRODUCTION

Parsons has prepared this Focused Feasibility Study (FS) Report for Per- and Polyfluoroalkyl Substances (PFAS) on behalf of The Chemours Company FC, LLC (Chemours) for the Fayetteville Works facility located near Duart Township in Bladen County, North Carolina (the Site). The Site was owned by E. I. du Pont de Nemours and Company (DuPont) until July 2015.

The purpose of this FS is to analyze potential remedial options to address discharges from the site to the surface-water, groundwater and, ultimately the Cape Fear river. This report is organized into six sections, including this Introduction, which presents site background, operational information, and objectives. Section 2.0 presents a site conceptual model. Section 3.0 presents the remedial action objectives (RAOs), while Section 4.0 identifies the proposed technologies and presents the technology screening. The path forward is presented in Section 5.0. Finally, references cited in the text are presented in Section 6.0.

It should be noted that in Chemours' response to a February 12, 2018 Notice of Violation from North Carolina Department of Environmental Quality (NCDEQ) (which required a response by February 26, 2018) Chemours addressed actions that Chemours is taking to address control of sources of groundwater contamination. Those actions are also summarized in this report.

1.1 Site Background

The Site is located on NC Highway 87, 15 miles southeast of the City of Fayetteville, and south of the Bladen-Cumberland county line. The Site encompasses 2,177 acres of relatively flat undeveloped open land and woodland bounded on the east by the Cape Fear River, on the west by NC Highway 87, and on the north and south by farmland (Figure 1).

E.I. du Pont de Nemours and Company (DuPont) purchased the property in parcels from several families in 1970. A former manufacturing area, which was sold in 1992, produced nylon strapping and elastomeric tape.

DuPont sold its Butacite® and SentryGlas® manufacturing units to Kuraray America Inc. in June 2014. On July 1, 2015, DuPont separated its specialty chemicals business into a new publicly-traded company named The Chemours Company FC, LLC. With this separation, Chemours became the owner of the entire 2,177 acres of the Fayetteville Works along with the fluoromonomers, Nafion™ membranes, and PPA[1] manufacturing units. The polyvinyl fluoride (PVF) resin manufacturing unit remains with DuPont.

In addition to the manufacturing operations, Chemours operates two natural gas-fired boilers and a wastewater treatment plant (WWTP) for the treatment of process and sanitary wastewaters from Chemours, Kuraray, and DuPont. Hazardous wastes generated from the Chemours manufacturing processes and laboratories are currently managed at the permitted Hazardous Waste Container Storage Area, in four permitted hazardous waste tanks, and at the 90-day ignitable waste accumulation area prior to being shipped offsite for treatment, disposal, or recycling.

[1] PPA – polymer processing aid

1.2 Plant Site Operations

Figure 1 depicts the location of the Chemours Fayetteville Works facility on an excerpt of the United States Geological Survey topographic map of the area. The site layout is depicted on Figure 2. The Site consists of five main manufacturing areas, one former manufacturing area, and two support areas as summarized in the table below:

Area	Description
Main Manufacturing Areas	
Chemours Fluoromonomers and Nafion™ Membrane	Manufactures Nafion™ fluoropolymer membrane for electronic cells and various fluorochemicals used for Nafion™ membrane, Teflon® fluoropolymer, Viton® elastomers, and other fluorinated products.
Chemours Polymer Processing Aid (PPA)	Manufactures a fluorochemical that is used as a processing aid for off-site fluoropolymer manufacturing. This area formerly manufactured ammonium perfluorooctanoate (APFO). (Note: The last date of APFO production at the Site was April 28, 2013. Although APFO was manufactured in this area, it was never used in any of the other manufacturing facilities at the Site.)
Kuraray Butacite®	Manufactures Butacite® polyvinyl butyral sheeting and polyvinyl butyral resin for automotive and architectural safety glass.
Kuraray SentryGlas®	Manufactures SentryGlas® structural interlayer for automotive and architectural safety glass (previous location of now defunct Dymetrol® nylon strapping).
DuPont Company PVF	Manufactures PVF resin used to produce Tedlar® film.
Former Manufacturing Area	
Polymer Manufacturing Development Facility (PMDF)	Manufactured Teflon® fluorinated ethylene propylene (FEP) for electrical wiring insulation and other applications. (Note: this Teflon® unit did not use APFO in its process.) The PMDF unit was permanently shut down in June 2009; it no longer manufactures DuPont Teflon®.
Support Areas	
Power	Generates steam via natural gas and fuel oil-fired boilers for the facility's manufacturing areas as well as comfort heating for employees. Produces process water and demineralized water from raw river water.
Wastewater Treatment Plant	The WWTP treats process wastewater and sanitary wastewater prior to discharge to the Cape Fear River.

1.3 Regulatory History

The Fayetteville Works facility received its initial Resource Conservation and Recovery Act (RCRA) Permit (NCD047368642) to operate a hazardous waste container storage area and tanks in February 1983, while under DuPont ownership. DuPont submitted an amended Part A application in 1991 to document upgrades to its fluorocarbon waste treatment and tank system. The RCRA Part B permit application submitted in August 1993 identified 71,750 gallons of container storage capacity at the container storage area. Stored waste included characteristic wastes (D001, D002, D003, D007, D009, and D029) and listed wastes (F002, F003, and F005).

In January 1998, the Site's RCRA Permit was reissued and was to remain in effect for 10 years. Part V of the permit required DuPont to investigate potential releases of hazardous substances into the environment. In June 2007, DuPont submitted an application for renewal of the Site's RCRA Permit. The North Carolina Department of Environment and Natural Resources (NCDENR; now NCDEQ) reissued the permit on September 28, 2012.

Since 1996, several stages of investigation have been conducted at the Site under NCDENR/NCDEQ oversight to meet the conditions of the permit. The Phase III (Final) RFI[2] report was submitted in August 2014 (DuPont Corporate Remediation Group [CRG]). In addition, the Site voluntarily agreed to the NCDENR request to investigate potential APFO releases as part the ongoing RFI. The findings of the APFO investigation activities (conducted during the Phase II RFI) were included in Appendix A of the Phase II RFI Report (DuPont CRG 2006). The Corrective Measures Study (CMS) Work Plan was submitted on December 2, 2016 (Chemours CRG) and approved on February 8, 2017.

1.4 Feasibility Study Objectives

The purpose of this FS is to analyze potential remedial options to reduce on-site groundwater contamination, with a focus on discharges to the Cape Fear River. Several interim measures (IMs) and source control measures have already been implemented that have significantly reduced or eliminated direct discharges from the plant. Other IMs are also being proposed for addressing impacts to drinking water wells near the plant. These IMs are briefly described in Section 2 of this report. The specific objective of the remedial options discussed in this FS are to reduce groundwater discharges from the site and discharges from Willis Creek, Georgia Branch, and the old outfall channel to the Cape Fear River.

[2] RFI – RCRA Facility Investigation

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2.0 CONCEPTUAL SITE MODEL

Chemours uses the conceptual site model (CSM) to develop a representation of the chemical and physical characteristics of a site to focus investigation efforts and remedial decision making. The CSM also assists in the identification of areas for additional collection of potentially relevant data that can be addressed during future investigations.

The CSM for the Site was based on an analysis of potential exposure pathways, constituents of concern (COCs), and environmental fate and transport mechanisms. An accurate understanding of the geology and hydrogeology at the Site is also essential in developing the CSM. The current CSM was developed based on a review of historical data and the results of the activities and investigations conducted at the Site.

2.1 Physical Setting

The facility topography is relatively flat within the developed portion of the Site; surface topography then decreases towards the Cape Fear River to the east and Willis Creek to the north of the Site. Topographic relief is approximately 100 feet from the main manufacturing area down to the top of the riverbank and approximately 40 feet from the main manufacturing area to Willis Creek. Surface topography generally remains flat to the west; however, there is a gentle increase of about five feet to a topographic divide near Highway 87. In the far southwestern portion of the property, surface topography again decreases by 15 to 25 feet where the Georgia Branch Creek channel runs along the property line. The Georgia Branch Creek confluence with the Cape Fear River is approximately 1.3 miles south of the dam (0.75 miles southeast of the property).

The Cape Fear River is located along the eastern property boundary of the plant, approximately 1,850 feet from the eastern portion of the manufacturing area. Willis Creek, a tributary of the Cape Fear River is in the northern portion of the Site, approximately 3,000 feet from the manufacturing area. Process wastewater is sent off-site for proper disposal. On November 29, 2017, Chemours severed the pipe conveying wastewater from the Fluoromonomers/Nafion™ Membrane manufacturing area to Outfall 002 and the Cape Fear River, thus reducing PFAS concentrations at Outfalls 001 and 002, as well as concentrations in the effluent channel. These reductions are in addition to those reductions Chemours had achieved since July 2017 by identifying and voluntarily capturing for off-site disposal various waste streams from within the Fluoromonomers/Nafion™ Membrane manufacturing area. Portions of the Georgia Branch, another tributary to the Cape Fear River, flow along part of the southern boundary of the Site. The plant facilities are located on a plateau at an approximate elevation of 145 feet above mean sea level (MSL). The plant is situated approximately 70 feet above the 100- and 500-year Cape Fear River floodplains and at least 1,000 feet from the 100-year floodplain's nearest approach.

2.1.1 Site Geology

The facility is in the northwestern portion of Bladen County. Bladen County is situated within the Coastal Plain Physiographic Province, which consists of a seaward thickening wedge of sedimentary deposits ranging in age from Cretaceous to Recent. Paleozoic; metamorphic and igneous rocks underlie these deposits. The Site is underlain by the Black Creek Formation. The Black Creek Formation is characterized by lignitic clay, gray to black, and contains thin beds and laminae of fine-grained micaceous sand as well as thick lenses of cross-bedded sand. The upper portion of the formation may also contain glauconitic, fossiliferous clayey sand lenses. The Black Creek Formation and surficial deposits are the principal potable water aquifers in the region.

The soil on the Site falls within the Norfolk-Goldsboro-Raines general classification (Leab 1990). These soils are located on old, high stream terraces in the northern part of Bladen County and are generally poorly drained soils that have a sandy or loamy surface layer and loamy subsoil.

Based on the lithology logged during on-site investigations, the Site is underlain by a fine- to medium-grained sand unit with thin discontinuous interbedded silt/clay lenses. The sand extends to a depth of approximately 65 feet below ground surface (bgs) (elevation of +80 feet MSL). The saturated portion of this unit has been identified as the Surficial Aquifer. Beneath this unit is a 7- to 15-foot-thick, laterally-continuous dense clay that has been identified as the Black Creek Confining Unit. The elevation of this unit (approximately +65 to +77 feet MSL) indicates that it, too, should outcrop along the bluff face adjacent to the Cape Fear River, and potentially along the embankment near Willis Creek. Beneath this confining unit is the Black Creek Aquifer, which is approximately 8 to 20 feet thick and is encountered at depth between 80 and 100 feet bgs (elevation of approximately +45 to +65 feet MSL). Beneath this aquifer is a massive dense clay (with minor sand stringers) that has been identified as the Upper Cape Fear Confining Unit. This unit was not fully penetrated; however, it extended to at least 200 feet bgs (elevation of -55 feet MSL).

Within the manufacturing area, the uppermost sand unit is locally bisected by an aerially extensive stiff clay/clayey silt lens (clay lens). This clay lens is limited in lateral extent to the east, north and south by local topography and pinches out (terminates) to the west of the manufacturing area.

The depth to the top of the clay lens is approximately 15 to 18 feet bgs. The clay lens becomes thinner moving west across the manufacturing area. It ranges from approximately one foot to approximately 19 feet thick. A visual inspection for the clay lens was conducted along the drainage channel beside the bluff leading to the Cape Fear River. The clay lens was observed in the drainage channel bottom and was approximately 10 to 12 feet thick in the channel banks. The area of the channel where the clay lens was observed also coincided with an area of the channel where seepage faces were observed. Based on the elevation of the clay lens, it should outcrop on the bluff adjacent to the Cape Fear River.

2.1.2 Site Hydrogeology

A shallow unconfined aquifer (Surficial Aquifer) is encountered at approximately 50 feet bgs. Groundwater elevations range from approximately 100 to 107 feet above MSL in the western areas of the Site to approximately 93 feet above MSL in the eastern areas of the Site, indicating that groundwater flow is generally toward the Cape Fear River.

The Cape Fear River stage was recently measured to be 29.18 feet MSL, which is lower than the base elevation of the Surficial Aquifer, indicating that the Cape Fear River is a discharge boundary for the Surficial Aquifer. Based on groundwater elevations near Willis Creek, portions of the creek are “gaining” (groundwater discharges to the creek) and portions are “losing” (surface water infiltrates to the underlying groundwater). Georgia Branch Creek also appears to be a gaining stream near where State Road 1303 crosses Highway 87.

The Black Creek Aquifer is under confined conditions at the Site and is separated from the overlying Surficial Aquifer by a clay confining unit. The Black Creek Aquifer is the uppermost identified regional “state-wide” hydrogeologic unit. Flow in the Black Creek Aquifer is toward the Cape Fear River. The Cape Fear River stage is also lower than the

base of the Black Creek Aquifer, indicating that the Cape Fear River is also a discharge boundary for the Black Creek Aquifer.

A series of incised erosional channels were observed in the Cape Fear River floodplain located east of the manufacturing area. These channels can contain a steady flow of water where they intersect groundwater.

An aerially limited perched water zone exists on top of the clay lens that underlies most of the manufacturing area. This Perched Zone appears mainly to result from seepage of surface water through the bottom of the North/South Sediment Basins that are used to hold solids from Cape Fear River water (this water is used on-site as non-contact cooling water) and infiltration of non-contact cooling water from the Nafion™ Area ditch. The Perched Zone may also be recharged to a lesser extent by direct infiltration of rainfall and leakage from other on-site stormwater and non-process water conveyance ditches. Perched zone water flows in a radial pattern away from a potentiometric high near the north and south sedimentation basins (Figure 2) and the Nafion™ Area ditch. Where perched water is present, it is encountered from approximately 6 feet bgs at the basins to a depth of approximately 20 feet bgs along the edges of the Perched Zone west of the basins.

The lateral extent of the Perched Zone appears to be controlled by the topography and lateral limits of the clay lens. Perched water flows away from the potentiometric high along the top of the clay lens until either reaching the perimeter of the lens (where it would flow off the edge), reaching a seepage face (such as the one observed along the bluff adjacent to the river), or until there is insufficient hydraulic head. Flora at the Site (especially the heavily forested areas) consume the perched water through transpiration processes.

