U.S. Environmental Protection Agency (EPA) Board of Scientific Counselors (BOSC)

Safe and Sustainable Water Resources Subcommittee

Face-to-Face Meeting Minutes

August 24–25, 2016

Date and Time: August 24, 2016, 8:15 a.m. to 5:30 p.m.; August 25, 2016, 8:15 a.m. to 3:00 p.m. Eastern Time

Location: Hyatt Regency Cincinnati (Bluegrass and Buckeye), 151 West Fifth Street, Cincinnati, Ohio

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 and the Participants are listed in Appendix B.

Wednesday, August 24, 2016

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

Welcome, Introduction, and Opening Remarks
Joseph Rodricks, Chair

Dr. Joseph Rodricks welcomed the Board of Scientific Counselors (BOSC), Safe and Sustainable Water Resources (SSWR) subcommittee. He explained that he was asked, and agreed, to chair SSWR subcommittee. Dr. Rodricks noted that several subcommittee members, including Dr. Lawrence Baker and Dr. Bruce Aylward, were absent from the meeting. Dr. James Galloway was a member of the BOSC Executive Committee (EC) and agreed to join the SSWR subcommittee. Dr. Galloway participated via phone. Dr. Inez Hua attended the U.S. Environmental Protection Agency (EPA) Drinking Water Workshop yesterday, but she was not present at the SSWR meeting. Dr. Rodricks recommended that missing subcommittee members be assigned to assist in responding to charge questions, similar to those subcommittee members who were present.

Dr. Rodricks then asked the subcommittee members and meeting attendees to introduce themselves.

Dr. Shane Snyder is a Professor in chemical and environmental engineering at the University of Arizona. He directs the University of Arizona's Water and Energy Sustainability Technology Center.

Mr. Shahid Chaudhry was formerly with the California Energy Commission and clarified that he did not represent the Commission. He is the Vice Chair of the subcommittee and has been involved in the Water Energy Nexus for the last decade and a half.

Mr. Tom Tracy is the Designated Federal Officer (DFO) of the SSWR subcommittee. He has taken over the responsibilities of Ms. Cindy Roberts, the former DFO.

Dr. Suzanne van Drunick is the National Program Director (NPD) of U.S. EPA's Office of Research (ORD)'s SSWR program. She is trained as an environmental toxicologist with a focus in aquatic ecosystems.

Dr. Joe Williams is the Deputy NPD for SSWR and has been working with SSWR for the past few years. His training is in well science and well physics, specifically in saturation zone and groundwater modeling. He has worked with the National Management Resource Risk Laboratory (NRMRL) and various EPA programs.

Mr. Scott Ahlstrom has spent his career working in different areas of water, ranging from research to ownership and operation of facilities and governance of water systems.

Mr. John Lowenthal is a Senior Ecologist at Cardno, a consulting group. He also led the East Coast Water Resources Group.

Dr. Rodricks asked Mr. Tracy to provide an overview of the Federal Advisory Committee Act (FACA) rules.

DFO Welcome and FACA Rules

Tom Tracy, Designated Federal Officer

Mr. Tracy explained that the BOSC is a federal advisory committee established and operated under the request of the ORD under the authority of FACA. He noted that the SSWR meeting was being recorded for the purpose of preparing the minutes. The meeting minutes, taken by EPA's contractor, would be provided to the SSWR subcommittee and made publicly available on the BOSC website after certification by the chair and within 90 days after meeting commencement. He added that EPA's contractor was also able to provide printed copies of any materials and a USB drive with all meeting materials was available at the registration desk.

As the BOSC SSWR DFO, Mr. Tracy was responsible for ensuring that all BOSC activities comply with the FACA, which required all meetings: publish a meeting announcement in the *Federal Register* at least 15 days prior to any meeting; are open to the public and all substantive subcommittee and EPA discussion will be had in an open forum; and include opportunity for public comment. Mr. Tracy noted that all federal advisory committee documents were available to the public and meeting materials were sent to a few members of the public who asked for them. However, as of the day prior to the SSWR subcommittee meeting, there was no member of the public who wished to comment during the public comment period being held on Thursday, August 25th at 8:00 AM EDT.

He reminded the audience that all meetings involving substantive issues—whether in person, by phone, or by email—are open to the public. This applied to all group communications that include at least half of the subcommittee.

Mr. Tracy explained the BOSC SSWR subcommittee process, noting that the next subcommittee public meeting would include a discussion of their answers to the charge questions they are submitting to the BOSC EC. All subcommittee members submitted financial disclosure forms to Mr. Tracy, but he asked that subcommittee members notify him on any potential impression of impartiality or conflict of interest from grants, contracts, or companies that might benefit from the subcommittee's discussions with EPA.

Dr. Rodricks highlighted the agenda item designated for discussion of the 2016 BOSC EC report, which included EPA's responses to all of the BOSC subcommittee reports. He then moved to the next section of the agenda designated for review of the 2016 EPA Drinking Water Workshop's Small Systems Poster Session. He asked the subcommittee to return to the meeting by 9:45 AM EDT.

Dr. van Drunick explained that all of the relevant posters for this meeting were clustered together so that subcommittee members could easily examine and discuss the posters with the researchers. She noted that some of the research required lengthy approval processes, so not all the posters were cleared to be presented. Information from those posters would become available to the subcommittee once approval was received. Dr. van Drunick added that the poster by Sally Gutiérrez, from the Water Technology and Innovation Cluster, might be of particular interest to the subcommittee.

2016 EPA Drinking Water Workshop: Small Systems Poster Session and Meet the Experts (Regency A and Regency BC)

The BOSC SSWR subcommittee attended the 2016 U.S. EPA Drinking Water Workshop Poster Session.

Discuss Meeting Objectives and Water Systems Charge Questions and Posters
Joe Rodricks, Chair, Suzanne van Drunick, National Program Director, and Tom Tracy, DFO

Dr. Rodricks noted that the subcommittee was well ahead of schedule. He recommended reorganizing the agenda. He suggested the subcommittee discuss the charge questions now. Dr. Impellitteri agreed to make his presentations early before Dr. Tom Burke, the Deputy Assistant Administrator of ORD, arrived to give his presentation.

Dr. Suzanne van Drunick explained that there were three water systems posters at the EPA Drinking Water Workshop, and several subcommittee members attended that session. She added that the subcommittee might not need the hour and a half provided in the agenda to review the posters.

Dr. Rodricks reviewed the meeting objectives. The subcommittee will report their findings, comments, and recommendations on each of the topics reviewed during this meeting. This report will then be sent to the BOSC EC for review during their meeting in January 2017. The BOSC EC will then write a final report which will be submitted to EPA ORD for their review and response.

Dr. Rodricks noted that the charge questions were more specific, and therefore easier to answer than last year's. He asked the subcommittee members to keep the charge questions in mind throughout the meeting. Dr. van Drunick read the charge questions and noted that the subcommittee had the opportunity to discuss the first BOSC report and ORD's responses later in the agenda. She asked the subcommittee to consider any follow-up work related to the projects that would be presented during this meeting. She added that these charge questions were specific to the research topics that would be presented during the meeting.

Dr. van Drunick read the first charge question:

1. Are we doing the right research? Taking resource limitations into consideration, are there any additional research needs that warrant new investment or current research that merits expansion, and are there areas of research that SSWR may consider disinvesting in?

Dr. van Drunick explained SSWR's efforts to balance short- and long-term research needs of the Office of Water (OW) and EPA regions in the face of a dwindling budget. She asked for the subcommittee's input on what research is really important, what research areas should be expanded on, and what research areas are not as high of a priority so EPA could stay on the right research track. She provided examples of why a research area could be of lower priority, including situations where work was being adequately done by other people or enough was already known about the topic.

Dr. van Drunick read the second charge question:

2. Are we doing the right research at the right time? Comment on the balance of near, current and long-term research objectives.

In regards to the second charge question, Dr. van Drunick explained that the program offices and regions often needed to react to situations within an immediate or short timeframe, but research

did not happen on that timeline. Thus, ORD needed to anticipate future research needs, which is there the second charge question came from.

Dr. van Drunick added that SSWR was seeking advice on the appropriate balance of near- and long-term needs in the SSWR research portfolio. SSWR used EPA's Science to Achieve Results (STAR) grants for long-term needs.

Dr. Rodricks asked the subcommittee to consider their responses to the charge questions during the three presentations on regulatory support, technology advances, and transformative approaches and technologies. He added that the presentations for the following day on the National Center for Environmental Research (NCER) STAR and National Priorities Water System Grants, the 2016 BOSC EC report, and ORD responses were all topics that the subcommittee would need to respond to or note why a specific response was not discussed in that area as part of their subcommittee report to the BOSC EC. Dr. Rodricks suggested that the subcommittee make assignments for drafting responses to each topic now so they could focus on their note taking and responses during the presentation on their assigned topic.

Dr. Rodricks asked Mr. Chaudhry to lead drafting the response to Project 1: Regulatory Support, but, instead, Mr. Chaudhry volunteered to lead the drafting effort for Project 2: Technology Advances.

Dr. Rodricks asked Mr. Ahlstrom to lead drafting the response to Project 1: Regulatory Support, and Mr. Ahlstrom agreed.

Dr. Rodricks asked Dr. Snyder to lead drafting the response to Project 3: Transformative Approaches and Technologies, and Dr. Snyder agreed.

Dr. van Drunick noted that the STAR and National Priorities Grants cover all the water system projects and asked if the subcommittee would like to assign someone to that topic or if they would like to incorporate that topic into the other sections. Dr. Impellitteri explained that the STAR grants were presented as parts of tasks under other projects and integrating the grants into other projects was a goal of SSWR. He suggested the subcommittee integrate that topic under the other sections of the draft report. Dr. Rodricks asked why the grants were being presented separately. Dr. van Drunick explained that it was because SSWR wanted Dr. Michael Hiscock to present the grants as a whole. Dr. Rodricks reiterated that Mr. Ahlstrom, Mr. Chaudhry, and Dr. Snyder should incorporate what they heard during Dr. Hiscock's presentation into their sections of the draft BOSC SSWR subcommittee report.

Dr. Snyder shared he would not attend the second day of the subcommittee meeting. He noted that it was too late for the subcommittee to provide input on the STAR grants because they were already awarded. Dr. van Drunick responded that SSWR was not able to announce future STAR grant projects, but she suggested that the subcommittee comment on the utility of the grants and how well they fit into the program. She also recommended the subcommittee discuss the topics that the grants should cover so they provide the most benefit to SSWR. Dr. Williams asked the subcommittee to review how the STAR grants are utilized and how EPA translates that information for dissemination. This discussion fit under charge question 2. Dr. Impellitteri explained that the Small Systems Centers have been converted to cooperative agreements. EPA was not allowed to direct the research and the research could not directly benefit the U.S. government, but those agreements did allow a greater degree of interaction between EPA and the

recipient than a grant did. Dr. Impellitteri reiterated Dr. van Drunick's suggestion that the subcommittee voice their concerns about research topics that seem to be off course. Dr. van Drunick added that the SSWR NPDs did not determine the amount of money allocated to the STAR grant program, although it was a large chunk of their budget. SSWR should provide input on whether or not those grants were being properly utilized.

Dr. Rodricks asked if SSWR was also interested in the subcommittee's comments on WINSS and DeRISK that would be discussed in the EPA Drinking Water Workshop. Dr. van Drunick responded that they are seeking comments from the subcommittee on those topics.

Dr. Rodricks circled back to Dr. Snyder about his inability to attend the second day of the meeting. Dr. Lowenthal agreed to assist Dr. Snyder with taking notes and drafting a response to the Project 3 topic.

Dr. Rodricks asked the subcommittee members to keep in mind the issues Dr. van Drunick asked them to consider during the presentations. Dr. Rodricks also asked the subcommittee to consider questions for Dr. Burke following his presentation.

Overview and Deep Dive into Regulatory Support Project 1
Christopher Impellitteri, Associate National Program Director

Dr. Rodricks asked what the best strategy was for taking questions during the presentation. He and Dr. Impellitteri agreed that the subcommittee could pose questions during his presentation.

Dr. Impellitteri's presentation was focused on work in the area of Water Systems, one of four topics within SSWR. The other three topic areas include Watershed Sustainability, led by Dr. Rick Greene; Nutrients, led by Dr. Anne Rhea; and Green Infrastructure, which is also led by Dr. Impelliterri. He explained that many issues span across these four topics (e.g., cyanobacteria/cyanotoxins), which is something for the subcommittee to consider when reviewing the projects within each of these four topic areas.

Dr. Impellitteri summarized the structure of the three projects under the Water Systems topic. These three project areas include Project 1: Current Systems and Regulatory Support, Project 2: Technology Advances, and Project 3: Transformative Approaches and Technologies. The projects are driven by input from the regions and the program offices (primarily from OW and the Office of Wastewater Management [OWM]) to address their immediate needs. The three projects were organized into four tasks; the first task was oriented towards resource water, the second task was on monitoring and analytical methods, the third task was on treatment, and the fourth task was on health effects.

Dr. Impellitteri presented the research activities, products, and impacts for Project 1, Current Systems and Regulatory Support. Project 1 includes four task areas. Under each task area is a series of sub-tasks, and other each sub-task is specific research projects.

Dr. Impellitteri described Task 1A – Current resource water treatment processes and resource recovery. This task is led by Dr. Eric Villegas. There are three sub-tasks: 1) Evaluating microbial and chemical contaminants in waste treatment streams; 2) Antibiotic resistance in resource water effluents that are discharged into the environment or recycled; and 3) Safe and sustainable management of waste residuals.

Dr. Impellitteri noted that as part of Task 1A; sub-task 1, there are Regional Applied Research Efforts (RARE), which provide an internally competitive funding process that allows ORD to partner with the EPA regions, particularly Region 6. This subtask is being used to characterize resource water, including characterizing microbial pathogens and emerging chemicals of emerging concern (CECs) for direct potable reuse in Texas. SSWR also had an additional comprehensive study examining modern methods (e.g., plating microorganisms and high-throughput sequencing) for determining microbial communities and CECs in resource water effluent.

Dr. Impellitteri noted that as part of Task 1A; sub-task 2, SSWR has started very preliminary research on exploring antibiotic resistance in resource water effluents discharged into the environment or recycled. This research used preliminary polymerase chain reaction (PCR) assays and high throughput sequencing to characterize individual microbes and microbial communities. This work also explores how microbial communities change throughout the water treatment system. Dr. Rodricks asked if these activities described a set of research undertakings or if they were specific research programs. Dr. Impellitteri responded that they were more specific research programs. Many of the researchers were the same for the RARE efforts and the high-throughput sequencing summaries. He confirmed that Dr. Rodricks was correct in his understanding that the study of microbial communities should be thought of as a single study.

Dr. Rodricks asked about microbial antibiotic resistance becoming an important topic and if there was evidence that antibiotic resistance poses a significant problem. Dr. Impellitteri responded that it is a serious problem. There is an increase in evidence that microbes in wastewater systems are becoming resistant to antibiotics, such as triclosan found in toothpaste and soaps. The extent of resistance or what happens to these microbes in the environment is unknown. This research is aimed at examining the potential impacts of microbial antibiotic resistance for water systems, particularly for drinking water. Dr. Impellitteri added that SSWR was moving away from thinking of their research mainly in terms of the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) and thinking more broadly about issues that impact drinking water. Dr. Impellitteri explained that this topic became a research priority because it is an issue for the Water Environment and Reuse Foundation (WERF). He reiterated SSWR's interest in the subcommittee's opinions of whether or not this should be a research priority.

Mr. Ahlstrom raised the topic of the overall direction of the research and explained his understanding of the driving forces of direct potable reuse research. He provided the example of Wichita Falls, which engaged in a 1 year period of direct potable reuse in response to drought that forced them to take quick action to ensure drinking water availability. As a result, the State of Texas and Region 6 were concerned about how to handle direct potable reuse, which likely promoted this research. Mr. Ahlstrom asked the meeting attendees to consider if direct potable reuse is a hot topic due to the failure of communities to plan for long-term solutions, or if it is something that the nation would like to move towards. Moving towards direct potable reuse is abandoning the American Water Works Association (AWWA) principle to use the best source for drinking water in the long term. If direct potable reuse is a short-term issue (i.e., less than 2 years), then research should focus on identifying health effects, if any, in the short term. If it is a long-term issue, then research should focus on identifying health effects over 30 years of use. Mr. Ahlstrom asked Dr. Impellitteri if there were discussions about researching the health effects

of direct potable reuse. Dr. Impellitteri responded that these discussions occurred, and he and Dr. van Drunick were aware of all the research being done in direct potable reuse by WERF and other organizations. Last year, one of the highest Water Research Foundation (WRF) subscriber priorities was alternative water resources, and direct potable reuse falls within that category. However, water reuse, whether it is direct, indirect, or non-potable, is not regulated by OW. Although EPA has a set of very effective drinking water standards in place, states like California are developing their own fit-for-purpose guidance and regulations for direct and indirect potable reuse. SSWR is hoping to find a niche where ORD can contribute to this topic area without conducting redundant research. Dr. Rodricks asked if Dr. Impellitteri would agree with Mr. Ahlstrom's characterization that direct potable reuse is headed towards long-term reuse. Dr. Impellitteri stated that in many places, long-term direct potable reuse is inevitable for drinking water and other water resources. He provided the example of the unsustainable practice used by many communities in California to use only bottled water. Communities need to figure out how to meet their water needs or there will be no community at all.

Dr. Rodricks concluded that while this research is important, the subcommittee should consider if there is adequate long-term research to address the needs of a future with direct potable reuse. Mr. Ahlstrom clarified that current research should be conducted with short- and long-term impacts in mind. The subcommittee should be thoughtful about those impacts when assessing the SSWR research projects. He added that there was interesting psychology behind the interest of people in the water treatment industry in direct potable reuse. In his opinion, direct potable reuse is not a good idea because better options are available. Mr. Ahlstrom added that planning needs to occur in order to utilize these other drinking water options.

Dr. Snyder noted the differences between inland communities like Wichita Falls and coastal communities like Los Angeles, California that have a water shortage yet discharge billions of gallons of freshwater into the ocean. A huge amount of energy could be saved if coastal communities did not discharge large amounts of freshwater into the ocean. He recommended that the word "direct" be dropped from the phrase "direct potable reuse" so it read as "potable reuse." The difference between direct and indirect potable reuse is negligible. Direct potable reuse describes water that is treated and reused without blending it with other sources of water, such as the practice in Singapore. In the United States, reuse water is blended with other water sources, making it indirect potable reuse. Mr. Ahlstrom agreed that the direct/indirect terms are not important and can be dropped. He added that the activities in Wichita Falls would be characterized as indirect potable reuse because they blended treated wastewater with raw water from other sources. Dr. van Drunick added that the National Academy of Sciences (NAS) also suggested dropping the word "direct" from the phrase. Dr. Snyder noted that there are instances all over the country where wastewater treatment facility discharge upstream of an intake point is not called potable reuse even though it should be. Mr. Lowenthal agreed and added the whether the potable reuse is direct or indirect should not change who regulates the water. Dr. van Drunick noted that it would be good to ask Dr. Peter Grevatt questions about direct potable reuse because he was a proponent for direct potable reuse. Dr. Snyder shared that he made a comment during the previous BOSC SSWR subcommittee meeting about how a lot of research transcends reuse and provided quantitative polymerase chain reaction (qPCR) as an example of research that was beyond only potable reuse. Dr. Impellitteri agreed with Dr. Snyder and noted that additional cross-cutting topics will come up throughout the presentations.

Dr. Impellitteri noted that as part of Task 1A; sub-task 3, research on the waste residual aspect of water management is in response to the needs of the regional offices. He explained that Part 503-The Biosolids Rule, which was last updated in 2013, regulates the biosolids that end up on land for various purposes (e.g., fertilizer or soil nodes). Some of the rule guidance could be updated with new and better methods. ORD conducted research that would be applied to updating the rule. Dr. Impellitteri explained that there was evidence of legacy sources of perfluorinated alkyl substances (PFAS) from wastes. As a result, ORD is working with OW to characterize PFAS in wastes.

Dr. Rodricks asked if it was accurate to say that PFAS does not degrade at all. Dr. Impellitteri responded that the half-life of PFAS is on the order of years and varies with the chain length. Although they do not persist forever, they do stay in the environment for a long time.

Dr. Impellitteri described Task 1B – Monitoring/Analytical Tools. This task is led by Dr. Jody Shoemaker. There are two sub-tasks: 1) Methods development (chemicals and microbes); and 2) Environmental/occurrence monitoring.

Dr. Impellitteri noted that as part of Task 1B; sub-task 1, ORD chemists have supported OW with their needs regarding the Contaminant Candidate List (CCL) and the Unregulated Contaminant Monitoring Rule (UCMR) 3 and 4. Dr. Impellitteri explained that UCMR 4 aims to develop methods to address six of the hundreds of congeners of microcystins. This research would inform future work to examine what is known and unknown about the toxicity of different microcystin congeners. Additional UCMR methods were also being developed for saxitoxin and related cyanobacterial neurotoxins; analyzing *Legionella* and mycobacteria in drinking water; and protozoans, particularly *Toxoplasma gondii* oocyst. Dr. Impellitteri explained that ORD also had efforts beyond method development for OW's UCMR processes and is developing monitoring methods, such as using cell immunoassays to assess human exposures to microbes, particularly in recreational waters.

Dr. Impellitteri shared that as part of Task 1B; sub-task 2, ORD is focused on environmental occurrence and monitoring. ORD is assessing drinking water for *Legionella* and non-tuberculous mycobacteria, which are resistant bacteria found in distribution systems. They are difficult to eradicate completely. ORD is applying the EPA distribution model, EPANET-RTX, to small systems, which are generally small buildings. EPANET is a basic computer model used to analyze distribution systems. The model has been available for 35 years and ORD's current effort is to shrink the model down to apply it to a smaller scale of a building or distribution system premise plumbing to look at disinfectant decay, microbial growth, and fate transport of contaminants in these smaller scenarios.

