

# **U.S. Environmental Protection Agency Board of Scientific Counselors**

## **Executive Committee PFAS Meeting**

### **Virtual Meeting Minutes**

**September 29-30, October 8, October 20, and November 23, 2021**

**Dates and Times:** September 29, 2021, 12:00 p.m. to 6:00 p.m.; September 30, 2021, 12:00 p.m. to 5:00 p.m.; October 8, 2021, 11:00 a.m. to 2:00 p.m.; October 20, 2021, 11:00 a.m. to 2:00 p.m.; November 23, 2021, 11:00 a.m. to 12:30 p.m., Eastern Time

**Location:** Virtual

#### **Meeting Minutes**

Provided below is a list of the presentations and discussions that took place during the meeting with hyperlinked page numbers. The minutes follow. The agenda is provided in Appendix A, the participants are listed in Appendix B, and the charge questions are provided in Appendix C.

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### **Wednesday, September 29, 2021**

The meeting generally followed the issues and timing as presented in the agenda provided in Appendix A of this meeting summary.

#### **Convene Meeting**

The meeting convened at approximately 12:00 p.m., Eastern Time.

#### **Welcome, Opening Remarks and Member Introductions**

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*  
*Lucinda Johnson, Vice Chair, Board of Scientific Counselors (BOSC) Executive Committee*

Mr. Tom Tracy opened the meeting and welcomed all participants. He noted that Dr. Paul Gilman had a conflict of interest and would not be joining, but that Dr. Lucinda Johnson would preside instead. Dr. Johnson then asked BOSC members to introduce themselves. Please see Appendix B: Participants for the full list of meeting attendees.

#### **Office of Research and Development Welcome**

*Chris Frey, Deputy Assistant Administrator for Science Policy, Office of Research and Development (ORD)*

Dr. Chris Frey thanked everyone for joining the meeting. He emphasized that PFAS has been and continues to be an important focus area for ORD. He noted that ORD has been at the forefront of research on the human health effects and environmental risks of per- and polyfluoroalkyl substances (PFAS) PFAS contamination. Dr. Frey outlined ORD's three PFAS-related research goals, which are to develop methods to detect PFAS, advance science needed to assess human health and risk assessment of PFAS contamination, and intervene and manage PFAS through remediation, prevention, and control technologies.

#### **Overview of Charge Questions and Meeting Format**

*Susan Burden, Scientific Support Advisor and PFAS Executive Lead, Office of Research and Development*

Dr. Susan Burden explained that the purpose of the meeting was to review the implementation of ORD's PFAS research and development portfolio about methods and approaches for measuring PFAS, to better understand risks to human health and the environment from PFAS, and to identify and evaluate approaches to addressing PFAS in the environment. She described the format of the meeting, breakout rooms, and deliberation. She explained that day 1 of the BOSC meeting would include an overview of total PFAS methods followed by breakout sessions on water and air methods, and then an overview of human health effects of PFAS, followed by breakout sessions on toxicity testing and assessments. Day 2 would include an overview of PFAS treatment and risk management, followed by breakout sessions on bench- and pilot-scale studies and field studies. The charge questions for consideration solicit recommendations on the utility of total PFAS methods and other analytical approaches for identifying total PFAS in environmental samples, how to select category characteristics that would maximize the utility of

the resulting PFAS categories for the broadest set of decision contexts, and approaches for working with communities in potential field study locations.

## **PFAS Overview**

### ***An Introduction to PFAS***

*Tim Watkins, Director, Center for Environmental Measurement and Modeling*

Dr. Tim Watkins explained that PFAS are a class of synthetic chemicals with chains of carbon atoms surrounded by fluorine atoms. They have water- and oil-repellent properties and a stable carbon–fluorine (C-F) bond. Notable PFAS include oxygen, hydrogen, sulfur, and nitrogen atoms, which create a water-soluble end. Dr. Watkins noted that perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) are well-known PFAS, but PFAS also include perfluoroalkyl acids (PFAAs), polyfluoroalkyl acids (PolyFAAs), and PFAA precursors. He noted that homes, businesses, and industry all use PFAS, which are found in food packaging, including pizza boxes and fast-food wrappers, waxes and cleaners, clothing, upholstered furniture, and electronics.

Dr. Watkins described PFAS sources, which include landfills and leachates from the disposal of consumer and industrial products containing PFAS, wastewater treatment discharge and biosolids, environmental transformation products, air emissions, and industrial facilities that directly release PFAS into the environment. Dr. Watkins explained that PFAS are toxic and a serious health concern because they can adversely affect the immune system, liver, thyroid, and overall human development. Dr. Watkins added that most people have already been exposed to PFAS and that PFAS resist decomposition in the environment and in human bodies.

Dr. Watkins emphasized that PFAS are an extremely high priority for ORD. He noted that in April 2021 EPA Administrator Michael Regan charged the council on PFAS with developing “PFAS 2021-2025: Safeguarding America’s Waters, Air and Land,” a multi-year strategy to deliver critical public health protections to the American public. Dr. Watkins added that EPA has already been working to validate laboratory methods for detecting PFAS in the environment and implementing guidelines to regulate PFAS exposure.

- **Jim Stevens:** Do contamination sites tend to be mixtures of PFAS?
  - **Tim Watkins:** We expect to see mixtures of PFAS at these sites. We rarely find individual PFAS.
- **Michael Kleinman:** What characteristic of PFAS compounds makes them so persistent in the environment and in human bodies?
  - **Tim Watkins:** The strong carbon-fluorine bond primarily leads to this persistence, but at varying levels due to chain length. EPA is trying to phase out long-chain PFAS, although we still see these as legacy compounds.
- **Joe Rodricks:** Are perfluorinated compounds fully fluorinated, while polyfluorinated compounds are only partially fluorinated?
  - **Tim Watkins:** That is correct.
  - **Joe Rodricks:** Is there a difference in the environmental persistence or degree of environmental degradation between perfluorinated and polyfluorinated compounds?

- **Tim Watkins:** I am not aware of any substantial differences. Chain length is a big driver of persistence for both types of compounds.
- **James McCord:** It depends on how we define persistence of a compound. For perfluorinated compounds, there is typically no observed transformation or degradation due to the strength of bonds. For polyfluorinated compounds, you cannot observe degradation, but the portion of the molecule that is not fluorinated can undergo transformation chemically and biologically, leaving a transformation product that is also a fluorinated compound. The parent molecule might degrade, but the product molecule does not, so it is typically just a different PFAS. The fluorination issue does not go away even if the chemicals transform slightly.

### ***Office of Research and Development PFAS Portfolio***

*Susan Burden, Scientific Support Advisor and PFAS Executive Lead, Office of Research and Development*

Dr. Susan Burden provided an overview of ORD's PFAS research over the past five years on analytical methods, human health toxicity and toxicokinetics, ecotoxicity and bioaccumulation, occurrence, exposure, treatment and remediation, disposal and destruction, fate, transport, deposition, risk assessment, communication, and management. She emphasized the need for reliable methods to measure PFAS in all types of environmental media, including air, water, and land. Because understanding human health effects is key to informing risk analysis and management, ORD is developing a tiered toxicity testing system for measuring human health effects across a broader class of PFAS.

Dr. Burden noted that ORD analyzes bioaccumulation and ecotoxicity data to inform ecological hazard assessments and benchmark development, working closely with colleagues in the Office of Water to develop water quality criteria and compile information related to bioaccumulation factors in aquatic species. ORD curates the scientific literature, routinely updating the ECOTOX Knowledgebase with data about ecohazards associated with PFAS in different species. Because most of this information is about PFOA and PFOS, there is a need to study a broader class of PFAS. She added that ORD is trying to use new approach methods to prioritize and categorize data-poor PFAS for further toxicity testing, and to develop new approaches to support predicting effects of untested PFAS in different species.

Dr. Burden explained ORD's efforts to gather data on sources, occurrence, environmental fate and transport, and human exposure to identify key human health exposure pathways. She noted that PFAS as a source can result in varying levels of exposure. She described ORD's risk management work, including finding ways to remove PFAS from drinking water and wastewater, addressing PFAS at contaminated sites, and effectively managing and disposing of PFAS and PFAS-containing materials. She noted that treatment and remediation approaches should be cost-effective, tailored to specific situations. She added that ORD is conducting research on thermal destruction, identifying new approaches for destruction, and evaluating the fate of PFAS in landfills. ORD is trying to find ways to dispose of PFAS-containing materials so as not to reintroduce PFAS to the environment.

- **Tim Verslycke:** To what extent does ecotoxicity research relate to Charge Question 2, which focuses primarily on grouping PFAS compounds in the context of human health?
  - **Susan Burden:** We are primarily discussing the human health and human health toxicity work we have underway, so we will not discuss details on ecotoxicity work. In terms of grouping, think about what synergies might exist between grouping from a human health context and grouping from an ecological risk context. We want to consider different ways to break up this huge class of chemicals for different risk decision purposes. How can we split chemicals into smaller categories in a way that addresses the most decision-making contexts?
  - **Tim Verslycke:** Will there be a portion of the agenda where EPA has identified these synergies?
  - **Susan Burden:** No, that is not included into the agenda.
  - **Michael Kleinman:** Bioaccumulation and transportation in the ecological system directly impacts food and water, so it is related. Things that promote transportation and bioaccumulation are related to human health.
  - **Susan Burden:** I agree.

## Charge Question 1 – Total PFAS Methods

### *Analytical Methods Overview*

*Chris Impellitteri, Associate National Program Director, Safe and Sustainable Water Resources Research Program*

Dr. Chris Impellitteri presented an overview of analytical methods for measuring PFAS in the environment. He explained that targeted methods analyze specific compounds and require analytical standards, while non-targeted methods can screen for a list of suspected compounds and quantitate analytes where standards might not exist. Targeted methods are only applicable to a defined set of known analytes on a targeted list and cannot identify additional analytes once the analysis is completed. Non-targeted methods involve the use of high-resolution mass spectrometry (HRMS) capable of identifying both known and unknown analytes in a sample, and allow scientists to go back to the data to look for analytes which were unidentified at the time of analysis but which later become known.

Dr. Impellitteri described the different categories of PFAS analytical methods, which include Safe Drinking Water Act, Clean Water Act, SW846 solid waste series, and air methods. He described Drinking Water Method 537, which was the first standardized and validated drinking water method involving liquid chromatography-mass spectrometry (LS/MS/MS) with internal standards, and noted details about other methods, including SW-846 Method 8327 and Prep Method 3512 for non-drinking water aqueous samples and Clean Water Act Draft Method 1633 for wastewater, surface water, soil, sediment, biosolids, and animal tissues. He explained that EPA developed the Clean Water Act Method for wastewater analyses and also developed a targeted method to estimate total oxidizable PFAS precursors, which are PFAS molecules that become different compounds over time. He noted that EPA is currently refining air methods to characterize PFAS in air emissions from stationary sources. The current draft method, Other Test Method (OTM-45), characterizes 50 PFAS and is expected to be evaluated and validated by 2022.



- **Joe Rodricks:** Are the detection limits for these methods adequate for addressing PFAS levels of potential concern for human and environmental health?
  - **Chris Impellitteri:** For drinking water, there is a patchwork of state guidelines. In drinking water methods, we target sub-10 ng/L, preferably in single digits. The main variable is the analyte itself and the medium or sample type. In cleaner sample types, we can get to below 1 ng/L.
  - **Joe Rodricks:** Is this the detection limit for individual PFAS or total PFAS?
  - **Chris Impellitteri:** EPA does not have a “total” method that gets us near sensitivity.
- **Rainer Lohmann:** I am perplexed by the different methods. Is there some rationale for always having a different number of PFAS?
  - **Chris Impellitteri:** There are many common PFAS as far as the specific analytes. We use the same core ones in our methods. Some methods use the same 24 analytes, while others use the same 40.
- **Kate Lajtha:** I appreciate the complexity of these methods, but some require solid phase extraction (SPE) while others do not. I worry about SPE complications. As you continue to develop methods, are you trying to move away from SPE, or will you continue its use?
  - **Chris Impellitteri:** Yes, we will continue to use SPE, because it helps us reach lower sensitivities. In some situations, SPE might be overkill, so direct injection would be sufficient, but we are trying to provide a variety of validated methods to keep options open. We envision that direct injection will be less costly, so we can start with that method. Then, if additional sensitivity is required, we can use SPE. The Department of Defense (DoD) has insisted on using a method that includes isotope dilution, so it was in our mutual best interest to develop an SPE method.
  - **Kate Lajtha:** Do you worry that SPE introduces error?
  - **Chris Impellitteri:** Absolutely, especially if everyone uses different methods
- **Viney Aneja:** Regarding Air Methods 45, how do you prevent degradation of the analyte on the collection substrate from the time of collection to the time of analysis?
  - **Tim Watkins:** We collect on different substrates, and we have tested for breakthroughs in that process. I cannot recall the specific types of substrates used.
  - **Chris Impellitteri:** I am not sure, but we can investigate and report back to you.
- **Paula Olsiewski:** When these compounds are in air, are they volatiles or semi-volatiles?
- **Rainer Lohmann:** Why do you target 29 PFAS in UCMR5 but develop a CWA Draft for 40 PFAS? Is this just a question of timing, or is there a reason to believe several of the 40 CWA PFAS are not in drinking water?

### ***“Total PFAS” Methods***

*Alice Gilliland, Deputy Directory, Center for Environmental Measurement and Modeling*

Dr. Alice Gilliland provided an overview of ORD’s ongoing research on Suspect Screening Analysis (SSA) and Non-Targeted Analysis (NTA), which are powerful tools for identifying unknown PFAS compounds and discovering emerging contaminants. She explained that modern



commerce introduces large numbers of novel chemicals with unknown properties, so there is a pressing need for comprehensive, rapid analysis to identify these unknown species. Dr. Gilliland added that NTA involves modern, high resolution, non-targeted mass spectrometry and provides quantitative and semi-quantitative measurements, as well as sensitive detection levels. She noted that NTA is time-intensive, relies on multiple experiments and techniques, and requires extensive expertise for processing data. She then described the Cape Fear Case study in which NTA was used to identify unknown PFAS compounds downstream of a manufacturing facility.

Dr. Gilliland next discussed the Total Organic Fluorine (TOF) and Adsorbable Organic Fluorine (AOF) analytic methods, which offer a screening level estimate for PFAS mass balance. Both TOF and AOF involve combustion ion chromatography and are relatively inexpensive and easy to use but provide less sensitive detection levels. She also described the Total Oxidizable Precursor (TOP) assessment, which is an oxidation procedure that converts PFAS precursors not identified by standard targeted analysis to measurable PFAS. EPA Method 537 or similar techniques extract and measure post-oxidized water, soil, sediment, and tissue samples. She explained that an increase in PFAS concentration after TOP indicates PFAS precursors are present in that sample. She noted that TOP is relatively easy to use, accessible without NTA expertise and equipment, and has a sensitive detection limit of ~0.002 ppb. However, the TOP procedure does not convert all PFAS, cannot confirm precursor identities, and is not a standardized.

Dr. Gilliland stated that there are multiple sources of PFAS in air, including from manufacturers, industrial users, and treatment and destruction facilities. She explained that TOF can be a powerful screening tool for PFAS air emission estimates. HRMS and NTA can help detect unknowns from a variety of sources and identify PFAS to add to targeted methods. She noted that unique challenges exist for measuring PFAS in air, explaining that large portions of total PFAS in the air are volatile, indicating a potential loss throughout the analytical method, so a variety of sources using multiple methods must efficiently capture and measure PFAS\

- **Rick Becker:** In what situations would the AOF method be used? What conclusions do the results indicate?
  - **Alice Gilliland:** The key is viewing wastewater as a screening tool.
  - **Chris Impellitteri:** AOF is a screening method, so we would use it in a situation where we think PFAS is present and want a quick idea of what the total PFAS level is without going into targeted analysis. For example, a wastewater treatment plant trying to evaluate PFAS sources could use AOF.
  - **Rick Becker:** To clarify, if I do not detect PFAS, can I be confident it is not there? If I do detect PFAS, would I have to perform other analyses for further characterization?
  - **Chris Impellitteri:** Correct. If there is an issue and we identify PFAS, we would need a highly targeted method to determine exactly what compounds are present.
- **Paula Olsiewski:** Is there any indication that the compounds are aerosols or attached to pollution particles?

- **Alice Gilliland:** I do not have an answer, but we are actively looking at those samples now.
- **Justin Teeguarden:** For NTA analysis, how confident are you that you found a PFAS?
  - **James McCord:** We are confident. It is easy to distinguish if a compound is a PFAS, and if it is fluorinated and long-chain.

## **Charge Question 1 – Breakout Rooms**

### ***Breakout Room 1 – Water Methods***

#### ***Analytical methods for PFAS measurement in environmental samples (aqueous)***

*Jim Voit, Chemist, Center for Environmental Solutions and Emergency Response (CESER)*

Jim Voit described his work developing and validating analytical chemistry methods to determine perfluorinated chemicals, focusing on existing validation methods for PFAS determination, which are considered the gold standard. He discussed EPA's role in providing other agencies and academic institutions with the necessary tools to develop databases for cataloging PFAS chemical information and using that data for decision making. He explained several analytical methods for measuring PFAS, including EPA 537.1, EPA 533, and SW846 Method 8327. He then described each method and thanked contributors who aided their development.

- **Kari Cutting:** I am not familiar with isotope dilution. Please provide additional details.
  - **Jim Voit:** Isotope dilution maps a mass labeled chemical analogue to a native PFAS and adds it to every sample prepared for analysis, allowing for measuring responses for both the mass labeled and the native PFAS. Then we use a ratio to measure and quantitate the native PFAS. This allows us to assess the level of matrix interference, which in some cases can be suppression and in others enhancement, and provides an accurate quantitation.

#### ***Analytical methods for PFAS in environmental media: CWA-1633***

*Marc Mills, Environmental Engineer, Office of Research and Development*

Marc Mills discussed Clean Water Act Method (CWA)1633, which is an isotope solution-based method. He explained the three broad categories of EPA standard methods that serve a regulatory purpose are the Safe Drinking Water Act, the Clean Water Act, and the SW846 Method, which has complex matrices, such as waste streams, soils, and tissues. CWA1633 is a targeted isotope dilution analytical method. Only a single laboratory-validated method has been released as of September 2021, but work continues on starting a multi-laboratory validation method. There are many matrices included, and within each there are various sample types. For example, wastewater includes influent and effluent, groundwater, surface water, soil, sediment, and fish tissue. The single laboratory validation method includes 40 PFAS analytes. He responded to a question asked in the earlier open session about why certain analytes are selected for use in the methods, stating the reason is because the analytical standards available in the marketplace are limited. Only 40 PFAS analytes are reliably available, so that is what was included in CWA 1633.

