water e-journal
Online Journal of the Australian Water Association
ISSN 2206-1991
Volume 5 No 1 2020
https://doi.org/10.21139/wej.2020.004

Community Acceptance For Indirect Potable Reuse

Developing a Validation and Acceptance Program for the Community

D Healy, D Middleton, A Salveson, D Owen, J Bishop, N Turner

ABSTRACT

Seqwater is beginning a three-year process to validate process performance and gain community acceptance and regulatory approval for indirect potable reuse through its Western Corridor Recycled Water Scheme. The current study reviewed the success of water reuse schemes and demonstration programs in southwest United States, through site visits and engagement with industry representatives.

The study compared log reduction values for process barriers and recommended further research in Reverse Osmosis validation, including indicators for challenge testing. Community engagement was found to be best achieved through leveraging off the medical community and industry, and linking engagement with process validation and resource sustainability.

Keywords: Potable reuse, recycled water, process validation, community engagement.

INTRODUCTION

Southeast Queensland's response to the Millennium Drought included the Western Corridor Recycled Water Scheme (WCRWS) comprising three large Advanced Water Treatment Plants (AWTP) and an interlocking pipeline to power stations and Lake Wivenhoe for future Indirect Potable Reuse (IPR).

Due to significant rain events following its construction, the WCRWS has so far only supplied power stations. The operation of the IPR component is currently dependent on drought trigger levels, but also community acceptance and regulatory approval. Seqwater's 'Water Future Program' seeks to improve community awareness and understanding of all future supply options.

Potable water reuse in the southwestern United States (US) began with California's Ground Water Replenishment Scheme (GWRS) over 50 years ago and since the 1970s there has been an increased focus on managing related health concerns.

In the late 1990s, a proposed surface water IPR scheme in San Diego initially failed to win community acceptance; but since 2011, the city has successfully fought hard to win it back through its PURE water program. This program and, more recently, El Paso's water reuse program are recent success stories for process validation, state regulatory approval and community engagement through demonstration (pilot scale) facilities. Many smaller schemes throughout Texas, Arizona and Colorado have also been accepted and have already successfully augmented supplies.

Community acceptance of potable reuse

Gaining community acceptance and regulatory approval for potable reuse in Australia can be a lengthy process taking over three years to accomplish. The delivery and commissioning of membranes and subsequent process validation takes a significant portion of this time.

The main driver for most potable reuse schemes is drought response as shown in Figure 1, due to either low surface water supply levels or increasing salt water intrusion in ground water supplies.

Both the US and Australia have desalination as a water supply option despite operating costs nearly double that of producing Purified Recycled Water (PRW) from an AWTP. Where the US water supply systems often differ is that PRW options are also supported by the higher cost of water importation via pumping and aqueducts (e.g. El Paso's imported water at $2840 compared with PRW at $1370 per acre-foot (Montoya 2018)).

100%	**Water efficiency awareness** Operational measures, supply system loss management and efficiency messaging
70%	**Drought readiness** Increase efficiency messaging
60%	**Drought response** Voluntary target 150 L/day messaging Desalination full production ***WCRWS recommissioning (within 2 years)***
50%	Voluntary and restrictions Target 140 L/day messaging and medium level restrictions
25%	**Drought contingency** Voluntary and restrictions Target 120 L/day messaging and high-level water restrictions
20%	Contingent infrastructure construction commences
10%	Voluntary and restrictions Target 120 L/day messaging extreme level water restrictions
5%	Contingent infrastructure available - Essential minimum supply volume restrictions
Min	**Minimum operating level**

Figure 1: Seqwater (2017) drought response plan

Whilst the operation of the WCRWS is currently based on drought-related triggers (Figure 1), Seqwater has planned a community engagement pathway to determine if, through community support, supplies can be augmented with PRW from one of its three AWTPs without reaching a drought trigger level.

This preliminary move, if approved, will improve climate resilience as it will allow rapid recommissioning and validation of the remainder of the scheme within the two years before other contingent infrastructure becomes necessary should the drought water supply levels worsen. This will also support increasing production by providing additional source water as southeast Queensland's population is expected to grow from 3.1 to over 4 million people by 2025.

Process validation and regulatory approval

The US schemes are comparable with Australian schemes in that their validation and approval are both subject to state-based regulation.

