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Potable Reuse: A New Frontier For Arizona's Water Resources

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ABSTRACT

Arizona, like many other states, faces uncertainty about the adequacy and reliability of our water resources. Arizona has long practiced water reuse for non-potable purposes and indirect potable reuse by aquifer recharge. Nationally, potable reuse is being developed as a way to meet growing demands in the face of climate change, drought, and environmental compliance. In 2014, the Governor's Panel on Water Sustainability identified potable reuse as a means to stretch our existing water supplies. The work of the Steering Committee for Arizona Potable Reuse, WateReuse Arizona, and the AZ Water Association over the subsequent three years culminated in development of a guidance document for implementation of potable reuse in Arizona. On January 1, 2018, the Arizona Department of Environmental Quality (ADEQ) adopted new rules that removed the prohibition on potable reuse, opening the door to the development and adoption of rules, guidance and permits for potable reuse.

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I. WHY IS POTABLE REUSE IMPORTANT TO ARIZONA?

The mild winters, abundant sunshine, lifestyle, and affordable cost of living continue to make Arizona one of the fastest growing states in the nation. Yet Arizona is also one of the most arid regions. As much as 97% of Arizona's water resources come from surface water and groundwater, while approximately 3% is from the direct (non-potable) use of reclaimed water.[1] The past decade has been punctuated by extended drought throughout the Southwest, raising concern for the long-term reliability of the State's surface water sources; specifically, the Colorado River, the Salt River, and the Verde River. Arizona is well ahead of other states when it comes to managing groundwater. The policies set forth by the 1980 Groundwater Management Act and the ongoing efforts of the Arizona Department of Water Resources have brought groundwater production into safe yield in what are defined as Active Management Areas (AMAs) that outline the major metropolitan areas across the state. However, some aquifers within Arizona continue to be unsustainably mined through excess groundwater pumping.

Water reuse is widely practiced in Arizona. Arizona, has historically included direct reuse for non-potable purposes and indirect potable reuse (IPR) where recycled water is introduced to an environmental buffer before being introduced to a drinking water treatment plant or distribution system. Direct potable reuse (DPR) involves the introduction of advanced purified water to a potable supply without an environmental buffer. The treatment technologies employed are more sophisticated and water quality specifications are more stringent as the use moves from non-potable reuse to IPR to DPR. During the 1980s direct reuse became a widespread means to reduce reliance on mined groundwater and offered a relatively simple way to provide large quantities of water for golf courses and turf facilities. The practice allowed many communities to avoid more stringent regulatory permitting and monitoring requirements of a surface water discharge permit. This is not in itself a best practice toward conserving water resources, but rather creates a demand to support full utilization of the reclaimed water. Indirect potable reuse via aquifer recharge has been used for decades in the more populated desert areas where hydrogeologic conditions support high recharge rates. But what about smaller communities with limited use for golf courses or areas where the geology does not support aquifer recharge?

DPR offers many opportunities and benefits for Arizona's water resource portfolio. The advanced purified water produced for DPR meets all safe drinking water requirements set forth by the EPA and is suitable for any use. This greatly expands the opportunities to support water demands for both municipal and industrial purposes. DPR can be implemented in places where the geology or depth to groundwater does not support aquifer recharge and recovery. DPR reduces the demands on natural surface or groundwater that may become stressed due to extended periods of drought. This lessens the pressure that limited water resources pose to the continued economic growth and vitality of Arizona.

II. HISTORY OF REUSE IN ARIZONA

Water reuse has been practiced in Arizona since very early in the State's history. In 1926, the first water reclamation plant built specifically for reuse was constructed at

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[1] Chuck Graf, Principal Hydrogeologist, ADEQ, New ADEQ Rules Advance Water Recycling (Nov. 9, 2017).

the Grand Canyon Village. The treated water was used for toilet flushing, boiler feed water, and water for steam locomotives.[2] Irrigation of crops with untreated sewage was practiced in Arizona and other states well into the 1930s. In 1932, the City of Phoenix began delivering water treated at the 23rd Avenue Wastewater Treatment Plant to the Roosevelt Irrigation District for agricultural irrigation purposes.[3] Arizona promulgated reclaimed water reuse rules for the first time in 1972 under the jurisdiction of the Arizona Department of Public Health.[4] The standards for water quality in these initial rules reflected the available technologies used in the wastewater industry.[5] At the time, the state of the industry was to employ primary and secondary treatment with disinfection, but with no nitrate removal. In 1984, the communities of Tucson and Scottsdale developed the first phases of their reclaimed water systems, beginning the conversion of large-scale turf facilities (e.g. golf courses) to reclaimed water. In 1986, the first two units of the Palo Verde Nuclear Generating Station became operational, using treated wastewater from the 91st Avenue Wastewater Treatment Plant for cooling.[6] This remains the largest public-private industrial water reuse scheme in the country to this day.