- **Rainer Lohmann:** Is there an optional filtration step in method 3512?
  - **Chris Impellitteri:** There is a filtration step after addition of internal standards to field samples and perform a quality control (QC) review. Samples might also undergo centrifugation.
- **Rainer Lohmann:** What is the state of the compound in the water, and how does that affect how the analytical process works? Are there differences if compounds are solids versus freely suspended in the aqueous media?
  - **Chris Impellitteri:** Marc Mills is probably the person who can best answer your question. From an analytical perspective, it is probably not a big concern, but from a sampling perspective, it is definitely a pain in the neck.
  - **Marc Mills:** There are two critical points. One is the sampling technique, and the other is preparation. You have to describe clearly in your standard operating procedures (SOP) whether you are including a filtration step or centrifuge step, because that will ultimately affect these results.

### *Non-targeted analysis of water*

*James McCord, Chemist, Center for Environmental Measurement and Modeling*

James McCord described the goal of performing non-targeted water analysis as detecting emerging new contaminants of concern using open-ended screening techniques. Additional goals include increasing the accuracy and reproducibility of approaches, formalizing methods so academic and state and regional laboratories can use them, and making analysis slightly more quantitative.

### *Development of adsorbable organic fluorine screening method with detection by combustion ion chromatography*

*Jody Shoemaker, Chemist, Exposure Methods and Measurement Division*

Jody Shoemaker explained that although mass spectrometry is the most common technique used as a targeted analysis for the detection of total PFAS, standardizing targeted analytic methods is difficult because there are more than 4,000 PFAS in existence. She stated the goal of the adsorbable organo-fluorine (AOF) method, which is to develop a screening method for wastewaters that measures AOF. She then briefly discussed her current research on PFAS in a variety of matrices, and her plans to submit a manuscript for publication before the end of the year.

- **Gina Solomon:** Jody, what was the reason behind the limited sensitivity of the method?
  - **Jody Shoemaker:** We tried to choose PFAS that were part of the functional groups had low and high numbers of carbons in the chain because that is where we expected to have problems. Also, these techniques are quite expensive, and there are only so many PFAS commercially available.
  - **Gina Solomon:** Thank you.
- **Gina Solomon:** It is interesting that so few PFAS are available for purchase. Is that because they are difficult to purify as individual chemicals?

- **Jody Shoemaker:** I do not know the answer since I am not a synthetic organic chemist.
- **James McCord:** I can provide some insight. I spent a lot of time studying industrial mixtures of perfluorinated chemicals and chemical effluents. It is difficult to purify them. Industrial usage is their primary purpose, and sometimes they are simply a by-product. GenX is the example we found that happened to be produced as a product, so it was something that we could access, but in that same study where we examined non-targeted compounds, there were another 40-50 produced only as by-products of their manufacturing process. They are not available to analysts, because they are only sold in massive quantities to specific manufacturers.
- **Rainer Lohmann:** Why do you target 29 PFAS in UCMR5 but develop a CWA Draft for 40 PFAS? Is this just a question of timing, or is there a reason to believe several of the 40 CWA PFAS are not in drinking water?
  - **Tom Speth:** UCMR is limited to 30 compounds (29 PFAS and lithium for UCMR5).
- **Rick Becker:** In what situations is the AOF method envisioned for use? What conclusions result?
- **Michael Kleinman:** Are PFAS compounds in water dissolved, dispersed as globules, or adsorbed on solids or biota?
  - **Chris Impellitteri:** This one is complicated. Long chain compounds tend to absorb onto particulates and surfaces. Short chain compounds tend to stay in solution. However, many PFAS might orient themselves to air or water interfaces due to their hydrophobic or hydrophilic nature.

### ***Breakout Room 2 – Air Methods***

#### ***Other Test Method 45 (OTM-45)***

*Lara Phelps, Senior Advisor, Office of the Science Advisor*

Before her presentation, Dr. Lara Phelps briefly mentioned another test method reviewed by EPA that has not yet undergone federal review. She noted that a preliminary performance evaluation is a useful method for emission measurement in communities.

Dr. Phelps identified the need for reliable and comprehensive emission measurement methods, both targeted and nontargeted, to measure volatile, semi-volatile, non-volatile, polar, and nonpolar PFAS for multiple purposes and sources. She stated that the ability to measure PFAS as a class is a recognized Program Office need. She provided a brief overview of OTM-45, which currently covers the basics of sampling and analysis. She indicated that OTM-45 is now available for polar PFAS compounds, whereas MM5 train is available for nonpolar PFAS compounds in development. She acknowledged the critical need of accessing facilities to conduct further field testing.

- **Kari Cutting:** What are the main factors involved in the difficulty of establishing field testing locations?

- **Lara Phelps:** We are communicating with various communities that have concerns about what would be in the public domain.
- **Susan Burden:** I propose we hold all questions until after all presentations have been made.

***Additional source air methods under development***

*Lara Phelps, Senior Advisor, Office of the Science Advisor*

Dr. Phelps reiterated that reliable and comprehensive emission measurement methods for the target and non-targeted molecules are needed for volatile, semi-volatile, and non-volatile PFAS compounds. She acknowledged the importance of field testing and discussed ongoing testing partnerships. She outlined different approaches, identifying their strengths and weaknesses. She then noted that the Canister method is the current focus for volatile emission testing and that the established NTA capabilities are supporting other projects. She concluded her presentation by emphasizing the importance of field evaluation.

- **Michael Kleinman:** How standardized are the sampling collection approaches and media?
  - **Lara Phelps:** The release of OTM-45 is an initial step to provide a consistent measurement approach for source measurements, but more work is needed on further approaches.
- **Michael Kleinman:** Canister samples provide a good snapshot, but are there efforts to develop continual monitors to examine variations in emissions over time?
  - **Lara Phelps:** Canisters are a snapshot, as mentioned, which is one of the reasons for the other techniques we are exploring, such as FTIR, ToF-CIMS and PTR-MS/CIMS.

***Wet deposition of PFAS***

*John Offenberg, Senior Research Chemist, Exposure Methods and Measurements Division*

Dr. John Offenberg emphasized the significance of measuring wet deposition because of its important role in air-surface exchange of PFAS chemicals and its potential to build on existing infrastructure. He defined current goals and noted that wet deposition measurement is largely dependent on National Atmospheric Deposition Program (NADP) wet deposition collections. There are currently four established NADP sites that collect excess water samples for the analysis of wet deposition.

- **Michael Kleinman:** Dry deposition might be important for western states, which have low levels of precipitation.

***Total organic fluorine analysis for PFAS in air***

*Hannah Liberatore, Physical Scientist, Center for Environmental Measurement and Modeling*

Dr. Hannah Liberatore presented the goals of the Program Office in measuring PFAS as a class of chemical compounds. She emphasized the need for a sufficiently sensitive and robust method

that is applicable to multiple source categories. Combustion ion chromatography is currently the most likely candidate method. She highlighted analytic challenges, including evaluating the sampling approaches to capture various PFAS classes and accounting for inorganic fluorine prior to analysis.

- **Viney Aneja:** Do we know the lifetime of these compounds in the air or atmosphere?
  - **John Offenber:** Ben Murphy and Emma Gambro have been working on a deterministic modeling evaluation, which was published at the beginning of this year. I believe the answer depends on the vapor pressure, the aqueous solubility, and Henry's law, but I don't think there is one specific clear answer. As they demonstrated, there was evidence for or a suggestion of the deposition field from a strong source, and they chose the Fayetteville work location as their case study. That deposition field goes out possibly hundreds of kilometers. Does that answer the question?
  - **Viney Aneja:** Yes and no. If the lifetime is large, these compounds will disperse in the atmosphere, and we need to be aware of that process. The compounds with a shorter lifetime will deposit rather quickly. I am concerned no one is discussing the lifetime of these compounds from an analytical perspective.
  - **Lara Phelps:** We need to learn more about what these processes emit into the air. As we are learning more about those products of incomplete combustion and products of incomplete destruction, I think that is going to help us answer this question. I do not think we have the answer yet, but I do believe that learning about all of the different contributing processes and understanding what is being discharged into the atmosphere will help us answer that question.
  - **Hannah Liberatore:** The only thing I would add is, a group in Toronto that measures PFOA in polar bears discovered that PFOA was made in the Arctic and then transformed in the environment to form PFOA.
- **Viney Aneja:** I have one last question for John. The presentation alluded to measurement under canopy. What is the usefulness of making measurements under the canopy?
  - **John Offenber:** There is some indication that these compounds might deposit onto leaves. One of the questions is whether this is a lineation process of deposition under the tree. No one has taken these measurements before, so it is an opportunity to work on this. It is a process of trying to figure out where the dominant forces are and where all of these atmospheric compounds reside.
- **Viney Aneja:** I have a question for Lara. Lara's presentation spoke to reliable and comprehensive emission measurements. Did it also imply reliable and comprehensive concentration measurement? If not, why is that left out?
  - **Lara Phelps:** I spoke about what we were measuring at that point in time. We have an entire team doing their best to try to find ways to take all of these measurements. They are at various concentrations, at various stages, and at various components of the process. We are trying our best to measure from beginning to end. So, we are targeting pieces as we progress.
- **Hannah Liberatore:** There is a question in the chat.
  - **Cindy Boyle (from the chat):** How can we secure a case study in the Peshtigo/Marinette, Wisconsin, area? Tyco / Johnson Controls (an aqueous film-



forming foam (AFFF) manufacturing plant) is in our community, and we have a severe contamination crisis there. I am the Chair for the adjacent community (Town of Peshtigo) and have been on the front lines for four years trying to secure safe drinking water for our homeowners with contaminated wells. We believe part of our contamination is linked to air deposition and need a case study to verify. Thank you.

- **Lucinda Johnson:** Thanks, Hannah. Are there any pressing questions from the chat?
- **Kate Lajtha:** Hearing John Offenberg's presentation, I was somewhat surprised by the use of NADP collectors. Because I work with a lot of the NADP collectors for nitrogen and sulfur compounds instead of inorganics, we use the NADP wet deposition collectors as extremely non-quantitative indicators of high-highs or high-lows, at least for nitrogen compounds. We know that is part of total deposition, that they can represent anywhere from 30 to 90 percent of total deposition. I am not an organic chemist. For the compounds that I worry about, they tend to be completely soluble. I wonder if the error would be worse, particularly for compounds which have a huge variety of solubility and probably have greater half-lives in the atmosphere. I wonder why this method targeted the wet deposition collectors at the NADP sites.
  - **John Offenberg:** We started with the wet deposition collectors, in large part because of the existing infrastructure and the initial indications that Wisconsin State Laboratory of Hygiene was seeing reasonable measures. There is likely not the same chemical reactivity during the week of integrated sampling that a lot of nitrogen compounds have. In terms of the broad range of aqueous solubilities, I agree that there could be some issues for longer-chain or less soluble compounds. Initial indications are that the methanol rinse of the bucket after the transfer helps with that. The dry deposition and bi-directional gas exchange are complex measurement challenges. This was a place to start.
  - **Kate Lajtha:** I will add a note of caution for the interpretation. The way we use the NADP collectors now is as a regional screening of what is high and what is low. We worry less about the internal transformations than about the partitioning between wet and dry, gas and non-gas, and wet deposition. It is only a vertical collector.
  - **John Offenberg:** I agree with all the previous comments. Part of what we are attempting to do is see what compounds are out there. Some of these sites are fairly close to production facilities, and Whiteface Mountain is relatively remote for the Eastern half the United States. We are surveying the problems, considering whether this is affected by wintertime when precipitation freezes or when buckets freeze, and trying to run into some of those problems for these classes of compounds.
  - **Kate Lajtha:** There is one last thing I want to ask. I know that some of the NADP sites are co-located with really good dry deposition gas collectors. Can we build on that? Or are the techniques for evaluating such things as ammonium sulfate not adequate for wet deposition research?
  - **John Offenberg:** There are limits of detection on the chemical analysis. The nice part about rain is that whenever it rains, there will be sufficient water to perform



the LCMS analysis. We must consider all that you mentioned as our research progresses.

- **Kate Lajtha:** I would love to talk to you about it later.
- **Paula Olsiewski:** It seems that many air sampling methods were established for measuring other things in the air. Are you trying to develop new sampling methods for the air or trying to build off of existing EPA infrastructure? EPA has an extensive infrastructure for monitoring air.
  - **John Offenberg:** It is difficult to measure things in a way that is fully evaluated and can meet needs.
  - **Paula Olsiewski:** It makes sense if you can use your current sampling infrastructure.
  - **John Offenberg:** We are beginning laboratory and field evaluation efforts for ambient air similar to those described by Laura and Hannah. The spiking of the OTM-45 with isotopically labeled compounds and tracking where they go through the sampling apparatus is part of what is done in the performance-based OTM-45 method. It requires a lot of labor.
  - **Paula Olsiewski:** It is amazing what you've already done.
  - **Lara Phelps:** Tomorrow we will hear about some of the thermal treatment work that we have been doing to test these methods.
- **Lucinda Johnson:** Are there any further questions? Have the folks that have been posting questions in the chat received satisfactory responses?
  - **Michael Kleinman:** My questions were answered.
  - **Lucinda Johnson:** Thanks to the folks who are responding and managing the chat.
- **Paula Olsiewski:** I have one more question. I was excited to see that some of the work involves real-time monitoring with some expensive mass spectrometry tools. How do you address the sampling issue? It is basically sniffing the air.
  - **John Offenberg:** Soon we will begin evaluating the importance of the type of transfer line medium. Should it be stainless steel? Should it be Teflon? Does it need to be glass or quartz?
  - **Paula Olsiewski:** This is important.
  - **John Offenberg:** We also will examine whether it is for ambient or for sources.

### Clarifying Questions on Charge Question 1 Content

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Dr. Lucinda Johnson asked for two volunteers to moderate the discussion. Dr. Paula Olsieski and Dr. Michael Klienman volunteered. Dr. Johnson read the first charge question and asked if there were any questions

- **Paula Olsiewski:** Sampling and sampling preparation is critical for some of the methods. Is that included in the scope?
  - **Susan Burden:** Yes, I would consider that within scope.
- **Paula Olsiewski:** Given how expensive some of the instruments are, is that something we should discuss?

- **Susan Burden:** Having methods available in a wide variety of laboratories is critically important so we can compare the data regardless of who conducts the methods. We want methods we can use broadly to detect PFAS.
- **Jim Stevens:** Are analytical folks thinking about a tiered strategy, and can we look for sentinel compounds that give us an opportunity to read across major classes that might be in mixtures at contamination sites?
  - **Susan Burden:** I would let the analytical folks respond.
  - **James McCord:** When we apply non-target analysis, we often do it at sites that have had some moderate or historical experience with targeted analysis to identify PFAS or FPAS source. The question is whether we know if historically there was PFOA or PFOS contamination at a site. If now we know it is replaced by something else, we go look for that something else. That is an example of a tiered approach we use.
  - **John Offenberger:** Similar to that, the work in the air program does not have the same depth of experience. There is no 20-30 years of measurements. Yes, we see a tiered approach to identify compounds using the least expensive method we should for promulgation and use by the states.
- **Jim Stevens:** Given the complexity of the problem, how do we break it down? How are you thinking about that approach, given the complexity of compounds, so we can determine how to prioritize sites?
  - **Susan Burden:** You put that well, it is a complex problem. This relates to the second charge question about human health effects and whether we can use that to decide on methods approaches. I think there is an interplay of learning from each other about what we are doing and an opportunity to use that to answer the question of next steps.
  - **Lucinda Johnson:** I think this is a great starting place for transitioning. Jim, we can talk about the topic you are asking about further at the 5 o'clock hour.

## Charge Question 2 – Human Health Effects

### *Overview: Human Health Effects Research*

*Annette Guiseppi-Elie, Associate Director for Science, Center for Computational Toxicology and Exposure*

Dr. Annette Guiseppi-Elie provided some background on the human health effects of PFAS. She identified the need to use grouping or category-based approaches to assess and address potential PFAS toxicity. She noted ORD's research strategy for studying human health risk of PFAS. ORD plans to curate scientific information, conduct toxicity testing and develop human health toxicity assessments. She highlighted the issue of most PFAS having limited or no toxicity data to inform hazard assessment. Therefore, she noted that ORD has used the [CompTox Chemistry Dashboard](#) and [Health & Environmental Research Online](#) (HERO) database to curate existing data. ORD also plans to group PFAS into a small number of categories based on structural, toxicological, and toxicokinetic similarity, and plans to prioritize PFAS for further toxicity testing and assessment. She then reviewed the layout of presentations for the Toxicity Testing

and Assessment breakout rooms. She concluded by reading the second charge question and by highlighting the goal of maximizing the groupings for the broadest set of decision contexts.

***Office of Research and Development's Tiered Toxicity Testing Strategy for PFAS***

*Rusty Thomas, Director, Center for Computational Toxicology & Exposure*

Dr. Rusty Thomas introduced himself and provided a quick review of the state of the science. He explained that the work starts with chemistry by curating names, structures, and identifiers. He mentioned that ORD now has PFAS information that can be found on the CompTox Dashboard and described the EPA chemical library. EPA selected 150 PFAS as representatives and out of the 150, and of those, 100 passed quality control (QC) and were selected for tiered toxicity and toxicokinetic testing. Dr. Thomas highlighted the study data curation work that will be presented in the breakout groups. He described how ORD's approach to develop and refine PFAS categories for hazard assessment will be in collaboration with the Office of Chemical Safety and Pollution Prevention (OCSPP). This team will use the [Distributed Structure-Searchable Toxicity \(DSSTox\) Database](#) and structural filters to perform primary, secondary, and tertiary structural categorization on secondary categories with structural diversity greater than the threshold. He then described how to calculate diversity threshold and centroids for each terminal category and mentioned the importance of overlaying the in vivo toxicity studies to identify categories with data gaps, emphasizing that the end goal is to refine the PFAS categories using the mechanistic, toxicokinetic, and in vivo data.

