

Safe and Sustainable Water Resources

BOSC Subcommittee

2016 Report

The SSWR BOSC Subcommittee met on 24-25 August, 2016, and was provided an in-depth review of one of SSWR's four research topics – Water Systems. The Water Systems topic consists of three projects:

Project 1: Current Systems and Regulatory Support

Project 2: Next Steps: Technology Advances

Project 3: Transformative Approaches and Technologies

Highly detailed briefings on Projects 1 and 2 were provided by Dr. Christopher A. Impellitteri, SSWR Associate National Program Director, and on Project 3 by Dr. Jay L. Garland, Director, National Exposure Research Laboratory, Systems Exposure Division. Dr. Suzanne van Drunick, SSWR National Program Director, members of her staff, and representatives from ORD were present for the entire meeting.

The Subcommittee found the presentations and associated commentary from Dr. van Drunick and others to be clear and thorough, and reflected a high level of commitment to a critical area of research. In general terms, the Subcommittee agreed that the Water Systems research program is very much on track, and that it is fulfilling its mandate.

The Subcommittee was asked to respond to two Charge questions:

Charge Question 1: *Are we doing the right research: Taking resource limitations into consideration, is there any additional research that warrants new investment or current research that merits expansion, and are there areas of research that SSWR may consider divesting in?*

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.*

The Subcommittee's responses follow, organized under the three projects. Responses consist of commentary and some specific recommendations.

The Subcommittee's meeting was held during the EPA's 13th Annual Drinking Water Workshop (23-25 August, Cincinnati, OH) and Subcommittee members had the opportunity to attend several sessions and review poster presentations. The topic of the workshop was Small Drinking Water Systems, and the Subcommittee clearly benefited by having this opportunity.

One presentation is highlighted here because it provided a model for research planning that may be useful to the SSWR program. (Our selection of this one presentation should by no means be taken to suggest others were less valuable; rather, it was selected because of its relevance to one of the critical SSWR activities – research planning).

The presentation was made by Dr. Chad Seidel, University of Colorado, who directs the Design of Risk-reducing, Innovative-implementable Small-system Knowledge (DeRISK) Center—one of two national centers for innovation in small drinking water systems funded by SSWR through the STAR Grants program. Dr. Seidel demonstrated how various research efforts directed to reducing health risk could be formulated and then analyzed with a decision model described in the important National Research Council report Science and Decisions (2009).¹ The NRC report was prepared for the EPA, and the Agency has adopted the decision framework for use in other contexts.

Recommendation: The EPA should consider adopting the research planning and evaluation framework developed under the DeRISK Center, and presented by Dr. Seidel.

Project 1: Current Systems and Regulatory Support

Response

1. Regulatory mandates under the Safe Drinking Water Act and Clean Water Act require periodic review so the most current information is used to inform regulatory requirements and to ensure new areas of concern are addressed. Project 1: Current Systems and Regulatory Support seeks to meet this need by conducting research activities that:
 - Support federal regulations and guidance.
 - Provide strategies to regions, states, and communities for improved regulatory compliance.
 - Provide rapid and effective response to emergencies, such as harmful algal bloom outbreaks.
2. Deliverables from this research will provide technical support for existing water-related rules as well as imminent issues, such as direct potable water reuse. The current research program includes the following tasks.
 - Task 6.01A: Evaluating current wastewater treatment plants for contaminant removal
 - Task 6.01B: Analytical methods and monitoring for regulatory and utility purposes
 - Task 6.01C: Cost and effectiveness of water treatment to achieve regulatory compliance
 - Task 6.01D: Improving the scientific foundation of regulatory decisions
3. A key activity in FY16 is to refine risk assessment models for direct potable reuse. Traditionally, water reuse practices have been categorized as non-potable, indirect potable and direct potable, primarily for regulatory purposes.
4. Indirect potable reuse is typically done by releasing treated wastewater into groundwater or surface water sources with the intent of using it for a drinking water supply, and then reclaiming it and treating it to meet drinking water standards.
5. Direct potable reuse is taking purified water, created from treated wastewater, and introducing it directly into a municipal water supply system without an environmental “buffer” of any kind.

