Australian Academy of Technological Sciences and Engineering (ATSE)

DRINKING WATER THROUGH RECYCLING

THE BENEFITS AND COSTS OF SUPPLYING DIRECT TO THE DISTRIBUTION SYSTEM

APPENDIX A

STAKEHOLDER SURVEY RESPONSES

Date of publication: October 2013

Identification of key issues: Qualitative survey of Australian stakeholders

A qualitative survey was undertaken for the purpose of identifying the range of potentially significant issues that would need to be addressed in order to make a comprehensive assessment of the benefits and risks of implementing a DPR project in Australia.

The survey was constructed using an online survey tool (SurveyMonkey) and the online address (URL) was distributed by email. Distribution was targeted to Australian individuals and organisations with known interests in wastewater management, drinking water management and/or water reuse. In all, 80 survey responses were received from a variety of industry bodies, academic organisations, State Government departments and agencies, health regulators, drinking water providers/managers, local government associations, local governments, Commonwealth Government departments and agencies, interested individuals, and private companies.

Efforts were made to acquire the views of a diverse range of stakeholders. For example, all members of the ATSE 'Water Forum' were invited to participate, regardless of their particular experience or past interest in water recycling. Furthermore, direct invitations were made to four community members considered to have been highly vocal opponents to previous potable water recycling proposals in Australia. Unfortunately, only one of these agreed to participate in the survey.

As a consequence of the broad range of participants, an equally broad diversity of opinion was captured within the survey comments. Indeed, some of the comments received clearly contradict others. ATSE does not endorse, nor necessarily agree with, any of the comments received. In fact, there are many with which ATSE believe there to be contradictory evidence. No such commentary is provided in the following sections, but relevant available evidence is presented within the other chapters of this report.

Background information provided to the survey participants

The following background information was provided to the survey participants and as an introductory section to the online survey.

> *INTRODUCTION: WHAT IS MEANT BY 'DIRECT POTABLE WATER REUSE'?*
>
> *During the last decade, there has been much discussion in Australia regarding the development of planned 'indirect potable reuse' (IPR) schemes. Prominent examples of IPR include the unsuccessful proposal for the City of Toowoomba (2006), the construction of the Western Corridor Recycled Water Project in South East Queensland (2007-2009) and the successful Groundwater Recharge Trial in Perth (2010-2013). The concepts underpinning all of these IPR projects include:*
>
> 1. *Water is sourced from municipal wastewater treatment plants (sewage treatment plants).*
> 2. *The water is then treated to a very high level using advanced water treatment technologies.*

3. *The water is then returned to an 'environmental buffer' such as a river, lake, reservoir or groundwater aquifer where it mixes with waters from other sources.*

4. *The mixed water is re-extracted from the 'environmental buffer' for conventional drinking water treatment and distribution to customers as a component of the municipal drinking water supply.*

The concept being examined in the current survey is direct potable reuse (DPR).This DPR differs from the above description of IPR by the exclusion of the 'environmental buffer' (step 3). That is, the highly treated water is not returned to a river, lake, reservoir or groundwater aquifer, but is instead treated to a level that is appropriate for direct distribution to customers as a component of the municipal drinking water supply. As such, the water may be delivered direct to the distribution system (or alternatively, blended with other sources of water and further treated via an existing water treatment plant). This concept is illustrated in Figure 1.

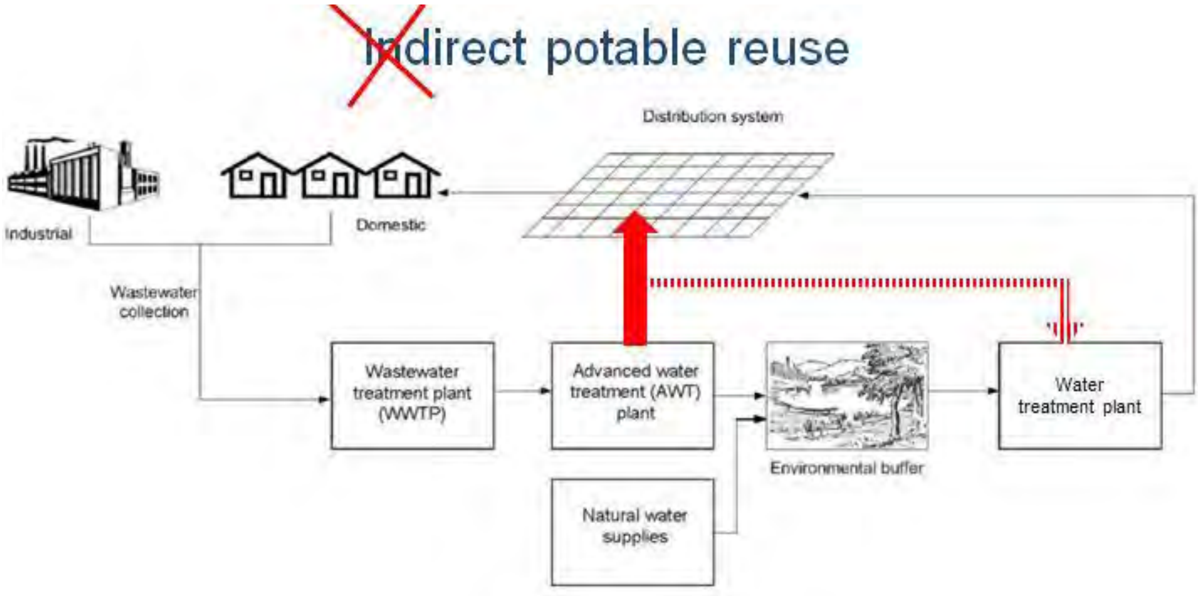

Figure 1 Illustration of direct potable reuse (DPR) and how it differs from indirect potable reuse (IPR).

Instructions given to the survey participants

The instructions given to the survey participants were as follows:

The following questions have been designed to solicit and organise input to this study by key stakeholders. They relate to specific areas of interest to the project. However, you are encouraged to provide whatever information that you feel is appropriate, even if it does not appear to be directly solicited by any of these questions. You are encouraged to elaborate as much as possible on all answers.

Participant background knowledge

All participants indicated that they were familiar with the concept of IPR prior to reading the introduction to this survey (see Figure 2). Furthermore, approximately 90% of the participants indicated that they were familiar with the concept of DPR. However, it should be noted that the actual degree of familiarity and direct experience with such schemes is expected to vary significantly among the participants. Some of the comments received appear to indicate that some participants did not necessarily have a clear understanding of what is implied by DPR. For example, the following comments were received in response to the question regarding whether the participants could "identify any perceivable benefits of DPR (compared to IPR)":

"I think DPR can be beneficial in some industrial applications. A good deal of recycled water in Queensland is supplied to power generation plants, which do not need IPR. Agricultural use may also benefit from DPR. Generally I think IPR can be used in many settings, and would think IPR is more of a community drinking water solution."

"Possibly for industrial use but don't see it being acceptable for a long time for domestic use."

4. Prior to reading the introduction to this survey (please select all that apply): Create Chart Download

	Response Percent	Response Count
I was familiar with the concept of IPR	**100.0%**	**78**
I was familiar with the concept of DPR	91.0%	71
Any additional comment Show Responses		7

Figure 2 Prior to reading the introduction to this survey (please select all that apply)

17. The opinions and information provided above: Create Chart Download

	Response Percent	Response Count
represent my personal views.	**91.0%**	**71**
represent the views of my organisation/department.	15.4%	12

Figure 3 Representation of opinions and information provided by survey participants

Survey participant responses to key issues are presented in the following sections.

Role(s) of the Environmental Buffer in IPR

QUESTION: What do you consider to be the role(s) of the 'environmental buffer' in IPR? In your opinion, how necessary is the 'environmental buffer' in performing such role(s)?

