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Memorandum

Date: 31 January 2020

To: The Chemours Company FC, LLC

From: Geosyntec Consultants of NC, P.C.

Subject: Response to Cape Fear River Watch Comments Dated December 19, 2019

Geosyntec Consultants of NC, P.C. (Geosyntec) has prepared this memorandum for The Chemours Company FC, LLC (Chemours) in response to a letter from the Southern Environmental Law Center (SELC) on December 19, 2019 (SELC, 2019). The letter contained questions and comments from Cape Fear River Watch (CFRW) on the *Cape Fear River PFAS Loading Reduction Plan – Supplemental Information Report* (the Supplemental Information Report; Geosyntec 2019a) regarding proposed actions to be completed by Chemours at the Chemours Fayetteville Works site (the Site). The Supplemental Information Report was submitted to the North Carolina Department of Environmental Quality (NCDEQ) and CFRW by Chemours on November 4, 2019 in response to requests from NCDEQ and CFRW for additional information regarding the C*ape Fear River PFAS Loading Reduction Plan* (the Reduction Plan; Geosyntec 2019b). The Reduction Plan was submitted by Chemours on August 26, 2019 pursuant to paragraph 12 of the Consent Order amongst Chemours, NCDEQ and CFRW.

The objective of this memorandum is to provide CFRW with responses and explanations to their questions and comments. The letter transmitted from SELC includes topical questions and comments which are repeated in a few places. To provide the responses to both the topical and specific comments, this memorandum is organized into the following sections:

- Summary of In-Progress and Proposed Corrective Actions (Section 1);
- Seep Remedy Responses and Explanations (Section 2);
- Old Outfall 002 Responses and Explanations (Section 3);

- Outfall 002 Responses and Explanations (Section 4);
- Groundwater Extraction (Section 5);
- Clarification Regarding Feasibility (Section 6); and
- Responses to Other Comments or Questions (Section 7).

1. SUMMARY OF IN-PROGRESS AND PROPOSED CORRECTIVE ACTIONS

Chemours has committed to perform eleven actions over the next five years to reduce remaining PFAS loadings to the Cape Fear River. These actions are anticipated to reduce loadings to the Cape Fear River by at least 75% consistent with paragraph 16 of the Consent Order. These actions, their associated timelines and anticipated loading reductions are presented in **Table 1**. These actions have been previously described in the following reports:

- *Cape Fear River PFAS Loading Reduction Plan* (the Reduction Plan; Geosyntec 2019b) submitted by Chemours on August 26, 2019 pursuant to paragraph 12 of the Consent Order.
- *Cape Rear River PFAS Loading Reduction Plan – Supplemental Information Report* (the Supplemental Information Report; Geosyntec 2019a) submitted by Chemours on November 4, 2019 pursuant to requests for additional information by DEQ and CFRW.
- *Corrective Action Plan* (the CAP; Geosyntec 2019c) submitted by Chemours on December 31, 2019 pursuant to paragraph 16 of the Consent Order.

Of these eleven actions, two have been implemented (sediment removal from the cooling water channel and installation of air abatement controls including commissioning of the thermal oxidizer), two are in-progress interim actions to support rapid reductions, and the remaining seven are in-progress actions. PFAS loading reductions from the Site to the Cape Fear River are proposed to be evaluated as described in the CAP (Geosyntec, 2019c). Additional details about the calculation of baseline river mass loads are provided in Attachment A – River Baseline Calculation Methodology.

Table 1: Overall Estimated Reductions Plan Schedule and Estimated Reductions to Cape Fear River Total Table 3+ PFAS Loadings

Proposed and Provisional Remedial Alternatives	Loading Reduction	Duration (Years)	Year					
			2019	2020	2021	2022	2023	2024
Air Abatement Controls and Thermal Oxidizer[1]	<2%	1	✓					
Conveyance Network Sediment Removal - Outfall 002[2]	NQ[3]	1	✓					
Capture and Treat Old Outfall 002	26%	1						
Terracotta Pipe Replacement - Outfall 002	0.1%	2						
Stormwater Pollution Prevention Plan - Outfall 002	NQ[3]	1						
Groundwater Intrusion Mitigation - Outfall 002	0.7%	2						
Interim Action - CFR Seeps	NQ[3]	2						
Interim Action - Onsite Groundwater	NQ[3]	1						
Targeted Stormwater Control - Outfall 002	1.3%	4						
Ex Situ Capture and Treatment - CFR Seeps[4]	33%	4						
Onsite Groundwater Treatment	18%	5						
Cumulative Estimated Total Table 3+ PFAS River Reductions to River[5]	79%	--	<2%	26%	27%	43%	60%	79%

Notes

- Schedule for multiple alternatives are dependent upon permitting requirements.
- Loading reductions to CFR based on average of May, June, Sep. 2019 data
- Duration listed for implementation

1 - Completed December 2019.
2 - Completed October 2019.
3 - Anticipated reduction from action cannot be quantified at present.
4 - Assumed to be Ex Situ Capture as the permanent remedial alternative for seeps.
5 - Cumulative estimated reductions assumes:
a) that reductions are achieved at the end of the implementation period; and
b) that the time period for contingent actions is not needed.

Legend

Action Complete	✓
Planned Action Implementation Period	
Time Period for Contingent Actions	

2. SEEP REMEDY RESPONSES AND EXPLANATIONS

Chemours has proposed implementing interim seep remedies by pilot testing both a flow through cell at Seep A where treatment occurs in situ and a French drain with ex situ treatment at Seep D. After optimizing and evaluating the performance of these two interim remedies, and assuming equivalent mass removal performance, Chemours would proceed implementing the flow through cells at Seeps B and C. Flow through cells are the preferred seep remedy since among other potential advantages they:

- are passive remediation systems;
- are less disruptive to local ecological habitats;
- have a higher likelihood of gaining the United States Army Corps of Engineers (USACE) approval;
- have lower costs; and
- they can likely be made operational more quickly.

While flow through cells are preferred to French drains as a seep remedy, both are expected to perform better than groundwater extraction near the headwaters of the seeps. Groundwater flow in the perched zone and the surficial aquifer ultimately flows toward the Cape Fear River and is expressed as seeps along the bluff. Smaller seeps toward the top of the bluff coalesce into larger flows as water moves downhill. This natural seep system is significantly more amenable to control at the seep than by extracting groundwater via wells. The water balance indicates that this flow represents the vast majority of flow transported toward the east beneath the facility. No configuration of pumping wells could capture as much of this flow as is already expressed at the capture location design of the seeps.

CFRW comments that flow through cells (or French drains) should be implemented at all seeps simultaneously. It is our professional judgment that given the technical challenges of the contaminants and the proximity of the river at the likely seep treatment locations, pilot testing is required to effectively design a resilient, effective, and implementable remedy; hence the pilot test approach at Seeps A and D. After the pilot test period (proposed to be six months) and collection of operational data, performance monitoring will demonstrate whether flow through cells are the suitable long-term remedy. While a six-month pilot period is proposed, the results of the pilot may indicate the viability of the flow through cell on a shorter timeframe, potentially as soon as 4 months after pilot system startup. Consequently, flow through cells could be installed at the remaining onsite groundwater seeps, without the need for further pilot testing at those other seeps. The findings from constructing and operating the pilot at Seep A will be valuable to implementing effective flow through cells at the remaining seeps.

We anticipate granular activated carbon (GAC), or potentially another material evaluated in bench scale testing, to be effective in flow through cells at reducing PFAS concentrations. The design of the flow through cells will incorporate pretreatment and filtration to optimize, to the extent practical, contact efficiency between adsorption media and the Table 3+ PFAS. Note that pretreatment and filtration will be a key engineering design element for the French drains as well.

During the pilot test phase, Chemours will prepare preliminary design drawings and engineering packages for implementation of French drains at Seeps A-C should assessment of pilot testing data result in French drains being selected as the long-term remedy. These drawings and engineering packages would be in addition to the design drawings and details being prepared for the Seep D pilot French drain or possible future flow through cells. This package would then be finalized as a detailed design package using the findings from the pilot tests.

Seep Remedy Performance

During normal operating conditions, to achieve a 95% total Table 3+ PFAS loading reduction from the seeps, the seep remedies will be designed to capture the maximum flow possible from the seeps and to treat such flow at a greater than 95% removal efficiency of total Table 3+ PFAS. The attainable removal efficacy of the seep remedies will be developed from the bench and pilot tests. Normal operating conditions are defined as the time when river levels are below the elevation of the seep remedy. Periodically, river levels may become elevated to levels above the seep remedies due to weather conditions such as flooding caused by hurricanes or heavy rain events. An extreme weather preparedness plan will be prepared to recommend measures to safeguard seep remedy infrastructure during these events.