Although under consideration for their *Water Act*, the United States does not yet have national regulation for potable reuse and all schemes are reliant on approval from the state's *Commission on Environmental Quality* and community acceptance. The US EPA currently provides an advise and assist role and organisations such as the Water Research Foundation coordinates collaborative research.

Similarly, Australian schemes have validation guidance at a national level through the *Australian Guidelines for Water Recycling (AGWR) and the WaterVal Protocols*. But challenges still exist for validation and much can be learnt from the well- established American examples for Australia's first IPR schemes.

Scope and Limitations

The current study aimed to compare the validation of process performance of the WCRWS with that of relevant IPR schemes in the United States. The study identified opportunities for Seqwater to improve validation processes for the WCRWS and identify priorities for further research.

The study also argues that an improved knowledge of log reduction values and chemical removal can avoid over investment and inform incident management processes in a true multi-barrier approach.

The study also aimed to examine programs for community acceptance and explored the interdependence between community acceptance, regulatory approval and the role of an effective validation.

The study also argues that both community acceptance is more than attitudinal; that it is hinged on an effective validation that provides assurances of safety and explains how IPR processes work.

METHODOLOGY

The study involved visiting potable water reuse programs and engagement with water industrial professionals who have been involved in demonstration facilities and community outreach.

This included Orange County Water District's GWRS and Fountain Valley AWTP, City of Wichita Falls Cypress AWTP, City of San Diego's PURE Water Program demonstration facility, Stone's Escondido brewery (involved in a PRW collaboration), and through access to a wide range of industry professionals at WateReuse's 33rd Annual Symposium in Austin.

The current study focussed on presentations at the *WateReuse 33rd Annual Symposium* held in Austin in September 2018 that were relevant to potable reuse in two areas:

1. The differences between various entities in their approach to validating the performance of process barriers in terms of Log Reduction Values (LRV) and chemical removal, the limitations imposed by their state regulators, and to identify areas for further research. It achieved this by comparing available information on US operations with Seqwater's validation.
2. The key areas for community acceptance: effective messaging, the best ambassadors for engagement, and the use of demonstration plants and exhibitions such as PRW in beer.

Seqwater conducted an initial small research program to establish an understanding around PRW language and terminology that best resonates and promotes community awareness. This included two qualitative focus groups with 8 people in each group; one consisting of 18-35 year olds and the other >35 year olds, each with a mix of gender, age (within the range), household income, occupation type, and household structure (Hindis and Clifford, 2018, p. 12).

The current study examined the results of the focus groups on influential language and compared this against American outreach programs and similar studies undertaken in the Australian context by Water Corporation.

The findings of the study were then recommended for the WCRWS to facilitate community outreach and position the WCRWS for successful commissioning verification and regulatory approval within two years.

RESULTS & DISCUSSION

Comparison of process performance validation

The validation of processes performance within the scheme to ensure that pathogens and chemical contaminants of concern are sufficiently removed is a critical part of the approval and acceptance process. The validation process for the WCRWS includes undertaking pre-commissioning validation as shown in Table 1, and then prior to the commencement of IPR, undertaking validation testing and verification monitoring during final commissioning.

This was found to be consistent with US schemes with some including demonstration plants to complete pre-commissioning validation and build regulatory and community support in programs typically completed in 3-10 years.

A comparison between the microbial LRV validated for WCRWS and PURE Water Program demonstration facility is shown at Table 2.

CCP	Validation methods	Monitoring parameters
1. WWTP (BNR activated sludge process)	Scientific literature Historical data Challenge testing	Ammonia
2. Membrane filtration	Scientific literature	Pressure decay test
3. Reverse osmosis	Scientific literature Historical data Challenge testing	Conductivity Sulphate removal
4. UV/AOP	Scientific literature Historical data	Present Power Ratio
5. Chlorine disinfection	Scientific literature Historical data	Chlorine C.t, concentration and dose rate

Table 1: WCRWS Pre-commissioning Validation

Critical Treatment Process	Validated Microbial Removal, LRVs [Estimated LRV in square parentheses]					
	Viruses		Protozoa			Bacteria
	WCRWS	PURE Water	Cryptosporidium# WCRWS	Cryptosporidium# PURE Water	Giardia PURE Water	WCRWS
STP (secondary effluent)	0.5 [2]	0.7	0.5 [1]	0.9	3.2	1 [2]
Ozone / BAC	NA	6	NA	1	6	NA
Microfiltration	0 [2]	0	3.5 [3.5]	4	4	3.5 [3.5]
Reverse osmosis	2 [5]	2.5	2 [6]	2.5	2.5	2 [6]
UV - Advanced Oxidation	4 [6]	6	4 [6]	6	6	4 [6]
Chlorine Disinfection	4 [4]	6	0 [0]	0	1	4 [4]
Total Log Removal	**10.5 [19]**	**21.2**	**10 [16.5]**	**14.4**	**22.7**	**14.5 [21.5]**
Required LRV (IPR)	9.5	9	8	9	8	8
Required LRV (IPR <180 days detention time in storage)*	NA	10	NA	10	9	NA