The reuse rules were updated in 1985, and the administrative responsibility for the rules was placed with ADEQ when it was created the following year.[7] The next 15 years saw explosive growth in the number of reuse permits. The state of industry had evolved and most waste water treatment plants included tertiary treatment, which generally consisted of filtration followed by higher level disinfection, but not necessarily nitrate removal. In 1997, ADEQ began an update to the rules, which were adopted in 2001. By this time, the state recognized Best Available Demonstrated Control Technologies (BADCT) and recognized five classes of reclaimed water quality for various non-potable purposes. Two of those water quality classes, Class A+ and Class B+, included nitrate removal to below the Federal drinking water standard of 10 mg/L, enabling indirect potable reuse via aquifer recharge. Class A/A+ requires filtration with strict water quality (turbidity) levels along with high level disinfection. This level of disinfection results in no detection of coliform bacteria and viruses in 4 out of 7 of samples, a much higher quality than the raw surface water in area canals which is fed to drinking water treatment plants.[8]

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[2] *Id.*

[3] *Id.*

[4] *Id.*

[5] ARIZONA DEP'T OF ENVTL. QUALITY, DRAFT FINAL REPORT OF THE BLUE RIBBON PANEL ON WATER SUSTAINABILITY 3 (2010), http://www.azwater.gov/AzDWR/waterManagement/documents/DRAFTBRPFinalReportDRAFT2-11-17-2010.pdf.

[6] *See* ECONOMIC BENEFITS OF PALO VERDE NUCLEAR GENERATION STATION, AN ECONOMIC STUDY BY THE NUCLEAR ENERGY INSTITUTE (2004), http://large.stanford.edu/courses/2017/ph240/carusa2/docs/nei-nov04.pdf.

[7] ARIZONA DEP'T OF ENVTL. QUALITY, *supra* note 5, at 5.

8 Chuck Graf, R.G., ADEQ, Principal Hydrogeologist, *After 90 Years of Reclaimed Water Reuse in Arizona, What's on Tap?*, (Nov. 18, 2016).

As technological advances allow our civilization to become more interconnected and use resources more efficiently, more opportunities for reuse become possible and higher quality recycled water can be produced. By 2017, the former reuse rules from 2001 were ready for an update that reflected the current state of the industry and future needs of Arizona communities.

III. DPR EXPERIENCE OF OTHER STATES

Currently, several states are expressing interest in DPR or are actively pursuing regulatory frameworks for DPR. Only Texas has constructed and permitted operational full-scale DPR facilities, although Arizona, California, Florida, and Georgia have all implemented successful DPR pilot and demonstration facilities. In addition, New Mexico's Cloudcroft facility is constructed, but has yet to be commissioned into service due to the complexity and high cost of operation. In 2016, the National Water Resources Institute (NWRI) completed a guidance document similar to the one prepared for Arizona.[9] California has led much of the research and discussion about direct potable reuse, and many states look to California for guidance in developing their own DPR programs. However, no full-scale DPR facilities have been constructed or permitted in California yet.

California and Texas have adopted different approaches, particularly toward establishing treatment goals for microbial contaminants. Microbial contaminant removal is measured in terms of log removal credit or value. The log removal credit is defined as "the number of credits assigned to a specific treatment process expressed in log units, for the inactivation or removal of a specific microorganism or group of microorganisms".[10] As an example, a 99% removal is a 2-log reduction and a 99.99% removal is a 4-log reduction. California's DPR regulations are on track to mimic their IPR rules for groundwater recharge projects which require 12-log removal of viruses, 10-log removal of *Cryptosporidium* and 10-log removal of *Giardia*. The removal requirement is typically expressed in shorthand as "12-10-10." *Cryptosporidium* and *Giardia* are indicator organisms for protozoa and bacteria. California considers the 12-10-10 removal requirement to begin with untreated wastewater. Alternatively, the Texas Commission on Environmental Quality (TCEQ), adopted a case-by-case approach that begins with the treated wastewater as a source water (secondary effluent) and established log removal requirements based on site specific source water characterization.[11] These concepts and other differences are discussed in more detail in Section V.