¹ Dr. Seidel did not specifically cite this report, but the decision and risk model he described was completely consistent with it.

6. In many cases, the distinction between indirect and direct potable reuse is insignificant. Treated wastewater discharged into an effluent dominated stream or pond and then pulled out a short distance downstream for treatment is not materially different than a direct reuse application.

Recommendation: We recommend EPA acknowledge this reality and evaluate risk based on the quality of the source water and its intended use.

Whether states continue to regulate reuse based on a division between indirect and direct potable reuse application will be based on factors the states deem important and that likely include social and non-technical considerations. From a technical research perspective, there is no reason for EPA to make this distinction.

Recommendation: We recommend ORD's health effects research focus on the technical aspects of potable reuse and not confuse the analysis with the variability surrounding whether the reused water enters the potable water supply directly or indirectly.²

7. Some potable reuse applications are implemented to address long term supply issues while others are implemented as a short-term (less than a few years) response to drought or emergency conditions, i.e., until the preferred water supply is available again. The goal would be to define impacts that must be mitigated if reuse were practiced for a few years versus additional impacts that would become important to address if reclaimed water is part of the permanent water supply. The research on short-term impacts would also be valuable to inform regulators, utilities, and technical experts dealing with response and recovery from natural disasters and other happenings that impact a community's water supply source.

Recommendation: We recommend ORD consider expanding their potable reuse research to specify acute versus chronic impacts.

8. We understand ORD is conducting research to support the Office of Water's consideration of a household lead concentration action level that might be used in a revised lead copper rule. The plan to couple the Stochastic Human Exposure and Dose Simulation (SHEDS) and the Integrated Exposure Uptake Biokinetic (IEUBK) models is good since they are recognized tools with a long history of use. The current approach appears to be one where exposure from all other sources of lead will be determined and any remaining exposure allowance will be allocated to water.

Recommendation: We recommend a more robust approach where all exposure pathways are defined and opportunities to reduce exposure from each of those pathways are prioritized.

We recognized this involves work outside the area of responsibility of water and thus see it as a partnering opportunity with other parts of EPA and other agencies. A more holistic approach will offer greater societal benefits for the costs involved and is preferred to burdening water utilities with meeting a restrictive lead concentration when other actions could be taken in the community

² The National Research Council publication Water Reuse: Potential For Expanding The Nation's Water Supply Through Reuse of Municipal Wastewater, 2012 also discusses an approach that does not define treatment requirements based on natural versus engineered processes but that is risk based and tailored to meet specific water quality objectives.

that have a greater impact. By providing opportunities for communities to respond to a total lead exposure across the various pathways and not just limit responses to lead in water may also spur actions to address currently ignored pathways.

9. **Recommendation: The SSWR Subcommittee recommends ORD consider expanding and accelerating its efforts to address perfluorinated alkyl substances (PFAS). This seems especially important given the current lack of understanding in how to treat shorter chain substitutes and the increasing presence of PFAS in drinking water sources.**

10. Current and impending regulations require reduction in the formation of disinfection by-products and have generated growing interest in the use of UV disinfection. UV disinfection is the process of using ultraviolet light to alter cellular molecular components essential to cell function. Significant research is proposed to expand the understanding of UV disinfection of drinking water and resource water and to optimize treatment processes. Research is also proposed on the health impacts of disinfection by-products (DBPs) associated with traditional disinfection processes. However, no research is proposed to investigate the potential chronic toxicity associated with UV disinfection.

Recommendation: The SSWR Subcommittee recommends ORD assess the current body of knowledge regarding human health effects from by-products of UV irradiation and determine if additional research is needed.

11. **Recommendation: Research about chlorinated DBPs should be expanded to include brominated DBPs.**

12. The vast majority of drinking water systems produce water safe for human consumption at the point where the water enters the distribution system. How water quality changes as the water flows through the distribution system to the end user is an area where significant discovery is still occurring.

Recommendation: It is recommended that ORD continue to define research activities that expand our understanding of how to manage drinking water after it leaves the treatment plant.