- **Jim Stevens:** When you say categories and compounds for testing, does that include mixtures for compounds within categories?
  - **Rusty Thomas:** Not currently. There are other parts of ORD that are developing mixture strategies for PFAS. We would have to address those in a separate discussion.
- **Lucinda Johnson:** Are machine learning statistical techniques coming into play, given the density and diversity of the data?
  - **Rusty Thomas:** Not on this, but we have been using machine learning approaches broadly in ORD in general.
- **Justin Teeguarden:** I wanted to note that the structure is logical, and I think you focused on the right things, but is your categorization going to consume the exposure data and show what is out there?
  - **Rusty Thomas:** Yes, we have talked about the category approach being specific for different decision contexts. For example, there has been discussion about combining the grouping and categories for the hazard assessment piece with water treatability, so you can see what PFAS are covered by different water treatments. There are grouping approaches for ecological data, and we will develop groups and a tiered testing approach for ecological toxicity.
  - **Annette Guiseppe-Elie:** We are also looking at rapid exposure to see areas where we can do real-world mixtures and see what is out there with non-targeted approaches.

- **Jim Stevens:** When you say categorization, is that categorization for testing purposes, or is it for saying these are the types of hazards we expect within a category?
  - **Rusty Thomas:** It is both. One of the first steps is identifying data gaps and which categories need further testing. Once we fill the data gaps we can use those categories to develop a toxicity value for risk assessment in an ultimate application.
  - **Jim Stevens:** Can you create that concordance in a point of departure with in vivo studies and some of the new approach methodologies (NAMS), then use the NAMS to create a read across opportunity to categorize potential effects of the class?
  - **Rusty Thomas:** Structure-based read-across has been used for decades and is the standard in risk assessment. What we are doing is continuing to evolve those structural categories in a systematic way to inform data-poor categories for structure-based read-across, then folding in the NAMS to add a mechanistic and toxicokinetic context. Therefore, we are making sure that those structural categories hang together mechanistically and toxicokinetically as a weight of evidence to support those structural categories.
  - **Jim Stevens:** Apologies. I tend to think about read-across in two contexts, both structural-based that you mentioned, and also reading across assay systems. Can you use NAMs for estimates to create a better characterization of the class or category?
  - **Rusty Thomas:** NAM data is being used, for example, to see whether a category activates a certain receptor or if only half of the category activates the receptor. In that case, you want to decide whether you want to keep that category whole.

## **Charge Question 2 – Breakout Rooms**

### ***Breakout Room 1 – Toxicity Testing***

#### ***New approach methods – toxicity***

*Richard Judson, Research Chemist, Center for Computational Toxicology and Exposure*

Dr. Richard Judson discussed his work using NAMs to broadly characterize the mechanistic and phenotypical responses across structurally diverse PFAS. He noted that to calibrate what they learn from in vitro data they must have a database of in vivo toxicity. This helps them identify gaps where there is no in vivo data. For the in vitro experiments, about 120 have passed QC. He explains they use the zebrafish embryo developmental assay for developmental toxicity, the bioseek diversity panel which allows them to study immunotoxicity, the microelectrod array assay for developmental neurotoxicity, and others. For the in vivo data, they use EPA's Toxicity Values database (ToxValDB), which gathers quantitative data from in vivo studies. He mentioned that they are currently developing a QC process for reviewing data. He finally thanked all contributors to the project.

### ***New approach methods – toxicokinetics***

*Barbara Wetmore, Toxicologist, Center for Computational Toxicology and Exposure*

Dr. Barbara Wetmore described EPA efforts in toxicokinetic (TK) research, which allows them to translate in vitro potency data into an external dose metric. The external dose metric is important because they hope to use these in PFAS risk evaluations. She states another key linchpin of the work they are doing is the ability to develop analytical chemistry methods. The TK approach has key characteristics of metabolism and plasma protein binding and uses that information to predict internal blood concentrations in combination with the in vitro points of departure. To date, there is generated data for about 120-130 PFAS. Though impacted by COVID-19, the TK data assessment is mostly complete. Other work underway is PFAS biotransformation and PFAS in vitro disposition, which should be ready for review in 2022. She concluded by thanking all those who collaborated and made this work possible.

- **Rick Becker:** Is the intention to release the whitepaper as a draft for both public review and comment and review by one of EPA's science panels, such as the BOSC?
  - **Susan Burden:** We are still discussing that internally, so I do not have an answer for you at this time.
- **Chris Gennings:** Can you use the TK information to estimate internal human concentrations or go from internal human concentrations to external exposure concentrations? Perhaps I asked my question too soon.

### ***In vivo toxicity testing***

*Justin Conley, Reproductive Systems Biologist, Office of Research and Development*

Dr. Justin Conley introduced the topic of his presentation which focuses on mammalian in vivo research. He provided several important background points, including the fact that in vivo toxicity data on developmental, liver, thyroid, or immune endpoints are the basis for essentially all risk assessment points of departure for PFAS that have been evaluated thus far. Secondly, there have been detection of numerous emerging or new generation PFAS in human serum or drinking water that have little or no toxicity data. Finally, combined exposure to multiple PFAS is common. He described his dose-response experiments on understudied PFAS that have known human exposure, which helps with toxicity data and advances their understanding of the multiple adverse outcomes that are relevant to PFAS. They also are conducting work on the in vivo estrogenicity of fluortelomer alcohols. He noted that ORD conducts much of their in vivo research in pregnant animals to study developmental effects. Currently there are four papers published that discuss the mammalian in vivo PFAS toxicity data. He concluded by thanking all the contributors who have collaborated with him.

- **Rick Becker:** For in vitro studies of receptor mediated effects, how do you account for and distinguish specific responses from non-specific surfactant mediated responses?
  - **Earl Gray:** In vitro assays are all for agonists of estrogen receptors (ERs), glucocorticoid receptors (GRs), androgen receptors (ARs) and 3 peroxisome proliferator-activated receptors (PPARs).

- **Richard Judson:** For ER and PPAR, we have assays from multiple technologies and cell types. One way to address this question is to look for consistency across these assays, and then compare with reference chemicals and other literature data on PFAS.
- **Rick Becker:** Thank you. Orthogonal approaches make sense. Depending on the assays, surfactants can produce pseudo-responses. For instance, ER binding assays are susceptible to false positives from detergent compounds by displacement of the ligand by receptor denaturation.
- **Graye:** Rick, these responses could be challenged with a receptor antagonist for specificity. I think we did that with the ER.

***PFAS and multimorbidity: Using electronic health records to probe systemic effects***

*Cavin Ward-Caviness, Computational Biologist, Public Health and Integrated Toxicology Division*

Dr. Cavin Ward-Caviness described his work on PFAS exposure and multimorbidity. PFAS exposure is associated with human health outcomes ranging from cancer to high cholesterol, and data evaluating the impact of PFAS exposure on the co-occurrence of multiple chronic diseases are limited. Although PFAS research has not widely incorporated electronic health records (EHRs), this effort aimed to establish EHRs as a tool for studying PFAS health effects and to estimate the systemic health effects of PFAS. The approach of this effort entailed using EPA's third Unregulated Contaminant Monitoring Rule (UCMR 3) data on occurrence of PFAS as an indicator of potential PFAS exposure. The work used the Centers for Disease Control and Prevention's (CDC) EHR-based definition of comorbidities and studied over 10,000 participants from the years 2004-2016. He stated that there are clear observed associations between PFAS exposure and multimorbidity and individual chronic diseases. He thanked all contributors.

- **Jim Stevens:** Cavin, would you further explain the association between exposure and chronic disease conditions?
  - **Cavin Ward-Caviness:** We determined which public water systems were serving which zone improvement plan (ZIP) codes of residents. We then reviewed the UCMR 3 data to determine whether any of those water systems tested as positive, which is defined as above the minimum reporting level for PFAS exposure. We also had participants' disease history from their EHRs, which we used to determine their chronic disease prevalence, as well as individual confounding data that we collected from both the individual medical record and the U.S. Census.
  - **Jim Stevens:** So you are examining incidence based on PFAS levels in the water source versus where there might be less PFAS. How do you account for other confounders, such as socioeconomic status where there might be radically different living conditions near industrial plants as opposed to the suburbs?
  - **Cavin Ward-Caviness:** Excellent question. Our models adjusted for 22-24 different confounders. By including those in our statistical modeling of the prevalence of PFAS, we are able to see the degree to which they independently impact multimorbidity and ensure that reported associations are independent of things such as rurality, socioeconomic status, poverty rates, access to health care,



- and other variables. All of those variables co-vary with PFAS exposure and can potentially be responsible for the associations, but we did not observe that.
- **Jim Stevens:** Thank you. Very interesting data. I am looking forward to the publication.
  - **Chris Gennings:** Very interesting work. How did you define multicomorbidity?
    - **Cavin Ward-Caviness:** We defined it as two or more of the diseases on our list. We tested whether or not people had two or more of those and tested for the most prevalent ones individually. We reviewed observed associations reported in literature and tested whether PFAS increases multimorbidity by increasing the number of chronic diseases. We saw positive associations across all of our analytical models.
    - **Chris Gennings:** So it was two or more?
    - **Cavin Ward-Caviness:** Yes, we did not weight it based on the number, but the modeling approach took account of the difference between three chronic diseases, and four is not the same difference between four and five, and so that's accounted for within our models. We also performed some early testing to determine whether there was a linear response if we went from two to three to four to five. As you can imagine, when you reach five or six chronic diseases the number of participants drops off sharply, so we stuck with a simple binary model to increase our sample sizes.
    - **Chris Gennings:** Do you have a sense from preliminary analyses which one might be the worst outcome?
    - **Cavin Ward-Caviness:** Hyperlipidemia was one of the worst case actors. Ischemic heart disease was another, as were arrhythmias. It seems metabolic diseases and some cardiovascular diseases are prevalent.

### ***Breakout Room 2 – Assessments***

#### ***Human health toxicity assessment for PFBS***

*Beth Owens, Assistant Director, Health and Environmental Risk Assessment*

Dr. Beth Owens presented the challenges of decision making on PFAS chemicals, emphasizing the limited number of available toxicity values. She introduced the current understanding of the toxicity of perfluorobutane sulfonic acid (PFBS) and potassium salt and summarized supporting evidence via oral exposure that focuses on thyroid, renal, and developmental effects. She then discussed the newly released toxicity assessment report of PFBS that provides the scientific foundations for risk decisions and replaces the 2014 version.

#### ***Draft IRIS assessments for PFBA, PFHxA, PFDA, PFHxS, PFNA, and their related salts***

*Andrew Kraft, Biologist, National Center for Environmental Assessment*

Dr. Andrew Kraft presented the five PFAS selected for Integrated Risk Information System (IRIS) assessments based on their diversity of structure, in vivo study availability, and quantifiability. These five PFAS include PFHxS, PFDA, PFNA, PFHxA, and PFBA. He provided an overview of the approach to assess these five PFAS, which is based on the November 2019 Systematic Review Protocol. He also introduced the preliminary cross-view to



demonstrate the current health effect evidence and discussed the actual and anticipated timing of progress on the five PFAS assessments.

***Systematic evidence maps to characterize available evidence for 9000 PFAS***

*Kris Thayer, Director, Chemical and Pollutant Assessment Division*

Dr. Kris Thayer introduced the goals of using systematic review methods to identify and summarize animal bioassay and epidemiology evidence for approximately 9000 PFAS. The ultimate goal is to create a repository that is easily updated, web-based, and shareable. She pointed out the systematic review method is pre-decisional without hazard conclusion, dose response analysis, or toxicity value presentation, and this method is primarily using machine-learning. Dr. Thayer presented interactive displays of animal bioassay information and health system studies. She explained currently available findings and noted data gaps and future research aims.

- **Beth Owens:** We can now take questions.
- **Chris Gennings:** This is really fabulous work that you are doing. I am actually interested in the discussion about mixtures. I am coming from the epidemiology biomonitoring framework and wonder about the role played by biomonitoring data. Is there a way of using biomonitoring data? Someone mentioned confounding, but statistical methods can address confounding. How can we use biomonitoring data, especially when we have so many datasets or studies on PFAS and related human health effects?
  - **Kris Thayer:** I am not an epidemiologist, but I would say the specific issue you raise is something that is certainly in the context of the IRIS assessment and is considered carefully. Some analyses could help tease apart the extent to which we might attribute an association, but I think it is case-specific. Sometimes we can, depending on the analyses that were done by the author and the availability of the studies, and sometimes we cannot, but I know that it is something that our team is thinking about carefully.
  - **Chris Gennings:** The broader question is whether there are a handful of PFAS that epidemiology studies are using. If they are in that five PFAS study on different structures, is there a way to connect epidemiology to the evidence of PFAS in different structures?
  - **Kris Thayer:** That is one of the reasons we started the evidence map focusing on animal bioassay data, because that was going to be applicable. We carefully study the epidemiology so we can determine where there are clusters of information and where there are gaps.
  - **Justin Teeguarden:** Rusty is working to advance analytical methods so they can understand human exposure. I would imagine some part of this could be biomonitoring, eventually. Maybe not EPA, but the academic community. I think the long-term goal is to anchor the analytical chemistry to support better biomonitoring in categorization work. They are studying structures now but plan on applying what they learn from the exposure in the future. Prioritizing the structural categories they are interested in would, I imagine, eventually move into

mixtures. Mixture is informed by exposure and structural categories. They need to focus on toxicokinetics.

- **Chris Gennings:** Biomonitoring is going to demonstrate mixtures, correct? Exposure concurrent measures for biomarkers know the sources.
- **Justin Teeguarden:** Absolutely right.
- **Kris Thayer:** In the evidence map we are focusing on health studies, but we do tag when we find a biomonitoring-only study that did not have a health outcome. We have not delved deeply into that literature, but we are trying to at least make sure we do not miss it.
- **Andrew Kraft:** Circling back to the confounding question, we do have some studies that apply more group models. We are looking across sets of studies showing similar effects for the relative exposures. If one study includes exposure to a lot of PFOA and another study includes less PFOA exposure, and both show the same effect of association with PFNA, that would produce more confidence that PFOA was not confounded for that effect. We are doing that type of cross-study and confounding analyses. We are not just assuming there is a confounding effect. We are doing that analysis in a more detailed manner, but also acknowledging that this possibility does exist.
- **Chris Gennings:** Thank you.
- **Bruce Rodan:** I want to follow up on Chris's question Rusty is working toward categorizations of massive different PFAS, but he said work is needed to study the mixtures question. Clearly, the next step is for us to do that with regard to high throughput. What patterns are we seeing in the exposures? What are the relevant chemicals? When are they going to act? Is that an additive reaction. Testing PFOA and PFOS for additivity is a priority, because that is part of the regulatory spoil. The Health Advisory structure of EPA includes drinking water with PFOA and PFOS. Are they additive? What is the plan with regard to those chemicals?
- **Leslie Rubin:** Thank you. This is impressive. Is this repository going to have all the data of all the PFAS chemicals and some correlation with health outcomes?
  - **Kris Thayer:** It will be a curation of the health studies. So including the findings, the health findings, and they would be in those interactive visuals and downloadable.
  - **Leslie Rubin:** Well, that is impressive and why you need so many people. Is there any mapping of location or increased concentrations of the PFAS, such as a Google map of PFAS prevalence or concentration?
  - **Kris Thayer:** I am not aware of that. In my group, we focus on health associations. That is not a repository or resource that we would create. I am not aware of whether there is one.
  - **Leslie Rubin:** I know Kevin had commented that there are areas where they find increased concentrations of PFAS in the waters, and then they correlated with the health data and in the electronic health records, which is a fascinating correlation.
- **Lucinda Johnson:** Jim had a comment in the chat.
  - **Jim Stevens:** Kris, very impressive. PFAS seem an excellent case study for application of all the automation tools we have been discussing in the Chemical

Safety for Sustainability and Health and Environmental Risk  
Assessment (CSS/HERA) reviews.

- **Kris Thayer:** Thanks, Jim. Yes, we could not have done this without automation.

### Clarifying Questions on Charge Question 2 Content

There were no clarifying questions prior to deliberations.

### BOSC Executive Committee Deliberations

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Dr. Lucinda Johnson left the meeting early, so Dr. Kate Lajtha led the discussion. Dr. Lajtha said that she was impressed by all the scientific presentations.

- **Jim Stevens:** Considering the content in today's presentations, I am having trouble making recommendations about how EPA should categorize PFAS compounds. I do not think BOSC has enough information to comment on the categorization issue referred to in Charge Question 2. I did not see how the categorization process is going to be implemented, so we can only comment on the tiered testing strategy. Categorization is essential but what drives it in terms of research priorities? I do not see how we can vertically integrate categories.
  - **Justin Teeguarden:** There is integration with categorization, because there are two analytical chemistry methods. Non-targeted methods and targeted quantitative estimates are dependent on each other.
  - **Jim Stevens:** There are two branches of categorization, including compounds in the same class that are chemically similar and in-vivo categorization. Do all chemically similar compounds have the same categorization profile when it comes to hazard identification?
  - **Justin Teeguarden:** ORD initially receives structural information and can only categorize compounds based on that. As ORD acquires toxicology data, new categories might emerge, and we can have exposure and biomonitoring as a third branch of categorization.
  - **Jim Stevens:** I agree with you, but I am talking specifically about Charge Question 2.
  - **Bruce Rodan:** We have a basic need for BOSC to peer review our work. Since BOSC members are present at this meeting, we want all your input on this challenging charge question. Regarding the categorization concept, we need to obtain structural, mechanistic information about compounds so we can categorize chemicals based on toxicology data as well. There is another opportunity to categorize compounds based on remedial technologies.
  - **Kate Lajtha:** Remember that during the writing process, BOSC can consult with ORD scientists to help us with difficult technical questions.
  - **Jim Kelly:** We can use non-targeted analyses for when we do not know exactly what compounds are in the environment, but we need to know how to focus our limited resources on these investigations.