2.2 Sources of PFAS

Results of the investigations indicate that Target PFAS releases to environmental media from primary sources (e.g., wastewater conveyances and industrial process activities) have resulted in secondary sources present in environmental media. These secondary sources are present in on-site soil and groundwater (Perched Zone water, Surficial Aquifer groundwater, and Black Creek Aquifer groundwater) and off-site Surficial Aquifer groundwater. The distribution of detected Target PFASs in soil would appear to suggest air deposition is the primary source (in areas away from ditches). Although leaching of Target PFASs could lead to some of the detected groundwater concentrations, the higher groundwater concentrations are likely the result of leakage from stormwater and wastewater conveyance ditches. The observed distribution in the aquifers appears to result from Target PFAS migration with natural groundwater flow. Detection of PFAS in the surface water of Willis Creek, Georgia Branch, and the Cape Fear River, suggests probable migration of these groundwater secondary sources to these surface waters. However, sampling has suggested there are upstream sources in the Cape Fear River for some of the Target PFASs. A conceptual level water balance-based mass flux estimate indicates that hexafluoropropylene oxide dimer acid (HFPO-DA) in groundwater discharging to the river would not alone result in river water HFPO-DA concentrations at or above 140 nanograms per liter (ng/L, or parts per trillion [ppt]). A summary of the mass flux assessment is included as Appendix A.

Chemours has already undertaken, is undertaking, or has committed to undertake, numerous actions to identify, evaluate, remove, treat, mitigate, or control various on-site primary PFAS sources. Additional actions have already been implemented to address concerns in nearby off-site water wells. The elimination of PFAS primary sources has

already had a significant effect on reducing observed river water concentrations. On November 29, 2017, Chemours severed the pipe conveying wastewater from the Fluoromonomers/Nafion™ Membrane manufacturing area to Outfall 002 and the Cape Fear River, further reducing PFAS concentrations at Outfalls 001 and 002, as well as concentrations in the effluent channel. These reductions are in addition to those reductions Chemours had achieved since July 2017 by identifying and voluntarily capturing for off-site disposal various waste streams from within the Fluoromonomers/Nafion™ Membrane manufacturing area. Long-term solutions for these waste streams are currently being evaluated and are not discussed in this study. Off-site disposal of process wastewater has substantially eliminated the largest presumed source of PFAS discharge to the river, as shown by surface water data.

2.3 Inputs to the Cape Fear River

2.3.1 Willis Creek and Georgia Branch

Based on available data, migration of impacted groundwater from beneath the Site may not be the primary cause for Target PFAS concentrations seen in these tributaries. Detectable Target PFAS concentrations in surface water upstream of the Site suggests that off-site affected groundwater discharging to these tributaries is the primary source of Target PFAS concentrations. As a result, mitigating the source of mass to off-site groundwater (air deposition) should result in the reduction of Target PFAS concentrations in these surface waters to acceptable levels.

2.3.2 Current Outfall 002

Based on the CSM, past PFAS discharges to the river through this outfall were the result of certain Chemours' process wastewaters passing through the WWTP and ultimately being discharged to the river through Outfall 002. In late 2017, all such Chemours process wastewater discharges were eliminated. Specifically, effective November 29, 2017, all process and contact water from Nafion™ production is collected and shipped off-site for disposal. As a result, the primary source of PFAS to Outfall 002 has been mitigated. However, there remains a steady low-level Target PFAS concentration in Outfall 002 that is likely related to:

1. The presence of Target PFAS in the site intake water from the Cape Fear River, and
2. Stormwater runoff during rainfall events that picks up PFAS mass from land and buildings before flowing into ditches and being conveyed, directly or indirectly, to Outfall 002.

For some period following the cessation of Nafion™ process area wastewater discharges, the concentrations at Outfall 002 remained consistently below 140 ppt for HFPO-DA. Extensive collection of wipe sampling data from outdoor equipment at the Ion Exchange Membrane (IXM)/Nafion™ area indicates that an October 6, 2017 upset event, likely resulted in HFPO-DA residue on structures and equipment. It appears that during significant rain events, the HFPO-DA is washed into the ditch system and through Outfall 002. As this sampling has shown, the highest levels of residual HFPO-DA material are in the vicinity on the Vinyl Ethers South part of the facility, Chemours plans to begin a program of power washing equipment and facility components to remove residual contamination. This work will be conducted in phases, starting at the Vinyl Ethers South part of the facility and beginning by March 2, 2018. The planning to ensure

that the water being used does not damage electrical components and will be captured for off-site disposal is underway.

2.3.3 Old (Former) Outfall 002

This channel was used to convey water to the former NPDES outfall, and now operates as a conveyance of stormwater to the Cape Fear River. There is no active wastewater discharge from the Site into this former outfall. It appears that the former outfall channel (which was an unlined natural erosional channel off the manufacturing area) continued to erode into the underlying land over the life of its operation to the point where it now intercepts groundwater in the Surficial and Black Creek Aquifers. Based on recent monitoring, water volumes approximately double during moderate rainfall events. Chemours recognizes that PFAS mass is being discharged into the river through this former outfall and is developing action to mitigate it.

By March 30, 2018, Chemours expects to select a remedial option for this channel and submit a schedule for its expeditious design and implementation. The anticipated remedial option will consist of lining and/or piping the channel to limit Perched Zone infiltration. It bears noting that river water concentrations downstream do not currently exceed 140 ppt. Chemours is collecting additional data required to determine how best to address the former Outfall 002 discharge channel before proposing final remedial actions to NCDEQ. Samples have already been collected at several locations along this channel to inform the remedial design.

2.3.4 Surficial and Black Creek Aquifers

Affected groundwater in the Surficial and Black Creek Aquifers contributes a small amount of mass to the Cape Fear River through discharge of the groundwater to the river. The CSM, however, suggests that this discharging mass would not lead to a HFPO-DA concentration at or above 140 ng/L, and that the Surficial and Black Creek Aquifers do not appear to be contributing significantly to the river water HFPO-DA concentrations. Nonetheless, this report does evaluate the feasibility of potential remedial actions for these aquifers.

The available data and CSM suggest that contamination from the Perched Zone is infiltrating the lower aquifers. By dewatering the Perched Zone, Chemours expects to substantially reduce infiltration to other aquifers, and consequently, groundwater discharge to the river.

2.3.5 Perched Zone

It appears that the primary source of site-wide groundwater contamination is past releases of process water from unlined ditches (with a secondary source of air deposition across the Site). The primary source of process water infiltration has been eliminated.

The data currently indicates that the flow of Perched Zone groundwater containing PFAS is a secondary source of contamination. A clay layer at a depth of approximately 18 feet bgs allows this infiltrating water to create a localized Perched Zone. This Perched Zone is approximately 25 feet above the Surficial Aquifer water table.

Nafion™ Ditch

Most of the Nafion™ Area process wastewater historically was piped to the WWTP. However, there were other process and non-process streams containing PFAS that were

discharged into the unlined Nafion™ ditch. Part of this ditch water infiltrated into the underlying sandy soil.

The available data suggests that the Nafion™ ditch has been a significant contributing source of contamination to the Perched Zone under the facility. The ditch also contributes to the watering of the Perched Zone and its infiltration of other aquifers. The Nafion™ ditch presently carries up to 5 to 8 million gallons a day of non-contact cooling water from the IXM/Nafion™ facility to Outfall 002.

Sedimentation Basins

In addition to water infiltrating the Perched Zone through unlined ditches, there are also two large unlined basins on the Site that are used for disposal of solids removed from river water that is used for non-contact cooling. The solids are pumped as a slurry to the basins from a clarifier. This water infiltrates into the underlying sandy soil, adding to the Perched Zone. This perched water flows radially away from the hydraulic high beneath the Nafion™ ditch and the North and South Sediment Basins.

Interim Measures

Chemours proposes to pump the PFAS mass in Perched Zone water to reduce or eliminate the pathway for mass entering the deeper Surficial and Black Creek Aquifers. The pumping wells have been identified and the facility has already obtained the pumps. To address the Perched Zone as a contributing source, Chemours will begin (by March 15, 2018) to pump water from the three highest concentration wells in the Perched Zone (NAF-12, NAF-03, and PZ-18). It is estimated that the amount of water pumped per well will be in the range of three gallons per minute, with the precise level to be determined based on the experience once pumping begins. The pumped water will be containerized for off-site disposal until suitable treatment technology can be installed on-site. The preparation for this project is already underway; the technical team has identified the wells to be used and has ordered the pumps (starting with rental pumps so that we can begin sooner). By dewatering the Perched Zone, it is expected that there will be a substantial reduction in infiltration to other aquifers.

By reducing the infiltration of contaminated water into the Perched Zone, there will also be a reduction in the overall water loading of the zone, so that the water levels in that zone drop and the Perched Zone will not infiltrate, or will infiltrate less, into the Surficial and Black Creek aquifers near the River.

2.3.6 Air Emissions

Chemours has undertaken a comprehensive source testing program, which began in January 2018, and provides the basis for better understanding the sources and quantity of air emissions of HFPO-DA and other PFAS from the facility. The available information suggests that air emissions from the facility are impacting surrounding soil and groundwater via deposition. Chemours has been developing, in coordination with the NCDEQ Division of Air Quality, short-term and longer-term abatement options to reduce PFAS air emissions from the facility.

3.0 REMEDIAL ACTION OBJECTIVES

Chemours will address PFAS releases to environmental media from historical and current operations in a manner that protects people and the environment. Remedial actions will be completed in accordance with appropriate standards and will comport to the extent reasonably feasible with state groundwater quality standards and their customary application or utilization at similar sites in North Carolina.

Toward that end, Chemours proposes to focus in the near-term on a set of remedial actions and objectives that meet the following goals:

- Mitigates PFAS releases of significance to environmental media from primary and secondary sources on the property or current Site operations
- Protects Cape Fear River water quality consistent with established NCDEQ water quality standards and the North Carolina Department of Health and Human Services (DHHS) provisional health goal for drinking water
- Identifies and addresses off-site drinking water wells that exceed the DHHS provisional health goals

Near-term and long-term objectives and associated remedial actions are discussed further below.

3.1 Near-Term Objectives

The following objectives have been developed to address near-term goals:

- Expand the current quantitative assessment and understanding of the actual or potential significance of current and historical releases into environmental media (air, soil, groundwater, surface water) of HFPO-DA and other site-related PFAS.
- Continue to mitigate further releases of significance to environmental media, specifically:
    - Reduce air releases consistent with targets and schedules approved and agreed upon by NCDEQ.
    - Identify and address any significant remaining ongoing sources of process-impacted stormwater released to onsite groundwater or to surface water bodies.
- Identify and take specific actions to address discharge of onsite groundwater/surface water as necessary to ensure concentrations in the Cape Fear River do not exceed 140 ppt of HFPO-DA at any established downstream river water intake.

3.1.1 Actions Required to Achieve Near-Term Objectives

The following actions are proposed to achieve the short-term objectives:

- Finalize based on newly collected data and resubmit to NCDEQ the CSM that reflects the best current understanding of mass inputs to the river, how mass has been released, and how and to what extent those releases have been or are proposed to be reduced or discontinued in pursuit of remedial objectives.
- For off-site residential impacts, Chemours will continue to work with NCDEQ to implement the Granulated Activated Carbon pilot program for residential water and to adopt other feasible and effective measures to mitigate impacts to

groundwater outside the plant watershed from air deposition. Mass will be reduced or eliminated so that released materials are not deposited on the ground and infiltrated into drinking water zones at levels exceeding state standards. Until such time when these source mass removal or mitigation measures enable off-site groundwater to meet applicable state standards for those waters, Chemours will offer point-of-exposure treatment with activated carbon systems, and connections to public water supplies where existing water mains already exist and tap connections alone are required.[3]

- Actions required for the various inputs to the Cape Fear River:
  - **Willis Creek and Georgia Branch:** It appears that off-site groundwater is discharging to these tributaries. As a result, mitigating the source of mass to off-site groundwater (air deposition) should result in the reduction of PFAS concentrations in these surface waters to acceptable levels. Therefore, no remedial alternatives are analyzed for these tributaries.
  - **Current Outfall 002:** Chemours performed wipe sample testing of exterior equipment of the IXM/Nafion™ area and soil sampling. This sampling has shown highest levels of residual HFPO-DA material in the vicinity on the Vinyl Ethers South part of the facility. This is consistent with Chemours' working hypothesis that the residual contamination on surfaces was caused in substantial part by an incident (previously reported to NCDEQ), at the Vinyl Ethers South facility on October 6, 2017, which resulted in emissions and residual contamination from that facility. Chemours has developed a program of power washing surfaces and cleaning equipment to remove the residual contamination.
  - **Former Outfall 002:** Chemours plans to limit the transport of contaminated groundwater into this channel by lining and/or piping the channel. Samples have already been collected at several locations along this channel to inform the remedial design.
  - **Perched Zone:** Chemours believes that addressing the Perched Zone will reduce or eliminate the pathway feeding the deeper Surficial and Black Creek Aquifers. This will, in turn, lead to substantial reductions in the mass of any releases from the Site to the surrounding environment. The Perched Zone pathway can be removed or flow curtailed by any or a combination of the following: lining the sediment ponds; lining ditches that are contributing water and/or contaminants to the Perched Zone; and pumping and treating the Perched Zone groundwater. Options for addressing these concerns are the subject of this FS and are presented in the following sections.
    - **Nafion™ Ditch:** A core component of Chemours' source abatement plan is excavating and then lining the Nafion™ ditch which presently carries up to 5 to 8 million gallons a day of non-contact cooling water from the IXM/Nafion™ facility to Outfall 002. The available data suggests that this ditch has been a significant contributing source of contamination to the Perched Zone under the facility, and it also contributes to the watering of the Perched

[3] Chemours has submitted a proposal to NCDEQ for installing granular activated carbon treatment systems at residences with drinking water wells exceeding 140 ppt. NCDEQ has asked that further pilot testing be conducted to confirm the systems can achieve the stated goals and plans for that testing are being finalized.

Zone and its infiltration of other aquifers. Accordingly, Chemours intends to excavate contaminated materials in the bottom of the ditch and then line it to reduce future infiltration. The design work is underway and will be completed (along with the preparation of a schedule for implementation of this project) by March 30, 2018. The final project and schedule will be impacted by the availability of materials, the need to operate safely in this area which is within the blast zone[4], and other operational issues.

- **Sedimentation Basins:** The available data suggest that these basins are contributing to the watering of the Perched Zone, which in turn causes the Perched Zone to infiltrate the Surficial and Black Creek aquifer. Chemours plans to limit further such contributions by sequentially emptying and lining each basin with a high quality synthetic liner. The design work for this project is already underway.