Table 2: Comparison of microbiological removal validated and estimated values for each CCP

* The PURE Water program's receiving lake has been hydrodynamically modelled to have <180 days storage which therefore requires the higher LRV shown.

The WCRWS is validated for protozoa but used Cryptosporidium as the indicator as it is regarded as the most difficult to remove.

A notable distinction is that Californian regulation is based on the microbial removal requirements of viruses/*Cryptosporidium/Giardia* (Ford 2018), typically expressed in the US as, for e.g., '9/9/8'. The AGWR referred to by Australian regulators combines *Giardia* and *Cryptosporidium* into a single protozoa treatment requirement and also includes a bacteria reduction requirement.

The achievable estimates shown in parentheses for the WCRWS validation in Table 2 are comparable with PURE Water's (except for RO), but are yet to be achieved through the methodologies shown in Table 1 or are limited by regulation.

Firstly, the estimated achievable LRVs for RO are not able to be demonstrated in either scheme. It is difficult to achieve these estimates through challenge testing and continuous monitoring due to challenges with performance indicators.

This includes finding surrogates that suitably represent pathogens such as viruses in size and charge, but also have sufficient feed concentrations to be within the detection limitations of current analytical laboratory techniques. Accordingly, improving the validation of RO is argued below as the highest priority for future research.

Secondly, the Australian guidelines and typical regulation limit the maximum credit for any one barrier to a LRV of 4-log for microbial removal to promote a multiple barrier approach in the design and construction of AWTPs. This limits the LRVs demonstrable for processes such as Ultraviolet- Advanced Oxidation (UV-AO) and disinfection.

Whilst this is distinct from most American regulation, similar arrangements exist in states such as Texas where processes such as RO are mandated for chemical removal despite not being afforded any microbial LRV credit. These are highly conservative approaches when some processes can be validated and monitored to be certain that the process has achieved much more than this limit.

Accordingly, it is argued below that this should be considered in managing incidents where sub- optimal performance for a single barrier is mitigated by the other barriers in a true ‘multiple barrier’ approach.

The validation of RO as a priority for research

The validation of RO is currently the subject of many investigations and debate. Mattingly (2018) has described two current major Water Research Foundation projects specific to advanced water treatment:

1. Water RF project 4958 – New techniques and tools and validation protocols for achieving log removal credit across nanofiltration (NF) and RO membranes.
2. Water RF project 4954 – integration of high frequency performance data for microbial and chemical compounds control in potable reuse treatment systems. This includes recommending suitable indicator viruses and validation methods.

Independent studies are useful as larger collaborative studies, such as those of the Water Research Foundation, and Water Research Australia, are only in their early phases.

Likewise, the US EPA is yet to formulate regulatory guidance at a national level in the United States but indicates it will do so as it has for drinking water through its Long-Term Surface Rule 2.

An accurate and well-regarded validation for Reverse Osmosis is the highest research priority as it will prevent over investment or operational costs through additional treatment that may not be required.

On the other hand, it will justify the expense of other barriers for chemicals not sufficiently rejected by the RO membranes.

Validation based on salt rejection in conductivity terms typically finds LRVs of 1.5-2.0. At present, a number of independent studies and demonstration facilities have gone on to find higher LRVs using sulphate (e.g. Seqwater), TOC and strontium (e.g. PURE Water Program), and MS-2 coliphages (e.g. Yucaipa Valley (Vickers 2018) to measure or challenge test process performance.

The advantage of parameters such as strontium used by PURE Water program is that they are easily monitored on an ongoing basis to measure reliability and respond to performance issues based on LRV. This is particularly useful to make operational decisions other than complete shutdown or diversion to waste. The advantage of challenge testing with MS-2 coliphages is that the estimated LRVs of 6 or higher for processes such as RO and UV-AO are demonstrated, but is not a practical approach to operational monitoring.

