NORTH CAROLINA PER- AND POLYFLUOROALKYL SUBSTANCES TESTING (PFAST) NETWORK

Quarterly Progress Report (#7) submitted to the North Carolina General Assembly Environmental Review Commission, the NC Department of Environmental Quality, the NC Department of Health and Human Services, and the Environmental Protection Agency (Region 4)

April 1, 2020

1.0 INTRODUCTION

The North Carolina General Assembly (NCGA), in the passing of Session Law (SL) 2018-5, Sections 13.1.(g), directed the North Carolina Policy Collaboratory (Collaboratory) to *"identify faculty expertise, technology, and instrumentation, including mass spectrometers, located within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T University, Duke University, and other public and private institutions, and coordinate these faculty and resources to conduct nontargeted analysis for PFAS, including GenX, at all public water supply surface water intakes and one public water supply well selected by each municipal water system that operates groundwater wells for public drinking water supplies as identified by the Department of Environmental Quality, to establish a water quality baseline for all sampling sites. The Collaboratory, in consultation with the participating institutions of higher education, shall establish a protocol for the baseline testing required by this subsection, as well as a protocol for periodic retesting of the municipal intakes and additional public water supply wells."* The term 'PFAS', listed above, refers to Per- and Polyfluoroalkyl Substances and the study is referred to herein as the NC PFAS Testing Network or PFAST Network.

The PFAST Network was funded by an appropriation from the NCGA. Section 13.1.(i) of SL 2018-5 states, *"Five million thirteen thousand dollars ($5,013,000) of the funds appropriated in this act for the 2018-2019 fiscal year to the Board of Governors of The University of North Carolina shall be allocated to the Collaboratory to manage and implement the requirements of this section, which shall include distribution to the Collaboratory and participating institutions of higher education (i) to cover costs incurred as a result of activities conducted pursuant to this section, (ii) for acquisition or modification of essential scientific instruments, or (iii) for payments of costs for sample collection and analysis, training or hiring of research staff and other personnel, method development activities, and data management, including dissemination of relevant data to stakeholders. No overhead shall be taken from these funds from the participating institutions that receive any portion of these funds. Funds appropriated by this section shall not revert but shall remain available for nonrecurring expenses."*

In addition to the water sampling identified above, additional study parameters are mandated in Section 13.1.(l), which states, *"The Collaboratory shall identify faculty expertise within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and use technology and instrumentation existing throughout the institutions to conduct the following research (i) develop quantitative models to predict which private wells are most at risk of contamination from the discharge of PFAS, including GenX; (ii) test the performance of relevant technologies in removing such compounds; and (iii) study the air emissions and atmospheric deposition of PFAS, including GenX. In addition, Collaboratory may, using relevant faculty expertise, technology, and instrumentation existing throughout institutions identified, evaluate other research opportunities and conduct such research for improved water quality sampling and analyses techniques, data interpretation, and potential mitigation measures that may be necessary, with respect to the discharge of PFAS, including GenX."*

Research activities to carry out these legislative mandates and progress made to date are summarized in this this document which represents the seventh [quarterly] report. For reference, all provisions passed by the NCGA in Section 13 of Session Law 2018-5 [related to this project] are included in Appendix I of this report.

2.0 REPORTING REQUIREMENTS

Section 13.1.(h) of SL 2018-5 states, *"Beginning October 1, 2018, the Collaboratory shall report no less than quarterly to the Environmental Review Commission, the Department of Environmental Quality, and the Department of Health and Human Services on all activities conducted pursuant to this section, including any findings and recommendations for any steps the Department of Environmental Quality, the Department of Health and Human Services, the General Assembly, or any other unit of government should take in order to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality in the State."* In addition, Section 13.1(g) states*, "No later than December 1, 2019, Collaboratory shall report the results of such sampling by identifying chemical families detected at each intake to the Environmental Review Commission, the Department of Environmental Quality, the Department of Health and Human Services, and the United States Environmental Protection Agency.*

The April 1, 2019 Quarterly Report noted submission of a letter by PFAST Network scientists to the NC Policy Collaboratory on March 13, 2019 (Appendix II of the April report) requesting a 1-year extension of the study. The reasoning for the request was twofold: 1) to ensure sufficient time for comprehensive analysis and interpretation of non-targeted data and 2) to enable additional sampling of drinking water supply intakes during different seasons. The Collaboratory transmitted this request to the NC General Assembly on March 25, 2019. An approved extension for the study was included in the compromise budget (H966) passed by the NCGA and sent to the Governor on June 27, 2019, which he subsequently vetoed on June 28th.

Since the future of bill H966 remained unclear, the NCGA included an extension for the PFAST Network study in another bill (S433) which Governor Cooper did sign. Session Law 2019-241 was adopted on November 6, 2019, and Section 7.(d) includes revision of the original language from Section 13.1(g) of S.L. 2018-5, now extending the deadline for submission of the final PFAST Network report from the Collaboratory to October 15, 2020. The legislative language in Section 7 of SL 2019-241 is provided for reference in Appendix II.

This report fulfills the initial NCGA requirement for the submission of quarterly progress reports and summarizes the work carried out since the January 1, 2020 report. One additional quarterly progress report will be submitted July 1, 2020, and per Section 7.(d) of SL 2019-241, a final report summarizing findings and recommendations will be submitted by the Collaboratory to the Environmental Review Commission, the Department of Environmental Quality, the Department of Health and Human Services, and the United States Environmental Protection Agency (Region 4) no later than October 15, 2020.

3.0 QUARTERLY PROGRESS UPDATE

NC PFAST Network researchers are in the final stages of their projects, completing their assessments of baseline levels of targeted PFAS throughout North Carolina in all public drinking water supplies, some private wells, wastewater (influent and effluent), landfill leachates, rainwater and ambient air (gas and particles). Network scientists have also been conducting experiments to investigate: the presence and impacts of PFAS in ecologically relevant animal species such as alligators and different species of fish; effects of soil composition on uptake and distribution of PFAS in crop plants; and effects of PFAS exposure on the immune response, pregnancy, and development.