- **Kari Cutting:** I appreciate everyone's comments on this. In the presentation, we did not hear what PFAS were present in the North Carolina multimorbidities study.
  - **Kate Lajtha:** I agree with Kari. As Justin pointed out, the second part of Charge Question 2 is confusing.
- **Chris Gennings:** I am surprised that there was not more discussion about biomonitoring studies, because there are so many published studies about perfluorinated compounds now. Am I wrong to think about these categories as a way to group compounds based on their risk to humans?
  - **Justin Teeguarden:** I think that is the inevitable outcome of the categorization. To your first point, where would biomonitoring studies influence what we are discussing today?
  - **Chris Gennings:** There is a huge data source. Human data is useful for more than just exposure.
  - **Justin Teeguarden:** I largely agree with you, but we should provide ORD with specifics about how to use that information.
- **Jim Stevens:** BOSC is asking for data-driven approaches to categorization. Why study compounds when there is no exposure potential? What are the health effects about which we should really be concerned? I think ORD is taking the right approach, but I do not think you have all the data yet. If we work from both the health outcome perspective and the exposure perspective, we can fill in data gaps.
  - **Bruce Rodan:** Our initial studies were data-driven, but we also wanted to have a spread of chemicals across functional groups in order to understand toxicity mechanisms across the suite of PFAS.
  - **Justin Teeguarden:** I agree with Jim. We are missing the road map and timeline for implementation of the various categorization schemes. We can consider four levels of categorization, including structure, toxicology, pharmacokinetics (PK), and human exposure. When would we have the ability and the need to implement the categorization? ORD has the chemical structure information on compounds, and they are currently working on analytical methods. We cannot do toxicology and exposure categorization yet because we do not have the data.
  - **Jim Stevens:** I would add health effects as a bin.
  - **Chris Gennings:** I agree with Justin, except for the timeline. We need to speed things up. We cannot just do one categorization at a time. I am concerned about all the studies about mixtures of perfluorinated compounds in humans.
  - **Justin Teeguarden:** I agree, but there are funding restrictions.
  - **Chris Gennings:** What about putting more credence into human studies? There are published human studies showing that there is a mixture effect of PFAS.
  - **Jim Kelly:** We know the general direction needed but are forced to draw the map as we progress.
  - **Justin Teeguarden:** The proposal then seems to be to make mixtures, informed by human biomonitoring data, a priority for EPA in early testing.
- **Rick Becker:** Justin, in your proposal, where does predictive exposure assessment come in?

- **Justin Teeguarden:** I am glad you mentioned that. Between time in the field collecting biomonitoring data and predictive work, we should try to do categorization prioritization as quickly as possible. We need categorization based on predictive exposure assessment.
- **Jim Stevens:** We did not talk much about points of departure. What is the exposure potential, and where is that relative to the point of departure below which you do not expect to have large human health consequences? That seemed to be a missing piece when I saw the animal data.
  - **Justin Teeguarden:** That is a great point. Barbara Whetmore and her team are trying to accomplish that.
  - **Rick Becker:** Some of their work included assays of convenience, which worries me.
  - **Jim Stevens:** Given the stability of polyfluorinated compounds, it is not likely that they are genotoxic, so I do not think we need to do carcinogenic studies.
  - **Chris Gennings:** There are compounds that are human-relevant.
  - **Justin Teeguarden:** With 9,000 compounds, we need to focus on the ones that really matter.
  - **Chris Gennings:** We need to publish points of departures in humans.
  - **Justin Teeguarden:** EPA should be more explicit about describing how they are using predictive exposure assessment to prioritize compounds based on the appearance of effects in test systems at internal concentrations likely to be present in target species of interest. As Chris Gennings mentioned, human studies show associations at internal concentrations equivalent to those showing effects in test systems. On the other side, EPA and others have many examples of log order differences between possible internal concentrations and those that cause effects.
  - **Annette Guiseppi-Elie:** Thank you, Justin. You are correct. This is a good discussion. EPA ORD can respond when we receive the full recommendation.
- **Kari Cutting:** Charge Questions 1 and 2 about feedback on PFAS methods and the need for categorization are related.
  - **Kate Lajtha:** I agree.
  - **Jim Stevens:** The categorization is not just about chemical structure. It involves categorizing compounds that all have the same particular hazard associated with them regardless of their chemical makeup.
  - **Kate Lajtha:** Yes, but they showed us structural similarities during the presentation. There are chemical similarities between compounds, but we also want to focus on effect similarities.
  - **Leslie Rubin:** As a clinician, I study the health outcomes and the developmental, kidney, and thyroid effects of these chemicals. What are the mechanisms of PFAS on human chemistry or biology that result in these adverse outcomes? It seems all these chemicals have slightly different effects, but collectively have adverse health outcomes. I am not sure how this fits into the larger discussion.

## Adjourn

The meeting adjourned at 6:00 p.m., Eastern Time.

## **Thursday, September 30, 2021**

### **Convene Meeting**

The meeting reconvened at approximately 12:00 p.m., Eastern Time.

### **Welcome Back**

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*  
*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Dr. Lucinda Johnson opened the meeting and welcomed all participants. Dr. Susan Burden reviewed the agenda.

### **Charge Question 3 – Treatment Field Studies**

#### ***Overview: PFAS Treatment and Destruction Research***

*Greg Sayles, Director, Center for Environmental Solutions & Emergency Response*

Dr. Greg Sayles began his presentation by discussing the importance of risk management research and describing how EPA is trying to develop approaches that reduce PFAS exposures and remove them from the environment. To accomplish this, EPA needs effective approaches in addressing PFAS in the natural and built environments and for end-of-life materials management. He described ORD's research approach to answer questions around laboratory studies, pilot-scale studies, and full-scale field studies. He then reviewed items ORD needs to consider when creating risk assessment and management approaches. He discussed various challenges in studying PFAS, including their chemical structure and surfactant nature, and explained positive and negative aspects of laboratory and pilot studies. He then described water treatment, site remediation, and destruction and disposal PFAS risk management approaches. He concluded by noting that ORD will continue to develop data on the treatment of PFAS for various media, focusing on the goal of using the most cost effective and sustainable method of PFAS mitigation while avoiding unintended consequences.

- **Lucinda Johnson:** Given the complexity of the sources of PFAS, I am assuming PFAS probably co-occur with other contaminants. The strategies for remediation need to account for the mixture of PFAS with other contaminants. At what point do you think the agency will be able to address these complex mixtures?
  - **Greg Sayles:** That is a big question. I do not have an answer. Those developing these applied solutions are accounting for, or at least trying to account for, these mixtures. That relates to my point of having solutions with intended and unintended consequences.
- **Michael Kleinman:** In the past we have had experience dealing with polychlorinated biphenyls and similar compounds. Does any of that experience transfer over to what is being done with PFAS?
  - **Greg Sayles:** We can carry forward lessons learned from that. I would guess the PFAS compounds are even more stable, but the same kind of issues are possible. We are not reinventing the wheel completely for this, and we are building from past experiences.



- **Michael Kleinman:** I think one of the successful techniques was incinerating calcining ovens where they make concrete. Fluoride reacts stably with calcium to form insoluble materials, so that could be an approach.
- **Greg Sayles:** We are trying to do some work with cement kilns. You should speak with our researchers about that.
- **Leslie Rubin:** You mentioned the three alternative ways of discarding waste. Is there a reality of land application? Is there a way to use it for agriculture, or is there risk in that?
  - **Greg Sayles:** Land application already happens. That is how many plants have dealt with disposal of their biosolids. Our question is, what does that do to PFAS, and where does PFAS end up? One of our breakout sessions today is about land application of biosolids.
- **Bart Croes:** Are there efforts to reduce the sources of these? Is there anything with similar properties that is more environmentally benign?
  - **Greg Sayles:** Sure. I do not know all the details, but some of my scientists could tell you what has happened over time in industrial production. We need approaches for all of the above. The legacy of longer chain PFAS are still out there, and we need solutions for that, too.

### ***EPA PFAS Innovative Treatment Team Findings on PFAS Destruction Technologies***

*Tim Watkins, Director, Center for Environmental Measurement and Modeling*

Dr. Tim Watkins reviewed the work of the PFAS Innovative Treatment Team (PITT) to remove, destroy, and test PFAS-contaminated media waste. He described PITT's goal of providing decision makers with state of the science data on incineration effectiveness, enabling them to better manage end-of-life disposal of PFAS containing materials. He described the four non-combustion technologies about which PITT wrote an introductory paper and research briefs. These technologies include mechanochemical, supercritical water oxidation, electrochemical, and pyrolysis. He concluded by describing PITT's findings, accomplishments, and lessons learned from working in communities.

- **Viney Aneja:** Would you share what the removal efficiency was for the other technologies?
  - **Tim Watkins:** For supercritical water oxidation, we saw around 98 or 99 percent removal efficiency. Max Krause, who is in one of the breakout rooms, can provide additional background on that. We have seen high removal efficiencies for polychlorinated biphenyls (PCBs) and dioxin. Erin Shields will talk about that in one of the breakout rooms.
- **Lucinda Johnson:** Who were the leaders and stakeholders with whom you work in the communities? Were they helpful in communicating and messaging?
  - **Tim Watkins:** Rahway, New Jersey, is a community with environmental justice (EJ) concerns. We communicated with a community meeting group of about five people and with the utility commission board. It was a one-way exchange where we communicated the information to them and did not engage with them on the



materials. We could improve that moving forward. There was a larger group in the state who heard inaccurate information about the study, which created concerns about what we were doing. We were trying to correct the miscommunication, but the decision was not to continue. There was some concern from the Bay Area Air Quality Management representatives with the other study in California, where press from the New Jersey incident led to questions. In that case, state partners helped us communicate through any issues.

- **Michael Kleinman:** Have you been able to integrate previous experience at Supersites, especially with Agency for Toxic Substances and Disease Registry (ATSDR) community interactions, into developing communication plans?
  - **Tim Watkins:** We have been working with ATSDR actively now. We had a strong set of communication materials, and the problem was that they were not available.
  - **Lucinda Johnson:** I have found having a champion in the local community before starting the communication is helpful.
- **Paula Olsiewski:** Is 99 percent destruction adequate, or does it need to be higher?
  - **Tim Watkins:** This is where we must make decisions, and it is difficult. We can ask if 99.99 percent destruction is different than doing nothing. That gets into the toxicity discussions we were having yesterday in terms of exposure.
- **Lucinda Johnson:** Are you considering different types of biochar for removal?
  - **Tim Watkins:** The pyrolysis unit produced a biochar, and through target analysis of PFAS we saw PFAS removal in the biochar end product. We are also following up with a non-target analysis.
- **Leslie Rubin:** You mentioned communities with EJ concerns. What proportion of the communities you have worked with are concerned about EJ?
  - **Tim Watkins:** I do not have a specific number. We are identifying such communities with EJ Screen. I think moving forward that is something we must keep in mind. Unfortunately, these waste treatment facilities are often located in such communities. When doing remediation, we must be cognizant about not transferring the PFAS burden to communities that already have another burden.

### **Charge Question 3 – Breakout Rooms**

#### ***Breakout Room 1 – Bench- and Pilot-Scale Studies***

##### ***Drinking water treatment***

*Tom Speth, Associate Director, Center for Environmental Solutions and Emergency Response*

Dr. Tom Speth began his presentation on drinking water treatment by stating that ORD's research focuses on both drinking water treatment and the treatment of residuals. They evaluate performance and cost data for PFAS removal, gather information for a range of system sizes and developments, and update treatment models, databases, and cost models. They also evaluate technologies for regeneration, destruction, or disposal of spent granular activated carbon (GAC) and ion exchange (IX) resins and other residual streams. The goals are to identify approaches for

removing PFAS from drinking water that are economically viable and sustainable and flexible enough to handle potential future changes in target PFAS and treatment goals. Currently, they have 37 PFAS in their database and over 100 references that are publicly accessible. Another goal is to review modeling and cost modeling data to determine optimal treatment approaches. He concluded by providing a list of collaborators.

- **Michael Kleinman:** How do you define “sustainable” and implement it in this context?
  - **Tom Speth:** Excellent question. We are most interested in small and/or disadvantaged systems that do not have the technical, managerial, or financial capabilities to implement a management approach. Not only do they need to be able to handle the capital and operating costs, but they need to be able to run the system appropriately and make any necessary changes in response to changing conditions or maintenance issues. The approach cannot create unintended consequences or residual stream disposal issues that are likely to be more complex than the original technology. Work on large systems concentrate more on issues such as greenhouse gas emissions, energy use, or distribution system management.

### ***Thermal treatment of PFAS***

*Bill Linak, Chemical Engineer, National Risk Management Research Laboratory Air and Energy Management Division*

Dr. Bill Linak discussed his work on treatment of PFAS. He provided background information on how bonds are formed in PFAS chemicals, which makes it difficult to degrade. A goal of the project is to accomplish destruction of the original PFAS materials and eliminate any products of incomplete combustion. The approach of their current work includes in-house experiments supported by fundamental modeling. This is encouraging for both the possibility of co-firing PFAS wastes in cement kilns and also developing control technologies for small sources. He concluded by thanking all contributors.

- **Paula Olsiewski:** Impressive interplay between modeling and measurements. Congratulations!
  - **Bill Linak:** Thank you. We were fortunate that DoD developed the computational fluid dynamics (CFD) model and that EPA colleagues expanded it to include three commercial incinerator designs.

### ***Non-combustion technologies for PFAS destruction***

*Max Krause, Environmental Engineer, Office of Research and Development*

Dr. Max Krause began his presentation by talking about non-combustion technologies and the goal of the PFAS innovative treatment team, which is to identify and assess technologies that could destroy PFAS. Their focus is to understand newer technologies that worked previously for other hazardous waste and might be practical for PFAS treatment. As mentioned in other presentations, the main hurdle is that the carbon fluorine bond is extremely strong, so the process of identifying technologies is difficult. The approach for this work, in particular, evaluated for waste waters, hydrothermal processes, and also e-beams used for radiation of products. The EPA

website hosts research briefs describing their work, and they have papers that have been accepted for publication. He concluded by thanking all contributors.

### ***Mechanochemical destruction of PFAS***

*Erin Shields, Center for Environmental Measurement & Modeling*

Dr. Erin Shields discussed mechanochemical destruction (MCD), a new area in chemistry that converts mechanical energy into energy required to create a chemical reaction. Reductive environments are effective at destroying organic molecules. Although ball-mills destroy PFAS in simple matrices, they are not that effective in soil. To remediate PFAS contaminated soils and other solids at a useful scale, their approach is to start treating PFAS impacted solids at laboratory-scale, then pilot-scale, and then full-scale.

### ***Breakout Room 2 – Field Studies***

#### ***Waste management***

*Thabet Tolaymat, Environmental Engineer, Center for Environmental Solutions and Emergency Response*

Dr. Thabet Tolaymat described ORD's work in evaluating PFAS emissions from solid waste management systems, explaining the goal of waste management is to fill a data gap and understand how end-of life management and the ultimate disposal of PFAS-containing materials can impact PFAS concentrations in the environment. Their general approach involves studying the flow of PFAS-contaminated waste through the system and environment. Approaches compare fresh waste versus landfill waste, evaluates PFAS in incinerator ash and PFAS waste solidification techniques, and mobilize PFAS from waste utilizing the Leaching Environmental Assessment Framework. Within a landfill, they use approaches demonstrating that PFAS transformation is conducive and examining the transport of PFAS through landfill lines. The approach in leachate is to quantify PFAS in landfill leachate, evaluate the effectiveness of conventional leachate treatment for the removal of PFAS, and examine PFAS emissions during landfill leachate treatment.

#### ***Land application of biosolids***

*Kirk Scheckel, Division Director, Land Remediation & Technology Division*

Dr. Kirk Scheckel provided an overview of the land application of biosolids, explaining that data gaps include a lack of knowledge regarding the fate of PFAS in land-applied biosolids and the transport of PFAS in the subsurface. With regards to the first data gap, the general approach is to collect data to assess current practices using Field Studies 2 and 3. For the second data gap, the approach is to study PFAS transport in the subsurface. The actions within this approach include conducting literature reviews, utilizing Region 3 field study data, adapting current models, developing models of PFAS source zones, and applying conceptual models to biosolids application sites. They have completed Field Study 2 sample collection and data reviews and found that initial concentrations of intermediates were more stable than PFAS, but after a year the concentrations of stable PFAS became four to 33 times higher. Literature surveys on

modeling of these components show a six-order magnitude of change dependent on the soil environment. The Two-dimensional Modeling Systems uses real aquifer material to apply conceptual models to biosolid application sites and compare to real world data.

### ***Field-scale thermal treatment***

*Phillip Potter, Center for Environmental Solutions and Emergency Response*

Dr. Phillip Potter reviewed ORD's field-scale thermal treatment projects. The data gap is the lack of knowledge regarding end-of-life management and ultimate disposal of PFAS-containing materials. Actions needed include characterizing waste streams, evaluating the efficacy of disposal, and evaluating products of incomplete destruction. Treatment types include incineration, pyrolysis and gasification, GAC reactivation, and thermal desorption of soil. In sewage sludge incineration, 17 percent of wastewater treatment residuals are incinerated, but the number might grow due to public concern and regulation. Sites include Region 7, Region 3, and Hazen Research Inc. Region 7's goal is to determine PFAS fate during wastewater treatment and sewage sludge incineration to serve as a model for future studies. Municipal and hazardous waste incineration are critical areas for thermal treatment of PFAS. In pyrolysis and gasification, treatment is at a range of temperatures in the absence of oxygen and produces material for beneficial reuse. Drinking water treatment for PFAS removal uses GAC reactivation. Lastly, thermal desorption in soil uses low temperature treatment to remove volatile species while limiting destruction to the sample matrix.

### ***Source characterization***

*Marc Mills, Environmental Engineer, Office of Research and Development*

Dr. Marc Mills presented on ORD's work in source characterization and remediation. With most contaminated sites, ORD works to develop conceptual models and understand mechanistically the fate and transport of PFAS. The objective is to manage PFAS at the source and make sure to work as a concentrated waste stream rather than allowing PFAS to leak into the environment. The data gap is associated with the lack of knowledge to support remediation of PFAS-contaminated sites. Actions taken include characterizing PFAS-contaminated sites, such as fire training and emergency response sites, evaluating technology for remediating PFAS-impacted soils, and generating performance and cost data to develop models. Goals include documenting successful site characterizations and remediation, groundwater remediation performance and cost models, improving models for PFAS transport in soils, and predicting migration potential of PFAS via vapor intrusion. The impact would allow responsible officials to have more information to reduce risk from PFAS. Formulations continue to change and include the shortening of carbon chain lengths, use of polyfluorinated chemistries, and use of alternative chemistries for linkages. They project source characterization will help provide a better understanding of the environmental conditions in which PFAS might be stratified in the water column.