Other states are either investigating or actively pursuing development of DPR frameworks, including Idaho, Colorado, Nevada, Oklahoma, Georgia, North Carolina,

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[9] *See* NAT'L WATER RES. INST., RECOMMENDED DPR GENERAL GUIDELINES AND OPERATIONAL REQUIREMENTS FOR NEW MEXICO (2016), http://www.nwri-usa.org/pdfs/New-Mexico-DPR-Panel-General-Report(1).pdf.

[10] *Id.* at iv.

[11] NAT'L WATER RES. INST., GUIDANCE FRAMEWORK FOR DIRECT POTABLE REUSE IN ARIZONA (2018), http://www.nwri-usa.org/pdfs/NWRI_Guidance-Framework-for-DPR-in-Arizona_2018.pdf.

Florida, Ohio, and Minnesota. Unlike Western states where water availability is the major driver toward DPR, states like Minnesota and Florida view DPR as a means to avoid even more costly compliance for discharge of treated wastewaters to the environment as well as a solution to sea water intrusion.

IV. EARLY STAGES OF DEVELOPMENT OF POTABLE REUSE IN ARIZONA

The investigation into potable reuse for Arizona became a more concerted effort in 2010 with the Governor's Blue Ribbon Panel on Water Sustainability. The Panel's stated purpose was to "advance water sustainability statewide by increasing reuse, recycling, and conservation to protect Arizona's water supplies and natural environment while supporting continued economic development and to do so in an effective, efficient and equitable manner."[12] Following the direction set by the Blue Ribbon Panel, the Steering Committee for Arizona Potable Reuse (SCAPR) was established. The objectives of SCAPR included:

1. Identifying impediments to direct potable reuse;
2. Defining a common technology;
3. Gathering best practices, state of the industry information and case studies;
4. Tracking DPR efforts in California and Texas;
5. Creating advisory panels;
6. Conducting a scoping process to provide recommendations to ADEQ and ADWR; and
7. Developing a road map to potable reuse in Arizona.[13]

The SCAPR continued its mission through the next three years until ADEQ approached the SCAPR and WateReuse Arizona about assisting with the 2017 update of the reuse rules. At that time, WateReuse Arizona reached out to the NWRI for assistance in developing a framework for potable reuse in Arizona, modeled after the Framework for Potable Reuse published by NWRI, WateReuse (national organization), Water Environment Federation and American Water Works Association in 2015. To support these efforts, a listening session was held in May 2016 at the AZ Water Association's Annual Conference. Many water and wastewater industry professionals—including consultants, Arizona utilities personnel, and academics—were in attendance to receive an overview of the scope of the framework effort and provide input on key elements pertinent to Arizona's unique conditions. In February 2017, ADEQ and WateReuse Arizona formed a committee to assist in the update of the Reuse Rules and to provide recommendations for the development of a regulatory framework for direct potable reuse in Arizona. There were few major changes to the existing rules, and the most noteworthy change involved striking the prohibition on potable reuse in Arizona. Broad language was also included giving ADEQ the primary role in reviewing and permitting of potable

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[12] ARIZONA DEP'T OF ENVTL. QUALITY, *supra* note 5, at 5.

[13] Timothy Thomure, Water Reuse Practice Lead, HDR, The Future of Potable Reuse in Arizona: A Changing Conversation (Nov. 15, 2013).

reuse projects. As NWRI developed the framework document, the expert advisory committee provided review and input toward its development. The final document, along with specific recommendations from the committee, were delivered to ADEQ in January 2018.

V. THE DPR FRAMEWORK GUIDANCE DOCUMENT AND RECOMMENDATIONS

The final version of the Guidance Framework for Direct Potable Reuse in Arizona was released in January 2018. The document contains an overview of reuse in Arizona and nationally, discussion on water quality considerations, recommendations on public health protection, findings and recommendations covering 18 topics, and additional considerations for system reliability, antibiotic resistant bacteria/antibiotic resistance genes, and recommendations for research advances. ADEQ will then implement recommendations through regulation, guidance, or permits as appropriate. The following discussion includes a synopsis of each topic from the NWRI Guidance Document for DPR in Arizona and the how that topic is relevant to Arizona's unique conditions.