The seep remedies will be designed to capture the maximum surface water based upon the possible placement location at the seep. Chemours recently received lidar topographic survey data of the Site adjacent to the Cape Fear River. This and other data will be used to target the most effective placement locations for the flow through cells. Selection factors include (a) locations where multiple seep flows have come together and (b) locations where natural topography is conducive to construction designs supporting mass loading reductions.

An essential requirement for a seep remedy that fulfills a 95% PFAS mass loading reduction is securing any necessary Clean Water Act (CWA) 401 permit from the NCDEQ Division of Water Resources (DWR) and a CWA 404 permit from the USACE. Potential seep remedy designs may exist in either or both Waters of the United States (WOTUS) or wetland areas. Chemours is actively engaging both DWR and USACE, including proposing Site visits to view the seeps, to discuss PFAS loading reduction objectives and potential seep remedy designs including advantages and disadvantages regarding both mass loading reductions and permitting needs.

Seep Remedy Performance Monitoring

At this time, seep remedy performance monitoring is proposed to be accomplished using the sum of the twenty (20) Total Table 3+ PFAS. Seep remedy mass removal rates, which will provide an indication of overall seep remedy performance, will be calculated using Equation 1 below where the influent and effluent concentrations are used to calculate percentage mass removals. As the design of the seep remedies are finalized, Chemours will develop a similar mass loading reduction equation consistent with the seep remedy designs. The final designs will identify the potential monitoring opportunities and constraints.

Equation 1 – Seep Remedy Mass Removal Rate

$$\boldsymbol{SMR = \frac{c_i - c_e}{c_i} \times 100\%}$$

Where:

SMR = seep remedy mass removal rate calculated as a percentage for a set of paired influent and effluent samples representing equivalent volumes of water flowing through the seep remedy treatment system;

c_i = the total Table 3+ PFAS concentration of the seep influent into the treatment system; and

c_e = the total Table 3+ PFAS concentration of the seep effluent after leaving the treatment system.

3. OLD OUTFALL 002 RESPONSES AND EXPLANATIONS

The Consent Order states in paragraph 12(e)(i) that the Old Outfall 002 treatment system, “shall … capture the dry weather flow” and, “shall meet such discharge standards as shall be set by DEQ, and shall, in addition and at a minimum, be at least 99% effective in controlling indicator parameters, GenX [HFPO-DA] and PFMOAA”.

Chemours is on track to meet these requirements of the Consent Order. First, the treatment system is being constructed to treat up to 750 gallons per minute. Second, treatability testing performed by Chemours has demonstrated that the treatment system will be at least 99% effective in controlling indicator parameters HFPO-DA and PFMOAA. CFRW’s comments about groundwater extraction and the Old Outfall are discussed later in Section 5.

4. OUTFALL 002 RESPONSES AND EXPLANATIONS

Chemours proposed five actions focused on reducing Outfall 002 PFAS concentrations including:

- Removal of Sediment from Conveyance Network (completed in 2019);
- Replacement of Terracotta Pipe (scheduled for 2021);
- Developing a Stormwater Pollution Prevention Plan (in progress);
- Assessment of Means to Mitigate Groundwater Intrusion (in progress); and
- Implementing Targeted Stormwater Control (in progress).

These five actions, in addition to the installation of air abatement controls, will reduce Outfall 002 PFAS loading to the Cape Fear River.

This section provides responses and explanations to CFRW comments and questions related to Outfall 002 including stormwater (targeted and Site-wide); process water and Outfall 001; and the Outfall 002 80% reduction target specified in paragraph 12 of the Consent Order. A response to CFRW's comment about groundwater extraction related to potential groundwater intrusion into Outfall 002 is provided later in the Groundwater Extraction section.

Stormwater

<u>Targeted Stormwater</u>

Building on 2019 data and analyses, Chemours is undertaking a set of detailed stormwater control assessments and investigations in 2020 to develop and implement a targeted stormwater control program. This includes performing a stormwater PFAS treatability evaluation, which will investigate effective treatment (and pretreatment) methods for treating PFAS in stormwater. Targeted stormwater sampling will also be conducted to sample numerous sources of stormwater runoff to Outfall 002 in order to determine how stormwater concentrations vary by source and spatially. A Stormwater Action Plan will then be developed to summarize findings from the treatability evaluation and stormwater sampling (site-wide and targeted) and outline actions to address source control and/or treatment of stormwater.

<u>Standalone Site-Wide Stormwater Treatment System</u>

The costs presented in the Supplemental Information Report (Geosyntec 2019a) for site-wide stormwater treatment include a standalone treatment system because of the nature of stormwater flows. Rainfall and consequently stormwater runoff are not both evenly distributed in time. Storm events vary widely, in both duration and intensity, and peak runoff can be very high. Consequently, site-wide stormwater treatment requires a combination of large equalization tank(s) and a treatment system that is much larger than the Old Outfall 002 system, hence necessitating a separate stand-alone system. As described in the Supplemental Information Report, the Site area draining to Outfall 002 was modeled using the hydrologic model and historical rainfall from 2006 through 2018. A range of storage volume sizes was also modeled, and the cost-effective storage size was determined based on the plot of storage volume size versus percent capture of runoff volume. The size used in the evaluation resulted in 85% average annual percent capture of runoff volume. Increasing the size greater than the storage volume used in the evaluation would add significant cost but would only result in minimal increases in the amount of runoff volume captured and treated. The required storage tank for this scenario was estimated to be 5.5 million gallons, and the treatment flowrate was approximately 3,800 gallons per minute. This is at least five times the Old Outfall 002 treatment system flow rate, a significantly larger flow rate. Therefore, the original costing presented in the Supplemental Information Report is appropriate to use in evaluating the economic feasibility of implementing a Site-wide stormwater remedy.

Additionally, the estimated Site-wide stormwater treatment system flow rate of 3,800 gallons per minute represents the peak flowrate to the treatment system (from the stormwater storage tank). This peak flow rate cannot be used to estimate yearly flows (these flows would result in incorrect estimates of 5,472,000 gallons per day or 2,000,000,000 gallons per year). Due to rain events and subsequent stormwater runoff rates being high in intensity at times, the design treatment flowrate will be used during these events but will not be utilized at a constant rate for the entire year. The annual treatment volume of 120 million gallons was estimated based on hydrologic modeling using long-term rainfall data, so that volume accounts for the expected fluctuations in stormwater runoff throughout an average year.

Stormwater Runoff Flows

On page 6 of the letter, CFRW expressed confusion regarding values in the Supplemental Report and the NPDES Application. It appears CFRW may have mistakenly read the value of stormwater runoff discharged from Outfall 002 in the NPDES renewal application as units of gallons per year instead of gallons per day. If the correct units, as presented in Attachment B.1.1 of the NPDES renewal application, are used (resulting in a value of 355,308 gallons per day of non-process stormwater), there is no conflict.

Outfall 001 Flows and Process Water

CFRW's comments mention process water but are not specific to which process waters are being referred to. Based on context, for the purposes of this response, we assume CFRW is referring to process water from Kuraray and DuPont, which presently is sent to the WWTP. Chemours process wastewater is presently sent for offsite disposal.

At the Site, the Wastewater Treatment Plant (WWTP) discharges to the open channel to Outfall 002. Prior to November 29, 2017, the WWTP received Chemours process water flows from the Monomers IXM area, which contained Table 3+ PFAS compounds from fluoroproduct manufacturing. At present, the WWTP receives water from: process water from Site tenants Kuraray and DuPont, stormwater, and sanitary water.

The processes at Kuraray and DuPont are not known to produce Table 3+ PFAS. In the paragraph 11(b) characterization sampling program results (Geosyntec, 2019d), process water sampling from both Kuraray and DuPont generally indicate total Table 3+ PFAS concentrations similar to river intake water at the Site (Location 1). Stormwater will have a component of PFAS. Stormwater is being assessed in 2020 as part of a focused stormwater management program.

Historically, the WWTP received process water containing Table 3+ PFAS via the terracotta pipe. While the section of this pipe from the Monomers IXM area has been disconnected and grouted, the remaining length of the terracotta pipe may still be contributing small releases of PFAS to the WWTP as past sedimentation in the pipe which may have contained PFAS from process water might be periodically re-mobilized. In the paragraph 11(b) characterization sampling program, Location 23A is located where the terracotta pipe is connected to the Monomers IXM area. The samples collected from this location after the grouting occurred indicate that water at this location continues to contribute total Table 3+ PFAS to the WWTP.

By the Fall of 2021, Chemours and Kuraray will replace the remaining in use portions of the terracotta pipe. As described in the Reductions Plan, Chemours will "remov[e] the connection of the terracotta pipe to the Wastewater Treatment Plant. Flows of water to the Wastewater Treatment Plant from the terracotta pipe will be transmitted through newly constructed above ground piping." This action is expected to further reduce the loading of total Table 3+ PFAS mass to the WWTP. Therefore, designing and implementing a treatment system for either flows of process water into the WWTP or for flow from the effluent the WWTP are not merited at present based on the upcoming planned terracotta pipe replacement.