A variety of roles were identified for the 'environmental buffers' of IPR. These included both performance-based roles, leading to improved water quality and/or water safety, as well as a number of public perception-related roles.

Negligible purpose

A significant number of the survey respondents indicated that they considered the environmental buffer of IPR schemes to serve negligible purpose. In most cases, this was based on the belief that engineered water treatment processes could provide the necessary water quality and additional improvement by environmental buffers was either not significant or not required.

"If the recycled water purification process is adequately risk assessed and validated, and incorporates appropriate treatment processes, real-time monitoring and fail-safes, the environmental buffer is effectively a redundant process step and should not ever be utilised."

"Technically not necessary. Also, doubtful if the public see the additional steps of dwell time in reservoirs and conventional water treatment as dealing with concerns they might have about IPR. Might be some advantage from adopting the Singapore approach of starting with only 1 or 2% with monitoring to gradually achieve public acceptance that it is safe, but which politician is going to push for this with dams overflowing and $6b spent on desalination plants to provide water security in the event of a drought?"

"The perception is that environmental buffers provide natural treatment by blending or dilution thus safeguarding a potable water supply, however I am not convinced as no two environmental buffers are the same and I am unaware of any validation that specifically applies to the effectiveness of an environmental buffer. Notwithstanding, the progress of the Alice Springs Managed Aquifer Recharge project is worth noting but it is possible that the quality of treated wastewater being injected into that non-potable aquifer greatly exceeds the quality of the groundwater that it augments."

"The environmental buffer nominally creates a buffer between the advanced water treatment plant and the drinking water plant which allows for the prevention of any contaminated water passing through the advanced water plant due to failure of some or all of the treatment system. In reality, advanced water treatment is so sophisticated and heavily monitored than, as long and there is a moderately sized storage tank or pond and/or long enough pipeline between the advanced water plant and the drinking water plant, that in the unlikely event of any failure or contamination event can be detected quickly enough and diverted to ensure that no contamination of the potable supply occurs."

"An environmental buffer is designed to provide a barrier for purified water after it has received advanced treatment such as microfiltration, reverse osmosis and UV-oxidation. It is regarded an as important stage in the water purification process by most western countries and has consequently been embedded in most water reuse policy, regulation and industry practice. An environmental buffer is regarded as an extra safety barrier in the urban water supply system to protect the public in the event of a contamination event at an advanced water treatment plant. Technically, an environmental buffer is not needed. There is now considerable evidence in Australia and overseas that shows DPR schemes can be managed safely, constantly and at a high standard."

"I would probably not have significant concern as to whether or not there is an 'environmental buffer' provided technical, governance and reporting arrangements were appropriate from the perspective of the public health regulator."

In one case, belief that environmental buffers served negligible purpose appeared to be based on the assumption that health authorities would be unlikely to permit unsafe water to be discharged upstream of drinking-water off-takes.

"It seems not necessary since I suspect it would not be allowed if those downstream had any doubts about the cleanliness of the treated water being passed back to the natural environment. If there is a general recommendation/regulation from authorities to not withdraw potable water from the environmental buffer until a certain amount of time or been distance has passed, then that is another matter, but I am not aware of any such recommendation."

There is a sense that environmental buffers are somewhat of a relic of earlier developments in water recycling, having once played an important role, but that role now diminished with more modern schemes and practices.

"The concept is one that has served us well. It is however one developed at a time when treatment technology and monitoring was less advanced than it is now. In the past, it was used to provide a suitable barrier of protection. The major one being providing additional time for natural processes to

treat the water. I think we would now be better served with clear WQ criteria to meet, irrespective of history of water."

"Given that there is now ample evidence that a high quality of water can be reliably produced at the AWTP, the necessity for the environmental buffer must be questioned. I consider that its inclusion in the IPR treatment train originated when the quality and reliability of operation of the AWTP had not been truly verified or tested and there was the belief that there would be further treatment achieved in the buffer, resulting in wider community acceptance of the concept of potable reuse. Many practitioners are now questioning whether the buffer actually does achieve any additional treatment or in fact any benefit - as is evidenced by the fact that the WaterReuse Research Foundation has recently commissioned a project to evaluate just this and the January 2012 National Research Council report also discusses it."

"Not relevant with modern systems."

A common observation was that, as opposed to providing water quality improvements, environmental buffers may, in fact, have a detrimental impact on water quality.

"I do not consider it necessary. The advice I have from technical experts is that the environmental buffer doesn't provide a safety assurance and in fact introduces new and unnecessary risks."

"The environmental buffer is not necessary with multiple barriers put in place to purify water sourced from a STP. The environmental buffer will only degrade purified water."

"In cases like the Western corridor in Brisbane the introduction of recycled water to dams impoverishes the recycled water quality and improves the dam water which in any case will go through a further set of treatments prior to release into the water system."

"A properly validated system ought to be capable of operating without the buffer, which in practice only acts to contaminate perfectly good drinking water (at least in the case of Western Corridor)."

"The use of the natural system for highly treated, potable recycled water actually only decreases the quality of the potable recycled water, and potentially creates ecological problems in the direct vicinity of where the pre potable water is added to the reservoir or aquifer."

"However, the buffer is likely to add contamination to water after so much effort has been made to clean it."

"On the problem side, mixing very clean recycled water with surface water means that the effort in treating the recycling water to a higher standard than drinking water is wasted by re-mixing it with slightly (hopefully) polluted water."

"In many instances, the quality of the water in the environmental buffer is lower than the treated water being mixed therein and the cost of delivering the water to the buffer is high. It would make far more sense to deliver the water directly to the reticulation scheme and avoid significant re-treatment costs."

"It is going to take some effort to make general public aware that recycled water may actually be cleaner than the water in the environmental buffer (in the case of surface water buffer) and this may not even be a good communication strategy for a government or water agency because of the risk of making the environmental water seen as very dirty."

Furthermore, it was suggested that the inclusion of an environmental buffer confounds the public communication message that highly treated recycled water is safe to drink.

"From a communications point of view, I have found it is very difficult to convince people that the water that's been recycled is safe to drink if you then say you're going to put it into a dam and then treat it all over again. This was contrary to my expectation - I thought the environmental buffer would provide an extra level of reassurance but in my experience it does not."

To provide a 'perception' of increased water quality or safety/public confidence

A commonly identified purpose for the inclusion of environmental buffers in potable water recycling projects was to enhance public confidence in the system or to provide a perception of increased water quality or safety. Note that this perception of increased water quality or safety is assumed to be distinct from the provision of actual increased water quality or safety, which is addressed in a subsequent section.