Due to the implementation of COVID-19 safety measures such as the stay-at-home order now in effect throughout North Carolina, our public (and private) universities have restricted on-campus access to individuals designated as mandatory employees supporting critical and essential functions only (https://www.unc.edu/coronavirus/). All classes have transitioned to remote learning platforms, and all academic labs including those associated with PFAS testing have been shut down to protect the safety of faculty, staff, and students during the pandemic. As a result, all sampling and analyses are suspended until we receive further notice from University leadership indicating it is safe and permissible to resume normal, in-person activities. When feasible, our dedicated Network members are working from home processing data and reviewing results, preparing manuscripts and new grant applications, and holding meetings remotely. Summaries of the progress made by our teams during this past quarter from January 1, through March 31, 2020 are provided below, and copies of prior reports can be accessed in the "Resources" section of the NC PFAST Network website: https://ncpfastnetwork.com/resources/.

Overall Program Activities

- Since its launch in April 2019, the PFAST Network website (https://ncpfastnetwork.com) has seen a steady increase in users, averaging over 200 visits per month. This website created and maintained by the Network's Communications Team is an important source of information providing background on the study objectives and research teams, details on events and public presentations, as well as other resources such as Frequently Asked Questions. Study results will be made available by the Data Science and Management Team via links on this website. Questions about the Network's PFAS testing or related research can be sent to the general e-mail at NCPFASTNetwork@unc.edu, and the Program Management Team will either respond directly or forward specific requests for information to the appropriate team leaders.
- PFAST Network members participated in national conferences, local workshops, and public meetings to raise awareness of the NC PFAST Network study and to share goals of the various research projects, workflow strategies, and updates with legislative and regulatory committees and community stakeholders. In 2020 the Program Management Team initiated monthly meetings to solicit feedback from a Stakeholder Advisory Committee. This group is comprised of community partners who are actively involved in increasing the collective understanding of PFAS exposures and impacts in North Carolina and who advocate for solutions to protect our environment and health. In mid-February, the Program Management Team also arranged another information exchange session with staff from the NC Department of Health and Human Services and the NC Department of

Environmental Quality. Similar in format to the June 2019 meeting held at NC State University, each organization shared progress updates and preliminary results and discussed next steps. A summary of presentations, manuscripts, and new grants from the past quarter can be found in Appendix III of this report.

PFAS Water Sampling and Analysis

- The Water Sampling and Analysis Team led by Dr. Detlef Knappe (NC State University) and Dr. Lee Ferguson (Duke University) completed targeted PFAS analysis of untreated (raw), public water samples collected in the Round 1 sampling campaign from 190 surface water intakes, 158 municipal groundwater wells, and 57 county or regional water supplies. They were in the midst of Round 2 sampling when the hiatus began in March. In the meantime, they have been working with the Network's Data Science and Management Team to finalize the data uploading process and to evaluate visualization tools for public access to the validated results.
- Reports of targeted PFAS levels in the first round water samples have been e-mailed to over 250 water systems and to representatives from NC DEQ, NC DHHS, and local legislators in accordance with the PFAST Network notification policy. While the project team continued to collect and analyze new samples and perform quality control and assurance (QA/QC) reviews of the existing data, the Program Management Team helped e-mail reports to the water systems and stakeholders. All remaining reports from Round 1 are expected to be distributed to water systems by mid-April, however delays are possible given the current circumstances. To date, ten water systems have been notified of PFAS levels in untreated water exceeding 70 nanogram per liter (ng/L) or parts-per-trillion (ppt) for the sum of PFOA + PFOS (the US EPA Health Advisory Level) or that one or more individual PFAS were observed above 70 ppt.
- Duke University finished method development experiments for the automated solid phase extraction HRMS method (online extraction and high resolution mass spectrometry for nontargeted analysis) and tested the method performance using NIST Standard Reference Materials (SRM) and a selection of ground and surface water samples. They also developed and tested a protocol for field sample preparation. A suspect screening database was compiled from publicly available PFAS data sources, and PFAS compounds were subjected to *in silico* (computer-simulated) reactions such as hydrolysis and biotransformation to generate structures of PFAS transformation products that may be present in environmental media. A spectral library was created from experimental PFAS fragmentation spectra and evaluated using representative samples. For those suspect PFAS and potential reaction products without existing library spectra, computational mass spectrometry tools like CFM-ID (Competitive Fragmentation Modeling-ID) were used to predict spectra from chemical structures. Data from HRMS analysis of raw water samples will be compared with the spectral library for PFAS compound identification.
- Dr. Mei Sun's lab at UNC Charlotte continued total fluorine assessment of water samples via Adsorbable Organic Fluorine (AOF) measurements. The AOF method has been applied to over 180 water samples collected in Round 1. Additional samples will be analyzed when laboratory operations resume. The team is comparing the total organic fluorine values to

the summed concentration of PFAS from mass spectrometry analyses to estimate the percentage of fluorinated substances accounted for (mass balance) by targeted analysis. Access to new analytical standards as well as results from nontargeted and suspect screening should improve the mass balance and will contribute to a more comprehensive understanding of PFAS exposures from North Carolina's public drinking water sources.