Outfall 002 and Paragraph 12 Reduction Targets

Paragraph 12 of the Consent Order states that Chemours must demonstrate that the concentrations of GenX [HFPO-DA] and PFMOAA detected in Outfall 002 cannot be reduced by at least 80%. The Outfall 002 Assessment (Attachment 3 to the Reduction Plan submitted on August 26, 2019) presented one potential control approach that could potentially achieve an 80% reduction at Outfall 002: treating all flows (i.e., stormwater and dry weather flows) to Outfall 002 end of pipe. The Supplemental Information Report showed that this option was economically infeasible.

Treating site-wide stormwater (at 85% average annual percent capture) was presented as a potential control approach in The Outfall 002 Assessment. However, this action was estimated to only result in a potential reduction to Outfall 002 of 40% (compared to the 2018 calendar year) and so would need to be paired with other actions to achieve an 80% reduction. The Supplemental Information Report showed that treating site-wide stormwater was economically infeasible. Therefore, together both the Reduction Plan and the Supplemental Information Report provided information to show that the 80% reduction of HFPO-DA and PFMOAA in Outfall 002 was economically infeasible.

5. GROUNDWATER EXTRACTION

Chemours's proposed remedial alternatives will treat PFAS in groundwater that have or are reaching Willis Creek, the Old Outfall 002, Seeps A-D, and the Cape Fear River. CFRW suggests Chemours perform significant additional extraction of groundwater at the Site. This groundwater extraction is unwarranted and also in cases infeasible since much of the groundwater extraction suggested by CFRW would:

- extract groundwater which would have been intercepted by other remedies; and / or
- compromise the schedule for implementing long-term remedies; and / or
- be economically infeasible.

This section describes why specific groundwater extraction recommendations by CFRW are unwarranted or infeasible.

Extracting groundwater from all three aquifers is not necessary

On page 8 of the letter, CFRW suggests that groundwater from all three aquifers be extracted to reduce PFAS loading to Willis Creek. Extracting groundwater from all three aquifers is not warranted. An effective hydraulic control remedy is one that will extract groundwater where it provides the most value. All surface water bodies at the Site are in contact with at least one geological formation at any given transect, therefore usually the most efficient place to capture this groundwater is before discharge to the adjacent surface water body. This approach makes groundwater extraction more targeted.

For instance, the Perched Zone is not in contact with the Cape Fear River. Groundwater from the Perched Zone must travel downwards and eastwards before being discharged at either a seep or the Cape Fear River via the Black Creek Aquifer. The seep remedies proposed in the Reduction Plan will treat this Perched Zone groundwater. For discharge to the Cape Fear River, the long-term groundwater remedy will capture and treat this water. Groundwater capture and treatment can be targeted and extracting groundwater from all three aquifers is unwarranted to attain PFAS loading reductions to surface water.

Extracting groundwater reaching Seeps A to D and Old Outfall 002 is unwarranted

Extracting groundwater that eventually reaches the seeps and Old Outfall 002 is unwarranted for two reasons. First, this water can be effectively treated by the seep and Old Outfall 002 remedies. Second, extracting this groundwater is unlikely to sufficiently stop the flow of groundwater to the seeps or Old Outfall 002 (i.e., dry up the streambeds) and hence would then require the seep and Old Outfall 002 remedies still be installed.

Extracting all groundwater reaching the seeps or Old Outfall 002 is likely not possible using either wells or extraction trenches. First, groundwater wells alone are unlikely to capture all flows. All geological formations are heterogenous. While the extraction wells may capture a large portion of flow, there can exist highly transmissive zones between wells where groundwater is not captured and still is expressed at the seeps or Old Outfall 002. Additionally, as groundwater expresses itself at the bluff in an unconfined aquifer environment, the groundwater layer becomes very thin, meaning that the radius of hydraulic influence of each well becomes much smaller, enabling greater opportunities for flow bypass.

Second, extraction trenches are unlikely to capture enough of the total groundwater flow. Extraction trenches would need to be built close to the point of discharge on the bluff to capture flows reaching the seeps and Old Outfall 002. Setting the trenches at the plant is technically feasible for construction but would allow for additional infiltration and seep and Old Outfall 002 discharge to occur. On the other hand, it is infeasible to effectively construct the extraction trenches on the steeply sloping terrain of the bluff. Therefore, extraction trenches would not completely capture the water reaching the seeps and Old Outfall 002.

In a remedy feasibility evaluation process, if two or more proposed remedies achieve the same desired results, but one at a lower cost, the lesser cost solution can be chosen based on qualified engineering judgement. Because of the need for many extraction wells or a large capture trench, both of the remedies described above will have a higher construction cost than the proposed flow through cells or French drains for the seeps or the Old Outfall 002 capture and treat system. Therefore, extracting groundwater before it reaches Seeps A – D or Old Outfall 002 is unwarranted since equally effective proposed seep and Old Outfall 002 remedies can be implemented.

Additional Interim Groundwater Extraction Wells

Additional interim groundwater extraction wells will compromise the ability to expeditiously implement the long-term groundwater remedy and provide minimal additional benefit. The "Install new Black Creek Extraction Wells (Interim)" alternative on p. 60 of the Supplemental Information Report (Geosyntec, 2019a) described installing seven additional Black Creek Aquifer wells on an interim basis in and near the plant area at the Site to provide an estimated 70 gallons per minute of groundwater extraction. This extraction rate will not meaningfully reduce loadings to the Cape Fear River. The results of a modeling simulation provided as Appendix H of the CAP (Geosyntec, 2019c) showed that if extraction wells were installed at the plant along with a barrier wall by the river, upwards of 30 wells would be required. These wells would reduce the flow of upwelling groundwater to the Cape Fear River by about 1,000 gallons per minute, approximately 65% of the volume of water reaching the river. By contrast, seven interim wells withdrawing a total of 70 gallons per minute of groundwater and lacking a barrier wall would achieve much less reductions to river loadings.

For interim extraction wells to meaningfully reduce groundwater loadings they would need to be placed in greater numbers and positioned at the base of the bluff adjacent to the Cape Fear River. This increase in numbers and placement position would compromise the ability to expeditiously implement the long-term groundwater remedy. These interim wells and their associated piping and power needs would create obstructions and logistical challenges for construction.

Extracting additional groundwater reaching Willis Creek is infeasible

Willis Creek PFAS loadings will be reduced by the long-term groundwater remedy and other actions being taken under the proposed corrective actions. Installing interim wells adjacent to Willis Creek is unwarranted and extending the potential length of the long-term remedy is economically infeasible.

Willis Creek runs adjacent to the Site for approximately 1.5 miles from North Carolina Highway 87 to where the creek empties into the Cape Fear River. Willis Creek gains approximately 14% of its total Table 3+ PFAS mass loading in the first mile adjacent to the Site starting from the highway and going towards the river. Willis Creek then gains approximately 70% of its total Table 3+ PFAS mass loadings for the last half mile before the creek empties into the Cape Fear River[1]. The groundwater remedy described in the CAP, a barrier wall with groundwater extraction, is estimated to potentially reduce the estimated 70% of loadings reaching Willis Creek.

Extending a groundwater hydraulic containment remedy to reach NC Highway 87 is economically infeasible. The additional benefit of extending the remedy would be at most a 14% reduction of loadings to Willis Creek. Willis Creek total Table 3+ PFAS loadings have been estimated to range between 3% to 10% of the loads in the Cape Fear River. This means that extending the Willis Creek remedy would contribute between 0.42% and 1.4% additional loading reductions to the Cape Fear River. Meanwhile the cost of extending the groundwater remedy an additional mile to encompass the distance from sampling point WC2 to Highway 87 is estimated to be $30,400,000 (with +50% / -30% ranges of $45,600,00 and $21,300,000). A cost of $30,400,000 divided by a Cape Fear River loading reduction of between 0.4% and 1.4% produces a cost of $22 million to $76 million per percentage river reduction. This cost is economically infeasible for the reduction achieved. Supporting costs for this are provided in Attachment B.

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[1] Data collected from five sampling locations in Willis Creek in February 2019 were used to calculate these loading values (see Seeps and Creeks Investigation Report (Geosyntec, 2019f)). Samples started at the creek mouth, Location WC1, and ended at Location WC5 near NC Highway 87. The value of 14% total Table 3+ PFAS loadings coming from the mile of the creek adjacent to the site from NC Highway 87 towards the river was calculated as the concentration at location WC2 (680 ng/L) minus the concentration at WC5 (370 ng/L) all divided by the concentration at WC1 (2,220 ng/L). The value of 70% of total Table 3+ PFAS loading coming from the half mile just before the river was calculated as the concentration at location WC1 (2,220 ng/L) minus the concentration at WC2 (680 ng/L), all divided by the concentration at WC1 (2,220 ng/L).