13. However, the proposed research activity to develop a decision support tool to “right-size” plumbing and distribution systems with the “right” materials is not the type of activity recommended. Many tools and design guides already exist for distribution systems and premise plumbing. These tools seek to balance peak water demand with the impacts of water conservation on water quality. Solutions rely on the installation of more looped and fewer dead-end pipes. There is limited need for additional research in this area. Instead, owners need to accept that the additional cost of a well-designed system is justified by the water quality benefits.

Recommendation: We recommend re-focusing this task on deliverables that build understanding of the benefits of a well-designed versus lowest cost system or to reallocate funding to other higher priority tasks.

14. The SSWR Subcommittee considers the characterization of antibiotic resistance in resource waters that are discharged to the environment to be a low priority research topic and is a candidate for reduced funding.

Recommendation: We recommend ORD re-evaluate the priority of this research activity and consider reallocating the funding to other higher priority activities.

Project 2: Next Steps – Water Systems Technology Advancements

Response

1. From a broader standpoint, the water sector in the U.S. is facing following challenges:
 - A. Need to develop alternative water resources that will often not be as high quality as conventional sources.
 - B. Innovative technologies and processes to treat emerging contaminants
 - C. Energy recovery and generation
 - D. Mitigating climate change and extreme weather event impacts for reliability and resiliency, and
 - E. Addressing regional challenges

In this context, the R&D efforts in technology advancement should be focused on providing safe, sustainable, and cost effective water resources.

2. Project 2, “Next Steps: Technology Advances,” is comprised of four broad tasks.
 - Task 2A: Treatment, Monitoring and Risk Assessment for Water Reuse
 - Task 2B: Novel Monitoring Technologies for Occurrence, Exposure and Effects for Individual and Groups of Contaminants
 - Task 2C: Water Treatment Technologies for Enhanced Reduction of Chemical and Microbial Risks
 - Task 2D: New methods and tools for measuring human and ecological health risks from chemicals (individual and mixtures) and pathogens

Each task involves numerous activities and each activity has its own outputs. These tasks, associated activities, and respective outputs are briefly discussed below:

Task 2A: Treatment, Monitoring and Risk Assessment for Water Reuse

- i. Development of anaerobic membrane bioreactor (AnMBR) technologies for domestic resource water (RW) treatment combined with direct potable reuse (DPR): The key outcome of this activity is an innovative AnMBR which will be an effective approach to extracting nutrients from resource water with minimal energy consumption, and can be used as an integral part of the scheme for direct potable reuse treatment.
- ii. Development of membrane technologies for water recovery from challenging water sources: Like the previous task, the key output of this task will be the evaluation of commercially available or in-development membranes, and selection of the most promising ones to optimize water recovery and salt rejection, using relatively new and innovative membrane distillation processes.
- iii. Water Waste Residuals: Strategies for Valuable Resource Recovery Product: This activity is expected to result in developing a solid pelletizing protocol for producing media from drinking water for multiple uses such as neutralization of acidic waste streams, treatment of air pollutants, and adsorption of multiple contaminants from various liquid streams.
- iv. Methods Development for Key Bacterial Populations associated with Phosphate Bioaccumulation in Low-DO RW Systems: The outcome of this completed activity is identification of a denitrifying bacterial group which removes nitrogen and accumulates phosphate at very high levels under low-DO conditions.

- v. Innovative Packaged Systems for Water Reuse and Removal of Contaminants: This activity focuses on using various types of granular activated carbon products and systems to help small communities comply with Safe Drinking Water Act in a cost effective manner.

Task 2B: Novel Monitoring Technologies for Occurrence, Exposure and Effects for Individual and Groups of Contaminants

- i. Adaptation of Advanced Methods for Regulatory Applications: The outcome will be next-generation analytical and monitoring tools to utilize advanced technologies for regulatory purposes. This set of tools will broaden OW's existing toolkit, ensuring a safe drinking water supply.
- ii. Novel Grouping Methods to Improve Understanding of the Effects of Groups/Mixtures of Chemicals: Work is in progress to develop a toolkit to assess the contribution of component chemicals and subgroup mixtures to the toxicity of complex mixtures.
- iii. Advanced Technologies for Small Water Distribution Systems will result in developing monitoring processes to quantify microbial contaminants in small, consecutive, DW distribution systems.