- **Surficial and Black Creek Aquifers** Based on the CSM, the current condition of the Surficial and Black Creek Aquifers meets the near-term RAOs. Removal of the source area located in the Perched Zone will further reduce the contribution of PFAS to surface water, therefore no action is required to meet near-term RAOs for this unit. Continued groundwater monitoring will be conducted to verify that conditions continue to meet the RAOs. This study will also evaluate the feasibility of potential remedial actions to address these aquifers.
- **Air Emissions** Data collected from a comprehensive source testing program has provided information on the sources and quantity of air emissions of HFPO-DA and other PFAS from the facility. Chemours is focusing its abatement efforts on areas where it can achieve the greatest level of short term abatement. This testing has required the development of sampling and testing standards and methods where none previously existed, and that process continues as NCDEQ has asked Chemours to be able to sample and test for additional compounds. Chemours has been developing, in coordination with the NCDEQ Division of Air Quality, short term and longer-term abatement options to reduce PFAS air emissions from the facility.

3.2 Long-Term Objectives

Chemours recognizes that additional long-term goals may be called for to address on-site or off-site groundwater quality, in accordance with current or future state standards. These include default standards or interim maximum allowable concentrations (IMACs) or other modified standards for specific parameters or waters. Toward that end, Chemours proposes an adaptive management approach to guide further long-range actions, monitor progress, and determine if and where actions taken are sufficient, or alternatively, additional action may be necessary to achieve compliance with approved remedial objectives or other applicable standards.

[4] The facility is designed so that if there were to be an accidental explosion, debris would be directed in a single direction, called the “blast zone,” which is off-limits during facility operation for safety reasons.

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4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The following sections contain an analysis of potential remedial technologies and corrective measures alternatives that could be implemented to address mass located in the Perched Zone as well as surface water discharges from the Surficial and Black Creek Aquifers and the Old Outfall No. 002. As previously mentioned, Chemours is in the process of evaluating, designing and implementing a number of these remedial actions as well as implementing other interim measures to address immediate concerns.

4.1 Identification of Preliminary Remedial Alternatives

4.1.1 Perched Zone

The highest groundwater concentrations at the Site have been identified in this zone. It is therefore presumed to be the remaining major secondary source of PFAS to the Surficial and Black Creek Aquifers. The Perched Zone water is relatively shallow and easily accessible, and remediation of this water should have a significant effect on reducing site groundwater concentrations.

To address the Perched Zone as a contributing source (until the final remedy is selected and installed), Chemours will begin (by March 15, 2018) to pump water from the three highest concentration wells in the Perched Zone (NAF-12, NAF-03, and PZ-18). It is estimated that the amount of water pumped per well will be in the range of three gallons per minute, with the precise level to be determined based on the experience once pumping begins. The pumped water will be containerized for off-site disposal until suitable treatment technology can be installed on-site. The preparation for this project is already underway; the technical team has identified the wells to be used and has ordered the pumps (starting with rental pumps so that we can begin sooner).

In addition to the interim measure described above, several technologies have been selected for evaluation to further address this zone. The following technologies have been selected for evaluation:

P1. **No Action / Groundwater and Surface Water Monitoring Only:** This option provides a baseline case for comparison of options and to determine if additional action at the Site is warranted. Except for groundwater monitoring, no work is proposed under this alternative. This option includes 30 years of groundwater monitoring at 40 wells and surface water points across the Site. All subsequent options will include some level of groundwater monitoring.

P2. **Lining of Sedimentation Basins and Nafion™ Ditch:** Based on the current CSM, the sedimentation basins and Nafion™ ditch provide a significant amount of recharge to the Perched Zone. Lining these systems will significantly reduce the recharge of the Perched Zone and thus reduce the flux of PFAS to the Surficial Aquifer. Chemours has completed surface soil and storm runoff sampling for the purpose of evaluating which soils need to be addressed. The design work is underway. The basins and ditch would be lined with either a high-density polyethylene (HDPE) liner or geosynthetic composite liner (GCL) system to prevent water from percolating out of them. Figure 3 shows the proposed areas to be lined.

The following scope of work is proposed:

1. Install a temporary 20 gpm groundwater treatment system consisting of two-stage carbon treatment (Figure 4).

2. Install a temporary dewatering system around the South Sedimentation Basin to lower the groundwater level for construction.
3. Dredge South Sedimentation Basin. Settled river solids will be removed from the basin and dewatered. Supernatant will be placed in the North Sedimentation Basin. The dewatered solids will be transported off-site for disposal in a Subtitle D landfill. Three feet of solids are assumed in the 1.3-acre basin.
4. Prepare the subgrade and line the South Sedimentation Basin. The basin will be lined with either a 45-mil HDPE liner or a GCL system. A one-foot soil cover will be placed on top of the liner for protection, and rip rap or similar material will be used on the side slopes to protect the liner and prevent erosion.
5. Return the South Sedimentation Basin to service and shut off the North Sedimentation Basin.
6. Install a temporary dewatering system around the North Sedimentation Basin to lower the groundwater level for construction.
7. Dewater the North Sedimentation Basin and remove settled solids. Supernatant will be placed in the South Sedimentation Basin, and dewatered solids will be sampled and managed in accordance with applicable regulations. One foot of solids is assumed in the 1.3-acre basin.
8. Prepare the subgrade and line the North Sedimentation Basin.
9. Provide bypass pumping for and dewater the Nafion™ ditch.
10. Prepare subgrade and install liner.
11. Return ditch to service.
12. Remove dewatering and treatment systems.

P3. **Single Recovery Trench with Pump-and-Treat System:** In addition to lining the ponds and Nafion™ ditch, this option involves the installation of a 1,500-linear-foot (LF) recovery trench east of the Nafion™ area. The combined system would reduce recharge to the Perched Zone and recover additional groundwater for treatment using either granular activated carbon, organoclay, or a combination of the two. The treated water would be discharged to the river.

The following scope of work is proposed:

1. Line the basins and Nafion™ ditch as described above with the exception that the proposed 20 gpm treatment plant (Figure 4) would remain on site to treat water from the recovery trench.
2. Construct 1,500 LF the recovery trench as shown on Figure 5. The 15-foot-deep by 2-foot-wide trench would be constructed using traditional construction methods (excavator).
3. At an estimated 20 gpm recovery rate, the treatment plant is estimated to operate for 10 years.

P4. **Two Recovery Trenches with Pump-and-Treat System:** In addition to lining the ponds and Nafion™ ditch and installing a 1,500 LF trench, this option involves the installation of a 2,000 LF recovery trench west of the Nafion™ ditch

and a recovered groundwater treatment system. The combined system would reduce recharge to the Perched Zone and recover additional groundwater for treatment using either granular activated carbon, organoclay, or a combination of the two.

The following scope of work is proposed:

1. Line the basins and Nafion™ ditch as described above.
2. Construct a 40 gpm treatment plant to treat water from the recovery trenches. The treatment plant would be similar to the 20 gpm system (Figure 4), but would consist of two parallel treatment trains.
3. Construct the 1,500 LF and 2,000 LF recovery trenches as shown on Figure 6. The 15-foot-deep by 2-foot-wide trenches would be constructed using traditional construction methods (excavator).
4. At an estimated 40 gpm recovery rate, the treatment plant is estimated to operate for 5 years.

P5. **Pump and Treat with Horizontal Recovery Well:** This option is similar to option 3 above, but the recovery trench is replaced with a horizontal recovery well. The well would be installed at the same location as the trench shown on Figure 5. The treated water would be discharged to the river.

The following scope of work is proposed:

1. Line the basins and Nafion™ ditch as described above, except that the proposed 20 gpm treatment plant (Figure 4) would remain on-site to treat water from the recovery trench.
2. Construct a 1,500 LF horizontal recovery well using horizontal directional drilling.
3. At an estimated 20 gpm recovery rate, the treatment plant is estimated to operate for 10 years.

P6. **Temporary Dewatering and Pump-and-Treat System:** In addition to lining the ponds and Nafion™ ditch, this option involves the installation of temporary vertical well points and headers to dewater the Perched Zone. A temporary treatment system would be utilized to treat the extracted groundwater prior to discharge to the river. Once the area is sufficiently dewatered, the well points and treatment system would be removed. Once the area is sufficiently dewatered, the well points and treatment system would be removed. This option has the advantage of quickly dewatering the Perched Zone without leaving behind any permanent or long-term infrastructure.

The following scope of work is proposed:

1. Line the basins and Nafion™ ditch and install temporary treatment system as described above.
2. The Site over the Perched Zone would be divided into areas roughly the same size as the sedimentation basins. The temporary well points and headers would be moved from section to section until the Perched Zone is dewatered.
3. The recovery rate is estimated at 20 gpm.

4.1.2 Surficial and Black Creek Aquifers

As previously mentioned, the current condition of the Surficial and Black Creek Aquifers meets the RAOs. Removal of the source area located in the Perched Zone will further reduce the contribution of PFAS to surface water. Therefore, no action is required to meet short-term RAOs for the aquifers. However, several options for capturing and treating groundwater in from these zones are presented below to further reduce the mass flux to the river.

S1. **No Action / Groundwater and Surface Water Monitoring Only:** This option will be evaluated to provide a baseline case for comparison of options and to determine if additional action at the Site is warranted. This option involves annual GW monitoring of select points. Except for groundwater monitoring, no work is proposed under this alternative. As with the Perched Zone, this option includes 30 years of groundwater monitoring at 40 wells and surface water points across the site.

S2. **Pump-and-Treat from the Five Existing LTW Wells:** In this option, a 20 gallon-per-minute (gpm) treatment system would be constructed, and pumps would be installed in the five existing LTW wells (Figure 7) to extract groundwater for treatment.

The following scope of work is proposed:

1. Construct 20 gpm groundwater treatment plant.
2. Install conduit and piping to LTW wells.
3. Install pumps in the LTW wells.

S3. **Pump-and-Treat with Vertical Recovery Wells:** In this option, 60 vertical recovery wells will be installed along the top of the bluff east of the Nafion™ area to a depth of approximately 120 feet. These wells will be used to recover groundwater from the two zones for treatment (Figure 8).

The following scope of work is proposed:

1. Construct 140 gpm groundwater treatment plant.
2. Install 60 vertical recovery wells to approximately 120 feet below grade. The wells would be screened to recover groundwater from both aquifers.
3. Install piping and conduit.

S4. **Pump-and-Treat with Horizontal Recovery Wells:** Two horizontal wells (one in the Black Creek Aquifer and one in the Surficial Aquifer) would be used to extract groundwater for treatment. The two horizontal wells would be installed one on top of the other roughly in the same area as the line of proposed vertical recovery wells (Figure 8).

The following scope of work is proposed:

1. Construct 140 gpm groundwater treatment plant.
2. Install two 4,000 LF horizontal recovery wells (one in each aquifer).
3. Install piping and conduit.

S5. **Sheet Pile Wall with Upflow Side Groundwater Management:** A sheet pile system would be installed parallel to the river with a groundwater recovery

system on the upgradient side to capture groundwater flow for treatment (Figure 9).

The following scope of work is proposed:

1. Construct 140 gpm groundwater treatment plant.
2. Install 6,000 LF sheet pile wall with upflow groundwater capture system.
3. Install piping and conduit.

S6. **Permeable Reactive Barrier Wall (PRB):** A PRB wall (carbon or organoclay) would be installed to intercept water in the two aquifers before it reaches the river. The PRB would be installed in approximately the same area as the sheet pile wall proposed under option S5 (Figure 9). The system performance would be monitored under a long-term monitoring program.

4.1.3 Former Outfall No. 002 Channel

As previously mentioned, By March 30, 2018, Chemours expects to select a remedial option for the channel and submit a schedule for its expeditious design and implementation. The anticipated remedial option will consist of lining and/or piping the channel to limit Perched Zone infiltration. It bears noting that river water concentrations downstream do not currently exceed 140 ppt. Chemours is collecting additional data required to determine how best to address the former Outfall 002 discharge channel before proposing final remedial actions to NCDEQ. Samples have already been collected at several locations along this channel to inform the remedial design.

The following remedial alternatives were considered when making this selection:

F1. **No Action / Groundwater and Surface Water Monitoring Only:** This option is evaluated to provide a baseline case for comparison of options and to determine if additional action at the Site is warranted. This option involves annual GW monitoring of select points. Except for groundwater monitoring, no work is proposed under this alternative. As with the Perched Zone, this option includes 30 years of groundwater monitoring at 40 wells across the site. All subsequent options will include some level of groundwater monitoring.

F2. **Line Channel:** This proposal includes stream restoration and lining activities for the ditch leading to Old Outfall No. 002 (Figure 10). This will reduce or eliminate the groundwater seeps discharging to the ditch. The following scope of work is proposed:

1. Clear and grub the channel and install erosion controls.
2. Prepare channel subgrade and install liner.
3. Install gabion blanket on top of liner to keep it in place and prevent erosion.
4. Restore area.

F3. **Pipe Flow:** This proposal includes installing an underground storm drain to carry the stormwater flow currently carried by the ditch (Figure 11). The existing ditch would then be filled in and closed in place. This will eliminate the groundwater seeps discharging to the ditch. The following scope of work is proposed:

1. Clear and grub the path for new pipe and install erosion controls.
2. Excavate and install new double walled HDPE pipe.

3. Backfill existing channel with spoil material from pipe installation.
4. Restore area.

F4. **Capture Water for Treatment:** In this option, a concrete sump would be constructed near the Former Outfall No. 002 location. Water captured by the sump would be pumped to a groundwater treatment system (Figure 12). The system would be sized to handle the initial flow from storm events, but large storm flows would be allowed to overflow and bypass the treatment system.

1. Clear and grub the treatment plant area.
2. Construct a 500 gpm treatment system (carbon, organoclay or combination of the two).
3. Construct cofferdam at sump location and dewater.
4. Construct 25' x 25' x 25' concrete sump.
5. Install submersible pumps and transfer piping.
6. Plant Startup.
7. Restore area.

Sample have already been collected at several locations along this channel to inform the remedial design. Chemours will fully assess each of these options, in consultation with NCDEQ, and will provide NCDEQ with a proposed remedial option by March 30, 2018 along with a schedule for expeditious implementation.

4.1.4 Air Emissions:

In consultation with NCDEQ and in recognition of the available information suggesting that air emissions from the facility are impacting surrounding soil and groundwater via deposition, Chemours is undertaking a comprehensive program to identify, evaluate, and abate PFAS air emissions at Fayetteville Works (in the short-term and longer-term). The specific abatement measures to be taken are beyond the scope of this report.

4.2 Screening of Preliminary Remedial Alternatives

The remedial alternatives listed above were screened based on the following criteria:

- Technical Implementability
- Effectiveness
- Administrative Feasibility
- Reduction of toxicity, mobility, or volume
- Cost (relative/qualitative)

Technical implementability considers whether there are technical limitations that would preclude a technology from further consideration. Examples of these limitations are geologic or hydrogeologic conditions (e.g., a formation may not be amenable to effectively applying technologies requiring injections), depth of impact, type of constituents or the presence of limiting constituents (e.g., metals or conditions toxic to bacteria). The options have been ranked for implementability as high, medium, or low. High means that there are no technical limitations, medium indicates that there may be some limitations and challenges, while low indicates that there are significant technical barriers to implementation of the technology.