Last, adding interim wells adjacent to Willis Creek is not recommended. As described previously, interim wells, their piping and power supply will interfere with the expeditious implementation of the long-term groundwater remedy, which will achieve meaningful mass loading reductions. Meanwhile, interim extraction wells will be far less effective and hamper the implementation of the long-term remedy. Therefore, interim groundwater extraction wells for Willis Creek are considered to be unwarranted.

Extracting groundwater from the Site reaching Georgia Branch Creek is infeasible

Georgia Branch Creek is entirely offsite and is groundwater fed. Concentrations are relatively uniform along the creek, therefore loadings are also assumed to be relatively uniform across the creek. Assuming relatively uniform loadings is also supported by the air deposition signature of PFAS in Georgia Branch Creek. Air deposition PFAS are not spatially clustered and concentrated like process water PFAS release signatures but are relatively evenly distributed in concentration on and offsite (Geosyntec, 2019e).

Georgia Branch Creek runs adjacent to the Site within 100 to 700 feet for approximately 2 miles between well SMW-01 where the Site has an intersection with NC Highway 87 to where the Southern Boundary of the Site intersects Glengerry Road. This 2-mile reach of Georgia Branch Creek represents approximately 25% of the length of Georgia Branch Creek and its tributaries. A groundwater remedy implemented here would limit discharge from only one side of the creek, and therefore would reduce loadings by 13%.

Georgia Branch Creek total Table 3+ PFAS loadings have been estimated to range between 2% to 4% of the loads in the Cape Fear River. This means that extracting groundwater from the Site reaching Georgia Branch Creek between well SMW-01 and Glengerry Road would contribute between 0.26% and 0.52% additional loading reductions to the Cape Fear River. Meanwhile the cost of extending this groundwater extraction remedy is estimated to be $43,300,000 (with +50% / -30% ranges of $65,000,00 and $30,300,000). A cost of $43,300,000 divided by a Cape Fear River loading reduction of between 0.26% and 0.52% produces a cost of $83 million to $166 million per percentage river reduction. This cost is economically infeasible for the reduction achieved. Supporting costs for this are provided in Attachment B.

6. CLARIFICATION REGARDING FEASIBILITY

CFRW's comments incorrectly state that the supplemental report, "[assumes] that less than $10 million per percentage reduction of loading to the Cape Fear is economically feasible". The remedy selection process outlined in the supplemental report identifies that in Step 1 of the process, initial screening, remedies with a score of 5 (i.e., greater than $10 million per percentage loading of total Table 3+ reduction to the Cape Fear River) were removed from the selection process. However, remedies can still be determined to be economically infeasible if they would cost less than $10 million per percentage loading reduction in this process. Beyond that, as shown above, the options not recommended consistently have costs per percentage reduction substantially in excess of $10 million.

CFRW stated that feasibility should not be assessed on a per-pathway basis. Because Geosyntec has identified potential treatment options on a per-pathway basis, it has also assessed the feasibility of those options on a per-pathway basis, while also looking holistically to meet overall loading reduction objectives specified in the Consent Order.

7. RESPONSES TO OTHER COMMENTS OR QUESTIONS

CFRW requested information about the timespan for the thermal oxidizer and other air abatement controls to produce reductions in PFAS in surface waters. The air abatement controls are expected to result in a 99% reduction of PFAS emissions to air. Over a multi-year timeframe, these air reductions will result in lower groundwater and surface water concentrations.

CFRW requested a copy of the groundwater model. Geosyntec will provide the model by March 30,2020. A functional description of the model will be developed to be provided with the model files. Since completing the CAP, the modeling team is in the process of updating the model to perform detailed remedy design simulations using transient groundwater solutions.

CFRW requested additional details on the ratings assigned to each remedy. These descriptions are provided in Attachment C.

CFRW requested that Cost-Benefit Analysis figures (Figures 21 and 22) of the Supplemental Information Report show values for all alternatives considered. Plotting all alternatives considered would not be appropriate since reductions from certain pathways would be double- counted since the reductions plotted on the y-axis are a cumulative sum. In other words, plotting all alternatives together on this graph would produce estimated river reductions greater than 100%. Instead, the most feasible alternatives to reduce loadings per pathway were plotted. Additionally, CFRW expressed confusion about which remedies were proposed for the Site. The CAP submitted to DEQ describes the set of remedies considered for the Site.

CFRW requested clarification on what reductions can be achieved, for targeted stormwater control and groundwater intrusion mitigation. The Mass Loading Model (Attachment 1 to the Reduction Plan) estimated total Table 3+ mass loading contributions to the Cape Fear River from each potential transport pathway. Outfall 002 was estimated to contribute 3.6% and 7.2% of the total loading to the river, based on data from the May 2019 and June 2019 sampling events, respectively (these values were rounded to 4% and 7% for presentation in the table). The average between the two events was calculated to be 5.5%. The estimate that targeted stormwater control would achieve a 1.7% reduction to the river (stated on page 63) used the averaged Outfall 002 loading to the Cape Fear River estimate of 5.5%. The 1.3% reduction estimate (stated on page 77) used an incorrect value for the Outfall 002 loading to the Cape Fear River.

The discrepancy in reduction estimates for groundwater intrusion mitigation resulted from using rounded numbers. Using the estimates of Outfall 002 loading to the Cape Fear River of 3.6% and 7.2% (based on the May and June 2019 sampling events, respectively), groundwater intrusion mitigation is expected to achieve between 0.5% and 0.9% loading reductions to the river.

ATTACHMENTS

Attachment A: River Baseline Calculation Methodology
Attachment B: Remedy Costing
Attachment C: Remedy Scoring Table Narrative

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ATTACHMENT A
River Baseline Calculation Methodology

Attachment A – River Baseline Calculation Methodology
Chemours Fayetteville Works

Recommended Mass Loading Baseline Calculation Formula

Geosyntec proposes that the mass load of total Table 3+ compounds in the Cape Fear River be calculated using Equation 1 shown below:

Equation 1 – Total Table 3+ Baseline Mass Loading

$$MTT3_{CFR} = m_{CFR} - m_{Remedies}$$

$$MTT3_{CFR} = \sum_{n} \sum_{j=1}^{j=20} c_{CFR,n,j} Q_{CFR,n} - m_{Remedies}$$

Where

$MTT3_{CFR}$ = is the total baseline mass load of the twenty Table 3+ PFAS compounds either in the Cape Fear River, or diverted from the Cape Fear River by applied remedies;

m_{CFR} = is the total Table 3+ PFAS mass load measured from samples taken in the Cape Fear River downstream of the Site where the river is well mixed;

$m_{Remedies}$ = is the total Table 3+ PFAS mass load prevented from reaching the Cape Fear River by remedies implemented by Chemours;

n = is the number of Cape Fear River samples collected in a monitoring period (e.g. annual) to calculate mass loading in the Cape Fear River, e.g., given no complications during sample collection, then total samples in an annual period would be, n = 365/3.5 = 105;

j = is the number of Table 3+ PFAS compounds (twenty) being summed to determine the total Table 3+ PFAS concentration in the sample;

$c_{CFR,n,j}$ = is the concentration of Table 3+ PFAS in a composite water sample collected from the Cape Fear River; and

$Q_{CFR,n}$ = is the volume of Cape Fear River water that flowed past the sampling point while the composite sample was being collected.

ATTACHMENT B
Remedy Costing

Rough Order of Magnitude Cost Estimate for Groundwater Capture Impacting Willis Creek
Chemours Fayetteville Works, North Carolina

Basis of Cost Estimate (Scope and Assumptions) for Willis Creek (WC) Groundwater Remedy:

Hydraulic containment along 5,280 linear feet of WC reach that is impacted by aerial deposition signature PFAS.
The portion of the Black Creek aquifer groundwater (process water signature) that is discharging to WC is covered in other cost estimates.
The discharging aquifer is the surficial aquifer in this area (in contrast with process water signature onsite groundwater).
This remedy scenario assumes groundwater capture only.
It is assumed that extraction wells will be spaced 100 feet apart and pumping rates will on average be 10 gpm.
A total of 54 wells and 540 gpm (0.8 MGD) would be required for hydraulic containment.
It would not be practical to convey this much flow to the OOF2 system location. A new standalone system would be required.
The average PMPA and PFMOAA concentration of the extracted groundwater is estimated to be 1,100 and 550 ng/L, respectively.
Wells will convey groundwater under pressure to the system, with basic heat tracing (no prefabricated building).
Piping will be HDPE and trenches will be approximately 3 feet deep, and reuse of excavated soils as backfill will be permitted.
HDPE pipe sizes range from 2 to 18 inch diameter SDR 11.
Treated groundwater will be discharged to the WC.
Includes a 20-year net present value cost with a 3.5% discount factor applied.

