NATIONAL WATER RESEARCH INSTITUTE

May 5, 2022

Paul Rochelle, PhD
Source Water Microbiology Team Manager
Metropolitan Water District of Southern California

Subject: Advanced Purification Center Demonstration Project
NWRI Independent Science Advisory Panel Workshop 5 Report

Dear Dr. Rochelle:

The National Water Research Institute (NWRI) is pleased to present this technical letter report on the findings and recommendations from Workshop No. 5 of the Independent Science Advisory Panel (Panel) for the Regional Recycled Water Program (RRWP), Advanced Purification Center Demonstration Project (Project). The full Panel met on January 5 and 6, 2022, via videoconference. Ed Means, principal of Means Consulting and a contractually required NWRI subcontractor, facilitated the meeting. The following Panel members attended Workshop 5:

- Panel Chair: Charles Haas, PhD, BCEEM, Drexel University
- Paul Anderson, PhD, Independent Consultant
- Joseph A. Cotruvo, PhD, BCES, Joseph Cotruvo and Associates
- Thomas E. Harder, PG, CHG, Thomas Harder and Co.
- Nancy Love, PhD, PE, BCEE, University of Michigan
- Adam Olivieri, DrPH, PE, EOA, Inc.
- Vernon Snoeyink, PhD, University of Illinois
- Paul K. Westerhoff, PhD, PE, BCEE, Arizona State University

Meeting Objectives

The Metropolitan Water District Project Team established three objectives for Workshop 5:

1. The Panel will review the tertiary membrane bioreactor (MBR) testing results (baseline and challenge phase), with emphasis on pathogen removal credit through MBR and the suitability of treated water quality for groundwater recharge.
2. The Panel will review and provide input on the (a) bench- and pilot-scale results of nitrification and denitrification (NDN) testing for treating primary effluent to help inform secondary MBR testing, and (b) elements of the secondary MBR testing and monitoring plan.
3. The Panel will meet in a closed working session to begin drafting a consensus recommendation report.

Questions Presented to the Panel

The Project Team presented the following questions for the Panel's consideration in Workshop 5. This letter report addresses each of the questions.

1. Is the information presented on the tertiary MBR testing results adequate to:
    a. Support regulatory application for more than 2.5 log removal credit for MBR?
    b. Demonstrate the product water will be suitable for groundwater recharge in the proposed groundwater basins?
    c. Characterize the impact of the reverse osmosis (RO) concentrate stream for ocean discharge, and residual streams on Joint Water Pollution Control Plant (JWPCP) operations?
    d. Adequately address source control for meeting project objectives?
2. Based on the tertiary MBR testing results and secondary NDN evaluation, or new information acquired since the last workshop, are there important additional factors that the Project Team should consider in evaluating secondary MBR for potable reuse applications?

General Comments

The Panel commends the Metropolitan Water District Project Team on the level of research effort, the quality of the results, and the straightforward presentation of the materials for Workshop 5.

The Panel recognizes Metropolitan's substantial effort to move the Project forward since Workshop 4 on December 9, 2020. Following Workshop 4, the Panel was unable to give a consensus opinion on the desirability of secondary versus tertiary MBR alternatives. Workshop 5 represents the Project Team's updated work; the Panel is generally satisfied with the information provided.

Panel Response to Questions

In this section, the Panel offers their opinions and recommendations in response to questions from the Project Team.

1a. Is the information presented on the tertiary MBR testing results adequate to support regulatory application for more than 2.5 log removal credit for MBR?

Response. The Panel is impressed with the microbial analytical results and level of effort undertaken to generate this information. It is a remarkable contribution to the advancement of using recycled water in the United States. The Panel believes the data support a minimum of 3.0 log removal credit for tertiary MBR for *Giardia* and *Cryptosporidium* based on the Demonstration Project operating conditions. The Panel will require additional analysis to support LRVs beyond 3.0 as described further below.

The Panel understands the binning approach used in the LRV analysis. There are alternative approaches that can be explored that make fuller use of the information in this very large dataset, which may have the potential for validating greater LRVs. The Panel requests a copy of the protozoan and turbidity data spreadsheet.