> *"Its major function is the public perception as another barrier."*

> *"Comfort only; it has little technical or economic value"*

> *"It is an attempt to provide 'confidence' to the community but has no scientific basis."*

> *"The environmental buffer is an important component of the establishment of recycle to potable schemes as it probably downgrades the fear of the consumer that if there is an engineering issue with the treatment process, that there is an opportunity for 'recovery' of the mistake. The environmental buffer seems to serve this purpose well in the establishment of recycle schemes. The technical role of the buffer seems to be quite limited and in a lot of ways makes no sense at all. As a technical buffer for ensuring water quality, there appears to be limited or no justification for the environmental buffer."*

> *"The buffer is primarily designed to build public confidence in purified water for drinking purposes by politicians and the community."*

> *"However its main importance is to improve perceptions of safety in the public mind."*

> *"Given that Australian communities are in general not very familiar with reuse in even relatively low contact situations (eg clothes washing, bathing/showering etc) let alone drinking, an 'environmental buffer' (for temporary storage and perhaps to contribute to the required 'treatment train') would probably be necessary as part of any process for seeking community support for drinking use - eg via presumably greater likelihood of a 'storage/time buffer' / opportunity to monitor/control."*

> *"Can say that it allows natural self-purification to take place (to further allay adverse perceptions/fears). There will be an element of dilution. Therefore this buffer, although technically not needed, will serve to mitigate adverse perceptions."*

> *"Offers the perception of providing additional treatment within a natural system eg river."*

> *"Public performance and confidence - This role is primarily a public perception role and is important in gaining public acceptance of the idea of indirect potable, which has been difficult in Australia."*

> *"The environmental buffer is helpful and will reduce some public concerns, but is not essential."*

> *"The only real benefit of using a natural system is for public confidence and perceptions."*

> *"Provides significantly increased community confidence in the concept of drinking recycled water"*

> *"The environmental buffer primarily acts to provide public confidence"*

> *"Therefore, 'environmental buffer' is not necessary from the engineering and safety aspect other than to provide assurance and confidence to public."*

> *"Public acceptance may be higher where there is the sense of dilution or detention."*

> *"The environmental buffer is important in giving confidence to the consumer and the regulators (health and environment) that every precaution has been taken to secure the safety of supply for human consumption."*

"A 'buffer' may also provide the community with confidence that the natural cleansing processes are providing additional barriers to the risks associated with recycling."

"Public perception (at least partly induced by the water industry) around the importance of a 'natural barrier' to anomalies the water."

"The environmental buffer is very important as it separates the treatment processes from the end consumers. People believe that the environment has the ability to "cleanse" recycled water and this is why buffers such as rivers and lakes are quite acceptable. Many people are still nervous about direct potable even though the treatment systems are very effective. People often hear about robust chemicals going straight through treatment plants however they forget that fish actually live in water whereas humans only drink water therefore the doses of these persistent chemicals would be miniscule to humans."

"I think there is also the possibility (again in the minds of the community) that it also provides a buffer against any issues with the system breaking down. System risk (i.e., the risk of something going wrong with the recycling process) is something that people often nominate as an issue they are concerned with in relation to recycled water."

"As a psychological barrier, providing reassurance to consumers/regulators that non-conforming recycled water can be contained."

To provide a perception of a disconnection between treated effluent and raw drinking water, to reduce the "yuck factor".

Many respondents indicated that the environmental buffer provides a perception of a 'disconnection' between treated effluent and raw drinking water. With such a disconnection, the water is assumed to lose its 'identity' as tarnished 'sewer water' and start anew as 'environmental water' to be treated to produce drinking water. This 'loss of identity' is clearly distinct to the perception of actual additional water treatment or improved safety (described previously). Numerous responses referred to the well-known 'yuck factor' that has commonly been associated with potable water recycling. This yuck factor is fundamentally based on recognition of the water's history as sewage. Accordingly, it was assumed that such references to environmental buffers being used to overcome or reduce the yuck factor, were indeed references to its role in providing this disconnection between sewage and drinking water.

"In my opinion, the environmental buffer used in IPR is there mainly to provide public confidence in water reuse. The idea is to assign 'nature's stamp' on the water. I think it is related to the concept of the 'magical mile', where wastewater discharged into a river quickly loses its identity and becomes 'pristine river water' for the drinking water supply of a township downstream. Something magical must happen between the wastewater discharge and the drinking water off-take, for this water to suddenly become 'pristine surface water'."

"In terms of PR, it seems to re-create the natural system, and put us back in the position where water from the environment is harvested by the water treatment plant."

"It is used in an attempt to assure the community that reclaimed water is safe - it becomes 'natural' and loses its identity. The attempt has failed. Instead it provokes the question 'Why spend money cleaning it up and then make it dirty again?'"

"To make public acceptance easier for water recycling for potable reuse application. By using the environmental buffer the 'yuk' factor may not be as pronounced as it could be for DPR applications."

"It provides reassurance to the water consumer (including industrial users e.g. food industry) that the recycled water is being 'naturalised' via its blending with 'natural water'. I realise this is a misconception and, generally speaking, the purified recycled water will have less contamination than dam water, but

people's attitudes are a key determinant of the potential success of any IPR proposal and are ignored at the peril of the project."

"Additionally, the environmental buffer may provide some degree of 'perceptual' separation of the source water from the product water in the eyes of consumers."

"Release of highly purified water into an environmental buffer in my opinion is polluting a product that has been produced at a relatively high cost just for the sake of providing a belts and braces approach to counter the yuk factor."

"Could be seen as a modern manifestation of the 'golden mile' mindset. In a practical sense, I would consider this role to be more significant in gaining community acceptance of potable reuse than any treatment barrier role."

"It also helps from the mind of the public to lose its original identity or source which is used water."

"It also goes some way to blurring the fact that recycled water is being reintroduced to the potable supply system."

"Public perception that return to environment magically purifies product. Very necessary."

"Public perception - the public has a perception that treated sewage becomes environmental water (surface water or groundwater) if it is returned to an environmental buffer."

"The buffer also provides an additional assurance to the public that maximum separation of their wastewater resource and drinking water resource is maintained."

"Dilution of purified water with other waters seen as more natural than purified water sourced from a STP."

"An environmental buffer theoretically provides a disconnect between treated wastewater returned to an aquifer/water body and then extracted for potable purposes."

"From a social viewpoint it provides a psychological barrier between the source water (no matter how highly treated is the sewage effluent) and its use as drinking water."

"The 'environmental buffer' provides an important psychological role allowing for drinking water to be sourced from a 'natural system'."

"I think the environmental buffer may provide a social advantage, as people have a tendency to trust the 'natural' source of water more than a man-made source."

"I think the environmental buffer is largely there for psychological reasons. When you talk to people about recycled water, they seem to feel more reassured about the idea that it gets incorporated with water collected in a 'natural' way before it gets treated and used."

"To distance or remove the source (sewage) from the product (drinking water) in the minds of users - perceptions do matter!"

To demonstrate that the project is following established international practice for potable reuse

One respondent provided the observation that the use of environmental buffers for potable water reuse is much more established practice compared to DPR. Accordingly, continuing to use them provides a reassuring message to the community that the industry is following established international practice as opposed to trying out something new.

"In addition, internationally there are not that many DPR schemes (the only one that I am aware of is in Windhoek in Namibia) while it's easier to find references for IPR schemes, thus improving the trust of general public."

To make potable reuse more socially acceptable (without a clearly articulated explanation)

Further responses indicated that an important role of the environmental buffer was to increase public acceptance generally, but did not provide sufficient additional information to enable an interpretation of how this was achieved. In other words, it was not clear which of the above three categories (if any) many of the additional responses belonged to.

"It makes the public feel good!"

"It is also important from a public perception perspective."

"Political"

"Important from a community perspective to enable drinking of recycled water."

"Provides no additional technical benefit for an advanced treatment recycled effluent but has social and environmental benefits when engaging with public."

"It helps alleviate public concerns."

"Potential improvement to public perception."

"Makes IPR much more socially acceptable."

"There is significant benefit from a customer perceptions perspective which should never be ignored."

"To obtain community acceptance of INDIRECT Potable Reuse before DIRECT reuse can be forcibly introduced. The buffer has no other purpose."

To provide an additional treatment barrier for pathogenic and/or trace chemical substances

Many respondents indicated that the environmental buffer had a legitimate (or important) role in providing a further treatment process for recycled water (beyond simply the public perception of this role). Among the various comments, this role was described as being (potentially) effective for nutrients, trace chemical contaminants and pathogenic microorganisms.

"On the positive side, however, is the fact that the environmental buffer can indeed provide an additional level of treatment. For example, volatile disinfection by-products are likely to evaporate quickly."