Task 2C: Water Treatment Technologies for Enhanced Reduction of Chemical and Microbial Risks

- i. Biological Drinking Water Treatment: Gaining Acceptance and Optimization to Achieve Desired Treatment Goals: Multiple outcomes engineering design guidance and full scale application of biological ammonia systems, development and pilot-scale demonstration of an innovative biological nitrate removal process, and treatment of emerging contaminants using UV light, percarbonate, and peracetic acid.
- ii. Development of Technologies to Meet Drinking Water Goals in Small Systems: This activity focuses on the development of communication materials and outcome of case studies using latest treatment options available for small systems.
- iii. LED Systems for Water Disinfection: This ongoing activity will provide an update on using UV-LED for disinfection.
- iv. Effectiveness of Current and Innovative Resource Water Treatment Operations for Managing Model Compounds will result in developing standard operating procedures for sample collection, preservation and analysis for CECs in resource water and biosolids; and will compare results of using medium-and low-pressure UV at existing RW treatment plants.
- v. Application of Microelectrodes to Optimize Disinfection
- vi. Treating Drinking Water in Buildings: Development of holistic approaches to providing safe water to consumers by improving plumbing systems and plumbing configurations during construction, additions, and changes.

Task 2D: New methods and tools for measuring human and ecological health risks from chemicals (individual and mixtures) and pathogens

- i. Identify Potential Exposure and Effect Posed by Contaminants to Manage their Risk in Source, Drinking, Waste and Re-used Water will result in developing the scientific basis for sound regulatory decisions on priority, unregulated waterborne contaminants

- ii. Development of Approaches to Evaluate Human Health Response to Waterborne Contaminants Associated with Drinking Water Quality is investigating an innovative salivary immunoassays to link health effects with drinking water exposures for future drinking water regulations.

In addition, extramural research is underway on water infrastructure sustainability, demonstration of innovative drinking water treatment technologies in small systems, and on subjects of mutual interest through collaborations and interagency agreements.

Task 2E: Advancing Public Health Protection through Water Infrastructure Sustainability (NCER-STAR)

- i. Provides an update on portfolio of 8 grants which will end in 2016.

Task 2F: Research and Demonstration of Innovative Drinking Water Treatment Technologies in Small Systems (NCER-STAR)

- i. Provides an update on research portfolio of 11 grants focusing on developing innovative treatment technologies specifically for small water systems.

Task 2G: Net Zero EPA-Department of Defense (DoD) Interagency Agreement (NCER-Interagency Agreement)

- i. Focuses on technology research which is of interest to DoD & EPA

The Subcommittee found the research content of Project 2 to be very impressive. It was difficult to identify any significant gaps, and we commend EPA's solid efforts regarding technology advancement.

3. The Subcommittee understands well that EPA's, and for that matter SSWR's, annual budget varies from year to year and continuation of on-going R&D programs sometimes may be severely impacted. However, for good or bad, there are many other federal agencies involved in water related research programs. For instance, in 2000, EPA spent only 15% of the total federal funding to research water related issues while remaining 85% was contributed by Department of Agriculture, Department of Health and Human Services, Department of Defense, Department of Energy, National Aeronautics and Space Agency, National Oceanic and Atmospheric Administration, National Science Foundation, Bureau of Reclamation, and U.S. Geological Survey (NRC, 2000).

Recommendation: To avoid any possibility of overlapping R&D efforts and stretch its limited resources, SSWR should increase its efforts to work closely with other federal agencies and departments involved in similar efforts.

4. Because there are always resource constraints, research planning could be made most effective if it were organized according to assumptions about possible budget increases, and the development of possible new research efforts under such assumptions. Once that step is taken, it can be asked whether and why any or all of those possible new efforts are less important than current efforts. It would seem an analysis of this type is necessary to ensure that current research is the "right research at the right time."