Item	Qty	Unit	Unit Cost	Total	Notes
Construction Costs					
Drilling Costs					
Driller mobilization	1	LS	$ 10,000	$ 10,000	Engineer's Estimate
Extraction Wells drilling and well installation (no appurtenances)	1,620	LF	$ 225	$ 364,500	Engineer's Estimate
Aquifer pump testing on 25% of extraction wells	14	EA	$ 15,000	$ 202,500	Engineer's Estimate
Monitoring Wells drilling and installation	540	LF	$ 75	$ 40,500	Engineer's Estimate
IDW	2,160	LF	$ 10	$ 21,600	Engineer's Estimate
Drilling Subtotal				$ 639,100	
Site Work Costs					
HDPE SDR 11 - 2"	180	LF	$ 1.35	$ 243	Engineer's Estimate
HDPE SDR 11 - 3"	250	LF	$ 2.35	$ 588	Engineer's Estimate
HDPE SDR 11 - 4"	500	LF	$ 3.90	$ 1,949	Engineer's Estimate
HDPE SDR 11 - 6"	500	LF	$ 8.43	$ 4,213	Engineer's Estimate
HDPE SDR 11 - 8"	600	LF	$ 14.28	$ 8,568	Engineer's Estimate
HDPE SDR 11 - 10"	600	LF	$ 22.18	$ 13,307	Engineer's Estimate
HDPE SDR 11 - 12"	750	LF	$ 31.20	$ 23,400	Engineer's Estimate
HDPE SDR 11 - 14"	900	LF	$ 37.61	$ 33,853	Engineer's Estimate
HDPE SDR 11 - 16"	600	LF	$ 49.07	$ 29,445	Engineer's Estimate
HDPE SDR 11 - 18"	400	LF	$ 62.17	$ 24,870	Engineer's Estimate
HDPE fusing and fittings	1	LS	$ 2,500.00	$ 2,500	Engineer's Estimate
3'x3'x3' Well Vault + H20-Rated Lid (4.5x4.5x4.5)	54	ea	$ 12,993.00	$ 701,622	Engineer's Estimate
Flow Meters, Level and Pressure Transmitters	54	ea	$ 1,603.00	$ 86,562	Engineer's Estimate
Grundfos 3" 15SQ05-110-240V Submersible Pump, fittings, appurtenances	54	ea	$ 2,190.58	$ 118,292	Engineer's Estimate
Power poles, hardware, guy wires, excavation, wiring, transformers	5	ea	$ 30,639.71	$ 153,199	Engineer's Estimate
Local control panels	54	ea	$ 5,000.00	$ 270,000	Engineer's Estimate
Utility Connection to System	1	ea	$ 100,000.00	$ 100,000	Engineer's Estimate
Subcontractor Installation Costs-Piping 2"-6"	1,430	LF	$ 75.00	$ 107,250	Engineer's Estimate
Subcontractor Installation Costs-Piping 8"-14"	2,850	LF	$ 100.00	$ 285,000	Engineer's Estimate
Subcontractor Installation Costs-Piping 16"-18"	1,000	LF	$ 125.00	$ 125,000	Engineer's Estimate
Subcontractor Installation Costs-Well Vault	54	ea	$ 5,000.00	$ 270,000	Engineer's Estimate
Subcontractor Installation Costs-Electrical	1	LS	$ 240,000.00	$ 240,000	Engineer's Estimate
Subcontractor mobilization	5%	of	$ 2,599,859	$ 129,993	Engineer's Estimate
Site Work Subtotal				$ 2,729,852	

Rough Order of Magnitude Cost Estimate for Groundwater Capture Impacting Willis Creek
Chemours Fayetteville Works, North Carolina

540 GPM (0.8 MGD) Treatment Plant Cost						
Land clearing and site prep for new system	Process Package		$ 500,000	$	500,000	Parsons
Influent & Effluent Handling, includes lift stations, EQ tanks, feed forward pumps, discharge pumps	Process Package		$ 147,600	$	147,600	Parsons
Multi Media Filtration, includes skids and backwash pumps	Process Package		$ 238,320	$	238,320	Parsons
Granular Activated Carbon, includes skid, water suppy tank, backwash waste tank, backwash pumps	Process Package		$ 892,080	$	892,080	Parsons
Solids Handling and Chemical Precipitation, includes feed pumps, clarifiers, sludge pumps, filter press, chemicals	Process Package		$ 773,280	$	773,280	Parsons
Enclosures and Heat Tracing	Process Package		$ 309,600	$	309,600	Parsons
Installation Cost (Construction, Site Preparation, Civil, Structural)	70%	of	$ 2,051,280	$	1,500,000	Parsons
Anciliary Cost (I&C, Piping-Mechanical & Electrical)	30%	of	$ 3,860,880	$	1,158,264	Parsons
0.8 MGD Treatment Plant Subtotal				$	5,519,144	
Total Construction Costs				$	8,888,096	
Professional Services Costs						
Modeling, Design, Work Planning, and Permitting	10%	of	$ 8,888,096	$	888,810	adapted from EPA Guidance
Construction Oversight	10%	of	$ 8,888,096	$	888,810	adapted from EPA Guidance
Project Management	8%	of	$ 8,888,096	$	711,048	adapted from EPA Guidance
Professional Services Subtotal				$	2,488,667	
Contingency	30%	of	$ 11,376,762	$	3,413,029	
Construction Cost				**$**	**14,800,000**	
+50%				$	22,200,000	
-30%				$	10,360,000	
Annual Operations & Maintenance Costs						
Electricity - Field Equipment	1	LS	$ 40,000	$	40,000	Engineer's Estimate
Electricity - Treatment Systems	1	LS	$ 16,704	$	16,704	Parsons
GAC Usage & Replacement	1	LS	$ 432,000	$	432,000	Parsons
Chemicals for treatment (Acid, Caustic, Ferric, Polymer)	1	LS	$ 19,440	$	19,440	Parsons
Solids Disposal	1	LS	$ 18,000	$	18,000	Parsons
Sampling & Analytical	1	LS	$ 38,160	$	38,160	Parsons
Operational Labor	1	LS	$ 324,000	$	324,000	Parsons
Equipment Maintenance	1	LS	$ 170,640	$	170,640	Parsons
Annual O&M Subtotal				$	1,058,944	
Annual Cost				**$**	**1,100,000**	
+50%				$	1,588,416	
-30%				$	741,261	
Years	**20**					
Discount Rate	**3.5%**					
Net Present Value (NPV) of Annual Costs over 20 Years				**$**	**15,600,000**	
+50%				$	23,400,000	
-30%				$	10,920,000	
Total Cost - Construction and Annual O&M						
Total: Construction + NPV of Annual Costs over 20 Years				**$**	**30,400,000**	
+50%				$	45,600,000	
-30%				$	21,280,000	

Costs are rough order of magnitude estimates, and assumed to represent the actual installed cost within a range of -30%/ +50% of the value indicated above. The estimates have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on final approved design, actual labor and material costs, and competitive variable factors. These estimates are not intended for budgetary or future planning purposes; they have been prepared to facilitate an inter-remedial alternative comparison.

Rough Order of Magnitude Cost Estimate for Groundwater Capture Impacting Georgia Branch Creek
Chemours Fayetteville Works, North Carolina

Basis of Cost Estimate (Scope and Assumptions) for Georgia Branch Creek (GBC) Groundwater Remedy:

Hydraulic containment along 10,850 linear feet of GBC reach that is impacted by aerial deposition signature PFAS.
The discharging aquifer is the surficial aquifer in this area (in contrast with process water signature onsite groundwater).
This remedy scenario assumes groundwater capture only.
It is assumed that extraction wells will be spaced 200 feet apart and pumping rates will on average be 15 gpm.
A total of 54 wells and 810 gpm (1.2 MGD) would be required for hydraulic containment.
It would not be practical to convey this much flow to the OOF2 system location. A new standalone system would be required.
The average PMPA and PFMOAA concentration of the extracted groundwater is estimated to be 1,450 and 310 ng/L, respectively.
Wells will convey groundwater under pressure to the system, with basic heat tracing (no prefabricated building).
Piping will be HDPE and trenches will be approximately 3 feet deep, and reuse of excavated soils as backfill will be permitted. HDPE pipe sizes range from 2 to 18 inch diameter SDR 11.
Treated groundwater will be discharged to the GBC.
Includes a 20-year net present value cost with a 3.5% discount factor applied.