Dr. Impellitteri described Task 1C – Water Treatment. This task is led by Dr. Michael Elovitz. There are three sub-tasks: 1) Research to support the program office and regional office needs; 2) Distribution systems and premise plumbing; and 3) Optimization of current drinking water and resource water processes. Task 1C became a bigger part of Project 1 than originally planned because of the issues in Flint, Michigan, related to lead in drinking water. ORD recognized that it was critical for their research to support the work in Flint, so ORD dropped some work in other research areas.

Dr. Impellitteri described the work done as part of Task 1C; sub-task 1 to support the response in Flint, Michigan. ORD worked with the region to install a pipe in the drinking water system that would allow testing of different water qualities in the actual Flint water pipes. He added that Dr. Carole Braverman would discuss the details of this research during her presentation. Sample analysis in Flint is ongoing. Dr. Impellitteri highlighted the poster at the EPA Drinking Water Workshop on copper and explained that there was research to support the Copper and Lead Rule. One example is the research done to profile lead pipes in Cincinnati, Ohio. Dr. Impellitteri added that ORD is also addressing the need to develop formalized standard operating procedures (SOPs) or standard protocols for samples that identify where lead service lines are located. Many municipalities across the country do not know where their lead or partial lead pipes are. For example, ORD was partnering with Dr. Michèle Prévost from the University of Montreal who was working on a system in Canada that integrated a sampling procedure with models to pinpoint exactly where lead lines were located. ORD is incorporating this research into a sampling procedure for the United States.

Also as part of Task 1C; sub-task 1 ORD is supporting an effort to combine two exposure models to assess the potential risk of lead in drinking water to children, infants, and adults. Dr. Rodricks noted that the Integrated Exposure Uptake Biokinetic Model (IEUBK) model has been around for 20 years. He asked if ORD was focused on improving the model or if they were exploring a new aspect of the model. Dr. Impellitteri responded that the details of this research were not available to the public at the time of the subcommittee meeting.

Mr. Ahlstrom asked if the household lead level took into account multiple sources of lead exposure beyond drinking water. Dr. Impellitteri responded that the guidance only covers drinking water exposure to lead. However, assumptions about the bioavailability of lead going into the consumer from different sources (e.g., soil, water, particulates, etc.) would need to be taken into account when combining the Stochastic Human Exposure and Dose Simulation (SHEDS) and IEUBK models, which requires a whole degree of uncertainty be captured when the models are combined.

Dr. Rodricks asked if this effort was a big investment. Dr. Impellitteri explained that this effort was a great example of ORD's quick response to a program office request. EPA's National Exposure Research Laboratory (NERL) was able to respond to the program office's request for this effort within 24 hours and has been working to combine these models for approximately 4 months.

Mr. Ahlstrom noted that different lead levels are associated with different sources of exposure. Dr. Impellitteri agreed. There is a high degree of uncertainty that occurs when combining these models, and ORD tried to address this uncertainty by incorporating it into model calculations. Researchers ran multiple scenarios through the models to ensure they are set up correctly with the right assumptions.

Dr. Snyder recalled the new Perfluorinated Chemicals (PFC) Health Advisory levels and asked if generating non-regulatory guidance is a function of ORD. If so, he wondered what EPA saw as the benefits of this work. Dr. Impellitteri responded that, simply put, supporting non-regulatory guidance is a function of ORD if the OW or regions request technical support. A fundamental part of ORD's mission is to support OW and the regions in any way possible, whether it be for a regulation, CCL, UCMR, guidance document, etc. Another function of ORD is to provide

technical support, but it is not a function of ORD to derive specific values. ORD regularly provides technical support that might contribute to generating a specific value, but a lot of additional information and work goes into that decision. Dr. Impellitteri added that ORD also conducts a fair amount of technical support for treatment options. Dr. Rodricks summarized that converting the available research into a specific action level or Health Advisory appears to be a policy decision. Dr. Impellitteri confirmed his statement and added that setting an exact value is a function of the program office.

Dr. Snyder asked for confirmation that BOSC, Science Advisory Board (SAB), and public comments were not incorporated into advisory levels or action levels where they would be in a regulatory construct. He asked if there was anything the BOSC would need to consider other than if the research was properly conducted. The BOSC would not be expected to provide input regarding the accuracy of the exact number. Dr. Impellitteri confirmed these statements.

ORD is also supporting research in the area of PFAS in drinking water under Task 1C; sub-task 1. This issue has become more significant. Dr. Impellitteri explained that ORD is working with OW and OWM to follow-up on the PFAS numbers published in the Health Advisory. The most immediate topic ORD was working on was providing technical support to EPA's National Sewage Sludge Survey. ORD planned to examine the concentration and fate-transport of PFOA, perfluorooctanesulfonic acid (PFOS), and the four other perflorinated compounds of the UCMR list in biosolids.

Dr. Rodricks noted the huge database available for perflorinated compounds and asked what toxicity studies ORD was examining (e.g., human, animal, or other types of toxicity studies). Dr. Impellitteri acknowledged the large database on perflorinated compounds. He explained that much of the toxicology work that went into the perfluorinated compound Health Advisories was done over the past decade. Dr. Rodricks asked if ORD is investing in more toxicity studies. Dr. Impellitteri explained that ORD wrote their research action plans three years ago and were at a crossroads as they began to think about their next cycle of research. ORD put together and circulated a four page rough draft of some possible ORD research avenues to OW and the regions. ORD would need to work fast to ensure all the pressing issues were identified and included in the next cycle of projects and would appreciate any input from the subcommittee on future research projects. Dr. Impellitteri considered the work on perfluorinated compounds to be a pressing issue. There was a voluntary phase out for many of the perfluorinated compounds over the past decade due to their toxicity, but those compounds were replaced with short-chain substitutes. There are uncertainties associated with the toxicity and fate and transport behavior of the replacement compounds. Dr. Impellitteri explained that ORD would like their research to answer these questions, but a lot of ORD's efforts are directed towards providing high-throughput chemistry and computational toxicology data to address the backlog of thousands of chemicals that EPA is assessing. This prompted SSWR to try to collaborate with the researchers at the National Center for Computational Toxicology (NCCT) to prioritize the substitute perfluorinated compounds and microcystin congeners that lack critical information.

Dr. van Drunick noted that the new Toxic Substances Control Act (TSCA) had guidelines on how to prioritize those compounds. Dr. Rodricks added that the new TSCA also mandated that EPA conduct a new review of whether or not PFOA and PFOS need to be banned.

Dr. Impellitteri noted that a new project that examined the contamination of brominated disinfection byproducts (DBPs) from coal fired power plants is also part of Task 1C; sub-task 1. Coal fired power plants are the most significant contributor of DBPs in rivers and streams. ORD is researching DBPs in surface water, including the precursor and formation of DBP in water.

Dr. Impellitteri described the work done as part of Task 1C; sub-task 2. ORD is examining what microbes grow in the water taps and shower heads of premise plumbing and how and why the microbes inhabit various parts of the system. ORD is also working to characterize the rare taxa that hide in water distribution systems before exploding in number when the conditions are right. The goal is to better understand these ideal conditions and their impact on the behavior of those taxa. Dr. Impellitteri shared that Dr. Hiscock would talk more specifically about the NCER projects included as part of this sub-task. ORD is working with NCER through STAR grants and other funding mechanisms to ensure their research was not redundant and to put together research proposals or request for applications (RFAs) of research projects outside the current expertise or capabilities of ORD. One example of such a project is the research examining the impacts of water conservation trends on water quality in premise plumbing systems designed for greater usage. A reduced water flow rate from conservation impacts microbial communities, biofilms, and disinfectant decay in water treatment systems. Dr. Impellitteri explained that some European countries considered the impacts of water flow on water quality in their plumbing codes but the United States did not. However, there was a push by some organizations, such as International Association of Plumbing and Mechanical Officials (IAPMO), for regulations and guidance on drainage pipe sites for removing toilet tissue. The question of how to retroactivity look at and adjust distribution systems to ensure drinking water is safe is an important issue from an engineering and drinking water perspective.

Dr. Rodricks asked if these efforts were all under the STAR grants. Dr. Impellitteri confirmed that the project he described was one STAR grant. Dr. Rodricks asked if the project idea was proposed directly to ORD. Dr. Impellitteri explained that the project was proposed to ORD but the idea for the work came from ORD's work with NCER. ORD met with WRF at least every 6 months to discuss current research and ensure they are not duplicating efforts.

Mr. Ahlstrom noted that Dr. Impellitteri touched on the correct size of a plumbing and distribution system, but peak water usage is what governs the systems and irrigation and lawn water are what drive peak water usage. Thus, changes in water conservation within the home are not going to change the size of the distribution or plumbing system. Water conservation within the home might not be the best metric. Dr. Impellitteri clarified that the project was focused on water conservation in large buildings (e.g., apartment buildings, hospitals, etc.), which would impact the size of the systems.

Dr. Rodricks noted that these efforts were done in Europe. He wondered if there were things the United States could learn from these systems. Dr. Impellitteri responded that there were things they could learn, but European systems are different because they do not include disinfection process. Mr. Ahlstrom added that the United States is unique in how they treat water.

Dr. Impellitteri described the work done as part of Task 1C; sub-task 3. ORD works with OW to maintain EPA's Treatability Database, which is a tool that provides very specific literature and references to the best treatment technologies based on the contaminant. Dr. Impellitteri explained that ORD's current effort was to merge the tool with OW's cost models to create a new tool that

would allow users to compare the best technologies and their costs to determine the best treatment option. Dr. Impellitteri explained that most of ORD's focus was towards UV disinfections because these treatments are easily applied. However, it is difficult to determine the efficacy of UV treatment and a lot of research is directed towards examining the effect of UV on microbes. For example, UV treatment is not very effective at killing adenovirus. ORD is developing dose-response curves and identifying surrogates for adenovirus in drinking water.

Dr. Rodricks asked if radiological contaminants were included in the UV research. Mr. Ahlstrom agreed that radiological contaminants were an important issue for ground water problems. Dr. Snyder added that radiological contaminants present an issue around mining operations in Arizona. Dr. Impellitteri responded that ORD relied on an expert from Wisconsin, where there are high levels of naturally occurring radium in ground water, to discuss radium contamination. The expert developed imperial formulas for calculating radium removal to address the issue of treating contaminated ground water to a level that would be considered radioactive waste. However, with the UV disinfection project, there were no specific radium or uranium issues included. Dr. Rodricks asked if anyone thought radiological contaminants were a neglected area of research. Dr. Impellitteri answered that they were not viewed as a neglected area of research because there is a known process for removing them from water. The challenge is how to deal with the waste from that process. Mr. Ahlstrom asked about ORD's research on radiological contaminants that was referenced in the presentation slides. Dr. Impellitteri clarified that treatment technologies for radiological contaminants were available within EPA's Treatability Database.

Dr. Snyder asked if any research was focused on byproducts from UV treatment, specifically on genotoxic byproducts, because he was aware of very few studies on that topic. Dr. Impellitteri explained that ORD is not currently researching UV byproducts, but they are aware of that issue. He asked the subcommittee to include this research recommendation in their response to the charge questions if they felt it was worth pursuing.

Dr. Impellitteri continued to describe the work done as part of Task 1C; sub-task 3. Traditional UV treatment typically occurs with low pressure and high pressure treatment lamps are a new development. He described several objectives of the UV treatment research, including the identification and use of surrogate microbes to determine treatment efficacy for microbes that are challenging to work with. He added that a lot of ORD's research is a continuation of research from WRF. Another research objective is a collaborative effort with EPA Water Technology Innovation Center, regional and state regulatory agencies, and water utilities to review and harmonize permitting protocols. ORD is working with state agencies to develop a framework for accepting new treatment technologies without burdensome testing requirements.

A UV disinfection in drinking water and adenovirus surrogate project was also conducted as part of Task 1B; sub-task 3. He underscored the preliminary results that showed that pairing a low-wavelength sensor with typical ÖNORM sensor monitoring could help when assessing the effectiveness of the UV treatment. This is in part because medium pressure lamps emit additional wavelengths compared to low pressure lamps. These lamps will have different effects on treatment. Dr. Rodricks recalled Dr. Snyder's question about research on UV reaction byproducts and noted that this research could also apply to this project. Dr. Impellitteri explained that the only difference between the UV lamps is that medium pressure lamps emit different

wavelengths whereas low pressure lamps are very specific to a 254 wavelength. Dr. Impellitteri added that evidence shows that medium pressure lamps result in different water treatment outcomes, although, some of those treatment results are controversial. Dr. Snyder added that other countries shield their water treatment UV bulbs to remove lower wavelengths because of nitrates and nitrites, which are related to byproduct formation.

Dr. Impellitteri described Task 1D – Health Effects for Regulatory Decisions and Guidance. This task is led by Dr. Jane Ellen Simmons. There are five sub-tasks: 1) Regulated DBP's relation to bladder cancer; 2) Regulated DBP exposure and colon cancer; 3) Regulatory technical support; 4) Internal dose/multi-route exposure from regulated DBPs through physiologically-based pharmacokinetic models; and 5) Impacts from varying source water quality and disinfection scenario on health impacts from DBPs.

Dr. Impellitteri described the work under Task 1D; sub-task 1. In order to explore the relationship between DBPs and bladder cancer, modern and cutting-edge assessment technology is used to examine how chemicals affect people at a cellular level. He introduced Dr. Simmons, who noted that this work provides a great example of how mechanistic toxicology can be applied to epidemiology studies, and how those human studies can then be used to inform ORD's work. She explained that DBPs were not mutagenic under traditional testing paradigms but it was found that they produce mutagenic toxic compounds when they are activated by glutathione S-transferase theta 1 (GSTT1), which are present in many human liver, kidney, and bladder cells.

Dr. Simmons explained that it is difficult to evaluate bladder cancer risk. The case control study, the Spanish Bladder Cancer project, was developed and genotyped bladder cancer patients. The project showed an increase in GSTT1 was associated with an increase in bladder cancer risk. She noted that the GSTT1 gene was present in a large part of European and U.S. populations. However, almost 700 DBPs have been identified which makes it challenging to determine the causative agent. The causative agent would need to be narrowed down to a class of chemicals before a regulation could be developed.

Dr. Simmons shared that, because human genotoxicity was observed with the GSTT1 genotype, the current research was focused on the concentrations in medium and extrapolating those results to human dosimetry models. Animal models were not good for extrapolating to human bladder cancer, so research on this topic would require human cells.

Dr. Rodricks asked about the status of the numerous epidemiology population studies in communities with higher levels of DBPs. He asked how ORD's research on the health effects of DBPs relate to this research. Dr. Simmons explained that several meta-analyses of epidemiology studies of bladder cancer had been conducted. One such analysis, conducted by the Manolis laboratory, showed excess risk of bladder cancer. She added that she was only aware of one bladder cancer study that genotyped individuals to see if they were GSTT1 negative or positive.

Dr. Rodricks asked if Dr. Simmons was also doing exposure modeling. Dr. Simmons clarified that she was doing exposure modeling within the bladder cancer system because DBP is a highly volatile compound. Determining the concentration of DBP in the headspace and medium and entering the cells is important. Research has successfully shown that *in vitro* data and physiologically based pharmacokinetic (PBPK) models could be used to predict human outcomes for non-volatile compounds. Dr. Simmons' laboratory planned to take what they had

learned from those models to determine an equivalent human dose from *in vitro* data. Currently, these methods are specific to the brominated compounds, but they planned to apply these methods to chloroform for the purposes of comparison. There are interesting differences between chloroform and DBPs. Dr. Simmons explained that she was also encouraged by the dedicated effort that moved the assays from the developmental stage to the implementation stage over the past 6 months. She expected to be able to run a reasonable number of compounds through the assay. She would eventually like the assay to be able to run mixed exposures, specifically mixtures that include chlorinated and brominated compounds. There is competition between chloroform and bromodichloromethane (BDCM) and, although it was not involved in the genotoxicity, there are implications for chemical availability for the genotoxic group.

Dr. Impellitteri explained that ORD recognized the importance of communicating with the program offices, which Dr. Simmons had been doing throughout her work on DBPs. A lot of cellular methods are new so it is unclear how they fit into program office plans. ORD has been working with the program offices to communicate the kind of information provided by new methods. ORD has thousands of chemicals that needed to be assessed, so they were looking for ways to speed up review process.

Dr. Rodricks asked where Dr. Simmons' laboratory is located. She responded that her laboratory is part of the National Health and Environmental Effects Research Laboratory, and she is chief of the Pharmacokinetics Branch. This branch is focused on dosimetry, specifically dosimetry from *in vitro* to *in vivo* models. All of the laboratory's efforts are directed toward DBPs because of the importance of the problem.

Dr. Rodricks asked who proposed the bladder cancer research project. Dr. Simmons shared that she was not involved with the project when it was first initiated, but OW brought the bladder cancer question to ORD as soon as a paper about the risk of bladder cancer from DBPs was published. DBPs were one of OW's most pressing questions, aside from the cardiomyopathy effects, because of their importance. Dr. Simmons explained that one reason why this research was within her laboratory and not NCCT is because high-throughput assays, such as ToxCast and Tox21, were not able to handle volatile compounds and compounds requiring metabolic activation. There was a need to develop an assay that could analyze those types of chemicals. Mr. Ahlstrom asked if it was fair to characterize this research as a feedback loop to existing regulations on DBPs. Dr. Simmons agreed with this characterization. This research answers OW's question on DBPs and will also would be very helpful if the 6-Year Rule on brominated compounds is re-opened.

Dr. Impellitteri described the work under Task 1D; sub-task 2 on regulated DBP exposure and colon cancer. Dr. Impellitteri pointed out that the meeting discussion had already touched on the colonocyte cytotoxicity assay. The subcommittee would hear about all of the assays being developed in ORD laboratories and the efforts to put some of these concepts into automated sensors to conduct real-world screening.

Dr. Impellitteri described the work under Task 1D; sub-task 3, which is focused on providing regulatory technical support. Dr. Impellitteri stated that Dr. Simmons touched on the technical work being done to support the 6-Year DBP rule process.

Dr. Simmons provided an overview of the work under Task 1D; sub-task 4 on internal dose/multi-route exposure from regulated DBPs through PBPK models. She explained that volatile DBPs often enter the home through water. Although DBP exposure through ingestion of contaminated drinking water is the most important route of exposure for the liver as a target organ, oral exposure is not the most significant route. Dermal and inhalation exposure must also be considered when looking at reproductive and developmental effects, kidney toxicity, and bladder cancer. She explained that a model was recently published showing the importance of dermal and inhalation exposure routes for delivery of DBP to all organs, except the liver. This model would be very helpful for translating animal studies to human exposures. Dr. Rodricks commented that this research could all drastically affect how DBPs are regulated.

Dr. Simmons described the work under Task 1D; sub-task 5 and highlighted ORD's research transition away from traditional *in vivo* studies to faster methods, such as zebra fish studies and microtox *in vitro* assays, to explore the impacts of disinfection by chlorine or chloramine on the same source water. Her focus over the last year and a half had been on comparative DBP formation and toxicity of mixtures formed from the same source water that has been either chlorinated or chloraminated. She has also evaluated how these processes are affected by varying water levels of bromide and iodide. A student from the University of North Carolina at Chapel Hill has been assisting with this project.

Dr. Impellitteri pointed out that the remaining two projects that would be discussed later in the meeting had the same structure as Project 1. These projects were also broken out into four components.

Dr. Rodricks thanked Dr. Impellitteri for his presentation.

Welcome and Remarks from Tom Burke
Tom Burke, ORD Deputy Assistant Administrator, EPA Science Advisor

Dr. Rodricks introduced Dr. Tom Burke, Deputy Assistant Administrator for ORD and EPA's Science Advisor. He thanked Dr. Burke for coming to the subcommittee meeting.

Dr. Rodricks noted that the subcommittee heard Dr. Burke's presentation at the EPA Drinking Water Workshop on the previous day. He asked the subcommittee members to reintroduce themselves.

Dr. Burke shared that he previously worked with Dr. Rodricks on risk assessment issues and that ORD was lucky to have him on the subcommittee. Dr. Burke's research career began with water, but his research scope broadened along with his responsibilities. He has worked in the area of epidemiology at the Johns Hopkins Bloomberg School of Public Health for a large part of his career. Dr. Burke became the Associate Dean of Practice at Johns Hopkins and noted that he thought academia was stronger when scholars were out in the field solving problems.

Dr. Burke explained that he had been a charter member of the BOSC when Bob Huggett of ORD created the BOSC to provide a focused group of world class scientists to ORD, in addition to the SAB. The BOSC could help guide ORD's research and provide evaluations of the conduct and context of the research. He found the BOSC reviews to significantly contribute to EPA's work and thanked the SSWR subcommittee for their work. He added that, having served on various BOSC subcommittees, the SAB, and the National Academy of Water and Environmental

Studies, he recognized the importance of external reviews and the contributions of the broader scientific world to the excellence of EPA's scientific research and noted the tremendous responsibility of being part of a science advisory group.

Dr. Burke turned the conversation over to water and thought that aspects of environmental protection had brought ORD's attention to the disadvantage of water science over the past couple of decades. However, the events of the past few years had given EPA the once-in-a-lifetime opportunity to protect water resources. Most people were unaware of how interwoven water science and epidemiology are. The drinking water community was at an important crossroads for understanding how to protect and apply science to drinking water and water resources in the United States.

Dr. Burke explained that when he was first nominated for his current position in ORD, he realized how broad and overwhelming the job would be. He recognized the opportunity he had that none of his predecessors did, which was to focus on water resources. He noted that how that opportunity came about was somewhat tragic for EPA, and there was the possibility that EPA Administrator Gina McCarthy's legacy might be the Gold King Mine disaster or the water crisis in Flint without showing the attempts to protect water resources as a system. However, he hoped the legacy would be the redirection of EPA as protectors of public health. EPA's efforts were not about limiting development or being an enemy to agriculture or future energy resources; their efforts were about the management of the country's resources so everyone could have a healthy water supply in the face of tough challenges.