"The environmental buffer is very important in my opinion as it allows for key microbial transformations to occur. As yet we don't understand all the reactions or their kinetics necessarily but think that the environment plays a pivotal role in detoxification."

"The buffer might also allow for the further degradation of compounds not removed by the treatment process."

"Provide an additional treatment train - While an environment buffer as a treatment train is difficult to quantify it will provide a certain amount of further treatment to the water. In role here is not significant as the treatment train should be designed to achieve the required quality before release into the environment."

"Potentially, additional biological and/or biogeochemical treatment."

"It is important to consider the extent of the environmental buffer. If an environmental buffer is limited (ie detention time and dilution) then it provides very little benefit. However if the buffer is quite extensive from a dilution and detention time, then it may provide benefits from a risk management perspective ie elapsed time from sewage treatment to customer consumption, environmental treatment benefits and ultimately it may actually reduce the levels of treatment required. It would be interesting to explore this from a Health Based targets perspective."

"I believe that the environmental buffer will provide the final polishing of the recycled water. Contaminants such as EDCs, and other micro-pollutants will be removed, by either biological assimilation, natural chemical processes or physical adsorption."

"Time in the environment provides both additional pathogen removal (though this is not technically required as the treatment train delivers drinking water quality water)."

"To provide further natural treatment of the wastewater and reduce costs of treating wastewater."

"Natural attenuation is an important and often neglected process."

"Further…purification."

"Treatment, barrier and redundancy needs."

"The environmental buffer serves as additional barrier in the multiple barrier treatment train from raw sewage through conventional, advanced treatment and environmental buffer before conventional water treatment. It is totally unnecessary from a technical aspect."

"It provides an additional physical barrier in the sense that it allows for further environmental degradation of contaminants in the processed recycled water."

Of limited importance in ensuring the safety of the water, although obviously some additional storage time will provide additional treatment of microbes and chemicals, in addition to traditional drinking water.

"The 'environmental buffer' in IPR acts as another safety barrier and gives the public the confidence to accept IPR."

"Treatment barrier..."

"Provision of an environmental buffer: 1) is consistent with the multiple barrier approach philosophy 2) may minimise the consequence to public health in the event of: a) a system failure at the treatment plant that is not detected in a timely manner (or not all) due to failure of controls or lack of them; b) limited treatment capability (all treatment processes individually & in combination have their limitations); c) lack of sensitivity in control system and monitoring techniques d) uncertainty in risk, and measurement; e) undetectable/unknown contaminants entering the system (note that chemicals are increasing being introduced for use at a rate greater rate than identification techniques, and for which there is no assessment of health risk for drinking purposes; f) Human error (which is inevitable)."

"Water quality changes - the environmental buffer may improve water quality, e.g. pathogen decay but also degrade water quality."

"The buffer provides an additional public health protection barrier to enable dilution and further treatment."

"Induce degradation of any remaining contaminants (of either a chemical toxicant or pathogenic nature) to be further degraded by natural physical, chemical and biological processes."

"Provide additional benefits in terms of dilution and environmental treatment i.e. solar disinfection"

“Water quality improvements through the use of an [aquifer storage and recovery] scheme”.

“Additional treatment of moderately recalcitrant organics and pathogens.”

“Ensures microbial levels are minimised. Also allows pharmaceutical residues to be broken down. As such, the buffer is necessary unless the reprocessing covers this aspect. With direct reprocessing, as a minimum, sterilisation is needed.”

“The 'environmental buffer' provides an additional barrier in the multiple barrier approach to water supply. The effectiveness of this barrier obviously varies dependent on the nature of the 'environmental buffer' and can be difficult to quantify.”

“Provide an actual additional treatment and dilution”.

“The environmental buffer should provide an effective barrier…for treatment or reducing the risk of a hazard”

“Provides time for biological and chemical decay of residual pathogens.”

“Attenuation of residual contaminants.”

The environmental buffer should…help [achieve] treatment targets for salt and nutrients.

“Through my experience community and stakeholder opinion of IPR has been more acceptable than DPR. Generally the environment is understood to provide a buffer function (safety guard) and carry out nature’s processes to cleanse the water for water treatment for potable supply. There is still a general lack of acceptance of direct potable water using reverse osmosis technology in the community. Notwithstanding the technology advances there is still a lack of willingness to accept highly treated waste water into the water supply system.”

“Environmental buffers are necessary in so far as current recycle water schemes are not designed to fully eliminate contaminants, particularly chemicals of emerging concerns that would make reclaimed water suitable for drinking. There are many water quality parameters that are currently not tested in treatment of drinking water and the concept of an environmental buffer may be to provide some form of natural dissipation of these water quality constituents. Simply reliant on an environmental buffer to be the 'catch-all' or to provide dilution of contaminants is inherently risky.”

“Provide a barrier for the attenuation/inactivation of pathogens (Time dependent)”

“Facilitate further transformation of organics.”

“Most existing water supplies already have these buffers but their effectiveness is poorly researched such that we can satisfactorily predict their response. This reflects the older dumping and 'dilution is the solution to pollution' attitudes. A good example of this are the sewer overflows and leaks which are still common in many system but tend to be institutionally denied sometimes through the simple expedient of not collecting data in the first place. Principles are understood but quantification is problematic.”

Many of these above comments suggest that the treatment role of the environmental buffer is for ‘everyday’ routine improvement to water quality. However, a few of the respondents suggest that the treatment role of the environmental buffer is predominantly as an ‘emergency back-up’ to be relied upon only when other processes fail.

“Merely a 'safety' buffer in case of breakdown of treatment processes. “

“It provides an additional barrier in case the treatment operations are not properly run/maintained.”

“To effectively provide a safety barrier in case of treatment issues on the advanced water treatment plants (AWTP). It would take major failures (probably at least 2 barriers failing simultaneously) at the AWTP to go unnoticed for some time for the water to be seriously compromised, especially with modern

risk management approaches and the implementation of Hazard Analysis and Critical Control Points. But while that risk can be managed, it cannot be completely removed."

"Role is a final fail safe and, depending on loading, a natural treatment system."

"The 'environmental buffer' in IPR is important further protection should something go wrong in the wastewater treatment process."

"The environmental buffer is effectively there for 'peace of mind'. Treatment prior to the buffer are ordinarily adequate for DPR but the buffer is added to reduce public perception issues and to provide extra contingency to buffer out process upsets"

The environmental buffer is considered important to ensure that reclaimed water is subject to the same treatment and established barriers against system failures as other sources of water. Major utilities currently have a system of quality control check points to ensure that the quality of water is maintained throughout the system. This enables the operator to manage water quality throughout the system under a range of scenarios i.e. different flow rates, usage, temperatures, contamination events. The environmental buffer diffuses the risk of system failure.

"It provides an opportunity for below spec recycled water to be treated and/or diluted in the environmental buffer. However for dams the subsequent log reduction in pathogens & chemicals is poorly defined."

"[Our organisation] has undertaken significant research in to the potential role of the 'environmental buffer' for managing water quality events in IPR. This research indicates that the environmental buffer would provide mitigation for the majority of contaminants, if it was required. This same research also determined that the likelihood of requiring this 'role' is low and that the risk of cyanobacterial blooms (and the associated downstream affects e.g. taste and odour, toxins) as a result of addition of recycled water to the environmental buffer is probably more significant. However, independently of such 'environmental buffer', the treatment processes implemented in IPR (and potentially DPR) schemes are robust systems that provide multiple barriers, particularly to pathogens. In addition the treatment trains are designed and validated to provide the required level of treatment for direct consumption (i.e. no log reduction or chemical removal is claimed for the environmental buffer or downstream water treatment processes as part of the IPR scheme validation to meet the log removal requirements of the [Australian Guidelines for Water Recycling] Phase 2). Guidelines for chemical parameters are generally set considering life-times of exposure and significantly higher concentrations would be required before an acute risk may occur. The fact that long exposure times are required before a public health risk would become apparent provides the necessary time for results to be received and actions implemented to mitigate the risk. The Australian Guidelines for Water Recycling provide the risk management framework under which IPR (and theoretically DPR) schemes would be operated in Australia. This Framework approach focuses on operational monitoring to indicate the integrity of treatment barriers. This operational monitoring is more frequent and 'timely'(i.e. generally online) enabling action to be taken in a timely fashion such that it is highly unlikely (considering the conservative validation) that treated water quality would be compromised such that guidelines are exceeded more than rarely."