The effectiveness of each alternative was evaluated based on four factors: ability to meet remedial goals, protection of people and the environment, whether the technology is proven or emerging, and reliability. The evaluation of administrative feasibility covers such items as the ability to obtain permits, the availability of resources (e.g., space, power, backfill, or other utilities), and the availability of contractors or other suppliers required to perform the work.

The technologies were screened based on the relative capital and operations and maintenance (O&M) costs for each technology. A detailed analysis was not performed, but the technologies were evaluated as high, moderate, or low relative to the other process options.

The results of the screening are discussed in the subsections below and Table 1 summarizes the screening of the technologies based on these factors.

4.2.1 Perched Zone (Including Nafion™ Ditch and Sediment Basins)

Technical Implementability

There are no technical limitations precluding any of the proposed Perched Zone remedial alternatives, and all the technologies are appropriate for treating PFAS. The impacted groundwater is relatively shallow and accessible. The geology and hydrogeology at the Site do not present obstacles to any of the proposed treatment options.

Option P4 has the most significant implementability concerns. The area west of the Nafion™ area is more developed, and the presence of underground utilities may complicate the installation of the trench.

Effectiveness

All the technologies meet the effectiveness criteria.

Administrative Feasibility

There are no administrative limitations for any of the options. Some options considered might need specific permits (e.g., injection or discharge permits); however, none of these permits are expected to be exceptionally difficult to obtain.

Reduction of toxicity, mobility, or volume

Option P1 has no effect on the toxicity, mobility, or volume of PFAS at the Site. Option P2 reduces the mobility of PFAS in the Perched Zone by eliminating much of the recharge to this zone; but it does not reduce the toxicity or volume of the existing material. Options P3 through P6 reduce the mobility and volume, but none of them reduce the toxicity.

Cost

See Table 1 for relative cost assessments.

Summary

All the technologies meet the screening criteria at the Site. However, lining the ponds followed by use of a temporary dewatering system appears to be the best alternative for meeting the remedial objectives in this zone (Option P6).

4.2.2 Surficial and Black Creek Aquifers

Technical Implementability

There are significant technical issues with Option S2 (pumping from the existing LTW wells). First, these wells are located very close to the river and any treatment system would need to be installed at the top of the bluff to protect the equipment from flooding. Second, the wells are spaced too far apart to provide complete capture. Third, the wells are too close to the river, which would cause capture of a significant quantity of river water as opposed to water from the aquifers. Finally, the wells are screened in the Black Creek Aquifer and would do little to capture water from the Surficial Aquifer.

There are no technical limitations precluding any of the remaining proposed remedial alternatives for this zone, and all the technologies are appropriate for treating PFAS. However, the impacted groundwater is relatively deep. The geology and hydrogeology at the Site do not present obstacles to any of the proposed treatment options.

Effectiveness

All the technologies except Option S2 meet the effectiveness criteria. Option S2 only captures water from the Black Creek Aquifer and may capture more river water than aquifer groundwater.

Administrative Feasibility

There are no administrative limitations for any of the options. Some of the options considered might need specific permits (e.g., injection or discharge permits); however, none of these permits are expected to be exceptionally difficult to obtain.

Reduction of toxicity, mobility, or volume

Option S1 has no effect on the toxicity, mobility, or volume of PFAS at the Site. The remaining options reduce the mobility and volume, but none of them reduce the toxicity.

Cost

See Table 1 for relative cost assessments.

Summary

Due to implementation and effectiveness concerns, Option S2 does not meet the criteria for further consideration at the Site. All other options meet the screening criteria. However, remediation of the Perched Zone will remove the source feeding the Surficial and Black Creek Aquifers and it is expected that this action will reduce or eliminate the need for active remediation of the lower aquifers. Therefore, it is proposed that monitoring be conducted following the Perched Zone remediation (Option S1).

4.2.3 Old Outfall 002

Technical Implementability

Except for the No Action option, there are expected to be significant implementability issues with all the proposed options. These are mostly related to the poor condition of the existing channel, steep slopes, and the need for remote dewatering operations to facilitate construction. However, none of these is believed to be insurmountable based on the current available information.

Effectiveness

All the technologies meet the effectiveness criteria, although maintenance of a lined channel would present problems due to the steep slopes.

Administrative Feasibility

There are no administrative limitations for any of the options. Some of the options considered might need specific permits (e.g., injection or discharge permits); however, none of these permits are expected to be exceptionally difficult to obtain.

Reduction of toxicity, mobility, or volume

Option F1 has no effect on the toxicity, mobility, or volume of PFAS at the Site. Options F2 and F3 reduce the mobility, but not the volume or toxicity. Option F4 reduces the mobility and volume, but not the toxicity.

Cost

See Table 1 for relative cost assessments.

Summary

All the technologies meet the screening criteria for further consideration at the Site. Based on the currently available data, lining the ditch appears to best alternative for meeting the remedial objectives related to this former outfall. However, due to the need to gather additional data to guide this effort, Chemours proposes to follow an adaptive approach of collecting the necessary additional data to determine the actual source of water in the outfall channel and review multiple technologies that might be applied to address this discharge.

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5.0 PATH FORWARD

Based on the detailed analysis of alternatives, the following conclusions have been made regarding the options presented herein. All the actions identified below are subject to further revision based on design, feasibility, schedule, and cost.

- Perched Zone: Pumping the Perched Zone and lining the ponds followed by use of a temporary dewatering system appears to be the best alternative for meeting the remedial objectives in this zone (Option P6).
  - By March 15, 2018, begin to pump water from the Perched Zone, which the sampling and analytical data have shown to be the subsurface zone with by far the greatest concentrations of HFPO-DA and other PFAS, and a source of groundwater contamination through infiltration of other zones. The pumped water will be containerized for off-site disposal until suitable treatment technology can be installed on-site.
  - *Sedimentation Basins:* For the two surface impoundments used to collect sediment generated during the filtration and clarification of intake water to be used at the facility from the Cape Fear River, sequentially empty and line each basin with a high quality synthetic liner. The design work for this project is already underway.
  - *Nafion™ ditch*: Excavate contaminated materials in the bottom of the ditch and line it with a HDPE (or similar) liner.
  - *Remove contaminated soils near the NafionTM ditch and dispose of them offsite.*
- Surficial and Black Creek Aquifers: Remediation of the Perched Zone will remove the source feeding the Surficial and Black Creek Aquifers and it is expected that this action will reduce or eliminate the need for active remediation of the lower aquifers. Therefore, it is proposed that monitoring be conducted following the Perched Zone remediation (Option S1).
- Old Outfall No. 002: Based on the currently available data, lining and/or piping the ditch appears to best alternative for meeting the remedial objectives related to this former outfall. However, additional data is required to confirm this choice. Chemours will fully assess each option, in consultation with NCDEQ, and will provide NCDEQ with a proposed remedial option by March 30, 2018, along with a schedule for expeditious implementation.
- Air Emissions: Continue the program already underway and in consultations with NCDEQ to identify, evaluate, and abate (in the short-term and longer-term), PFAS air emissions at Fayetteville Works.

To confirm the effectiveness of each of these alternatives and to progress their designs, additional data is required. An outline of the path forward is presented below:

- Conduct a detailed land survey of the ponds and drainage channel to Old Outfall no. 002.
- Collect sediment samples from the sedimentation basins in order to determine disposal options.
- Conduct treatability study to determine the suitability of organoclay for treating PFAS alone or in combination with GAC.
- Prepare detailed design for each alternative.

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FIGURES

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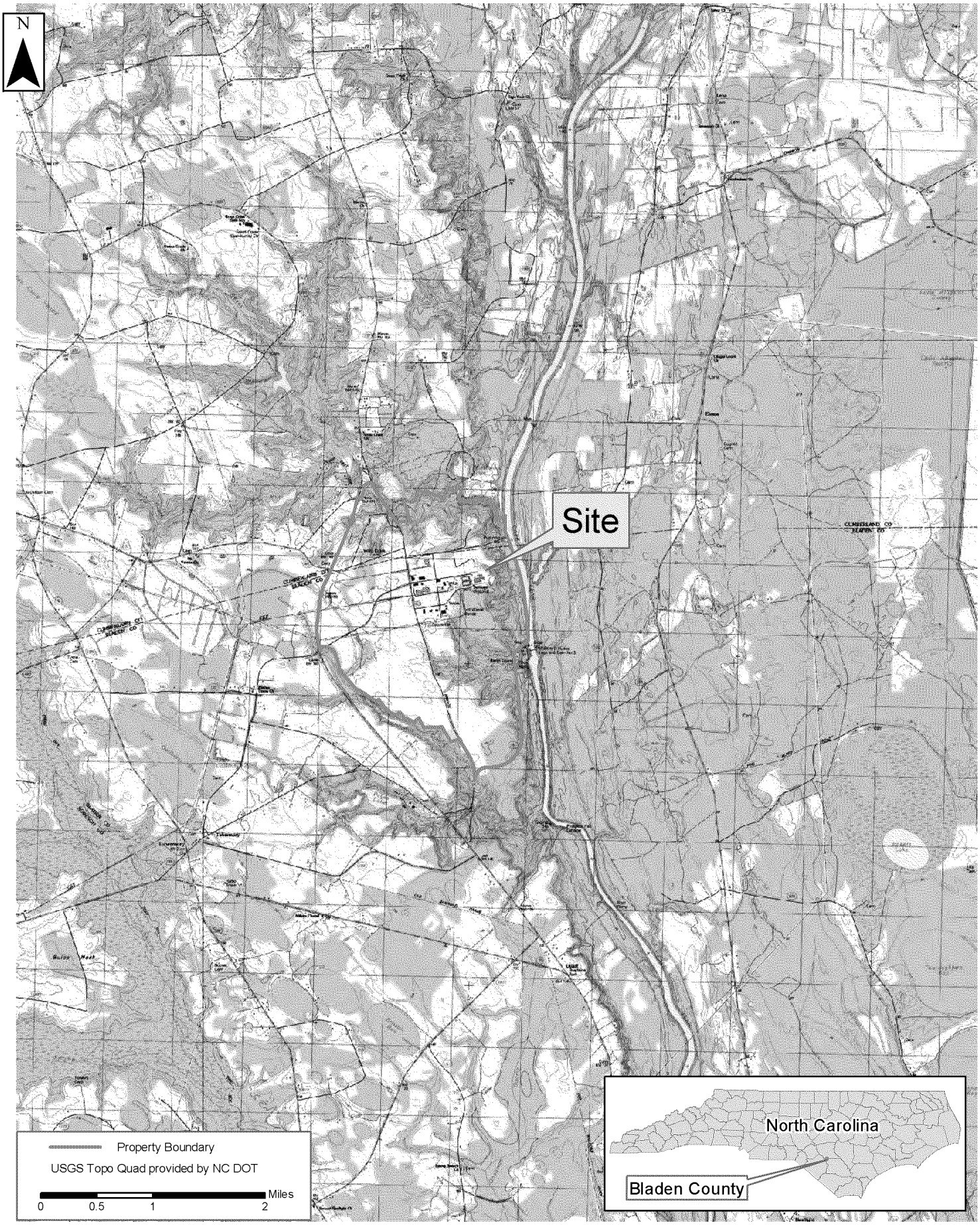

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PE&I
4701 Hedgemore Dr.
Charlotte, NC 28209

Site Location Map
Focused Feasibility Study Report - PFAS Remediation
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 1/29/2018
File Project Number: 450768
Revision: 1

Figure Number: 1

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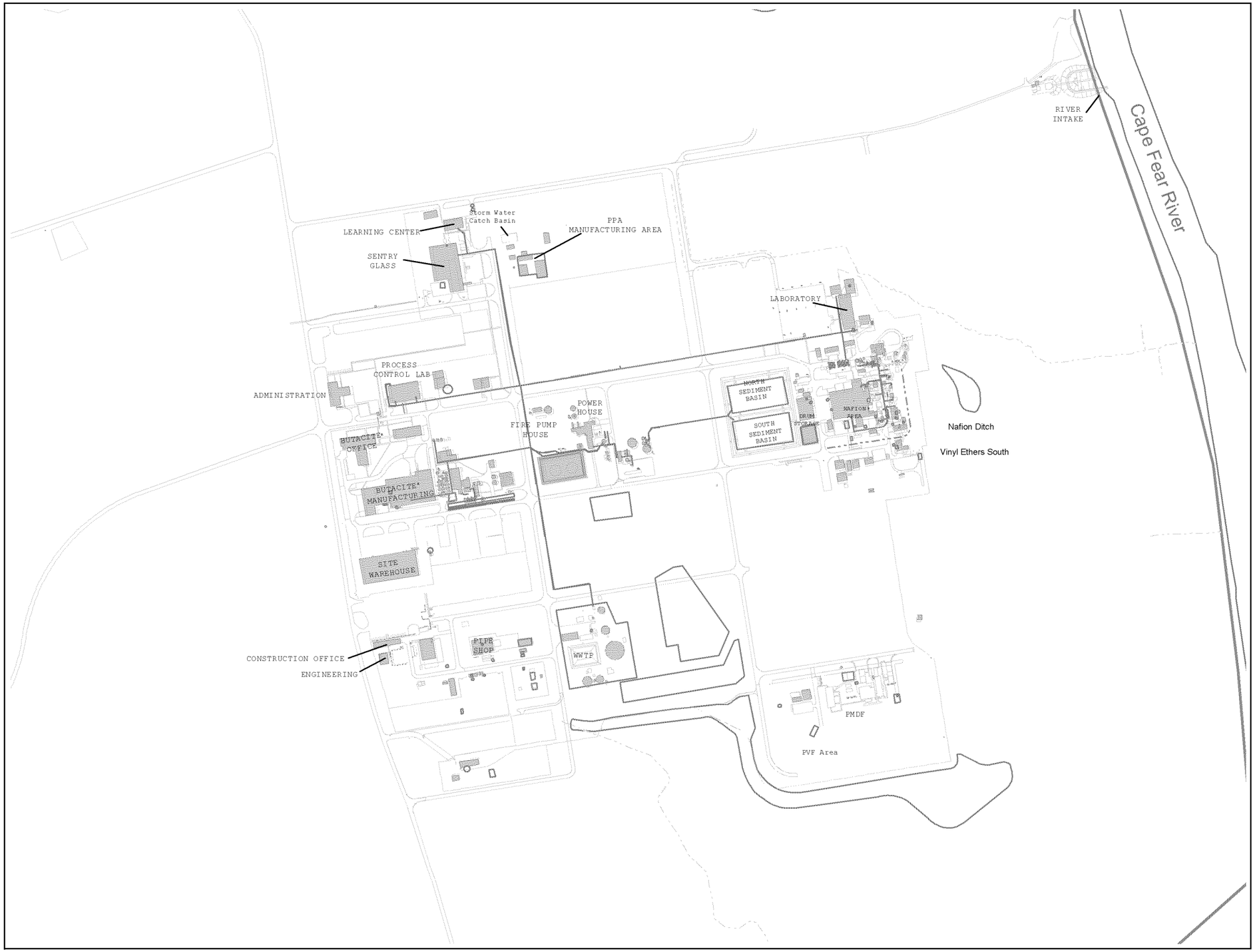