The Panel is interested in working with the Metropolitan Project Team to look at other analytical approaches contingent on authorization and funding by Metropolitan Water District.

The Panel recommends that Metropolitan:

- Keep the monitoring approach for compliance with LRV requirements as simple as possible. The Panel suggests further statistical analysis of the MBR data for the proposed LRV/turbidity binning approach. In addition, the Panel suggests that Metropolitan investigate a simpler compliance monitoring approach. The Panel believes that additional data analysis might lead to more monitoring approaches. At this time, the Panel does not have enough information to suggest appropriate modifications to the monitoring approach, such as changes in turbidity, pressure decay tests (PDTs), or pathogen monitoring.

  However, NWRI Panel members can work with the Metropolitan Project Team to analyze data and determine what, if any, modifications to the binning and monitoring approaches are appropriate. Please note that the NWRI DPR Criteria Panel advising the State Water Board Division of Drinking Water suggested a simpler compliance approach in its February 28, 2022, presentation; this information may be useful to consider for an MBR approach for the entire advanced water treatment (AWT) facility.

1b. Is the information presented on the tertiary MBR testing results adequate to demonstrate the product water will be suitable for groundwater recharge in the proposed groundwater basins?

Response. The treatment plant can produce water that is suitable for recharge.

The Panel recommends that Metropolitan:

- Verify that boron concentrations can be reduced at demonstration scale. It is likely that boron concentrations in the RO product water can be reduced sufficiently with pH adjustment to a portion of the first-pass product water followed by RO and blending with first-pass water to meet Main San Gabriel Basin objectives through the use of partial second-pass RO.

- Provide the pending report on basin assimilative capacity for boron to the Panel. The Panel supports the concept of basin assimilative capacity to address boron

concentrations in the product water delivered and recharged in the Main San Gabriel Basin.

- Try to assess the useful life of the oilfields that contribute boron to the Joint Water Pollution Control Plant (JWPCP). The Panel supports continued efforts to manage sources of boron in the feed water to the treatment plant. Perhaps these fields will reduce production over time and will become less meaningful contributors to boron concentrations. The oil producers may be able to provide information on their projections for future production, which could help clarify concerns about meeting boron targets through removal or blending. Please note the link below to a recent Los Angeles Times article citing the phasing out of some regional oil field production in the near to mid-term: https://www.cnbc.com/2022/01/26/los-angeles-bans-new-oil-and-gas-wells-will-phase-out-old-ones.html
- Assess potential interactions between basin water, aquifer media, and recharge water. This process can begin with a review of available literature on introducing recycled water into groundwater basins and managing any effects on basin geochemistry.
- Provide the Panel with any studies/analyses that are underway to support the upcoming environmental documentation.
- The Panel noted that the proposed California Public Health Goals (PHGs) for PFOA and PFOS of 0.007 ppt and 1 ppt, respectively, effectively drive unnecessary and expensive treatment. By comparison, the EPA's Health Advisory for PFOA and PFOS is 70 ppt, although they are likely to lower it. Standards should reflect significant health-based target risks for important contaminants. Also, while future MCLs for these compounds will not likely be as low as the PHGs, the analytical reporting limits may need to be adjusted to reflect new limits (Slide 149 PFOA/PFOS).
- The Panel noted that the PFAS-TOPA (total oxidizable precursor assay) test is adequate, but adsorbable organic fluorine (AOF) is emerging as an important measurement (https://www.epa.gov/system/files/documents/2021-09/cq1_br1_shoemaker.pdf).

1c. Is the information presented on the tertiary MBR testing results adequate to characterize the impact of the reverse osmosis (RO) concentrate stream for ocean discharge, and residual streams on Joint Water Pollution Control Plant (JWPCP) operations?

Response. The RO concentrate toxicity levels appear low. The Panel noted that the proposed 1/166 dilution ratio is more conservative than necessary, since 1 percent seems to be adequate from the tests.

