NDWAC MDBP Rule Revisions Working Group

National Drinking Water Advisory Council (NDWAC)

December 13, 2022 Meeting 5 Summary

Meeting Summary

Background on the MDBP Working Group

The United States Environmental Protection Agency (EPA) has sought public input and information to inform potential regulatory revisions of eight National Primary Drinking Water Regulations (NPDWRs) included in five Microbial and Disinfection Byproducts (MDBP) rules following the third Six-Year Review. EPA hosted an initial virtual public meeting in October 2020 to solicit input on further improving public health protection from MDBPs in drinking water. Throughout 2021, EPA sought input relevant to potential rule revisions through additional public meetings focusing on topics identified through public comments and information.

EPA has now charged the National Drinking Water Advisory Council (NDWAC or Council), a Federal Advisory Committee (FAC) established under the Safe Drinking Water Act (SDWA) of 1974 to provide the agency with advice and recommendations on potential revisions to the MDBP Rules. In addition, to support the work of the Council, EPA asked the NDWAC to form a working group to explore specific issues and identify potential MDBP rule revision options for the Council to consider in making recommendations to EPA. More information on the NDWAC MDBP Rule Revisions Working Group meeting schedules and other information are available at: https://www.epa.gov/ndwac/national-drinking-water-advisory-council-ndwac-microbial-and-disinfection-byproducts-mdbp. EPA is currently providing the public with an opportunity to send written input to EPA via the public docket at www.regulations.gov, Docket ID: EPA-HQ-OW-2020-0486.

Meeting summaries and background documents on each meeting topic are available in the MDBP Rule Revisions public docket at www.regulations.gov, Docket ID: EPA-HQ-OW-2020-0486. More information on the potential rule revisions is available at: https://www.epa.gov/dwsixyearreview/potential-revisions-microbial-and-disinfection-byproducts-rules.

Meeting Purpose

The fifth Working Group (WG) meeting was held to continue problem characterization discussions on opportunistic pathogens, disinfectant residuals, disinfectant byproducts, as well as risk-balancing/interdependencies and begin focused discussion on problems relevant to disadvantaged communities.

This document provides a summary of presentations and discussions from the meeting on December 13, 2022. Reference articles were shared with the WG ahead of the meeting, with the presentation shared on the day of Meeting #5. In addition to WG members, approximately 130 observers attended the meeting.

Segment 1

Agenda Review and Meeting Procedures

Elizabeth Corr, MDBP Rule Revisions Working Group Designated Federal Officer, Office of Ground Water and Drinking Water (OGWDW), Office of Water, EPA

Ms. Corr welcomed all to the fifth meeting.

Eric Burneson, Director, Standards and Risk Management Division, OGWDW, Office of Water, EPA.

Mr. Burneson stated his appreciation for all of the work done to date on problem characterization related Microbial and Disinfection Byproduct Rules Revisions Working Group. Mr. Burneson explained that environmental justice is the fair treatment and meaningful involvement of all people, regardless of race or color, national origin or income, with respect to development and implementation and enforcement of environmental laws, regulations, and policies. Environmental justice is an important priority for the EPA Administrator, Michael Regan, and an important priority for this administration and EPA appreciates the opportunity presented in this meeting to bring experts together to discuss these issues in the MDBP context.

Lisa Daniels and Andy Kricun, NDWAC MDBP Rules Revision Working Group Co-chairs.

Mr. Kricun welcomed all to the fifth meeting. Ms. Daniels shared thanks to all who are offering their expertise and time throughout the process. Thanks was extended to EPA, as well as to Ross Strategic. Ms. Daniels noted an essential need to devise recommendations on points relating to environmental justice, and that results and benefits should be made equally available to all people.

Robert Greenwood, Principal, Ross Strategic

Mr. Greenwood reviewed controls for the Zoom platform and provided an overview of the agenda. He noted that WG members are providing their unique points of view and are not representing those from affiliated organizations. Mr. Greenwood noted how WG members have stressed the importance of creating a strong foundation of problem characterization and common understanding before moving to interventions.

See Appendix 1 for a roster of Working Group members and an indication of those in attendance.

Segment 2

Follow-up on Problem Characterization Discussions on Opportunistic Pathogens and Disinfectant Residuals; Follow-up on Problem Characterization Discussion on Disinfectants/Disinfection Byproducts

Ken Rotert, OGWDW, EPA thanked the WG, analysts, and all virtual participants for attending and providing their time and supporting answers. Mr. Rotert presented slides with questions from WG members raised during prior meetings, whose answers were provided by the following technical analysts: Nancy Love (University of Michigan), Andrew Jacque (Water Quality Investigations), Zaid Chowdhury (Garver), Susan Teefy (East Bay Municipal Utility District), and Chris Owen (Hazen and Sawyer).

'What are problems related to CT values?': Mr. Rotert noted that CT values were developed as an indicator of disinfection efficacy. These were products of disinfectant concentration and contact times which were derived from various studies. One problem highlighted by technical analysts is the built-in safety factor which some in the industry feel is too large. Another issue stems from CT values only going up to a pH of nine. Analysts noted that some systems operate with their pH at a higher level than nine. In those cases, there may be no credit awarded for systems operating at those higher levels (unless states allow). In addition, technical analysts pointed out how current regulations do not necessarily account for new or modernized measurement methods of residuals. This raised questions on how compliance should be calculated and whether compliance is open to interpretations in different monitoring scenarios.

'What problems are related to Public Notification?': An issue pointed out by WG members is public notification. Some feedback indicated that public notification requirements may not consider modern communication mechanisms, and this may lengthen time for notifications to reach the public.

'What unintended consequences are associated with source water contamination?': Mr. Rotert noted how wastewater discharges can affect water quality going through treatment processes. Some contaminants that have found their way into the drinking water include DBP precursors, nitrosamines, pharmaceuticals, and PFAS. It was shared by a technical analyst that sucralose has been identified as reliable marker for wastewater discharges. It has been used in some studies and other applications for identifying potential wastewater contamination. Further mentioned was how wildfires in watersheds can affect water quality, resulting in organic material serving as DBP precursors. Mr. Rotert noted that nitrogenated precursors include nitrate, natural nitrogen sources, runoff, and wastewater.

'What water quality considerations are relevant for hydraulics?': Technical analysts noted several consequences of high water age and water quality, such as DBP formation and disinfectant decay. In addition, mixing waters can affect solubility of some constituents, and is one factor that can lead to decay of disinfectants. A suggestion was made to assess waters prior to mixing them. Emphasis was placed on transient hydraulics, which can dislodge biofilms and scales, thereby releasing embedded contaminants downstream. In addition, high water age can support growth of opportunistic pathogens and change the microbial ecology within drinking water systems. At least one technical analyst suggested that additional research may be needed in this area. With regards to depressurization, analysts noted how backflow contamination can introduce a wide range of contaminants into the public water supply's distribution system. The analysts mentioned that water shutdown following a contamination event may not be feasible because water is still needed for other purposes beyond ingestion such as toilet flushing, firefighting, etc. Therefore, the risk of shutting off water entirely due to contamination could exacerbate and create other issues entirely.

'What are problems associated with nitrification?': There were several problems with nitrification highlighted by Technical Analysts. Nitrification can vary by source waters, types of treatment provided, TOC concentrations, ammonia concentrations, levels of nitrogenous compounds, and by some system conditions such as custom configurations of source water collection and treatment methods. One specific item noted was the rapid loss of residuals, as this has been described as being a prominent indicator of nitrification. A pH drop can result as well, leading to 'red water' issues and/or accelerated corrosion. There is also proliferation of heterotrophic bacteria, or ammonia oxidizers, which nitrify bacteria leading to increases in nitrate and nitrite in distribution systems.

Biofilms associated with nitrification can be looked to as 'nitrosamine precursors' on addition of monochloramine. Technical Analysts noted nitrification predominantly occurs in water storage tanks and can be carried over into plumbing, as well as distribution systems. Beyond this, nitrification is also noted as increasingly common in chloraminated systems with excess ammonia, or where there are elevated proteins in the drinking water. A related issue is where compliance monitoring may miss elevated levels of nitrate and nitrite, especially because nitrate sampling and testing efforts are carried out prior to water entering distribution systems.

A technical analyst provided an illustration noting how chloramine additions under certain circumstances can lead to the propagation of nitrification. It can also lead to the formation of nitrate and nitrite in distribution systems, particularly when bacteria are nitrifiers (and there is organic nitrogen and iron already in the system).

Presentation

Dr. Joan Rose from Michigan State University was welcomed, presenting on a National Academies of Science report on *Management of Legionella in Water Systems*. Dr. Rose serves as Director of the Global Water Pathogens Project, is an international expert in water microbiology, water quality and public health publishing, and is also a member of the National Academy of Engineering.