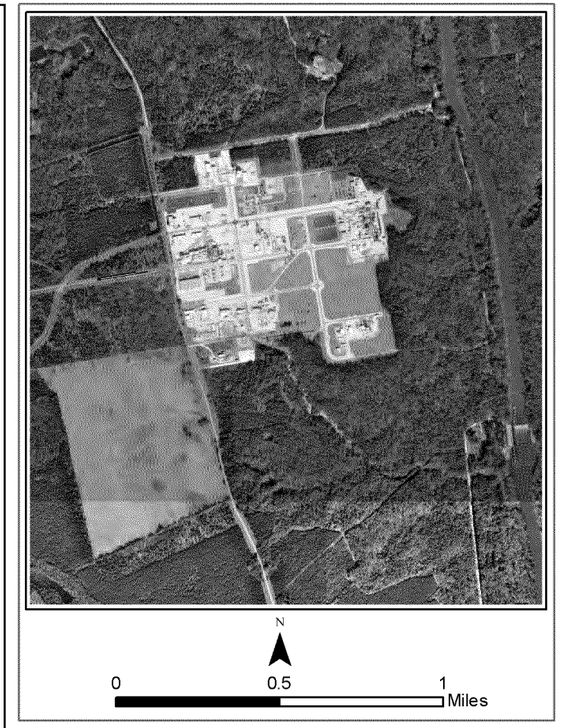

Pavement/Curb
Plant Border
Drainage Channel
River
Site Structure
SWMU

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0 750 1,500 Feet

Path: D:\GIS\Fayetville\Gis\Project_figures\2017\Fay_Site_Layout.mxd

PARSONS
PE&I
4701 Hedgemore Dr.
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Site Layout Map
Focused Feasibility Study Report - PFAS
Remediation Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 1/29/2018
File Project Number: 450768
Revision: 1
Figure Number: 2
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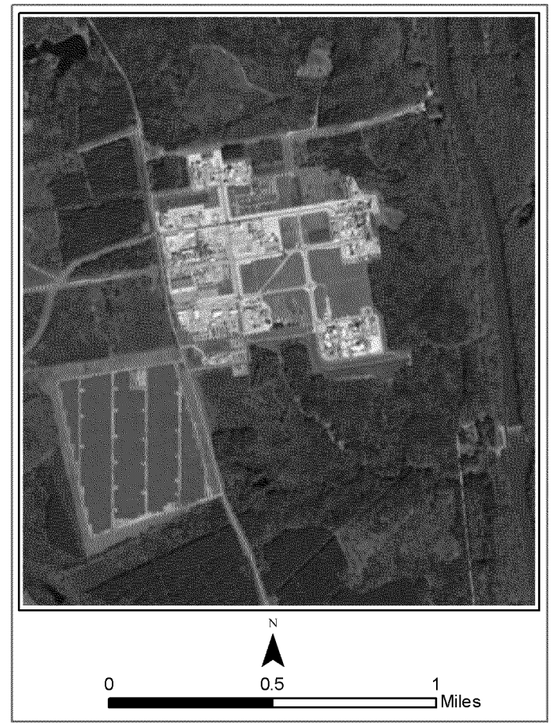

Nafion Ditch
Pavement/Curb
Plant Border
Drainage Channel
River
Site Structure
SWMU

N

0 750 1,500 Feet

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Option P2 - Lining of Sedimentation Basins and Nafion Ditch
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/14/2018
File Project Number: 449338.01050
Revision: 1
Figure Number: 3
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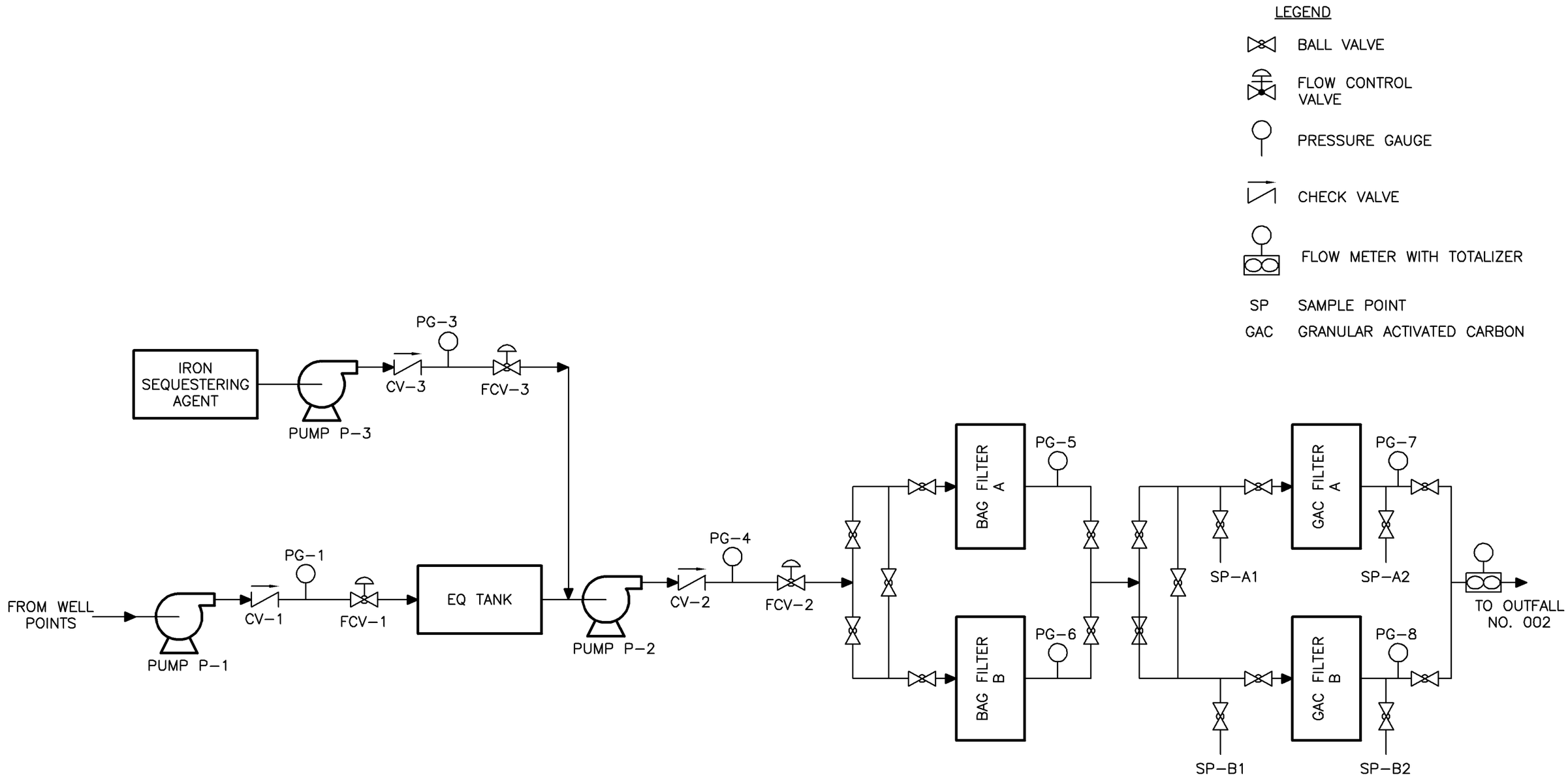

CHEMOURS
FAYETTEVILLE, NC

FIGURE 4

TREATMENT SYSTEM PROCESS FLOW DIAGRAM

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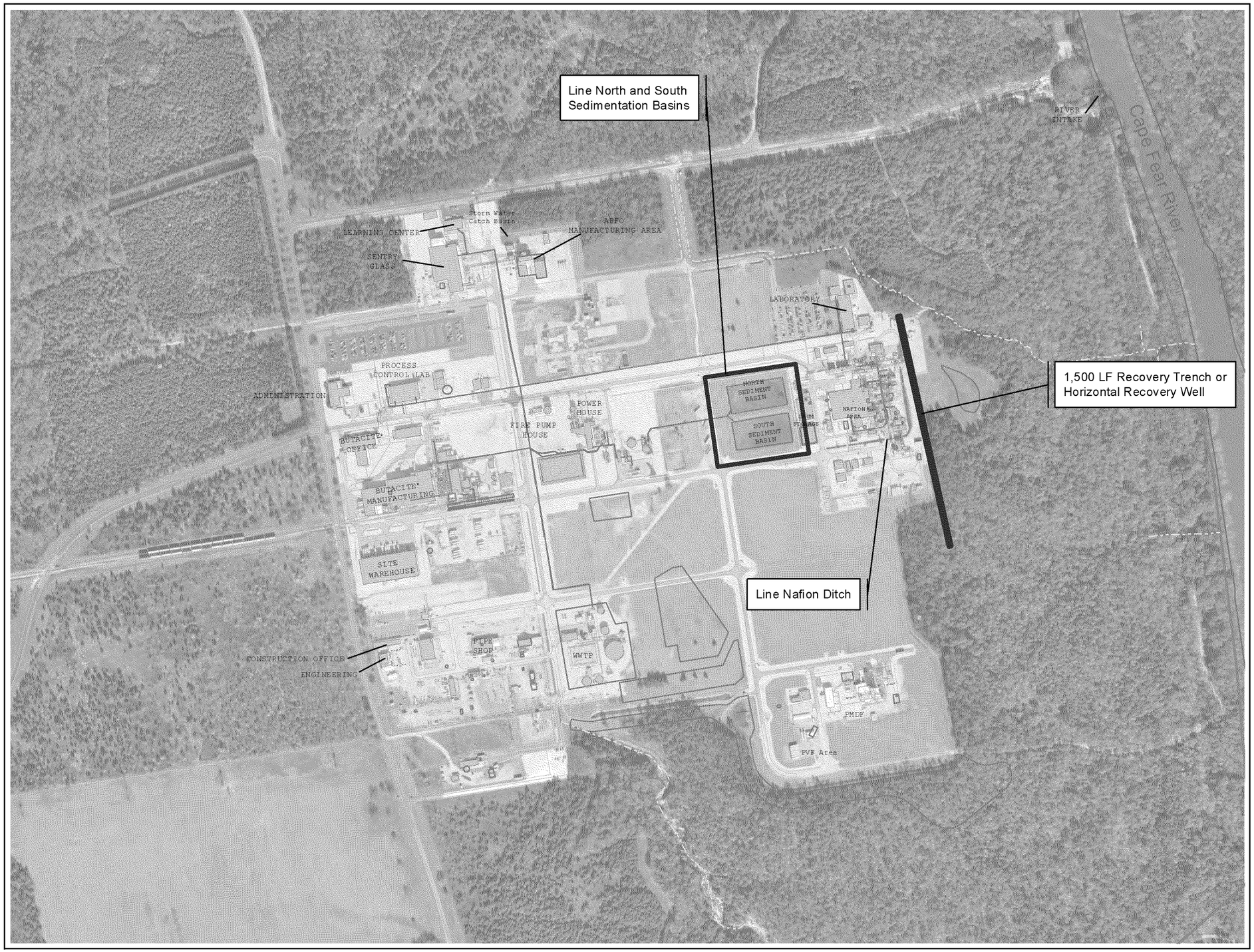
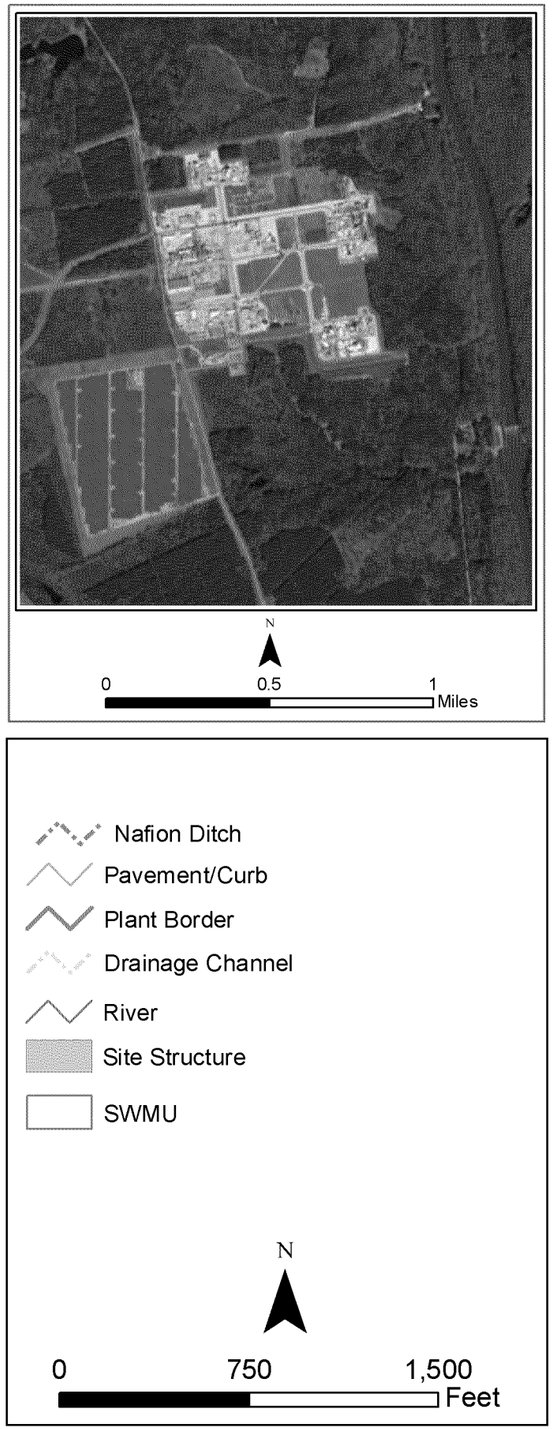
450768.04020