However, these surrogates are not without their challenges. Schemes such as the WCRWS have difficulties of low feed concentrations, often below the limit of detection, for parameters such as strontium. Other surrogates are often limited by analytical laboratory techniques both in difficulties separating or isolating the compound or the limits of the instrument’s detector.

Another disadvantage is that strontium ions are charged and do not perfectly represent exclusion of larger non-charged molecules such viruses which are mostly rejected on size alone and could pass through imperfections in the membrane, leaking seals, etc.

The independent study (Vickers 2018) using MS-2 coliphages was particularly challenged in keeping the coliphages viable before challenging the process and being certain that the results obtained represented actual removals. This involved multiple attempts and short turnarounds between the laboratory and challenge testing on-site.

Multiple barriers and incident management

The PURE Water program proposes a system shown in Figure 2 where the full benefit of having multiple barriers is realised in the event that a single barrier’s performance is sub-optimal. This allows operations to continue when the risk is sufficiently mitigated by the other barriers.

One point of difference is that the PURE Water scheme includes ozone and Biological Activated Carbon (BAC) in pre-treatment stages of the AWTP, giving them an advantage over typical GWRS and WCRWS operations which do not.

A BAC or Graphite Activate Carbon (GAC) process step is advantageous in a multiple barrier context as it compares with RO membrane free operations (e.g. Windhoek in Namibia) which are reliant on BAC and GAC processes to ensure sufficient chemical removal occurs.

In essence, it ensures that chemicals that are not well rejected by RO membranes, such as Volatile Organic Carbon (VOC) compounds, are further removed from what is achieved in the wastewater treatment processes. BAC or GAC processes also have the benefits that pre-treatment provides in terms of reduced backwashing and maintenance on membranes.

Whilst chemical removal is important, arguably in the context of an IPR scheme, a short-duration incident of sub-optimal performance will be diluted in the water storage and in many cases concerns only chronic health parameters.Accordingly, critical incidents could be assessed in the same light of the PURE Water Program, where response to exceedance of critical limits is risk-based.

Community awareness and negative sentiment

Some outreach studies have found that most people have been taught to see anything related to wastewater as 'bad' or a disease burden, creating a perceived 'yuk' factor (e.g. Nix 2018).

The difficulties with community acceptance is dominated by the perceived 'yuk' factor. Our capacity to absorb factual information is blocked by negative associations of dirty water that are based on fear rather fact (Carpenter 2018).

This 'yuk' factor appeared in media reporting and community perceptions when San Diego unsuccessfully first raised the plans for its IPR scheme only to achieve 26% acceptance. Their PURE water program has been successful in raising this to 76%.

Currently, according to Seqwater research, 65% of residents in southeast Queensland believe using PRW is appropriate to replenish Wivenhoe Dam during times of drought (Hampton and Abrha, 2018).

Key parts of successful programs in the US include public messaging that uses terms such as 'pure water' and avoids the waste related terms such as 'recycled water' which surveys indicate are not well received with American audiences.

However, research conducted via focus groups by Seqwater (Hindis and Clifford, 2018) found that residents of southeast Queensland were sceptical of terms like 'pure water' as they thought someone was trying to sell them something.

Participants in these focus groups liked 'purified recycled water' the most out of several terms presented to them. Seqwater will continue to research which IPR terms will best resonate with Queensland audiences.

The best messengers were found to be through the medical community and industry, with all outreach programs creating alliances or using these professionals as ambassadors or key influencers.

Figure 3 shows that in a US survey undertaken by WateReuse (Carpenter 2018), the community was found to trust information about recycled water provided by medical and Department of Health professionals.

In the same figure, it appears that there is always 19-24% who will be suspicious of any recycled water information and 4-13% who are ambivalent or unable to answer, and success in influencing these groups through outreach can drive support above 80% levels.