Dr. Rose provided an overview of key findings and recommendations from the National Academies report, discussed work on the occurrence and growth of bacteria, and provided insight on implications for the water industry. The committee working on the National Academies report reflected expertise from public health to engineering, as well as hospitals and distribution systems. A statement of tasks was divided into those areas and asked: What do we know about the ecology, diagnosis, and transmission via water systems? How do we quantify that? How do we look at prevention and control and then policy and training issues?

Dr. Rose outlined how Chapter 1 described the knowledge and history of waterborne diseases and outbreaks. Chapter 2 focused on diagnosis from the clinical side and also assessment of ecology and exposure pathways (expanding on the *Legionella* genus with 61 known species with focus being *Legionella pneumophila*). It was pointed out how bacteria go through various forms from transmissive, replicative, and mature forms. Understanding this meant the scientific community understood how *Legionella* survives within amoeba. However, significant research is still needed to understand the various forms of *Legionella*, their virulence, and roles while freely living within amoeba. This turns attention to biofilms, where bacteria are protected from environmental forces, as well as by association with amoeba.

Dr. Rose moved to Chapter 3, where quantification of *Legionella* and Legionnaires' disease were discussed. Traditional measures were used for diagnosis, outbreak investigations, routine monitoring, mitigation, assessment, and research. At that time, emerging molecular tools began to provide new specificity and quantification methods. Culture methods may underestimate presence and generally present difficulty when attempting to derive speciation and isolate variants. She also pointed out the detections using molecular methods are not always viable. A statistical demarcation of 10^4 organisms per Liter was also highlighted as a concentration observed during outbreaks.

Dr. Rose noted that environmental justice was also raised as an issue for incidence of Legionnaires' disease. Data monitoring and collection measures may neglect known areas and at-risk and/or disadvantaged communities. Monitoring funded by various research and national monitoring strategies may miss those communities and therefore data gaps can exist in older parts of certain regions, and towns.

Chapter 4's overview noted strategies and characterization of problem issues with *Legionella*, with focus on temperature, indoor plumbing, hydraulics, disinfection, and engineered systems. Chapter 5 covered regulation guidelines and controls. She suggested that the Surface Water Treatment Rule provides no specific control for *Legionella*. A data collection such as an Information Collection Rule could be used to look at *Legionella* occurrence such as was done for *Cryptosporidium*. Dr. Rose then moved into the report's overviews and recommendations. Focus on risk assessments were emphasized and the adaptation of frameworks for chemicals for protection against microbes. Dr. Rose discussed Quantitative Microbial Risk Assessment (QMRA) noting a better understanding of species-level risks may be needed. She suggested a 'reverse-QMRA' approach could be used to estimate risks, starting with a target risk level and calculating a critical concentration. Exposure assessments used monitoring data which fed into modeling to estimate the probabilities of infection and illness. However, questions remained such as: What is the understanding of hazards associated with the different species and the forms? Do we understand different outcomes like Pontiac fever? How common is that compared to full blown Legionnaires' disease following exposure through cooling towers, fountains, hot tubs, and showers? How to factor sensitive populations into the risk estimates? How does amoeba association factor into risk estimates? What forms of bacteria are being aerosolized? How do they survive and what is their persistence? How do they regrow in these areas? These questions were incorporated into exposure assessments. She mentioned that the only dose-response information on *Legionella* was published in 1983. When looking at those assessments in terms of risk levels, different locations were noted to hold different notions of acceptable risks. Hospitals preferred colony forming units to be held to a zero-tolerance level. This poses problems for different industries seeking to protect more of their vulnerable populations. Therefore, developing a standardized risk model was difficult.

A study by Dr. Logan Jackson from Michigan State University was discussed (https://www.mdpi.com/2076-2607/10/1/81). After sampling reservoirs, groundwater, water at disinfection points, pumping stations, and entrance to pipe buildings along with internal plumbing fixtures, it was found that, with PCR, numbers of microbes lowered from entrance into reservoir and through disinfection. However, there were not large differences between hot water and cold water fixtures within buildings themselves but there were differences between those closest to the reservoir and those furthest away where there was a 20-hour residence time (similar to levels found in cooling towers). As distance increased from reservoirs, the bigger the difference between entrances into building taps as residence times increased. The precise hydraulics of studied buildings are not presented in detail but their use (such as classrooms or laundry rooms) was noted as 'significant-use' flows. Relationships between turbidity, temperature, heterotrophic plate counts, and pH were looked at as well. *Legionella* species beyond *L. pneumophila* were observed. An estimated 99% of organisms were not accounted for since the sampling focused on detached bacteria.

To conclude, Dr. Rose noted how monitoring plans can utilize new tools to promote understanding of species ecology and growth throughout distribution systems, especially those accounting for hydraulics and temperature. Greater focus can be placed on environmental justice in terms of sampling locations. This would serve to improve the science of disinfection, as that is generally not as understood in distribution systems. Dr. Rose reiterated that partnering is an important aspect to integrate, specifically with building owners and community leaders.

Jason Kunz from the **U.S. Centers for Disease Control and Prevention (CDC)**, provided a presentation on evaluations of outbreak data and system characteristics relating to *Legionella*. Mr. Greenwood noted that Mr. Kunz would be presenting this evaluation as a follow-up to Meeting #2. His colleague, Megan Gerdes, an epidemiologist with the CDC, provided support to Mr. Kunz during the presentation.

Background was shared on an outbreak surveillance system used to look at drinking water outbreaks known as the National Outbreak Reporting System (NORS). NORS is used to collect information on foodborne, waterborne, animal contact, person-to-person, and environmental outbreaks. Each outbreak in NORS includes the number of estimated people who became ill, which for an outbreak by NORS definition is at least two people. The date the first case became ill, primary mode of transmissions, and then the state in which exposure occurred are also included. Waterborne outbreaks within NORS can include water exposure type (for example, treated, untreated waters, recreational, etc.). Reporting of outbreaks by states is voluntary, and outbreaks are considered to be under-reported. Additionally, as not every data field is required when entering an outbreak, variation exists in the amount of information entered in outbreak reports. Most outbreaks in the United States are investigated by state, local, or territorial health departments. The capacity of local and state health departments to investigate also places limitations on available data. CDC reviews outbreak information and includes them in outbreak publications or summaries. Another point mentioned is how data input into NORS may change over time, whether updates are made into the system well after the outbreak has concluded, or if it is ongoing.

Mr. Kunz presented information from NORS as of September 2, 2022. Between 2015 and 2020 there were 215 drinking water outbreaks associated with an estimated 2,212 illnesses, 563 hospitalizations, and 88 deaths. Water systems associated with the outbreaks include community and non-community systems. 170 of the 215 drinking water outbreaks were involved with community water systems and this included 1,178 illnesses, 470 hospitalizations and 70 deaths. Of those, 156 of these outbreaks were associated with legionellosis, which included 656 illnesses, 456 hospitalizations and 68 deaths. Of the 215 drinking water outbreaks (total), from 2015-2020, 184 were legionellosis outbreaks, comprising 786 illnesses, 544 hospitalizations, and 88 deaths. Data on legionellosis outbreaks excludes drinking water outbreaks associated with private wells.

Background on the representation of outbreaks and illness in community water systems relative to the portion of non-community systems was provided. A take-home point shows that cases of illness associated with outbreaks in community systems and individual private wells as evenly split. However, it was presented earlier that of the 215 drinking water outbreaks, 170 were associated with community water systems (79%). The cases of illness are more even between the community systems versus private wells because outbreaks in wells are more often associated with enteric Illnesses, which have a larger number of illnesses per outbreak. Healthcare and long-term care facilities make up half of the reported outbreaks, and these are much more associated with opportunistic pathogens, rather than enteric pathogens. For drinking water, contributing factors fall into 4 sections: source water, treatment factors, distribution/storage factors, and premise or point-of-use. Those are all factors noted to be considered, not just those under the jurisdiction of water utilities. There can often be more than one contributing factor, whether documented or suspected. A majority of outbreaks in this data set are prompted by illnesses associated with building water systems. This returns to a point discussed in previous meetings with premise plumbing systems, where *Legionella* and Legionnaires' disease may dominate in this portion of drinking water reported outbreaks. Mr. Kunz mentioned that it's important to recognize the data limitations related to the NORS information.

43% of drinking water related outbreaks from 2015-2020 were associated with individual/private systems The NORS data focuses on the setting of the outbreak but also includes information on contributing factors. Mr. Kunz also mentioned that outbreaks can have multiple contributing factors. He went further to explain that treatment related outbreaks are easy to identify, whereas those associated with biofilms are much more difficult to identify. Of 148 drinking water outbreaks with contributing factor information, 99 of 148 outbreaks have more than one unique contributing factor and 46 outbreaks have more than one factor type. Based on outbreaks associated with community and non-community systems, premise plumbing contributing factors are the most frequently reported in NORS. Chlorine levels in premise plumbing were identified in 25% of the outbreaks entered into NORS.