"The environmental buffer also provided significant redundancy in the controls as demonstrated by the Western Corridor scheme."

To provide dilution of contaminants in recycled water

In addition to water treatment by actual chemical removal or pathogen inactivation, some respondents identified dilution of recycled water constituents as a function of environmental buffers.

"Dilution with environmental water also provides a simple way to 'reduce' the concentration of problematic chemicals, such as chlorate."

"Dilution"

"The environmental buffer provides a dilution to recycled water and increased retention time in the system. Recycled water produced at our treatment plant has relatively high salinity >800 TDS and nitrogen/ phosphorous... blending water sources would provide water quality to the Aust. Std and treatment cost implications would be cheaper than DPR. DPR would also pose significant energy consumption/ carbon emissions."

"Also allowing for some dilution"

"It also provides some dilution with natural/other water sources."

"The buffer provides dilution"

"Further dilution"

"Dilution"

"The buffer provides an additional public health protection barrier to enable dilution and further treatment."

"Enable mixing with potentially higher quality natural waters thereby effectively lowering the concentration of any contaminants present)."

"It provides an opportunity for below spec recycled water to be…diluted."

Dilution of any potential pathogens."

"Environmental buffers provide the means for blending (dilution of residual contaminants)."

"Provide a source of non-recycled water to dilute the content of organics of wastewater origin."

"Blending opportunity - e.g. managing salt and hardness/softness."

To stabilise/equilibrate highly purified reverse osmosis permeates

It is known that water directly produced by reverse osmosis membrane filtration (i.e. 'reverse osmosis permeates') can be exceptionally low in concentration of dissolved minerals such as calcium and magnesium. Such low mineral content can render water highly 'aggressive', which means that the water has a high potential to corrode and degrade many water infrastructure materials including concrete and metallic pipes. Low mineral content is also known to detrimentally affect drinking water taste. Two survey respondents indicated that the environmental buffer may play a role in 'remineralising' water subsequent to reverse osmosis treatment.

"Enable equilibration of the treated wastewater with constituents of the natural environment (for example, dissolved salts are removed from treated wastewaters by processes such as Reverse Osmosis with the result that the treated water is highly corrosive; equilibration with naturally occurring minerals will increase the ionic strength of the treated water thereby rendering it less corrosive)."

"The buffer also has the ability to remineralise the water, which would affect taste and biological suitability for water that may have been made too pure."

To provide 'time to respond' to treatment malfunctions or unacceptable water quality

Among the most commonly identified roles of environmental buffers was the provision of 'time to respond' to any incidents of unacceptable water quality from the advanced water treatment plant. It was suggested that if a water quality 'incident' occurs, or water quality objectives are not met, the buffer provides some period of delay before the water is delivered to consumers. The implication is that this period of delay then provides the necessary time to identify the incident and respond by the implementation of some additional means of water quality management.

> *"The environmental buffer provides time, and in doing so, provides extra assurance to the community regarding perceived risks regarding the treatment of waste water. The need for it will depend on the sophistication of the WWTP/AWTP system. We have now good experience with a very sophisticated system (Western Corridor) which has been able to extensively demonstrate the reliability of the system over time. The performance relates both the technical specificity of the system, and the performance culture of the organisation. It can't be automatically assumed that, from a regulatory point of view, all proponents of systems will necessarily invest to the same extent."*

> *"Finally, while I think it is a little tenuous, the argument that the long residence time in the environmental buffer would provide additional time to respond to a failure in the advanced water treatment does have some relevance, although it would be surprising for a significant failure of the advanced water treatment stage to go unnoticed and uncontrolled."*

> *"Time delay to detect and rectify the inevitable mishaps by treatment plant operators."*

> *"Assuming DPR would be conducted only with advanced treated purified water (ATPW; RO+AOP or equivalent), the only meaningful role of the environmental buffer is to provide time/space to react to inadequately treated water. Thus the env buffer is not needed if treatment reliability can be assured by other means."*

> *"The environmental buffer provides time to respond to human operational failures. As such it has a certain importance intrinsically."*

> *"First, it provides an insurance policy against any treatment failure that results in below specification water being delivered to the buffer. In other words, it provides dilution (where necessary) and it allows time for possible contamination to be managed before the non-compliant water enters the drinking water treatment plant, weeks, months or years later."*

> *"Provides another 'barrier' which prolongs the time lag between toilet and tap. Provides an opportunity to enable containment (and additional treatment) if water went out of spec."*

> *"The environmental buffer is very important in my opinion as it allows for a time margin."*

> *"The environmental buffer can provide the opportunity to address water quality issues that might arise due to malfunction of the treatment plant, before the water is supplied for distribution."*

> *"Provide an additional barrier between consumption and production- This is especially important in light of potential treatment train failure. While most things can be managed by online monitoring the addition of an environmental buffer is to ensure a time lag between consumption and production."*

> *"Time (in case of WW treatment failure). Given the apparent efficacy of advanced treatment, I suspect [this] may be the most important - ie the ability to avoid contamination of the DW distribution system in the event of WW treatment failure."*

> *"It is important to consider the extent of the environmental buffer. If an environmental buffer is limited (ie detention time and dilution) then it provides very little benefit. However if the buffer is quite extensive from a dilution and detention time, then it may provide benefits from a risk management perspective ie elapsed time from sewage treatment to customer consumption."*

> *"The environmental buffer also provides a necessary barrier between the treatment and the customer, which will reduce the impact on customers if something does get through the process, and also enables a time lag to enable identification and action if out of spec water or treatment disruption occurs."*

> *"Capacity to maintain safety of supply in the event of treatment train malfunction."*

> *"Provides a dwell time to enable responses to a breakdown in treatment."*

"Risk mitigation strategy (dilution if something goes wrong and purportedly more time to take corrective action). How necessary: not sure, there might be more efficient ways to provide the same risk mitigation plus more control."

"Ideally, a means of quarantining non-conforming treated recycled water in the result of a catastrophic or undetected process failure."

"From a public health point of view the primary role of environmental buffers is in providing a time element to enable intervention in the event of poor performance in sewage treatment. Without environmental buffers an additional fail-safe mechanism would need to be incorporated into the wastewater treatment plant. One alternative considered by some proponents (e.g. Cloud Croft) is to incorporate a treated water storage to provide a reaction time allowance."

"Practically, the buffer can allow time for recognition of any treatment failures and allow the source to be taken off line."

"May facilitate system isolation in a timely manner."

"Longer detention before human consumption, so if something goes wrong you have time to test and react to alter supply."

"Removing the barrier implies that there is real-time critical control points that are capable of identifying out of spec water & bypassing it to another part of the treatment chain. If the potable water treatment has more sophisticated treatment than sand filtration & chlorination (eg ozonation , membranes, UV, GAC) then the risk of out of spec recycled water is much reduced if it passes inadvertently onto the potable water treatment process."

"It provides a degree of protection against process upsets in the AWTP, before treated wastewater is put into distribution."

"A passive preventive measure in the event of failure of a treatment process and the automated shutoff."