### Clarifying Questions on Charge Question 3 Content

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

- **Monica Schoch-Spana:** Who is the intended audience for Charge Question 3? Is BOSC specifically advising ORD, or can we expand the audience to include all of EPA? Given the ubiquity of the chemicals, as well as their longevity and complexity, it might make sense to advise the Agency at large rather than one division at a time.
  - **Lucinda Johnson:** BOSC is only charged with providing guidance to ORD specifically. We can offer suggestions to the Agency broadly, but our focus is on ORD.
  - **Bruce Rodan:** I agree with Lucinda, but we do need to work in close consultation with the entire EPA and all communities involved.
- **Matthew Naud:** Is there any research on personal water filters, such as those in a new refrigerator, that capture and concentrate compounds and ultimately end up in municipal landfills?
  - **Tom Speth:** Yes, we have completed home treatment system studies and are continuing this research. In these situations, the cost of the adsorbent is a small percentage of the total cost, and therefore, the columns can be overdesigned in that fashion, so they are typically fairly successful. The great unknown is for select short chain PFAS. With regard to landfill disposal of the spent home systems, homeowners have exemptions from waste disposal regulations for such devices. Therefore, they do end up in the landfill.
- **Matthew Naud:** Is there research on PFAS in municipal compost that includes food waste?
  - **Thabet Tolaymat:** Currently there is no ongoing research to evaluate PFAS in food waste compost. There was an evaluation of the topic a few years ago, but I believe the compost evaluated was municipal solid waste compost or food waste that was combined with biosolids before composting.
- **Leslie Rubin:** Can Kirk Scheckel elaborate on the possibility of attenuation and transformation of the PFAS towards a non-toxic chemical compound?
  - **Kirk Scheckel:** My area of expertise is not PFAS, but the question is interesting to share with the researchers associated with the project. Soil is a catalytic wonderworld, and perhaps long-term studies might show attenuation. Research from Peter Jaffe's group at Princeton examines microorganisms and defluorination of PFAS, which would be an interesting technology to apply to soils.
  - **Bill Linak:** From a thermal destruction perspective, several countries have active research programs, particularly in Europe. There are some field studies in Australia and sorbent studies in Asia. All of these studies focus on the few waste constituents and do not measure any byproducts. For point sources, PFAS sampling and analytical methods are in their infancy.
  - **Tom Speth:** We are following Peter Jaffe's microbial work. Some of those organisms require select conditions, such as the presence of iron and ammonia. We hope to find relevant applications.

- **Lucinda Johnson:** Is the issue of substitution out of scope for EPA?
- **Leslie Rubin:** The use of selected bacteria with appropriate nutrients is a tantalizing potential solution.
- **Kirk Scheckel:** Industry is trying to make non-fluorinated fire-fighting foams. A small group of EPA researchers are working with Strategic Environmental Research and Development Program (SERDP) to develop a whitepaper to evaluate these new materials when they become available. We currently have no information about what the new materials are.

### **Office of Research and Development Wrap-up Presentation**

*Susan Burden, Scientific Support Advisor and PFAS Executive Lead, Office of Research and Development*

Dr. Susan Burden summarized ORD's PFAS three research themes on PFAS analytical methods, human health risks, and PFAS treatment and field studies. She asked BOSC to provide feedback and recommendations on ORD's total PFAS methods for measuring PFAS in the environment. She noted that ORD also sought suggestions from BOSC about how to break the larger class of PFAS into smaller categories for toxicity testing and risk assessment. Finally, Dr. Burden asked BOSC for recommendations on how to work with communities in field study locations. Dr. Burden acknowledged that PFAS is a complex research topic. She thanked the ORD scientists for presenting their research and BOSC members for their participation.

Dr. Bruce Rodan noted that PFAS research is a priority to the Biden administration and to previous administrations. He emphasized the need for collaboration to manage and remediate the problem of PFAS contamination in the environment. Dr. Rodan thanked the BOSC members for their time and ideas for tackling these challenges.

### **Public Comment**

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*

Tom Tracy opened the floor to public comments. He summarized Cindy Boyle's comment on the need for PFAS regulation and referenced the contamination of drinking wells by the Tyco Johnson controlled firefighting testing facility. There were no other public comments.

### **BOSC Executive Committee Deliberations**

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Lucinda Johnson reviewed the schedule and logistics for Executive Committee deliberations and for the upcoming October 8<sup>th</sup> and October 20<sup>th</sup> meetings

- **Kate Lajtha:** On my calendar there is a BOSC follow-up meeting scheduled for the 8<sup>th</sup> and the 20<sup>th</sup>, is that right? For those follow-up meetings, is that when the breakout group will work on the charge questions?
  - **Lucinda Johnson:** That is correct. Yes, what we have done in the past was to meet in plenary to discuss the progress of the charge questions and then we break into groups to discuss specifics.



- **Kate Lajtha:** Can we assume that the contractor is going to send each group an email of the SharePoint set-up?
  - **Lucinda Johnson:** I am going to assume yes. Before we go into breakout groups, we will review who will go to the various charge question groups.
- **Paula Olsiewski:** Have the questions changed?
  - **Lucinda Johnson:** No, they are the same.
  - **Leslie Rubin:** Can you tell us what will happen during the meetings so I can plan accordingly?
  - **Lucinda Johnson:** You assemble in your charge question group and use that opportunity to clarify any issues with the EPA folks in your group. Will there be EPA folks in the wings with whom we can consult? We do not have a firm deadline for the submission of this report. We will have some slack to reach a point of consensus.
  - **Susan Burden:** We should have EPA folks on the line, and I could search for questions, too, should you need.
  - **Lucinda Johnson:** Jim, I am going to call on you for your points about the integration paragraph.
- **Jim Stevens:** I was not aware we were going to go into the individual breakout groups, but that is a great idea. When we do the Strategi Plan reports, there is an introduction section. We could bring up the concept of vertical integration in the introductory section of the report and take it out of other sections. Do others agree? If so, who will write it?
  - **Lucinda Johnson:** Jim, I am happy to contribute to the development of the vertical introduction piece.
  - **Kate Lajtha:** I support it. We could also include language that states there was an overwhelming sentiment from all three charge groups.
  - **Jim Stevens:** It is not typical to put a recommendation in the introduction, but it seems a good idea.
- **Justin Teegarden:** I think I understand what you mean by vertical integration. I think it is important to be clear what the value proposition is and what it takes to accomplish it.
  - **Jim Stevens:** I think you are on track. If there are groups developing analytical methods and testing what PFAS are out there, how does that influence the collection of PFAS in the Charge Question 2 toxicity testing? How does that affect remediation efforts? How this is done is not our responsibility. Our responsibility is to highlight how important that activity is.
  - **Justin Teegarden:** I concur.
  - **Lucinda Johnson:** I observe that there is a fair amount of this thinking and activity already taking place. Susan might be able to help us identify alignments that already occur so our recommendations are actual and not perceived gaps.
- **Paula Olsiewski:** I agree with Jim and Justin about the integration. Would it be appropriate to cross reference? Is that integrating too early?
  - **Justin Teegarden:** The question is whether they are leveraging these activities in various pockets.



- **Jim Stevens:** As a recommendation to your question, Paula, what if we stick to the purview of the charge questions and then mention that in the end?
- **Viney Aneja:** I am not clear about the definition of vertical integration. What EPA wants are answers to the three charge questions. I need some clarity.
- **Justin Teegarden:** In short, the perception of the committee is there are three or four activities that are going on in parallel. The group sees there is value in ensuring activities are helping the activities of the others.
- **Viney Aneja:** I am not arguing against the value of vertical integration, but the question is whether EPA wants that.
- **Jim Stevens:** I think the charge questions are asking us to comment on how they are doing. I think the questions are broad enough to allow us to comment on this.
- **Bruce Rodan:** I think it is fair game. We are talking about the research program as a whole. I believe the program is reasonably well coordinated, but if you believe it is not, we can provide suggestions.
- **Leslie Rubin:** I was wondering how to ask questions of the presenters?
  - **Susan Burden:** It would be through the chat. I could connect you to them.
  - **Leslie Rubin:** The speakers from yesterday are not here today. How could I ask them a question?
  - **Susan Burden:** If you know to whom you want to ask follow-up questions, I can see if they are available this afternoon.
  - **Leslie Rubin:** Are we able to speak with them outside of the forum?
  - **Tom Tracy:** My preference would be through email due to Federal Advisory Committee Act (FACA) rules, but if you have to have a conversation, we can have that as well. Let me know with whom you want to connect.
- **Chris Gennings:** I am wondering if we can review the regulations of PFOA and PFAS and their impact? Can we access information on how chemicals are being used as we move forward?
  - **Lucinda Johnson:** Chris, I think your question is whether the effectiveness of policies align with the strategies and priorities of some of the work?
  - **Chris Gennings:** Yes. Is there a way of evaluating the success and the trends of regulations and substitutions?
  - **Lucinda Johnson:** That does seem out of the charge questions' scope. It could relate to prioritization. We are not dealing with the policies and regulations at this point.
- **Jim Steven:** I do not want to leave vertical integration as controversial. I am sure there is coordination in the program. My comment was intended to be supportive and constructive, not to be critical. I thought it was important to highlight we should talk to each other. It helps you to say to scientists that integration is important. Workflow also was not a large part of the presentations.
  - **Lucinda Johnson:** No organization this large and complicated can work without communication and coordination. I like the strategy of having the writers of these

working groups hold this discussion once we formulate the response of the charge questions.

***Charge Question 1 – Total PFAS Methods***

*Rainer Lohmann, Rick Becker, Paula Olsiewski, Kari Cutting, Gina Soloman, Kate Lajtha, Justin Teeguarden*

Dr. Paula Olsiewski and Dr. Rainer Lohmann discussed the strengths and recommendations for the first charge question based on the presentations provided during the meeting.

**Strengths:**

- Leveraged partnerships with government entities and businesses.
- Good progress in water methods.
- Two validated methods.
- Analyte list expanding.
- New Clean Water Act method in development.
- Success with conducting leading-edge research on non-targeted analysis of PFAS in support of states.
- They have a collection of over 400 chemical standards.
- TOF And TOP method development in progress.

**Suggestions:**

- Leverage the work of well-resourced partners, such as DoD air and wastewater.
- Establish a timeline for development of methods for air.
- Develop methods aimed at both gas phase versus particles.
- Aim for measuring volatile compounds, precursors, and ionic compounds in real time.
- Use canisters for integrated measurements where applicable.
- Identify the most important compounds to measure in air.
- Study the role of the Clean Air Act, whether PFAS are hazardous air pollutants, and how to you measure and prove them harmful.
- Strengthen connection between groups developing methods for water and air.
- Examine whether hydrofluorocarbons (HFCs) are part of PFAS and any problems with what chemicals would be included in “total PFAS” if brought to a policy level.

**Recommendations:**

- The group included only two active participants, who did not develop any recommendations.

### ***Charge Question 2 – Human Health Effects***

*Jim Stevens, Michael Kleinman, Tim Verslycke, Leslie Rubin, Joseph Rodricks, James Kelly, Sandy Smith, Chris Gennings*

Jim Stevens suggested the team begin deliberations by writing a short, concise draft report that will grab readers' attention. He suggested starting with the strengths and the suggestions in a two-sentence combination.

#### **Strengths:**

- An integrated plan that includes exposure estimates linked to a NAM testing plan to fill data gaps and the stated goal to “calibrate” assay data to in vivo safety data.
- Experience in developing and applying NAMs for safety assessment.
- Plans to “calibrate” NAMs against in vivo PFAS safety data.
- An ambitious goal to establish Systematic Evidence Maps (SEM) with preliminary evidence that this can be accomplished using existing automation tools.
- The inclusion of real-world health outcomes research from Center for Public Health and Environmental Assessment (CPHEA) to identify human health risks.
- A plan to use PFAS grouping and categorization strategies with chemical or biological response similarities to reduce the complexity of the toxicity testing.
- Research on curation of data and generating new data using a battery of toxicokinetic NAMs will help create supporting information to potentially group PFAS on the basis of structural, toxicological and toxicokinetic similarity.
- Use of mechanistic and toxicokinetic data in a category-based strategy to identify candidate PFAS for in vivo testing and provide toxicity values for the constituent substances.

#### **Suggestions:**

- More clearly articulate how current research on PFAS grouping will be prioritized in the context of needs from end users.
- Explain how ORD will address the challenge of assessing toxicity of mixtures that might reflect real-world exposure as a gap toxicity testing plan. Summarize how ORD will address the mixture issue and which groups are responsible.
- Summarize information on metabolic pathways for PFAS groups and categories, and characterize the in vitro models for metabolic competence vis-a-vis those pathways.
- Clearly explain how ORD will integrate real-world evidence data into testing strategies.
- Include real-world health outcomes research from CPHEA to identify human health risks.
- Use PFAS grouping and categorization strategies (both chemical similarity and biological response similarity) to reduce toxicity testing complexity.

Recommendations:

- Consider potential additional approaches to grouping that consider environmental relevance, such as using information on commercial relevance, environmental occurrence, fate, and transport.

***Charge Question 3 – Treatment Field Studies***

*Matthew Naud, Michelle Lorah, Bart Croes, Louie Rivers, Viney Aneja, Monica Schoch-Spana, Katrina Waters, Kate Lajtha*

Matthew Naud reviewed the Charge Question, which asked participants to comment on the implementation of ORD's PFAS treatment research.

Strengths:

- The agency has examined a host of technologies for mitigating PFAS in the environment.
- ORD has examined PFAS in different water quality media.
- Details in the presentation on technology readiness level scale.
- Use of a variety of method platforms.
- Cross agencies work and partnerships with universities and the private sector.
- Engagement in social learning interactions and consequences in community field studies.

Suggestions:

- Clarify the selection made on the four technologies.
- State the cost of the different approaches.
- Review new publications to better understand technology readiness.
- Address what kind of destruction technology is good enough for a compound that is of concern at part per trillion (PPT) levels.
- Clarify the framework for selecting remedies and treatment goals.
- Note how much attention is paid to PFAS reduction and destruction in the air.
- Address how the results at one scale inform work at the next scale.
- Focus greater attention on source reduction.
- ORD should adopt more systematic approaches for community engagement.
- Study municipal compost.
- Create a flowchart that explores life cycle thinking and includes priorities and important opportunities.
- Include information on PFAS production and management.
- Clarify whether there is an exploration amount treatment and which field studies are associated with ecological system services and local economic activities.

Recommendations:

- Implement best practices on community engagement.
- Ensure that different field study sites, specific to PFAS, have cross-learning.

- ORD should facilitate peer-to-peer exchanges between different PFAS field study sites so there is collective learning and collective trust building.

## Plenary Session

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

- **Lucinda Johnson:** We are assuming EPA has a handle on what PFAS are generated. Has there been any attempt to prioritize the treatment issues with respect to the risk of the amount being generated in the various sectors? Do we know where PFAS is?
  - **Viney Aneja:** When you say we, do you mean EPA?
  - **Lucinda Johnson:** That is correct.
- **Lucinda Johnson:** I would point to Chris Impellitteri since this was in his presentation. He had a landscape diagram of different sources, and I was wondering if there were numbers associated to it.
  - **Chris Impellitteri:** This was not my diagram, but through the Toxic Substances Control Act (TSCA) program there is a process of registering chemicals. James McCord said that these are industrial process and that in many instances we do not know what the total make up is for a particular producer. The second part of that question was about prioritization. Yes, in the water treatment world we are developing a better understanding of what is there. Marc Mills' group has gone through wastewater and state generated data to determine whether we can see patterns and whether there is a prevalence of particular PFAS. We have looked for common PFAS compounds in eight different municipalities.
  - **James McCord:** Chris covered part of that when he said most of the knowledge about PFAS comes from our non-targeted screening. We determined what is available and looked for availability of standards. Even if these chemicals have been patented since the 1970s, most are not available to us. It is difficult to know what is in these products. Most of these products are in use and 100 percent emissive. Our goal for non-target analysis is to identify and inventory these chemicals.
  - **Marc Mills:** Most of these chemicals are manufactured as tactical grade mixtures. They are formulated to a certain performance standard and rarely are created for a certain compound. There is a lot in the mixtures.
  - **Bruce Rodan:** I think the general point is the complexity and scale of this. Last count there were 602 active commerce. I would point out that we are still finding different PFAS.
- **Viney Aneja:** Is it fair to tell EPA that we do not have a reasonable inventory of these compounds and therefore we cannot have an effective control strategy for the nation?
  - **Bruce Rodan:** I think that is more of a policy than a research question.
  - **Viney Aneja:** The research question is to quantify the substances. EPA does inventory routinely for all sorts of substances and why not for PFAS?

- **Bruce Rodan:** All these questions flow into that. There are difficulties around confidential business information, the large amount of PFAS, and targeted methods. You are touching on the complexity of the situation on PFAS.
- **Susan Burden:** I would also add EPA has posed a rule under [TSCA](#) to gather additional information on PFAS.
- **Jim Stevens:** Can you clarify why they are not doing work on the mixtures in the NAMS program when others are studying mixtures?
- **Bruce Rodan:** We are already including mixtures in our EPA work. Unfortunately, Justin Conley did not present about his mixtures work.
- **Jim Stevens:** You are saying we will be working on mixtures in the future? We had the impression that we were not doing work on mixtures.
- **Bruce Rodan:** The logic is we have toxicity patterns and waste of chemicals and when we have that knowledge, we will work on the mixture stage. That said, we are doing work on some mixtures similar to PFOA and PFAS. Justin Conley has worked on a manuscript comparing GenX with PFOA.
- **Jim Steven:** We could think about it as bottom-up or top-down. With the bottom-up approach we obtain knowledge of the individual compounds and start to mix them. My impression is the complexity of that approach is daunting.
- **Bruce Rodan:** Yes, you had it exactly right yesterday. Rusty Thomas is working on the bottom-up approach. We are doing both directions.
- **Jim Steven:** Are there other people who are using the top-down approach?
- **Bruce Rodan:** We could, but it would have to be site specific.
- **Leslie Rubin:** Is there a map for where we know PFAS is found?
  - **Susan Burden:** We do have internal work on mapping and using a geographic information system (GIS) to help us understand that question.
  - **Leslie Rubin:** Is that available?
  - **Susan Burden:** It is currently not available.
- **Lucinda Johnson:** Are we quantifying ecosystem impacts?
  - **Susan Burden:** There is some conversation about doing a type of toxicity testing strategy looking at ecological effects. Rusty Thomas might have presented on this.
  - **Lucinda Johnson:** I did hear him say that. Would this target a specific ecosystem process or have a species-by-species approach?
  - **Susan Burden:** We do not know that yet.
  - **Lucinda Johnson:** How does this thought process and decision making take place?
  - **Susan Burden:** This would take part with the conversations we have with our internal partners.
  - **Lucinda Johnson:** So, the Office of Water might raise this as a priority?
  - **Susan Burden:** Yes, both the Office of Water and the Office of Chemical Safety and Prevention would have an interest.