Private Well Risk Modeling

- The overall goal of this team led by Dr. David Genereux (NC State University) and Dr. Jackie MacDonald Gibson (formerly UNC Chapel Hill, now Indiana University) is to uncover factors influencing the risk of GenX and other PFAS contamination in water supply wells near the Chemours plant by collecting and interpreting new data on the fate and transport of PFAS contaminants in the groundwater system near Chemours and by building and validating machine-learned Bayesian Network (BN) computer models for predicting risk of private well contamination by PFAS.
- To quantify the variation of PFAS storage over time and the PFAS output from local watersheds, the team has been taking monthly measurements of stream export of PFAS in several tributaries of the Cape Fear River. Water samples were collected for PFAS analysis in the Knappe mass spectrometry lab at NC State University from 6 streams (Georgia Branch , Willis Creek, Old Outfall, and 3 unnamed tributaries east of the Cape Fear River), and salt tracer releases were carried out in order to quantify volumetric stream discharge. Results have been returned for a subset of the samples, and analyses are on-hold until the laboratories reopen.
- New stream water samples were collected from two locations in Georgia Branch (one upstream and one downstream) for age dating by multiple techniques (sulfur hexafluoride, noble gases, and tritium) in the Noble Gas Lab at the University of Utah (Kip Solomon). The goals of this work were to test hypotheses to explain the presence of a large number (21 of 24) of young groundwaters sampled in February 2019 and to help clarify the true age of groundwater samples and the relationship between groundwater age and PFAS. The team also consulted with Troy Gilmore at University of Nebraska regarding future sampling design and next steps to assess the validity of their new hypothesis (matrix diffusion) to explain the large percentage of apparently young groundwater. Following the discussion, they carried out streambed mapping in Georgia Branch at 11 locations (including sites where they had groundwater age data from 2019) to identify the main differences in physico-chemical parameters (temperature, electrical conductivity and pH) and major ions between stream water and groundwater beneath the streambed in Georgia Branch. They also collected 20 groundwater samples and 2 stream water samples for major ions analysis in the Environmental Analysis Lab (NC State University Department of Biological and Agricultural Engineering).
- A letter was sent to a home owner near Georgia Branch to ask if they would consider hosting a piezometer nest on their property. This equipment would be used to measure the liquid pressure or level of groundwater at a specific point. In addition, Drs. Genereux and Petre also obtained permission from Chemours to measure water levels in two offsite wells during future samplings. Access to the Bladen 1S and Bladen 1D wells was facilitated by Beau Hodge of Geosyntec. These wells are the closest to Georgia Branch, and water

level data there could help in determining the thickness of the saturated zone over time.

- The team has interacted with Michael Pjetraj, Assistant Director of the Division of Air Quality (DAQ) at NC Department of Environmental Quality (DEQ), to better understand the available estimates of PFAS emissions to air by DuPont/Chemours. Also, in response to the release of Chemours' Corrective Action Plan at the end of 2019, Dr. Genereux sent a letter to DEQ with three recommendations regarding monitoring and treatment of contaminated groundwater and a potential alternate water supply source for affected residents.
- Drs. MacDonald Gibson and Roostaei received a new dataset from DEQ containing results from 1055 houses and 3204 measurements of PFAS-related chemicals. Data from these additional locations were used to verify the model that had been developed using previous data from 805 wells and to generate a new, more comprehensive Bayesian Network model for the consolidated data sets (1207 unique wells). The team finalized their predictive model, and is preparing to release the online version for public use. Homeowners will just need to enter the well depth information while the other inputs are provided to them.

PFAS Removal Performance Testing

- The overall goals of this team led by Dr. Orlando Coronell (UNC Chapel Hill) and Dr. Mei Sun (UNC Charlotte) are to identify optimum technologies for removing both legacy and emerging PFAS from contaminated surface and ground waters in NC as well as from finished drinking water and treatment waste streams. This research involves multiple collaborating laboratories (Coronell, Sun, Knappe, Stapleton, Leibfarth) each focused on a particular technology.
- Dr. Knappe's lab conducted Rapid Small-Scale Column Tests (RSSCTs) using granular activated carbon (GAC) and water collected from the Sweeney Water Treatment Plant operated by the Cape Fear Public Utilities Authority (CFPUA) in Wilmington, NC. They compared the total organic carbon (TOC) concentrations from their RSSCTs and the pilot columns from CFPUA. Data from the RSSCTs are now being evaluated (using adsorption models) for development of scale-up approaches to confidently predict full-scale GAC performance from bench-scale RSSCT data.
- Dr. Coronell's lab examined resin recovery for the 5 best performing Ion Exchange (IX) resins under practical conditions, including 10% brine and 5-20% methanol. Three IX resins, A592E (Purolite), DOWEX1-TAN1 (DOW), and IRA910 (DuPont) showed significantly better regeneration when the brine concentration was increased from 0.5 to 10%. These three resins were selected for additional testing to conduct isotherm experiments and to evaluate effects of water matrix, pH, competing anions, and the concentration of natural organic matter.
- PFAS rejection experiments by commercially-available and modified membranes were performed in PFAS-spiked waters (e.g., groundwater, surface water, and laboratory-grade water) at different pH values, with and without background conductivity. Feed and permeate samples are awaiting analysis for PFAS concentrations to assess PFAS rejection by the membranes. The team is characterizing membrane properties (e.g., size, charge, water contact angles, and surface functional groups) to understand the property-performance relationships and the factors that govern rejection/permeation of PFAS in

commercially-available high-pressure membranes.

- Dr. Stapleton's lab has completed their assessment of residential filtration options for PFAS removal from finished drinking water and published their results in Environmental Science and Technology Letters in a paper titled "Assessing the Effectiveness of Point-of-Use Residential Drinking Water Filters for Perfluoroalkyl Substances (PFASs)". The complete citation is included in Appendix III.
- Dr. Sun's lab continued their evaluation of electrochemical degradation for PFAS removal from waste streams. They determined that the loss of PFOA over time to reactor walls (HDPE bottle), stir bar, and salting out effect were within acceptable limits. They made additional modifications to the airtight electrochemical reactor, moving the electrodes completely inside the reactor and replacing the narrow PEEK tubing that connects the reactor to the absorption solution by a larger diameter silicone tubing. These modifications reduced PFOA losses during control experiments (no current applied) from around 12% (Airtight Reactor-I) to less than 2% (Airtight Reactor-II). Likewise, reduction of PFOA was greater with reactor-II, and the standard deviation for multiple measurements was improved (from 20% to 1.3%) compared to reactor-I. Next steps include evaluating GenX degradation using the Boron Doped Diamond electrode at different electric current densities.
- A new library of Ionic Fluorogels was synthesized in Dr. Leibfarth's lab to include trifluoroethyl methacrylate in varying weight percentages, and the resulting materials were characterized via Swelling Ratio, Modulus, and Batch Equilibrium PFAS Adsorption tests. Trends in PFAS adsorption are still being elucidated. Their paper "Ionic Fluorogels for Remediation of Per- and Polyfluorinated Alkyl Substances" was recently published online in ACS Central Science (see Appendix III). They are now performing a thorough study of crosslinking density in relation to PFAS sorption and testing the chemical stability of the Ionic Fluorogels under environmentally relevant conditions. Furthermore, they obtained new fluorinated polymers that are more economically viable and chemically stable to act as the continuous phase for Ionic Fluorogel technology. They plan to screen chemical methods for modifying these materials into resins for water purification.