Dr. Burke explained part of his confirmation process for taking his position as the Deputy Assistant Administrator of ORD included a hearing referred to as the "murder board," which consisted of experts that ask him the toughest questions they could think of. He further described the vetting process, including review of all the work he had ever published and preparing to answer impossible questions about environmental protection. Through this process, the comments Dr. Burke made during his time serving on the BOSC and SAB came up and he came to learn that many of his comments really challenged EPA. One quote in particular that Dr. Burke made during a joint BOSC and SAB meeting, "EPA science is on the rocks in terms of its credibility and if EPA didn't start to get it right, they would become irrelevant." He explained that he was that passionate about the importance of getting the science correct and wanted the subcommittee to have the same thought process.

Dr. Burke underscored the importance of credibility and explained that scientists disagree all the time but they typically examine the weight of the evidence and come to a consensus. Dr. Burke asked the subcommittee to be fully open and transparent with ORD so they could produce the best research possible. He added that the subcommittee was especially important to ORD because of where they were in water resources research. The country's water resources were threatened in a lot of different ways, whether it be water quality or investment in infrastructure, and a lot of issues needed to be addressed in order to protect water resources.

The subcommittee was aware of the current policy challenges posed to EPA. Dr. Burke provided the Water Rule as an example, noting that there was inherent uncertainty in the science behind the rule. He explained that some people would rather attack the science then have a regulatory debate because attacking the science was easier than debating whether a law is appropriate and cost effective or not. He had to deal with comments along the lines of "EPA's flawed science"

and solicited the subcommittee's help to address ORD's need to strengthen the science so that it is defensible while also acknowledging the uncertainties. He clarified that ORD's job was to inform policy decisions, not to make them. Dr. Burke concluded by stating that he took the BOSC very seriously and welcomed new comments and suggestions. ORD was based in science and he suggested taking the scientific discourse for solving issues. He hoped the subcommittee would be vigorous, willing to take on tough challenges, and that ORD could count on a great partnership with the subcommittee before opening the discussion up to the subcommittee's thoughts and questions.

Dr. Rodricks thanked Dr. Burke for his comments and noted that only half the subcommittee was present at the meeting. Dr. Rodricks brought the discussion back to the attack on the science and explained that he thought the research was being conducted appropriately. He asked if the attacks were on the research or how the science was being translated and used by EPA for regulatory purposes.

Dr. Burke noted that the interpretation of science for policies was not under ORD's preview and there was a dotted line somewhere between science and policy that could be as blatant as not funding a particular project. However, ORD would like to protect the conduct and science of the research and, therefore, considers how ORD's science could potentially be applied to policy by OW. For example, ORD considers if their research has undergone good peer review and how their research could be used in the public review process. Dr. Burke explained that he took issue when the research was called "flawed" because that threatened the validity of the research. Most of ORD's research does not answer the question of what is acceptable risk, but rather quantifies various aspects so as to present data to inform that question. If ORD was going to succeed, they would need a longer view of research over time and not just research that answered the question of the day.

Dr. Burke stated that he expected more criticism to be aimed at the policy side of decisions rather than the science side and raised his concern about the intrusion of policy criticism into the science process, particularly the implications that had for research that was so important for the country's current and future water resources. He explained that there was a tendency for critics to attack the core science as flawed or inadequate and that was where ORD needed more vigorous peer reviews.

Dr. Rodricks stated that the science was sound, but part of the disconnection between science and policy was the discrepancies between the definitions used in the research and policies. These discrepancies left gaps where people could say that the science was bad, which was an issue that needed to be addressed. Dr. Burke explained that ORD was looking at how to marry the words "system" and "health effects," especially as ORD tried to frame the Lead and Copper Rule. He added that it would be great to get any additional information in that area so ORD could make more headway in that area. He added that the regulators made the decisions and other factors, such as feasibility, are considered in those decisions in addition to the science.

Mr. Chaudhry explained that the actual science is sometimes lost when the findings are translated for a broader audience because the research parameters are often overlooked. So, unless the research translation and interpretation are mentioned upfront, then the science will always be attacked. Dr. Burke responded that ORD needed better ways to prepare the science for that attack because everyone will have an opinion on the adequacy of the data when the stakes

are high. Dr. Burke provided the example of the science behind the safety of bathing a child in water from the tap and explained how ORD needed to be able to explain how the evidence that supports a regulatory decision was acquired and reviewed by the best experts available. However, this becomes a greater challenge when the scientific community is divided. He added that all regulatory decisions come back to the human side of ORD's research, which is to answer the question is it safe? ORD conducts research in tough areas that are going to inform decisions across the spectrum.

Dr. Rodricks recalled a question that Dr. Burke raised during his talk at the EPA Drinking Water Workshop. He asked Dr. Burke to identify the pressing issues that were not getting enough attention. Dr. Burke responded that he thought everyone felt comfortable with the U.S. water supply, but there are instances where he had seen really tough decisions made about water resource management. One issue is the decline in the water resources workforce due to decreased training in engineering and sciences. Dr. Burke stated that he was kept up at night concerned about if community members of Flint would ever feel comfortable using their tap water like most Americans do, which ties the social as well as the chemistry aspects into water resource issues. EPA was very aware of the vulnerability of the finite U.S. water supply and the need to protect it. He stated that there were reasons to be very concerned about water resource protection because awareness of the water system fragility is more acute now than ever before.

Mr. Ahlstrom asked if EPA was more or less confident in the U.S. water supply. Dr. Burke responded that he feared communities were going to lose faith in their drinking water and explained that historical context was needed to determine if drinking water quality had improved. In terms of confidence, ORD had the data to support that U.S. drinking water was better off now. Dr. Burke added that he would like water resource management jobs to become the best jobs in the business again.

Dr. Rodricks suggested that water resource managers improve their communication to consumers about the low level of water contaminates and how that information was derived. Mr. Lowenthal added that analytical processes for water quality have improved which allows more contaminants to be detected. Dr. Burke agreed, noting that he remembered when disinfection byproducts were measured in parts per billion. He also referenced a presentation of research that showed how Flint water was better than bottled water. Mr. Chaudhry stated that thinking bottled water is better than tap water is the mindset of this country. Customers are uncomfortable with what they don't know so proper communication with customers is needed to better inform them about their water. Dr. Burke noted that he loved the shelter academia provided when exploring these problems, but ORD needed the BOSC perspective in terms of communicating these issues. Dr. Burke concluded by thanking the subcommittee for their help and asking them for their candid input about ORD's research.

Dr. Rodricks called for a subcommittee break and noted that new member Dr. James Galloway would be dialing into the meeting after lunch.

Partner Input: EPA Office of Water and Regions
Peter Grevatt, Director of OW Office of Groundwater and Drinking Water, Carole Braverman, Region 5 Regional Science Liaison

Dr. Peter Grevatt discussed the partnership between OW, OGWDW, and ORD. Drinking water has been the focus of many recent news stories, such as those about the events in Flint, Michigan. This has been an extraordinary year for EPA's Drinking Water program. ORD supported the mobilization of national response during emergency situations. Dr. Grevatt noted that his presentation at the EPA Drinking Water Workshop focused on the fortieth anniversary of the SDWA in 2014 and the national events that took place that same year. In each event, OGWDW turned to ORD to ensure there was strong technical footing. ORD provided outstanding research and real-time technical support.

Dr. Grevatt shared several examples of ORD's emergency response support efforts in Charleston, West Virginia; Toledo, Ohio; and Flint, Michigan.

Dr. Grevatt noted that ORD provided critical support to OGWDW during the 4-methylcyclohexanemethanol (MCHM) disaster in Charleston, West Virginia. MCHM has a relatively low toxicity, but a low odor and taste threshold. The MCHM spill created a huge problem for the community, and ORD was there throughout the cleanup process. ORD helped determine the toxicity of the compound and how to remove the chemical from the system. The advisory period lasted for 5 days, but it took much longer to flush MCHM out of the system.

Dr. Rodricks asked if ORD used high-throughput toxicity tests in their analysis of MCHM. Dr. van Drunick replied that Dr. Russell (Rusty) Thomas's group at NCCT did some preliminary high-throughput toxicity testing. Much about MCHM toxicity was unknown because few literature articles had been published.

Dr. Grevatt stated that he learned of the Toledo, Ohio, microcystin advisory on the news. ORD's National Risk Management Research laboratory was already engaged with the state of Ohio by the time the story was reported in the news. ORD supported Toledo with sample analysis and results interpretation. Toledo was doing the best they could to collect samples, but lacked the facilities for sample analysis. The National Guard was deployed and flew samples from Toledo to the Cincinnati laboratory. This was a unique and new scenario for ORD. There were some issues with collecting and preparing samples with microcystin. The Toledo sample collectors understood that microcystin cells need to be lysed, but not that chlorine needed to be punched before lysis. Chlorine deactivated microcystin during sample transport, so un-lysed cells appeared to have a higher microcystin concentration than lysed cells. Dr. Grevatt added that he personally communicated the sampling results to the Governor of Ohio and the Mayor of Toledo, who needed to know what to tell Toledo residents about the safety of their drinking water. The Toledo incident represents ORD's ability to provide real-time support in a critical situation. ORD can provide this support because of their previously developed expertise.

Dr. Grevatt mentioned briefly that ORD provided assistance in Flint, Michigan to re-optimize the system.

Dr. Grevatt explained that ORD and OGWDW are also involved in regulatory processes, such as the day-to-day process of upholding the SDWA. One example of this type of activity is the work done with perchlorate. Under the Bush administration, a negative regulatory determination was issued for perchlorate. However, under the Obama admiration, a positive regulatory determination was issued. OGWDW is working with ORD and the U.S. Food and Drug Administration (FDA) to develop a biologically-based dose response model for perchlorate. The

steps that lead to endpoints of concern are included in this model. The final model is nearly complete; it will be peer reviewed and then shared with the public.

Dr. Grevatt described ORD's work on strontium, another example of ORD's involvement in the regulatory process. Strontium was included in UCMR3 and was detected at many sampling locations. The regulatory process includes a regulatory determination, which serves as EPA's signal to the world that this compounds will be regulated. A final determination will not be made until more information is gathered about relative source contributions (e.g., diet and other sources of exposure compared to drinking water). ORD has helped OGWDW with their evaluation of the toxicity of strontium, health reference values, and relative source contributions. It is important to explore exposure levels experienced by the public and identify safe exposure levels.

Dr. Grevatt shared that Dr. Susan Glassmeyer at ORD assisted OGWDW in understanding potential contaminants of concern in wastewater. This work contributes to potable reuse of wastewater, which has been explored in several areas of the country. Consideration of what is in wastewater becomes more important as the distance is shortened between the release of treated wastewater into drinking water sources, treatment, and addition to the distribution system. *De facto* potable reuse is applied in many areas of the country. There are many places where the public drinks water that has been treated upstream of the intake, including in Washington, D.C. and Cincinnati, Ohio. Much of the country experiences potable reuse on a regular basis with the use of environmental buffers before ingestion. El Paso, Texas is looking at introducing highly treated wastewater downstream of the drinking water treatment facility. This is a novel system. Orange County, California virtually distills water before drinking using a highly advanced water purification system. Water re-filtrates into the groundwater and is then pulled back up for drinking water. OGWDW needs to consider the use of multiple buffers before drinking water and introduction into the distribution system. It is important to understand what is in the wastewater source before it is used for drinking water and what buffers are needed before wastewater is introduced into the distribution system.

Dr. Grevatt stated that the STAR grant small systems research centers are very important to OGWDW. There are approximately 156,000 drinking water facilities in the United States, which include community water systems and non-community water systems (i.e., transient and non-transient systems). The STAR grant small systems research centers help OGWDW find on-the-ground solutions.

Dr. Grevatt stated that ORD has assisted with ongoing *Legionella* issues by identifying potentially useful treatment techniques. The Veteran's Administration has been heavily engaged with these issues due to hospital-related outbreaks as a result of improper premise water management. *Legionella* represents the largest known public health burden related to drinking water. Drinking water serves as the vehicle that delivers *Legionella* to the receptors.

Dr. Grevatt noted that he left EPA Region 2 in 1997 and then moved to Washington, D.C. and became the Senior Science Advisor for the Office of Solid Waste and Emergency Response. In that job, he oversaw research coordination for the waste program with ORD. Over his 19 years working with ORD, the current relationship between OGWDW and ORD is better than any other he has witnessed.

Mr. Ahlstrom asked why drinking water is the source of strontium exposure that causes so much concern when exposure is known to be a result of accumulation from other sources. Dr. Grevatt responded that no decisions have been made on how OGWDW will address the use of a household action level, which was suggested by the Drinking Water Advisory Council. OGWDW is still considering the best approach, which should take into account all potential source contributions. Scientists focused on evaluating lead exposure believe that other sources of lead contribute more significantly to exposure than drinking water. Lead dust, soil, and paint are also key sources of exposure. OGWDW needs to think carefully about how to address these issues in the revised Lead and Copper Rule. If background exposure from other sources is treated as a given and an acceptable level is defined based on a specific health effect, a rule can be written that ratchets down on drinking water because those other exposures are a given and can't be minimized. The goal is to minimize exposure to lead, but revision of the Lead and Copper Rule requires more thought. This becomes a policy question, not a science question. Dr. Rodricks noted that 20 percent of total relative source contribution is allocated to drinking water. Dr. Grevatt confirmed this assumption. OGWDW is further evaluating existing data on drinking water source contribution for strontium. Mr. Ahlstrom asked if the research needed to identify source contribution for strontium is available. Dr. Grevatt responded that some dietary data have been identified, but not all of the necessary data are available.

Dr. Rodricks asked Dr. Grevatt to provide more information about OGWDW and ORD's work with other partners. Dr. Grevatt replied that OGWDW and ORD need to find ways to effectively leverage resources. OGWDW has worked closely with FDA on perchlorate projects. The Science Advisory Board recommended that OGWDW develop a perchlorate PBPK model. FDA had done more work on this model than EPA. The two agencies worked together to develop the biologically based dose-response model. Another example is OGWDW's collaboration with Dr. Linda Birnbaum and her staff from National Institute of Environmental Health Sciences (NIEHS) on MCHM, PFOA, PFOS, and cyanotoxins. OGWDW has also worked with CDC and the Agency for Toxic Substances and Disease Registry (ATSDR) during the Flint, Michigan response. The Department of Health and Human Services (HHS) was the lead agency during the federal Flint response. These agencies have collaborated to characterize filters. In Flint, there has been a do not drink advisory issued for nearly 100,000 people for almost a year. During the MCHM emergency in West Virginia, a do not drink advisory was issues for 5 days and cost $70 million. Agencies are collaborating to determine when the drinking water in the Flint system can be consumed without the use of filters so that the advisory can be lifted. States are important collaborators on all of these issues. Ohio has been more impacted by harmful algal blooms than any other state in the country. Ohio has developed a regulation for microcystin in drinking water. EPA worked with the State of Ohio to develop EPA's microcystin Health Advisory.

Mr. Chaudhry asked why a "do not drink" advisory remains in Flint, Michigan. The issues with treatment were resolved. He wondered if the distribution network is the cause of the issue. Dr. Grevatt explained the cause of the recent water distribution system issues in Flint. As part of the emergency response sampling, drinking water continues to exceed the lead action level. Thus, there continue to be problems with elevated lead levels in drinking water. The Flint drinking water system is now the most sampled drinking water system in the country and more is known about lead levels and how they change over time. The presence of particulate lead in the water distribution system results in high levels of lead in many homes. Progress has been made to

optimize corrosion control, but more work is needed. Dr. Grevatt added that the original issue began when the city of Flint decided to switch their drinking water supply from the city of Detroit to Lake Huron. The city decided to treat water from the Flint River until water from Lake Huron could be properly routed. Flint is back to using Detroit drinking water. Questions remain on the long term plan. It is important that the solution that is selected is properly executed.

Mr. Chaudhry asked what measures EPA is taking to ensure another emergency like the one in Flint does not happen in another city. Dr. Grevatt responded that he does not believe that there are other situations like the one in Flint present today, but there are precursor conditions taking place in other areas. Nearly every problem that emerged in Flint occurred after the switch in water supplies and was associated with the distribution system. Violations were reported caused by high levels of DBPs, *Escherichia coli*, and lead. Other financially distressed cities are struggling to manage similar issues. With respect to lead and copper, the EPA Administrator wrote to every Governor and commissioner of every state, tribe, and territory and requested transparency on their drinking water distribution systems and confirmation that the most recent corrosion control guidance was implemented. Communities should follow recommendations in the Lead and Copper Rule for sample collection at Tier 1 sites. Systems with Action Level exceedances were confirmed to be taking the steps required in the Lead and Copper Rule to ensure the public is protected. EPA has gone system by system at sites with Action Level exceedances and evaluated the measures taken to address these exceedances and provided public health education, as needed. EPA is working with every drinking water distribution system in the country. EPA will identify available tools and techniques for increased transparency in data reporting as part of the long term revisions to the Lead and Copper Rule and the development of the Drinking Water Action Plan. Improvements in transparency of data reporting and tracking could help EPA avoid the need for "brute force" and system by system approaches to evaluate the implementation future Rules and improve the provision of targeted technical assistance.

Mr. Ahlstrom noted that the issues don't appear to be related to getting the water out of the treatment plant. However, something is happening between drinking water consumption and when the water leaves the treatment plant. Dr. Grevatt responded that this was the case in Flint. Corrosion control occurs at the treatment plant, but this did not happen in Flint. Issues with drinking water are not all attributed to the distribution systems. There are plenty of small systems, such as those in the Central Valley in California, that struggle with arsenic and nitrates.

Mr. Ahlstrom observed that a lot of research is focused on premise plumbing. Dr. Grevatt agreed with this observation. Premise plumbing is not regulated by EPA, but is very important to lead, *Legionella,* and other contaminants. ORD is exploring the factors that contribute to maintaining disinfectant residual in distribution systems. Dead ends in water distribution systems result from depopulation. Corrosion control is difficult to manage when flow is reduced because there are fewer distribution system users.

Dr. Carole Braverman from EPA Region 5 stated that all EPA regions benefit from ORD's research program. However, no region has benefited more than Region 5. EPA Region 5 staff are welcome in Flint because they brought in the best experts to assist with emergency response. ORD provided experts in corrosion control and water distribution system repair. These experts were only available because of the strong ORD research program. Dr. Braverman noted that the

harmful algal bloom in Toledo created a huge emergency. ORD provided insight on potential problems in the future and emerging algal toxins.

Dr. Braverman described how the EPA regions are involved in research planning. The relationship between the regions and ORD has never been better because the regions provide input for ORD's Strategic Research Action Plans (StRAPs). ORD and the regions are establishing alliance and coordination teams, which will allow the regions to continue to provide input on ORD research and translation.

Dr. Braverman responded to the question "What keeps me up at night?" which was posed by Dr. Burke during the EPA Drinking Water Workshop. She stated that there are two issues that keep her up at night. First, there are residents in Flint and Toledo who may never drink their tap water. EPA needs to improve science communication and translation to the public. Second, there could be a day when there is an emergency and ORD no longer has the necessary expertise to assist. The research areas that ORD invests in are crucial to how everyday business is managed in the regions.

Mr. Ahlstrom asked if the engagement of the regions varies in the development of the StRAP. Dr. Braverman replied that a lead region selected among the 10 regions. Region 4 was the lead region for water for most of the StRAP development process. Region 4 sought input from all regions and now Region 5 is the lead region and does the same. The lead region coordinates input from the other regions and works with colleagues from these regions. ORD piggy backs on the system initiated by the program office, which improves efficiency and communication between the regions and the program office. Regions are responsible for working together and communication is frequent. Occasionally there are too many representatives from each region. There are three teams that follow the research.

Dr. Braverman described how communication takes place among the Regional Support Leaders (RSLs). The 10 RSLs have a conference call every week, and during the year the action plans were developed, communication was more frequent. Input is always encouraged.

Dr. van Drunick noted that Region 8 was the outgoing lead and Region 4 was the incoming lead. During this transition, communication between ORD and the regions was doubled-up to involve both the outgoing and incoming leads. In some cases, more regional representation is needed. There were ongoing issues in Region 5, so Region 5 was also included in many conversations.

Dr. Braverman added that the RARE projects are initiated in the regions. The regions expressed the most interest in water-related projects and are most engaged in water-related issues. Dr. van Drunick added that 75 percent of the RARE program is focused on water-related work.

Mr. Lowenthal asked if it is more efficient to rotate the leads among the regions. Dr. Braverman responded that a 3 year rotation could be better, but staff can only serve in an acting position for 2 years since this position is at a program level.

Dr. Snyder asked if ORD's efforts should be focused on point of use devices during disaster relief or emergency response. Dr. Braverman responded that the issue is distributing the information to the public, not acquiring the information. This is a social science question.

Dr. Rodricks recalled several key topics noted during this discussion. These include: 1) relative source contribution of strontium and lead; 2) communication among partners; 3) social science

and risk communication as it relates to assuring the public their drinking water is safe; and 4) point of use devices. Mr. Ahlstrom added that the responses to the charge questions should include regional participation.

Overview and Deep Dive into Technology Advances Project 2
Christopher Impellitteri, Associate NPD

Dr. Impellitteri presented the research activities, products, and impacts for Project 2, Next Steps: Technology Advances. Project 2 includes seven task areas. Under each task area is a series of sub-tasks, and other each sub-task is specific research projects. Dr. Impellitteri noted that the overall objective of Project 2 is to examine areas that are right around the corner. These tasks are in between current ORD projects to provide immediate support and projects where ORD is re-thinking water systems as a whole.

Dr. Impellitteri described Task 2A – Treatment, monitoring, and risk assessment for water reuse. This task is led by Dr. Jonathan Pressman. There are five sub-tasks: 1) Development of anaerobic membrane bioreactor (AnMBR) technologies for domestic resource water treatment combined with direct potable reuse; 2) Synthesis report on state of the science in membrane technologies for water recovery from challenging water sources such as brine streams; 3) Water waste residuals: Strategies for valuable resource recovery product; 4) Method development for key bacterial populations associated with phosphate bioaccumulation in low dissolved oxygen in resource water systems; and 5) Innovative packaged systems for water reuse and removal of contaminants.