Based on additional insight into the data, under chlorinated factors, mostly non-community systems or smaller systems with chlorination issues could show associations with outbreaks. This underscores the importance of disinfection to prevent disease outbreaks. Unfortunately, the municipal water link was unclear or suspected, showing it remains difficult to identify contributing factors from municipal waters into these types of data investigations. Distribution systems were associated with 61 of the outbreaks. Of those, 25% report *Legionella* growth promoting water temperatures and chlorine levels within the potable water system inside buildings. Additionally, 6.6% report aging water distribution components (e.g., pipe, tanks, valves) within the outbreak report, and 13% note water temperatures greater than 30 degrees Celsius. In terms of data entry with respect to premise plumbing failures, NORS holds significant leeway in terms of how data can be entered into the system. A short demonstration was provided for this.

In closing, from the perspective of Legionnaires' disease, premise plumbing dominates within the number of contributing factors, however contributing factors related to the public water supply were identified in some. These contributing factors include water temperatures, low chlorine levels, aging distribution system components, and low pressures. In some cases, multiple factors were cited in the same outbreak. Legionnaires' disease is continuously reported as a primary cause of drinking water outbreaks. In addition, most drinking water outbreaks have multiple contributing factors. However, distribution system level contributing factor information related to outbreaks is infrequently captured. An additional analysis is needed to determine the extent to which cold water is implicated within premise plumbing investigations.

Mr. Greenwood introduced **Dr. Scott Summers**, a professor emeritus at the **University of Colorado Boulder**. Dr. Summers provides insight as a technical analyst. Dr. Summers acknowledged and thanked EPA and Cadmus for providing much of the data used in this presentation. The objective was to address WG questions about DBP precursors by evaluating formation model equations, evaluate precursor occurrence in source waters, and evaluate control of Total Organic Carbon (TOC) through use of the Stage-1 D/DBPR 3x3 TOC removal matrix for surface waters.

A detailed overview of DBP formation models was provided by Dr. Summers with focus placed on Central Tendency models. The first case looked at model development under free chlorine with respect to precursors. One trihalomethane (THM) formation model involved using 300 full scale system data from information collected for the 1996 DBP Information Collection Rule, where a corrective factor was then developed. A calibrated model was then used in making predictions for an additional 600 systems. The resulting models performed well with respect to predicting the central tendencies of observed data. Additional equations were developed for different forms of Haloacetic Acids and THMs.

For outputs regarding residence times in distribution systems, the median value was about 24 hours. Looking at maximal points in distribution systems, the median value ranged to two days and 90th percentile ranged to five days. Systems with a residence time of more than five days were treated as consecutive systems. Models showed that most HAAs formed within the first 8 hours. In addition, the sum of HAA9 and sum of THM4 accounts for about 50% of the TOC precursors, with the remaining DBP formation not covered by existing regulations.

Next, Dr. Summers showed the impacts of temperature and pH on THM formation using a sensitivity analysis. It was noted that, as pH is lowered, HAA formation increased. The opposite effect applies to TTHM formation. A larger impact was noted between TOCs and TTHM in treated waters. Based on the given examples, when TOC values were 2.0 mg/L the MCL was exceeded at 5 days, and the MCL was exceeded at 2 days when the TOC was 2.5 mg/L. Dr. Summers suggested that this may allow for the development of maximum TOC values for predicted exceedances. With respect to bromide, it was demonstrated that TTHM concentrations increase as Br levels increase. More

importantly, the parameter of "TOC*Br" (related to the combined effects of TOC and Br) appears to be in a strong correlation with TTHM.

One question posed is, how well can measured characteristic of precursors across system types relate throughout the country? Dr. Summers shared observations showing, for surface waters, small system TOC distributions were similar to that for large systems (at the 50th percentile). There are much higher TOC values associated with small systems and groundwaters. The overall conclusion with a comparison of groundwater to surface water is that groundwaters often have higher bromide levels (2-3x that of surface waters), but lower TOC levels than surface waters. Those systems at the upper ends of distribution curves for source water TOC levels may have a more difficult time treating their waters for TOC.

The next set of slides focused on coagulation, flocculation, sedimentation, and filtration. Dr. Summers noted how lower TOC values allow for use of non-conventional treatment for groundwater. Higher TOCs necessitate use of more extensive and advanced treatment. For surface water, where TOC levels were above 3 mg/L, more facilities used conventional treatment whereas when TOC was around 2 mg/L, non-conventional treatment was utilized. Ultimately, a lower TOC allowed facilities to use a wide range of treatment but as TOC shifts above 1 mg/L, there is a direction towards more conventional surface water treatment for groundwater. TOC precursors impact treatment selected as well as distribution system disinfectant. With surface waters, 2/3 of all systems used free chlorine. High levels of source water TOC, and bromide may drive systems to use chloramines with those characteristics. However, some systems use chloramines for other reasons such as their stability. The actual TOC removal using the 3x3 matrix was 14-22% higher than what was predicted. Only 7% of systems achieved less than the required removal.

Focus was then placed on water quality entering the distribution system. In terms of areas of low TOC levels (<1mg/L), formation of THMs in distribution systems were significantly lower than other TOC concentration ranges. As TOC increased, the data showed that THMs were only slightly impacted, reinforcing the understanding that TOC is only one factor in TTHM formation.

In summary, Dr. Summers shared that TOC and bromide concentrations strongly impact regulated DBP formation and selection of the disinfectant used. Groundwater systems have relatively higher bromide levels but lower TOC levels than surface water systems. Lower levels of TOC were associated with lower concentrations of THMs and HAAs.

<u>Facilitated Discussion</u>

Mr. Greenwood thanked presenters for their time and detail. Discussions were then opened with the following:

- Clarifying questions
- Do you have additions or refinements to the characterization of opportunistic pathogens or D/DBPs presented today or previously?

One WG member noted that exposure assessments from 1983, as well as information collection rules, may need updating to affect major decisions with regards to water quality. It was noted there are lots of studies on occurrence however, many are not systematic. Dr. Rose responded that more information is needed on aerosolization, especially as it relates to distribution systems, premise plumbing, and cooling towers. For a national approach, a suggestion was made to increase research with focus on distribution systems and look at interactions between them and premise plumbing systems, as well as disinfection science.

Other members raised questions about potential correlations between temperature and *Legionella*, for premise and distribution systems respectively. They questioned whether seasonal variability is taken into account for studies of

Legionella, and knowing their transmission through distribution systems (in relation to outbreaks) might be helpful. This is especially important for surface water systems.

WG members asked about risk tradeoffs between chloramines and free chlorine as it relates to exposure to other DBPs outside the regulatory framework. With regards to chlorine versus chloramines, Dr. Summers noted associations with more nitrogenous DBPs when chloramines are used. However, knowing the trade-offs between different disinfectants, with respect to currently unregulated nitrogenous DBPs might be useful. The tradeoffs have not been quantified, but they are known to exist. There is little NDMA occurrence when using free chlorine. It was also encouraged that based on available data and studies, to not rely too heavily on single endpoints within studies, as that might detract from looking at the general population. Many DBP toxicity studies have been conducted based on the use of a Chinese Hamster Ovary (CHO) assay which has been estimated for 60 different compounds, including on a lot of nitrogenous DBPs. Using these assays, we see potency differences, even at lower concentrations. However, the use of CHO is only one available assay type for determining toxicity.

Mr. Kunz noted concerns around ambient summer temperatures potentially affecting surface water temperatures, and as water is pulled in through treatment systems and sent out into distribution systems. Frequently water temperatures are observed in the *Legionella* amplification temperature zone entering buildings. Within buildings themselves, the concept of seasonality may be correlated directly to an increased risk of *Legionella* growth. There are concerns about water temperatures during summer months when looking at routine investigations, especially in the southern and western portions of the US. Other aspects were also considered, including municipal water temperatures entering premise plumbing. Disinfectant residual becomes important to maintain along with managing water age. Mr. Kunz encouraged awareness on incoming water temperatures and establishing routine control points as part of water management programs – alongside disinfectants. With respect to *Legionella* risk in premise plumbing, vigilance was encouraged during colder months as *Legionella* can still proliferate in buildings during winter seasons, even at lowered growth levels. Dr. Rose mentioned that her observation of the occurrence data did not show a relationship between temperature and occurrence.

It was further pointed out by WG members that not enough is understood on the issue of existing research and hot water temperature. In terms of disinfection science, research in developing CTs stemmed from the 1980s. Its concept was aimed for disinfection and selection of inactivation rates for a select group of pathogens for drinking water, surface water, and drinking water systems. There is not an existing CT for distribution systems. A need for a similar measure as CTs for distribution systems and premise plumbing was mentioned. As far as outbreak data and disinfectant residual monitoring data, a clear relationship was not established. Investment into this type of research, as it pertains to distribution systems and premise plumbing may prove beneficial.