The Panel recommends that Metropolitan:

- Explore the single kelp toxicity finding further. The Project Team should identify what actions would be taken to manage a potential full-scale toxicity finding. The Project Team should also consider permit discussions with regulators regarding allowing some level of retesting if an outlier finding occurs. The Panel would like to review any additional information on the kelp study.
- Consider how higher CEC concentrations in the discharge might be perceived and addressed in the environmental documentation. The Panel understands that the contaminants of emerging concern (CEC) loading in the outfall will remain unchanged, although there will be changes in CEC concentration.
- Review literature on scaling inhibitors and apply that knowledge to the outfall; it appears to be a manageable issue. Chemical equilibrium model calculations should show whether the secondary effluent-RO concentrate is supersaturated with minerals of concern after mixing, and the experience of other AWT systems should give information on the life of inhibitors in RO concentrate.
- Review experience at other RO plants to determine if scaling is a problem in similar concentrates. The tests that showed no increase in turbidity or suspended solids in a sample that was allowed to stand for some time was not convincing because scaling can occur without either of these parameters increasing. Also, using a chemical equilibrium model to show the degree of supersaturation with solids that might scale after the RO concentrate is diluted with secondary effluent can provide

useful information as to whether or not a problem might exist. If scaling is likely, it might be necessary to add more scale inhibitor.

- The Panel noted that, given the low concentration of pathogens in the RO concentrate, it does not appear that disinfection of the concentrate before discharge to the outfall is necessary.
- The Panel would like to understand and review the plan for continued toxicity testing over the next 6 to 18 months of AWT operations.
- The Panel noted that the current draft of the final tertiary MBR testing report provides median, maximum, and diluted concentrations of many CECs in both the JWPCP secondary effluent and the RO concentrate. However, the Panel did not see interpretation of those results in the report. The Panel recommends interpreting these results in the final report to give readers some perspective on the environmental relevance of the CEC monitoring data.

1d. Is the information presented on the tertiary MBR testing results adequate to address source control for meeting project objectives?

Response. Yes.

The Panel recommends that Metropolitan:

- Establish a standard operating procedure to guide the collaborative assessment and response to unanticipated discharges that impact plant operations.
- Continue outreach through the advisory board.

2. Based on the tertiary MBR testing results and secondary NDN evaluation, or new information acquired since the last workshop, are there important additional factors that the project team should consider in evaluating secondary MBR for potable reuse applications?

- The Panel is satisfied with the data and the proposed approach; the proposed approach is logical, and the model results match the data.

- Carefully consider the operational/coordination requirements of tertiary and secondary MBR and where an institutional line is drawn. Since MBR is a critical part of LRV compliance, the AWT operations team should have, at minimum, high visibility of MBR performance information. Notwithstanding physical site constraints, MBR should ideally be under the operational control of the entity that has permit responsibility for drinking water compliance.
- The Panel acknowledges the high level of collaboration between Metropolitan and the Los Angeles County Sanitation Districts. The Project Team should ultimately establish a standard operating procedure to guide the collaborative assessment and response to unanticipated discharges that impact plant operations to ensure timely resolution of issues.
- The Panel believes the use of chlorine in the AOP is appropriate, minimizes the use of other chemicals, and somewhat reduces costs and handling issues.

Additional Panel Comments

- The Panel is comfortable reducing pressure decay testing (PDT) frequency. The Project Team should propose an alternative frequency.
- The Project Team should consider making a formal request to the State to update several key Public Health Goals (PHGs) that can affect reuse treatment process decisions. Several PHGs are far out of date and much lower than necessary to protect public health (examples are bulleted below). Mode of Action results conclude that these should be assessed using safety factors rather than the unvalidated hypothetical linear risk models.

  This issue was raised in the last report, but the technologists responded it was outside of their scope. It is something that Metropolitan and water providers can/should initiate and could help avoid some unnecessary limitations and expenditures. Considering an initiative to the Office of Environmental Health Hazard Assessment (OEEHA) from a broader segment of conventional and recycled water producers would be desirable.