Dr. Impellitteri noted that as part of Task 2A; sub-task 1, work is being done on using AnMBRs in addition to conventional domestic resource water treatment because there is potential for methane and resource recovery. ORD is looking at multiple scales for AnMBR application, including a larger scale project with the U.S. Army. A vertical hollow fiber membrane can be used to capture methane. ORD is focused on optimizing this process.

As part of Task 2A; sub-task 2, Dr. Impellitteri shared that work is being done on developing advanced membranes for water and salt recovery from reverse osmosis brine-concentrates. Dealing with brine concentrates from reverse osmosis is costly for both inland and coastal water distribution systems. Dr. Impellitteri stated that he and Dr. van Drunick discuss avoid engaging in duplicative work already being conducted by other federal entities. This is the only time during the presentation of ORD's research projects that hints at desalination.

Also as part of Task 2A; sub-task 2, ORD has entered into a Cooperative Research and Development Agreement (CRADA) with Aquatech International for membrane material development. A CRADA allows ORD to work with private entities. Evaporation is not practical for drinking water treatment; it is too slow.

Dr. Impellitteri explained that the work on waste residuals under Task 2A; sub-task 3 is specific to recovery of resources from drinking water processes. Materials such as iron or lime present in lime softening sludge could potentially be repurposed to improve sustainability. Dr. Impellitteri described the Pathfinder Innovation Project, and internal "competition" to find high risk/high reward research projects within ORD. One of the successful applicants from this year focused on water utility lime sludge, which could provide an environmental sorbent for power utilities. Lime

sludge could be reused to remove sulfur dioxide, mercury, and metals from power plant air emissions.

Dr. Impellitteri noted that Task 2A; sub-task 4 is focused on phosphate recovery in low dissolved oxygen (DO) resource water systems. An ORD researcher identified a denitrifying bacterial group (*Accumulobacter* sp.) that bioaccumulates phosphate in low-DO conditions. Aeration-based resource water treatment systems use an enormous amount of energy. ORD is examining the efficacy of non-aeration based processes that operate at low-DO concentrations. Mr. Chaudhry asked for more information on what is specifically being done as part of this project. Dr. Impellitteri clarified that ORD is looking at whether or not bacterial populations can be engineered in low-DO resource water treatment systems that can bioaccumulate phosphate. ORD is also determining if phosphate can be recovered and reused. This is an on-going project. Preliminary findings cannot be shared at this time because it is in progress.

Dr. Impellitteri stated that Task 2A; sub-task 5 is focused on developing an innovative packaged system for water reuse and removal of contaminants. ORD is looking at the use of packaged systems in an emergency situation or in very small communities.

Dr. Impellitteri described Task 2B – Novel monitoring technologies for occurrence, exposure and effects for individual and groups of contaminants. This task is led by Dr. Susan Glassmeyer. There are three sub-tasks: 1) Adaptation of advanced methods for regulatory applications; 2) Novel grouping methods to improve understanding the effects of groups/mixtures of chemicals; and 3) Advanced technologies for small water distribution systems.

Dr. Impellitteri noted that as part of Task 2B; sub-task 1, ORD is adapting advanced analytical and monitoring methods for regulatory applications. This research is not supported by the immediate needs of the regional offices. The application of these technologies, such as bioassays, for regulatory purposes may be just around the corner. ORD needs to begin having this dialogue with the program offices because it can take a long time to apply these technologies for regulatory purposes. ORD is looking at where these analytical assays and monitoring tools are used in non-regulatory settings. ORD hopes that the program office finds this work helpful as EPA moves towards 21st century processes for regulation.

Dr. Rodricks asked what characteristics of these methodologies could advance the field. Dr. Impellitteri responded that, traditionally, toxicology work has been based on historical data that may or may not be of good quality. Data is then extrapolated down to a level of toxicological concern. With cell-based methods, a more direct approach can be taken without extrapolation or use of macro-scale data. Assays can be conducted on a chip or sensor. Dr. Rodricks added that it sounds like ORD is adapting the current ToxCast program to an assay-specific program.

Dr. Snyder noted that wet testing has produced interest in the area of resource water reuse. He wondered if assays are being developed that are non-human health based. There are known ecological effects. Dr. Impellitteri responded that the dialogue on these issues has begun. EPA's laboratory in Duluth, Minnesota is leading this work.

Dr. Impellitteri stated that Task 2B; sub-task 2 is focused on the issue of chemical grouping. ORD needs to start looking at chemicals as groups rather than individually. ORD has made some progress in the world of DBPs. Dr. Simmons explained that adverse outcome pathway (AOP) data from ToxCast is typically used to determine the appropriate risk assessment approach. This

is important because there is often a lack of *in vivo* data that can be used to show toxicological similarity for a group of chemicals. Different risk estimates result from the use of different risk assessment methods. This relates back to DBPs and identifying which DBP is important for the toxic endpoint. ORD has developed an assay where you can assess the whole complex mixture and then apportion out the toxicity. The chemical within a mixture responsible for the majority of the toxicity can be identified. The chemical found in the highest concentration is not typically responsible for the majority of the toxicity.

Dr. Impellitteri shared that Dr. Glassmeyer's poster on monitoring 247 CECs in source water, treated drinking water, wastewater effluents, surface water and ground water is summarized in the presentation on Slide 11. This work is complete and there are six manuscripts either under development or in press. Dr. Impellitteri requested that the subcommittee provide feedback on where to go next with this work.

Dr. Rodricks recalled that Dr. Glassmeyer's poster reported that high levels of pharmaceuticals were not found in the survey. He asked who is responsible for looking at pharmaceuticals in drinking water and resource water and determining the risk attributed to these chemicals. Dr. Impellitteri responded that the available data indicates this is more of an ecological issue than a human health issue. A human would have to drink 1,000 liters of water per day to get the dose of acetaminophen present in one tablet. When you put these concentrations in the volume of drinking water consumed in a day, the amount of required consumption is astronomically high. Dr. Snyder suggested that this is an area where collaboration between the pharmaceutical industry and EPA would be helpful. The pharmaceutical industry has a wealth of human data. Dr. Rodricks added that the available human data don't tell you much about safety compared to data available for environmental chemicals. Dr. Rodricks stated that he would like to see what has been done to address human exposure to low doses of pharmaceuticals in drinking water. Dr. van Drunick shared that Dr. Tina Bahadori and Dr. John Vandenberg's groups within the Chemical Safety and Sustainability Program and Human Health Risk Assessment Program, respectively, have done some research on low-dose cumulative exposure. OW tried not to overlap the work done by these other groups. There are two pieces to this work: monitoring exposure and exploring the effects of exposure.

Dr. Impellitteri stated that Task 2B; sub-task 3 involves the application of advanced technologies to detect microbial contaminants in small building scale distribution systems. Some patients could be more susceptible to opportunistic pathogens such as mycobacteria and *Legionella*. ORD is also developing a monitoring process for these smaller distribution systems.

Dr. Impellitteri described Task 2C – Water treatment technologies for enhanced reduction of chemical and microbial risks. This task is led by Dr. Darren Lytle. There are six sub-tasks: 1) Biological drinking water treatment: Gaining acceptance and optimization to achieve desired treatment goals; 2) Development of technologies to meet drinking water goals in small systems; 3) Light-emitting diode (LED)/ultraviolet light (UV) systems for water disinfection; 4) Effectiveness of current and innovative resource water treatment operations for managing model compounds; 5) Application of microelectrodes to optimize disinfection to control biofilms; and 6) Treating drinking water in buildings: A holistic approach to providing safe water to consumers.

Dr. Impellitteri noted that work under Task 2C; sub-task 1 includes a CRADA and technology license agreement with AdEdgeto develop EPA biological ammonia technology to full-scale application. Biological treatment has effectively been applied to nitrogen removal in a small system in Iowa and researchers are looking to further develop this technology. This sub-task also includes a newly-awarded Pathfinder Innovation Project focused on the treatment of emerging contaminants using alternative drinking water treatment method of UV light, percarbonate, and peracetic acid.

Dr. Impellitteri shared that ORD is following up on over a decade of arsenic technical support in small systems under Task 2C; sub-task 2. This support was the reason the EPA Drinking Water Workshop was started. It was originally the "Arsenic and Small Systems" workshop and was broadened as participation grew. Research is focused on identifying technologies that can be used for the removal of ammonia and other compounds.

Dr. Impellitteri noted that work under Task 2C; sub-task 3 is focused on the next generation of UV treatment using LED, which is a more energy efficient technology. ORD is evaluating the cost effectiveness of LED treatment technology.

Dr. Impellitteri noted that work under Task 2C; sub-task 4 is focused on the development of SOPs for sample collection, preservation and analysis for CECs in resource water and biosolids. Much of this work is focused on PFCs. Dr. Rodricks asked if this a new challenge or a continuation of previous work. Dr. Impellitteri responded that ORD is looking at method development for PFCs. There are two American Society for Testing and Materials (ASTM)-approved analytical methods for PFCs in biosolids. ORD is developing SOPs for a wider class of PFCs in a broader set of matrices.

Dr. Impellitteri shared that work under Task 2C; sub-task 5 examines the use of microelectrodes to optimize disinfection control. This work can be applied to examine biofilms in pipes or water solid interfaces in storage tanks. Microelectrodes allow view of changes in various parameters (e.g., pH, oxidation potential) as a function of changes in depth. Chemistry is different in different states. Thus, the contents of storage tanks could be different. There is little to no penetration of disinfectants in storage tank sediments. This research will be applied to determine when drinking water storage tanks need to be cleaned out before they cause problems in the water distribution system. Microbes in the sediment can colonize the distribution system.

Dr. Impellitteri stated that work under Task 2C; sub-task 6 is focused on evaluating the impact of disinfectants on biofilm formation in premise plumbing. The work also looks at secondary considerations (e.g., corrosion, nitrification, DBP's, etc.) when installing disinfection to a building to control *Legionella*. EPANET is also being further developed to model these small systems.

Dr. Impellitteri described Task 2D – New methods and tools for measuring human and ecological health risks from chemicals (individual and mixtures) and pathogens. This task is led by Dr. Simmons. There are two sub-tasks: 1) Identify potential exposure and effect posed by contaminants to manage their risk in source, drinking, waste and reused water through a tiered screening approach, which couples bioassays/bioactivity and analytical chemistry in an effect-directed analysis; and 2) Development of approaches to evaluate human health response to waterborne contaminants associated with drinking water quality.

As part of Task 2D; sub-task 1, Dr. Simmons explained that ORD recognized that computational toxicology cannot be used in all cases for waterborne contaminants. Rapid *in vivo* screening assay (MicroTox) studies are in progress to examine relative potency of priority unregulated chemicals. MicroTox studies fell out of favor in the United States, but have been revitalized in the European Union. Preliminary prototype PBPK models are under development. PBPK models cannot be developed for every chemical, so ORD is developing screening PBPK models. ORD is also looking at *in vivo* developmental toxicity screening of water contaminants for effects on pregnancy disruption and ocular development. ORD is trying to see how they can work more efficiently at developmental toxicity. Dr. Rodricks asked what the purpose is for priority setting. Dr. Simmons clarified that priority setting is for further testing. Dr. Rodricks asked if inhalation exposure is an issue for waterborne contaminants. Dr. Simmons responded that inhalation exposure could be a concern for some chemicals. More data are available on this exposure route than on the dermal exposure route, which represents a more prominent data gap. Dr. Rodricks asked why the emphasis was on *in vivo* developmental toxicity. Dr. Simmons replied that the epidemiological literature supported the hypothesis that consumption of disinfected water by pregnant women could lead to increased pregnancy loss. More recently, epidemiological data are pointing to cardiac defects. Cardiac defects are better supported by epidemiological data than pregnancy loss, so ORD is trying to gain a better understanding of this reported effect. This is a new effort.

ORD is developing omics based bioassays to assess exposures to specific classes of chemicals under Task 2D; sub-task 1. Dr. Impellitteri shared that this work is related to CDC's development of a potential indicator list. Research efforts could be focused on a list of representative CECs rather than on individual chemicals. Indicator chemicals could be used as CECs.

Under Task 2D; sub-task 2, the use of salivary immunoassays to link health effects with drinking water exposures to 10 pathogens are being investigated. Saliva samples were collected from Wisconsin and similar samples will be collected in Puerto Rico in mid-2017. This work could support OW's use of alternative methods for exposure assessment. ORD is also developing improved biological markers to link health effects with drinking water exposures. The use of biomarkers would expand the list of available assay targets. These results may support future drinking water regulations. Dr. Impellitteri shared that ORD is developing an animal model to address uncertainty surrounding the risk posed by aerosolization of waterborne pathogens in drinking water. ORD is also developing a new methodology for measuring human health risks from pathogens in aerosols in drinking water. ORD is conducting a comparative toxicity of microcystin congeners found in U.S. freshwaters. Dr. Impellitteri noted that many microcystin standards are not commercially available. This work will take some time, but is considered high priority because toxicology data are an important component of the risk assessment decision process.

Dr. Impellitteri described Task 2E – Advancing public health protection through water infrastructure sustainability (NCER-STAR) and Task 2F – Research and demonstration of innovative drinking water treatment technologies in small systems (NCER-STAR). Many of these research projects are funded by NCER as part of their STAR grants. A fair amount of work has been focused on small systems and water quality monitoring in distribution systems. Eight STAR grants end in 2016. This portfolio of work is winding down.

Dr. Impellitteri described Task 2G – Net zero EPA-Department of Defense (DoD) Interagency Agreement (NCER-Interagency Agreement). This is a collaboration with DoD to test new technologies, including the use of a field scale AnMBR. Dr. Impellitteri provided more information on the joint Environmental Security Technology Certification program solicitation for water reuse technology between EPA and DoD. This is a program to test and evaluate new technologies. Dr. Chaudhry shared that this group funded AnMBR projects in Singapore and Malaysia have demonstrated that this technology seems to be very promising in reducing energy consumption. He offered to provide more details to the subcommittee.

Dr. Rodricks asked the subcommittee members if any technologies appear to be missing from those discussed under Project 2. He found the list fairly exhaustive. The subcommittee members had no objections.

Mr. Ahlstrom recalled that one of the posters presented at the EPA Drinking Water Workshop addressed finding a simple way to measure arsenic. Dr. Impellitteri noted that Dr. Garland will discuss this issue in Project 3. There are many research projects that are high risk but high reward. There is a lot of interest in advancing monitoring technologies for water reuse, resource water, source water, etc. There is a big effort within ORD to advance these technologies.

Dr. Rodricks asked for clarification on the difference between advanced technologies and transformative technologies. Dr. Impellitteri shared that ORD often considers how they would build water systems and treat and monitor the water in these systems if able to start from scratch. The projects discussed under Project 2 are all things we are very close to achieving. Transformative research will not be achieved for a bit longer. Dr. Simmons added that ORD wanted to focus on the low hanging fruit. ORD has spent many years looking at currently regulated DBPs. ORD cannot spend 5 years investigating ten individual DBPs and needs a way to identify the most important DBPs to human health. Most advances made by ORD, and unique to EPA, are in developing grouping technologies and using existing data to accurately predict the effect of a mixture. ORD has accomplished these activities, but needs to determine how to move that data into something that can be used by risk managers or remediators.

Dr. Chaudhry noted that there are challenges associated with applying advanced technologies in a cost effective manner. He asked if any work is being done in this area. Dr. Impellitteri responded that this is not being explicitly investigated because it is not included in the StRAP or project plans, but cost is considered when evaluating alternative disinfection technologies. Small utilities do not usually think beyond 1 or 2 years with respect to cost. Cost is not something to consider from a research perspective.

Mr. Ahlstrom asked if Dr. Impellitteri was aware of what El Paso, Texas is doing to capture chemicals out of brine. A private company built a facility where brine will be sent. Chemicals will be extracted from the brine and marketed to a supplier who use the chemicals. This process closes the loop so that there is no waste residual. The facility is expected to come online later this year. Theoretically there will not be brine, only usable chemicals and clean water. Mr. Ahlstrom offered to send this information to Dr. Impellitteri.

Mr. Ahlstrom made an observation that the phrase “distribution system” is considered from treatment to point of use, but ORD seems to be referring to building systems as well. We need to

come up with a different term to refer to building systems because they do not fit under the term distribution system and will be confusing to the industry.

The participants watched a short video summarizing the work done in El Paso, Texas to convert brine in resource water to commercial chemicals. EWM developed the technology. The facility can process 1 million to 1.5 million gallons of water per day can.

Overview and Deep Dive into Transformative Approaches and Technologies Project 3
Jay Garland, Director NERL, Systems Exposure Division

Dr. Garland presented the research activities, products, and impacts for Project 3, Transformative Approaches and Technologies. Project 3 includes six task areas. Under each task area is a series of sub-tasks, and other each sub-task is specific research projects. Dr. Garland described the meaning of transformative approaches. ORD tries to lay out a structure that represents a gradient from research that can be addressed right now to more advanced work. This gradient is not temporal. A clear line cannot be drawn between projects that are considered next steps and projects that are considered to be transformative. ORD adopted a three-pronged approach with some overlap. A key component of transformative projects is consideration of different approaches. It is important that projects are manageable in size. ORD is looking at different systems and providing input that will make a difference in the near term and catalyze the adoption of these transformative approaches.

Dr. Rodricks asked Dr. Garland to point out projects considered to be transformative during the presentation. Dr. Garland agreed and offered to also point out projects that could be considered "next steps" rather than transformative.

Dr. Garland described Task 3A – System approaches for assessment of transformative fit-for-purpose and resource recovery-based water systems. This task involves systems level evaluations. The sustainability of the approach is considered and life cycle assessment is used. This task is led by Dr. Cissy Ma. There are three sub-tasks: 1) Development of a transformative technology toolkit library – different treatment trains or usage processes being developed; 2) Metrics, tools improvement, and expansion; and 3) System analyses comparing conventional and transformative community water systems and applications in community-based case studies. Tasks 3A and 3C are highly leveraged. Task 3A is focused on modelling and virtual assessments of the system while Task 3C is where virtual assessments are applied to real systems.

Dr. Garland noted that the use of various unit processes (i.e., AnMBR, aerobic membrane digestor (AMBR), constructed wetland, etc.) are evaluated as part of Task 3A; sub-task 1. ORD considered the different scales and footprints of these technologies at various operational temperatures. The net costs and benefits were considered for each system. The benefit is the drinking water that is not treated for non-potable water reuse. Both AnMBRs and AMBRs consume a lot of energy, but are energy positive at certain temperatures and trade thermally from a cost perspective. This project considered life cycle costing and life cycle assessment. Dr. Garland clarified that these results were based on an inventory analysis, which is conducted as part of all life cycle assessments. Robust datasets are available for AMBRs because they are commercially available. Data on the AnMBR is from peer reviewed literature on the developmental efforts. The data represent the average estimates for the given elements of the system.

Also as part of Task 3A; sub-task 1, ORD worked with OW to evaluate a 5-level nutrient removal treatment train. A range of different treatment technologies with varying intensities provide a range of total phosphorous in the effluent. ORD examined the cost of each system, which considers the output of the system and the cumulative energy demand of the system. The system that requires reverse osmosis results in an increase in energy consumption.

Dr. Garland described the approaches for methodology improvement under Task 3A; subtask 2. These include risk assessment, life cycle assessment, and energy analysis. Work on the Water Scarcity Index is part of improving life cycle assessment. This work will make the water impact factor for a specific treatment system more regionally relevant. ORD has done a lot of work on log reduction targets for non-potable water reuse.

Dr. Garland noted that a systems analysis is performed under Task 3A; subtask 3. ORD has conducted an energy footprint for a scenario system (current centralized water and wastewater systems modeled after Cincinnati, Ohio). ORD identified major energy consumption activities for each element of the treatment system. ORD is also evaluating decentralized non-potable water systems. ORD is working with a small city (1 million gallons per day) to turn the system into a resource recovery hub.

Dr. Garland described Task 3B – Novel detection tools for systems applications. This task is led by Dr. Eunice Varughese. This task is focused on addressing questions related to monitoring, There are two sub-tasks: 1) Development of a knowledgebase and proof-of concept for AOPs and biosensor technology to capture the presence of major classes of contaminants that pose a risk to human health; and 2) Design and development of an AOP targeting biosensor, which will provide guidance for evaluating the methods employed for water quality characterization and provide information for risk and exposure assessment.

Dr. Garland shared that EPA issued an innovation challenge as part of Task 3B; sub-task 1. ORD initiated discussions inside and outside EPA on implementation of AOP biosensor technology (assay on a chip). Putting bioassays on a chip would be a transformative project, but ORD does not have the internal resources to complete this work. Partners inside EPA include individuals from ORD and OW. Partners recruited outside of EPA include individuals from USGS, NOAA, U.S. Army, WEF, and Greater Cincinnati Water Works. There are weekly meetings focused on developing the knowledgebase on which toxicity pathways and AOPs should be targeted for biosensor technology. The findings are captured in a review document.

Dr. Garland noted that ORD has partnered with the EPA Innovation Team under Task 3B; sub-task 2. Phase 1 of the challenge is underway. Phase 2 includes challenges to develop a prototype. If funding is available, a field-deployable sensor will be produced as part of Phase 3. This sensor will provide real-world use of toxicity data for the characterization of water quality. These sensors can be applied for use in water reclamation efforts to mitigate procedures for water reuse. The near-term impact is a life cycle assessment of sewer mining using different treatment technologies at different scales and population densities. The mid-term impact (2018) is a summary report of AnMBR performance.