A WG member pointed to limitations in monitoring strategies for *Legionella* and invoking environmental justice. There are on-the-ground implications of not having all desired data, as was the case with Flint, and though this poses a scientific problem, it also is a problem from the view of residents, utilities, and regulators. Economic vitality and monitoring in poorer neighborhoods also need to be stressed, along with funding for small and disadvantaged communities. Many still don't know about the potential for this issue at a household level.

Retaining seasonality as a point of additional research was echoed by other WG members, as seasonality affects not just chlorine dosage but also use of mechanical equipment. The member stated there are a lot of variabilities across systems and within a system, and that these variabilities need to be considered. The member also stated that they are on the fence about *Legionella.* That member concluded that while *Legionella* appears to be primarily a premise plumbing issue, there are things that can be done with distribution systems with minimal costs. One member noted that depending on equipment use, chlorine adjustments are more readily made or less easily performed depending on the season. It was also noted that there may be shared responsibilities with partner systems, to ensure others meet their requirements, particularly for consecutive systems. One suggestion from a WG member included considering

starting from source waters to the distribution, and then extending considerations to consecutive systems for a larger picture.

A question arose for further discussion to obtain the NASEM Committee's input regarding maintaining residuals throughout the water system (as opposed to premise plumbing), to prevent and monitor for *Legionella*. The member asked for more discussion on minimum residuals and *Legionella* monitoring. Dr. Rose noted that recommendations from the Committee stemmed from surveillance work undertaken by utilities and focused more on distribution systems rather than premise plumbing. Utilities found a decrease in colony forming units with measurable residuals and showed differences between those measurements from chloramine to chlorine use.

Dr. Rose pointed to WG suggestions on how variability plays strong roles in study outcomes, specifically when it comes to seasonality. Data becomes further muddled once water leaves the distribution system and enters into premise plumbing. Recommendations were therefore directed towards the water industry with focus on ensuring there is a disinfectant residual in distribution systems. At the time, it further made sense to have minimum disinfectants in distribution systems based on those recommendations and monitor for *Legionella*, to ensure colonization and seeding were not occurring ahead of water reaching premise plumbing. Dr. Rose also suggested additional research on residual persistence in building water systems.

Another WG member pointed to increase in cases of *Legionella* over the last 18 years. The question was: have correlations been drawn between those increases and promulgation of the DBP rule (from adoption to implementation). A separate point questioned if increases were a result of having water utilities spend more time looking at DBPs and decreasing residuals leading to a further decrease in efficacy of disinfection overall.

A WG member asked if systems with larger distribution systems have looked at compliance relative to the miles of pipe they maintain and use, along with water rate usage, regardless of whether they are consecutive systems or not. Dr. Summers noted correlations were observed between use of chloramines and populations served, alongside system size, with a higher proportion of large systems than small systems using chloramines. It was pointed out that large populations served may run into similar water age issues as small communities based on density and the complexity of piping. However, smaller communities may find much larger than expected water age because of lower density populations. Mr. Weisman added that the Disinfection Profiling and Benchmarking requirements are meant to address treatment changes.

One WG member noted issues in southern regions with large systems, high water temperature, and age. Problems collectively manifest in distribution systems. Limited regulatory options due to the vastness of distribution systems is notable and there was a question to see if any correlation has been undertaken on this subject nationwide. Similar correlations on the decrease of outbreaks and related waterborne diseases when temperature and water age are better controlled might also prove helpful.

A point was made around the increasing incidence of Legionnaires' disease and why this is multifactorial. Another point was made to take a gradual approach between microbial growth and DBP control as conversations with the WG have shown how challenging it would be to redirect both in a short period of time.

Clarity was requested on whether findings of different species of *Legionella* will need to play a role in DBP rule modifications. Dr. Rose noted how the National Academies of Science, Engineering, and Medicine noted difficulties in culturing organisms. Examples of testing for detections of Legionnaires' disease and pneumonia in Flint were discussed, where challenges included test types, detections, and which tests were instituted based on available data. Discussions led to suggestions such as evaluating PCR approaches to gain more insight into other species of *Legionella* and their presence in distribution systems, across a range of water conditions. A member noted that non-

pneumophila species were implicated in disease in New York City. This member noted that, in Flint, diagnosis was done using the urine antigen test (UAT), and that these tests detect only *L. pneumophila* disease outcomes. Ultimately determining which species are viable for growth, and which species are viable for disease may be important for the WG to understand, for helping to direct future recommendations. It was noted that viable, but non-culturable organisms may play a role, and that these ultimately were identified in playing a key role in determining cholera cases when knowledge about cholera being a waterborne disease first emerged. Dr. Rose described that undiagnosed cases of pneumonia in Flint increased during the same time as the Legionnaires' disease cases. She added that viability methods using PCR are needed. She further described international policies in place to provide more control, including monitoring, and response measures, as well as the possibility of a combination of tools. Another Working Group member noted that a lot of time has been spent on *Legionella*, with relatively little time on other opportunistic pathogens.

A Working Group member inquired about more data on dissolved organic carbon (DOC). Dr. Summers shared how the humic nature of water can play strong roles in variability of DOC, along with seasonality. One point to consider is the variation of TOC and DOC in groundwater – which could indicate groundwater is under more significant influence of surface waters. This is where the fast flux of surface water could be entering into a groundwater network. He said that in his observations the difference between TOC and DOC are quite small, but TOC may be higher in raw water. Less is known in groundwaters. The characteristic of the TOC and DOC can have a big impact as well. The member mentioned that in their experience, ground water DOC levels can vary as much as four-fold.

Discussions returned to *Legionella* and ensuring clarity is provided on which data is being discussed and which items are being compared to it specifically. An example noted includes *Legionella* data likely being more aggregated to surface water than to groundwater but where that lies in the context of precursors or conventional filtration is important to separate.

One member raised a question about safety considerations between chlorine gas and other delivery methods for chlorine. The member also questioned whether chloramines are improving risk balancing. Dr. Summers responded that chloramine use may not come down to one versus the other (chloramine versus chlorine). Chloramines are used in distribution systems, but there are downsides. These downsides and the risk balancing are better understood than they were 20 years ago when the rules were developed, and he suggested there is no "silver bullet".

A WG member noted a challenge is the tradeoff between treating OPs rather than the unintentional impacts of creating DBPs. Retaining this point in context of emerging contaminants (i.e., per- and polyfluoroalkyl substances (PFAS)) and treatment processes for their removal, might also alleviate issues between managing tradeoffs.

Related questions arose if there are innovative technologies available or under development at institutes or universities which could achieve the desired pathogen protection outcome while minimizing the risk of increasing DBP formation. WG members noted there is no single solution however, retaining an outlook and search for new items might prove advantageous for the rule revision process currently or going forward.

Other points raised by Dr. Rose included the encouragement for more investment in infection sciences. The water industry has known much of the current information for a significant period of time and are leaning on new science to assist in better understanding the overall risks, how those risks can be managed, and how systems may be able to implement the risk management practices.

A WG member asked how ASHRAE Standard 188 for building premise plumbing is being applied. Also, how effective is it in terms of its penetration (adoption scope and rate by building owners/managers) into places where it should be

being applied? Dr. Rose mentioned that it's largely a voluntary standard that has been in place for years. She noted that the approach has brought different stakeholders together and has encouraged looking at how other countries have engaged in learning of recommended practices and their efficacy. High risk populations are frequently looked at, such as those in hospitals. An issue which remains is the sharing of knowledge beyond individual buildings and their specific industry or use (for example a building manager from a hospital may not interact with that of a residence). In thinking on improving the OP issue, particularly in premise plumbing, Dr. Rose suggested that a series of more effective partnerships and commitment to doing the right thing on both sides of the water meter will be critical.

A point was also made that certain healthcare facilities are required in some places to have compliant water management programs and there may be opportunities for knowledge sharing on water management programs. Certain industries are more aggressive than others with respect to formation and implementation of water management plans and there may be lessons learned there to help the WG. The Veterans Administration was given as a suggestion.

A takeaway raised by a WG member with respect to TOC is how reducing organic matter in waters will reduce THMs, HAAs, and unregulated DBPs, and provide for better disinfection. This method holds potential to reduce biofilm, which is reduced food for microbes (in raw waters). A question was if this correlates to a decreased likelihood of opportunistic pathogens, and therefore makes water easier to disinfect. The member further noted how reducing organic matter in raw water would help both sides of the equation, from DBPs to disinfection itself. This was echoed by other WG members. Another WG member responded and agreed but Dr. Summers noted there may be concerns in some cases about the cost of treatment associated with such a method. It may also fall over into controlling elements such as pH, or creating additional sludge, and addressing disposal of associated waste products. Dr. Rose added that upstream treatment would help reduce TOC in long distribution systems but what that means in older infrastructure remains to be understood.