Air Emissions and Atmospheric Deposition

- The overall goal of this team led by Dr. Barbara Turpin at UNC Chapel Hill and Dr. Ralph Mead at UNC Wilmington is to enhance our understanding of the airborne composition, distribution and concentrations of PFAS. There is limited data available regarding the atmospheric gas-particle partitioning, reactions, and deposition of legacy and emergent PFAS, and it has been recognized that airborne PFAS have been found far from point sources due to limited environmental degradation (persistence) and ubiquitous release from consumer products and waste streams.
- The team successfully completed a one-year field campaign at five sites (Fayetteville, Charlotte, Research Triangle Park, Wilmington and Greenville). All the collected samples were shipped back to the lab at UNC-Chapel Hill for analysis of PFAS levels in particles (PM2.5) and gases. Quartz fiber filter samples collected at each site were composited quarterly and sample extracts were analyzed by mass spectrometry to estimate the quarterly average PFAS in the particle phase. Following targeted analysis, 7 (out of 34

targeted PFAS) were detected in the quarterly samples with concentrations mostly below 1 picogram per cubic meter (1pg/m3). Across the 5 sites, PFOA and PFOS dominated the PM2.5 and had the highest detection frequency. Higher concentrations were observed in warmer months at Charlotte for PFOA and Wilmington for PFOS.

- The Turpin lab completed an intensive 6-month field campaign using high volume (HiVol) air sampling conducted weekly from September 2019 to March 2020 at two locations close to the Chemours facility and in line with the main wind directions (SSW and NNE). Real-time monitoring of PM2.5 and meteorological data were collected along with HiVol filters (particle phase) and PUFs (gas phase). Samples will be processed and analyzed when the labs resume operation.
- Two different sources of ionization (nitrate and iodide) were compared for analysis of volatile PFAS by Chemical Ionization Mass Spectrometry (CIMS). Different concentrations of PFAS mixtures were directly injected into nitrate-source and iodide-source CIMS and data are being evaluated to estimate detection limits. Qualitative analysis showed that both nitrate-source and iodide-source CIMS are capable of detecting volatile PFAS such as fluorotelomer alcohols (FTOHs) and HFPO, however only iodide CIMS enabled detection of fluorinated vinyl ethers.
- The Mead lab completed one year of intensive sampling to determine the concentration of PFAS in rainwater at the Wilmington site. They collected an additional 18 samples this past quarter. Air-mass back trajectory analysis indicates that of the 18 rain events there were 13 mixed, 2 marine, and 3 terrestrial events. Nine dry deposition samples were also collected, extracted and analyzed for PFAS.
- The team continued collection of wet and dry deposition samples at other selected locations on a less frequent basis (e.g., ECU, UNCCH, UNCC, WCU, Bald Head Island). Analyses are temporarily suspended because UNCW has closed down the academic research labs with no clear reopening date at this time. As the team acquires more data, they will be able to assess the contribution of wet/dry areal deposition of GenX and other PFAS to surface waters including the Cape Fear River drainage basin.

Other Applied Research Opportunities:

Novel PFAS Inputs into the environment: landfill leachates and wastewater treatment:

- The Barlaz lab at NC State University has sampled leachate from 15 landfills twice. Samples have been extracted and samples from ten landfills have been analyzed once. Based on analysis of the first 10 samples, they discovered some contamination with respect to one of the compounds being measuring. As a result, they stopped extracting other samples (e.g. wastewater influent and effluent) to track the source of contamination. The team has identified the source of the contamination and were prepared to start extractions again before the end of March.
- A total of 31 wastewater treatment plants have been sampled twice. All the samples collected during the first sampling event have been extracted and 10 analyzed. However, due to the contamination described above, extractions were stopped for troubleshooting. The remaining samples were to be extracted by the end of March, however the schedule has been affected by lab closures.

- To date, 4 C&D landfills have been sampled and the team hopes to sample one more. Similar to the wastewater and landfill leachate samples, all the samples collected from C&D landfills will be extracted and analyzed when lab operations resume. They have already identified the total area for C&D landfills in NC and are working to estimate the total leachate flow.
- During a presentation at the February 2020 Global Waste Management Symposium in California, Dr. Barlaz explained how landfills will be important inputs to Publicly Owned Treatment Works (POTWs) in cases where there is a large landfill in a rural area. The message was received and understood by the audience which included representatives from over 700 landfills.