Item	Qty	Unit	Unit Cost	Total	Notes
Construction Costs					
Drilling Costs					
Driller mobilization	1	LS	$ 10,000	$ 10,000	Engineer's Estimate
Extraction Wells drilling and well installation (no appurtenances)	1,620	LF	$ 225	$ 364,500	Engineer's Estimate
Aquifer pump testing on 25% of extraction wells	14	EA	$ 15,000	$ 202,500	Engineer's Estimate
Monitoring Wells drilling and installation	540	LF	$ 75	$ 40,500	Engineer's Estimate
IDW	2,160	LF	$ 10	$ 21,600	Engineer's Estimate
Drilling Subtotal				$ 639,100	
Site Work Costs					
HDPE SDR 11 - 2"	500	LF	$ 1.35	$ 674	Engineer's Estimate
HDPE SDR 11 - 3"	600	LF	$ 2.35	$ 1,410	Engineer's Estimate
HDPE SDR 11 - 4"	750	LF	$ 3.90	$ 2,924	Engineer's Estimate
HDPE SDR 11 - 6"	800	LF	$ 8.43	$ 6,741	Engineer's Estimate
HDPE SDR 11 - 8"	1,000	LF	$ 14.28	$ 14,280	Engineer's Estimate
HDPE SDR 11 - 10"	1,000	LF	$ 22.18	$ 22,178	Engineer's Estimate
HDPE SDR 11 - 12"	1,000	LF	$ 31.20	$ 31,200	Engineer's Estimate
HDPE SDR 11 - 14"	2,000	LF	$ 37.61	$ 75,230	Engineer's Estimate
HDPE SDR 11 - 16"	1,700	LF	$ 49.07	$ 83,427	Engineer's Estimate
HDPE SDR 11 - 18"	1,500	LF	$ 62.17	$ 93,262	Engineer's Estimate
HDPE fusing and fittings	1	LS	$ 2,500.00	$ 2,500	Engineer's Estimate
3'x3'x3' Well Vault + H20-Rated Lid (4.5x4.5x4.5)	54	ea	$ 12,993.00	$ 701,622	Engineer's Estimate
Flow Meters, Level and Pressure Transmitters	54	ea	$ 1,603.00	$ 86,562	Engineer's Estimate
Grundfos 3" 15SQ05-110-240V Submersible Pump, fittings, appurtenances	54	ea	$ 2,190.58	$ 118,292	Engineer's Estimate
Power poles, hardware, guy wires, excavation, wiring, transformers	10	ea	$ 30,639.71	$ 306,397	Engineer's Estimate
Local control panels	54	ea	$ 5,000.00	$ 270,000	Engineer's Estimate
Utility Connection to System	1	ea	$ 120,000.00	$ 120,000	Engineer's Estimate
Subcontractor Installation Costs-Piping 2"-6"	2,650	LF	$ 75.00	$ 198,750	Engineer's Estimate
Subcontractor Installation Costs-Piping 8"-14"	5,000	LF	$ 100.00	$ 500,000	Engineer's Estimate
Subcontractor Installation Costs-Piping 16"-18"	3,200	LF	$ 125.00	$ 400,000	Engineer's Estimate
Subcontractor Installation Costs-Well Vault	54	ea	$ 5,000.00	$ 270,000	Engineer's Estimate
Subcontractor Installation Costs-Electrical	1	LS	$ 270,000.00	$ 270,000	Engineer's Estimate
Subcontractor mobilization	5%	of	$ 3,575,447	$ 178,772	Engineer's Estimate
Site Work Subtotal				$ 3,754,219	

Rough Order of Magnitude Cost Estimate for Groundwater Capture Impacting Georgia Branch Creek
Chemours Fayetteville Works, North Carolina

810 GPM (1.2 MGD) Treatment Plant Cost						
Land clearing and site prep for new system	Process Package		$ 500,000	$	500,000	Parsons
Influent & Effluent Handling, includes lift stations, EQ tanks, feed forward pumps, discharge pumps	Process Package		$ 221,400	$	221,400	Parsons
Multi Media Filtration, includes skids and backwash pumps	Process Package		$ 357,480	$	357,480	Parsons
Granular Activated Carbon, includes skid, water suppy tank, backwash waste tank, backwash pumps	Process Package		$ 1,338,120	$	1,338,120	Parsons
Solids Handling and Chemical Precipitation, includes feed pumps, clarifiers, sludge pumps, filter press, chemicals	Process Package		$ 1,159,920	$	1,159,920	Parsons
Enclosures and Heat Tracing	Process Package		$ 464,400	$	464,400	Parsons
Installation Cost (Construction, Site Preparation, Civil, Structural)	70%	of	$ 3,076,920	$	2,200,000	Parsons
Anciliary Cost (I&C, Piping-Mechanical & Electrical)	30%	of	$ 5,741,320	$	1,722,396	Parsons
1.2 MGD Treatment Plant Subtotal				$	7,963,716	
Total Construction Costs				$	12,357,035	
Professional Services Costs						
Modeling, Design, Work Planning, and Permitting	10%	of	$ 12,357,035	$	1,235,704	adapted from EPA Guidance
Construction Oversight	10%	of	$ 12,357,035	$	1,235,704	adapted from EPA Guidance
Project Management	8%	of	$ 12,357,035	$	988,563	adapted from EPA Guidance
Professional Services Subtotal				$	3,459,970	
Contingency	30%	of	$ 15,817,005	$	4,745,101	
Construction Cost				**$**	**20,600,000**	
+50%				$	30,900,000	
-30%				$	14,420,000	
Annual Operations & Maintenance Costs						
Electricity - Field Equipment	1	LS	$ 56,000	$	56,000	Engineer's Estimate
Electricity - Treatment Systems	1	LS	$ 25,056	$	25,056	Parsons
GAC Usage & Replacement	1	LS	$ 648,000	$	648,000	Parsons
Chemicals for treatment (Acid, Caustic, Ferric, Polymer)	1	LS	$ 29,160	$	29,160	Parsons
Solids Disposal	1	LS	$ 27,000	$	27,000	Parsons
Sampling & Analytical	1	LS	$ 57,240	$	57,240	Parsons
Operational Labor	1	LS	$ 486,000	$	486,000	Parsons
Equipment Maintenance	1	LS	$ 255,960	$	255,960	Parsons
Annual O&M Subtotal				$	1,584,416	
Annual Cost				**$**	**1,600,000**	
+50%				$	2,376,624	
-30%				$	1,109,091	
Years	**20**					
Discount Rate	**3.5%**					
Net Present Value (NPV) of Annual Costs over 20 Years				**$**	**22,700,000**	
+50%				$	34,050,000	
-30%				$	15,890,000	
Total Cost - Construction and Annual O&M						
Total: Construction + NPV of Annual Costs over 20 Years				**$**	**43,300,000**	
+50%				$	64,950,000	
-30%				$	30,310,000	

Costs are rough order of magnitude estimates, and assumed to represent the actual installed cost within a range of -30%/ +50% of the value indicated above. The estimates have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on final approved design, actual labor and material costs, and competitive variable factors. These estimates are not intended for budgetary or future planning purposes; they have been prepared to facilitate an inter-remedial alternative comparison.

ATTACHMENT C
Remedy Scoring Table Narrative

Attachment C – Remedy Scoring Table Narratives
Chemours Fayetteville Works

The Supplemental Information Report (Geosyntec 2019) contained details on the ranking of alternatives. This section is presented below. Following this a remedy scoring table summary is provided.

2.3 Compare Remedial Alternatives

Remedies can be assessed and scored for the following criteria:

i. Environmental Protection (i.e. reduction of PFAS Mass Loading);
ii. Adverse Environmental Effects;
iii. Technical Feasibility;
iv. Timing (i.e., 2 years or 5 years); and
v. Economic Feasibility (i.e., reduction achieved per relative cost expended).

These criteria recognize the adverse impacts may result during remediation and that selected alternatives must be both technologically and economically feasible. The following sub-sections describe each assessment criteria and how it was scored on a scale of 1 to 5 where 1 was the most favorable score and 5 the least favorable score.