Dr. Garland described Task 3C – Case studies and demonstrations of transformative approaches for water systems and water reuse. This task is led by Dr. Andra Morgan and is closely aligned with Task 3A. ORD designed Tasks 3A and 3C to merge the actual (i.e., measured data) with the

virtual. Task 3C represents the "actual." There are three sub-tasks: 1) Demonstration and evaluation of decentralized wastewater treatment for water reuse; 2) Development of improved guidance for non-potable water reuse; 3) Application and evaluation of integrated approaches for sustainable water resource management.

Encompassed in Task 3C; sub-task 1, EPA issued a joint EPA-Department of Defense (DoD) solicitation for development of innovative, energy-efficient, low maintenance systems for decentralized treatment and recycling of wastewater, or sewer mining, on military installations. CDM Smith received this award for their AnMBR design. Dr. Garland provided an update of this work. A trailer with the AnMBR was installed in Fort Riley, Kansas in June 2016 and the AnMBR has been running since mid-July 2016. The AnMBR provides treatment and methane gas removal from the permeate using hollow fiber membrane modules. Methane discharges defeat the purpose of having an energy efficient system. The system will run for 18 months. EPA Region 6 provides on-site system support.

Dr. Garland noted that ORD has dedicated the most time to non-potable water reuse, which is encompassed in Task 3C; sub-task 2. The San Francisco, California Public Utilities Commission is a major partner. Water consumption per capita per day is very low in San Francisco. Distribution system efficiencies are in place, but more alternative approaches for water conservation are needed. All types of non-potable reuse are promoted in San Francisco, and in particular the collection of greywater at the building scale. An expert panel was developed through National Water Research Institute (NWRI) to develop a framework for decentralized non-potable water systems. The panel will provide additional information and guidance to state and local health departments. The panel recommended developing a risk-based approach to define log reduction targets for various waters used for non-potable reuse. The stakeholders embraced this approach. ORD assisted in the development of the risk-based models. These values were developed for various pathogens (i.e., viruses, bacteria, and protozoa) in municipal wastewater, greywater, stormwater, and rainwater using quantitative microbial risk assessment (QMRA). A greater log reduction is required if the water will be used for drinking or home use.

Dr. Rodricks asked what value is the target risk reduction. Dr. Garland responded that the values are based on an acceptable risk of 1 case of illness in 10,000 persons. The first step in arriving at this risk level is developing a best guess of the concentration of the pathogen in source water. The exposure model accounts for the typical volume of water consumed. A dose-response model is then incorporated. Dose-response models vary for each pathogen. EPA has not set standards for direct potable reuse. Options are provided to the stakeholder group to permit systems based on their definition of the acceptable level of risk. Dr. Rodricks asked if the risk attributed to each of the microbial contaminants is additive. Dr. Garland responded that QMRA involves selecting representative viral, parasitic, and bacterial pathogens. The acceptable risk level is based on the representative pathogen that has the highest probability of infection in the source water.

Dr. Snyder shared that the World Health Organization (WHO) recently completed a similar exercise. Data on the presence of virus in greywater and raw sewage was insufficiently robust. The work being completed in San Francisco is based on data from one book chapter written 15 years ago. Unless additional data became available and he is unaware, more robust data on the presence of pathogens in greywater and other water sources are needed. The log removal values rely on these data. Dr. Garland agreed that data is sparse for measured pathogens in greywater,

but some data are available on pathogens in raw sewage. Some available data are on indicator organisms, not pathogens. ORD linked an indicator model to an epidemiological model to predict the amount of contaminated feces in the water. This is a valuable component of the partnership with San Francisco, who collect samples from their utility systems. Estimates of pathogen concentrations in stormwater varied broadly. Stormwater composition varies by location. In the modeling, stormwater was considered either a 10-fold or 1,000-fold dilution of wastewater.

Dr. Garland added that the stakeholders wanted recommendation on monitoring. NWRI recommended operational monitoring rather than monitoring indicator organisms. Users should validate their system to ensure it meets the log removal targets. Challenge testing could be used for validation. ORD's other research project is focused on mining existing systems to identify endogenous microorganisms that could be used as surrogates. This work includes consideration of the microbiome. Traditional surrogates are too dilute in the system. ORD used quantitative polymerase chain reaction (qPCR) to quantify dominant organisms (at the genus level) in various greywater sources (i.e., laundry, shower, etc.) and looked at the genera associated with human skin cells and infrastructure. *Staphylococcus* had the highest concentration.

Dr. Snyder asked if the viability of the organisms must be known since qPCR is used. Dr. Garland responded that viability would be important. For some organisms, other culture-based approaches could be developed.

Dr. Garland shared that two publications will be submitted to a peer-reviewed journal. The NWRI panel will use these papers as part of their framework document, which will be published at the end of summer. Involvement with stakeholders will continue as the best scenarios of water reuse are defined. This area overlaps with Task 3A.

Dr. Garland presented an additional element of the case studies. ORD is collaborating with DoD to develop low-impact infrastructure and artificial aquifer recharge to evaluate the effectiveness of low-impact development infrastructure and best management practices for wet weather capture and aquifer recharge in the southwestern United States. The project is currently in the planning stages and is somewhere between next steps and transformative. ORD will monitor these systems.

Dr. Garland described Task 3D –Water technology innovation clusters. This task is led by Dr. Sally Gutierrez. There are two sub-tasks: 1) Leveraging technology clusters to solve water challenges and create economic opportunity; and 2) Water technology cluster research, development and demonstration (RD&D) and impacts. This task area could fit anywhere in the research program. Research and development is transferred to the private sector. Dr. Impellitteri added that one of the challenges to transferring research and development to the private sector is the myriad of requirements in each state on test result acceptance. ORD is working with Kentucky, Ohio, and Indiana to develop common objectives that must be met for acceptance of new technologies. Dr. Garland provided a list of projects taking place in these water technology clusters. Many of these projects link ORD-developed methods to commercial companies.

Dr. Garland described Task 3E – Approaches to assess the overall health of a community. This task is led by Dr. Tim Wade and Dr. Betsy Hilborn. There are 3 sub-tasks: 1) The role of waterborne and environmental pathogens as a trigger for Type 1 diabetes; 2) Characterizing

waterborne disease through outbreak surveillance; and 3) Waterborne disease associated with distribution system deficiencies. This task is focused on alternative approaches for looking assessing the effects of water on the health of the community rather than on transformative systems.

Dr. Garland described ORD's work to evaluate the role of waterborne and environmental pathogens as a trigger for Type 1 diabetes as part of Task 3E; sub-task 1. ORD formed a collaboration with the University of Colorado Medical School and obtained access to plasma and saliva samples from a cohort of T1D patients (The Diabetes and Autoimmunity Study in the Young - DAISY). ORD is developing multiplex methods to detect antibodies of waterborne echoviruses and coxsackie viruses in saliva and serum that may "trigger" T1D. Two manuscripts are in preparation describing the assay methodology. ORD is searching for additional cohorts to evaluate associations with waterborne exposures.

Dr. Garland describe ORD's collaboration with CDC to characterize waterborne disease through outbreak surveillance. This task is led by Dr. Wade and is covered under Task 3E; sub-task 2. ORD and CDC are developing a summary of the 2013–2014 waterborne disease outbreaks will be published in 2017. Data is normally collected at the county scale, but it can be related retrospectively to a specific drinking water system.

Dr. Garland described ORD's work under Task 3E; sub-task 3 to explore waterborne disease associated with distribution system deficiencies. PRD identified sources of data on Type 1 diabetes mellitus, waterborne disease, and distribution deficiency data. ORD is developing an Interagency Agreement with CDC to enhance study of health effects associated with low pressure events, repairs and breaks. Mr. Lowenthal asked if a large portion of disease is related to issues with the water delivery system. Dr. Garland responded that this project seeks to answer that question.

Dr. Garland explained that CDC is closely monitoring pressure and distribution systems in several communities and collecting disease occurrence data for users of those systems. This work will help track the relationship between disease and the drinking water system as well as the impact of distribution system issues on disease. Dr. Impellitteri noted that the goal of this work is to quantify what it means to have a water break. The American Society for Civil Engineers consistently grades U.S. water infrastructure as a "D." We want to understand what this grade means and if the water distribution systems are inoculated with pathogens when there is a break. ORD also wants to strengthen their relationship with CDC. CDC is skilled at collecting data and ORD is skilled at applying this data. Dr. van Drunick added that this research helps identify the healthcare implications and cost of a water main break. A participant pointed out that in CDC's surveillance summary for 2010–2012, most waterborne disease outbreaks were directly attributable to distribution system issues. However, the outbreaks are the tip of the iceberg of the actual number of occurrences of waterborne disease. The number of community acquired illnesses is much higher. This data could help improve our understanding of the number of community acquired illnesses attributed to the water distribution system. Dr. Impellitteri concurred and added that ORD can better understand the cost of waterborne diseases. Dr. Garland noted that CDC uses this data to understand health burden of waterborne diseases. Past CDC surveillance summaries have contributed to OW's regulatory activities related to emerging waterborne contaminants, such as *Legionella*.

Dr. Garland described Task 3F – Human and ecological health impacts associated with water reuse and conservation practices. This task is led by Dr. Ben Packard. There is 1 sub-task: STAR grants. The grants will evaluate water conservation practices that promote reuse such as aquafer recharge, potable reuse, and agricultural reuse. The kickoff takes place in Washington, D.C. in October, 2016. Dr. Garland noted each of the STAR grant recipients and their research projects. The early career award was provided to Daniel Gerrity from the University of Nevada - Las Vegas. The project is titled Framework for Quantifying Microbial Risk and Sustainability of Potable Reuse Systems in the United States.

Dr. Snyder asked for clarification on how engagements develop between ORD and external partners. He asked for more information on the origin of relationships between external partners and EPA. There are a limited number of STAR grants and these grants do not provide a viable mechanism for obtaining feedback from EPA or beginning a collaboration where funding is not expected to be provided from EPA. Dr. Impellitteri responded that the cooperative research and development agreement (CRADA) program provides a vehicle for ORD collaboration with private companies. Dr. Impellitteri advised interested collaborators to reach out to him directly. He would then refer interested parties to the Water, Technology, and Innovation cluster. ORD had many memoranda of understanding (MOUs) with partners inside and outside of the government. These are formalized agreements of how two parties can work together.

Dr. Snyder asked how ORD prioritizes research. Dr. Impellitteri explained that ORD asks OW to identify their highest priorities. OW is currently re-drafting their priorities list. ORD then gets the Regions involved. ORD meets at least twice per year with WERF and other key research organizations to discuss the priorities of their subscribers. For example, they have identified water quality impacts from forest fires as an important issue. ORD receives input on their research priorities from states, regions, and research associations.

Dr. Snyder asked if ORD has interacted with the National Science Foundation (NSF). The Water Institute just won a grant from NSF on one of the same ORD projects presented today. Dr. van Drunick confirmed that ORD and NSF do interact. Each of the agencies has at least one representative that works together on various initiatives. They meet at least 11 times a year and the meetings focus on different topics; each agency discusses the topics. The meetings aren't recorded and there are no minutes, which provides a space for the agencies to communicate more freely about their current work or work that was planned but cut due to funding limitations. Some interaction happens at the inter-agency level. Each of the five OW offices developed a list of what they wanted ORD to do for them. These projects were captured in an Excel spreadsheet. OW then prioritized these projects by office. This spreadsheet was then shared with the regions. Regions receive requests from different parts of the agency and could react to the research prioritization list. The list of priorities needs to be tightened up due to funding limitations. ORD will continue discussions with our partners on research prioritization and resources. It's a dynamic world, and ORD needs advice from the BOSC to make the most of the available funding. ORD is limited because everything shared with the BOSC must be public information.

Dr. Snyder pointed out that the BOSC has been provided with an overview of each project, but not information on funding allocated to each project. Funding information would be helpful so that the BOSC can provide better feedback on project funding levels. Funding could be linked to a perception of prioritization.

Dr. Rodricks asked if these ideas were developed solely within ORD or if they reflect collaborations outside of ORD. Dr. Garland responded that all science builds on something else and these projects are not *de novo*. ORD has had similar projects in earlier versions of the StRAP. The focus is on identifying partners with similar interests to implement the same projects in the near term. ORD often enters in to their partners' discussions to identify their needs. It is important for ORD to talk to regions and utilities about their needs and goals.

Dr. Snyder asked if San Francisco is discussing what would happen if they pull all of the greywater out of the sewers. This approach did not work in Australia and the sewers stopped flowing. Dr. Garland replied that San Francisco's black water is not very clean and is not cheaper to clean. San Francisco may not need to worry about source separation. San Francisco wants to promote any new development that improves water efficiency. The city believes that in 30 years they will have a different water distribution system that is either a centralized direct potable reuse system or a decentralized nodular system. ORD is working with the city in the development process to make these systems more efficient.

Mr. Ahlstrom asked if the salivary amino assays in Puerto Rico will provide clarity or result in more confusion. He wondered why Puerto Rico was specifically selected as the study site because this location introduces many novel variables. There are many factors in this area that contribute to drinking water outbreaks and waterborne disease. Dr. Impellitteri replied that Puerto Rico is part of Region 2. Puerto Rico has many small drinking water systems that serve small communities of 20 to 50 people. These systems pose a significant problem to the drinking water distribution system. Region 2 has a significant number of drinking water violations and conducting this work in that area is important. With salivary assays, it is unclear if exposure to that agent happened yesterday or 10 years ago. This could lead to more confusion, but ORD is supportive of the value in conducting these analyses.

Mr. Ahlstrom noted that ORD discussed the use of EPANET at the building level. He asked if ORD has taken a step back and thought about creating something for removal. Dr. Impellitteri replied that the RTX program is a joint research program between SSWR and NHSRC. This group is trying to use EPANET as the core for developing a new way to look at a smaller system.

BOSC Only Discussion of the Day 1 Project Presentations
Subcommittee

As a reminder to the subcommittee, Dr. Rodricks read the two water systems' charge questions:

1. Are we doing the right research? Taking resource limitations into consideration, are there any additional research needs that warrant new investment or current research that merits expansion, and are there areas of research that SSWR may consider disinvesting in?
2. Are we doing the right research at the right time? Comment on the balance of near, current and long-term research objectives.

Dr. Snyder observed that many of the projects presented today include work that is already being done by other organizations. He was curious about how the subcommittee was supposed to comment on work that has already been either completed or is near completion. Dr. Rodricks responded that the charge questions ask the subcommittee to comment on additional research needs that are not receiving the proper attention.

Mr. Chaudhry noted that what the subcommittee saw today was an overview of ORD's SSWR research projects. When the subcommittee receives the full description of each project description, there will be more information on how the current work is different than the work that has already been done. The program appears to be on track, but it is difficult to answer these charge questions without more detail on each project. Dr. Rodricks added that the work presented today was still considered in progress.

Dr. Snyder stated that it would be valuable to see a summary of the input provided by partners and stakeholders summarized. The project prioritization spreadsheet that Dr. van Drunick described would be helpful. Mr. Lowenthal agreed that it would be helpful to look at what projects were selected and which of these projects were suggested by the Regions.

Dr. Snyder added that it is difficult to get a sense of the research projects without information on the magnitude and amount of resources dedicated to a specific project. This information will help the subcommittee respond to the charge question that asks if the right amount of resources are being dedicated to the right research areas. Mr. Lowenthal noted that funding is very limited, so all of the research investment is on the smaller scale.

Dr. Chaudhry stated that the research is correct. The second part of the question asks if ORD should disinvest in any research areas. The subcommittee cannot answer this question without information on funding. Funding is related to the available resources and the subcommittee does not impact funding or resource availability.

Mr. Lowenthal noted that ORD did a better job in this year's presentation to provide information on partner collaboration. It appears that ORD received the subcommittee's feedback from the last meeting about incorporating the involvement of partners in research. ORD often has to work in a reactive mode rather than in a proactive mode because of all of the emergency events.

Mr. Ahlstrom suggested that the subcommittee review all of the project slides and select a few projects that are not as high of a priority as some of the other projects. He noted that ORD wanted to illustrate that they are doing some research to address a wide range of areas of concern. He expressed concern with the work on salivary immunoassays and drinking water systems in Puerto Rico. He suspected that no major research questions would be answered with this limited amount of work. Mr. Lowenthal asked if it is better to do some research than to do nothing at all. Mr. Ahlstrom responded the real question is "why is this research being done."

Dr. Snyder commented that the use of biosensors in distribution systems is far into the future. He imagined that the National Institutes of Health (NIH) or NSF would be leading work in the area of biosensors rather than EPA. Dr. Snyder considered constructed wetlands and aquifer re-charge in engineered systems to be more important and more near-term areas to discuss. ORD only briefly mentioned these areas. It is unclear of the depth that constructed wetlands or other engineered systems approaches were considered or if they are adequately addressed in the research. Mr. Lowenthal concurred and suggested including this in the subcommittee's response to the charge question.

Dr. Snyder noted that the research on the log removal of pathogens in building system is very important. ORD presented values developed by NWRI, but this work is widely disputed because of the uncertainty associated with the starting concentrations of the pathogens. Transformative work would be if EPA is going to evaluate the log removal values developed by NWRI.

Historically, WHO and the National Research Council (NRC) have struggled with this topic because of a lack of data on the starting concentrations for these pathogens. There are significant data gaps. If EPA began filling these data gaps, this work is right on target. The wrong approach would be for EPA to just use NWRI's recommendations on log removal values. Dr. Rodricks supported including this comment in the subcommittee's response.

Dr. Snyder recommended that ORD review NRC's list of national research priorities, which was reported in 2010. He cautioned that this list may be slightly dated. Some of these data gaps were focused on the removal of microbes.

Mr. Chaudhry shared that there was a recent survey of water utilities released several days ago. Four major issues were identified: 1) old infrastructure; 2) operational cost; 3) resilience; and 4) climate change impacts on sustainability. It is important for ORD to consider the cost of implementing any new technology developed as part of their program. Dr. Rodricks responded that ORD did mention that cost was considered and that cost is part of their research program.

Mr. Ahlstrom asked if ORD is doing the research that needs to be done on aging infrastructure. Mr. Chaudhry replied that it does not appear that much research is being done in this area. Mr. Lowenthal recalled only one project that involved checking leaks within a water distribution system.

Dr. Snyder asked if ecology fell under the SSWR project portfolio. Most of the emphasis has been on human health rather than aquatic or ecological receptors. He did not recall any projects related to ecosystems. Dr. Rodricks agreed that ecology is under the SSWR project portfolio. Dr. Snyder noted that the new aquatic life criteria could impact drinking water and wastewater utilities. Mr. Lowenthal recalled that Dr. Impellitteri stated that pharmaceuticals create ecological issues and not human health issues. Dr. Rodricks replied that he is skeptical of Dr. Impellitteri's statements on pharmaceuticals and plans to comment on this in the response to the charge questions.

Wrap-up and Adjourn
Joe Rodricks, Chair, Tom Tracy, DFO

Dr. Rodricks asked the present subcommittee members how to involve the subcommittee members absent from this meeting in answering the charge questions. Mr. Lowenthal suggested assigning each of the absent subcommittee members to a project topic area that aligns with their area of expertise. This subcommittee member can check-in with the subcommittee member present at today's meeting who is leading the development of the response for the charge questions for that project area. This would be an exchange of information between three subcommittee members, which is within the FACA rules. Mr. Chaudhry asked Dr. Rodricks to send the project topic areas and the charge questions to each of the absent subcommittee members and ask them to provide their preference for their project topic assignment. Dr. Rodricks concurred with this suggestion and asked Mr. Tracy to prepare and send this email to the absent subcommittee members.

The subcommittee members agreed to the following assignments:

Project 1: Mr. Ahlstrom (response lead)

Project 2: Mr. Chaudhry (response lead)

Project 3: Dr. Snyder and Mr. Lowenthal (response lead)

Dr. Rodricks dismissed the subcommittee for the day at 5:30 PM.

Thursday, August 25, 2016

DFO Reconvene Meeting, Attendance
Tom Tracy, DFO

Mr. Tracy welcomed the subcommittee members back and opened the meeting at 8:15 AM.

EPA Drinking Water Workshop: WINSS and DeRISK Status Reports (Regency ABC Ballroom)

Subcommittee members attended two of the EPA Drinking Water Workshop presentations; the National Centers for Innovation in Small Drinking Water Systems: WINSS Status Report by Bruce Dvorak from the University of Washington, and the National Centers for Innovation in Small Drinking Water Systems: DeRISK Center Status Report by Chad Seidel from the University of Colorado Boulder.

Public Comment Period
Tom Tracy, DFO

No public comments were made during the meeting.

NCER STAR and National Priorities Water System Grants
Michael Hiscock, National Center for Environmental Research

Dr. Michael Hiscock was the lead for the Extramural Research Grants program for NCER. He provided some information on his background and explained that he was trained in coastal marine biology and oceanography. He came to EPA through a project on climate modeling before he moved to his current position within NCER.

Dr. Hiscock explained that, within the Water Systems topic areas, the Extramural Research Grants had a total of thirty-two grants, including request for applications (RFAs) and Cooperative Agreements. The RFAs were either STAR or National Priorities Grants. He explained that under Project 1, Current Water Systems and Regulatory Support, there was one National Priorities RFA in plumbing that was nationally directed and national in scope. Dr. Hiscock added that, because the project was a National Priorities RFA, it was on the fastest track and would be awarded much faster than the 180 days Congress had to award traditional RFAs.

Dr. Hiscock explained that the three STAR RFAs under Project 2, Next Steps: Technology Advances, were notable because they arose from a separate call in RFAs for a non-tenured track for early career scientists. He added that the productivity metric used for grants was the number of publications per $100,000. Dr. Hiscock explained that two early career grants were awarded under Project two; one grant was awarded to Jeffrey Kutchins from the University of Connecticut, who had already produced seventeen publications from his grant. The second award went to Jason Zwara at the University of Florida. Dr. Hiscock added that he thought the early career grants were exciting because they funded scientists' research relevant to EPA and early in their career. This increased their likelihood of continuing to work on those important research topics and produce results that provide EPA with great information. He added that the grants

were also good for the communities they served and for the research scientists themselves because the application pool was small, increasing the probability of being funded.