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Options P3 (Single Recovery Trench) and P5 (Horizontal Recovery Well)
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/14/2018
File Project Number: 449338.01050
Revision: 1
Figure Number: 5
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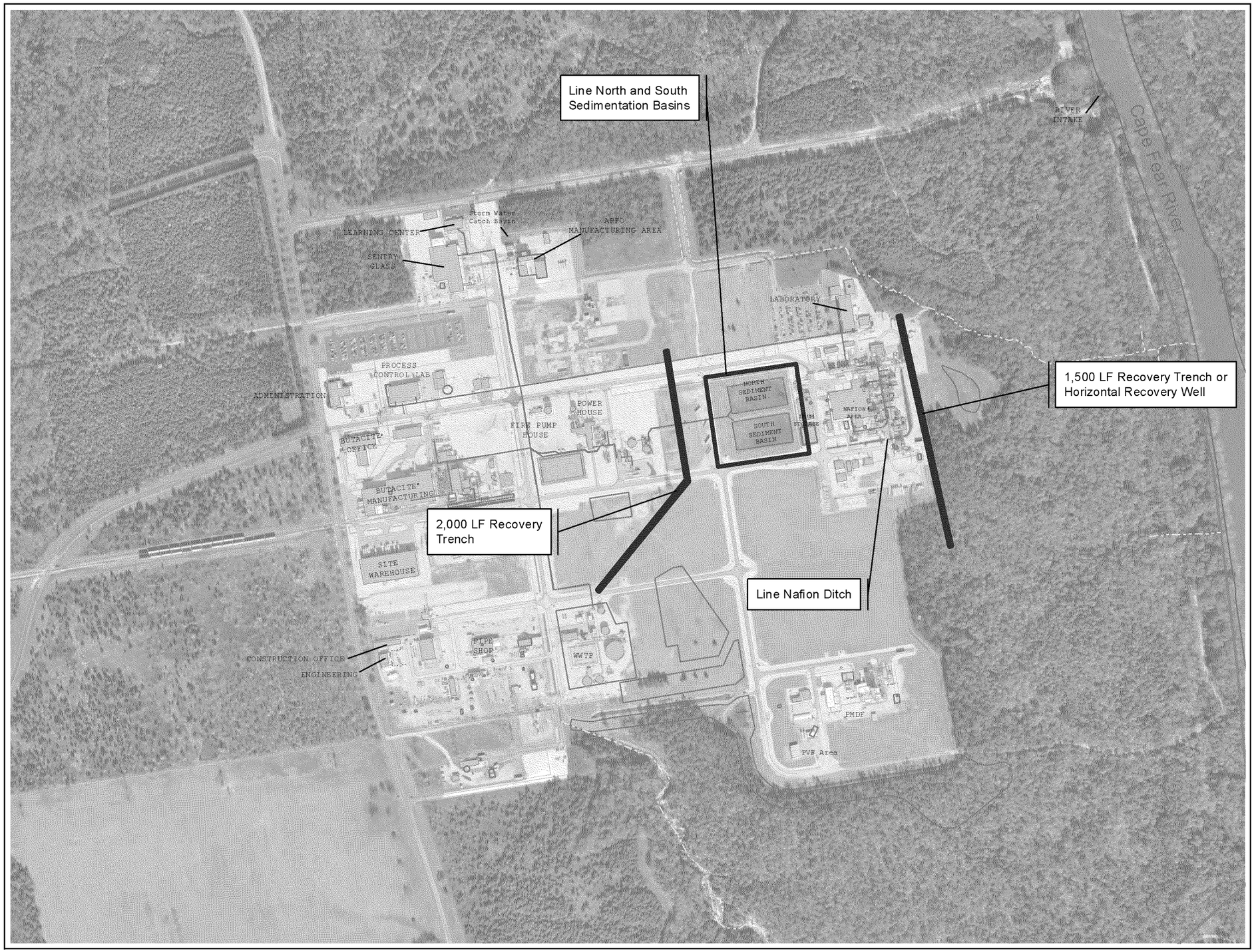

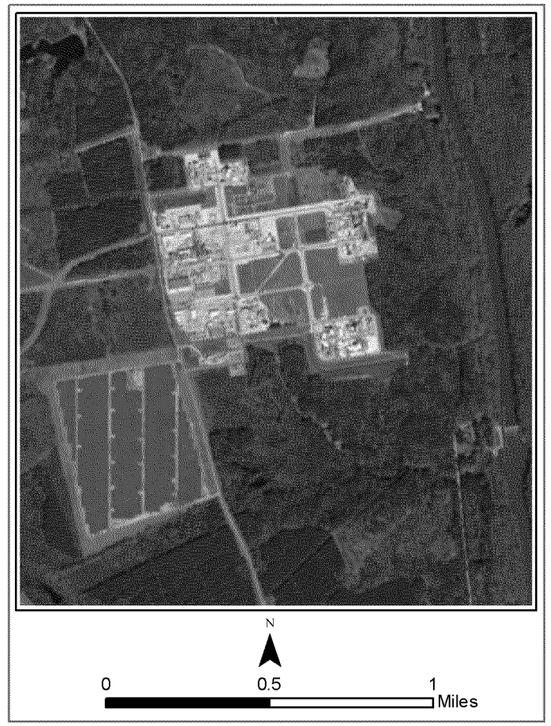

Nafion Ditch
Pavement/Curb
Plant Border
Drainage Channel
River
Site Structure
SWMU

N
0 750 1,500 Feet

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Option P4 - Two Recovery Trenches
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/14/2018
File Project Number: 449338.01050
Revision: 1
Name: Option4

Figure Number: 6

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Option S2 - Pump and Treat with Existing LTW Wells
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Created: C. Oneal	DuPont Project Number:
Date: 2/6/2014	Parsons Project Number:
Revision:	Figure Number: 7
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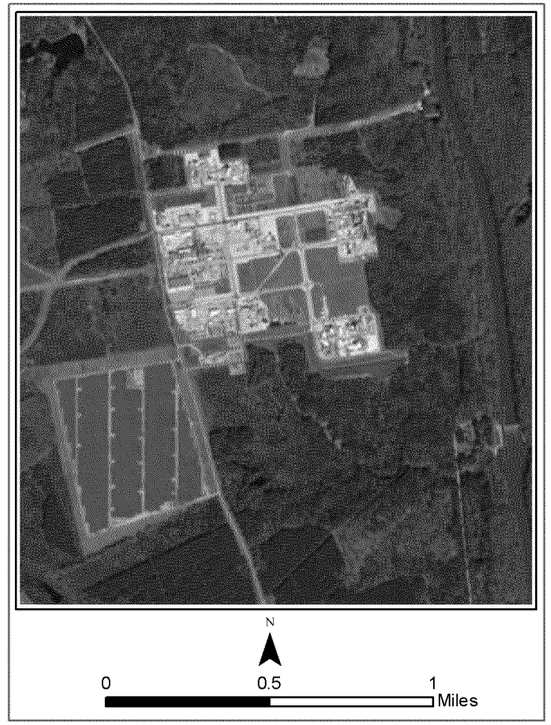

Extraction Well
Nafion Ditch
Pavement/Curb
Plant Border
Drainage Channel
River
Site Structure
SWMU

N

0 750 1,500 Feet

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Option S3 - Pump and Treat with Vertical Recovery Wells
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

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Date: 2/19/2018
File Project Number: 449338.01050
Revision: 1
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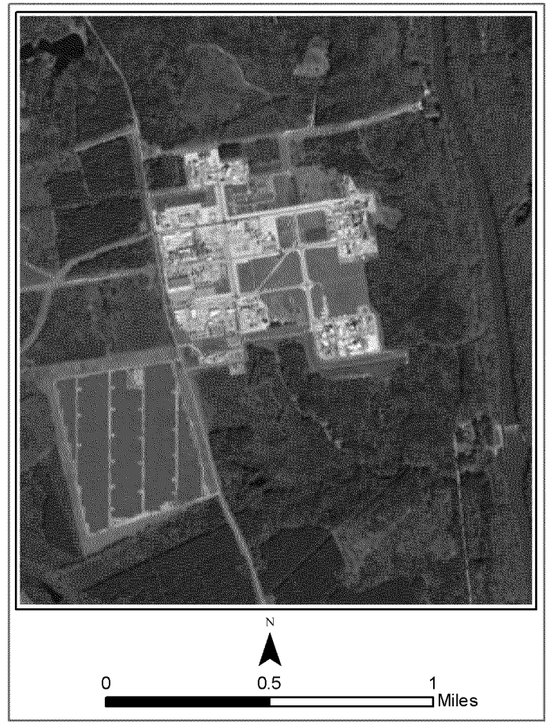

Sheet Pile Wall
Nafion Ditch
Pavement/Curb
Plant Border
Drainage Channel
River
Site Structure
SWMU

N
0 750 1,500 Feet

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Option S5 - Sheet Pile with Upflow Side Groundwater Management
Focused Feasibility Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/19/2018
File Project Number: 449338.01050
Revision: 1
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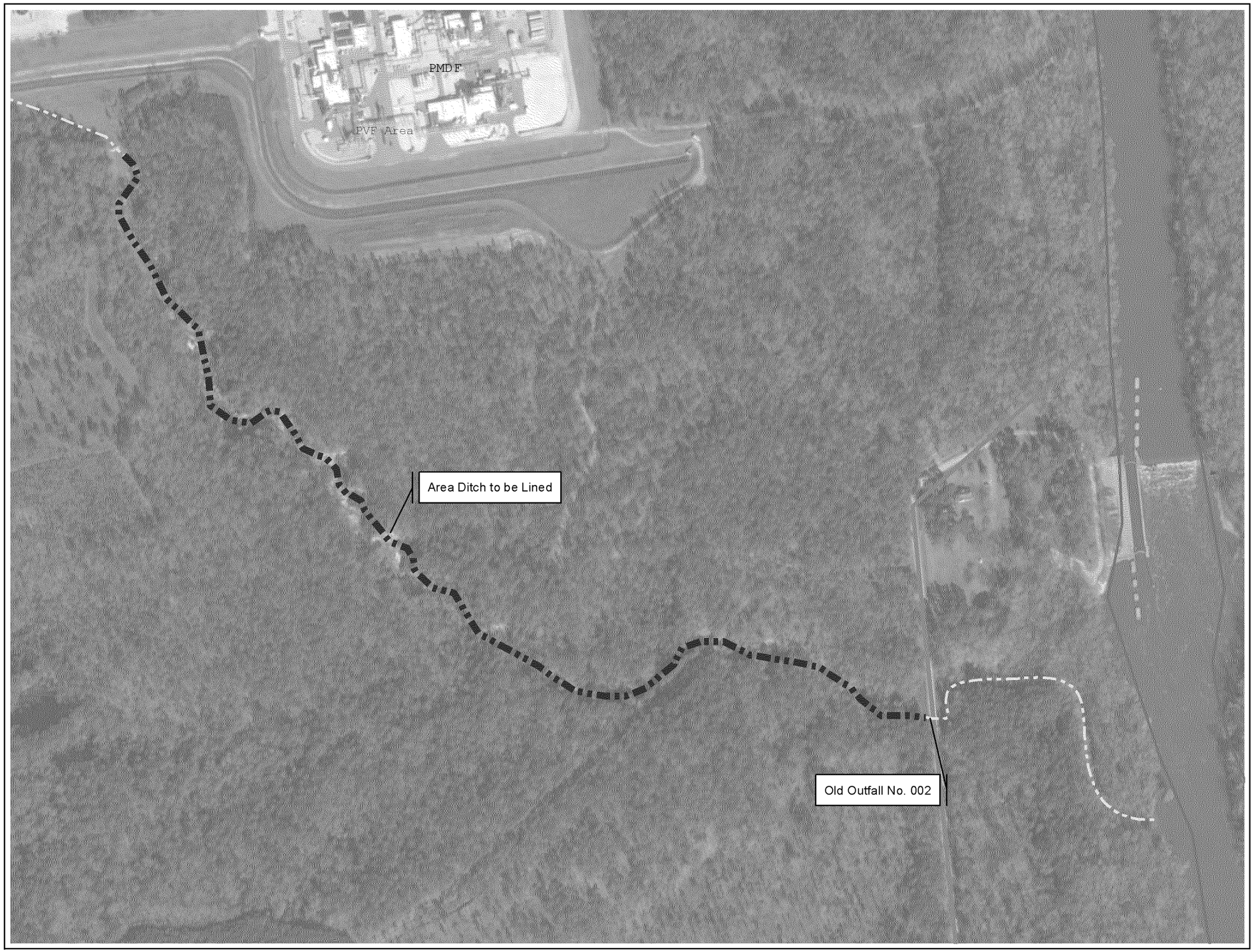