2.4 Assessment Criteria 1 – Environmental Protection

Remedial alternatives were assessed to establish the expected degree of loading reduction they would provide to the Cape Fear River, Willis Creek, Georgia Branch Creek, and Outfall 002. For each waterbody based on professional engineering and scientific judgement and analyses of the alternatives presented in this Supplemental Report, the alternatives were assigned scores as follows:

Total Table 3+ PFAS Mass Loading Reductions to Surface Water Body	Scoring
>20%	1
>10 - 20%	2
>5 - 10%	3
>2 - 5%	4
0 - 2%	5

2.5 Assessment Criteria 2 – Adverse Environmental Effects

Remedial alternatives were assessed to establish the potential degree of adverse environmental effects they might cause (e.g. habitat destruction). Based on professional engineering and scientific judgement and analyses of the alternatives presented in this Supplemental Report were assigned scores as follows:

Adverse Environmental Effect	Scoring
No anticipated local effect	1
Some destruction of local habitat	2
Some alteration to local waterbody	3
Habitat destruction or alteration over a large extent	4
Extensive destruction of habitat type or waterbody	5

2.6 Assessment Criteria 3 – Technical Feasibility

Remedial alternatives were assessed to establish their potential technical feasibility. Based on professional engineering and scientific judgement and analyses of the alternatives presented in this Supplemental Report were assigned scores as follows:

Technical Feasibility Criteria	Scoring
Simple to Implement	1
Some Challenges, Success Fairly Certain	2
Complex or Large, Some Uncertainty about Degree of Success	3
Complex, Large, Access Issues, Success Potentially Possible	4
Complex, Large, Access Issues, Success Unlikely	5

2.7 Assessment Criteria 4 – Timeframe

Remedial alternatives were assessed to establish the timeframes in which they could be implemented. Based on professional engineering and scientific judgement and analyses of the alternatives presented in this Supplemental Report were assigned scores as follows:

Time To Implement	Scoring
Up to 1 year	1
From 1 to 2 years	2
>2 - 3 years	3
>3 - 5 years	4
> 5 years	5

2.8 Assessment Criteria 5 – Economic Feasibility

Remedial alternatives were assessed to establish their economic feasibility, where feasibility was established using the metric of cost in millions of dollars per reduction of one percent of Total Table 3+ PFAS Loading to the Cape Fear River. Based on the reductions to the Cape Fear River for each alternative and the estimated costs of each were assigned scores as follows:

Cost (Millions of Dollars) to achieve a 1% Reduction in Cape Fear River Total Table 3+ PFAS Loading	Scoring
$0 - $1M	1
>$1M - $2.5M	2
>$2.5M - $5M	3
>$5M - $10M	4
>$10M	5

2.9 Selection Process

Chemours is committed to taking actions to achieve expedited loading reduction for groundwater seeps and onsite groundwater, and the feasibility of each is evaluated in this Supplemental Report. The remedial alternatives for these pathways are still undergoing a final remedy selection process, as the technical evaluation of these options is in progress as described in Sections 5 and 6 (see Supplemental Information Report, Geosyntec 2019).

For remedies considered as part of the Reduction Plan (Geosyntec 2019a), selection is advanced herein as follows:

- Step 1: Initial screening
- Step 2: Selection of several viable remedial alternatives per pathway

In Step 1, alternatives with scores of 5, the least favorable score, for criteria 2, 3 and 5 (adverse impacts, technical feasibility and economic feasibility) were removed from the selection process.

Criteria	Action
1 – Achieves Reductions	All remedies regardless of scores are advanced
2 – Adverse Impacts	Remedies with a score of 5 are removed from selection process
3 – Technical Feasibility	Remedies with a score of 5 are removed from selection process
4 – Implementation Timing	All remedies regardless of scores are advanced
5 – Economic Feasibility	Remedies with a score of 5 are removed from selection process

If a proposed remedial alternative would cause severe adverse environmental impacts, it was not advanced as the purpose of remediation is to protect human health and improve environmental quality. If a remedy was infeasible, in other words if it was scored as 5, it was not advanced as it would not be implementable. If two proposed alternatives effectively achieved the same goals, the lower cost remedy was advanced. If a remedy was economically infeasible, i.e. it did not provide benefit that was commensurate with the cost to implement the remedy, it was not advanced for consideration. In Step 2, remedies were selected for further evaluation after balancing perspectives from all criteria presented here, comparison against remedial objectives and using professional engineering and scientific judgement.

Ultimately, those remedial options selected to advance will require further evaluation in the context of how the remedy integrates into the longer-term remedial approach. The additional evaluation includes groundwater flow modeling and the empirical studies currently underway.

Remedy Scoring Table Summary
Chemours Fayetteville Works

Pathway	Remedial Alternative	Reductions to the Cape Fear River Rank		Adverse Environmental Effects		Technology Feasibility		Time		Cost per Loading Removal	
Direct Aerial Deposition	Air Abatement Controls	Air abatement consists of less than 2% of loadings to the Cape Fear River.	5	Air abatement controls are all being constructed in the built area of the facility causing limited local impacts. Additional emissions of greenhouse gases from granular activated carbon (GAC) and natural gas usage are not considered in this scoring.	1	The air abatement controls, particularly the Thermal Oxidizer, are large capital projects executed on an extremely rapid timeline.	3	The Thermal Oxidizer and other air abatement controls have been implemented between 2018 and 2019.	1	Cost per loading removal was not scored because air abatement controls were not considered or installed to reduce total Table 3+ PFAS loading to the Cape Fear River.	
Old Outfall 002	Capture and Treat Old Outfall 002	The Old Outfall 002 has been estimated to contribute between 23% and 29% of total Table 3+ PFAS loading to the Cape Fear River.	1	Capturing and treating the Old Outfall 002 requires cutting down acres of forested area, placing a structure in a stream, and dramatically reducing flow in a portion of the stream.	3	Using GAC to treat PFAS is an established method, but the system must be installed in a flowing stream.	3	The Old Outfall system will be operational by September 2020 pending necessary permits/approvals.	2	The estimated price per percentage loading reduction was $1,700,000.	2
Seeps	Flow Through Cells - CFR Seeps A, B, C & D - Interim	Remedy reduction scores were not assigned for interim remedies at the time of remedy development in the Supplemental Information Report.	NA	Installing the flow through cells and French drains would require installing infrastructure in the seep streams and also require access roads through the forested area.	2	Long term operation of the flow through cells will require implementing a relatively long-lived treatment media and dealing with sedimentation.	3	Remedy is expected to take 2 years to implement.	2	Percentage loading reductions not estimated where reductions could not be estimated.	
	Flow Through Cells - CFR Seeps A, B, C & D – Long-Term	Remedy expected to reduce approximately 27% of total Table 3+ PFAS loading to the Cape Fear River.	1	Installing the flow through cells and French drains would require installing infrastructure in the seep streams and also require access roads through the forested area.	2	GAC is a potential material that has been proven to sorb PFAS. Flow through cells will have to manage GAC contact time, sedimentation issues and extreme weather events.	2	Remedy is expected to take 2 years to implement.	2	The estimated price per percentage loading reduction was $450,000.	1
Seeps	Flow Through Cells - WC Seeps – Long-Term	Remedy expected to reduce approximately 0.1% of total Table 3+ PFAS loading to the Cape Fear River.	5	Installing the flow through cells and French drains would require installing infrastructure in the seep streams and also require access roads through the forested area.	2	GAC is a potential material that has been proven to sorb PFAS. Flow through cells will have to manage GAC contact time, sedimentation issues and extreme weather events.	2	Remedy is expected to take 2 years to implement.	2	The estimated price per percentage loading reduction was $1,500,000.	5

Remedy Scoring Table Summary
Chemours Fayetteville Works

Pathway	Remedial Alternative	Reductions to the Cape Fear River Rank		Adverse Environmental Effects		Technology Feasibility		Time		Cost per Loading Removal	
	Ex Situ Capture and Treatment - CFR Seeps A, B, C & D – Interim	Remedy reduction scores were not assigned for interim remedies since interim remedies performance is not expected to be as certain as fully designed and piloted long-term remedies.	NA	Installing the flow through cells and French drains would require installing infrastructure in the seep streams and also require access roads through the forested area.	2	French drains will have to manage sedimentation issues and extreme weather events.	2	Remedy is expected to take 3 years to implement.	3	Percentage loading reductions not estimated where reductions could not be estimated.	
	Ex Situ Capture and Treatment - CFR Seeps A, B, C & D – Long-Term	Remedy expected to reduce approximately 27% of total Table 3+ PFAS loading to the Cape Fear River.	1	Installing the flow through cells and French drains would require installing infrastructure in the seep streams and also require access roads through the forested area.	1	French drains will have to manage sedimentation issues and extreme weather events.	2	Remedy is expected to take 3 years to implement.	3	The estimated price per percentage loading reduction was $940,000.	1
	Plume Stop - CFR Seeps A and B – Interim	Remedy reduction scores were not assigned for interim remedies since interim remedies performance is not expected to be as certain as fully designed and piloted long-term remedies.	NA	PlumeStop would require the drilling of wells and then injecting PlumeStop into wells, a relatively minor disturbance.	1	Considerable volumes of PlumeStop material are required and PlumeStop is potentially challenged as a long-lasting remedy to maintain sequestration of PFAS.	4	Remedy is expected to take 1 year to implement.	1	Percentage loading reductions not estimated where reductions could not be estimated.	
	Plume Stop - WC Seeps – Long-Term	Remedy expected to reduce approximately 0.1% of total Table 3+ PFAS loading to the Cape Fear River.	5	PlumeStop would require the drilling of wells and then injecting PlumeStop into wells, a relatively minor disturbance.	1	Considerable volumes of PlumeStop material are required and PlumeStop is potentially challenged as a long-lasting remedy to maintain sequestration of PFAS.	3	Remedy is expected to take 1 year to implement.	1	The estimated price per percentage loading reduction was $39,100,000.	5
Onsite Groundwater	Extract from Black Creek Monitoring Wells - Interim	Remedy reduction scores were not assigned for interim remedies since interim remedies performance is not expected to be as certain as fully designed and piloted long-term remedies.	NA	Wells exist and are in the plant area of the Site.	1	The wells can be connected with piping across the active manufacturing facility and pumped to the Old Outfall 002 treatment system.	2	Remedy is expected to take 1 year to implement.	1	Percentage loading reductions not estimated where reductions could not be estimated.	
	Install New Black Creek Extraction Wells - Interim	Remedy reduction scores were not assigned for interim remedies since interim remedies performance is not expected to be as certain as fully designed and piloted long-term remedies.	NA	Wells would be installed in the plant area of the Site.	1	The wells can be connected with piping across the active manufacturing facility and pumped to the Old Outfall 002 treatment system.	2	Remedy is expected to take 2 years to implement.	2	Percentage loading reductions not estimated where reductions could not be estimated.	
	Groundwater Extraction	Remedy expected to reduce approximately 23% of total Table	1	Wells would be installed with ideally minimal disturbance in the forested area adjacent	1	A large number of wells would need to be installed over a long length of river.	3	Remedy is expected to take 5 years to implement.	4	Remedy costs were not available at the time of the	