There was one cooperative agreement regular grant with the National Risk Management Research Offices that resulted in the WINSS Center. The California EPA agreed to work with the WINSS Center to provide expertise and research capabilities. Dr. Hiscock noted examples of centers, including the WINSS and DeRISK Centers, and explained some of the characteristics that distinguished them as centers, including their larger funding and scope and their involvement of multiple institutions and scientific advisories that annually worked with them on their research plan and results.

Dr. Rodricks asked how the WINSS and DeRISK Centers and research program fit into Dr. Hiscock's presentation. Dr. Hiscock explained that his presentation was an overview of ORD's grants and the WINSS Center appeared in Project 2, next steps, which included technology advances. Dr. Rodricks asked if the WINSS Center would be another bullet point or if they fit in one of the grant categories that Dr. Hiscock presented, and Dr. Hiscock clarified that the center would fit into one category because it was a center rather than a cooperative agreement.

Dr. Hiscock briefly touched on Project 3, Transformative Approaches and Technologies for Water System, which included one STAR RFA, five regular grants, and one early career grant.

Project 1, Current Water Systems and Regulatory Support, came about because EPA wanted an RFA for water systems and the RFAs used the National Research Council's definition of premise plumbing, which was defined as "portion of the distribution system from the main water ferrule or water meter to the consumer's tap in schools, hospitals and other buildings."

Dr. Rodricks asked if the national priorities in Dr. Hiscock's presentation were congressionally mandated, and Dr. Hiscock responded that they were congressionally directed. He explained that the EPA budget included line items in bill appropriations that required EPA to allocate $4 to $5 million to RFAs that were not STAR grants, were national in scope, and needed to be funded quickly. This appropriation appeared about 5 years ago and has persisted ever since. Dr. Hiscock added that the appropriation was good for EPA because it did not come from their general budget. He added that EPA had two awards pending and expected work on predictive models, models for failure to meet plumbing goals, and health risks from declining plumbing to come from those National Priorities RFAs.

Dr. Hiscock explained there were 10 grants that were closing or closed in 2016. The STAR RFA, Advancing Public Health through Water Infrastructure Sustainability, was aimed at understanding the roles of pathogens and understanding their health impacts. The projects included designing strategies to prevent water quality deterioration and projects to improve water energy efficiency. Dr. Hiscock provided further details of some of the grants under Project 2.

Dr. Hiscock described the cooperative agreement grant to the University of Illinois, the Association of Pathogens with Biofilms in Drinking Water Distribution Systems, aimed to characterize biofilm filters. He described two papers that came from that project. One paper was on how the roughness of the biofilms affected the transmission of *Legionella* using coherence ophthalmology. The paper found that *Legionella* was enhanced by increased roughness because roughness provided a larger surface area and it slowed down the movement of *Legionella*. Dr. Hiscock further described how the larger surface area of the rougher biofilms had less

detachment of *Legionella* because the biofilms created a low sheer zone so the bacteria did not detach from the biofilms once they attached.

Dr. Hiscock described the second paper that came from the biofilms project on biofilm stiffness and thickness change during long-term disinfection. He described how biofilms in waste water treatments systems had a general thickness and stiffness. The paper found that, after 1 month, the stiffness had increased by 4–9 times and the thickness had decreased by 20 percent. After 3 months of chlorine or hydrochloride disinfection, the thickness and stiffness rebounded to the original levels.

Dr. Hiscock described a second project, Development of Mobile Self-Powered Sensors for Potable Drinking Water, from Purdue University that developed a mobile sensor that allowed real-time monitoring of water systems. The sensor was aimed to detect mineralization and nanomaterials and was able to measure pH, hardness, and chemical ions in potable water for 2 days.

A third grant, STAR researcher discovers the mechanism for fat, oil, and Grease (FOG) deposition, was the first study to provide FOG levels in water systems and examine how the deposition of FOG created additional solids in the system that blocked sewer pipes, which could lead to blocks in sewer flows.

Dr. Hiscock explained there were also a second group of STAR RFAs under Project 2 that were focused on Innovation in Small Drinking Water Systems. He explained that there were two calls for RFAs for projects for innovation of the drinking water system. The first call for RFAs was for the DeRISK and WINSS centers, and the second call was aimed at funding smaller water system innovation grants. The goal of these grants was to develop technology and collaborate with local and regional national water system efforts.

Dr. Hiscock highlighted one project under the innovative small water systems STAR grants from the University of Texas Austin on Sustainable Catalytic Treatment of Waste Ion Exchange Brines for Reuse during Oxyanion Treatment of Drinking Water. Charles Werth published a paper that examined a new way to isolate perchlorate from drinking water using a rhodium metal rhenium-organic complex. Dr. Hiscock explained that traditional methods for removing perchlorate from drinking water used a resin that either had to be regenerated, which had a residual high concentration of perchlorates in saline, or deconstructed after use, which was a very energy-intensive process that outgassed harmful chemicals. The new method showed to be a much more sustainable way to isolate perchlorate from drinking water and allowed destruction of perchlorates at room temperature with the same type of residuals.

Another project from the University of Iowa, Research and Demonstration of Electrospun Nanofiber Filters: Multifunctional, Chemically Active Filtration Technologies for Small-Scale Water Treatment Systems, was attempting to create a range of nanofiber filters that were sustainable and robust. Dr. Hiscock explained the project objective was to develop iron oxide capacitors that could filter out lead and arsenic better than commercial options at a lower cost.

Dr. Hiscock moved on to explain the grants under Project 3, Transformative Approaches and Technologies for Water Systems. He explained that there were five grants under the STAR RFAs aimed to improve approaches and technologies for Human and Ecological Health Impacts Associated with Water Reuse and Conservation Practices. The grants would evaluate the human

and ecological health impacts from water, including water recharge and potable reuse practices. Dr. Hiscock noted that the kick-off meeting for the grants would be held on October 26–27, 2016.

Dr. Hiscock noted that the human and ecological health impacts grants were only 1 year old but a couple of projects were already showing interesting progress. One project by the principal investigator, Jay Gan from the University of California, Riverside, was on Reclaimed Water Irrigation: Plant Accumulation and Risks of CECs.

Dr. Hiscock explained that the project was looking at how pharmaceutical and personal care products (PPCPs) were absorbed by plants, particularly in the edible parts of plants. The study found that PPCPs were quickly metabolized and, therefore, incorporated into cell walls. This suggested that the quick uptake prevented people and animals from eating it. The Early Career Grant went to Daniel Gerrity from the University of Nevada to conduct his project to develop a Framework for Quantifying Microbial Risk and Sustainability of Potable Reuse Systems in the United States. The team was working to quantify the microbial and chemical risks associated with various treatment trains in water reuse paradigms. They were also working to create a system dynamics model to evaluate the risk of cryptosporidiosis from water reuse and describe water systems in southern Nevada. Dr. Hiscock concluded his presentation summarizing the STAR and National Priorities awards in the SSWR portfolio and opened up the discussion to questions.

Dr. Rodricks asked if SSWR was attempting to evaluate the impacts of all this research on improving water quality. Dr. Hiscock responded that the entire EPA grants program was going under NAS review. EPA had been presenting to NAS on the progress of their grants using publication metrics and the positive impacts of the science on SSWR and other programs within ORD. He added that EPA always concluded the RFAs with a synthesis of all the work and impacts that the research had, which would be released in the near future for some older RFAs.

Dr. Rodricks asked about the translation of the grant work into utility and if there was a measure for how useful the work was. Dr. van Drunick responded that there was a NAS study that was currently addressing that question. Dr. Rodricks asked if the NAS study was different from the internal EPA grant evaluation process that Dr. Hiscock described. Dr. Hiscock clarified that the review process was different and the NAS was also measuring how ORD research impacted their sister programs. He added that NCER also looked for ways to disseminate research information to the program offices and provided webinars as an example. Dr. Rodricks asked if the grant researchers were involved in the webinars, and Dr. Hiscock responded that they were.

Mr. Lowenthal asked if EPA was aware of any preliminary conclusions from NAS but Dr. Hiscock responded that they did not and did not expect a first draft of the NAS review until January 2017. Dr. van Drunick added that she had a meeting with the NAS committee on the first Sunday after the meeting. Dr. Rodricks asked if the NAS review was their first effort to review EPA's grants but Dr. Hiscock clarified that the EPA grant program was formed in 1986, and Dr. van Drunick added that the NAS performed their review 10 years ago.

Mr. Chaudhry asked if the project that developed the sensors was being tested in the field but Dr. Hiscock explained that the sensor project was in development so he was not sure if it had been tested yet. Although, he added that the sensors were getting close to field testing. He clarified

that the sensors had been tested in different ways but had not yet been tested with all of its components together. Mr. Chaudhry stated that he perceived that these sensors would be used in small systems, but Dr. Hiscock was not sure that the project had gotten to the point where they knew which systems the technology should be applied to. He added that the project team was planning to work with one individual group but hadn't brought their sensors to the greater market yet.

Mr. Ahlstrom noted the pressure on the STAR grants to include more research and asked how much money went to the STAR grants. Dr. van Drunick explained that SSWR was trying to internally and externally leverage their budget as much as they could. She explained that EPA used to use the STAR grants to conduct longer-term grants that were on topic areas outside EPA's areas of expertise, such as economics research and a number of STAR grants on green versus gray lifecycle structure analysis. One big project was on life quality benefits and premise plumbing was a good example of that leverage. EPA didn't navigate that project but they were interested in the project because they thought it would be very helpful down the road. Although the process Dr. van Drunick described was how EPA usually used the STAR grants, she was open to suggestions for how to use them better. She added that SSWR could not cut the STAR program budget like they could for other sections because of the federal requirements.

Dr. Rodricks asked what fraction of the applications were funded and what the grantee selection process was. Mr. Hiscock explained that the application selection was a two-step process. First, an extramural peer review of the applications is completed by an organization like NSF. The panel evaluates the applications based on the criteria set out in the RFAs, and the applications were scaled (e.g., excellent, very good, good, fair, poor). Only the very good and excellent applications went to the person within the EPA program office in charge of the grants. The program office then assembled an internal panel of different EPA experts that included people from ORD, the program offices, and the regions. The panel selected the most relevant proposals to EPA's mission. Dr. Hiscock clarified that the EPA panel did not review the science because the external panel would have already done that. The EPA panel was charged with ensuring that the selected projects fit into the intramural program and were relevant to EPA's mission. The percentage rate of funded applications varied between the RFAs and the rates were going down due to EPA's declining budget. Dr. Hiscock estimated that about ten percent of the STAR grant applications and about 30 percent of the Early Career grant applications were funded. Dr. van Drunick noted the differences between the National Priorities and STAR grants. The National Priorities were directed to certain recipients and required big chunks of money to be contracted out to a small number of projects while the STAR grants were not limited by those requirements, so they had the potential to fund more projects.

Mr. Chaudhry asked if the grants received $100,000 but Dr. Hiscock clarified that the $100,000 number was the metric EPA used to determine the productivity of the grants program as a whole. The Early Career grants were awarded $300,000 and the National Priorities grants had a minimum award of $2 million. He added that the DeRISK and WINSS centers were formerly grants. Mr. Lowenthal asked if the grant money had to be spent in a certain timeframe, and Dr. Hiscock responded that ORD had two fiscal years to obligate the money to the award winners. Once the money was awarded, the grantee could spend it over 5 years. Dr. van Drunick added that the grant kick-off meetings, which included the principle investigator and ORD experts, were open to the public and the Water Reuse meeting was going to be held on October 26–27,

2016. The Water Quality Benefits meeting would be held on December 12–13, 2016 and the Small System meeting was going to be provided as a webinar. She added that the last grant kick-of meeting had 1,500 participants; anyone is more than welcome to come. Dr. Hiscock noted that STAR grantees also participated in those grant kick-off meetings.

The BOSC SSWR subcommittee members thanked Dr. Hiscock for his presentation, and Dr. Rodricks concluded the discussion of the SSWR grants. He asked the subcommittee members to return from their break to discuss the EC report, specifically section three of the report.

2016 BOSC EC Report Discussion
Joe Rodricks, Chair, Subcommittee

Dr. Rodricks noted that the subcommittee had access to the 2016 BOSC EC report, which included the SSWR subcommittee report and ORD's responses. The report was grouped into common threads across research programs that began on page two. Dr. Rodricks suggested that the subcommittee begin their review of the report with the SSWR section and ORD's responses to their section, which began on page seventeen. He gave the subcommittee some time to read and digest those sections.

Mr. Lowenthal noted that he thought the subcommittee's comments on all of the common threads were addressed well in ORD's response and added that the responses were overall really well done. Dr. van Drunick explained that the responses were a joint effort from all the ORD NPDs.

Dr. Rodricks stated that he would like to hear more on the Partner Alliance and Coordination Teams (PACTs) and added that it appeared the subcommittee had a much better handle of ORD's terminology this year. Dr. Williams explained that the PACs were initiated by the ORD Air, Climate, and Energy (ACE) program office and some of the other ORD programs because of the lack of partnerships in place. He clarified that SSWR already had existing coordinated efforts with partners so they just turned those partnerships into PACs. Dr. Impellitteri provided the harmful algal bloom PAC as a specific example, which is led by OW. The PAC included membership from regions, ORD, and other labs. He added that the green infrastructure PAC, which was led by the Office of Waste Water Management, was another example of a PAC that included ORD researchers. ORD was also working with OW and the regions to develop a water reuse research program. However, water reuse was a tricky topic because it was not regulated so it did not have regulatory drivers pushing the research, which made the water reuse workgroup a particularly important workgroup to form.

Dr. Impellitteri noted that Dr. Garland provided a good overview of the work ORD was doing directly with localities, such as San Francisco, California, that were moving forward with state-wide regulations for water reuse. He added that he was unsure of where that work fell at the federal level because 50 percent of people believed regulation of water reuse should be the responsibility of the states while the other half of people thought there should be federal involvement. Dr. Impellitteri noted that Ms. Nicole Tucker was the program office liaison with the EPA regions and asked her to provide the subcommittee with a brief description of her job.

Ms. Tucker explained that she worked as a research coordinator between the Office of Groundwater and Drinking Water and OW but her position was within OW. Her objective was to

bring people together to coordinate projects. Dr. Impellitteri explained that she was the person ORD SSWR reached out to when they needed to get in contact with OW to discuss the regions.

Dr. Greene explained SSWR's water quality research project partnership, including partnership with the National Center for Environmental Economics and collaboration on the harmful algal blooms, green infrastructure, and water reuse projects. He added that there were two additional projects. One project was on microbial pathogens in ambient water, which included ongoing interactions that were already established, and the second project was on chemicals in ambient water. Dr. Rodricks added that the projects and partnerships had improved in clarity and operations since the previous BOSC SSWR subcommittee meeting. Mr. Ahlstrom agreed and stated that the subcommittee had the impression that there was a lack of communication with regional coordinators but Dr. Braverman explained that ORD's partnership with Region 5 was working. Mr. Ahlstrom asked if there was anything the subcommittee could do to help with regional coordination.

Dr. van Drunick noted the point Dr. Braverman mentioned about the synchrony within the 2 year Regional Science Liaisons (RSL) and SSWR thought it would be helpful if the BOSC commented on the continuity of the RSLs. She explained that a 2 year term for the RSLs was short and suggested 3 years might be a more reasonable timeline because it would allow the NPDs and RSLs more time to learn about the program, making them more effective in the field. She added that because the RSLs had traditionally been 2years long did not mean that they always had to be that length. Mr. Lowenthal asked if 4 years would be a better length of time and Dr. van Drunick responded that she thought 3 years was a good length.

Dr. Williams explained that the RSAs and ORD had a considerable amount of communication, with a monthly call and a meeting every 2 years at one of the ORD facilities. Dr. van Drunick agreed that they were a tight group and noted that five RSLs attended the groundwater workshop in Oklahoma.

Dr. Impellitteri explained that the regions and OW were heavily involved in the Division Directors Meeting, which was a meeting between all the division water directors from each region, OW, and ORD. He explained that those meetings were important for ORD because of all the coordination required between the regions and program offices. He provided the example that OW was in control of the loan funds, but the regions were responsible for administering and managing those funds. Although ORD was not directly involved in the loan funds, Dr. Impellitteri added that it was important for ORD to be aware of those events so they knew where the funds were being allocated and what the OW and regional burning issues were.

Mr. Lowenthal asked if ORD could share their spreadsheet that included the regional prioritization of their needs. Dr. Williams explained that the regions recently initiated the process for updating that spreadsheet. Dr. van Drunick stated that SSWR would need to follow up with OW to see if they would like to share that information with the subcommittee or not.

Mr. Ahlstrom returned to the subcommittee's previous discussion about how the RSLs did not have sufficient time to commit to their job. He asked if the request for higher level management to receive the RSLs so they could have more time in their position was resolved. Dr. van Drunick explained that the RSLs were funded by ORD, under the Office of Science Policy (OSP), but they reported to the regions. ORD has done a lot of work with OSP to address these concerns or

inconsistencies. She noted the accessibility problem and explained that some RSLs were located within the same offices as their ORD and program office partners but other RSLs did not have that option. Mr. Lowenthal asked if being a RSL was a full time job and Dr. van Drunick responded that it was. She explained that the RSLs were trained scientists and six of the ten RSLs had PhDs.

Dr. Rodricks asked if the subcommittee had any other comments on the common thread issues. There was discussion about the need for social sciences in the EC report. He noted the section of the agenda for the subcommittee to discuss new members and suggested discussing the addition of a social scientist.

Dr. van Drunick provided some details about what ORD had done since reading the BOSC evaluations. Dr. Robert (Bob) Kavlock was taking on the task of including more social sciences in ORD and a workshop was being planned for early October in Research Triangle Park that would be chaired by the BOSC Sustainable and Healthy Communities (SHC) subcommittee co-chairs. Dr. van Drunick explained that the SHC subcommittee was working with Dr. Kavlock to take the social science issues head-on, and they were discussing how to use social science within the ORD SHC program. She suggested that the SSWR subcommittee discuss ideas of how to include the social sciences into SSWR either during the meeting or on a follow-up teleconference.

Dr. Rodricks asked if the social science decisions included the economics (e.g., the cost of technology) in their decisions. Mr. Lowenthal added that the public perception of whether their tap water is safe to drink or not was a big social issue. Dr. van Drunick explained that the pillar of environmental, economics, and social aspects of research was maintained but she thought ecological and social issues were in separate disciplines. Dr. Rodricks summarized that the subcommittee would be tasked with finding SSWR project areas that were most suited for including the social sciences.

Dr. Rodricks noted that he found ORD's response on page six, about research synthesis and translation, interesting and noted that moving all research into operation was a big task. Mr. Ahlstrom asked if the subcommittee should be looking at projects with the probability of research moving into practical applications in mind. Dr. van Drunick clarified that research translation was its own discipline. She explained that research application was a big part of her role at the University of Colorado at Boulder, and she recognized the importance of people understanding what and why the research was being conducted. EPA was developing fact sheets, hosting webinars, and hired Ms. Michelle Latham and Ms. Katie Massey to work on research communication but EPA had limited support to provide those translational services. Dr. van Drunick noted that an important step preceding communicating research was the step to distill the science into terms that can be understood by the general public, and EPA recognized how critical this step was.

Mr. Lowenthal asked if ORD used fact sheets to disseminate their information. Dr. van Drunick responded that they did, and Ms. Latham and Ms. Massey were developing a lot of fact sheets, which were included in the subcommittee's distributed material. Dr. Impellitteri added that the draft resiliency fact sheet was one that SSWR was already working on and noted the importance of keeping the fact sheets updated. Mr. Lowenthal asked how ORD distributed their fact sheets

aside from posting them to their website, and Dr. Impellitteri responded that the fact sheets were also disseminated during meetings and webinars.

Dr. van Drunick added that ORD also disseminated their fact sheets through their list servs. She provided an example of when SSWR pulled together all of EPA's drought related research to inform interested parties. Compiling this information was also an example of leveraging work from other EPA offices for internal benefits as well as the external benefit of informing other players that EPA was also a major player within the area of drought resiliency, which was critical in order for EPA to protect drinking water.

Dr. Impellitteri explained that SSWR has pulled together internal fact sheets in the past, which can then be used to distill out and boil down the information so that it can be effectively communicated to the public. He added that pulling together internal fact sheets were also helpful for producing quick turnaround products for congress rather than having to drop everything and scramble to pull together all their information on one topic in a week.

Mr. Lowenthal asked if there was a way to track the effectiveness of their fact sheets and Dr. van Drunick responded that SSWR would love the subcommittee's recommendations for how to track that. Mr. Ahlstrom explained that, whenever a new small water system is developed, someone from the National Rural Water Association would meet with them and explain the rules, requirements, and how to interact with EPA. Mr. Ahlstrom suggested that meeting as a potential way to disseminate the information of SSWR's factsheets. Dr. van Drunick clarified that SSWR did provide information to Eros. Mr. Ahlstrom noted that AWWA had a seminar on disseminating factsheets.

Dr. Rodricks suggested the subcommittee move on to discuss ORD's responses to their report and directed the subcommittee's attention to page 17. He noted the common question the subcommittee had last year regarding the amount of information available. The subcommittee was not sure if they had a complete understanding of the information that was needed to respond to their 2015 meeting charge questions, but Dr. Rodricks saw in ORD's responses that a lot of the subcommittee's 2015 suggestions were already being addressed by ORD. Mr. Chaudhry added that the subcommittee's charge question responses were based on the information that was available during their 2015 meeting. The reason the subcommittee asked the questions they did in the report was because more information was needed on SSWR's research. The research was presented more clearly during this meeting. Mr. Lowenthal noted that SSWR's presentations were geared towards answering the subcommittee's questions from last year.