1. Terminology

The Guidance for DPR in Arizona provides definitions for the terminology used in regulations, permits, and guidance. The national framework for potable reuse uses the same terminology, which supports collaboration between states.

2. Public Health Protection

The protection of public health is the highest priority of direct potable reuse. The entire framework—including regulatory requirements, design of systems, operations, monitoring, managerial functions and contingencies—plays a role in the protection of public health. There are specific approaches to control pathogens and chemicals including: identification and level of control of pathogens and chemicals, a multi-barrier approach to control of pathogens and chemicals[14], , the use of indicator organism/compounds or surrogate parameters to monitor and assess treatment performance, the use of critical control points (CCPs) and critical operating points (COPs) to verify treatment performance,[15] compliance monitoring, including monitoring for regulated contaminants.

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[14] This includes treatment technology, and managerial and operational controls. For treatment, the multi-barrier approach means providing multiple treatment processes in series to provide redundancy of treatment. For example, pathogen inactivation or removal is accomplished by membrane filtration, ultraviolet light disinfection, and chlorine disinfection. By using different processes, there is an inherent robustness to the treatment train such that a process condition that reduces effectiveness of one process can be compensated by another.

[15] "CCPs are unit processes where the reduction of risk (removal of contaminants) can be demonstrated and verified by monitoring. CCPs provide information for automatic alarms and plant shutdowns based on trigger values." (NAT'L WATER RES. INST., *supra* note 11, at 35) COPs pertain to operational monitoring, but not risk reduction directly.

3. *Pathogen Control and Log Reduction Requirements*

Pathogen control is one of the most critical performance aspects of advanced water purification systems for potable reuse. The end game of pathogen reduction is to reduce the risk of infection to less than 1 in 10,000 persons per year. This is consistent with the Surface Water Treatment Rule (SWTR) under the Safe Drinking Water Act (SDWA).[16] While wastewater contains a wide array of bacteria, viruses, protozoa, and other microorganisms, the same three classes of microorganisms are used for defining log reduction requirements for potable reuse and for surface water. These three include *Cryptosporidium*, *Giardia*, and viruses.

There is a large body of research and historical data on the removal of these pathogens by different treatment processes, including processes that make up the advanced water treatment (AWT) facilities. The Guidance document includes log reduction values adopted by both California and Texas, which serve as examples while Arizona develops its own guidance documents. Interestingly, California and Texas do not always recognize the same log reduction values for similar treatment processes. This reflects the nature of ongoing research and data gathering on log reduction values.

Log reduction values for the DPR facility are the sum of the log removal values for individual processes. The total log reduction value for the facility must be greater than the required log reduction value. Processes are selected based on their robustness, as well as their ability to meet log reduction targets and provide multi-barrier protection. The California 12-10-10 approach assumes the starting point for log reduction value determination is untreated water. The California Guidance documents include recommendations for log reduction values based on the types of wastewater treatment. This approach requires no evaluation of the quality of the source water. The Texas approach follows the SWTR and begins with the effluent from the wastewater treatment plant, requiring evaluation of the effluent water quality for pathogen concentrations. However, the Texas approach includes lower log reduction requirements. For Arizona, it is likely that both approaches will be adopted and some guidelines may be established crediting the quality of Class A+ and B+ effluents.

4. *Chemical Control Approach*

A three-tiered monitoring approach is recommended for inclusion in the regulations, but implementation details may be set through permitting or guidance. Tier 1 includes all SDWA and state-specific drinking water requirements. In Arizona, there are no primary drinking water standards more stringent than, or in addition to, the SDWA. In general, wastewater meets most SDWA requirements for primary maximum contaminant levels (MCLs). Disinfection by-products, formed by the chemical reaction between disinfectants like chlorine or ozone and certain organic compounds, may occur in treated wastewater, but the advanced water purification processes used in DPR

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[16] National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule; Final Rule, 71 Fed. Reg. 653 (Jan. 5, 2006) (codified at 40 C.F.R. pt. 9, 141, 142).

removes or prevents their occurrence. Nitrate, formed in wastewater by the oxidation of ammonia, must be removed to less than the MCL of 10 mg/L. This is already a requirement under the 2001 rules in order to meet Class A+ or Class B+ quality, so no further treatment by the advanced water purification facility (AWPF) is necessary. In nearly all cases, chemicals under the Tier 1 category are regulated at the parts per million or parts per billion scale.