  Examples of PHGs that could be updated are:

- 1,4-Dioxane has been reexamined in detail in the latest Canadian Drinking Water guideline. It is not a genotoxic carcinogen at drinking water levels, and the official Canada guideline is now 50 ppb.
- The human health-based value for boron (borate) should be updated from 0.5 ppm.
- Bromate is about to be reported to be non-genotoxic in drinking water for all of the animal tumors from the old National Toxicology Program (NTP) study. A Water Research Foundation (WRF) report has been released and a peer-reviewed publication is in the works.
- Chromium VI has been shown to be a non-genotoxic carcinogen in drinking water. Protective health-based value is at least 50 ppb. California has proposed an MCL of 10 ppb that was remanded due to inadequate consideration of small-system impacts.
- The Project Team should have a plan to address how changing regulations in California or by the EPA may influence key design and operating decisions. OEHHA is treating trihalomethanes (THMs) as genotoxic carcinogens with PHGs below 1 ppb, whereas the World Health Organization (WHO) and EPA do not treat them as such. These should be handled similarly.

- The Panel would like to see an analysis of the advantages and disadvantages of the proposed MBR approach. It would be instructive to see the capital and operations and maintenance (O&M) cost projections for the proposed 45 to 50 MBRs compared to a tertiary treatment plant. The Panel would also like a comparison of water quality and maximum LRVs that could be obtained from a tertiary plant or an Orange County-type treatment train with secondary treatment followed by microfiltration.
- The Panel believes it is likely that secondary MBR performance results will be less satisfactory than the tertiary results since the input will be a much lower quality water. The decision logic for selection should be developed in advance, including an evaluation of the minimum performance requirements to make secondary MBR a viable

choice. Potential LRVs associated with the secondary treatment process should also be considered as part of the evaluation of secondary versus tertiary MBR approaches.

- The Project Team should develop an understanding of likely DPR requirements that might provide some basis for current treatment and operating decisions if DPR becomes an option.

Conclusion

The Panel looks forward to Workshop 6. If you have any questions or concerns, contact Suzanne Sharkey, Project Manager, at ssharkey@nwri-usa.org.

Sincerely,

Dr. Charles Haas
Panel Chair

Attachment 1 • About NWRI

The National Water Research Institute is a 501c3 nonprofit organization and Joint Powers Authority, founded in 1991 by a group of California water agencies in partnership with the Joan Irvine Smith and Athalie R. Clarke Foundation to promote the protection, maintenance, and restoration of water supplies and to protect public health and improve the environment. NWRI's member agencies include Inland Empire Utilities Agency, Irvine Ranch Water District, Los Angeles Department of Water and Power, Orange County Sanitation District, and Orange County Water District.

Disclaimer

This report was prepared by an Independent Expert Advisory Panel (Panel), which is administered by National Water Research Institute. Any opinions, findings, conclusions, or recommendations expressed in this report were prepared by the Panel. This report was published for informational purposes.

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Attachment 2 • Panel Member Biographies

Chair: Charles N. Haas, PhD, BCEEM

Professor of Environmental Engineering and Head, Department of Civil, Architectural, and Environmental Engineering, Drexel University

Dr. Charles Haas has more than 45 years of experience conducting research in water treatment, risk assessment, environmental modeling and statistics, microbiology, and environmental health. He has led the Department of Civil, Architectural, and Environmental Engineering at Drexel University since 1991, and previously served on the faculties of Rensselaer Polytechnic Institute and Illinois Institute of Technology. Haas holds a BS in Biology and an MS in Environmental Engineering from Illinois Institute of Technology, and a PhD in Environmental and Civil Engineering from University of Illinois.

Paul A. Anderson, PhD

Independent Consultant

Dr. Paul Anderson has more than 30 years of experience in human health and ecological risk assessment. He has been involved in evaluating the potential effects of pharmaceuticals in the environment as well as constituents of emerging concern. His work has also included investigation and assessment of PAHs and metals in sediments and he has done significant work on the assessment of human health and ecological risks posed by dioxins/furans. Anderson holds a BA in biology from Boston University and an MA and PhD in biology from Harvard University.