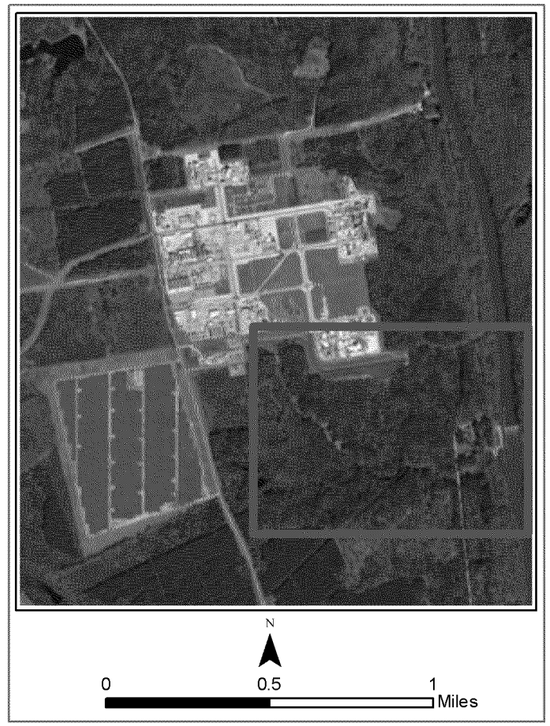

Plant Border
Drainage Channel
River

N

0 462.5 925 Feet

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Option F2 - Line Channel
Focused Feasability Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/19/2018
File Project Number: 449338.01050
Revision: 1
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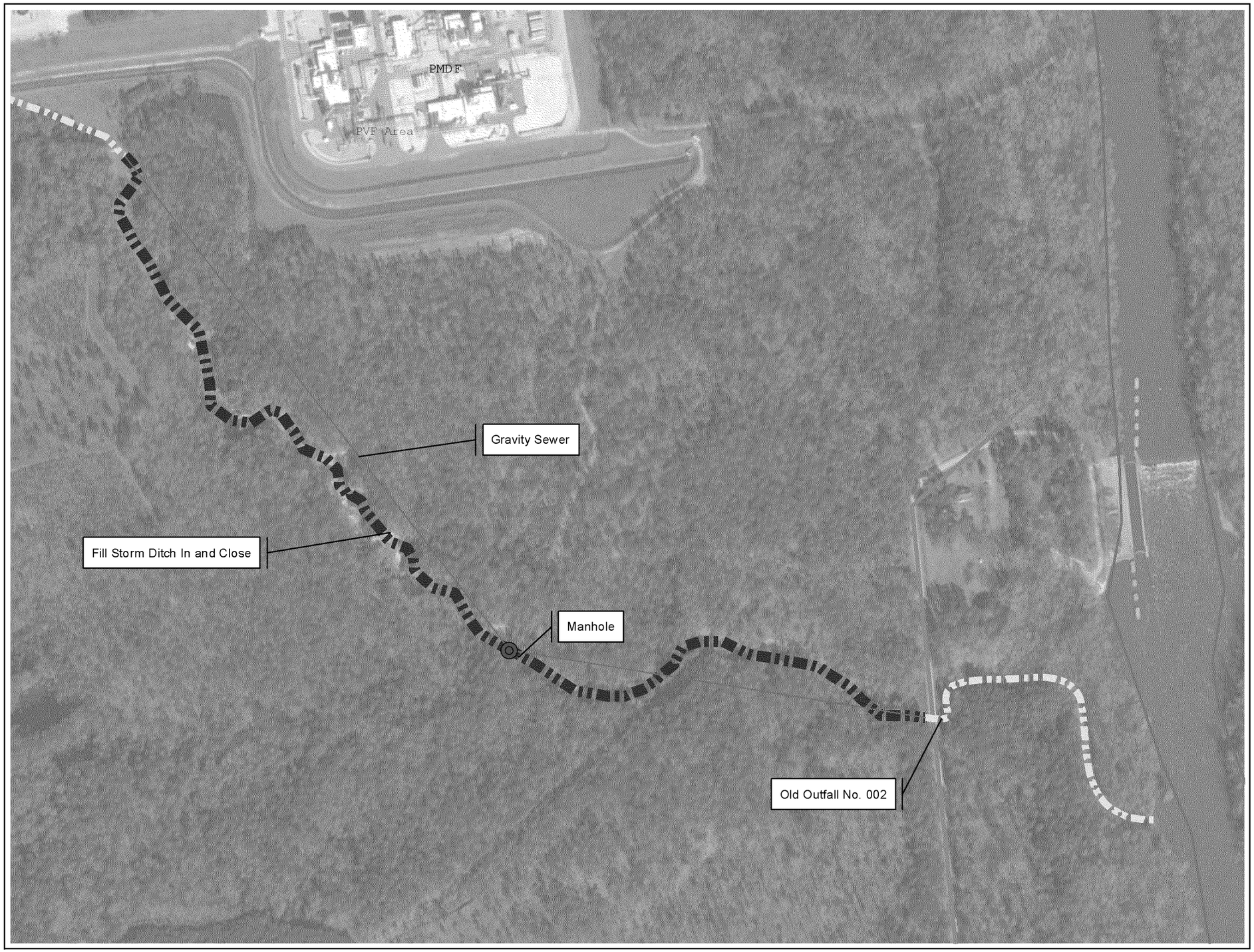

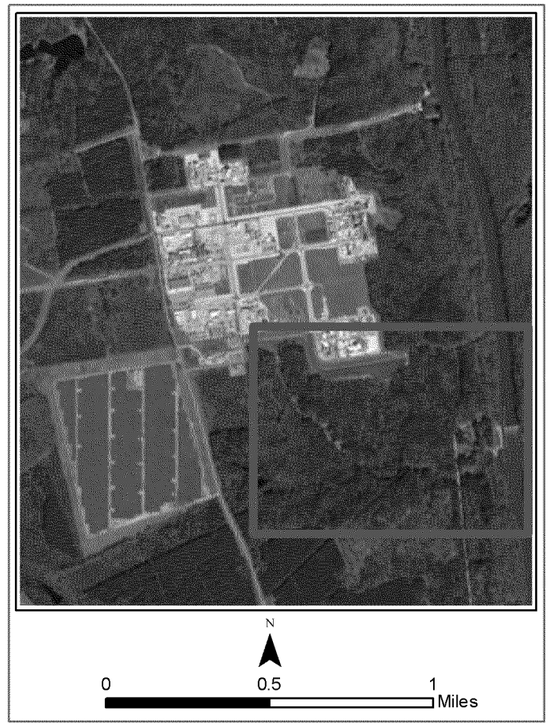

Plant Border
Drainage Channel
River

N

0 462.5 925 Feet

Path: D:\GIS\Fayetvle\Gis\Project_figures\2018\Option_F3.mxd

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Option F3 - Pipe Flow
Focused Feasability Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal
Date: 2/19/2018
File Project Number: 449338.01050
Revision: 1
Figure Number: 11
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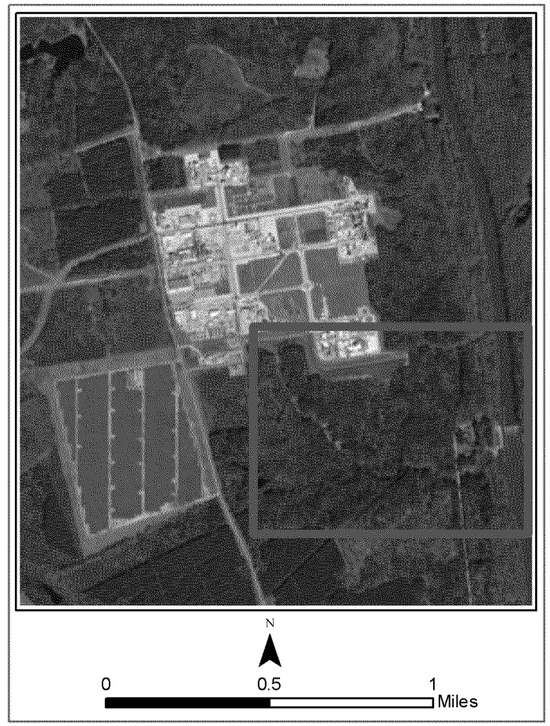

Plant Border

Drainage Channel

River

N

0 462.5 925 Feet

Path: D:\GIS\Fayetvle\Gis\Project_figures\2018\Option_F4.mxd

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Option F4 - Capture Water for Treatment
Focused Feasability Study Report - PFAS
Chemours Fayetteville Works
Fayetteville, North Carolina

Drawn: C. Oneal

Date: 2/19/2018

File Project Number: 449338.01050

Revision: 1

Figure Number: 12

Name: Option_F4

TABLE

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Table 1
Remedial Alternative Screening
Chemours Fayetteville Works
Fayetteville, North Carolina

Alternative		Technical Implementability	Effectiveness						Administrative Feasibility	Reduction of Toxicity, Mobility, or Volume	Cost
			Ability to Meet Remedial Goals		Protection of Human Health & the Environment		Proven Technology	Reliability			
			Achievabile	Time Required	Current	Future					
Perched Zone											
P1	No Action	High	Yes	NA	Yes	Yes	NA	NA	No Limitations	None	Low
P2	Lining of Sedimentation Basins and Nafion Ditch	High	Yes	Long	Yes	Yes	Proven	High	No Limitations	Reduces mobility, but not toxicity or volume	Moderate
P3	Single Recovery Trench and Lining Ponds	High	Yes	Long	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High
P4	Two Recovery Trenches and Lining Ponds	Low	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High
P5	Pump and Treat with Horizontal Recovery Well	High	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High
P6	Temporary Dewatering and Pump and Treat System	High	Yes	Short	Yes	Yes	Proven	High	No Limitations	Reduces mobility and volume but not toxicity	High
Surficial and Black Creek Aquifers											
S1	No Action	High	Yes	NA	Yes	Yes	NA	NA	No Limitations	None	Low
S2	Pump and Treat from the 5 Existing LTW Wells	Low	No	NA	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	Low
S3	Pump and Treat with Vertical Recovery Wells	High	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High
S4	Pump and Treat with Horizontal Recovery Wells	High	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	Moderate
S5	Sheet Pile Wall with Upflow Groundwater Mgt.	Medium	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High
S6	Permeable Reactive Barier (PRB) Wall	Medium	Yes	Medium	Yes	Yes	Proven	High	No Limitations	Reduces mobility and volume but not toxicity	Moderate
Former Outfall 002											
F1	No Action	High	Yes	NA	Yes	Yes	NA	NA	No Limitations	None	Low
F2	Lining of the Channel	Medium	Yes	Short	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility, but not toxicity or volume	Moderate
F3	Pipe Flow	Medium	Yes	Short	Yes	Yes	Proven	High	No Limitations	Reduces mobility, but not toxicity or volume	Moderate
F4	Capture Water for Treatment	Medium	Yes	Medium	Yes	Yes	Proven	Moderate	No Limitations	Reduces mobility and volume but not toxicity	High

APPENDIX A
MASS FLUX ASSESSMENT

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CAPE FEAR RIVER DIMER ACID CONCENTRATION AND MASS FLUX ASSESSMENT SUMMARY

Dimer Acid is present in the Cape Fear River (the river) down river of the Chemours Fayetteville Works Site (the Site). Dimer Acid river concentrations are controlled by Dimer Acid mass flux to the river and the volume of water flowing in the river. An assessment of Dimer Acid mass flux in the river was performed to achieve the following objectives:

- Identify potential pathways for Dimer Acid to reach the river;
- Evaluate the mass flux contributions from each potential pathway; and
- Estimate future concentrations of Dimer Acid in the river by preparing an analytical model.

The objectives listed above build upon each other and were thus fulfilled sequentially. The paragraphs below describe how each objective was fulfilled, and the observations obtained from each objective.

Identify Potential Pathways

Potential pathways for Dimer Acid to reach the river were identified by reviewing Site cross sections, Site aerial imagery, Site data and discussions with Chemours personnel. Identified potential pathways are listed below and are graphically represented in the conceptual image presented in Figure 1:

- The up-stream river;
- Willis Creek;
- Direct aerial deposition to the river;
- Outfall 002;
- On-Site upwelling groundwater;
- Surface water runoff;
- Flow in the historic outfall channel;
- Off-Site (up- and down-river) upwelling groundwater; and
- Georgia Branch Creek.

ED_002096A_00016544-00057

Evaluate Mass Flux Contributions

The mass flux reaching the river is the combined mass per unit time (e.g. nanograms per second) from each identified potential pathway listed above. For mass transported by water (e.g. groundwater, surface water, outfalls) mass flux is calculated by multiplying the volumetric flow of the water (e.g. liters per second) by the concentration of Dimer Acid in the water (e.g. nanograms per liter; ng/L). Mass flux for each potential pathway was estimated using Site data, and representative physical properties where Site data were unavailable. The mass flux assessment was prepared and compared to Site data. This included data collected as part of a surface water sampling event conducted on 26-27 September 2017. Sample collection dates for data used to quantify each pathway are presented in Table 1.

The data used to quantify the mass flux for each pathway and the results of the assessment are presented in Table 2. The results are compared against the average, down-river Dimer Acid concentration from the 26-27 September 2017 sampling event, 39.25 ng/L. The mass flux assessment estimated that the combined mass flux contributions to the river would result in a Dimer Acid concentration ranging from 26 to 64 ng/L, (i.e. 66% to 160%) of observed Dimer Acid on 26-27 September. The two largest contributors of Dimer Acid mass flux were first upwelling Site groundwater and second the Historic Outfall. Upwelling groundwater was estimated to potentially contribute between 12 to 47 ng/L, (i.e. 30% to 120%) of observed Dimer Acid in the river. The Historic Outfall, using data from 16 January 2017, was estimated to contributed 9 ng/L (i.e. 23%) to observed river concentrations.

It should be noted that upwelling groundwater mass flux estimates have more uncertainty than any of the mass flux estimates for the outfalls or creeks. This is because the groundwater mass flux estimates are based on measured concentrations and calculated (estimated) flow, while for creeks and outfalls both concentrations and flow were measured. Consequently, a second approach was used to estimate upwelling groundwater contributions to in-river Dimer Acid concentrations. The second approach estimated these contributions by subtracting all other mass flux contributions from the observed river concentrations. Based on this assessment upwelling groundwater was estimated to contribute between 22.5 to 26 ng/L (i.e. 57% to 66%) of Dimer Acid concentrations observed in the river, which is within the range of the previous estimate.

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Estimate Future River Dimer Acid Concentrations

An analytical river mass flux model was created to estimate future river Dimer Acid concentrations. The model estimated both Dimer Acid: i) concentrations in the river; and ii) travel times in river water. Specifically travel times are estimated for the down-stream public utility water intakes at Bladen Bluffs, 7.5 miles down-river, and Kings Bluff Intake Canal, 55 miles down-river. The model was created in Microsoft Excel using the following data sources:

i. Input mass fluxes from the mass flux assessment;

ii. Outfall 002 concentration and flow data provided by Chemours to calculate Outfall 002 mass flux for specific dates; and

iii. Daily mean river volumetric flow data and gauge height data reported by United States Geological Survey (USGS) for the W.O. Huske Dam gauging station.

The model operates by first estimating mass flux inputs into the river for a given date using the approach described for the mass flux assessment. Model calculations are only performed for dates where measured Outfall 002 concentration and flow data exist. The concentration of Dimer Acid in the river is then calculated by dividing the mass flux (e.g. nanograms per second) by the USGS reported river flow rate (e.g. liters per second). Next the arrival time of this water at the down-river intakes is estimated using the estimated river water velocity. River water velocities were estimated by calculating how quickly the measured volumetric flow of water must pass through the estimated cross-sectional area of the river. River cross sectional areas were estimated using river gauging data from the 26 to 27 September 2017 sampling event and USGS reported river gauge heights.

River mass flux model results using input data from 14 June 2017 to 29 January 2018 are presented in Figure 2 for Bladen Bluffs and Figure 3 for Kings Bluff Intake Canal. In each figure the modeled results are compared to publicly reported, measured river concentrations. The river mass flux model results show a good fit compared to observed river Dimer Acid concentrations at the two down-river water intake locations.

Since 1 August 2017 river concentrations have been measured to be less than 140 ng/L except for the temporary increase in early October 2017, which matches the model results. The increase in October 2017 was related to a temporary increase in Outfall 002 concentrations and mass flux. Assuming standard operating conditions at the Site and similar environmental conditions, future river concentrations are estimated to remain below 140 ng/L.