Tier 2 chemicals include those not regulated under the SDWA but of interest in terms of public health or under consideration for inclusion with the SDWA at a future date. Examples of Tier 2 unregulated chemicals include nitrosodimethylamine (NDMA) and related nitrosamines, perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and 1,4 dioxane. When detected in wastewater, these chemicals usually occur in the parts-per-billion or parts-per-trillion level.

Tier 3 chemicals include a broad array of pharmaceutical compounds and personal care products. It also includes caffeine and sucralose, two widely consumed chemicals that are common in wastewater. Tier 3 chemicals are not known to have, nor suspected of having, associated health risks. However, these chemicals are known to occur frequently in wastewater and are good indicators of treatment process performance and can serve as surrogates for other chemicals. Their occurrence is typically measured in the parts per billion or parts per trillion level. Concentrations greater than the performance criteria of the AWPF may not require a shutdown of the treatment operation, but are an indication that further evaluation is warranted.[17]

One of the challenges with modern technology and our ability to detect chemicals at such low levels is how to communicate the risks to the public. The detection of a chemical, particularly at parts per trillion concentrations, does not necessarily equate to a public health or environmental health risk. For most of these chemicals, it would take years of ingesting copious quantities of advanced purified water just to get a therapeutic dose or serving (as in the case of sucralose or caffeine), let alone pose a health risk. As engineers and scientists, we can only use the available research, knowledge base, and our best judgement. Yet, it is all too easy to create undue concern because a chemical is detected in water.

5. *Potable Reuse Applications in Arizona*

With an existing regulatory framework for indirect potable reuse via groundwater recharge, the focus of new DPR regulations is on raw water augmentation and treated drinking water augmentation. Raw water augmentation is the introduction of advanced treated water to a source water ahead of a drinking water treatment plant. In this case, the pathogen reduction and chemical control capabilities of the drinking water treatment plant are included with the overall treatment requirements for DPR. Treated drinking water augmentation is the introduction of advanced treated water directly to the

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[17] NAT'L WATER RES. INST., *supra* note 11, at 41.

distribution system or blended with other drinking water prior to entering the distribution system.

6. *Utility Collaboration*

In many instances, DPR facilities will involve or affect multiple utilities. Utilities producing advanced treated water might deliver drinking water to another utility. Alternatively, one utility may be responsible for wastewater treatment while another is responsible for advanced treated water. There are many utilities in Arizona where such conditions could exist. In these instances, a memorandum of understanding or inter-agency agreement should be required.

7. *Source Control Program*

An efficient and cost-effective strategy for managing chemicals of concern is to prevent them from being discharged into the wastewater collection system through an aggressive source control program.[18] A source control program can prevent chemicals that might be difficult to remove from ever reaching the treatment plant and, if properly implemented, can be an effective barrier for chemical control in DPR. An existing industrial pretreatment program can serve as a basis for a source control program. The General Pretreatment Regulations of the National Pretreatment Program require a local pretreatment program for wastewater treatment plants designed to treat flows of 5 million gallons or more per day. Smaller wastewater treatment plants, that accept wastewater from industrial users that could affect the treatment plant or its discharges, must also establish local pretreatment programs.[19] This requirement could be extended to all utilities implementing DPR, regardless of size or presence of industrial users. The local limits, established through a source control program for DPR, should focus on meeting chemical concentrations suitable for drinking water, which may be different than concentrations acceptable for surface water discharge permitting. A source control program can provide education and outreach to the public about proper disposal of household chemicals, pharmaceuticals, and personal care products that might otherwise find their way into wastewater. It should be noted that the various regulatory frameworks being developed for DPR do not assume that a pre-treatment program is in place; rather, they assume a worst-case scenario for raw wastewater quality. A robust pre-treatment program serves as a best practice to reduce overall risk and support the downstream treatment processes.