PFAS bioaccumulation in aquatic environments: alligator and fish studies:

- The Belcher lab at NC State University has begun analysis of the 2019 striped bass serum and tissues from across NC including the Cape Fear, Pamlico and Roanoke rivers to compare exposures. Results of the 2018 sample analysis have now been published in Environment International (see Appendix III). The 2019 Striped bass samples from the Pamlico and Roanoke Rivers have been prepared and are awaiting analysis.
- Samples have been collected from ~90 alligators in NC. Analysis of serum PFAS concentrations and biomarker analysis is now complete for all 2019 samples. The team analyzed numerous biomarkers and also characterized white blood cells. They established that there are important changes in immune function between alligators from a reference site with low levels of PFAS exposure (Lake Waccamaw) and those from the Cape Fear water shed. Significantly, the findings demonstrate that an increase in autoimmune-like phenotypes are found only in animals with comparatively higher PFAS concentrations. This is the first documented evidence of autoimmune-like phenotypes in a crocodilian. A manuscript for submission to the Journal Science that detailing these findings is near completion. Due to increasing seasonal temperatures, the team initiated their 2020 field season over a month earlier than expected. They made 2 sampling trips to the reference site at Lake Waccamaw and sampled from 9 alligators. These early season samples will likely yield important data about variation of PFAS seasonally, and repeated measures will be useful for estimating biological half-lives of some PFAS.
- The team has collected numerous tissue samples from 2 species of sun fish, 2 species of catfish, American shad, and striped bass from the lower and North East Cape Fear, the Deep and the Haw Rivers (upstream and downstream of known PFAS point sources). The analysis is ongoing and has greatly exceeded the sampling proposed in the original research plan. Methods were developed for sampling and analysis of PFAS for a variety of tissues from multiple fish species that are consumed by NC fishers. Preliminary analysis defining PFAS levels in muscle of 6 fish species from the Cape Fear River have been completed, however the comprehensive analysis is dependent on availability of instrumentation.
- In a closed meeting, October 29, 2019, Dr. Belcher presented their guideline sample collection methods and the preliminary analysis of PFAS levels in the Cape Fear River fish tissues to staff from the NC Departments of Environmental Quality and Department of Health and Human Services (Division of Public Health Occupational and Environmental

Epidemiology Branch (DPH OEEB). This data has now been expanded to include historical PFAS levels found in fish from the upper Cape Fear and a manuscript is being finalized that details the finding of these studies.

Health effects following exposure: mouse model of immunotoxicity:

- The DeWitt lab at East Carolina University completed dosing of animals with PFMOAA, PFMOPrA, PFMOBA, and Nafion BP2, four of the PFASs found in high concentrations in the Cape Fear River in 2016, and analysis of data for all four studies are ongoing. The team is preparing a manuscript describing results for PFMOAA, PFMOPrA, and PFMOBA.
- Two separate experiments with Nafion BP2 in mice have been completed, and the team is preparing a manuscript summarizing findings from both.
- The team planned repeat experiments of PFMOAA with higher administered doses, and a mixture of Nafion BP2 and PFMOAA, however plans to start these experiments are on hold until the threats of COVID-19 are diminished. The team would still like to complete a study with PFHxA.
- Dr. Woodlief was scheduled to present data from the studies with PFMOAA, PFMOPrA, and PFMOBA at the annual Society of Toxicology meetings (March 15-19, 2020), but that meeting was cancelled due to COVID-19. The data demonstrated that at the concentrations administered, these compounds did not produce robust increases in the weights of livers from mice exposed for 30 days.
- Dr. DeWitt was on a panel focused on community engagement at the annual American Association for the Advancement of Science meetings in February of 2020 (Seattle, WA) and talked about being a PFAST Network member. Mr. Michael Lee (former NC Senator) also was on the same panel and talked about his efforts to fund the PFAST Network. Dr. DeWitt is also involved in several PFAS-related publications (commentaries/reviews) that will acknowledge the PFAST Network. These are being prepared for submission.

PFAS bioaccumulation and distribution in crop plants: greenhouse studies:

- The Duckworth lab at NC State University has been conducting greenhouse experiments with compost-amended and PFAS-spiked soils and have determined concentrations of eight PFAS in soil, porewater, roots, and shoots of lettuce. The results clearly demonstrate a reduction in PFAS uptake with increasing organic matter content. They also completed a second greenhouse trial to look at uptake by other crops and started working on extraction methods for those samples. They submitted a proposal to the Canadian Light Source for imaging time by STXM (scanning X-ray transmission spectroscopy) to determine the distribution and molecular associations of PFAS in plant tissues found to contain high level PFAS.

Health effects following exposure: placental inflammation and immune cell signaling:

- The Fry lab at UNC Chapel Hill completed experiments to address the question: "do PFAS in drinking water pose a risk to pregnant women and could they affect the health and function of her placenta?" They measured levels of PFAS in drinking water, placenta, cord blood, and maternal serum samples from pregnant women in NC and conducted laboratory experiments using placental cells to investigate the effects of PFAS on placental

health and function. The team is finalizing their results which will provide information about the PFAS exposure profile for NC women during pregnancy and help determine whether their exposures are coming from drinking water.

- The team also completed laboratory experiments with placental cells exposed to different PFAS to identify changes in genes expression (production of functional proteins or RNA) related to cellular pathways involved in normal placental function.

Communications:

- In regards to engaging stakeholders, the Communications Team (Kathleen Gray, Megan Rodgers, Jane Hoppin, Katy May, Marisa Incremona, Ariana Eily, Jory Weintraub) has been involved in several events in the last quarter. They provided slides for the meeting with NC Department of Health and Human Services and Department of Environmental Quality on Feb. 17, 2020; presented a research poster about PFAS risk communication at the NIEHS Partners in Environmental Health (PEPH) Annual meeting in Durham, NC Feb. 12-13, 2020 (https://www.niehs.nih.gov/news/events/pastmtg/2020/peph_2020/index.cfm); and in response to a request from Representative Szoka, were working with Jeff Warren of the NC Policy Collaboratory to prepare for a meeting on March 26, 2020 at Gray's Creek High School in Hope Mills, NC highlighting NC PFAST Network results. Due to the recent pandemic, these plans have changed.
- Increasing awareness among lay publics has been an important aim of the Communications Team. They hosted a community meeting at Fayetteville State University on February 26, 2020, highlighting network research on food crops and ground water. The evening event was moderated by Jory Weintraub (Duke), and there were about 70 people in attendance, including several members of the media as well as elected officials. PFAST Network Director Jason Surratt (UNC-CH) presented an overview of the network. David Genereux (NC State) and Jackie MacDonald Gibson (Indiana University formerly UNC-CH) presented their research on how PFAS impact groundwater near the Chemours facility. Owen Duckworth's (NC State) graduate student Kate Holden presented findings related to how compost can influence PFAS uptake. Virginia Guidry, Head of the Occupational and Environmental Epidemiology Branch at NC Department of Health and Human Services, presented their recent community survey results. Greg Cope, Toxicology professor and NC State Extension Leader, and Mark Strynar, EPA chemist, joined the presenters for a panel discussion that took questions from the audience. Presentations and a compilation of questions and answers will be available on the PFAST website.
- Preparations and agenda for the Spring PFAS Network Symposium planned for May at the Museum of Natural Sciences in Raleigh have been halted because of the viral pandemic, but the team is still aiming to hold a symposium later in 2020.
- Kathleen Gray (Communications Team) and Lee Ferguson (Water Sampling and Analysis Team) collaboratively presented about PFAS and Risk Communication in the Duke Science Communication Lunch & Learn Series organized by Jory Weintraub and Ariana Eily. (https://scienceandsociety.duke.edu/engage/events/scicomm-lunch-and-learn/). The session was titled "Water, Water Everywhere." There were 100 people in attendance, one of the most highly attended Lunch & Learn events to date.

Data Science and Management

- The PFAST Network's Data Science and Management Team led by Dr. Helena Mitasova at NC State University and Chris Lenhardt at UNC Chapel Hill developed data submission guidelines and started receiving data from the research teams. They have been working on controlled vocabularies for PFAS classification and associated terms, as well as a visual style guide (including symbols, icons, and colors) to identify categories of data and locations, which will be integrated with the geospatial views.
- The team has also been working on data visualization tools with options to display aggregated metadata, visualize reported PFAS concentrations, and view additional basemaps. They presented an overview of cartography and visualization options in a recent meeting with members of the Water Sampling and Analysis Team, Program Management Team, and the Collaboratory and received positive feedback and suggestions.
- Also in consultation with the Water Sampling and Analysis Team, they matched the sampling points from Round 1 with DEQ records using GPS coordinates to reconcile any remaining ambiguities in specific sampling locations. This information was used to optimize the sampling plan and trip schedules for greater efficiency in Round 2 sampling.

APPENDIX I

LEGISLATIVE LANGUAGE PASSED BY THE NORTH CAROLINA GENERAL ASSEMBLY

(Session Law 2018-5, Section 13.1 (f) through (l), effective June 12, 2018)

FUNDING TO ADDRESS PER- AND POLY-FLUOROALKYL SUBSTANCES, INCLUDING GENX/USE OF EXPERTISE AND TECHNOLOGY AVAILABLE IN INSTITUTIONS OF HIGHER EDUCATION LOCATED WITHIN THE STATE

SECTION 13.1.(f) The General Assembly finds that (i) per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), are present in multiple watersheds in the State, and impair drinking water and (ii) these contaminants have been discovered largely through academic research not through systematic water quality monitoring programs operated by the Department of Environmental Quality or other State or federal agencies. The General Assembly finds that the profound, extensive, and nationally recognized faculty expertise, technology, and instrumentation existing within the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions of higher education located throughout the State should be maximally utilized to address the occurrence of PFAS, including GenX, in drinking waterresources.

SECTION 13.1.(g) The North Carolina Policy Collaboratory at the University of North Carolina at Chapel Hill (Collaboratory) shall identify faculty expertise, technology, and instrumentation, including mass spectrometers, located within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and coordinate these faculty and resources to conduct nontargeted analysis for PFAS, including GenX, at all public water supply surface water intakes and one public water supply well selected by each municipal water system that operates groundwater wells for public drinking water supplies as identified by the Department of Environmental Quality, to establish a water quality baseline for all sampling sites. The Collaboratory, in consultation with the participating institutions of higher education, shall establish a protocol for the baseline testing required by this subsection, as well as a protocol for periodic retesting of the municipal intakes and additional public water supply wells. No later than December 1, 2019, Collaboratory shall report the results of such sampling by identifying chemical families detected at each intake to the Environmental Review Commission, the Department of Environmental Quality, the Department of Health and Human Services, and the United States Environmental Protection Agency.

SECTION 13.1.(h) Beginning October 1, 2018, the Collaboratory shall report no less than quarterly to the Environmental Review Commission, the Department of Environmental Quality, and the Department of Health and Human Services on all activities conducted pursuant to this section, including any findings and recommendations for any steps the Department of Environmental Quality, the Department of Health and Human Services, the General Assembly, or any other unit of government should take in order to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality in the State.

SECTION 13.1.(i) Five million thirteen thousand dollars ($5,013,000) of the funds appropriated in this act for the 2018-2019 fiscal year to the Board of Governors of The University of North Carolina shall be allocated to the Collaboratory to manage and implement the requirements of this section, which shall include distribution to the Collaboratory and participating institutions of higher education (i) to cover costs incurred as a result of activities conducted pursuant to this section, (ii) for acquisition or modification of essential scientific instruments, or (iii) for payments of costs for sample collection and analysis, training or hiring of research staff and other personnel, method development activities, and data management, including dissemination of relevant data to stakeholders. No overhead shall be taken from these funds from the participating institutions that receive any portion of these funds. Funds appropriated by this section shall not revert but shall remain available for nonrecurring expenses.

SECTION 13.1.(j) The Collaboratory should pursue relevant public and private funding opportunities that may be available to address the impacts of PFAS, including GenX, on surface water and groundwater quality, as well as air quality, in order to leverage funds appropriated by this section, or any other funds provided to the Collaboratory, including the Challenge Grant authorized in Section 27.5 of S.L. 2016-94, as amended by Section 10.4(a) of S.L. 2017-57.