A WG member mentioned consideration of a new approach for disinfectant residuals. The member mentioned the consideration of other factors like energy conservation and efficiency be included.

One WG member pointed out how conclusions from these discussions will be important to translate into non-technical terms, for those not as well-versed in water industry terminology.

Regarding chloramine, a WG member noted the reason for a switchover to secondary disinfectant is the presence of cost-effective technology. The member mentioned that the silver bullet is precursor removal, but it's very expensive. Many systems that better remove precursors switch back to chlorine as a secondary disinfectant. In response to technologies potentially solving DBP and OP issues, as discussed and echoed earlier, an area to look at is regulations around secondary disinfectant. The WG member suggested regulations are looser around secondary disinfectants, giving utilities more room to move and addresses issues like DBPs. Finally, the member clarified an earlier remark about disinfection benchmarking by stating that it applies only to primary disinfection.

Segment 3

Environmental Justice in the MDBP Context

Presentation

Dr. Kirsten Studer, OGWDW, USEPA provided a presentation on Environmental Justice (EJ) considerations for the MDP Rule Revisions Working group. The presentation provided a background on EJ and explained why it matters for

rulemaking and described how it is relevant for this WG. There were two main executive orders described, which focus on EJ issues that provide the aim and purpose of these directives. Executive Order 12898, issued in 1994, directs agencies to make EJ part of their mission by identifying and addressing as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations, and low-income populations in the US. Executive Order 14008, issued in 2021, builds on Executive Order 12898 and further directs federal agencies to consult and partner with stakeholders to increase resilience with a focus on advancing EJ. These stakeholders include tribes, states, local governments, and territorial governments, as well as other federal agencies, community groups, scientists, and adaptation experts, as well as businesses. From these executive orders, EPA plans to focus EJ efforts on improving the health and environment of overburdened communities and demonstrating progress on significant national EJ concerns.

To look in more detail at the Executive Order 12898 and how this applies to MDBP rule revisions, this specifically directs federal agencies to identify and address the disproportionately high and adverse human health and environmental effects of their actions on minority and low-income populations. It also directs federal agencies to develop a strategy for implementing EJ and to promote non-discrimination and federal programs that affect human health and the environment. This further includes providing minority and low-income communities access to public information and opportunities for public participation.

In early 2021, the White House announced the Justice 40 initiative under Executive Order 14008 as a whole of government approach jointly led by the Council on Environmental Quality, the Office of Management and Budget, and the White House Office of Domestic Climate Policy, along with the White House, and Environmental Justice Interagency Council. Justice 40 mandates that at least 40% of the overall benefits of certain federal programs should flow to disadvantaged communities. The purpose of the White House initiative is to advance EJ across the full federal government. It will also provide recommendations for how federal investments could be used to ensure that 40% of overall benefits flow to disadvantaged communities, including remediation and reduction of legacy pollution, as well as development of critical clean water infrastructure. EPA is continuing to engage in developing the benefits, methodology, and metrics to ensure that 40% of benefits from covered programs as mandated under this Justice 40 initiative will flow to disadvantaged communities.

The Bipartisan Infrastructure Law aims to help meet the needs of many communities. It will provide significant investments and safe drinking water infrastructure as well as drinking water programs. EPA is working to ensure that funds are available to drinking water systems with specific focus on disadvantaged communities. Some examples of how those funds, which will be distributed over a 5-year time span, are supporting implementation of drinking water regulations including funding for the drinking water state revolving loan fund (DWSRF), and for small and disadvantaged or underserved community grants.

EPA has committed to ensuring fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income. This commitment involves the development, implementation, and enforcement of laws, regulations, and policies. EPA also developed technical guidance in 2016 for assessing EJ. Regulatory analysis in this guidance specifically outlines technical approaches and methods to help EPA analyze potential EJ considerations for regulatory actions. There are three questions that were developed for analyzing potential EJ concerns for future potential regulatory actions from that technical guidance.

• Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?
• Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for each regulatory option under consideration?

• For each regulatory option under consideration, are potential EJ concerns created or mitigated compared to the baseline?

The focus of this guidance looks at environmental stressors and how they impact communities with EJ concerns and comparison to the baseline or conditions absent or prior to the implementation of rule revisions. It is also part of the reason input from the WG is relevant and why EJ is included specifically within the working group charge. EPA is seeking consensus recommendations on opportunities to advance environmental justice through regulatory revisions to ensure equitable protection of consumers health, particularly disadvantaged and historically underserved customers or consumers.

Based on the previously outlined executive orders and technical guidance, EPA identified potential EJ analysis areas that can inform MDBP rule revisions. Prior to proposing rule revisions, EPA will conduct an EJ analysis to evaluate the rules' impacts on disadvantaged communities. During the rule proposal comment period EPA will seek comments on the EJ analysis before finalizing the rule revisions. In addition, EPA is considering various options for undertaking analyses which will be subject to data availability. These various options entail looking at existing scientific literature and relevant case studies, while also looking at historical concentrations of contaminants in drinking water, specifically those that serve disadvantaged communities. Historic exceedances will potentially be looked at, along with non-compliance of public water systems that are serving these disadvantaged communities. With regards to demographic distribution of health benefits and incremental household costs anticipated from any proposed MDBP rule revisions, EPA can evaluate this using existing tools, such as EJ Screen or other cost benefit models.

As part of the EJ analysis, EPA will consider whether population groups of concern are disproportionately affected by microbial contaminants and DBPs. Published literature mainly focus on small scale analysis. This particular analysis is expected to evaluate whether population groups of concern are disproportionately affected by potential regulatory options for the MDBP. As part of this analysis and rule proposal, EPA will seek input from key stakeholders, organizations, and other interested groups. This would include any impacted communities through outreach meetings, with specific focus on EJ considerations. In addition, input will be sought from the Science Advisory Board, the Small Business Advocacy Review Panel, with tribal government officials, state and local government officials, as well as the full NDWAC.

EPA is also interested in input on potential analysis, and EPA will consider the information gained from these engagements and from public comment process during the regulatory development process.

Dr. Studer noted initial thoughts received from WG members on potential EJ analysis. It was noted these are specifically coming from the WG.

• Understand levels of underlying health conditions, vulnerable populations, and the cumulative impacts of MDBP exposures;
• Consider utilizing spatial data to perform an accurate analysis of drinking water challenges and impacted communities and localities;
• Aim for a compliance analysis for MDBP rules, with focus on water utilities that serve disadvantaged communities, demographics of impacted communities, and the number of violations;
• Collate knowledge from residents of impacted communities; determine how they learned of violations; and review information provided to them;
• Perform literature reviews of relevant research on MDBPs and environmental justice;
• Assess linkages between small and potentially understaffed systems and water quality violations;

• Find solutions to improve and provide well maintained infrastructure for EJ communities at the system and premise levels;
• Ensure communities are aware of best practices and share practices that balance disinfection and DBPs.

Mr. Greenwood thanked Dr. Studer for the presentation and introduced the next set of presenters. **Dr. Shawn P. McElmurry** (**Wayne State University**, Department of Civil and Environmental Engineering) and **Dr. Nancy G. Love** (**University of Michigan**, Department of Civil and Environmental Engineering) presented on 'Considerations for Bringing an Environmental Justice Lens into Water Quality Research and Design'.

Dr. McElmurry began his presentation by describing the importance of chlorine residuals in providing high quality water. However, he also noted that while chlorine suppresses biological growth, nutrients that may be present in the system promote biological growth. The role of organic carbon and role of organic nitrogen were discussed in context of microbial growth and DBP, and EJ issues, with carbon noted to help promote microbial growth. Dr. McElmurry stated that the microbial and DBP data are often biased and added that a specific focus on carbon is needed. He went on to mention that unregulated DBPs are regarded as more toxic.

Dr. McElmurry described Flint as a case of a convergence of factors leading to water quality problems. He noted Flint as a free-chlorine system. At that time, there were eight monitoring locations established in their distribution system. Those were used for monitoring chlorine residual and adopted for biological monitoring. However, he noted that data could be biased by adopting these sampling strategies since the sites were not originally chosen for the type of biological monitoring conducted. Other issues described include a lack of monitoring in some areas, aging infrastructure, and significant water age issues. The water age issues are partially a result of industries leaving due to economic downturns, which led to water age of at least over a week in some portions of the southeast and southwest corners of Flint. Furthermore, residents face higher water rates as there are fewer people paying for water usage. In addition to the Flint example, presenters shared that a study is being conducted on how water age disproportionately impacts predominantly Spanish-speaking communities. There are also relationships between environmental justice issues and boil water notices in Texas following large winter storms a year ago. Race, income, and other social demographic factors were pointed to as significant related issues here as well.