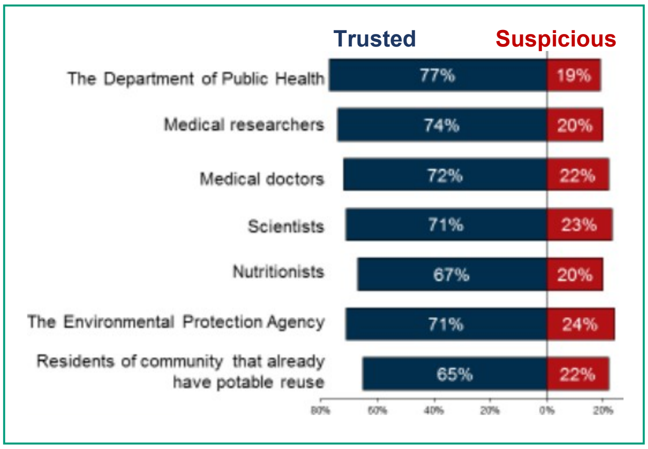

Figure 3: WateReuse US survey on the best messengers for PRW information (Carpenter 2018)

Outspoken individuals who voice concerns at community 'Town Hall' meetings can be positive as they provide an opportunity to provide factual information and identify themselves for follow up engagement.

This is important in countering the influence of opposing non-expert sources such as celebrities with limited scientific or medical backgrounds as evident for other contemporary health-related issues such as vaccination (Motta et al., 2019).

Accordingly, 'finding new ways to present scientific consensus' to those who are 'sceptical' of experts should be a priority for current programs and future community engagement studies.

PRW language for effective engagement

The results of Seqwater's focus groups on PRW language and terminology that best promotes community awareness are shown in Table 3.

Both focus groups found terms such as 'potable' or brand names such as '6-star water' did not appeal to them. This was also identified by Water Corp's research (Turner 2019) on consumers in Perth.

Rather, names that appeared honest and direct, but also promoted a 'purity' aspect such as 'purified recycled water' were found to be the most acceptable in the Australian community.

Potential names	Rating
Purified recycled water	√√√
Dam replenishment	√√√
Water	√√
Reclaimed Water	√√
Groundwater replenishment	√
Water reuse	√
Reycled water	√
New water	X
Potable reuse	XXX
Potable recycled water	XXX
Direct potable reuse	XXX
Indirect potable reuse	XXX
6-star Water (Simpson 2006)	XXX

Table 3: Focus group ratings of PRW terms (Hindis and Clifford 2018, p. 12)

These results are distinct with American programs that have used a brand name to promote PRW or avoid reference to recycled or wastewater.

But on the other hand, those organisations using branding such a 'PURE Water' (e.g. San Diego) or relating to its use as 'Ground Water Replenishment' (e.g. Orange County and Perth) remain consistent with this purity and honesty approach.

What remains important is that terminology in community engagement and demonstrations and plant tours promotes awareness of how the process works and the safety of PRW, helping counter potential 'yuk' factor perceptions.

PRW demonstration plants

The use of mobile demonstration plants or larger on-site pilot plants as demonstration facilities (e.g. San Diego, El Paso, Denver) has also been effective in changing community attitudes.

The mobile demonstration facility pictured in figures 4 and 5 has toured across the mid-west United States and was built for USD 250,000 with assistance through donated components and engineering design.

The mobile plant connects to the municipal wastewater treatment plant's effluent and produces purified recycled water using a typical, albeit small- scale, treatment train arrangement. However, the final product is not approved for consumption compared with tasting and free samples provided at Orange County and San Diego tours held at fixed plants.

Figure 4: Mobile demonstration plant tour

Figure 5: Mobile demonstration plant's UF process

On-site pilot plants have been successful in Denver, El Paso and San Diego and are consistent with full-scale plant tours (e.g. Orange County).

The PURE water post tour survey found an increased understanding of water purification from 56% before the tour to 96% who rated 'good' or 'excellent' afterwards.

A key feature of the tours is that an engineer is present to respond to technical questions and, where needed, to further explain the science behind the process.

Promotions using PRW in beer and resource sustainability messaging

A number of programs across the United States have increased the momentum of their outreach programs through collaborations with breweries using recycled water in single batches of promotional beer (e.g. Stone Brewing Full Circle) or brewing competitions and festivals (e.g. Arizona's AZ Pure Water Brew Challenge).

Stone Brewing is considering a second collaborative beer with the PURE Water Program and indicated that the collaboration is mutually beneficial for smaller independent brewers who embrace sustainability and benefit from the media attention.

The benefits to the water service provider of recycled water in beer promotions are through demonstrated support and confidence of a safe high-quality product from industry representatives who are trusted experts in water quality, albeit through brewing.

Participation and subsequent media coverage of brew masters and highly regarded community leaders, for example, San Diego's Mayor (Figure 6), tasting the product is also effective.