Remedy Scoring Table Summary
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Pathway	Remedial Alternative	Reductions to the Cape Fear River Rank		Adverse Environmental Effects		Technology Feasibility		Time		Cost per Loading Removal	
		3+ PFAS loading to the Cape Fear River.		to the river along the existing access path.						Supplemental Information Report preparation.	
	Groundwater Extraction with Barrier Wall	Remedy expected to reduce approximately 23% of total Table 3+ PFAS loading to the Cape Fear River.	1	The barrier wall would require removing acres of forested cover.	1	A large number of wells would need to be installed over a long length of river along with a barrier wall.	3	Remedy is expected to take 5 years to implement.	4	Remedy costs were not available at the time of the Supplemental Information Report preparation.	
Outfall 002	Conveyance Network Sediment Removal	Reductions to the Cape Fear River could not be quantified with the data available in the Supplemental Information Report and the Reductions Plan.	NQ	Sediment were removed from existing channels at Site.	1	Areas were easily accessible using common construction equipment.	1	Remedy is expected to take 1 year to implement.	1	Percentage loading reductions not estimated where reductions could not be estimated.	
	Stormwater Pollution Prevention Plan (SWPPP)	Reductions to the Cape Fear River could not be quantified with the data available in the Supplemental Information Report and the Reductions Plan.	NQ	The plan will be prepared in office environments and implemented in the active plant areas at Site.	1	Plan is prepared in the office and likely implementable with common construction equipment and practices; final assessment will depend on results of SWPPP	1	Remedy is expected to take 2 years to implement.	2	Percentage loading reductions not estimated where reductions could not be estimated.	
	Targeted Stormwater Control	Remedy expected to reduce approximately 1.7% of total Table 3+ PFAS loading to the Cape Fear River.	5	Targeted stormwater will be implemented in active plant areas at the Site.	1	Targeted stormwater control may require infrastructure to be built in the active plant area.	2	Remedy is expected to take 4 years to implement.	4	Remedy costs were not available at the time of the Supplemental Information Report preparation.	
	Terracotta Pipe Decommissioning	Remedy expected to reduce approximately 0.1% of total Table 3+ PFAS loading to the Cape Fear River.	5	Terracotta pipe decommissioning will be implemented in active plant area at the Site.	1	Terracotta pipe decommissioning will require construction in the plant area to active water transmission lines.	2	Remedy is expected to take 2 years to implement.	2	Remedy costs were not available at the time of the Supplemental Information Report preparation.	
	Groundwater Intrusion Mitigation	Remedy expected to reduce approximately 0.7% of total Table 3+ PFAS loading to the Cape Fear River.	5	Potentially required groundwater intrusion mitigation actions will be implemented in the active plant area at Site.	1	Groundwater intrusion mitigation may require construction in the plant area to active water release and transmission lines.	2	Remedy is expected to take 3 years to implement.	3	The estimated price per percentage loading reduction was $100,000.	1
	Treat site-wide stormwater at Outfall 002	Remedy expected to reduce approximately 2.2% of total Table 3+ PFAS loading to the Cape Fear River.	4	Site-wide stormwater treatment would be implemented in the active plant areas at Site.	1	Site-wide stormwater treatment would require considerable infrastructure construction, treatment plant construction and modification to the actively used conveyance network at Site.	4	Remedy is expected to take 5 years to implement.	4	The estimated price per percentage loading reduction was $4,500,000.	5
	Treat site-wide flows at Outfall 002	Remedy expected to reduce approximately 4.4% of total Table 3+ PFAS loading to the Cape Fear River.	4	Site-wide Outfall 002 flows treatment would be implemented in the active plant areas at Site.	1	Treating all site-wide flows at Outfall 002 would require building a large treatment plant adjacent to the Outfall capable of handling the large volumes of flow.	2	Remedy is expected to take 5 years to implement.	4	The estimated price per percentage loading reduction was $3,900,000.	5

Remedy Scoring Table Summary
Chemours Fayetteville Works

Pathway	Remedial Alternative	Reductions to the Cape Fear River Rank		Adverse Environmental Effects		Technology Feasibility		Time		Cost per Loading Removal	
Willis and Georgia Branch Creeks	Treating all Flows at Willis Creek Mouth	Remedy expected to reduce approximately 7% of total Table 3+ PFAS loading to the Cape Fear River.	3	Requires damming up Willis Creek and capturing these flows, significant alternation to the local habitat.	3	The dam and water capture system would be subject to extreme weather events; the treatment system would be large and potentially complicated to place at the mouth were topography is quite steeply sloped.	3	Remedy is expected to take 5 years to implement.	4	The estimated price per percentage loading reduction was $1,200,000.	5
	Treating all Flows at Georgia Branch Creek Mouth	Remedy expected to reduce approximately 3% of total Table 3+ PFAS loading to the Cape Fear River.	4	Requires damming up Georgia Branch Creek and capturing these flows, significant alternation to the local habitat.	3	The dam and water capture system would be subject to extreme weather events; the treatment system would be large and potentially complicated to place at the mouth were topography is quite steeply sloped.	3	Remedy is expected to take 5 years to implement.	4	The estimated price per percentage loading reduction was $2,400,000.	5
	PlumeStop™ along full Willis Creek Length	Remedy expected to reduce approximately 6% of total Table 3+ PFAS loading to the Cape Fear River.	3	Requires many wells to be installed adjacent to the creek causing periodic disruption for miles along the creek's length.	2	Numerous access agreements would need to be arranged, certain areas would require the construction of access roads, the application of PlumeStop may be heterogeneous in areas, and the PlumeStop remedy would have to be re-applied periodically as PlumeStop will not permanently degrade, sorb or remove the Table 3+ PFAS reaching the Creek.	5	Remedy is expected to take 9 years to implement.	5	The estimated price per percentage loading reduction was $24,000,000.	5
	PlumeStop™ along full Georgia Branch Creek Length	Remedy expected to reduce approximately 3% of total Table 3+ PFAS loading to the Cape Fear River.	4	Requires many wells to be installed adjacent to the creek causing periodic disruption for miles along the creek's length.	2	Numerous access agreements would need to be arranged, certain areas would require the construction of access roads, the application of PlumeStop may be heterogeneous in areas, and the PlumeStop remedy would have to be re-applied periodically as PlumeStop will not permanently degrade, sorb or remove the Table 3+ PFAS reaching the Creek.	5	Remedy is expected to take 9 years to implement.	5	The estimated price per percentage loading reduction was $31,000,000.	5

Remedy Scoring Table Summary
Chemours Fayetteville Works

Pathway	Remedial Alternative	Reductions to the Cape Fear River Rank		Adverse Environmental Effects		Technology Feasibility		Time		Cost per Loading Removal	
Offsite Groundwater	Offsite Groundwater Extraction with Barrier Wall	Remedy expected to reduce approximately 11.5% of total Table 3+ PFAS loading to the Cape Fear River.	2	Requires significant disruption to miles of shoreline on both sides of the Cape Fear River to install the barrier wall and groundwater wells. Continual operation of the extraction system may also continually interfere with local wildlife habitats.	4	The length of the barrier is extreme in length and will potentially be considerably challenging in areas. Also, there are many private lands where access would need to be negotiated to create a continuous barrier. Last the amount of pipe and the size of the needed treatment system is significant	5	Remedy is expected to take 10 years to implement.	5	The estimated price per percentage loading reduction was $19,000,000.	5

Notes: See Tables in introduction for information on the rankings.