8. *Wastewater Treatment*

Effluents from wastewater treatment plants are the source for AWTFs. The processes and performance of the wastewater treatment plant directly affect the treatment

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[18] Tchobonoglous, G., Cotruvo, J., Crook, J., McDonald, E., Olivieri, A., Salveson, A., Trussell, R.S.; FRAMEWORK FOR DIRECT POTABLE REUSE. WateReuse Association (2015), at 45.

[19] EPA, INTRODUCTION TO THE NATIONAL PRETREATMENT PROGRAM 2-4 (2011), https://www3.epa.gov/npdes/pubs/pretreatment_program_intro_2011.pdf.

processes and performance of the AWTF. In Arizona, most wastewater treatment plants treat to a Class A, A+, B or B+ standard. The Class A+ standard is the highest quality effluent, is highly disinfected, and is denitrified to meet drinking water standards for nitrate. It is a very suitable feedwater quality for AWTF performance. New wastewater treatment plants must be capable of producing Class A+ water. Therefore, for most AWTFs, a Class A+ effluent should be the starting point. The Guidance document recommends allowing Class A+ or B+ effluent as the source for AWTF. Alternatively, an AWTF could include the process functions of wastewater treatment, but, at some point along the treatment process, a Class A+/B+ water quality must be demonstrated through monitoring.

9. Advanced Water Treatment Technologies

The past two decades have seen great advances in water treatment technologies, and many of these advanced treatment processes have been thoroughly studied for their application in DPR. Without delving into each of the possible combinations of processes, two stand out as generally accepted configurations. The first is what is referred to as ‘full advanced treatment’ (FAT), which includes membrane filtration, reverse osmosis (RO), advanced oxidation with UV, and usually a final disinfection with chlorine. This is the same process used at Scottsdale’s Water Campus since 1998, even though the end-use is indirect potable reuse. This treatment configuration produces very high-quality water, effectively removes all Tier 1, 2, and 3 chemicals, and easily meets all pathogen log removal targets. Typically, the total organic carbon (TOC) content of the RO product water is less than 0.5mg/L (for reference, TOC in the surface waters used for water supply in the Phoenix area are typically greater than 3 mg/L). The downsides of this process configuration is that it generates a waste stream—the concentrate—that is very difficult to dispose of in inland settings[20]. The other ATW process configuration, the ‘non-RO based’ approach, uses membrane filtration, ozonation, biologically active filtration, advanced oxidation with UV, and usually final disinfection with chlorine. This process does not generate concentrate and is not capable of removing dissolved salts and minerals. Additionally, the TOC of the water produced by the non-RO process is typically between 3 and 4 mg/L. Despite having a slightly higher TOC, the process is very effective at removing most trace organic compounds of emerging concern (Tier 2 and 3 chemicals) and usually has a very low potential for formation of disinfection by-products. The industry consensus is that the higher TOC of the non-RO process does not pose significant human health risk.

10. Pathogen Reduction Values for Treatment Processes

This section provides examples, based on data from California and Texas, for establishing appropriate pathogen log reduction values for individual advanced water purification processes. The State of Arizona could adopt these values as guidance for

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[20] *See discussion infra* Part 13.

DPR systems or could allow utilities to demonstrate log reduction values for treatment processes.

11. Potential Water Quality Impacts of Blending

Blending of ATW with existing drinking water supplies is likely to have some effect on the water quality served to customers. In many cases, ATW is of higher aesthetic quality than existing water sources, either by lower mineral content or lower taste and odor. AWTFs that use RO in their process will produce water that is very low in TOC and mineral content. This may improve the quality of many drinking water systems but could result in corrosion issues. For non-RO based treatment trains, there may be higher levels of total organic carbon and higher mineral content than the existing drinking water. As part of the development and implementation of a DPR system, the blended water characteristic and impacts on the drinking water distribution system must be evaluated and appropriate steps must be taken to mitigate impacts.

12. Monitoring, Instrumentation and Process Control Requirements

This section includes an introduction into the concept of CCPs and provides examples of process performance monitoring and verification methods for non-RO based processes. Redundant monitoring of critical processes is recommended, as are automated system controls that can provide system shutdown and diversion of off-spec water. The recommendations for regulation include start-up performance monitoring of each treatment process prior to ADEQ approval.