As a first step, Seqwater recently promoted the idea of 'manufactured' water through free desalinated water refills and a 'desalichinos' coffee stand at the Ekka, Brisbane's largest agricultural show.

Coincidently, there were coffee industry representatives present when the current author toured Orange County's plant who share the same interest as brewers in sustainability and water quality for their processes.

Figure 6: 'Full Circle Pale Ale' PRW promotion

Surveys were conducted with willing participants who had tasted the desalinated water at Seqwater's Ekka stand.

Consistent with the focus group results, some people indicated that potable water reuse could work, but that people would need to understand how the process works.

Interestingly, a small minority of visitors showed a confirmation bias that a salty taste existed even though salt levels in re-mineralised desalinated water are much lower than Brisbane's conventional drinking water supply system.

Likewise, recycled water in beer competitions, such as one held in Florida, found a bias towards lighter coloured lagers and ales, compared to those willing to sample darker beers such as porters and stouts.

In the same surveys, resource sustainability was also found to be important to respondents for reasons such as the current drought conditions affecting farmers in rural areas and the rising cost of food and living expenses.

An environmental focus was evident when some visitors to the stand expressed disappointment in the use of plastic sample cups after paper cups had run out. Sustainability, including recycling and reducing waste, is becoming increasingly important to the community.

The initial stages of San Diego's potable reuse campaign had arguably been set back by advertising by a major brewer in Denver highlighting that their product was made from fresh mountain water compared with their Los Angeles rival using water supplies that were being augmented by a GWRS scheme.

Fortunately, it would be more difficult for the same public campaign to affect potable reuse outreach today as the community becomes increasingly savvy in sustainability.

The fresh mountain water in this example is most likely impacted by upstream communities and agriculture, referred to today as 'defacto recycled water', and is only subject to conventional treatment processes before its supply to the community.

Opportunities still exist in improving community awareness of future water supply options and Seqwater has included this in its strategic plan.

The interdependence between validation, community acceptance and regulatory approval

It is important that the treatment technology will remove microbial and chemical contaminants from the water; that regulation will protect public health without being unnecessarily conservative; and that 'negative associations and fears can be reframed by creating a better understanding of water' (Carpenter 2018). Process validation, community acceptance and regulatory approval are interdependent in the following ways:

Process validation and community acceptance

The interest in the community in understanding PRW amongst other future supply options can be summarised by one respondent from Seqwater's focus groups (Hinds & Clifford 2018, p.9):

"I think technology these days could do it. I think there would need to be some convincing evidence for the average person to understand, but I think I could get there and consider it."

The challenge is to be able to communicate in an understandable way how the treatment technology works and the science behind it.

Community acceptance and regulation

Consumer sentiment is important to regulation and regulatory approval with both the decision to proceed with potable reuse and its regulatory approval ultimately requiring the support of the responsible minister.

This is an important democratic dimension and ultimately results in giving the wider community what they want in terms of source options as the population grows and sources are impacted by climatic variation.

Regulation and process validation

This is necessary for regulatory approval that ensures safe drinking water and protects public health. But like the general community, regulators are also influenced by information in the public domain.

There is currently a high degree of conservatism, limiting the validation claimable based on literature and mandating some barriers such as the receiving lake in the WCRWS or RO in Wichita Falls TX, whilst not affording them any LRV credit.

Accordingly, there exists a potential for over investment or the potential for overreaction during incident management when a single process has sub-optimal performance and the coverage provided by multiple barriers is not considered.

CONCLUSION

The study found that much can be learnt from US experience in potable reuse schemes to improve the validation of Australian AWTP process performance and community acceptance.

It found that the highest priority for further research is the validation of RO membrane performance including identifying suitable surrogates for challenge testing and integrity monitoring.

It identified 'honest' terminology as the most effective for community outreach and found medical professionals as the most trusted ambassadors.

It also found demonstration plants that improve process awareness, exhibitions such as PRW in beer, and the support of well-regarded celebrities and leaders as important in improving community acceptance.

ACKNOWLEDGMENT

The author is appreciative of the knowledge gained from the community outreach teams from Orange County Water Supply District (GWRS) and City of San Diego PURE Water Program, and the staff from Carollo Engineers and their partner organisations' mobile AWTP demonstration facility.

Ashlea Clifford (Seqwater) and Nick Turner (Water Corp), and their teams, are acknowledged for their recent work on understanding the best approaches in engaging the Australian community.