Joseph A. Cotruvo, PhD, BCES

President, Joseph Cotruvo and Associates, LLC

Dr. Joe Cotruvo is president of Joseph Cotruvo & Associates, an environmental and public health consulting firm in Washington, DC, and a Research Professor in the Departments of Chemistry and Biochemistry, and Environmental Sciences at the University of Toledo. Previously, he was director of the Drinking Water Standards Division of the EPA Office of Drinking Water. He has a BS in Chemistry from the University of Toledo and a PhD in Physical Organic Chemistry from the Ohio State University. He is board certified by the

American Academy of Environmental Engineers and Scientists and received the AAEES Science Award for 2019.

Thomas E. Harder, PG, CHG

Principal Hydrogeologist, Thomas Harder & Co.

Mr. Thomas Harder has more than 22 years of professional groundwater consulting experience. He has provided technical direction and management for large water resource projects in southern California, including the Chino Desalter Well Field Design and Construction, the West Coast Basin Barrier Project, and the Mojave Water Agency's Regional Recharge and Recovery Project. His expertise includes regional groundwater basin analysis, perennial (safe) yield, artificial recharge, groundwater management and models, contaminant hydrogeology, and wells. Harder has a BS in Geology from California Polytechnic University, Pomona, and an MS in Geology with emphasis in Hydrogeology from California State University, Los Angeles. He is a registered geologist and hydrogeologist in California.

Nancy G. Love, PhD, PE, BCEE

Borchardt and Glysson Collegiate Professor, University of Michigan

Dr. Nancy Love is the Borchardt and Glysson Collegiate Professor in the Department of Civil and Environmental Engineering at the University of Michigan. There, she directs the Love Research Group, which works at the interface of water, infrastructure, and public health in both domestic and global settings. They focus on assessing and advancing public and environmental health using chemical, biological, and analytical approaches applied to water systems using both physical experiments and computational models. Dr. Love received her BS and MS at the University of Illinois, Urbana, and her PhD is from Clemson University. She has also been recognized for her scholarship and leadership with the Water Environment Foundation, the Water Research Foundation, and the National Science Foundation. She is a licensed professional engineer in Michigan.

Adam Olivieri, DrPH, PE

Principal/Founder, EOA, Inc.

Dr. Adam Olivier has more than 35 years of experience in the technical and regulatory aspects of water recycling, groundwater contamination by hazardous materials, water

quality and public health risk assessments, water quality planning, wastewater facility planning, urban runoff management, and on-site waste treatment systems. Dr. Olivieri is currently Vice President of EOA, Inc., in Oakland, California, where he manages a variety of projects, including serving as Santa Clara County Urban Runoff Program's Manager since 1998. He received a BS in Civil Engineering from University of Connecticut, an MS in Civil and Sanitary Engineering from University of Connecticut, and both an MPH and DrPH in Environmental Health Sciences from University of California, Berkeley. He is a registered professional engineer in California.

Vernon Snoeyink, PhD

Professor Emeritus, Civil and Environmental Engineering, University of Illinois

Dr. Vernon Snoeyink's research has focused on drinking water quality control, including removal of organic and inorganic contaminants from water using adsorption systems, especially granular and powdered activated carbon systems coupled with membrane systems. His expertise includes mechanisms of formation and means to control water quality in distribution systems in response to reactions of iron, aluminum, and other inorganics. He has also been recognized for excellence in teaching and advising. He holds a BS in Civil Engineering, an MS in Sanitary Engineering, and PhD in Water Resources Engineering from University of Michigan.

Paul K. Westerhoff, PhD, PE, BCEE

Professor, Sustainable Engineering/Built Environment, Arizona State University

Dr. Paul Westerhoff's research focuses on emerging contaminants, water treatment processes, and water quality, including occurrence, characterization, and oxidation of natural organic matter; removal of oxo-anions from drinking water; algal metabolites and algal biotechnology; wastewater reuse; and nanotechnology and sensors. Westerhoff holds a BS in Civil Engineering from Lehigh University, an MS in Civil and Environmental Engineering from University of Massachusetts, Amherst, and a PhD in Civil, Architectural, and Environmental Engineering from University of Colorado at Boulder. He is a registered professional engineer in Arizona.