Dr. Rodricks asked if the subcommittee could take SSWR's presentations to be representative of SSWR's research program or if they needed to look beyond the presentations to all of the specific projects. Dr. Impellitteri recognized that SSWR threw a lot of information at the subcommittee last year so they decided to focus on one topic this year, which is how they will proceed with future subcommittee meetings. He clarified that the presentations during this meeting were specific to one topic, not the whole SSWR program, and the next subcommittee meeting would focus on a different topic. Dr. van Drunick noted that focusing on one topic during a meeting was in response to the subcommittee's request for more information and project descriptions and asked if the subcommittee would like SSWR to send them their project descriptions. Mr. Lowenthal said he would like to receive the project descriptions, and Mr. Chaudhry noted that it would be helpful to have the details behind the project information.

Dr. Rodricks noted ORD's response to the subcommittee's comment about priorities and needs for SSWR to address chemical contaminants, contaminants of emerging concern, etc. and added that he did not hear anything about product toxicity in SSWR's research presentations. Dr. Greene clarified that the response Dr. Rodricks' was referring to was housed within the Watershed Sustainability research topic, not the Water Systems topic. Dr. Impellitteri added that there were soft lines between the research topics and a lot of research crossed over multiple topics. Mr. Ahlstrom stated that he hoped what the comments the subcommittee provided the previous year were useful to SSWR.

Dr. Galloway asked if there were any big ticket items from the subcommittee report that were especially helpful or really unhelpful to SSWR. Dr. Rodricks asked for clarification on the question and Dr. Galloway confirmed that he was asking about comments where the subcommittee clearly lacked information and understanding. Dr. Rodricks responded that he did not remember any huge gaps in the subcommittee's understanding of the SSWR program and asked Mr. Chaudhry for his thoughts. Mr. Chaudhry explained that most of the subcommittee comments were based on the information they had at the time of the meeting and didn't necessarily mean that SSWR wasn't working on those topics. SSWR's response to the subcommittee report indicated that they were involved in all the areas the subcommittee was concerned about. The 2016 meeting had very targeted presentations and charge questions, which exhibited that the BOSC subcommittee and SSWR was learning how to work together.

Dr. Rodricks noted that the common thread issue mentioned the need to expand and cut across program work and SSWR mentioned working with the Chemical Safety for Sustainability (CSS) program during their presentations. He asked if some of that recommendation was covered in SSWR's work and if they envisioned more cross program activity. Dr. Impellitteri responded that SSWR was collaborating with CSS, specifically with their bioassay work. He explained that the Chemical Research Program's (CRM) driver was to inform chemical safety and pollution prevention so they were responsible for determining the safety of new pesticide or chemical. However, the CRM was backlogged by thousands of chemicals so SSWR began working with CSS and asked them if they could prioritize chemicals found in water when running their high-throughput assays. CSS did run polychlorinates and short chain chemicals because they agreed that those chemicals were a high priority and SSWR was now aware that other program offices were also interested in that particular group of chemicals. Dr. Impellitteri added that a lot of toxicology research was housed within CSS and SSWR had been trying to work with CSS more over the past year.

Dr. van Drunick provided a few additional examples of SSWR working with and reporting across the other ORD programs. SSWR was looking into the possibility of using CSS's AOPs as a way to address toxicology issues in their program assessment, which was a good example of how SSWR and CSS were working together. SSWR was also working with NCCT to identify and assess four to five algal cyanotoxins using the high-throughput assay to determine if it was possible to use the assay to analyze cyanotoxins. Dr. Impellitteri highlighted the importance to staying in constant communication with OW about SSWR's potential partnerships and research topics to make sure they are approved by OW and the regions. SSWR was trying to navigate these partnerships because these approaches to problems are different than the way EPA had operated in the past.

Dr. van Drunick confirmed that SSWR would like subcommittee comments about the report and Dr. Rodricks asked the subcommittee to keep that in mind during their discussion. Mr. Lowenthal made a global comments that ORD's responses addressed all of the subcommittee's concerns expressed in the report.

Dr. Rodricks noted that there was a lot of text about environmental justice in the report and asked if environmental justice was within the SSWR program. Dr. Impellitteri responded that environmental justice was program wide and cut across all of ORD, including SSWR. He provided background information of the cross program roadmaps. The final draft of the Environmental Justice roadmap was going to Dr. Kavlock for review and would then go to the EPA ORD EC for review but the final roadmap had not been released. Dr. Impellitteri explained that the Green Infrastructure research topic was where most of the environmental justice work was focused and included projects that looked for challenged communities where green infrastructure could be implemented.

Dr. Rodricks asked what the subcommittee should except to cover the following year and Dr. Impellitteri suggested Watershed Sustainability. Dr. van Drunick noted that the next topic was up to the subcommittee and they had three remaining topics to choose from.

Dr. Rodricks asked for any additional comments on the 2016 BOSC EC report and, hearing none, he explained that he would like to cover any further questions from ORD before the subcommittee began their working lunch. Dr. Rodricks noted that he liked the EPA Drinking Water Workshop presentation from the Colorado speaker that was about the model for risk assessments. He though the systematic way in which the risk assessments were conducted was a perfect approach for making technology decisions. He also thought the model was a perfect match for the recommendation about research priorities that came from the SAB report. He added that the SAB report also included a roadmap with a viable risk-based approach. Mr. Chaudhry agreed with Dr. Rodricks and took his suggestion a step further by recommending that, once that approach was developed, it be applied to a real-world situation to see if it could be utilized by the water sector and, if it cannot be, identify the areas where it can be improved. Dr. Rodricks clarified that he was referring to the presenter's decisions model that used a systematic approach and included research within different risk and sustainability models to ensure the decision maker was receiving the correct research and information needed to make their decision. Dr. van Drunick noted that she had seen that approach applied to water research before.

Dr. Rodricks explained that the EPA developed their own version of that model and a handbook for decision making based on risk models, which too what was done in academy a step further. Mr. Ahlstrom noted that this was a good example of an area of ORD research that required a lot of thought about how it could be translated into the real-world, which is where social sciences come in. He explained that social science was not a linear way of thinking, yet engineers are taught to think and make decisions based off of linear decisions. However, incorporating the social sciences was asking them to do something totally different.

Dr. Rodricks asked if the subcommittee had any additional questions or comments for EPA. Mr. Chaudhry asked Dr. van Drunick her take on the questions the subcommittee had raised thus far. Dr. van Drunick responded that, limiting her comments to this meeting, the subcommittee was very engaged and prepared in advanced of the meeting. Some of the comments were thought provoking, specifically the comments about direct potable reuse and planning.

Dr. Rodricks noted that he wished the full subcommittee was present and asked if the meeting for the following year could be scheduled so that all the members could attend. Dr. van Drunick explained that the 2016 meeting was planned in conjunction with the EPA Drinking Water Workshop but future meetings could be planned at the convenience of the subcommittee's schedule. She added that the meeting could also change locations if they preferred a different location. Mr. Ahlstrom noted that he thought scheduling the subcommittee meeting with the Drinking Water Workshop was a good idea. Dr. Rodricks thanked the EPA participants for joining the meeting before moving to the next item on the agenda.

Committee Membership, Next Subcommittee Meeting, January BOSC EC Meeting
Joe Rodricks, Chair, Suzanne van Drunick, NPD, Tom Tracy, DFO

Dr. Rodricks reorganized the agenda a bit and began the discussion of the new subcommittee members and the subcommittee's future work. Mr. Chaudhry added that the subcommittee would discuss the charge question responses following the discussion of the subcommittee's future plans.

Dr. Rodricks noted that Dr. van Drunick sent him the resume of an economics expert, and Dr. van Drunick clarified that Dr. Tom Hughes was already added to the subcommittee. Mr. Tracy explained that the BOSC was waiting for the EPA Administrator to approve Dr. Hughes' membership before officially adding him to the subcommittee, which was expected to occur in mid-October. Mr. Tracy added that Dr. Fred Hitzhusen was also being considered as an economics expert subcommittee member.

Dr. Rodricks steered the discussion towards adding a social scientist to the subcommittee. Dr. van Drunick explained that there were four failed attempts of bring a social scientist onto the subcommittee and suggested revisiting this topic after the Social Science Workshop took place when EPA had a better understanding of role they were looking for. She further suggested that the BOSC could recruit a social scientist in January of 2017. Mr. Tracy explained that all of the subcommittee members' terms would be over and up for reappointment from April through the summer of next year so the new membership package that renewed current membership and added new members would be submitted sometime after January. Mr. Tracy added that if the subcommittee new the topic they were going to cover the following year, then they could recruit new members accordingly. Mr. Lowenthal asked how long a subcommittee term was and Mr. Tracy responded that the terms are for 3 years with the possibility to be reappointed to serve on the BOSC for a total of 6 years.

Dr. van Drunick explained that the BOSC SSWR subcommittee was fairly small, which was intentional because of the time it takes for the BOSC approval process. She suggested the subcommittee and EPA go through the four research topics in order to identify any gaps in subcommittee expertise. She noted that there was a lot of Water System expertise on the subcommittee and reviewed the other three research topics, including Watershed Sustainability, Green Infrastructure, and Nutrients and asked if there were other areas of expertise that SSWR should be considering.

Dr. Rodricks asked if the subcommittee was prepared to address Green Infrastructure. Mr. Chaudhry responded that he thought it would depend on the specific charge questions and SSWR's needs. Dr. van Drunick commented that some of the areas SSWR was moving towards

included water reuse and water quality issues. Mr. Chaudhry noted that the subcommittee was in good shape to address the water reuse topic. Mr. Lowenthal stated that green infrastructure was his area of expertise so he would be better suited to address that topic. Mr. Ahlstrom suggested adding someone with expertise in watershed management and environmental concepts would helpful but the subcommittee already had a fair amount of expertise in water treatment. Mr. Lowenthal noted that he had some experience with watershed sustainability and thought that some redundancy was a good thing on a subcommittee. Dr. van Drunick commented that Dr. Inez Hua had expertise in environmental concepts, green chemistry, and waste water treatment. She suggested that the subcommittee needed more expertise in watershed management and groundwater. Dr. Rodricks suggested adding a geochemist to contribute to the watershed sustainability topic, and Dr. Greene explained that Project 3 was about protecting water while developing resources, such as mining and aquifer storage.

Dr. Rodricks asked what Dr. Galloway and Dr. Larry Baker's skills were. Dr. van Drunick explained that Dr. Galloway's strengths were in nutrients and watershed sustainability; Dr. Baker was an expert in lake acidification, water reuse, and ecology. Dr. Galloway added that Dr. Baker was broadly trained. Dr. van Drunick noted that Dr. Bruce Aylward had more of an economic focus so he, in addition to the pending new subcommittee member, should covered the economics expertise. Mr. Ahlstrom and Mr. Chaudhry were water treatment experts, and Mr. Ahlstrom was also a water quality science expert.

Dr. van Drunick explained that she thought about combining the watershed sustainability and nutrients research topics into one meeting but that would include seven projects, which seemed like a lot. Mr. Lowenthal asked about the possibility of combining nutrients with green infrastructure. Dr. van Drunick responded that it was possible and asked if the subcommittee preferred to do the nutrients and green infrastructure topics next. Dr. Rodricks responded that they would and the subcommittee was strong in those areas, with Dr. Galloway, Dr. Baker, and himself all being experts.

Dr. Greene raised the point of adding expert redundancy to the subcommittee, especially if a number of members are unable to attend future meeting. Dr. Impellitteri suggested considering the academic year when scheduling the next subcommittee meeting. Dr. van Drunick offered the possibility of holding the next meeting over the summer when school was not in session but added that SSWR was flexible. Dr. Rodricks stated that a watershed expert and groundwater expert were not critical. Dr. van Drunick disagreed and said that a groundwater expert would be important for the green infrastructure research topic; she suggested someone like Kathy Jacobs could fill that role. She further explained that an expert who could address the connections between quantity and quality for both surface and groundwater would be important for the remaining three research topics.

Mr. Chaudhry suggested the subcommittee make a decision about the topic of the next subcommittee meeting. Dr. Rodricks suggested the subcommittee have a conference call with all of the members to decide the next meeting topics. Dr. van Drunick suggested sending out the bios of all of the current and new subcommittee members. Mr. Chaudhry noted that the next subcommittee meeting would be held in July of 2017 and Dr. van Drunick asked if that was the earliest the subcommittee could expect their new members to be brought on board. Mr. Tracy responded that the new members' terms would probably begin around April or May of 2017. Dr.

van Drunick noted that the BOSC EC would meet in January with their report in hand. Dr. Rodricks added that the SSWR subcommittee would need to submit their report before the January EC meeting, although they were the first subcommittee to meet in 2016.

Mr. Chaudhry summarized the next steps for the subcommittee, including the current preliminary discussion of the topics for next meeting, followed by the subcommittee conference call discussion to determine the next meeting topics, and the subcommittee could fill-in the needed expertise from there.

Water Systems Charge Questions Discussion
Joe Rodricks, Chair, Subcommittee

Dr. Rodricks reminded the subcommittee of the two water systems' charge questions:

1. Are we doing the right research? Taking resource limitations into consideration, are there any additional research needs that warrant new investment or current research that merits expansion, and are there areas of research that SSWR may consider disinvesting in?
2. Are we doing the right research at the right time? Comment on the balance of near, current and long-term research objectives.

Dr. Rodricks asked the subcommittee to consider these charge questions during the discussion of the specific research projects presented under Project 1 – Current Systems and Regulatory Support and Project 2 – Next Steps: Technology Advances.

Subcommittee Discussion and Writing
Subcommittee

The subcommittee members discussed two projects from ORD's SSWR Research Program: Project 1 – Current Systems and Regulatory Support and Project 2 – Next Steps: Technology Advances. Dr. Impellitteri presented the research activities, products, and impacts for each of these projects during the first day of the meeting.

The subcommittee members discussed Project 1 – Current Systems and Regulatory Support.

Work under Task 1A – Current Resource Water Treatment Processes and Resource Recovery includes 3 sub-tasks.

The subcommittee discussed the following projects, which are part of sub-task 1 Evaluating Microbial and Chemical Contaminants in Waste Treatment Streams:

- Regional Applied Research Effort (RARE) with Region 6, NERL, and NRMRL to characterize microbial pathogens and emerging CECs in Texas resource water effluents to refine risk assessment models for direct potable reuse
  - Mr. Chaudhry noted that impacts on human health are not well established for some emerging CECs. This study may aid in the identification of risk factors for CECs.
  - Mr. Chaudhry shared that there was an issue 8 years ago in Sacramento, California, where lines were cross-connected for home supply and recycled water and then connected with lines for potable water. Residents complained several years later about a foul odor, and the cross-connection issue was identified. Public perception and risk communication can be more important than technological efficacy.
  - Mr. Ahlstrom stated that the refinement of these risk assessment models should not be unique to direct potable reuse; a risk assessment model is needed for reusing resource

water. Defining a level of treatment that addresses risk based on the use could be part of the risk assessment model. It is flawed to say that an indirect use is less hazardous than a direct use. Mr. Ahlstrom clarified that the project title should be broader and phrased as "refine risk assessment models for potable reuse."

- Comprehensive study on microbial communities and CECs in resource water effluent using high throughput sequencing
  - Mr. Ahlstrom noted that if resources were limited, this project could be cut because it is less important. Microbial communities and CECs in resource water are widely varied and dependent on size, influent, and operations, among other parameters.

The subcommittee discussed the following project, which is part of sub-task 2 Antibiotic Resistance in Resource Water Effluents that are Discharged into the Environment or Recycled:

- Research on understanding the diversity and fate of antibiotic resistant bacteria in resource water systems and elucidating mechanisms and transfer rates of antibiotic resistant genes
  - Dr. Rodricks asked the subcommittee members if issues related to antibiotic resistant bacteria are prominent. Antibiotic resistant bacteria could relate to other health issues, such as adequate treatment in patients with waterborne disease.
  - Dr. Rodricks did not consider this as a priority research area when compared to other research projects.

The subcommittee discussed the following project, which is part of sub-task 3 Safe and Sustainable Management of Waste Residuals:

- Semi-continuous activated sludge reactors established to characterize transformation and fate of PFAS
  - Dr. Rodricks noted that this study is already complete. As expected, PFAS persist in water.
- Support revision of Part 503 – The Biosolids Rule
  - Mr. Ahlstrom stated that the research done in this project area will be incorporated into revisions to the Biosolids Rule. Revisions to the rule may make it more challenging to deal with biosolids.

The subcommittee discussed work under Task 1B – Monitoring/Analytical Tools. This task includes 2 sub-tasks.

The subcommittee discussed the following projects, which are part of sub-task 1 Methods Development (chemicals and microbes):

- Method 544-Microcystins (six congeners) and nodularin in drinking water
- Chemical methods development for UCMR initiated for saxitoxin and related cyanobacterial neurotoxins
- UCMR method development for *Legionella* and mycobacteria
  - Dr. Rodricks stated that the development of the above methods targeting cyanotoxins, *Legionella*, and mycobacteria seem appropriate and well placed.
- UCMR method for protozoa

  - Dr. Galloway pointed out that protozoa in water present health issues. The increased presence of these protozoa in water distribution systems may be linked to an increase in nutrients.
  - Mr. Ahlstrom clarified that this issue is not limited to small systems.
  - Mr. Ahlstrom noted that toxoplasmosis is a significant illness with serious health outcomes. The issue is determining if the treatment in the distribution system is adequate for the removal of protozoa that could be present in source water. Protozoa are not easily deactivated. This research is focused on developing methods to identify protozoa in source water that survive the treatment process.
- Application of a salivary antibody multiplex immunoassay to assess exposure to microbial contaminants in premise plumbing
  - The subcommittee members agreed that more information is needed on this project.
  - Mr. Ahlstrom supported the execution of this project.
  - Dr. Rodricks asked what the value of this project is to assess current infections; antibodies could be present as a result of past infections. It is not clear how this assay assesses current exposure. This issue should be raised as a comment.
- Experiments on relative source contribution of strontium in contaminated drinking water
  - Dr. Rodricks summarized that, with this project, EPA seeks to investigate the contribution of drinking water exposure to total exposure to strontium. EPA sets a default assumption that 20 percent of exposure to a given chemical is attributed to drinking water. This project would provide a more accurate measure of source contribution.
  - The subcommittee agreed that this project is valuable. Similar studies of the source contribution of other chemicals are also needed.

The subcommittee discussed the following projects, which are part of sub-task 2 Environmental/Occurrence Monitoring:

- Water quality parameters and their influence on *Legionella* and non-tuberculous mycobacteria occurrence in water
- Potable water occurrence study of non-tuberculous mycobacteria
  - Dr. Rodricks pointed out that this project is already complete and the work will be published.
- Small drinking water distribution system modelling and assessment
  - Mr. Lowenthal suggested that this project related to the revision of EPANET-RTX and the use of this software as a starting point.
  - Mr. Ahlstrom added that this project is focused on premise plumbing in a large building (e.g., hospital). He supported this project because it contributes to understanding conditions that favor *Legionella* growth in premise plumbing.

The subcommittee discussed work under Task 1C – Water Treatment. This task includes three sub-tasks.

The subcommittee discussed the following projects, which are part of sub-task 1 Research to Support Program Office and Regional Office Needs:

- Flint, Michigan and the Lead and Copper Rule: Provision of technical support to Regions and the Office of Water; Development of sampling protocols for identifying lead service lines; Development of improved exposure model to support OW decision on a Household Action Level for the revised Lead and Copper Rule
  - Mr. Ahlstrom suggested that cities could have been selected for the program because there were known lead and copper issues.
  - Mr. Chaudhry supported EPA's proactive assistance to utilities before an outbreak.
  - The subcommittee agreed that it would be valuable to have a better understanding of why specific cities were selected for the monitoring program. EPA should consider how future cities are selected for monitoring programs because the current cities represent a limited geographic area. Similar lead and copper issues may be present in other areas of the country; these might not be captured with the current monitoring effort.
  - With respect to developing sampling protocols for identifying lead service lines, Mr. Ahlstrom clarified that lead service lines cannot be identified without digging them up, which is very invasive and impacts water distribution. This research supports communities in the identification of lead service lines.
  - Mr. Lowenthal added that there is an existing protocol for identifying lead service lines. He provided details on a recent project he was involved with where lead could have been introduced to service lines in solder.
  - With respect to the development of improved exposure model to support OW decision on a Household Action Level for the revised Lead and Copper Rule, Dr. Rodricks reminded the subcommittee that the existing exposure model is more generic and takes into account all the sources of lead exposure, not just drinking water exposure to lead.
  - Mr. Lowenthal added that a refined exposure model would allow EPA to identify the threshold concentration of lead exposure for drinking water. Although paint and dust also contribute to total lead exposure, drinking water is the only source that can be controlled. This work could improve awareness of other sources of lead exposure.
- PFAS
  - Dr. Rodricks stated that, although some PFAS compounds have robust toxicity datasets, limited databases are available for lower chain length PFAS compounds. Treatment is almost completely ineffective at removing PFAS compounds with lower chain lengths from water.
  - Studies should be focused on the toxicity of PFAS compounds with lower chain lengths.
- Cyanotoxins
  - Mr. Ahlstrom cautioned that the Toledo, Ohio incident should not be repeated.
  - Dr. Galloway suggested exploring the conditions that give rise to hazardous blooms and where these blooms might occur in the future. EPA should provide insight on what is being done to predict harmful algal blooms.
  - Mr. Lowenthal responded that harmful algal blooms occur everywhere all the time, but issues arise when they occur in a drinking water source. The blooms lead to fish kills in other waterbodies.
- Brominated DBPs

  - Mr. Ahlstrom shared that brominated compounds are sprayed on coal at generating stations to help with mercury removal. He noted that this process created a new problem. There are hundreds of coal fired generating stations across the country.