- **Rainer Lohmann:** To what degree does the work expand to rainwater and filters? Also, regarding research on the ionic side, how much is that used for identifying unknown PFAS in different gas phases and air?
  - **James McCord:** We had a collaboration with Region 5 where we looked at rainwater. There is interest within the air research group to focus on the non-ionic semi-volatile types of PFAS using a high-resolution gas chromatography (GC) instrument using a front end that is more amendable to items not in water. The development of the technology is behind because the instruments were used for biopharma and is only now transitioning to use in ecotox research. I know it is a major research focus, but is taking time to launch.
- **Lucinda Johnson:** Could one representative of Charge Question Group 3 share their thought process and considerations?
  - **Paula Olsiewski:** I am reluctant to raise any of our deliberation to the level of a recommendation. We had the observations that the work on water is going well. However, the work on air is not as developed. It would be helpful if the air and water groups worked together. Do you have anything to add, Rainer?
  - **Rainer Lohmann:** No, that sums it that up.
  - **Jim Stevens:** We chose to focus on strengths and suggestions. We hope to streamline our suggestions by next Wednesday.
  - **Matthew Naud:** We discussed strengths. We appreciated the idea of cross-agency work. For example, working on DoD and the partnerships with universities and the public-sector. Questions included whether there is a stronger role for ORD in supporting destruction research? Our charge question also included cost, but we did not hear a lot about cost in the presentations. If we had any recommendations, we focused on community work and how ORD can facilitate communications across sites so communities can learn from each other.

## Adjourn

The meeting adjourned.

## Friday, October 8, 2021

The meeting generally followed the issues and timing as presented in the agenda provided in Appendix A of this meeting summary.

## Convene Meeting

The meeting convened at approximately 11:00 a.m., Eastern Time.

## Welcome and Opening Remarks

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*  
*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Dr. Lucinda Johnson opened the meeting and welcomed all participants. Please see Appendix B: Participants for the full list of meeting attendees.

## Plenary Session

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

### **Charge Question 1**

Dr. Kate Lajtha reported that the Charge Question 1 plenary session discussed PFAS classes besides total PFAS, their alignment with toxicology efforts, and ways they can help scientists understand various pathways. They determined ORD should confirm that the chemists' classes are the same as the toxicologists' and that both groups of scientists should develop one class for PFAS. They suggest bringing to scale the Singular Spectrum Analysis (SSA) and Nanoparticle Tracking Analysis (NTA) and encourage a refinement of air methods. They drafted four recommendations and noted it would be beneficial to include an ORD scientist in future meetings.

- **Gina Solomon:** We were disturbed by how difficult it is for EPA to field test. Field testing should be a higher priority for ORD scientists. EPA headquarters staff should support the scientists.
  - **Lucinda Johnson:** That makes perfect sense. Charge Question 3 also provided a recommendation related to this approach.
- **Justin Teegarden:** At one point you made a recommendation around binning things in toxicological classes. Could you think about opening the recommendation to topics other than toxicology, so we could classify bins according to already established work?
  - **Kate Lajtha:** That is a good point. Please send me one or two sentences for us to review.
  - **Gina Solomon:** We like the total PFAS approach because it is critical for surveillance, so we are not saying to avoid total PFAS, but we should also think about whether there are approaches appropriate for new PFAS.
- **Viney Aneja:** I need clarity on why total PFAS is important to this deliberation, considering we cannot measure it entirely?
  - **Kate Lajtha:** The charge question mentions a noncompound specific PFAS. This is a screening tool. The stakeholders have asked for this, which is why we are addressing the total PFAS as a screening.
  - **Gina Solomon:** We do have an entire paragraph in our charge question discussion mentioning why we are focusing on total PFAS. This includes gaps between PFAS tested and the total, volatile organic compounds (VOCs), evaluating technologies that are designed to remove PFAS, and many other reasons. We think there are some useful scientific reasons.
- **Erin Hines:** With the idea of including total PFAS, it is important to realize that locality has an impact on what you want to research. There might be a locality fingerprint, which is why we study total PFAS.
- **Michael Kleinman:** Things are evolving rapidly, and sometimes you might target a specific calcification that could be removed from the stream while something else is added. The total allows you to keep track of the total output of PFAS.

### ***Charge Question 2***

Dr. Jim Stevens reported on Charge Question 2 plenary deliberations. The group still needed to refine and trim the report. The strengths in the research included the integration of the new assessment methodologies. There was rich substrate for supporting the strategy and the suggestions. The group examined the topic of mixtures and discussed how the research fits in with the needs of those who conduct risk assessments. The recommendation discussed how biomonitoring links to the categories. Although categories are useful, ORD could expand PFAS categorization past chemical similarity. Categorizations should consider the needs of the end user as more human health outcome data and exposure situations develop, and how will that fill research gaps.

- **Michael Kleinman:** These proposals are not static, and they can evolve. It also provides EPA a forward-looking perspective on how to keep up with this evolving threat.
- **Leslie Rubin:** There are some breakdowns and elements in the group that have specific health outcomes that will emerge over time. The recommendation I have is to continue with health outcomes research. In addition, make sure to study vulnerable populations and how they are exposed to PFAS. This will enrich our ability to obtain good health outcome data and see the critical elements in PFAS toxicity.
- **Justin Teeguarden:** To make this categorization process more responsive to emerging data and make ORD supportive of more than just toxicity assessments. ORD is already thinking along those lines and is working with the chemistry.

### ***Charge Question 3***

Bart Croes described the deliberations of the group evaluating Charge Question 3 Two concerns they had were the issue of community engagement and whether there might be a role for EPA to conduct more for source reductions. Matthew Naud added that he had spoken with a local nongovernmental organization (NGO), The Great Lakes PFAS Action Network. He mentioned they had a website where they listed best practices for government folks to communicate with affected communities.

- **Monica Schoch-Spana:** In the conceptualization of community engagement, we typically assume place-based communities, but we also need to talk about community engagement from affected community to affected community. Community engagement requires a process of capacity building where people become adept with the technical side but also feel there is mutual understanding and relationships of trust. I recommend we elevate the community engagement strategy to a higher level as opposed to field studies constrained to one place.
  - **Lucinda Johnson:** I think we should have relatively less focus on the place-based community engagement. They want to make sure they have the resources and staff to go into the labor-intensive roles of community engagement.
  - **Monica Schoch-Spana:** I agree, a sort of peer learning could happen.
  - **Kari Cutting:** I was serving on the North Dakota State Emergency Response Commission that met monthly with the local emergency response teams. They

always had an EPA representative at those community meetings. I am thinking that EPA could best serve by placing community champions in the local emergency response groups since communities are going to want to see a familiar face. This could cut down on specific community engagement required.

- **Lucinda Johnson:** Can other EPA staff members speak on the community engagement process?
  - **Susan Burden:** We have been thinking about community engagement on a project-by-project basis.
- **Gina Solomon:** Could you answer how many community engagement staff you have?
  - **Susan Burden:** We communicate with people in our division but also with those in research centers. We also work with regional partners and draw on the relationships they have. We do not have an exact number.
  - **Gina Solomon:** Were you receiving support to conduct community engagement operations? Communication can assist this in one respect, but there are also folks who work separately with environmental justice issues or community engagement specifically. Those two groups are different.
  - **Susan Burden:** Agreed.
- **Lucinda Johnson:** Given that this is a presidential level priority, trying to conduct community engagement on a project-by-project basis seems inefficient, and EPA has been discussing how to elevate the issue and organize on a larger scale. Is this something they are making up as they go?
  - **Susan Burden:** Administrator Regan established the administrative council for PFAS. The function of that council was to think about community engagement across the agency. There are efforts underway, but we are not at the point where we are ready to announce those efforts.
  - **Leslie Rubin:** What Susan described is a fledgling infrastructure for community engagement that needs to be built on, and it seems as though the administrator is ready to invest in that element. Another element Susan mentioned was risk communication, which is a critical part of community engagement. Identifying leadership within communities is critical because partnerships are important to avoid patronization. Also, community science has potential for communities to become more engaged and active.
- **Erin Hines:** There have been community engagement activities in the past with agency representatives visiting various sites throughout the United States. I was a part of the team that went to Fayetteville, and others went to Denver. We had community engagement dialogue in the past that seemed effective because the community was providing feedback about issues.
  - **Lucinda Johnson:** It is of interest to share thoughts about what did and did not work. How do we take the information learned from those experiences and consolidate them into something that informs programmatic and agency-wide activities? Who oversees that?

- **Erin Hines:** That is a great question, and if you have any thoughts or opportunities for guidance, we would be happy to hear them.
- **Lucinda Johnson:** How do we elevate community engagement in the context of our overall group, and are there any other issues that seem important enough to be considered in our discussion?
  - **Gina Solomon:** I was wondering if it would make sense for us to create a subgroup. I heard interest from Monica and Leslie about developing a short supporting statement and recommendations for the group on the community engagement piece. I also want to thank Erin, because the history is helpful. If Erin could brief us a bit more, that would be useful. Justin also proposed in the chat the idea of categorizing or grouping PFAS, and it seems to be crosscutting. We maybe should have a subgroup on that.
- **Lucinda Johnson:** I recall Jim also proposed that concept of integration across different programmatic areas associated with PFAS. How much communication across research programs is there, and how does that communication occur?
  - **Susan Burden:** There are a couple of ways this occurs. One is through their normal professional relationships, and the other is routine meetings where folks from across research centers come together. There are formal and informal ways of communication.
  - **Justin Teegarden:** Thank you, Jim and Gina. I appreciate your aspirations. If EPA wants to benefit from the products Jim and Gina are leaning into, it has to be a stated priority and they need a plan.
  - **Jim Stevens:** Leveraging what Justin just said, boards have the function to support the group. They have fiduciary responsibility to be constructively critical and to analyze plans laid out by groups they are responsible for overseeing, but an equally important function is to be supportive of the group. I agree with Justin, and I think this must be something we need to raise to a higher level than ORD. If EPA as a whole does not take on communication challenges, it hinders the scientist's ability to produce data that allows us to make good risk-based decisions at a community level. I think it is a good idea to create a subgroup include an introductory section for the report that states something like, "In order for these plans to be successful, the following crosscutting issues need to be considered at the level of recommendation, given the presidential level concern of PFAS. Integration is important for scientists, and the strategy EPA communicates to the communities in need must be integrated at a higher level than ORD". Lucinda and Paul, as chairs of the BOSC, this is something you could organize.
- **Lucinda Johnson:** I appreciate the conversation and the need to tackle these high-level issues. As BOSC, our job is to focus on the activities and the programs of ORD. It is not in our purview to make direct recommendations for the whole agency. I do think we have an opportunity to frame our recommendations at ORD to be considered at the level of the entire agency.

- **Paul Gilman:** I agree. We can frame up recommendations to ORD that speak beyond it without presuming that we are telling people what they ought to do. We are just making observation recommendations.
- **Jim Stevens:** That will help make the recommendations successful.
- **Justin Teeguarden:** My only comment is that I am supportive of what has been said.
- **Lucinda Johnson:** Paul and I can have a chat while you are in breakout sessions and develop a strategy. The issue of program integration and community classification are important crosscutting issues. The issue of classification does not feel as important and broad or far-ranging as the other two issues. I was wondering if we could agree to keep the comments about the classification issues in the charge question to where it currently resides. I will only ask folks from Charge Question groups 1 and 2 to read their comments.
- **Jim Stevens:** I agree. What if we go ahead and make our comments about classification, and then once we complete the individual sections we can see if we can incorporate those into the charge question.
- **Lucinda Johnson:** As a reminder to everyone, you should all have access to the three charge question reports.

### Breakout Groups

Notes were not taken for breakout groups.

### Resolution on the Recommendations

Participants discussed the recommended resolutions.

- **Paul Gilman:** We had some crosscutting themes, so I think that this is old ground, and we are not breaking new ground.
  - **Lucinda Johnson:** I had a sense that there was discomfort with that, but I am completely comfortable with elevating the process by which the organization is directing community engagement and communicating through the overall PFAS program.

Dr. Monica Schoch-Spana presented text from Charge Question 3 that emphasized community engagement. Dr. Gina Solomon noted that community engagement was also discussed in the Charge Question 1 breakout session. Dr. Johnson noted that the group wanted to put together one template that deals with community engagement and another with integration and move relevant text from the charge questions to these documents. Dr. Johnson noted that the group would set up another call and includesuggestions and recommendations for these templates.

- **Gina Solomon:** Who is going to be in the subgroup? I want to capture the discussions this week and run a draft the following week.
  - **Lucinda Johnson:** We can do that. Let us work on the draft online. We have a follow-up meeting on the 20<sup>th</sup>. Is there a possibility to meet on Friday the 15<sup>th</sup>?
  - The participants agreed that they would follow up on Friday, October 15<sup>th</sup>.



- **Gina Solomon:** I am not sure whether we should eliminate text from Charge Question 3. We can add some overarching language in the introduction instead.
  - o **Lucinda Johnson:** Monica's suggestion to create a community of practice is overarching. Try to make something specific to work the overarching section.
- **Gina Solomon:** In Jim's proposal, he discussed overarching language in the report. Is our subgroup in charge of writing that or just writing on the community engagement aspect?
  - o **Lucinda Johnson:** You should focus on the community engagement piece, and some of us will contribute to the integration description.

Dr. Johnson noted that on the topic of integration, the group would focus on ORD.

- **Paul Gilman:** You need someone to exercise what has been written and what is to be considered.
- **Lucinda Johnson:** Unlike community engagement, integration did not fall into any of the charge questions and was more of an observation. It called for an organized approach for highlighting the information flow within the subcomponents across the program. This led to realizing it was an overarching issue. It would have helped to include a conceptual diagram of how the pieces of the program fit together. Given the history of the PFAS issue, it would be surprising if there was no conceptual diagram of how the pieces and issues fit in with one another.
  - o **Susan Burden:** There is no such diagram available. That is not to say that we have not thought about it. We do not have anything available that has mapped it out the way you are looking at it.
  - o **Justin Teeguarden:** I think that the overview you suggested is a great first step. In the end we need to have individuals within the programs who are responsible and accountable for integration and making it happen. These individuals need to write out some outcomes that can be measured and hold themselves accountable for a goal in those elements. I am comfortable that this team could articulate the value proposition for integration.
  - o **Susan Burden:** The PFAS work shows up within grants and documents developed for the research programs. There is an overlap and matrix where some of that work is in different parts of the research programs, but do not cross or overlap with other various aspects.
  - o **Justin Teeguarden:** Is there anything preventing you from putting together some PFAS research strategy?
  - o **Susan Burden:** No.
  - o **Justin Teeguarden:** I think you would have to be careful, because the various divisions might reject this.
- **Lucinda Johnson:** Where can we find those documents if they are available to us?
  - o **Susan Burden:** We do not have anything that we have shared publicly. I think what is most helpful is thinking about what mechanisms to put in place to integrate. If you think that having a document is helpful, then that would be one way to do it. If there could be other ways to do it, it would also be good to know.

- o **Justin Teeguarden:** The document is just a starting point. Until you articulate a clear strategy and roadmap of how to implement these strategies, then nothing can happen.
  - o **Susan Burden:** How do we take the different decision contexts and establish a program that is integrated in a way that still meets partner needs?
  - o **Justin Teeguarden:** Strategy is based on drivers. You need to figure out what is the priority.
  - o **Susan Burden:** Given the overall priority of PFAS, there are a lot of priorities that we are trying to meet.
- **Lucinda Johnson:** There are so many opportunities for amplifying the lessons learned and taking advantage of the good science that is happening and ensuring that it is incorporated as a priority. To what extent does it happen now, and how can we help improve the process?
  - o **Susan Burden:** Identify the most specific and important opportunities that you see. Issuing a good reminder would provide the most value moving forward.
  - o **Jim Stevens:** That input needs to be supported at a higher level in EPA, and the information must be filtered through the programs so the resources can be given to these rapidly evolving problems.
  - o **Susan Burden:** We have different approaches to detect PFAS in the environment, but we are struggling with the hazards of these PFAS. That is why we have a broader effort to understand the chemical space. We know that the chemical-by-chemical approach is not efficient enough to make decisions.
- **Jim Stevens:** We are trying to understand how best to support ORD in making sure that their products have the impact they want to have.
  - o **Lucinda Johnson:** I think it is critical that the research has proper communication. If that does not happen, the research needs to be informed by the programs. Fundamentally even below that, the individual research programs need to be integrated and inform one another.
  - o **Jim Stevens:** We could point out that we agree with the way ORD has designed the research strategy to produce these categories. We can say that the output is a hazard identification for entire classes of compounds that might not be tested. This requires integration and understanding of these assessments and how they can be used by the program offices. The goal of the research is to create categories, which will require changes in how program offices make decisions.
  - o **Lucinda Johnson:** I suggest that Jim and Justin work on a template for the rationale and what we think and follow the templates used in the past and propose some text and circle back.

## Concluding Plenary

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

There was no concluding plenary.

## Adjourn

The meeting adjourned.

## Wednesday, October 20, 2021

The meeting generally followed the issues and timing as presented in the agenda provided in Appendix A of this meeting summary.

## Convene Meeting

The meeting convened at approximately 11:00 a.m., Eastern Time.

## Welcome and Opening Remarks

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*  
*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Mr. Tom Tracy opened the meeting and welcomed all participants. Please see Appendix B: Participants for the full list of meeting attendees.