"Provide a time buffer between production of water and when it will be consumed by the public. This enables monitoring results to be received, evaluated and if adverse results identified actions implemented to manage the public health risk."

"The environmental buffer provides a reaction time to manage toxic substances and to allow pathogens to degrade. The environmental buffer is critical for performing this role."

"Also for allowing time to respond to an event or incident. For example the environmental buffer may dilute or allow sufficient time for action to be taken in response to unfavourable results from samples of final water produced by an AWTP. Furthermore, the environmental buffer may allow sufficient time to manage an emerging hazard identified in the recycled water, which may require additional mitigation measures. Additional mitigation measures may include significant investment in the infrastructure downstream of the environmental barrier before the drinking water reticulation network, or timely investigation of the source and extent of the contamination."

"A risk management opportunity - it does provide a time delay and a cost effective means of managing a catastrophic failure."

Buffering the production and use of recycled water/storage

As the term implies, an environmental 'buffer' may provide an important 'buffering' function. That is, the storage capacity of the environmental buffer facilitates balancing variable mismatches between the production of recycled water and its demand. This buffering may manage these water supply/demand variations on an hourly, daily, seasonal or even annual basis. A number of respondents identified buffering as an important role.

“It would also serve as a buffer between supply and demand.”

“Buffering”

“I some cases especially with aquifer storage and recovery, it may provide storage capabilities.”

“Storage - the treated sewage may be stored in the environmental buffer, balancing supply and demand.”

“In some regions a buffer may provide a cost-effective storage and conveyance mechanism that provides protection from evaporation, reduces energy and infrastructure costs. There are several MAR schemes in Australia that have quantified these benefits including in Salisbury SA.”

“Storage option”

“Primarily for storage”

“An additional benefit is that it can provide some ‘storage’ for the recycled water, such that it may be produced at consistent rate, rather than ramping up and down based on demand.”

Providing environmental outcomes/protecting water resources

Two respondents indicated that an environmental buffer could be used to benefit the environmental system itself or provide for the enhanced protection of natural water resources.

“Providing environmental outcomes - e.g. contributing to environmental flows.”

“In the case where the environmental buffer is an aquifer, recharging with treated water has the dual role of mitigating depletion of the aquifer and in many instances, stopping salt infiltration and permanent damage to the water source. There appears to be many opportunities around the world where this opportunity exists and represents both a social and environmental imperative for the use of recycled water.”

However, other respondents expressed concern for potential negative impacts on natural systems used as environmental buffers.

“Philosophically it is problematic however if the water discharged is of very high quality, the loading is tolerable, the time before reuse is substantial enough for warnings and other responses (days to weeks) and the treatment processes properly QA/QCs e.g. by MF/RO, I see no technical problem. But I have strong reservations which include the wider natural resource utilisation philosophy. The natural environment can no longer be treated as an ad hoc dumping ground but regrettably that is the history of 'the magic mile' and I don’t see the attitudes that led to the latter being completely dead yet. Indeed it can be argued they are on the rise.”

“The recycling water may also contain nutrients, which are irrelevant for human health impacts (at least at the concentrations routinely encountered), but could cause algal bloom in environmental buffers - thus adding a problem and a negative stigma on recycled water quality.”

“The absence of environmental buffer means less impact of accidents on the environment and no effect on the water source the treated waste water was mixed with.”

Perceivable Benefits of DPR

QUESTION: Can you identify any perceivable benefits of DPR (compared to IPR) that may apply in some (hypothetical) future circumstances? In other words, why might DPR ever be an idea worth considering above IPR?

A range of potential benefits for DPR was identified. These include potential cost savings, some of which were related to reduced energy requirements for transporting water. Improved flexibility, including the ability to practise potable reuse in the absence of a suitable environmental buffer was also proposed. Elimination of an environmental buffer was seen to have potential benefits to be derived from the maintenance of high quality water, produced by advanced treatment processes, without contamination by environmental sources. Notably, a number of respondents were unable to identify any particular benefits for DPR.

Improved economics/more cost effective

Respondents commonly presumed that DPR was less costly than IPR. Some respondents referred to savings in capital infrastructure costs. Others highlighted savings in operational costs, such as reduced energy requirements for water transport, reduced water treatment costs, and reduced land management costs. It is notable that many respondents indicated a relatively high degree of uncertainty about these cost savings and some pointed out that they would be highly case-specific.

> *"Presumably much more economic? But I have no reliable knowledge."*

> *"DPR is likely to be more cost effective, as you are not treating water to a high standard, then releasing to the environment, then treating again. Thus, it eliminates the need for a second round of treatment. The benefits depend of the local situation. If you have plenty of dam water, for example, then the economics of IPR or DPR cannot be justified."*

> *"Where it is expensive to pump water to and from the environmental buffer (eg deep aquifer)."*

> *"No, except for some probable minor cost savings."*

> *"Economics are better, especially if lakes and rivers are unavailable."*

> *"DPR would have benefits where it could augment supply during periods of water shortage, if it could be delivered within the same risk profile and at a more economical cost than other avenues of supply e.g. desalination. It is difficult to answer this question in general terms as each site will have a range of circumstances unique to it that will impact on the most appropriate supply shortage solution. i.e. is it more economically feasible to substitute recycled water where potable water is used for non-potable purposes (e.g parks and gardens) than to invest in the technology and system water quality barriers necessary for DPR?"*

> *"Lower cost of retreatment and distribution. Reduced infrastructure costs associated with transport of the treated water to the environmental buffer. Lower cost of total sewage and supply infrastructure in green fields distributed networks."*

> *"The obvious benefit is the cost of pumping water uphill."*

> *"Lower energy use than IPR and therefore better…economically."*

> *"There are a number of economic…benefits for DPR over IPR such as to reduce the high treatment and pumping costs associated with moving high quality purified water to a dam, aquifer or river, and then mixing it with low quality water which then needs to be filtered, re-treated and purified all over again."*

> *"Lower operations costs: when recycled water is pumped directly to the distribution system or just at the head of the potable water plant it reduces the energy required to pump water either long distance upstream into a natural reservoir or into the aquifer from where it needs to be pumped back to the surface – thus providing major savings in terms of electricity consumption. In addition, since recycled water is extremely clean, when it's blended with natural water in a dam it gets dirty again and then requires additional chemical treatment which produces sludge that needs to be trucked out of the plant. All these very significant operational costs could be discarded by using DPR over IPR."*

"There could be considerable savings in capital works if purified recycled water did not have to be taken back to an environmental buffer."

"Capital and operating cost savings."

"Environmental economists I expect would likely see benefits in DPR in the case of some schemes (tapping an existing stream such as happens indirectly at Richmond NSW however is an example where IPR makes more utilitarian sense as the environment provides a minimum cost pipeline and storage and removes water excess to needs as well as providing quality improvements of a sort). DPR could also be considered in some future where economics has moved to something akin to what is currently described as 'Ecological Economics' where environmental values, not bottom lines, drive decision making. For the moment though I am of the opinion that DPR is very problematic because current economic analyses are likely to be based solely on poor utilitarian models of costs and benefits."

"Economic costs related to pumping of the treated water to the environmental buffer. An example is the movement of water back to the dam which feeds the headworks of a WTP would have a significant impact on the cost of the production of the water. It would be significantly cheaper to treat the water to a high standard at the WWTP and inject it back into the distribution system at a point close to the WTP."

"From a system design perspective, this greater control could potentially be more cost-effective. However, monitoring and contingency costs would also be significant."

"Primarily economic related to the costs of pumping water uphill (normally) for IPR and the costs of treating the water at least twice."

"It will be easier and cheaper to implement."