The subcommittee discussed the following projects, which are part of sub-task 2 Distribution Systems and Premise Plumbing:

- Tap and shower head sampling in building premise, plumbing in high density buildings
- Distribution systems
  - Mr. Ahlstrom summarized that studies on the microbes in tap and shower heads and distribution systems seek to understand what is happening in the distribution system between treatment and use.
  - Dr. Rodricks supported these projects because they provide valuable health information. More information is needed on how this information will be applied to improve health, next steps for the research, and follow up activities related to these two projects.
- NCER funding for examining the impacts of water conservation on water quality in premise plumbing and water distribution systems
  - Mr. Chaudhry stated that this work could result in different dynamics of sewage system design and construction. The high concentration of resource water would change the dynamics of design. Use of resource water may not be conducive to existing systems. Water conservation results in a lower flow of water in distribution systems and premise plumbing. This could have detrimental impacts on pipe material.
  - Mr. Ahlstrom noted that while it is important to recognize how the water flow is going to change, the sizing for commercial buildings is determined by fire flow and peak water usage for residential homes. These factors will not change in spite of water conservation. The issue is addressing how to handle lower flow in a water distribution system.

The subcommittee discussed the following projects, which are part of sub-task 3 Optimization of Current Drinking Water and Resource Water Processes:

- Maintenance and updates to EPA's Treatability Database
  - The subcommittee members agreed that maintaining and updating EPA's Treatability Database is important and should be continued.
- Evaluation of UV disinfection techniques for traditional WWTPs using bacteriophage to model treatment effectiveness
- UV disinfection in drinking water
  - Dr. Rodricks suggested that Dr. Snyder provide some thoughts on this project area. During the presentation, Dr. Snyder mentioned that UV treatment could result in photochemical changes in contaminants that lead to genotoxic agents. Certain parts of the spectrum are shaded out to address this issue.
  - Dr. Rodricks noted that UV treatment can occur at different pressures (i.e., high, medium, low), which could also result in different photochemical changes.

The subcommittee discussed work under Task 1D – Health Effects for Regulatory Decisions and Guidance. This task includes five sub-tasks.

The subcommittee discussed the following project, which is part of sub-task 1 Regulated DBP's Relation to Bladder Cancer:

- Human urothelial cells were engineered to stably overexpress GSTT1 a protein coding gene that plays a role in human carcinogenesis
  - Dr. Rodricks stated that this research is aligned with the National Cancer Institute's work. This research is led by EPA's NHERL. While this work is very interesting, it is very specialized. This research is part of a very complicated question and would only provide support for answering this question. Proving that a substance causes cancer is a very big task.
  - Mr. Chaudhry asked what EPA will do with the outcome of this research. The coordination of this research with other research conducted by the National Cancer Institute and other organizations should be described. Dr. Rodricks added that other epidemiology studies that support this research question should also be described. Few published epidemiology studies showed an association between DBPs and bladder cancer.
  - Dr. Rodricks noted that it is unclear what change would result if this research linked DBPs and bladder cancer. Mr. Ahlstrom responded that if bladder cancer and DBPs were linked, the level of DBP use would decrease. Dr. Rodricks concurred.
  - Mr. Chaudhry summarized that EPA should identify what other components need to be considered as part of this regulatory framework and other agencies studying this research question.
  - Dr. Rodricks suggested that an epidemiology study examining the association between DBP exposure and bladder cancer would be a good topic for a STAR grant.

The subcommittee discussed the following project, which is part of sub-task 2 Regulated DBP Exposure and Colon Cancer:

- Development of updated and improved human colonocyte cytotoxicity assay
  - Dr. Rodricks concluded that the concerns expressed above for research linking DBP exposure to bladder cancer also apply for research linking DBP exposure and colon cancer.

The subcommittee discussed the following project, which is part of sub-task 3 Regulatory Technical Support:

- Technical support to the 6-Year DBP rule process, including being members of the Support Document writing team
  - Mr. Ahlstrom pointed out that the work done to relate DBP exposure to bladder and colon cancers will feed into regulatory and technical support to the 6-Year DBP rule process.

The subcommittee discussed sub-task 4 Internal Dose/Multi-route Exposure from Regulated DBPs through PBPK Models. Dr. Rodricks supported the modeling work.

The subcommittee discussed sub-task 5 Impacts from Varying Source Water Quality and Disinfection Scenarios on Health Impacts from DBPs. Mr. Ahlstrom noted that these projects aim to improve our understanding of measuring DBPs and their toxicological effects. Dr. Rodricks suggested that bromoacetic acid should also be considered.

The subcommittee members discussed Project 2 – Next Steps: Technology Advances.

The subcommittee discussed work under Task 2A – Treatment, Monitoring and Risk Assessment for Water Reuse, which includes five sub-tasks.

The subcommittee discussed the following project, which is part of sub-task 1 Development of AnMBR Technologies for Domestic Resource Water Treatment Combined with Direct Potable Reuse:

- AnMBR experiments for net positive energy recovery from domestic resource water treatment
  - The subcommittee pointed out that this project should look at potable reuse more broadly rather than only for direct potable reuse.
  - Mr. Chaudhry noted that AnMBR is somewhat new technology. This technology will not suffice for the potable reuse treatment standards. AnMBR could be used for non-potable reuse. There is some promise for application at resource water facilities. AnMBR could be used so these facilities can have neutral or net positive energy use. This research is valuable but more is needed to determine if AnMBR should be applied at resource water facilities.

The subcommittee discussed the following projects, which are part of sub-task 2 Synthesis Report on State of the Science in Membrane Technologies for Water Recovery from Challenging Water Sources such as Brine Streams:

- Conducting in-house experiments, process simulations, and literature reviews in preparation for fiscal year 2019 product focusing on water and salt recovery from reverse osmosis brine-concentrates
- Evaluating commercial and developmental membranes for water transmission and salt rejection in both membrane distillation and pervaporation modes of operation.
  - Mr. Chaudhry stated that this research is focused on zero liquid discharge treatment plants. Water and salt recovery from reverse osmosis brine-concentrates is similar to the process on brine conversion from brackish water in El Paso, Texas, that was described in the video the subcommittee viewed yesterday. He was supportive of giving this area a boost in priority.
  - Mr. Lowenthal stated that it was interesting to see a private company invest in this type of technology rather than EPA. The chemicals produced by this process are not high end. The only out-of-pocket expense is the cost of the facility; there are no materials cost. Mr. Chaudhry added that this is a step forward for sustainability.
- CRADA with Aquatech International for membrane material development is in effect through May 2017.
  - Dr. Rodricks clarified that CRADAs are with private/public partners.
  - Mr. Chaudhry supported this research and giving work in this area a boost in priority.

The subcommittee discussed the following projects, which are part of sub-task 3 Water Waste Residuals: Strategies for Valuable Resource Recovery Product:

- Review of the composition of residuals from a variety of historical EPA drinking water treatment plant studies

- Development of a solid pelletizing protocol for producing media from drinking water treatment plant residuals
- Evaluation of residual pellets for alternative uses
  - Mr. Chaudhry pointed out that these projects address physio-chemical water treatment and the development of other products from treatment sludge and residuals. The volume of residuals produced by drinking water treatment plants is minimized by transforming residuals into a usable product that removes air pollutants.
  - Mr. Lowenthal asked if EPA should encourage private industry to support and conduct this research. Mr. Chaudhry responded that private industry will jump into this venture only when this technology is demonstrated as viable and economical, similar to the brine conversion technology.
    - Dr. Rodricks suggested including this point in the response to the charge questions. The subcommittee will ask EPA if the objective of this research is to develop the basic technology and then transfer this technology to commercial companies.

The subcommittee discussed sub-task 4 Method Development for Key Bacterial Populations Associated with Phosphate Bioaccumulation in Low DO Resource Water Systems. Mr. Chaudhry explained that this project seeks to correlate the presence of bacteria with nutrients in resource water. When water conservation approaches are used, both the organic load and carbon level in the water will be high. Organisms occur in the production system. If more bacteria are present, more DO is consumed. Thus, the DO present in the water distribution system is low. This results in system discharge containing excess phosphate. Additional control is needed to address this issue. Resource water treatment plants have to use more energy to provide more DO for the phosphorous conversion.

The subcommittee discussed sub-task 5 Innovative Packaged Systems for Water Reuse and Removal of Contaminants. Dr. Rodricks asked if a package system is already available for water reuse. Mr. Chaudhry replied that multiple package systems exist, but he is not sure if these systems are commercially available for application for use in a drinking water system. He offered to look into this issue further while developing the responses to the charge questions for Project 2.

The subcommittee discussed work under Task 2B – Novel Monitoring Technologies for Occurrence, Exposure, and Effects for Individual and Groups of Contaminants, which includes three sub-tasks.

The subcommittee discussed sub-task 1 Adaptation of Advanced Methods for Regulatory Applications. The subcommittee supported the utility of projects in this research area.

The subcommittee discussed sub-task 2 Novel Grouping Methods to Improve Understanding of the Effects of Groups/Mixtures of Chemicals. Dr. Rodricks noted that this is a tall order. This research seems valuable but requires a lot of effort to reach milestones. The subcommittee discussed the following project:

- Monitoring of CECs in source water, treated drinking water, wastewater effluents, surface water and ground water

- Mr. Chaudhry suggested that information on the identity of specific CECs would be helpful.
- Dr. Rodricks added that it would be helpful to know how the UCMR lists have been used.

The subcommittee discussed sub-task 3 Advanced Technologies for Small Water Distribution Systems. The subcommittee supported the utility of projects in this research area.

The subcommittee discussed work under Task 2C – Water Treatment Technologies for Enhanced Reduction of Chemical and Microbial Risks, which includes six sub-tasks.

The subcommittee discussed sub-task 1 Biological Drinking Water Treatment: Gaining Acceptance and Optimization to Achieve Desired Treatment Goals. Mr. Chaudhry shared that this topic is a relatively new area of research. The use of biological treatment processes for drinking water used to be unthinkable, but the use of biological treatment is growing. Biological treatment is typically paired with other treatment processes; they are not used as the sole treatment process. Dr. Rodricks noted that these processes would not be effective in removing some emerging contaminants such as strontium or fluorochemicals. Mr. Lowenthal and Mr. Chaudhry agreed that the development of an innovative biological nitrate removal processes has utility. It would be valuable to see the outcome of the pilot scale project. Work on a larger scale is needed to determine efficacy. Much work remains before this research is applied for commercial use.

The subcommittee discussed sub-task 2 Development of Technologies to Meet Drinking Water Goals in Small Systems. Dr. Rodricks stated that it would be helpful to know more about how emerging contaminants are impacted by these treatment technologies. Dr. Rodricks will include in his comments a note about EPA's consideration of pharmaceuticals in drinking water. Mr. Lowenthal added that the only discussion EPA provided on pharmaceuticals were that their levels are so low that they pose only an ecological risk; they pose no risk to human health. It is unclear why pharmaceuticals in drinking water are not considered a human health risk. There is a robust database on pharmaceuticals.

The subcommittee discussed sub-task 3 LED Systems for Water Disinfection. The subcommittee supported the utility of projects in this research area.

The subcommittee discussed sub-task 4 Effectiveness of Current and Innovative Resource Water Treatment Operations for Managing Model Compounds. Mr. Chaudhry stated that this project is important because it addresses emerging contaminants.

The subcommittee discussed the following projects, which are part of sub-task 5 Application of Microelectrodes to Optimize Disinfection to Control:

- Microprofiling experiments investigating free chlorine and monochloramine penetration into drinking water storage tank sediments were completed. Analysis of acquired microprofile data is ongoing.
  - Mr. Ahlstrom explained that this project seeks to analyze sediments collected in a distribution system storage tank. Mr. Lowenthal added that applied chlorine does not penetrate the sediment in these tanks. The analysis addresses what happens in the sediment in a chlorine free environment. Mr. Ahlstrom added that this research

contributes to the understanding of what happens to water after it leaves the treatment plant.
    - This work has been complete and will be presented at a future conference.
    - Dr. Rodricks suggested asking EPA for information on how this work is being translated and implemented and who has been informed of these research outcomes.

The subcommittee discussed sub-task 6 Treating Drinking Water in Buildings: A Holistic Approach to Providing Safe Water to Consumers. Dr. Rodricks recalled that there was a lot of discussion from the subcommittee on this project during Dr. Impellitteri's presentation. Mr. Chaudhry reminded the subcommittee that this project is focused on high density buildings, not single family homes. He suggested that different terminology rather than "household" be used to refer to water use in buildings. It is important to specify whether the building is a high density building or a single family dwelling. Mr. Chaudhry suggested involving other stakeholders in this research. Dr. Rodricks asked if this research is important at a building level. Mr. Ahlstrom responded that many current problems are associated with premise plumbing, especially for Legionella. This issue presents an interesting challenge because the presence of microbes in premise plumbing is not regulated. Mr. Lowenthal added that building codes only provide some regulation on construction and renovation, but not on microbial load. Mr. Ahlstrom emphasized the importance of this project. Issues related to *Legionella* will not be solved without projects like this one. This could represent a priority issue. The subcommittee agreed to evaluate the use of the term "household" when referring to premise plumbing in high density buildings.

The subcommittee discussed work under Task 2D – New methods and tools for measuring human and ecological health risks from chemicals (individual and mixtures) and pathogens.

The subcommittee discussed sub-task 1 Identify Potential Exposure and Effect Posed by Contaminants to Manage their Risk in Source, Drinking, Waste and Reused Water through a Tiered Screening Approach, which Couples Bioassays/Bioactivity and Analytical Chemistry in an Effect-Directed Analysis. Dr. Rodricks noted that this project is focused on advanced toxicology for unregulated contaminants. Many of these contaminants are poorly studied; good toxicity data are important. He supported the increased use of high throughput toxicity testing and recommended advancing this project forward. Dr. Rodricks supported multi-agency efforts.

The subcommittee discussed the following projects, which are part of sub-task 2 Development of Approaches to Evaluate Human Health Response to Waterborne Contaminants Associated with Drinking Water Quality:

- Application of innovative salivary immunoassays to link health effects with drinking water exposures
    - Dr. Rodricks stated that more information is needed on the salivary immunoassay study before it can be evaluated. Dr. Timothy Wade is the lead investigator from EPA and could provide more information.
    - The subcommittee identified the following areas where more information is needed:
        - Is this the best choice for an assay to address this research question?
        - Is this work a collaboration with other agencies (e.g., FDA, CDC)?
        - Why was Puerto Rico selected as a study location?
        - How will other factors impacting waterborne outbreaks be accounted for in this study?

- Development of improved biological markers to link health effects with drinking water exposures
  - Dr. Rodricks pointed out that this work seems better aligned with the work done by the National Institutes of Health (NIH). EPA might not be the best agency to lead this effort.
  - Mr. Chaudhry suggested that the subcommittee request more information on this topic.
  - Mr. Ahlstrom noted that EPA is looking for biomarkers and assays that might be integrated into a more technologically advanced monitoring approach. It is unclear if something of this nature can be achieved and if this is the best approach.
  - Dr. Rodricks recalled discussion during the presentation of using a "chip" for detecting toxicity and exploring toxicity pathways.
  - Dr. Rodricks concluded that this is a high risk research area that presents many challenges to success. With limited research funding, this might not be the best area to allocate that funding. This research is better aligned with NIH. This should be a "minor comment" in the subcommittee's report.
- Animal model to address uncertainty surrounding the risk posed by aerosolization of waterborne pathogens.
  - The subcommittee discussed exposure routes for drinking water aerosols. These exposure routes include in-home water uses, such as showering.
  - There are multiple exposure pathways for many microbial pathogens, including inhalation. Inhalation is the primary exposure route for *Legionella.*
  - Mr. Chaudhry asked what the life expectancy is for pathogens in aerosol as well as the concentration of these pathogens.
    - Mr. Ahlstrom responded that this information is unknown for some pathogens, which is why quantification assays are needed.
  - Dr. Rodricks pointed out that EPA is commonly asked whether or not there are pathogens in the water and will the public get sick.
  - Mr. Ahlstrom noted that, while this issue is important, this work should not be considered a priority area. There are other research areas that are higher priority.
  - Mr. Chaudhry agreed to ask in his response why this area is considered a priority.

The subcommittee did not discuss Task 2E – Advancing Public Health Protection through Water Infrastructure Sustainability (NCER-STAR).

The subcommittee did not discuss Task 2F – Research and Demonstration of Innovative Drinking Water Treatment Technologies in Small Systems (NCER-STAR).

The subcommittee did not discuss Task 2G – Net Zero EPA-DoD Interagency Agreement (NCER-Interagency Agreement).

Wrap-up and Adjourn

The subcommittee discussed the next steps for addressing the charge questions. Mr. Tracy informed Dr. Rodricks that the BOSC SSWR needs to deliver the report to the EC in early December, which is 1 month before the January 2017 EC meeting. The subcommittee agreed to complete the draft response to the charge questions within 2 months (i.e., by the end of October). The subcommittee can then review the draft and there will be 1 more month available to revise

the report before submitting the final version. Dr. Rodricks asked each of the three project teams to provide a draft of their responses to the charge questions by Friday October 14, 2016. Dr. Rodricks and Dr. Chaudhry will combine the comments into one cohesive version by the end of October, 2016. Dr. Rodricks reminded the subcommittee to include Mr. Tracy on all email correspondence sent between members working together on charge question responses.

Mr. Ahlstrom suggested that he and Dr. Bruce Aylward partner to address the charge questions for Project 1.

Dr. Chaudhry noted that the subcommittee can request more information from EPA on any of the projects.

Mr. Tracy shared that he submitted a draft of the Homeland Security BOSC's response to their charge questions to the program managers to ensure the report was on the right track. Afterwards, the subcommittee could have a teleconference to review the draft and get final approval from the subcommittee.

Dr. Rodricks offered to review the comments on the EC report. Dr. Lowenthal stated that he will provide comments on the EC report to Dr. Rodricks.

Mr. Tracy will send out a Doodle poll for a subcommittee conference call at the beginning or middle of November.

Mr. Tracy will send out a separate Doodle poll for a conference call to discuss membership and discussion topics for next year's SSWR BOSC meeting. Mr. Lowenthal supported combining the topics of nutrients and green infrastructure for next year's meeting.

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Appendix A: Agenda

United States Environmental Protection Agency
Board of Scientific Counselors (BOSC)
Safe and Sustainable Water Resources (SSWR) Subcommittee
Meeting Agenda – August 24–25, 2016
Cincinnati, Ohio

TIME	TOPIC	PRESENTER
Wednesday, August 24, 2016		
8:00 – 8:15	Registration	
8:15 – 8:30	Welcome, Introduction, and Opening Remarks	Joe Rodricks, Chair
8:30 –10:00	2016 EPA Drinking Water Workshop: Small Systems Poster Session and Meet the Experts (Regency A and Regency BC)	
10:00 – 10:15	Break	
10:15 – 10:30	DFO Welcome and FACA Rules	Tom Tracy, DFO
10:30 – 11:30	Discuss Meeting Objectives, Water Systems Charge Questions, and Poster Session	Joe Rodricks, Chair; Suzanne van Drunick, NPD; Tom Tracy, DFO
11:30 – 12:00	Welcome and Remarks from Tom Burke	Tom Burke, ORD Deputy Assistant Administrator, EPA Science Advisor
12:00 – 1:00	Lunch	
1:00 – 1:30	Partner Input: EPA Office of Water and Regions	Peter Grevatt, Director OW GDW; Carole Braverman, Region 5 RSL
1:30 – 2:30	Overview and Deep Dive into Regulatory Support Project 1	Christopher Impellitteri, Associate NPD
2:30 – 3:30	Overview and Deep Dive into Technology Advances Project 2	Christopher Impellitteri, Associate NPD
3:30 – 3:45	Break	
3:45 – 4:45	Overview and Deep Dive into Transformative Approaches and Technologies Project 3	Jay Garland, Project Lead, NERL
4:45 – 5:00	Wrap-up and Adjourn	Joe Rodricks, Chair and Tom Tracy, DFO

TIME	TOPIC	PRESENTER
Thursday, August 25, 2016		
8:00 – 8:15	Registration	
8:15 – 8:25	DFO Reconvene Meeting, Attendance	Tom Tracy, DFO
8:30 – 9:45	Small Systems Workshop: WINSS and DeRISK Status Reports (Regency ABC Ballroom)	
10:00 – 10:30	Public Comment Period	Tom Tracy, DFO
10:30 – 11:00	NCER STAR and National Priorities Water System Grants	Michael Hiscock, NCER
11:00 – 11:30	2016 BOSC EC Report Discussion	Joe Rodricks, Chair, Subcommittee
11:30 – 12:30	Water Systems Charge Questions Discussion	Joe Rodricks, Chair, Subcommittee
12:30 – 2:30	Subcommittee Discussion and Working Lunch	Subcommittee
2:30 – 3:00	Committee Membership, Next Subcommittee Meeting, January BOSC EC Meeting	Joe Rodricks, Chair, Suzanne van Drunick, NPD, Tom Tracy, DFO
3:00	Adjourn meeting	

Breaks at the discretion of the chair.

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Appendix B: Participants

BOSC SSWR Subcommittee Members:

Joseph Rodricks, *Chair*
Shahid Chaudhry, *Vice Chair*
Scott Ahlstrom
Bruce Aylward (absent)
Lawrence Baker (absent)
James Galloway*
Inez Hua (absent)
John Lowenthal
Shane Snyder**

**participated via phone*
***present on Day 1 of the meeting only*

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

EPA Presenters:

Carole Braverman, *Region 5, Regional Science Liaison*
Tom Burke, *Office of Research and Development*
Jay Garland, *Office of Research and Development*
Peter Grevatt, *Office of Water*
Michael Hiscock, *Office of Research and Development*
Chris Impellitteri, *Office of Research and Development*
Jane Ellen Simmons, *Office of Research and Development*
Suzanne van Drunick, *Office of Research and Development, National Program Director for the SSWR Research Program*

Other EPA Attendees:

Thomas Baugh	Matt Heberling	Maya Paclinowski
Lindy Farrar	Matt Hopton	Anne Rea
Jay Garland	Michelle Latham	Thomas Speth
Rick Greene	Syloana Li	Hale Thurston
Ann Grimm	Rachel Matney	Joe Williams
Hibu Grust	Mark Mills	

Other Participants:

Shugen Pan
Steve Via

Contractor Support:

Kaedra Jones, ICF
Maureen Malloy, ICF