5. The Subcommittee also recognizes that the research efforts are prioritized and selected in consultation with and based on the needs of regional offices and research partners. In this context, apparently on-going projects are in line with stake-holders' needs. Looking at on-going projects, it seems that research is appropriate for identified needs, but without clearly specifying which projects focus on short term issues and which ones on the long term.

Recommendation: Efforts should be made to divide more carefully technology research efforts according to the timelines for completing and implementing developments. This would provide clarity regarding technology development and short and long-term needs for these technologies.

6. As we move forward, several broad problems that limit water utilization will become important. First, salinization of water supplies seems to be increasing for several reasons: (1) droughts result in increased salts in rivers, to the point of being problematic in the West (e.g., Colorado River); (2) salts are concentrated in some desert cities, such as Phoenix and El Paso, where ground waters often exceed 1000 mg/L TDS; (3) seawater intrusion is a global problem, likely to become much worse due to sea level rise and high withdrawals from near-coastal freshwater aquifers; and (4) in cold climates, application of road salt over the past several decades has caused salt levels in aquifers to increase. Learning to treat and use saltier waters may be essential for cities of the future. Second, in rural areas particularly, nitrate has now become a problem not only in domestic wells, but also in some community water supplies. We can expect that nitrate problems in groundwater will steadily become worse as the use of high rate N fertilization continues. Finally, there is growing concern regarding CECs as well as organic contaminants of known concern (pesticides, etc.). These concerns will require considerable research to develop water treatment technologies for the 21st century. Doing this research is urgent, because we will need to replace much water infrastructure within the next few decades.

Unexpected crises, as in Flint, and less publicized St. Joseph (Louisiana) and in many other parts of the country, remind that regional offices need to be more vigilant on long-term potential challenges especially in areas and communities with high levels of lead, copper, arsenic, etc.

Recommendation: SSWR should develop long term perspectives on problems related to salinization, nitrate, and chemical contaminants, both existing and emerging, to identify long term technology needs, and the research programs required to meet those needs.

Project 3: Transformative Approaches & Technologies

Response

Project 3, Transformative Approaches & Technologies, contained 4 Tasks (A-D): System Approaches (3A), Monitoring & Analytical Methods (3B), Treatment (3C), and Health Effects (3D).

Task 3A: System Approaches for Assessment of Transformative Fit-for-Purpose and Resource Recovery-Based Water Systems

Development of a transformative technology toolkit library: Key outputs from this toolkit library would include information regarding newer technologies, including aerobic membrane digester (AeMBR), anaerobic membrane digester (AnMBR), anaerobic digestion, constructed wetlands, struvite, and 5-level nutrient removal treatment train. Example data was shown which compares AeMBR and AnMBR at scaling levels a scaling levels (0.05-10 MGD) and AnMBR at 35 and 20 degrees C. Another example of 5-level nutrient removal trains compared for cumulative energy demand. Without question, AnMBR is an important technology for consideration, which may lead to savings in energy and improvement in water quality. The same is true for the 5-level nutrient removal, which compares (generally) technologies for achieving various levels of phosphorus and nitrogen removal and compares to cumulative energy demand. Both examples are of great value to water agencies in the USA; however, it is unclear how these examples are applicable to water quality scenarios in various geographies. While the BOSC committee assumes the actual toolbox will be far more comprehensive, and the current two examples seems promising, far more data will be needed to be certain these examples are applicable to water qualities encountered in various regions of the USA. It is also unclear how the US EPA will define a “transformative” technology, for instance, 5-stage Bardenpho is already operating at full-scale in some cities. How does the EPA define “transformative” and how can the EPA ensure that examples will be applicable across broad geographies and water qualities?

Metrics, Tools Improvement, and Expansion: Three examples were provided as simple bullet points, risk assessment (Log reduction targets for non-potable water reuse), life cycle assessment (water scarcity index), and energy (loop and recycling pathway). The BOSC committee commended US EPA for proposing to develop LRV’s for non-potable reuse, but strongly advocated that US EPA also consider developing LRV’s for potable water reuse. While the National Water Research Institute (NWRI) has proposed LRV’s for potable water reuse, there are not federal standards and there is controversy regarding the appropriateness of the LRV’s developed by an NWRI panel. As best the BOSC committee understands, the NWRI panel was not vetted through a rigorous process such as that used by the EPA under FACA.