## Progress Report

Dr. Susan Burden announced EPA released a [strategic road map](#) on Monday, October 18<sup>th</sup>, 2021. It contains EPA's approach to addressing PFAS in air, land, and water. EPA also released its [national PFAS testing strategy](#). The document describes the approach EPA is taking to issue test orders for toxicity testing.

- **Kari Cutting:** I think these documents are pertinent to our discussion. I find this useful to fill in the blanks, especially for charge question one.
- **Viney Aneja:** Environmental Science and Technology recently published a recent paper about PFAS in indoor air. Does EPA have any thoughts on how to address this issue?
  - **Susan Burden:** EPA is aware of different consumer products that are in the home. In ORD, we are evaluating this through our exposure work. In addition to drinking water and food, we are studying other pathways.
  - **Viney Aneja:** How does policy impact the already made efforts?
  - **Susan Burden:** I will not speak on policy decisions, because this is a meeting about EPA's Research and Development. One way to view it is for the committee is to ask whether there is a place where you might want to provide a perspective on what ORD might do or how we might use our science to better understand indoor air.
  - **Tim Watkins:** I would add EPA does have a research effort on vapor intrusion, which might have implications for indoor air.
- **Rainer Lohmann:** How do the documents impact ORD efforts?
  - **Susan Burden:** As we see developments, it helps ORD pivot our direction as we move forward.
- **Jim Stevens:** Who were the authors of the national testing strategies document?
  - **Susan Burden:** It would be ORD and the Office of Chemical Safety and Pollution Prevention (OCSPP) that created the document.

- **Jim Stevens:** If it is a strong document with ORD, I did not see much of this in the presentation, but it touches the topics we are describing.
- **Susan Burden:** There were elements of Rusty's presentation that mirror the document.
- **Jim Stevens:** I am looking at this section of flow schemes that arrives at a list of 24 chemicals for which EPA feels it can make recommendations for additional testing.
- **Susan Burden:** That was a section that was not ready to be discussed during the BOSC meeting in September 2021.
- **Lucinda Johnson:** I am aware of the ecotox work taking place in the Duluth Lab. Does that testing strategy articulate how the ecotox work is interfacing with the mammalian testing and the overall strategy?
  - **Susan Burden:** I do not know if the document speaks directly to that and will have to review it.
- **Kari Cutting:** We did not receive full information because we had five-minute presentations. I want to review the documents before we conclude our response to the three charge questions.
  - **Lucinda Johnson:** I agree, especially with the classification. Does that mean we need to reconvene that group?
  - **Tom Tracy:** If we need to reconvene more people, that would be less than 50 percent of participants, then we can do that. If it is a whole group deliberation, it is a public meeting, and I would need to register it.
  - **Lucinda Johnson:** How about we have BOSC workgroup meetings for Charge Question 2?
  - **Tom Tracy:** That would be fine, but if we all must meet, it would take another month to set up, and I do not think we want to extend deliberations.
  - **Paul Gilman:** I agree, if workgroup two can receive a briefing and incorporate the new information into the report, that would be great. If others want to include more information secondarily, we can set that up.
  - **Jim Stevens:** I do not agree. I do not feel comfortable including the two documents on behalf of the committee.
  - **Paul Gilman:** What you come up with can be considered by the whole group, who can modify and correct.
  - **Jim Stevens:** I do not feel comfortable with that. I advocate we do the best job, regardless of the timeframe, and I do believe this data is important for our deliberations.
  - **Paula Olsiewski:** I commend EPA for issuing these documents, and the timing is unfortunate. Given these deliberations, the documents will be relevant to our final report for Charge Question 1. How soon do we need to have this out is important, but it seems to me that everything I do in EPA is in the public's eye. We have a dedicated group trying to make important decisions, and this additional information will help us.

- **Viney Aneja:** I agree, and I am a bit concerned that EPA knew for some time that indoor air is important, but it was not mentioned in our meetings. In the morning when I reread Charge Question 3, I inserted indoor air in the document. I believe we need more time and clarity from EPA.
- **Gina Solomon:** I think we should move ahead, but it might not be feasible due to our disagreement. The first document is quite general and broad. It will be useful for context, but it will not substantially change our recommendations for ORD. The main issue is to comment on the categories EPA has come up with in the second document. I also understand the frustrations of not being given an advance briefing on this, but this is taking place in public meetings. We need to move on with our work and incorporate this as best we can.
- **Lucinda Johnson:** Could we take a week to digest the report and review the Charge Question 2 report and then convene by email on whether the Charge Question 2 issues are addressed adequately?
- **Tom Tracy:** If you are asking people to read the document and provide documents that the workgroup can take up, that is okay. If we are sending emails to everyone and sending the document, that gets into a grey area we should avoid. Could you elaborate?
- **Lucinda Johnson:** I think we should read the document and go into the SharePoint site and provide comments for the Charge Question 2 document. I am suggesting we use the next week to review the national testing report and then review the Charge Question 2 document and provide comments to the charge question group and reactions to the report.
- **Jim Stevens:** Given I am in the Charge Question 2 group, I am reluctant to have responsibility for editing the document for the committee. I prefer we take the next week to digest the document and testing strategy and give our committee a week to finish our Charge Question 2 document.
- **Lucinda Johnson:** Ok. Let us amend this instruction. How much time do you need?
- **Jim Stevens:** I would appreciate support from Tom and Paul to arrange a meeting. We might need more than a week.
- **Lucinda Johnson:** I suggest we plan to have the rest of the committee read the Charge Question 2 report by November 3<sup>rd</sup>. That provides you two weeks. Tom, can you select a date for the whole committee to meet? We are going to have to meet as a group anyway for a final deliberation. Please start working on finding us a date for another full committee meeting. If we can arrive at a consensus for Charge Question 2 by providing comments, that will help the whole committee achieve a consensus. Paul, does that make sense to you?
- **Paul Gilman:** I think it does.
- **Tom Tracy:** I will poll for three Executive Committee (EC) meeting dates a month from now, but that puts us around Thanksgiving. I then will poll for

- finalizing the PFAS report and the subcommittee meeting. That provides us flexibility. It would push us out to complete this in December at the earliest.
- **Lucinda Johnson:** Could you arrange a meeting before Thanksgiving, and then we hold the EC meetings after that? We have folks involved in the discussion who are not formally apart of the EC. I wish to maintain this group as an intact group.
  - **Rainer Lohmann:** I think my Charge Question 1 group would like to reconsider and update accordingly based on the documents.
  - **Lucinda Johnson:** Absolutely, that makes sense for your question.

## Plenary Session

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

### **Charge Question 1**

Dr. Paula Olsiewski summarized discussions about Charge Question 1, stating they did not finalize recommendations but made good progress. They needed to review provided materials because they struggled with terms. They recommend EPA invest in research and development optimizing suspect screening analysis (SSA) and Non Targeted Analysis (NTA) methods for PFAS. In addition to continuing to measure individual PFAS and “total PFAS,” EPA should evaluate the value of developing methods for “groups” of PFAS reflecting characteristics of potential importance to other aspects of the EPA PFAS program and to other stakeholders, and if warranted, invest in development of said methods. Finally, they recommend increased focus on methods development for measuring PFAS in air and strengthening links between research groups developing methods across environmental media.

- **Lucinda Johnson:** Do any parts of these recommendations include activities that are already occurring? There is work that is already ongoing in screening analysis. How does this recommendation augment ongoing activities?
  - **Paula Olsiewski:** We were developing a way to say that we need methods that are faster and cheaper in the first recommendation.
  - **Lucinda Johnson:** Maybe you could be more direct.
  - **Paula Olsiewski:** We had a discussion on this, and one of our concerns was giving EPA enough leeway to accomplish what is needed.
  - **Lucinda Johnson:** I want to make sure our recommendations are enhancing action or is a new action.
  - **Paul Gilman:** We will deliberate more, and I appreciate your point.
  - **Lucinda Johnson:** I have the same comment for the second recommendation.
- **Gina Solomon:** For the first recommendation we were trying to bring up the scale. The second recommendation will be changed by the EPA reports. We were saying that they should examine categories and subgroups.
- **Michael Kleinman:** It would be good to recommend additional efforts to include in high throughput analytical techniques.
  - **Paula Olsiewski:** Thanks, we will discuss it.



### ***Charge Question 2***

Dr. Jim Stevens reviewed the work for Charge Question 2. They currently have six recommendations but will cut it down. Their work highlighted the mixture issues, how to distinguish a compound from a class categorization, and how categorization and tier testing strategies help with mixtures. They also made recommendations on making quantitative structure activity relationship decisions. Dr. Tim Verslycke added it would be good to have a clear understanding of end uses of the data generated to avoid strategies that have no toxicological relevance.

- **Tim Verslycke:** We now have two additional documents. Who is the author? Some of this might not be purely ORD, so I am trying to understand to what extent we can draw from these documents.
  - **Lucinda Johnson:** It is not always possible to separate programmatic from ORD content, but please try your best to focus on research.

### ***Charge Question 3***

Mr. Bart Croes noted that Charge Question 3 group members agreed on their recommendations and only had a few edits remaining. He was impressed with EPA's PFAS strategy but added that the Agency should focus more on source reduction rather than just remediation.

### ***Discussion***

- **Lucinda Johnson:** A small group of BOSC members convened to address the issue of integration. We have one recommendation but two different options for how to word it. First, ORD should articulate a strategy and develop a roadmap that demonstrates how research supports regulatory decision release and how regulatory decisions are addressed across research programs, including communication strategies that ensure that priorities are informed by results from individual programs. It was unclear whether formal strategies for ensuring there is communication across different research programs were used. A second way to phrase this recommendation is that ORD should create a plan to integrate results from PFAS research programs into evolving program strategies and priorities. We want to know how the research informs the program's priorities and research strategies.
  - **Justin Teeguarden:** Your suggestions look good. My version was that ORD should articulate and implement a strategy and roadmap for improved integration and coordination across the research program elements (analytical methods, toxicity and hazard testing, and environmental remediation) that assures research products are most effectively and efficiently used to support regulatory decisions and assures that each research area is evolving and benefiting in response to findings in the other research areas.
  - **Paula Olsiewski:** It is important that different research groups communicate. Part of our recommendation in Charge Question 1 covers this.
  - **Lucinda Johnson:** Given the complexity of this issue, there needs to be a specific strategy and set of defined tactics.

- **Rainier Lohmann:** The next round of ORD's research is probably informed by research they have already accomplished.
- **Lucinda Johnson:** The programs inform research priorities for ORD, but the tactics for how that happens is unclear.
- **Paul Gilman:** There are lag times in program development, knowledge, and feedback. We need a framework for real-time relationships not just a biannual discussion to talk high-level research priorities.
- **Monica Schoch-Spana:** We had three main points about community engagement. First, community engagement and citizen science can strengthen research in support of the PFAS research enterprise. Second, there is a record of ORD holding PFAS listening sessions in a variety of locales. Our committee encourages ORD to continue in that vein and build trust with communities. Third, we urge ORD, with support from EPA, to move away from engaging with one community at a time to a centrally coordinated, multi-site model of community engagement.
  - **Gina Solomon:** These recommendations were designed with EPA in mind, not just ORD, so our BOSC report will go to the EPA administration. ORD needs support from the top of the Agency to implement these technologies effectively in communities and should not be doing this alone.
  - **Monica Schoch-Spana:** We have three recommendations. First, EPA public participation experts should support ORD engagement with local communities to ensure that new measurement and remediation methods for PFAS can be tested quickly under field conditions. Second, ORD should develop a community of practice among the communities where field or pilot studies are being deployed to allow for local exchange of best practices to inform advanced planning and outcomes. Third, ORD should facilitate peer-to-peer exchanges between different PFAS field study sites so there is collective learning and collective trust building between the communities. Then, EPA can apply the lessons learned to future field studies and more broadly implement successful treatment and remediation programs. We want to combine our second and third recommendations.
  - **Gina Solomon:** Some guidance would be helpful.
  - **Lucinda Johnson:** I do not have a strong opinion. If we present this as similar to the charge questions, then it will be elevated to the level that I think it deserves.
  - **Paul Gilman:** I agree. We could highlight a recommendation in the text in a paragraph before the charge questions.
  - **Gina Solomon:** We will condense our content, focus on our two main recommendations, and present them at the end of the introductory paragraph.
  - **Lucinda Johnson:** You already have a strong narrative. You could go right from the narrative to your suggestions.
- **Jim Stevens:** The National Testing Strategy document has categories, then identifies categories for which there is no safety data, then nominates candidate molecules from 56 of the 74 categories – some of which have no safety data – and then asks manufacturers to provide more testing information. Does this document encompass the ORD tiered

testing strategy discussed during the presentations and the ask to manufacturers, or is the document only designed to address what is needed from the manufacturers?

- **Susan Burden:** The National Testing Strategy document is targeted more towards how EPA will generate toxicity data and use that data to help refine the initial, structural-based categories to prioritize PFAS categories for hazard assessment. The information that the Agency requests from manufacturers would go into this set of data.
- **Jim Stevens:** To clarify, ORD will be testing and gathering data using the tiered toxicity testing strategy as it was outlined in the presentations to categorize hazards of more than one member of each category.
- **Susan Burden:** Yes, and then that information will feed into the National Testing Strategy. We are asking manufacturers to potentially collect additional data. We should consider the National Testing Strategy document as the vehicle for which hazard identification data will impact regulatory decisions. It can also be used outside of that context for decision making.
- **Jim Stevens:** You might characterize the safety of categories, but then those categories do not overlap with the chemical mixtures, exposures, and hazards occurring in real-time. This seems outside the scope of the National Testing Strategy document, so how do you account for this?
- **Susan Burden:** That is correct. The strategic roadmap that the Agency released on Monday briefly describes EPA's desire to move away from a biochemical approach to using PFAS categories for decision making purposes. Instead, the document describes at a high-level how EPA will first try to develop categories for hazard assessment based on toxicity data. EPA will also develop categories based on what we know about treatment and removal technologies.
- **Jim Stevens:** That is helpful. To probe further, on one hand the National Testing Strategy document identifies specific compounds that need further testing. In addition, a category of PFAS could be declared high risk based on the internal tiered testing strategy and safety decisions could be made based on that data alone. What additional testing would be needed as per the National Testing Strategy document for those candidate members?
- **Susan Burden:** It depends on what the category is, where we think the exposure is, and the decision the agency faces.
- **Jim Stevens:** On a case-by-case basis, EPA could make a decision, either based on data from the National Testing Strategy for a particular compound or based on the perceived risk of an entire category of chemicals from the hazard identification and hazard assessment work done for the tiered testing strategy.
- **Susan Burden:** Yes, we must be flexible and adapt to different decision contexts.
- **Tim Watkins:** We are still missing a lot of information, so we will use both in-house data and data we request from industry to fill in the gaps and inform hazard-based categories.

- **Jim Stevens:** Yes, I understand. The confusion was about whether the National Testing Strategy was the only way to make a safety decision, but now I understand that it is case- dependent. The Agency cannot commit to what it will do in a given situation before the situation arises, because it is a case-by-case basis. BOSC recognizes the enormous challenge EPA is facing, so please take all of our questions and recommendations as constructive input.
- **Lucinda Johnson:** I echo that. Our action items are to read EPA's two reports. BOSC members responsible for Charge Question 2 will finalize their recommendations in the next two weeks.

### **Breakout Groups**

Notes were not taken for breakout groups.

### **Adjourn**

The meeting adjourned.

### **Tuesday, November 23, 2021**

The meeting generally followed the issues and timing as presented in the agenda provided in Appendix A of this meeting summary.

### **Convene Meeting**

The meeting convened at approximately 11:00 a.m., Eastern Time.

### **Welcome, Opening Remarks and Member Introductions**

*Tom Tracy, Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*  
*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

Dr. Lucinda Johnson opened the meeting and welcomed all participants, noting the meeting would consist of a plenary session followed by breakout sessions. She stated development of drafts is progressing and noted everyone will have a chance to review the final report. She indicated a final meeting may take place on December 8. She asked team leaders if they needed room for breakout sessions. Charge Question 1 and 2 groups replied their discussions were complete and awaiting comments. Charge Question 3 group requested 10-15 minutes for discussion.

### **Plenary Session**

*Lucinda Johnson, Vice Chair, BOSC Executive Committee*

### ***Charge Question 1 Suggestions and Recommendations***

Dr. Paula Olsiewski noted they received informative comments from attendees and BOSC members and summarized Charge Question 1 group's progress. They focused on developing new, actionable suggestions and recommendations. They recommend continuing to increase the applicability and value of non-target analysis (NTA) and suspect screening analysis (SSA) across EPA programs and increasing efforts to expand throughput and lower costs while maintaining data quality. They also recommend increasing focus on methods development for measuring

PFAS in air and strengthening links between research groups developing methods across environmental media. They noticed they previously mentioned EPA instead of ORD in the draft document and corrected the text. Their recommendations have changed little.

- **Paula Olsiewski:** There are many suggestions on the topic of NADP national atmospheric standards for capturing air concentrations. Do any members want to add reflections or recommendations about this?
  - **Jim Stevens:** Each suggestion should include specific BOSC recommendations to ensure consistency across the document.
  - **Paula Olsiewski:** I will include such edits.
  - **Lucinda Johnson:** We do not need to state BOSC suggestions for every bullet.

### ***Charge Question 2 Suggestions and Recommendations***

Jim Stevens summarized Charge Question 2 group's discussions of the human health effects of PFAS. They noticed their efforts were unclear in coordinating with the other charge questions and issues and wondered about the intersection between testing and risk-based assessments. They noted real-world data determine the testing of substances and real-world exposures are likely to be mixed exposures, which the ORD road map addresses. The success of PFAS programs depends on the standardization and validation of NAMs. They want to emphasize the goal of supporting the broadest range of decision-making contexts. Their suggestions generally include increasing the emphasis on real chemical mixtures and exposures and ensuring included assays are appropriate for real-world assessment and incorporate biostatistical support. Their two specific recommendations are to formulate better how PFAS research outcomes will support end users and to prioritize validation and standardization of NAM tests. They believe the draft document is ready for review by the rest of the committee.