The presentation shifted to the concept of monitoring through different methods. In an example of collecting different samples inside and outside of treatment plants and analyzing using chromatography, shifts were observed from low water age to high water age, where high water age held higher molecular weight organic matter. Using excitation emission spectroscopy, shifts were observed indicating the presence of more proteinaceous material from low to high water ages. The presence of microbially derived dissolved organic matter and dissolved organic carbon in the signatures were also observed.

In a comparison of low and high water ages, shifts in types of amino acids present are notable, particularly between those found in drinking water distribution systems, relative to those from cooling towers. Cooling towers generally have about 50% more proteins than drinking water. This dramatic shift in the type of amino acids that are present was underscored. *Legionella* isn't unique because it uses amino acids, but it does prefer amino acids over other readily available carbon sources. Combinations of amino acids vary from species to species that different organisms seek, but all *Legionella* species require an external source assisting because it can't synthesize such amino acids on its own. It was noted that there was no cysteine found in samples containing lower molecular weight compounds.

Data suggests a shift in the type of organic nitrogen present in these systems would help *Legionella* gain a foothold in distribution-type ecosystems. In addition, proteinaceous material yields to production of unregulated DBPs. In an

example, nitrogenated DBPs were cited as potentially more problematic from a toxicity perspective as nitrogenous DBPs often have a greater toxicity than regulated DBPs.

In conclusion, three takeaway messages were provided. The first is that data is often biased and alternative data collection approaches must be used to account for this, including from an EJ perspective. The second is the need to understand or at least consider the role organic carbon and nitrogen have in promoting the changes in distribution system ecology as well as DBP formation. The third point is that the formation of unregulated DBPs can have a greater impact on the toxicity of the overall DBP mixture.

Dr. Nancy Love continued with the second portion of the presentation. Dr. Love noted limited expertise in EJ however, she regularly interacts with experts in that field, and is a subject matter expert in issues of water quality, design, and management. The presentation focused on design aspects with regards to the future of water regulations. Dr. Love trains individuals who designed and will design water systems and an important part of that process is to ensure current generations of graduates are conscious of incorporating EJ into their work. Design and management has historically been informed by information available at hand.

One particular point is how systems may be designed around uncertainty and, as a result of applying safety factors, be subject to unintended consequences. Those can include overdesign, and water quality implications as population levels shift. Who provides information as part of design processes, for whom we design, the quality of information, granularity of the information, how much we have, how information is acquired, the vetting process, and where information is stored influence the design process. When it comes to environmental justice, consideration of highly technical information and its translation into resilient designs and efficient maintenance, along with day-to-day management, is also important. Where past design processes were very linear, current processes should be more circular and include inputs of stakeholders, government officials, and those in charge of identifying the resources and funding for system development. There should be more incorporation of equity-centered community design, where it brings in the notion of community history, knowledge of existing systems, and next generation practices. A sociotechnical approach that goes beyond what is historically used for design and management is essential in both training and practice. A paper that looks at bringing sociotechnical frameworks into the design process for making decisions about water infrastructure investments can be made available to the WG. The paper describes how infrastructure investments in response to violations may not consider socioeconomics.

A highlighted point encourages understanding and thinking from perspectives of engineering design, coupled with historical community knowledge, which can be effective and powerful. An overarching goal is to more widely impart knowledge in bringing sociotechnical elements and community advisory processes to inform and work with utilities. The result should be to conduct this in a way which brings information in and allows communities and utilities alike to be listened to and consider all information in design of water systems.

A related consideration is looking at how people view their water systems. Recruiting individuals who may not trust their water system into the drinking water workforce is important to consider in the context of EJ. The water system, as well as workforce, should reflect the communities it serves. These points were made towards design of water systems as well as rules that may affect them. Comprehensive data collection and data transparency were also underscored.

Equitable rate structures were mentioned, specifically to question if different models that are available are being properly utilized. A notion was raised to ensure different models for affordable water rate structures are being implemented, and to broaden these to additional utilities. These efforts can result in universal high quality, well maintained water infrastructure, spread of community knowledge, achieving partnership, and creating trusted

affordable systems. Dr. Love noted infrastructure investment disparities should be overcome by prioritizing areas least invested in historically, in order to further inform an open design and management process.

Mr. Greenwood thanked presenters and welcomed **Nakia Clemmons** who is an environmental health specialist with the Safe Water Section for the **CDC's National Center for Environmental Health**. The presentation focused on Legionnaires' Disease Health Disparities: Social Determinants of Health Perspectives. Background was provided on *Legionella*, its infectious nature, and inherent risks associated with outbreaks of Legionnaires' disease. She stated that safe drinking water is a strategic priority for CDC, with *Legionella* being a specific focus resulting from the built environment. Health disparities were then discussed in association with changes over time. In 2018, the disease incidence was 2.5 cases per 100,000 people. While these numbers are considered underestimates, they also reflect diseases from all water exposures, not just drinking water. The National Academy of Sciences, Engineering, and Medicine estimates the number of US cases of Legionnaires' disease ranges from about 52,000 to 70,000 each year. Nationally, the notifiable disease surveillance system showed that racial disparities exist when looking from 2014 to 2018. Specifically, the incidence of Legionnaires' disease was more than two times higher in Black or African American persons when compared to White persons in 2018. Other studies showed that Black or African American persons and those who lived in high poverty areas had higher rates of Legionnaires' disease. The objective of the study described included exploration of underlying determinants to target interventions and conducting narrative review of health disparities for Legionnaires' disease and respiratory related diseases.

Social determinants of health were defined as circumstances in which people are born, grow, live, work, worship, and age. These circumstances were indicated to hold a relationship to the distribution of money and resources. They also determine differences in the exposure to health risk factors and in morbidity and mortality.

Authors of the study then conducted a narrative literature review of potential health disparities related to Legionnaires' and other respiratory diseases. The literature review covered 220 articles identified through PubMed and Scopus. Ninety-eight full text articles were retained for review, with 79 being excluded either because they were unrelated to social determinants of health or were limited to children. A total of 19 articles met the criteria for review. The medical subject of heading search terms included Legionnaires' disease, legionellosis, racial and ethnic minority health, health care disparities, health disparities and social determinants of health. Based on the results of the literature review, authors aimed to characterize results into the five social determinants of health as they relate to disparities in the incidence of Legionnaires' disease. These are economic stability, education, social and community context, health and health care, neighborhood, and built environment.

With economic stability, the review showed that poverty levels may be associated with the highest incidence of Legionnaires' disease among all community acquired cases (not just from drinking water). In New York City, Legionnaires' disease incidence in areas with high rates of poverty was 2.5 times higher than in areas with lower rates of poverty and the same trend was seen in the Bronx outbreak as well. Occupation seems to have a role in the incidence of community acquired legionellosis, where a study found that most cases were amongst people employed in hazardous or service industry-related jobs.

Lower education levels were associated with higher census tract incidents of Legionnaires' disease. Unfortunately, no studies measured the social and community context factors such as stress, discrimination, or social capital and the context of Legionnaires' disease.

For health and healthcare, comorbidities of Legionnaires' disease and other pneumonia-related diseases were frequently described in literature. A higher incidence of Legionnaires' may be associated with diabetes and invasive pneumococcal disease. It was acknowledged that diabetes is more common among people of some racial and ethnic

minority groups with lower social economic status. Immunocompromised comorbidities were associated with community acquired pneumonia. Pneumonia related hospitalizations and comorbidity studies show that individuals identifying as black ethnicity have higher rates of pneumonia and morbidity and mortality than other race ethnicities.

Although several articles acknowledge the lack of health insurance and medical care as factors contributing to disparities and adverse respiratory related outcomes, most articles did not explore healthcare access or type of health insurance in their analysis. However, one study did find that Medicare comprised the largest percentage of primary payer firm pneumonia associated hospitalizations in New York City, followed by Medicaid.

For neighborhood and built environments, certain housing and facility conditions may create environments conducive to *Legionella* growth. This was shown in a study undertaken in New Jersey where the incidence of Legionnaires' disease showed increases associated with a higher percentage of vacant homes, rented homes, and older homes. Water age, water pipe material, water quality, and drinking water sources may influence the growth of *Legionella* and other opportunistic pathogens in these environments.

Ms. Clemmons noted how racial, ethnic minority groups, and low-income populations are more likely than non-Hispanic, White, and high-income populations to be exposed to contaminated drinking water and often have poorer access to safe drinking water. Previous studies indicated that potable water sources in homes could be sources of exposure as well.

A separate study suggested proximity to cooling towers to be an environmental risk factor for Legionnaires' disease outbreaks. Suggestions from that study encouraged continued maintenance of towers and water systems, particularly in lower income neighborhoods. Air pollution and Legionnaires' disease are understudied and represents an area for future studies.