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TABLE 1
POTENTIAL DIMER ACID PATHWAYS TO CAPE FEAR RIVER AND DATA SOURCES FOR ASSESSMENT
Chemours Fayetteville Works

Pathway	Concentration Data	Flow Data
Up-Stream River	26-27 Sept. 2017 Data	26-27 Sept. 2017 Data
Willis Creek	26-27 Sept. 2017 Data	16 Jan. 2018 Data
Aerial Deposition on River	Estimated from NCDEQ Air Dispersion Modelling	
Outfall 002	26-27 Sept. 2017 Data	26-27 Sept. 2017 Data
On-Site Groundwater	26-27 Sept. 2017 Data	Calculated
Surface Water Run-Off	Inferred. No Rain.	Inferred. No Rain.
Historic Outfall Channel	16 Jan. 2018 Data	16 Jan. 2018 Data
Off-Site Groundwater (Up & Down River)	Residential Well Data	Calculated
Georgia Branch Creek	26-27 Sept. 2017 Data	16 Jan. 2018 Data

TABLE 2
POTENTIAL PATHWAY ESTIMATED DIMER ACID MASS FLUXES COMPARED TO MEASURED RIVER CONCENTRATIONS
Chemours Fayetteville Works

Potential Pathway	Concentration (ng/L)	Flow (L/s)	Mass Flux (ng/s)	Estimated Contribution to River Concentration (ng/L)
Up-Stream River	0	25,500	0	0
Willis Creek	310 – 450	170 – 250	52,700 - 112,500	2.0 - 4.5
Aerial Deposition on River[1]	--	--	6,000	0.25
Outfall 002	35	900	31,500	1.25
On-Site Groundwater[2]	25,000 – 50,000	12 – 24	300,000 – 1,200,00	12 – 47
Surface Water Run-Off[3]	NA	NA	0	0
Historic Outfall	8,400	27	227,000	9
Off-Site Groundwater (Up & Down River)[4]	147 – 179	110 – 180	16,000 - 32,250	0.5 - 1.25
Georgia Branch Creek	540 – 1,100	8 – 16	4,500 – 17,500	0.2 – 0.7
Total Estimated Mass Flux and Corresponding River Concentration	--	--	**665,000 – 1,625,000**	**26 – 64**
Measured[5] Concentration and Flow Down River 5 Miles and Calculated Mass Flux	**39.25**	**25,500**	**1,000,000**	**39.25**

Notes

[1] Direct aerial deposition to the river mass flux estimates were made based on NCDEQ presented modelling results. https://www.ncleg.net/documentsites/committees/house2017-185/Meetings/3%20-%20Nov%2030%202017/DEQ%20Final%20PowerPoint%20Pres.pdf

[2] On-Site groundwater flux range estimated assuming discharge areas of 18,500 to 37,000 square meters, calculated gradient of 0.064 between LTW Wells to Cape Fear River, measured maximum and average LTW Well concentrations of 50,000 and of to 25,000 ng/L, and a estimated hydraulic conductivity of 10^{-5} m/s, representative of silty sand.

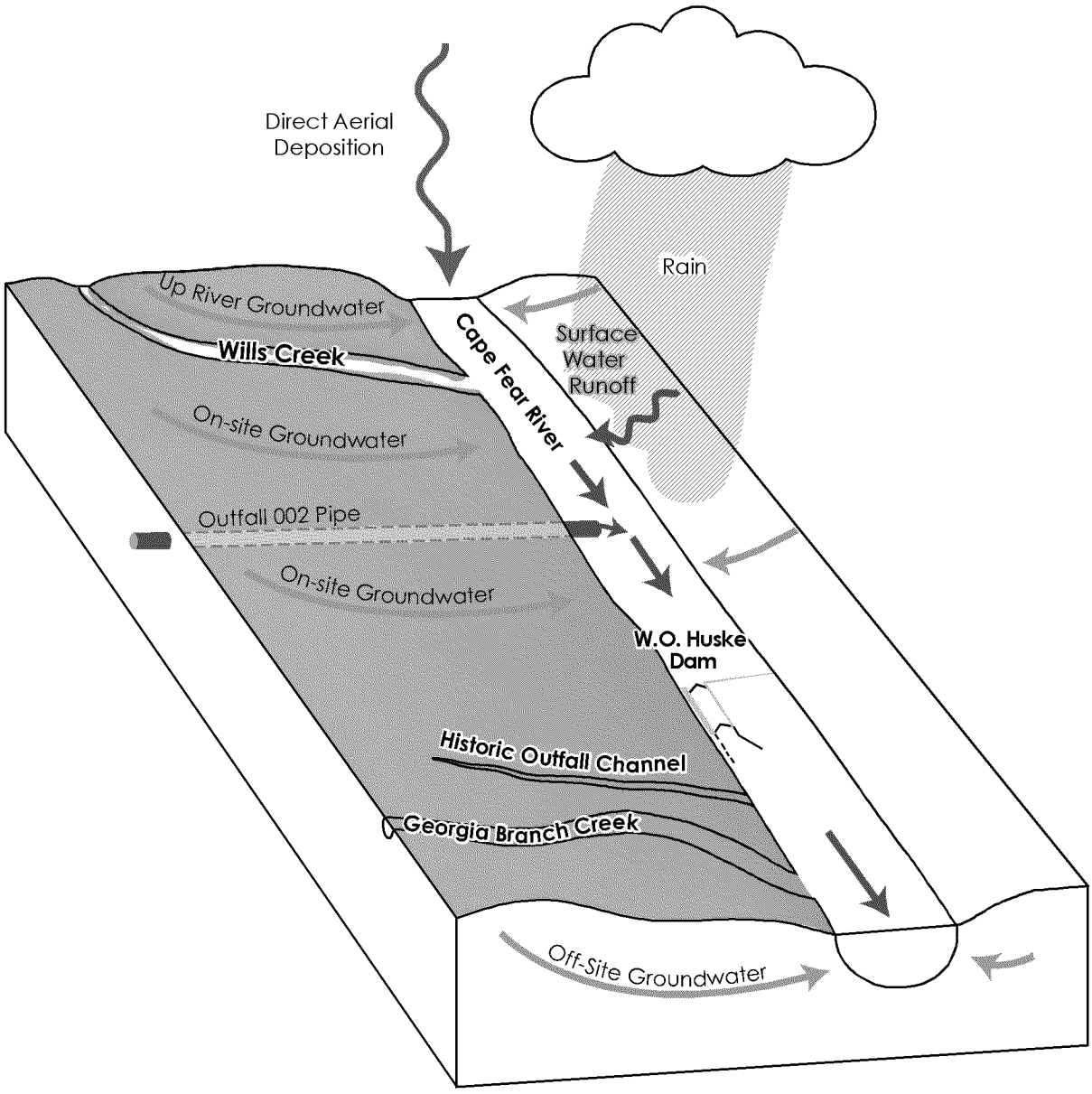
[3] During the 26-27 September 2017 sampling event there was no rain before or during the event, therefore the run-off flux is 0 ng/s.

[4] Off-Site groundwater was estimated using residential well concentration data and the same hydraulic conductivity value, 10^{-5} m/s, used for on-Site groundwater upwelling estimates. The on-Site gradient value, 0.064, was used in estimating upwelling on the same side of the river as the site (west). A lower gradient, 0.0064, was used for the opposite side of the river (east) where land surface topography is more subdued.

[5] Measured data are from the 26-27 September 2017 surface water sampling event.

Acronyms

L/s - liters per second
m/s - meters per second
ng/L - nanograms per liter
ng/s - nanograms per second



Conceptual Diagram: Potential Dimer Acid Pathways to Cape Fear River
Chemours Fayetteville Works

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Figure 1

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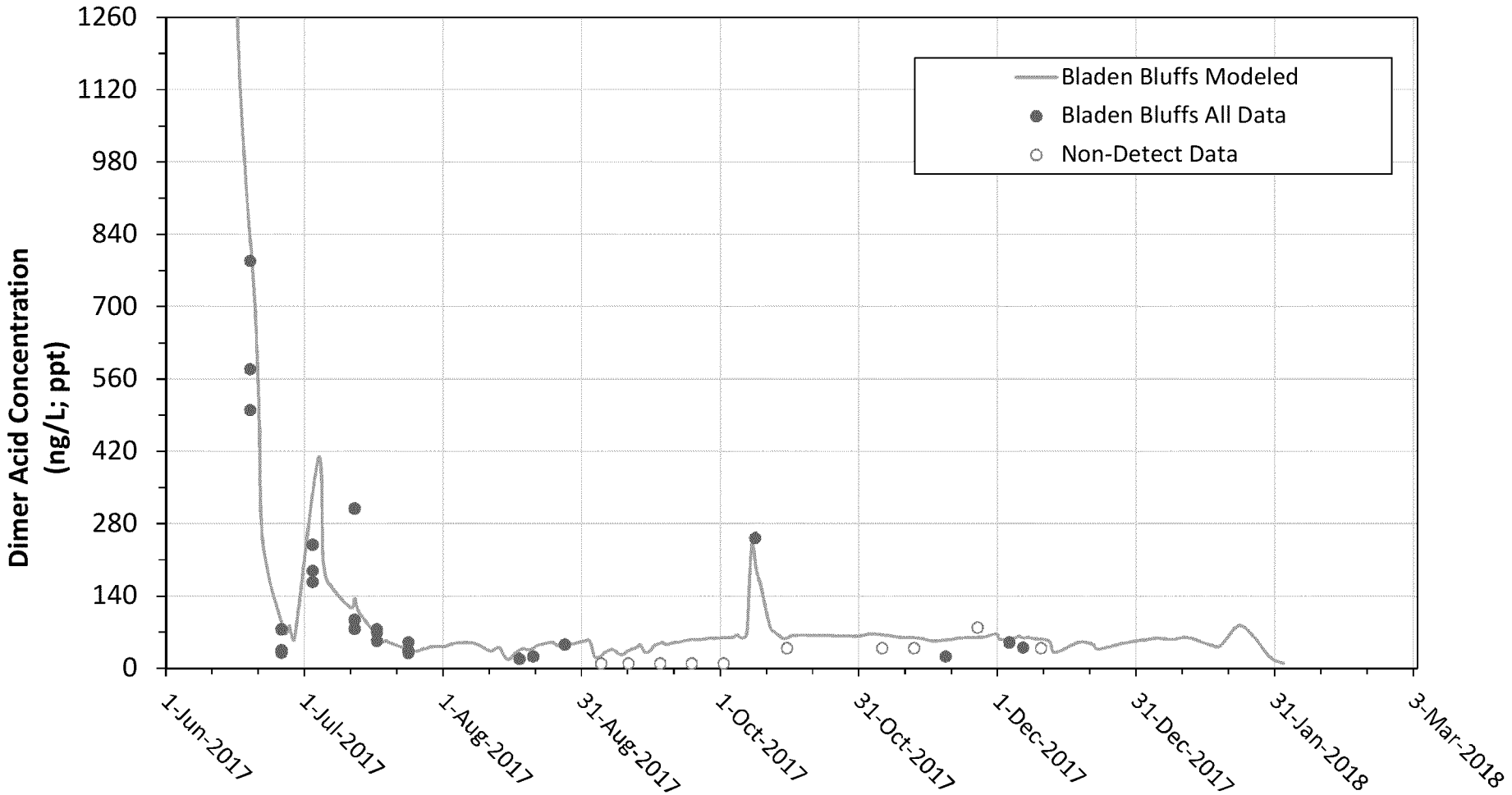

Notes:
ng/L - nanograms per liter
ppt - parts per trillion

River Mass Flux Model Estimates at Bladen Bluffs
Chemours Fayetteville Works

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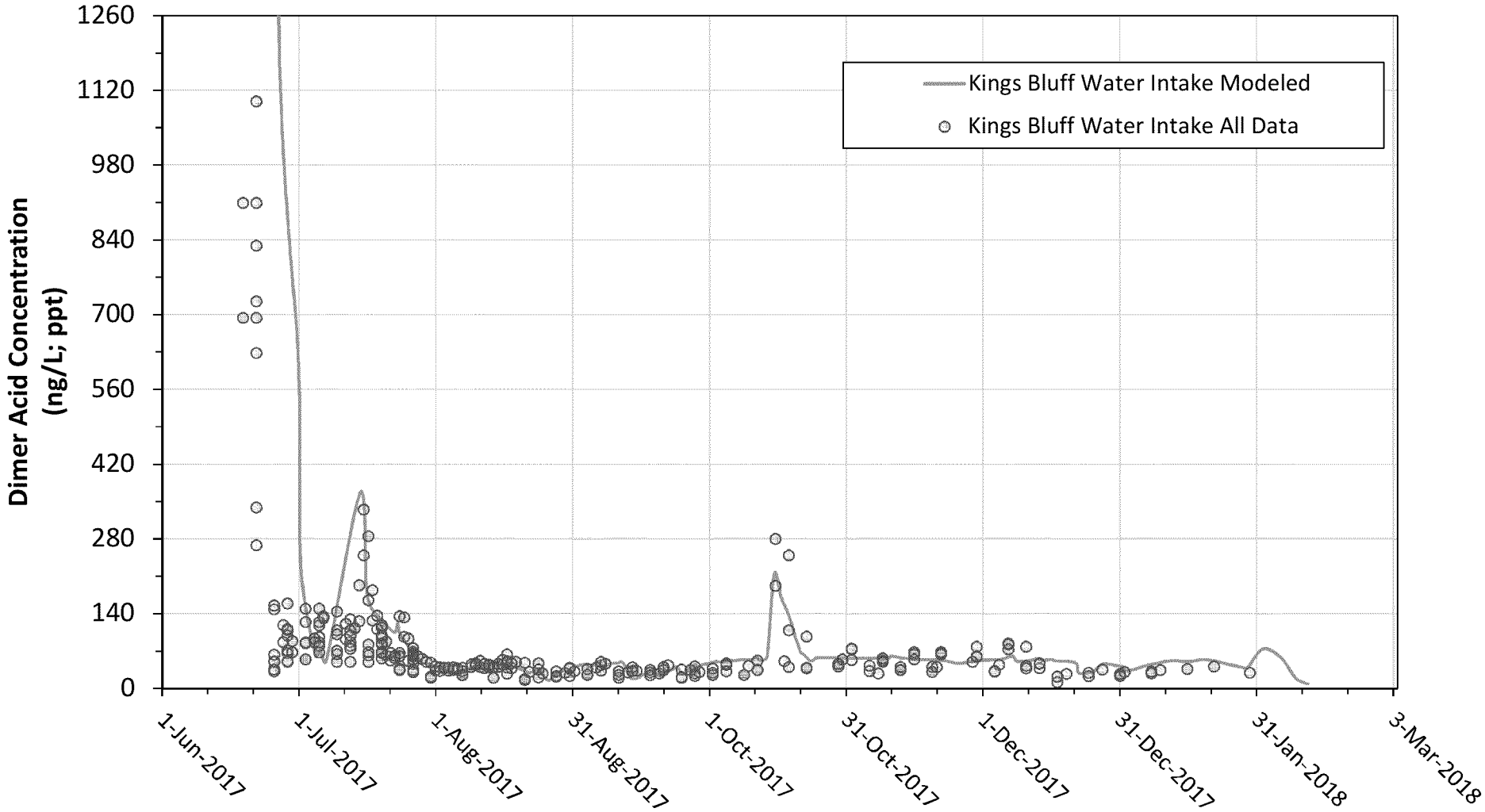
Figure **2**



Notes:
ng/L - nanograms per liter
ppt - parts per trillion

River Mass Flux Model Estimates at Kings Bluff Intake Canal
Chemours Fayetteville Works

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Figure 3