13. Management Options for Reverse Osmosis (RO) Concentrate

RO is a key treatment process in many advanced water purification plants. RO is highly effective at removing dissolved organics and minerals. However, the process generates a significant waste stream called brine or concentrate. Concentrates from advanced water purification treatment trains are typically five to ten times more saline that the feed stream and the volumes are commonly 10-20% of the feed stream. Disposal of concentrate is very problematic in inland areas like Arizona. Concentrate disposal options for inland sites include: surface water discharge, deep well injection, discharge to wastewater collection systems, evaporation ponds, land application, and zero liquid discharge.

Any surface water discharge must have an Arizona Pollutant Discharge Elimination System (AZPDES) permit. This is challenging due to the high Total Dissolved Solids (TDS) and probable presence of regulated compounds in excess of surface water quality standards. This method can work where the receiving water body is sufficiently large or with sufficient flow to dilute the brine; that is very difficult to find in Arizona.

Deep well injection technology is in use in other parts of the country. Deep well injection requires the right geologic conditions and the receiving aquifer may not be used as a drinking water source. As the name implies, these wells can be quite deep (several thousands of feet), costly, and prone to plugging of the surrounding soil resulting in loss of injection capacity. In the view of ADWR, all aquifers in Arizona have the potential to be a domestic water source, so there is no regulatory framework to allow deep well injection.[21] Proposals have been made for allowing deep well injection for concentrates from regional desalting facilities, but suitable sites are not easy to find.

Discharge to wastewater collection system is probably the least expensive means of concentrate disposal, when available. It requires a much larger wastewater facility downstream in order to dilute the concentrate. Clearly, this is not available to the many smaller, dispersed communities in Arizona considering DPR as a future water supply option. The City of Scottsdale's Water Campus discharges its brine to the 91st Avenue Waste Water Treatment Plant (WWTP), owned by the Sub-Regional Operating Group (SROG). However, if other SROG member agencies choose to discharge RO concentrate to the 91st Avenue WWTP, the concentration of salts would increase to unacceptable levels impacting treatment processes and rendering the effluent unusable. Limits on the TDS of discharges to the SROG system have been proposed in the past.

With Arizona's abundant sunshine, evaporation ponds are seemingly an ideal solution. To put the scale of the ponds in perspective, the concentrate from a 1 million gallon per day facility generating 125 gallons per minute of concentrate requires approximately 55 acres of ponds in the Phoenix metropolitan area. To prevent contamination of the underlying aquifer, the ponds must be lined (and typically double lined) with leak detection systems and monitoring wells. Even if land is inexpensive, liners and monitoring wells are not, and the evaporation pond option becomes a very costly option. The salt residue may require disposal in an industrial waste landfill depending on the concentrations of chemicals that are present.

The land application option is rarely available and suitable only for low concentration RO concentrate solutions and/or salt tolerant plants. Zero liquid discharge (ZLD) involves the use of evaporators, brine concentrators and crystallizers to concentrate the brine and dry it to a solid suitable for landfill disposal.[22] As with evaporation pond residues, disposal to an industrial waste landfill may be required. The City of Chandler operates such a system to treat brines from the industrial process water recovery plant serving the Intel FAB facility. These systems are very expensive due to the specialty metallurgy required to resist corrosion and the high energy input needed.

There are several technologies, many of them proprietary, that concentrate brines and may recover valuable salts and minerals. The economic benefit to these processes is primarily to reduce the scale and cost of evaporation ponds or ZLD systems. "High recovery and ZLD processes are technically feasible, but generally are not economically

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[21] NAT'L WATER RES. INST., *supra* note 11, at 80.
[22] *Id.*

feasible for municipal applications."[23] Consequently, advanced water purification processes that do not require RO, or limit the use of RO, to only what is necessary to reduce salinity have a greater chance of success for DPR in Arizona.

14. Facility Operations and Maintenance

A robust operations and maintenance (O&M) program is essential to the success of an advanced water purification facility and protection of public health. The O&M program of any utility can make or break its success. The state of the industry in Arizona is characterized by a shortage of qualified operators for existing water and wastewater treatment operations. The advanced water purification processes used for DPR system require education and training beyond what is offered by current operator certification programs. During the development and review of the Guidance document, there was a lot of discussion regarding operator certification and whether the lead operator's primary certification should be a wastewater treatment certification or a drinking water treatment certification. The argument for wastewater treatment operator certification is that many of the processes used in wastewater treatment are like water treatment, and the quality of wastewater treatment operations directly impacts the quality of water feeding the AWTF. There are benefits to having operators with certifications in both wastewater treatment and water treatment, and ultimately, in practice, this may become the norm. However, the committee concluded that the Operator of Record should hold a Grade 4 (highest level) water treatment operator certification and that a supplemental certification or endorsement in advanced water purification operations should be required. Arizona does not have a separate certification or endorsement for advanced water purification operators; however, other states are evaluating this and it is likely that some private entity will offer such certifications at a national level in the future.