The literature review also helped authors realize the scarcity of understanding Legionnaires' disease regarding social determinants of health related to education, social and community contexts, and neighborhood, and built environments. Some possible interventions include having community health workers and environmental health practitioners work together to comprehensively address health disparities related to social determinants of health. This should include outreach to organizations that have an interest in combating poor housing quality, comorbidities, air pollution, and any condition that disproportionately affects people with lower incomes and people from racial and ethnic minority groups. Future studies could examine the variables related to poor building infrastructure, building code violations and air quality. In summary, the disproportionately higher incidence of Legionnaires' disease among black or African American persons and people with lower socioeconomic status suggests a need for public health action. Ms. Clemmons suggested such actions could include incorporating social determinants of health data sources with geocoded addresses from Legionnaires' disease surveillance data and using current data sources to link environmental and social economic socioeconomic variables.

Facilitated Discussion

Mr. Greenwood introduced the next portion of Segment 3 with a panel and facilitated discussion. **Dr. Chris Edens**, an epidemiologist with the CDC was introduced. **Blanca Surgeon** was also welcomed, from the Rural Community Assistance Corporation. Ms. Surgeon assisted rural communities and Native American nations in the western United States, along with Pacific territories and holds experience in drinking water systems management, developing regional collaborations, and forming regional entities for management of several small public water systems. **Andy Kricun** and **Dr. Benjamin Pauli** were welcomed to participate as members of the National Environmental Justice Advisory Council (NEJAC). Mr. Greenwood asked the panelists to provide observations on the presentations that had been made.

Ms. Surgeon noted how research and design of systems for SDWA compliance are pivotal and will require change at the education system level to support rural utilities. Small, rural communities, are at a disproportionate disadvantage not just because of location and size but also from a communications standpoint. Communication in small communities involves moving technology along in a different way and is highly dependent on funding. Managing and navigating funding is a challenge. Many of these small, rural communities are eager to return to in-person meetings and hold discussions one-on-one. It was pointed out to the WG to help create or promote funding mechanisms to encourage creation of systems that comply with rules and provide safeguards for rural residents. Regionalization of water systems is often discussed, but this is an unpopular option because small system personnel are often proud and want to be regarded as independent and self-sufficient. In addition, encouragement of jobs in regions as part of those funding mechanisms can pull workforces from rural areas to help implement projects with use of local knowledge and experience. A funding management hub was suggested. However, accessing technical knowledge was pointed to as a consistent challenge for these same communities.

Dr. Pauli thanked presenters for the input and remarks so far. Background on the NEJAC was shared. Originating in 1993, its role is to provide independent advice to the EPA Administrator on broad, cross-cutting issues related to environmental injustice. To work towards recommendations around specific issues, NEJAC listens to presentations from agency staff on specific issues and how those agencies work on them. At public meetings, NEJAC has the opportunity to enter into conversations with people who have personally suffered from environmental contamination. People who speak to the NEJAC about their 'lived experience' of environmental injustice is key. It is considered a central principle of EJ that those who have been harmed and marginalized have the opportunity to speak for themselves, to tell their stories, and to be listened to with respect. This moment of empathy provided by hearing their stories helps ground the work and better understand the bigger issues.

Dr. Pauli noted how lived experiences allow a better and larger understanding of the environmental justice issues at hand. Dr. Pauli also noted that how people experience water contamination and water regulation is critically important to incorporate into instructive lessons. To ensure experiences of vulnerability are not exacerbated by future rule changes or modifications, Dr. Pauli encouraged taking the perspective of those who could be harmed, particularly those who are already suffering, and whose trust in the system may remain fragile from previous experiences. It was encouraged to take opportunities to consider consequences of compromises from the vantage point of those who may be affected. Affected community members possess a depth of understanding of existing consequences and of harm in general that goes beyond what official facts and figures can convey. They can connect dots that are difficult to connect from afar, and Dr. Pauli stressed how this is critical to thinking about cumulative impacts, as well as in thinking on how different harms intersect and interact with underlying disadvantages. He provided the example of how Flint, Michigan could provide lessons. In Flint, DBP issues were first identified, but the residents weren't informed because it wasn't required. This led to mistrust in the utility, especially considering that the system was in compliance while some residents were exposed. Compromise within the rule is needed and such residents can help connect the dots by them teaching regulators what may not be able to be put into words. He mentioned a case example of 26-year-old Jassmine McBride, who had an underlying health condition and contracted Legionnaires' disease, leading to her death at 30.

Dr. Pauli noted that the structure of conversations provided to the WG should consider this context, to facilitate this type of learning, along with those presented on earlier by different speakers. Building such conversations into the core process may prove increasingly beneficial to the ultimate rule modification effort, without assuming which individuals or groups may hold the best sole expertise. Dr. Pauli encouraged finding ways of incorporating those considerations and different kinds of knowledge into the work being undertaken here.

Mr. Kricun thanked the preceding speakers on their tremendous work and for speaking to EJ and environmental injustice. Mr. Kricun conveyed personal experience in working with economically distressed communities in New Jersey. It was conveyed that how or where one lives should not be a predeterminant, and the bottom line with EJ is to ensure every individual has access to safe drinking water at an affordable rate. Discussion shifted to eliminate current deficits and gaps which EJ communities are currently facing. The first point was to ensure benefits that come out of the recommendations or technical advances also consider funding and resources. A goal should be to bridge existing gaps which preceding speakers spoke on, and ensure that future ideas, technologies, procedures, and recommendations are incorporated into EJ communities. The overarching idea is that everyone is entitled to the same quality of life no matter where they live or who they are.

Mr. Kricun noted how poorer communities tend to have less resources, fewer people, the inability to attract either the number or to pay higher salaries. They lack resources and funding to bring about capital which is necessary for changes in infrastructure. As a result, these communities may not have the operations, maintenance skill, or capacity to optimally manage equipment to meet regulatory thresholds. A compounding issue is how those living in low-income areas may not receive the medical care they need due to disproportionate burdens from other issues apart from drinking water, such as with wastewater or air pollution. Therefore, even unintentionally creating issues with drinking water from a lack of optimal treatment adds to this pre-existing burden. Mr. Kricun encouraged minimizing any unintentional harm from potential byproducts and to help close existing gaps in advance of recommending drinking water changes that could further widen the gap. Mr. Kricun also pointed to ensure knowledge sharing occurs around capital improvements. This would improve the ability of EJ communities to operate systems in the way infrastructure upgrades require and also from the perspective of required maintenance to continue optimized, compliant, and healthy treatment.

Mr. Greenwood thanked presenters and panelists and opened up the floor for discussion:

- Clarifying questions
- Based on your experience, do you have additions or refinements to the characterization of environmental justice considerations in the context of the MDBP rules?
- What additional information, perspectives, or experience will be helpful to further understand Environmental Justice in the MDBP context?

One WG member underscored the importance of sharing knowledge with respect to media used in water treatment. Two points related to this include sharing of best practices amongst operators of utility water systems but also cross-sharing amongst regulators. If one state is performing really well on optimizing a certain regulation and its implementation, the outcomes could be shared with other states.

A WG member noted ongoing practices and what is supposed to be occurring in terms of regulation and treatment implementation isn't often reported to the press. The WG member believed elected officials must also be educated on requirements for running utilities and providing capacity development for those utilities to run efficiently. Some utilities are going backwards, however. In addition, where state trainings are not mandatory they should shift to being fully required in some cases. More qualified operators are needed. Separately, from a utility standpoint with regards to growth, utilities should conduct a thorough future look. A combination of planning and growth were encouraged as well as adaptation strategies to facilitate new regulations or even when designing new or additional facilities to meet regulatory requirements. There are a lot of options for fixing distribution system problems, but don't make it heavy sided on the utilities. Another separate point includes consolidation of small systems and looking at water utilities regionally apart from individually. Arkansas was pointed to as an example where rescue plan funds came through DWSRF for both drinking water and wastewater. Investments were made into small systems, as opposed to larger ones that should be able to stand individually on their own funds. Finding adequate workforce to facilitate

disadvantaged systems was further reiterated. Mr. Kricun responded that many systems are not like the Arkansas example and that EJ needs further discussion.

Another WG member pointed out that regionalization (connecting some or all aspects of governance, management, and operations of utility systems on a regional basis) is helpful but may not always be necessary. Alternatively, shared services such as peer-to-peer assistance cooperatives might be helpful, as some regions might have too many systems, or are disparately placed.

A separate WG member noted how utilities cannot or have not had sufficient funds put into their system. Whether this issue stems from the utility itself or its governing bodies is a separate issue. However, mandatory training was strongly encouraged such that both understand their responsibilities.

Ms. Surgeon provided a follow-up on regionalization and acknowledged there is information available on where it works. However, acknowledgement was also provided in that this type of thinking will not take away required management agencies that are essential to working with individual or groups of utilities in a region. Also, to add, with investments in billions on infrastructure and funding, allocating this to regional project managers might still prove beneficial and provide oversight and trust on a regional level rather than in a segmented fashion (in particular for rural areas).