"Often the distance between advanced water treatment plants (which are commonly located adjacent to wastewater treatment plants) and a natural system such as a reservoir can be large (not such an issue with the use of aquifers). The cost and energy required to pump the water from the Advanced Water Treatment plant and the natural system negates any advantage the use of the natural system would provide."

"One scenario may be cost. If there was a technology advancement that meant reducing costs significantly compared to IPR, then that could be a change. The costs could include treatment, storage or distribution infrastructure costs."

"DPR is cheaper than an IPR solution, as retreatment is not required and transport costs can be minimised."

"Primary benefit would be in inner city supply augmentations - when the transfer pipelines are at capacity and there is significant cost from transfer augmentation and local / decentralised supply sources become more attractive."

"There are a range of potential advantages including reduced pumping costs."

"DPR would have less costs…through not having to pump long distances and retreat."

"DPR could be economically cheaper. Water returned to the environment needs to be cleaned again by conventional treatment."

"Pumping costs in returning IPR to reservoirs."

"DPR may represent value in circumstances where wastewater treatment facilities are in close proximity to existing drinking water supply systems."

"Least cost to community of completing the water cycle. Sewage treatment infrastructure and drinking water treatment infrastructure are usually located at the opposite ends of the catchment and the cost of providing infrastructure (pipes and pumps) to return treated wastewater to the head of the catchment is prohibitive. DPR would usually provide the least cost community cost."

“DPR would be lower cost than IPR as you would not need the additional cost of retreating the water contaminated by 'environmental buffer'.”

“Advanced treatment technology for wastewater has greatly improved in recent years and therefore a DPR may be more cost efficient providing an engineered buffer as an alternative to constructing a site specifically designed IPR.”

“DPR reduces pumping costs (both $ and energy)”

“Reduced pumping and energy costs.”

“May have potential lower infrastructure costs (not regarding treatment and community engagement requirements).”

“[A] theoretical benefit of DPR over IPR (in theory and dependent on specific circumstances) may be reduced cost. The treatment plants are often located near the metropolitan area and as such are in close proximity to the drinking water network, whereas the environmental buffer is often in a location remote to (and in the case of surface waters typically higher) the treatment plant and as such significant pumping may be required. Therefore the cost of producing water for DPR is likely to be lower due to reduced pumping cost and distribution infrastructure.”

“From my perspective the only benefit of DPR over IPR is it can alleviate potential water quality issues in situations where IPR means water needs to be pumped a long distance to storage or aquifer and therefore creating extra treatment costs.”

“The cost of DPR is likely to be lower than IPR. IPR requires considerable pumping costs and infrastructure. DPR would need sophisticated process monitoring and bypass facilities.”

“Key benefits include reduced pumping costs”

“It would provide a lower community cost solution (subject to suitable monitoring etc.).”

“Intuitively I imagine there might be some cost savings in DPR”

Two respondents noted that DPR could help defer major upgrades in existing water infrastructure.

“In a country where a lot of major drinking water assets are ageing and getting close to the end of their lifecycle, DPR used upstream a drinking water plant could significantly extend the asset life cycle and postpone major capital expenditure.”

“It also ‘saves’ water treatment capacity as it is a ‘water work’.”

One respondent noted that DPR could avoid the potential costs of IPR associated with integrated land, vegetation, and water management.

“Reduced land management-i.e. no land management costs for environmental buffer- vegetation around water bodies/ herbicides/ BGA-etc.”

However, one respondent argued that it was unrealistic to expect substantial capital and operational cost savings from DPR over IPR in most existing urban areas. Within existing drinking water systems, the cost and complexity of establishing distributed nodes to receive the output of treatment plants could erode the potential cost savings of locating these nodes closer to end-consumers.

“This is a case where perceived benefits do not match the reality. The argument for DPR is based on lower capex and opex achieved by eliminating the long pumping distances between the AWT and the raw water supply or drinking water intake. The reality is that the distance between STP's (site of the AWT) and reservoirs in Sydney, Brisbane, Melbourne and Adelaide, ranges from 40 km to over 100 km. The argument for DPR is that delivery of recycled water directly into the distribution will reduce this cost.

However, if you look at a Hardy-Cross analysis of drinking water distribution systems it is not a trivial exercise to establish reservoir nodes capable of handling the daily output from an AWT. Sydney Desal is a case in point. The reality in Australia is that water and wastewater network planning makes extensive use of gravity for drinking water distribution and wastewater collection. Large scale DPR could well decrease the length of a single product water transport line, however, integrating DPR into an established drinking water network would need to consider demand profiles, ages of different assets (New DPR vs Old drinking water) and the complexity of construction in residential areas and industrial areas served by existing gas, water and sewer networks. DPR would have benefits in distributed treatment systems. However, if lower capex and opex are the drivers for DPR, the poor economies of scale for distributed treatment would quickly erode the savings on transfer pipes."

Reduced energy requirements

As discussed above, reduced energy requirements were commonly identified as an important source of presumed cost savings from DPR. However a number of responses appeared to imply that reduced energy requirements had additional implications beyond reduced costs. A number of respondents separately mentioned both reduced energy requirements and reduced costs. Others mentioned reduced energy requirements without any mention of costs. A small number specifically stated that reduced energy implied "a more sustainable solution", "better environmentally" or "environmental benefits". Only a single comment explicitly referred to a "lower carbon footprint", but it is assumed that this is implied in most of these responses.

"DPR does not require the transport of the high quality drinking water to surface reservoirs or to aquifer injection points, thus generally reducing the energy requirements and achieving a more sustainable solution."

"IPR schemes typically involve more energy (e.g. groundwater injection and extraction, lift into reservoirs)."

"Lower energy use than IPR and therefore better environmentally."

"There are a number of economic and environmental benefits for DPR over IPR such as to reduce the high treatment and pumping costs associated with moving high quality purified water to a dam, aquifer or river, and then mixing it with low quality water which then needs to be filtered, re-treated and purified all over again."

"Lower carbon footprint from the lower electricity consumption."

"The…energy required to pump the water from the Advanced Water Treatment plant and the natural system negates any advantage the use of the natural system would provide."

"Potentially energy savings (e.g. pumping etc)."

"In the case of Toowoomba the wastewater treatment plant (Wetalla) is located about 1.5km from and 150m below the Water treatment plant (Mt Kynoch). Should an AWTP be built at Wetalla for treated water to be sent the short distance to Mt Kynoch it would reduce the demand for raw water sourced from dams well below the Water Treatment Plant at Mt Kynoch resulting in considerable savings in energy costs. Lifts from dams are as follows: Wivenhoe 700m, Cressbrook Dam 457m, Perseverance Dam260m, Cooby Dam 230m. Water from bores pumped 200m and from Great Artesian Basin Bores 700m."

"It saves energy"

"DPR would have less …energy use through not having to pump long distances and retreat."

"DPR reduces pumping costs (both $ and energy)"

“Reduced pumping and energy costs”

“DPR may save considerable energy in being able to deliver the water directly to the grid. Water from IPR schemes may have to be pumped a considerable distance or use extra energy to deliver recycled water to the environmental buffer. Furthermore, the water may be treated again through drinking water treatment plants which maybe unnecessary.”

“The benefits of DPR are quite significant in terms of less pumping.”

Improved flexibility of water supply

Two respondents suggested that the avoided need to include the services of an environmental buffer in a potable water reuse scheme would improve flexibility in scheme design and/or operation.

“Presumably much more…flexible? But I have no reliable knowledge.”

“More flexibility in managing potable water sources: using a dam as environmental buffer comes with major challenges as experienced recently in Brisbane. In times of very heavy rain the level in the dam goes up, thus preventing IPR. But at the same time the quality of source water degrades and can be extremely difficult to treat to drinking water standards. Having DPR to the head of the drinking water plant could provide an effective answer to both challenges by effectively “diluting” the dirty natural water with clean recycled water at the plant inlet.”