Duncan Middleton (Seqwater) and Elyse Harding (Veolia Water Australia) are acknowledged for their enduring work on the WCRWS validation program.

REFERENCES

Australian Guidelines for Water Recycling. 2008. Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies, National Water Quality Management Stategy, 22, Australian Government, Canberra, ACT, Australia.

Carpenter, G. 2018. Precription for Public Acceptance. WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

Ford, H. 2018. It's Just Water: San Diego North City Pure Water Facility. WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

Hinds, A., Clifford, A. 2018. Seqwater PRW Terminology Research – Summary Report. Colmar Brunton and Seqwater, Brisbane, QLD, Australia.

Hampton, D., Abrha, Y. 2018. Seqwater Water Insights 2018 – Summary Report. TNS Kantar and Seqwater, Brisbane, QLD, Australia.

Mattingly, J. 2018. An Update on Water Research Foundation Projects (Potable Water Reuse). WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

Montoya, C. 2018. Community Engagement for Potable Reuse Success (El Paso Water). WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

Motta, M., Callaghan, T., Sylvester, S. 2018. Knowing less but presuming more: Dunning- Kruger effects and the endorsement of anti- vaccine policy attitudes. Social Science & Medicine, 211, pp. 274-281. New York, NY, United States of America.

Nix, D. 2018. Communicating with the Public regarding Direct Potable Reuse – The Wichita Falls Success Story. WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

Seqwater. 2017. Water for Life – South East Queensland's Water Security Program 2016- 2046. Seqwater, Ipswich, QLD, Australia.

Turner, N. 2019. Is Direct Potable Reuse a Technically and Socially Viable Safe Source Option for Perth. Draft submission, Ozwater'19, Australia Water Association, Melbourne, VIC, Australia.

Simpson, J. 2006. From waste-d-water to pure water. Woombye, QLD, Australia

Vickers, J.C. 2018. Removal of MS-2 Coliphage in a Full-Scale Reverse Osmosis System. WateReuse 33rd Annual Symposium, Austin, TX, United States of America.

WaterSecure. 2017. WaterVal Validation Protocols. Series of protocols. Australian WaterSecure Innovations Ltd, Brisbane, QLD, Australia.

THE AUTHORS

Dan Healy

Dan Healy (M.Sc., M.Bus.) has over twenty years of experience in water and wastewater. His recent work with Seqwater's Water Quality Unit includes the implementation of the ADWG Framework and the review of recycled water management plans. He is an Exemplar Global certified lead auditor for water quality management systems.

Duncan Middleton

Duncan Middleton is employed with Seqwater, Southeast Queensland's Bulk Water Supply Authority, as Principal Water Quality. Duncan is a tertiary qualified scientist with over fifteen years experience in water, wastewater and recycled water across a number of water service providers in southeast Queensland and Australian Capital Territory. He is also an Exemplar Global certified lead auditor for water quality management systems. His recent work includes the implementation of the Health Based Targets approach for microbial water quality and the validation program for the Western Corridor Recycled Water Scheme.

Andrew Salveson

Andy is Carollo's Water Reuse Practice Director. Andy has led more than 60 advanced treatment designs, pilot tested more than 100 systems, and conducted more than $10M in applied research.

Andy has been honored with the WateReuse Person of the Year Award and been part of teams honored with the CWEA Research Achievement Award, the WateReuse Association Innovative Project Award, and the International Water Association Market Changing Water Technology Award. Andy serves on a number of expert panels with NWRI and The WRF and has published guidance documents on potable reuse and disinfection for WHO, NWRI, IUVA, and WEF.

Doug Owen

Doug Owen is a Program Manager for Stantec, currently serving as the Consultant Team Manager for the Pure Water Program for the City of San Diego. The first phase includes a $1.4B capital improvement program to provide 30 mgd of purified water for the drinking water system while offloading 52 mgd of wastewater from the City's Point Loma WWTP.

Jeremy Bishop

Jeremy is a Community Relations Advisor at Seqwater. In his current role, he coordinates stakeholder engagement efforts for the Water Security Program, Seqwater's 30-year plan for providing safe, reliable and affordable drinking water for South East Queensland.

Nick Turner

Nick Turner is a senior principal of strategic programs at Water Corporation. Nick pioneered groundwater replenishment as a drinking water source for Perth and has worked for his entire career in the water industry. Nick was named Australian Water Professional of the Year for WA in 2018.