Operating plans should also contain: an emergency response plan, an off-spec water response plan, and an alternative water supply should the DPR source become non-operational. The AWTF should have fully automated monitoring for CPP indicators and be able to generate and communicate alarms to operators through the utility's supervisory control and data acquisition (SCADA) systems. Automation is now widely used in the industry and is the norm for new plants and existing plants can be retrofitted.

15. Technical, Managerial, and Financial Capacity

Technical, Managerial, and Financial (TMF) capacity is necessary to demonstrate the long-term viability of a utility and its ability to provide safe, dependable drinking water.[24] The treatment process technology and operation are only a part of the TMF capacity. The 1996 SDWA defined requirements and responsibilities for ensuring that public water systems maintained TMF capacity and the State of Arizona has an existing

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[23] *Id.* at 81.

[24] *Id.* at 88.

program in place for public drinking water systems. The TMF capacity assessment evaluates a utility's capacity to:

a. Build, operate, manage, and sustain a DPR system for the long-term;
b. Plan, achieve, and maintain regulatory compliance;
c. Provide effective public health and environmental protections; and,
d. Make efficient use of public funds and sustainable public investments.[25]

Given the source of water for DPR, additional considerations and requirements should be included in any TMF assessment. Despite the technologies at our disposal, there is no substitute for the responsible and conscientious management and operation of DPR systems. The Guidance document recommends that TMF be required for DPR projects, but that the assessment may not involve the State's existing program.

16. Considerations for Small Water Systems

Small water systems are defined as those serving fewer than 10,000 people[26]. In all aspects, small water systems must comply with all of the rules and regulations the State requires for DPR systems. This may present challenges to many small systems, particularly for demonstrating TMF capacity and the ability to attract and retain qualified operators. While implementation of DPR for small communities may be challenging, it is those Arizona communities that likely have the greatest need for DPR due to the State's limited water resources.

17. Considerations of Alternatives to the Criteria for Direct Potable Reuse

This provision allows a utility to propose alternatives to DPR criteria or requirements. The utility must prove that the proposed alternative is as protective of public health as the State's adopted criteria and requirements. Arizona will review the adequacy of the proposed alternative before approving it for implementation. This provision allows for new technologies and approaches to be considered without an update to current rules and Guidance documents. This is nothing new or unique. Much of ADEQ's current guidance for treatment process design for water reclamation facilities is over 30 years old and there have been substantial advancements in the understanding and design of treatment processes, as well as many new suitable technologies available to utilities.

18. Public Acceptance and Outreach

In terms of importance to the success of DPR, Public Acceptance and Outreach might be rated Topic Number1. Public outreach for individual DPR projects is not the

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[25] *Id.*

[26] *See Supra Note 17*

role of the State of Arizona. That responsibility lies with the utility. Each utility should develop a communication plan for public outreach. However, the State can play a vital role in the public outreach effort. The State can adopt a general outreach program, engage in activities to impact public perception of DPR, and lead the establishment of consistency in appropriate terminology for discussions about DPR with the public.

VI. CONCLUSION

The Guidance document is comprehensive and contains the most current information available from industry professionals, yet this does not guarantee successful implementation of DPR. The next phase of development of direct potable reuse involves further development of rules, permitting requirements, and guidance by ADEQ. The Reuse Rule Update Committee has provided its own recommendations to ADEQ which further clarifies certain elements of the Guidance document. As these recommendations are currently under review by ADEQ, they are not detailed here. There is also a need for suitable operator certification programs and training of operators for DPR systems. The ADEQ will need additional resources and support to implement permitting and compliance monitoring of DPR systems. But perhaps the most pressing need is to develop a positive message and cultivate the public's trust that DPR is safe and offers tremendous benefits toward the sustainability and reliability of Arizona's water resources.