Recommendation: We recommend that EPA consider an evaluation of the LRV’s used and particularly investigates the assumptions of pathogen occurrence in raw sewage, since the NWRI LRVs are based upon a very limited amount of data on pathogen occurrence in raw sewage. The US EPA is developing various pathogen identification and quantification techniques, the BOSC committee recommends these be applied to raw sewage to better understand the types and quantities of pathogens occurring in order to make better decisions on LRVs for potable water reuse.

Those values may also be informative for non-potable reuse. Insufficient information was provided to the BOSC on the water scarcity index and energy topics to enable the committee to provide meaningful comment on those aspects.

System Analyses Comparing Conventional and Transformative Community Water Systems and Applications in Community-Based Case Studies: This project focuses on comparison of centralized (Cincinnati, OH) to de-centralized (San Francisco, CA) and a small-scale community system (Bath, NY). The committee notes that working with San Francisco on alternative scenarios is a good example of partnership with a municipality. The evaluation of centralized and decentralized systems is an excellent topic that could be transformative. The EPA is encouraged to expand this work to consider other geographies and water qualities in the future. The resource recovery small system project also has great promise and is generally understudied.

Recommendation: The BOSC committee recommends that EPA to continue, and potentially expand, research efforts in this area.

Task 3B: Novel Detection Tools for Systems Applications

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: This project brings together a diversity of stakeholders to discuss adverse outcome pathways (AOPs) along with biosensor technologies. The BOSC committee believes that use of bioassays/biosensors to rapidly screen chemical mixtures in water for AOP toxicity is of great importance. This is especially true in potable water reuse where the “source” water is known to contain highly complex and unpredictable mixtures of chemicals and subsequent water treatment techniques also can form potentially hazardous transformation products (aka by-products). The BOSC believes that this type of work is critical for the advancement of potable water reuse and for more comprehensive monitoring of conventional water resources. Partnerships from USGS, WEF, US Army, NOAA, and Cincinnati Water Works is encouraging. However, EPA would also benefit by establishing additional partnerships with NIH/NIEHS, Academic Institutions, and possible commercial entities who already produce technologies that are implementable.

Recommendation: The BOSC committee recommends that EPA also should consider non-in situ bioassay screening tools which could provide relatively fast information but without the necessity/complexity of being on-line or field deployable. While field deployable and on-line offer even faster resolution, it is likely not a necessity for most water resource screening scenarios, thus we recommend that EPA not exclude off-line rapid high-throughput bioassays in this evaluation.

Design and Development of an AOP Targeting Biosensor: This task follows on to the previous knowledgebase and develops novel sensor systems. The BOSC committee comments to this task are generally the same as provided to the first (above).

Recommendation: In general, the BOSC committee recommends that EPA should equally consider non-deployable technologies and consider additional partnering institutions.

Task 1C (assumed 3C): Case Studies & Demonstrations of Transformative Approaches for Water Systems & Water Reuse

Demonstration and Evaluation of Decentralized Wastewater Treatment for Water Reuse: This task includes the demonstration of an AnMBR in collaboration with the Department of Defense (DoD). A trailer-mounted AnMBR pilot was installed at Fort Riley, Kansas, in June 2016. The BOSC committee believes these types of partnerships are important to leverage resources and to provide additional data for larger dissemination within the water community. The long-term goal to show performance data from the pilot is reasonable. The short-term goal for “sewer mining using different treatment technologies and different scales and population densities” is not clear. This short-term goal is admirable, but it is not clear how the EPA research program is addressing this goal as a FY16 product. More details would be required for the BOSC to provide additional feedback on the short-term goal.

Development of Improved Guidance for Non-Potable Water Reuse: The BOSC committee has discussed this topic previously above.