A WG member pointed to Mr. Kricun's comments earlier on local decisions and how solving issues on drinking water may be one matter but ideas need to be part of a holistic solution, including best practices and knowledge sharing, and should consider other challenges faced by water utilities, such as cumulative impacts of drinking water regulations. The member questioned what strategies within Justice 40 will be successful and that review, permitting, design, etc. is a multi-year process. They further stated that 60% of customers in their system are paying 4% or more of their disposable income for water and that the percentage will soon increase to 80% percent of residents paying 5% of disposable income for water. These costs are attributed to aging infrastructure, climate change, and regulations. Encouragement was provided on hearing how investments, project management, project development, and distribution of funds will fit into that larger burden of EJ issues affecting local communities. Following the process of environmental reviews, permitting, design, etc. are all part of a multi-year process therefore, considering how to make a difference by allocating funding will require thinking through what it takes to deliver and develop projects. Another point with funding is to provide additional allocation to address aging infrastructure in the context of climate (and regulatory requirements), but from sources outside of the typical funding sources available to water utilities. The point was to share how current circumstances, such as with climate, are greatly different than when the last massive infrastructure spending bill took place.

Another WG member noted a pilot study looking at affordability rates with customers and expanding such a study to other states, but also mentioned that difficulty in creating a study exists due to availability of funds. The WG member noted an example of a conglomerate of smaller utilities creating a sustainable partnership where customer billing services are consolidated relieving pressure on the individual utilities that faced difficulty retaining administrative staff. There are also other similar small utility partnership ventures such as joint water tower inspections, painting, and satellite leak detection programs where smaller communities pay based on geographic size. The member notes that systems could pay into a central fund to obtain maintenance support services. Although this is not a full 'regionalization' approach, reaching out and working together to reduce overall costs has proven beneficial to the utilities involved.

A WG member pointed out that best practices might range across disciplines, particularly in the context of EJ. It might be useful to hear what other staff in different disciplines are doing outside of water, such as with air, and vice versa,

as EJ issues are interrelated. With regards to regional project managers, looking at the mutual aid model for regional EJ was encouraged, as was skill sharing.

The conversations continued to public notification where, with DBPs, delays in notification can erode trust between consumers and utilities. The Tier for DBP notifications should be Tier 2. A next step could be to take DBPs to tier-two level advisories and then undertake serious research on that front. Another point is to utilize existing equity-based projects, such as maps of heat islands or floodplains to further contextualize EJ issues in areas where drinking water needs may also be a compounding burden on communities.

A WG member stressed the importance of utility governance, specifically pointing to how any recommendations might be implemented by EPA, states, and systems. The member added that a context for potential regulatory recommendations is needed, in that the WG would consider the ability of utilities to implement or carry out any recommendations adopted into regulation.

A WG member asked whether there is information on DBPs and their health impacts on specific population, similar to the information provided on OPs and Legionnaire's disease.

Another WG member underscored the importance of training and developing a pipeline of certified operators that are able to fill positions, especially in EJ communities. Opportunities were cited to recruit from local communities, and identify students at the high school level, as well as develop scholarships and mentorships to get operators trained to serve in communities where they live. A note was made on how current operator certification programs are not simple to navigate. Most operators currently require mentors at water utilities or state-level to move through it, and therefore under-represented groups might find more difficulty. To address the earlier conversation on infrastructure, helping utilities pay for it was encouraged but without operators to maintain new infrastructure, the investment can be put at risk. Therefore, a positive loop would be to invest in operator training to help maintain the system, which should help communities, economic stability, and public health in the end.

A systematic review to identify barriers to disadvantaged systems for applying for funding, and identifying specific strategies to break down those barriers was suggested by a WG member. Applications for funding may prove cumbersome and difficult to navigate for small, underserved communities, but proper planning is also important. Precise identification of the challenges with strategies to maintain protections may be needed. Bias in sampling locations related to water quality representation was noted by this member.

With respect to analyses for water supply alternatives (e.g., source changes, independent treatment plant vs consolidation) for small, underserved drinking water communities, the same analytical rigor expected from a high-income community was encouraged. A WG member noted there should be transparency and respect of community needs and restricting the scope of analysis to only the engineering perspective must be limited. As for public notice of violations, the importance of exploring timing, content, and delivery mechanisms of violations is critical, as well as language used in consumer confidence reports. All of these need to be timely and informative for communities to feel confidence in their water systems. There is an opportunity with this group to improve that whole process, improve transparency, spell out what information must be readily available to residents, and for utilities, how to avoid biased sampling plans.

With respect to issues of governance, one WG member noted a helpful document from the National Association for Clean Water Agencies regarding wastewater that can be shared with the members. Second, the importance to identify solutions that are affordable was noted, and a suggestion was offered regarding low-income household water assistance programs. Providing services to EJ communities that they can afford, with programs in place to ensure

this occurs in partnership with utilities was noted. This might ease burden on utilities themselves, who might be concerned with making choices between improving infrastructure or charging a rate which their customers cannot afford. In addition, a new effort towards creation of a regional assistance center for communities, where communities can go to get help, knowledge, and assistance was shared. EPA is developing Thriving Communities Technical Assistance Centers that can assist capacity building with grants and other needed services. Other WG members added on how the idea is to create a one stop shop location for holistic environmental knowledge to be disseminated across multiple levels of government and communities.

Another member stated a need for a systematic review of DWSRF funding. The NEJAC has an infrastructure group that could recommend this. They may be able to compile some information for this WG.

Segments 4 and 5

Topic Areas for Possible Problem Characterization Findings; Meeting 6 Agenda & Next Steps

Mr. Greenwood began the next portion of the meeting and combined Segments 4 and 5 due to time constraints. He presented the question: How do we land problem characterization among this group and then pivot into conversations about interventions, consistent with the charge given to the working group? Also, another charge not yet addressed as part of problem characterization is addressing implementation challenges to reduce the burden of existing MDP regulations while maintaining or enhancing public health protection. Discussions are ongoing to have presentations about current implementation challenges. A substantial portion of Meeting 6 will be dedicated to rewind back through the material that's been presented and land problem characterization.

Eleven topic areas were shared in the presentation, and WG members will be invited to share their input via e-mail:

Topic 1:
Drinking water system pathogen-related public health impacts – evidence and root causes related to water quality conditions in distribution systems and their relationship to outbreaks/illness. (NDWAC charge areas 1, 2)

Topic 2:
Premise plumbing pathogen-related public health impacts – evidence and root causes related to water quality conditions in premise plumbing and their relationship to pathogen-related outbreaks/illness. (NDWAC charge areas 1, 2)

Topic 3:
Distribution system water quality conditions related to pathogens – evidence and root causes of variable conditions and related vulnerabilities within the distribution system. (NDWAC charge areas 1, 2)

Topic 4:
Drinking water system DBP-related public health impacts – evidence and root causes related to DBPs in drinking water and their relationship to public health risks. (NDWAC charge areas 1, 2)

Topic 5:

Distribution system water quality conditions related to DBP formation – evidence and root causes of the potential for unaddressed public health risks. (NDWAC charge areas 1, 2)

Topic 6:
Source water conditions and related treatment requirements – evidence and root causes of challenges posed by source water quality. (NDWAC charge areas 1, 2)

Topic 7:
Storage tanks – evidence and root causes related to negative water quality impacts resulting from contaminant entry, formation, or growth due to improper or inadequate storage tank maintenance, operations, and management. (NDWAC charge areas 1, 2)

Topic 8:
Consecutive systems – evidence and root causes related to negative water quality impacts related to the unique circumstances of consecutive systems. (NDWAC Charge Areas 1, 2)

Topic 9:
Environmental justice impacts related to drinking water system water quality, maintenance, operations, and management in the context of pathogens and DBP risks. (NDWAC Charge Area 6)

Topic 10:
Areas that may introduce implementation or compliance challenges for drinking water systems/communities related to regulation and management of pathogens and DBPs. (NDWAC Charge Area 6)

Topic 11:
Data and analysis gaps.

Ms. Daniels and Mr. Kricun echoed this portion will be necessary to move onto the next step. They noted how these topics are interim and the list is considered a living document. Thanks were extended to the WG members and those from outside the WG who attended.

Ms. Corr extended thanks to all on the WG and to the team who helped bring this meeting together. Ms. Corr then adjourned Meeting #5.

Appendix 1: MDBP Working Group Meeting Attendance – December 13, 2022

Name	Attendance
Andy Kricun, WG Co-Chair	x
Lisa Daniels, WG Co-Chair	x
Alex Rodriguez	x
Benjamin Pauli	x
Bill Moody	x
Elin Betanzo	x
Erik Olson	x
Gary Williams	x
Jeffrey Griffiths	x
John Choate	x
Jolyn Leslie	x
Kay Coffey	x
Lynn Thorp	x
Lisa Ragain	x
Michael Hotaling	x
Nancy Quirk	x
Rosemary Menard	x
Scott Borman	x