SECTION 13.1.(k) In the event that the United States Environmental Protection Agency no longer provides access to its analytical instrumentation at no cost to the State for water quality sampling analysis related to per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), or if the Department of Environmental Quality determines that such analysis is not being performed in a sufficiently timely manner, the Collaboratory shall coordinate such analysis in the most cost-effective manner using relevant faculty expertise, technology, and instrumentation, including mass spectrometers, existing throughout institutions of higher education located throughout the State, until such time as the Department of Environmental Quality is able to perform such analysis with instrumentation acquired pursuant to subsection (q) of this section. The Collaboratory, in consultation with the Department and relevant experts across institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, shall establish a protocol for delivery of such samples taken by the Department to the entity designated to perform analysis of the samples, chain of custody protocols, and other matters to ensure proper handling and processing of the samples, which protocols shall be subject to approval by the United States Environmental Protection Agency, if such approval is required pursuant to authority delegated from the United States Environmental Protection Agency to the Department to administer federal environmental law.

SECTION 13.1.(l) The Collaboratory shall identify faculty expertise within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and use technology and instrumentation existing throughout the institutions to conduct the following research (i) develop quantitative models to predict which private wells are most at risk of contamination from the discharge of PFAS, including GenX; (ii) test the performance of relevant technologies in removing such compounds; and (iii) study the air emissions and atmospheric deposition of PFAS, including GenX. In addition, Collaboratory may, using relevant faculty expertise, technology, and instrumentation existing throughout institutions identified, evaluate other research opportunities and conduct such research for improved water quality sampling and analyses techniques, data interpretation, and potential mitigation measures that may be necessary, with respect to the discharge of PFAS, including GenX.

APPENDIX II

LEGISLATIVE LANGUAGE PASSED BY THE NORTH CAROLINA GENERAL ASSEMBLY

(Session Law 2019-241, Section 7.(a) through 7.(d), effective Nov. 6, 2019)

GENERAL ASSEMBLY OF NORTH CAROLINA
SESSION 2019

SESSION LAW 2019-241
SENATE BILL 433

AN ACT TO MAKE VARIOUS CHANGES TO THE STATUTES GOVERNING THE DEPARTMENT OF NATURAL AND CULTURAL RESOURCES AND TO REMOVE CERTAIN LANDS FROM THE STATE NATURE AND HISTORIC PRESERVE, AS RECOMMENDED BY THE DEPARTMENT; TO AMEND CERTAIN REPORTS OF THE NORTH CAROLINA POLICY COLLABORATORY TO THE GENERAL ASSEMBLY; TO CLARIFY CERTAIN APPROPRIATIONS IN THE 2018 HURRICANE FLORENCE DISASTER RECOVERY ACT; TO CORRECT AN EFFECTIVE DATE; TO REPEAL AND REPLACE AN ACT PROVIDING FOR EMERGENCY OPERATING FUNDS FOR UTILITIES; TO ADJUST FOR INFLATION THE THRESHOLD FOR DEPARTMENT OF ADMINISTRATION APPROVAL OF STATE LEASES; AND TO CLARIFY AND AMEND THE SEPTIC TANK SITE SUITABILITY DETERMINATION PROCESS.

The General Assembly of North Carolina enacts:

COLLABORATORY/FIREFIGHTING FOAM

SECTION 7.(a) The North Carolina Policy Collaboratory at the University of North Carolina at Chapel Hill (Collaboratory) shall create an inventory of aqueous film-forming foam (AFFF) used or stored by fire departments in North Carolina operated, managed, or overseen by units of local government, including those located at or serving airports. This inventory shall include, at a minimum, the following:

(1) The name and address of each fire department that owns or otherwise has on the premises of a fire station a firefighting vehicle that carries AFFF or a storage tank or other vessel for AFFF.
(2) The volume, trade name, and CAS number of AFFF used by each department in 2018 for fighting fires or firefighter training.
(3) The number of firefighting vehicles carrying AFFF and the volume of AFFF carried by each vehicle.
(4) Each fire department's annual cost of acquiring AFFF and last known purchases of AFFF.

(5) The volume, trade name, and CAS number of AFFF stored by each fire department or unit of local government for firefighting use and the portion of these AFFFs that are no longer utilized and could be removed from inventory for disposal.

(6) Other data deemed relevant by the Collaboratory to establish a statewide inventory of AFFF used for fighting fires or firefighter training.

The Office of the State Fire Marshal of the Department of Insurance and all units of local government shall provide any assistance requested by the Collaboratory to acquire and compile the data required by this section.

SECTION 7.(b) The North Carolina Policy Collaboratory at the University of North Carolina at Chapel Hill (Collaboratory) shall develop a proposal for identifying and collecting AFFF that is expired or no longer needed or wanted by each fire department in North Carolina operated, managed, or overseen by units of local government, including those located at or serving airports. This proposal should include recommendations on which State agency or agencies could oversee such a collection effort and cost estimates on this collection, stockpiling, and disposal. The Department of Insurance Office of the State Fire Marshal, the Department of Environmental Quality, the Department of Health and Human Services, and the Department of Public Safety shall provide any assistance requested by the Collaboratory to acquire and compile the data required by this section.

SECTION 7.(c) The Collaboratory shall submit an interim report with the results of the studies required by subsections (a) and (b) of this section no later than April 1, 2020, and a final report no later than October 15, 2020, to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources and the Environmental Review Commission.