Recommendation: The BOSC committee believes that working with NWRI can provide additional benefit; however, we recommend the EPA consider developing independent guidance with their own experts and independent experts retained under FACA rules.

The BOSC further believes that both potable and non-potable LRT’s from EPA would provide large benefit to US agencies that are seeking to reuse water. The BOSC committee believes that development and validation of more appropriate pathogen surrogates is of high-value to US water systems. These data extend beyond potable and non-potable reuse and should be considered for conventional drinking water systems in the USA, especially in consideration of those utilities drawing source waters from wastewater impacted sources.

Recommendation: The BOSC recommends the EPA to consider further investigation of molecular (i.e., PCR) methods to infectivity and culturable techniques.

The use of molecular techniques alone could lead to erroneous decision making since non-viable organisms are still detectable.

Case Studies and Demonstrations of Transformative Approaches for Water Systems and Water Reuse (note - listed as a second “2” in PowerPoint provided): This objective includes low-impact development (LID) and best management practices (BMPs) for capturing rain and storm water for aquifer recharge in the arid southwest USA. Within this objective, the EPA has provided an example of an aquifer recharge technology demonstration at Fort Irwin, California. The BOSC committee believes, as stated previously, that these types of partnerships with DoD entities are likely to yield synergistic value. However, the BOSC is uncertain of the type of technologies to be considered.

Task 3D: Water Technology Innovation Clusters

Leveraging technology clusters to solve water challenges and create economic opportunity: Several example technologies and benefits were described. The Cincinnati Water Cluster was shown as an example of broad partnerships between the US EPA, local and state government agencies, academia, and the private sector. The BOSC committee sees great value in the cluster coordination and within the project examples provided.

Recommendation: The BOSC committee recommends increased transparency as to how, specifically, interested parties can cooperate in technology testing by the US EPA and how conflicts of interest can be avoided in such circumstances (i.e., when multiple companies produce the same type of equipment – how does EPA select a partner to go forward).

Two objectives were listed, but they seem intertwined and indistinguishable by the BOSC committee.

Task 3E: Approaches to Assess the Overall Health of a Community

The role of waterborne and environmental pathogens as a trigger for Type 1 Diabetes: This project sounds transformative towards better understanding of diabetes. The BOSC committee recommends the EPA consider collaboration with CDC and NIEHS for this project.

Characterizing Waterborne Disease through Outbreak Surveillance: This project seems to be of very high value and the BOSC committee looks forward to the anticipated publication. The BOSC committee is particularly intrigued by the figure suggestion chemical association to outbreaks, it is unclear if this is about chemical contamination or chemicals associated with disinfection.

Waterborne Disease Associated with Distribution System Deficiencies: This is yet another project that seems to be of great value; however, only sparse details were provided. Water pressure is well known to be of great importance to the protection of public health from drinking water exposures. Further linking of water contamination from low-pressure events is of value.

Task 3F: Human & Ecological Health Impacts Associated with Water Reuse & Conservation Practices

STAR Grants: Five STAR grants were awarded and the titles provided to the BOSC Committee. The committee believes these topics are of value towards moving forward on water reuse topics; however, the link to water conservation and ecological health impacts are not clear. The committee notes that the explanation of how STAR grants interface with ORD needs was improved and additional information regarding these projects will be of great interest to the BOSC committee going forward. However, the links to ecosystem health and conservation are not clear. The EPA is highly recommended to increase the STAR grant program resources going forward as the program provides clear synergy with leading research groups within the USA.

Additional Comments:

The BOSC Committee greatly appreciated the opportunity to meet with US EPA staff to learn more about transformative research endeavors. The BOSC Committee expressed concern that very little, if any, information was provided relative to ecological receptors. Specifically, how does the work at Mid-Continent Ecology Division Laboratory (Duluth), and others, tie into the transformative research programs of ORD? In terms of water reuse, most of the research to date indicates potential impacts to aquatic organisms from wastewater discharges, while impacts to human health (from chemicals) seems far less likely.

Recommendation: The BOSC committee recommends that EPA provide more information as to how ecological impacts are being considered by the ORD within the transformative research framework.