- **Lucinda Johnson:** You all did a commendable job summarizing complicated issues.
  - **Bart Croes:** We suggest studying ecosystem level impacts. Is that something you would consider adding to the write-up?
  - **Jim Stevens:** We could add it.
  - **Tim Verslycke:** Ecosystem toxicity also.
  - **Lucinda Johnson:** I noticed the focus has been on human health and the categorization of compounds relative to human health and toxicity. There is already a lot of research on ecotoxicity using non-human testing. I am unsure know where this would fit in with the different charge questions.
  - **Michael Kleinman:** We could include it under the first bullet. We also could consider it for the future as a suggestion, because it is an important narrative.

### ***Charge Question 3 Suggestions and Recommendations***

Bart Croes summarized Charge Question 3 group's progress, noting they added a narrative summary to the text today. They did not edit their recommendations, which include facilitating peer exchanges at sites to ensure cross community learning and increasing source reduction work.

- **Monica Schoch:** Gaining local knowledge and community trust are critically important to PFAS research. This set of comments talks about the role of the community. The

recommendations hinge on two things: ORD scientists cannot do this research on their own and require broader agency help to support scientists when they reach out to communities. The second point articulates that the Agency should support the development of a larger structure for community engagement at remediation sites. It is important social learning takes place so everyone the research is inclusive.

- **Lucinda Johnson:** I think it would be useful to define community in the document. We should also insert language regarding working with stakeholders.

### **Charge Question: Integration**

- **Lucinda Johnson:** We have talked about how this is a complicated set of research problems. The ecotox portion of the program is also embedded in the overall strategy. We felt there may be missed opportunities to accelerate resolution across research programs. We explicitly want to develop a strategy allowing ORD and the Agency to trade information and ensure efficient use of research projects.
  - **Michael Kleinman:** I note there is no long-term integrative process for analyzing effectiveness.
  - **Paula Olsiewski:** Perhaps we should add a recommendation.
- **Lucinda Johnson:** As next steps everyone should include their recommendations in the document. By December 1, have the composite document ready to distribute to BOSC and then submit any comments by December 8. We will then make sure everyone agrees with the document text before submission.
  - **Jim Stevens:** Do you want comments resolved before submitting the final document?
  - **Lucinda Johnson:** Yes. Include final edits by December 1.
  - **Tom Tracy:** Will we cancel the December 8 meeting?
  - **Lucinda Johnson:** Not yet. We will keep the date as a placeholder in case we need to meet again.

### **Adjourn**

The meeting adjourned at 12:28 p.m. Eastern Time.



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**Appendix A: Agenda**

**United States Environmental Protection Agency**  
**Board of Scientific Counselors (BOSC)**  
**Executive Committee PFAS Meeting**  
Meeting Agenda  
September 29–30, October 8, October 20, and November 23, 2021  
Virtual

**Day 1: Wednesday, September 29, 2021, Eastern Daylight Time**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
12:00 – 12:15	Welcome, Opening Remarks and Member Introductions	<b>Tom Tracy</b> , Designated Federal Officer (DFO)  <b>Lucinda Johnson</b> , BOSC Executive Committee (EC) Vice Chair
12:15 – 12:30	ORD Welcome	<b>Chris Frey</b> , Office of Research and Development (ORD) Deputy Assistant Administrator (DAA) for Science Policy
12:30 – 12:45	Overview of Charge Questions and Meeting Format	<b>Susan Burden</b> , Scientific Support Advisor and PFAS Executive Lead, ORD
	<b>PFAS Overview</b>	
12:45 – 13:00	An Introduction to PFAS	<b>Tim Watkins</b> , Director, EPA Center for Environmental Measurement and Modeling (CEMM)
13:00 – 13:15	ORD's PFAS Research and Development Portfolio	<b>Susan Burden</b> , ORD
	<b>Charge Question 1 – Total PFAS Methods</b>	
13:15 – 13:30	Analytical Methods Overview	<b>Chris Impellitteri</b> , Associate National Program Director, Safe and Sustainable Water Resources Research Program

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<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
13:30 – 13:45	“Total PHAS” Methods	<b>Alice Gilliland</b> , Deputy Directory, CEMM
13:45 – 14:45	<b>Charge Question 1 – Breakout Rooms</b>	
	<b>Breakout Room 1 – Water Methods</b> Analytical methods for PFAS measurement in environmental samples (aqueous) Analytical method for PFAS in environmental media: CWA-1633 Non-targeted analysis of water Development of absorbable organic fluorine screening method with detection by combustion ion chromatography	<b>Jim Voit</b> , Chemist, Center for Environmental Solutions and Emergency Response (CESER) <b>Marc Mills</b> , Environmental Engineer, ORD <b>James McCord</b> , Chemist, CEMM <b>Jody Shoemaker</b> , Chemist, EPA Exposure Methods and Measurement Division
	<b>Breakout Room 2 – Air Methods</b> Other Test Method 45 (OTM-45) Additional source air methods under development Wet deposition of PFAS Total organic fluorine analysis for PFAS in air	<b>Lara Phelps</b> , Senior Advisor, EPA Office of the Science Advisor <b>Lara Phelps</b> , Senior Advisor, EPA Office of the Science Advisor <b>John Offenberg</b> , Senior Research Chemist, EPA Exposure Methods and Measurements Division <b>Hannah Liberatore</b> , Physical Scientist, CEMM
14:45 – 14:55	<b>Break</b>	
14:55 – 15:15	<b>Clarifying Questions on Charge Question 1 Content</b>	<b>Lucinda Johnson</b> , BOSC EC Vice Chair
	<b>Charge Question 2 – Human Health Effects</b>	
15:15 – 15:30	Overview: Human Health Effects Research	<b>Annette Guiseppi-Elie</b> , Associate Director for Science,

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Time	Topic	Speaker
		Center for Computational Toxicology and Exposure
15:30 – 15:45	ORD's Tiered Toxicity Testing Strategy for PFAS	<b>Rusty Thomas</b> , Director, EPA Center for Computational Toxicology & Exposure (CCTE)
15:45 – 16:40	<b>Charge Question 2 – Breakout Rooms</b>	
	<b>Breakout Room 1 – Toxicity Testing</b> New approach methods – toxicity New approach methods – toxicokinetics <i>In vivo</i> toxicity testing PFAS and multimorbidity: Using electronic health records to probe systemic effects	<b>Richard Judson</b> , Research Chemist, CCTE <b>Barbara Wetmore</b> , Toxicologist, CCTE <b>Justin Conley</b> , Reproductive Systems Biologist, ORD <b>Cavin Ward-Caviness</b> , Computational Biologist, EPA Public Health and Integrated Toxicology Division
	<b>Breakout Room 2 – Assessments</b> Human health toxicity assessment for PFBS Draft IRIS assessments for PFBA, PFHxA, PFDA, PFHxS, PFNA, and their related salts Systematic evidence maps to characterize available evidence for 9000 PFAS	<b>Beth Owens</b> , Assistant Director, EPA Health and Environmental Risk Assessment <b>Andrew Kraft</b> , Biologist, EPA National Center for Environmental Assessment <b>Kris Thayer</b> , Director, EPA Chemical and Pollutant Assessment Division
16:40 – 17:00	<b>Clarifying Questions on Charge Question 2 Content</b>	<b>Lucinda Johnson</b> , BOSC EC Vice Chair
17:00 – 18:00	BOSC Executive Committee Deliberations	<b>Lucinda Johnson</b> , BOSC EC Vice Chair
18:00	Adjourn	

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**Day 2: Thursday, September 30, 2021, Eastern Daylight Time**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
12:00 – 12:15	Welcome Back	<b>Tom Tracy</b> , Designated Federal Officer (DFO)  <b>Lucinda Johnson</b> , BOSC Executive Committee (EC) Vice Chair
	<b>Charge Question 3 – Treatment Field Studies</b>	
12:15 – 12:30	Overview: PFAS Treatment and Destruction Research	<b>Greg Sayles</b> , CESER
12:30 – 12:45	EPA PFAS Innovative Treatment Team Findings on PFAS Destruction Technologies	<b>Tim Watkins</b> , Director, CEMM
12:45 – 13:45	<b>Charge Question 3 – Breakout Rooms</b>	
	<b>Breakout Room 1 – Bench- and Pilot-Scale Studies</b>  Drinking water treatment Thermal treatment of PFAS Non-combustion technologies for PFAS destruction Mechanochemical destruction of PFAS	<b>Tom Speth</b> , Associate Director, CESER  <b>Bill Linak</b> , Chemical Engineer, National Risk Management Research Laboratory Air and Energy Management Division  <b>Max Krause</b> , Environmental Engineer, ORD  <b>Erin Shields</b> , CEMM
	<b>Breakout Room 2 – Field Studies</b>  Waste management Land application of biosolids Field-scale thermal treatment Source characterization	<b>Thabet Tolaymat</b> , Environmental Engineer, CESER  <b>Kirk Scheckel</b> , Division Director, EPA Land Remediation & Technology Division  <b>Phillip Potter</b> , CESER  <b>Marc Mills</b> , ORD

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<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
13:45 – 14:05	<b>Clarifying Questions on Charge Question 3 Content</b>	<b>Lucinda Johnson</b> , BOSC EC Vice Chair
14:05 – 14:20	<b>ORD Wrap-up Presentation</b>	<b>Susan Burden</b> , ORD
14:20 – 14:30	Break	
14:30 – 15:00	Public Comment	<b>Tom Tracy</b> , DFO
15:00 – 17:00	BOSC Executive Committee Deliberations	<b>Lucinda Johnson</b> , BOSC EC Vice Chair
17:00	Adjourn	

**Day 3: Friday, October 8, 2021, Eastern Daylight Time**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
11:00 – 14:00	Committee Worktime	

**Day 4: Wednesday, October 20, 2021, Eastern Daylight Time**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
11:00 – 14:00	Committee Worktime	

**Day 5: Tuesday, November 23, 2021, Eastern Daylight Time**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
11:00 – 12:30	Committee Worktime	

**Appendix B: Participants**

**BOSC Executive Committee Members:**

Paul Gilman, Chair  
Lucinda Johnson, Vice Chair  
Viney Aneja  
Shahid Chaudhry  
Kari Cutting  
Courtney Flint  
Charlette Geffen  
Matthew Naud  
Paula Olsiewski  
Joseph Rodricks  
Leslie Rubin  
Sandra Smith  
James Stevens  
Justin Teegarden  
Katrina Waters

**BOSC Air, Climate, and Energy Subcommittee Members:**

Bart Croes  
Michael Kleinman  
Louie Rivers III  
Annette Rohr

**BOSC Chemical Safety for Sustainability and Health and Environmental Risk Assessment Subcommittee Members:**

Richard Becker  
Chris Gennings  
Gina Solomon  
Jennifer McPartland

**BOSC Homeland Security Subcommittee Members:**

Monica Schoch-Spana

**BOSC Safe and Sustainable Water Resources Subcommittee Members:**

Steve Carr  
Kate Lajtha  
Michelle Lorah  
Tim Verslycke  
Stephen Weisberg



**BOSC Sustainable and Healthy Communities Subcommittee Members:**

James Kelly  
Rainer Lohmann  
Barret Ristroph

**EPA Designated Federal Official (DFO):** Tom Tracy, *Office of Research and Development*

**EPA Presenters:**

Susan Burden, *Scientific Support Advisor and PFAS Executive Lead, Office of Research and Development*  
Justin Conley, *Reproductive Systems Biologist, Office of Research and Development*  
Chris Frey, *Deputy Assistant Administrator for Science Policy, Office of Research and Development*  
Alice Gilliland, *Deputy Directory, Center for Environmental Measurement and Modeling*  
Annette Guiseppi-Elie, *Associate Director for Science, Center for Computational Toxicology and Exposure*  
Chris Impellitteri, *Associate National Program Director, Safe and Sustainable Water Resources Research Program*  
Richard Judson, *Research Chemist, Center for Computational Toxicology and Exposure*  
Andrew Kraft, *Biologist, National Center for Environmental Assessment*  
Max Krause, *Environmental Engineer, Office of Research and Development*  
Hannah Liberatore, *Physical Scientist, Center for Environmental Measurement and Modeling*  
Bill Linak, *Chemical Engineer, National Risk Management Research Laboratory Air and Energy Management Division*  
James McCord, *Chemist, Center for Environmental Measurement and Modeling*  
Marc Mills, *Environmental Engineer, Office of Research and Development*  
John Offenberg, *Senior Research Chemist, Exposure Methods and Measurements Division*  
Beth Owens, *Assistant Director, Health and Environmental Risk Assessment*  
Lara Phelps, *Senior Advisor, Office of the Science Advisor*  
Phillip Potter, *Center for Environmental Solutions and Emergency Response*  
Greg Sayles, *Director, Center for Environmental Solutions & Emergency Response*  
Kirk Scheckel, *Division Director, Land Remediation & Technology Division*  
Erin Shields, *Center for Environmental Measurement & Modeling*  
Jody Shoemaker, *Chemist, Exposure Methods and Measurement Division*  
Tom Speth, *Associate Director, Center for Environmental Solutions and Emergency Response*  
Kris Thayer, *Director, Chemical and Pollutant Assessment Division*  
Rusty Thomas, *Director, Center for Computational Toxicology & Exposure*  
Thabet Tolaymat, *Environmental Engineer, Center for Environmental Solutions and Emergency Response*  
Tom Tracy, *Designated Federal Officer, Office of Science Advisor, Policy, and Engagement*

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Jim Voit, *Chemist, Center for Environmental Solutions and Emergency Response*  
Cavin Ward-Caviness, *Computational Biologist, Public Health and Integrated Toxicology Division*  
Tim Watkins, *Director, Center for Environmental Measurement and Modeling*  
Barbara Wetmore, *Toxicologist, Center for Computational Toxicology and Exposure*

**Other EPA Attendees:**

Gerald Ankley	Cheryl Hawkins	Minday Pensak
Heidi Bethel	Tala Henry	Paul Randall
Aimee Boucher	Susan Hester	Michelle Rogow
John Bourbon	Erin Hines	Elizabeth Sams
Amanda Brennan	Anne Holleran	Risa Sayre
Mark Cantwell	Bryan Hubbell	Imran Shah
Kristina Chialton	Michael Hughes	Avanti Shirke
Elaine Cohen Hubal	Sherri Hunt	Larry A Sievers
Kathleen Compton	Scott Jenkins	Matt Small
Jed Costanza	Samantha Jones	Jamie Strong
Katherine Coutros	David Katz	Dawn Taylor
John Cowden	Vasu Kilaru	Laura Taylor
Diana Cutt	Steph Kim	Thabet Tolaymat
Jeff Dawson	Christy Lambright	Emily Trentacoste
Kacee Deener	Taylor Lass	Scarlett VanDyke
Kathie Dionisio	Michelle Latham	Jim Voit
Aaron Dixon	David Lattier	Cavin Ward-Caviness
Nicki Evans	Monica Linnenbrink	Leah Wehmas
Logan Everett	Madeline Luster	Joe Williams
Stiven Foster	Charles Maurice	Catherine Wooster-Brown
Earl Gray	Garret Nelson	Suzanne Yohannan
Joshua Harrill	Katie Paul Friedman	

**Other Participants:**

Carolyn Acheson	Matthew Duffy	Robert Martin
Hilda Arellano	David Dunlap	Scott Miller
Sandra Baird	John Gardella	Ed Monachino
Veera Boddu	Cy Genna	Nicole Moody
Cindy Boyle	Priyanga Gunasekar	Michael Morton
Diandra Brennan	Terra Haxton	Ashley Parr
John Byrd	Maria Hegstad	Keith Petka
Seung-Hyun Cho	Page Hingst	Nathan Puckett
Caitlin Dardenne	Deepak Kapoor	Doruntine Rexhepi
Anita Desikan	Lam Leung	Edward Rice
Morgan Dickie	Xiaoyu Liu	Steve Risotto
Diana DiGangi	Jason Lowery	Mary Ross
Hanna Dooley	Sriram Madabhushi	Jaimeson Sinclair

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James Smith  
Sheryl Telford  
David Thal  
Phillip Theriault

Amaran Toppa  
Jessica Vitale  
Travis Voyles  
Jay West

Linda Wilson  
Erik Wright  
Tabby Zeb

**Contractor Support (ICF):**

Canden Byrd  
Denyse Marquez Sanchez  
Kathryn Van Artsdalen  
Afroditi Katsigiannakis  
Parisa Shirzadi  
Leah West  
Connie Xiong  
Maricruz Zarco

### **Appendix C: Charge Questions**

**Charge Question 1: “Total PFAS” Methods:** Many stakeholders have identified a need for validated “total PFAS” methods, such as total organic fluorine (TOF) or total oxidizable precursor (TOP) methods, to quantitatively measure a non-specific amount of PFAS in environmental samples. EPA has expanded the scientific foundation for identifying and quantifying PFAS in the environment through the development of validated analytical methods for specific PFAS and the use of non-targeted analysis methods. ORD researchers are working to develop validated TOF methods for wastewater and air emissions.

Please comment on the implementation of ORD’s PFAS methods research. In addition, what suggestions and recommendations can the Executive Committee offer on the utility of “total PFAS” methods and other analytical approaches for identifying “total PFAS” in environmental samples?

**Charge Question 2: Human Health Effects:** Due to the large number of PFAS in commerce and the environment, there is an emerging consensus on the need to use grouping- or category-based approaches to assess and address potential PFAS toxicity. Although structure-based categories are most common, there is no clear consensus method for categorizing PFAS, and ORD researchers are evaluating other features (e.g., chemical and physical properties, toxicokinetic properties, toxicity mechanisms) for use in categorizing PFAS for human health risk assessment and risk mitigation purposes.

Please comment on the implementation of ORD’s research on the human health effects from PFAS. In addition, what suggestions and recommendations can the Executive Committee offer on common category characteristics that would maximize the utility of the resulting PFAS groupings for the broadest set of decision contexts?

**Charge Question 3: Treatment Field Studies:** Data on the efficacy and costs of different approaches for removing PFAS from the environment and managing PFAS and PFAS-containing materials are needed to inform federal, state, tribal, and local decisions on drinking water and wastewater treatment, contaminated site clean-up and remediation, and end-of-life materials management. ORD is working to increase our understanding of approaches for addressing PFAS in the environment through analytical method development, laboratory-based studies, pilot-scale studies, and field studies.

Please comment on the implementation of ORD’s PFAS treatment research. In addition, what suggestions and recommendations can the Executive Committee offer for working and communicating with communities in potential field study locations?