SECTION 7.(d) Section 13.1(g) of S.L. 2018-5 reads as rewritten:

"**SECTION 13.1.(g)** The North Carolina Policy Collaboratory at the University of North Carolina at Chapel Hill (Collaboratory) shall identify faculty expertise, technology, and instrumentation, including mass spectrometers, located within institutions of higher education in the State, including the Universities of North Carolina at Chapel Hill and Wilmington, North Carolina State University, North Carolina A&T State University, Duke University, and other public and private institutions, and coordinate these faculty and resources to conduct nontargeted analysis for PFAS, including GenX, at all public water supply surface water intakes and one public water supply well selected by each municipal water system that operates groundwater wells for public drinking water supplies as identified by the Department of Environmental Quality, to establish a water quality baseline for all sampling sites. The Collaboratory, in consultation with the participating institutions of higher education, shall establish a protocol for the baseline testing required by this subsection, as well as a protocol for periodic retesting of the municipal intakes and additional public water supply wells. No later than ~~December 1, 2019,~~ October 15, 2020, the Collaboratory shall report the results of such sampling by identifying chemical families detected at each intake to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources, the Environmental Review Commission, the Department of Environmental Quality, the Department of Health and Human Services, and the United States Environmental Protection Agency."

APPENDIX III

LIST OF MEETINGS, CONFERENCES, MANUSCRIPTS AND GRANTS FROM THE NC PFAST NETWORK SCIENTISTS DURING THE JAN. 1 – MAR. 31, 2020 REPORTING PERIOD

Science Communication Monthly Lunch-and-Learn Series, Jan. 22, 2020, Duke University
Presentation:
Kathleen Gray and Lee Ferguson, "Water, Water, Everywhere" Testing North Carolina's Drinking Water and Communicating Risk

2020 American Association for the Advancement of Science Annual Meeting: Envisioning Tomorrow's Earth, Feb. 13-16, 2020, Seattle, WA
Session: Bringing Scientific Evidence to Meet Local Policy Challenges
Jamie DeWitt was on a panel focused on community engagement and talked about being a PFAST Network member

2020 Global Waste Management Symposium, Feb. 23-26, 2020, Indian Wells, CA
Track A: PFAS Characterization
Presentation:
Morton Barlaz, "Per- and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Municipal Wastewater"

Fayetteville Public Forum, Feb. 26, 2020, Fayetteville State University
Presenters/Panelists:

- Jason Surratt, Overview of the NC PFAST Network
- David Genereux, Recent NC State Work on PFAS in Groundwater Near Chemours
- Jackie MacDonald Gibson, Risk to Private Wells Near Chemours
- Kate Holden (NCSU graduate student with Owen Duckworth), How compost can influence PFAS uptake in crop plants

Featured in the Press:
Studies conducted by the Belcher lab at NC State have been featured in the following stories:

- https://news.ncsu.edu/2020/02/pfas-striped-river-bass/
- https://www.newsobserver.com/news/state/north-carolina/article240039653.html
- https://www.newsobserver.com/news/state/north-carolina/article240885896.html

Manuscripts published:

- "Ionic Fluorogels for Remediation of Per- and Polyfluorinated Alkyl Substances from Water," E. Kumarasamy, I. M. Manning, L. B. Collins, O. Coronell, F. A. Leibfarth. 2020. *ACS Central Science*, https://dx.doi.org/10.1021/acscentsci.9b01224.
- "Assessing the Effectiveness of Point-of-Use Residential Drinking Water Filters for Perfluoroalkyl Substances (PFASs)," N.J. Herkert, J. Merrill, C. Peters, D. Bollinger, S. Zhang, K. Hoffman, P. Lee Ferguson, D.R.U. Knappe H.M. Stapleton. 2020. *Environmental Science and Technology Letters*, https://doi.org/10.1021/acs.estlett.0c00004
- "Elevated levels of per- and polyfluoroalkyl substances in the Cape Fear River Striped Bass (*Morone saxatilis*) are associated with biomarkers of altered immune and liver function," T.C. Guillette, J. McCord, M. Guillette, M.E. Polera, K.T. Rachels, C. Morgenson, N. Kotlarz, D.R.U. Knappe, B.J. Reading, M. Strynar, S.M. Belcher. 2020. *Environment International*, https://doi.org/10.1016/j.envint.2019.105358

Manuscripts in preparation:

- T.C. Guillette, M. Guillette, M.E. Polera, J. McCord, M. Strynar, S.M. Belcher. Working title: "Increased PFAS Exposure is linked to autoimmune disorders in American Alligator" In preparation for submission to *Science.*
- M.E. Polera, T.C. Guillette, M. Guillette, J. McCord, M. Strynar, and S.M. Belcher. Working title: "Historical and Contemporary PFAS levels in Tissue of Freshwater Fish from along the Cape Fear River Demonstrate Bioaccumulation of Short-Chain PFAS" In preparation for submission to *ES&T*.
- L. Koropeckyj-Cox, M. Barlaz, et al. Working title: "Per- and polyfluoroalkyl substances (PFAS) transport from groundwater to streams near a manufacturing facility in North Carolina" In preparation- journal to be determined.

New grants received: (PFAST Network members in bold)

- **J. DeWitt**, "Do Per- and Polyfluoroalkyl Substances Found in the Cape Fear River of North Carolina Pose a Risk to the Immune System?"
  Brody Brothers Endowment: $32,000, 1/1/20-12/31/21
- C. Mattingly, **D. Knappe**, **J. Hoppin**, S. Kullman, D. Collier, S. Lea, **J. DeWitt**, J. Yoder, **S.M. Belcher**, D. Buchwalter, A. Planchart, **M. Barlaz**, D. Muddiman, E. Baker, R. Smart, R. Ranjithan, D. Reif, D. Fourches, **K. May**, N. Wilkinson, "Center for Environmental and Health Effects of PFAS"
  National Institute of Environmental Health Sciences Superfund Research Program: $7,408,011, 2/28/20-2/27/25
- **F. Leibfarth** and **O. Coronell**, "Ionic Fluorogels as a Flow-Through Resin Technology for PFAS Remediation from Water"
  NC Policy Collaboratory and UNC Institute for Convergent Science: $225,000, 3/1/2020-6/30/2022
- **M. Sun**, **F. Leibfarth**, J. Liu, J. Niu, "Passive Samplers for Per- and Polyfluoroalkyl Substances with Innovative Sorbents"
  DOD Strategic Environmental Research and Development Program (SERDP): $887,556, 5/1/2020-7/31/2024