Improved water supply security/emergency water supply

A number of respondents indicated that the adoption of DPR as a component of municipal water supply could improve the overall security of supply. The means by which this may be achieved were relatively diverse and included the use of DPR as an emergency or ongoing supply during drought periods. Others suggested that DPR could be more resilient to extreme weather events such as floods when conventional sources might be susceptible to contamination.

“DPR could provide an essential stop-gap water supply during times when conventional water supplies are unavailable, as occurred in the recent (2013) Brisbane flood, or at low levels (e.g. during an extended drought). In the case of the recent flood desal water provided this stop gap, but [purified recycled water] could also do the same job. In this scenario, adding the [purified recycled water] to the dam would not have achieved the same benefit as DPR could have as the bulk of the contamination entered the water supply downstream of the dam but upstream of the drinking water treatment plant.”

“It could be considered in an emergency where conventional water supply is extensively disrupted over long time like drought, floods etc....”

“DPR is not susceptible to climate conditions (e.g. drying of an aquifer)”

“DPR is potentially a more reliable source of potable water supply and less susceptible to the effects of natural disasters or long periods of drought conditions.”

“Good emergency water supply, particularly in times of drought.”

“DPR may allow for increases in water security that exceed those achievable through IPR”

“The availability of an additional drinking water source that could be supplied somehow independently of extreme events which can have a negative impact on the catchment (e.g. during flood events when conventional raw water is difficult to treat a DPR scheme could provide a contingency supply).”

Maintenance of high water quality produced by advanced treatment processes/improved water quality control

Many respondents identified a potential advantage of DPR as the maintenance of high water quality produced by an AWTP as the water is transferred either to a subsequent drinking water treatment plant of direct to a distribution system. This is clearly in contrast with many IPR systems where the water may be subject to detrimental impacts to quality while maintained in an environmental buffer. Identified consequences of this 'quality maintenance' included reduced demand on subsequent treatment processes, reduced exposure to environmental risks and potentially higher quality finished water for distribution.

> *"Mixing recycled water with surface water (which is likely to be polluted with a wide range of chemical compounds and pathogens, even with proper catchment management) dilutes both the water and the efforts expended thus far to clean it. This is not the case with DPR, which would immediately use the high-quality water produced by advanced water treatment plants in the drinking water network."*

> *"IPR schemes involve groundwater recharge or reservoir augmentation, and, inevitably, blending with other raw waters. Such raw waters are usually of inferior quality so IPR generally results in a degradation of water quality."*

> *"Guaranteed water quality since many IPR schemes use conventional treatment rather than advanced treatment for 're-treatment' of the water after storage."*

> *"By avoiding the large storage it would avoid…degradation of quality due to bird life, algae growth, earthen banks etc."*

> *"Better quality water than conventional supplies"*

> *"More control over water quality- i.e. eliminate risks of contamination to the environmental buffer- i.e. floods, fire, groundwater contamination, sabotage."*

> *"One scenario might be where the environmental buffer itself became polluted or otherwise dangerous. For example, if ever there were a terrorist attack on the principal city water storage, the opportunity to supply DPR water directly into the supply system could be very valuable."*

> *"Water quality could conceivably be better controlled if [purified recycled water] could be supplied directly into the drinking water plant, without being blended with environmental water in a dam or river."*

> *"The water is purified and return to an environmental buffer will degrade the quality."*

> *"DPR may be considered if…the environment is degraded or polluted to the extent that the use of IPR will contribute to the degradation in water quality from that already treated."*

> *"With appropriate buffering, monitoring and controls, DPR may provide a greater level of certainty regarding water quality through the system."*

> *"Also it is more controlled environment not impacted by other environmental risks like floods or other contaminations."*

> *"It provides a more controllable water source."*

> *"More controlled risk mitigation?"*

> *"DPR makes far more treatment sense than IPR where the treatment has to be done twice."*

> *"DPR is not susceptible to…storm induced contamination of a surface water."*

"Avoidance of water quality deterioration associated with mixing of high quality recycled water with untreated surface water."

"Seems a shame to take excellent quality water and then pollute it in an aquifer or (potentially) muddy storage."

"Avoids the contamination that occurs when essentially pharmaceutical grade water is mixed with run off from catchments, many of which have farming/grazing land uses."

"Consistent quality, i.e. surface reservoirs have variable quality which wouldn't be the case with DPR."

"In the event that a natural catchment or aquifer system becomes polluted by a contaminant which the water treatment plant was not designed to remove, eg becomes salinised."

"When the water quality produced from the treatment process is better than the receiving water, then I believe a case can be made for DPR."

Reduced chemical consumption and/or waste production

A few respondents suggested that maintaining the high quality of water produced by an advanced water treatment plant, and avoiding mixing with lower quality environmental waters, would reduce potable water treatment requirements. Such reductions in treatment requirements would lead to a number of additional benefits including reduced chemical consumption and reduced waste production.

"Since recycled water is extremely clean, when it's blended with natural water in a dam it gets dirty again and then requires additional chemical treatment which produces sludge that needs to be trucked out of the plant."

"Lower chemical consumption and lower solids production."

"It saves…chemicals."

Ability to practise potable reuse in the absence of a readily available suitable environmental buffer

Many respondents pointed out that some areas simply lack suitable environmental buffers that can be readily used in IPR. In such circumstances, DPR could be an option to realise potable reuse.

"Where there is no readily available environmental buffer, for example if water is piped in a great distance (Kalgoorlie)."

"Additionally, many communities lack the necessary hydrogeology to support groundwater recharge or lack a reservoir in which to blend as part of an IPR scheme."

"Only if it was the only available water source available due to limitations to growth in use of a rainfall reliant river and groundwater sources."

"Only in circumstances where temporary storage (eg via aquifers or in a reservoir) is not feasible."

"DPR could be used where there is no source of water into which the treated water can be added to allow for IPR."

"DPR may be considered if there are insufficient beneficial environmental attributes."

"Application in towns in arid regions using a limited ground water source where an above ground reservoir may not exist and the aquifer may not be suitable/acceptable for recharge."

“If environmental flow is low, DPR might be preferable.”

“A key requirement for IPR is having convenient and economic access to a suitable groundwater or surface water storage buffer, and, ideally, the ability to isolate the buffer storage without compromising alternate water supply options. Many water service providers do not have access to such a buffer storage, and are therefore unable to consider IPR as an option. As conventional water resources become fully utilised it is inevitable that communities will need to seriously consider potable reuse, and it is extremely likely that some of those communities will not be able to consider IPR for the above reasons. Under those circumstances, DPR will need to be considered.”

“DPR make sense when reservoirs / lakes (environmental buffers) and the water works are far away and at high elevation.”

“If the technology is sufficiently robust and fit for purpose then it could be appropriate for regions that have limited catchment areas or insufficient groundwater supplies.”

“One can envisage instances where…a suitable environmental buffer is not available.”

“If an environmental buffer was unavailable (dry lake or no base flow in a river), the IPR scheme would effectively become a DPR scheme, so it would either need to be taken out of service, or operated as a DPR scheme.”

IPR is not always feasible due to lack of large reservoirs or suitable groundwater geology for [aquifer storage and recovery] schemes, this would be overcome with a DPR scheme.

“The reality is that some cities and towns will not have any other option at their disposal.”

“The lack of availability of a buffer due to geographical or space constraints.”

Minimisation of losses from an environmental buffer/storage

Several respondents identified DPR as being more water efficient than IPR due to the avoidance of potential losses from environmental buffers. Sources of water losses included evaporation from surface water reservoirs and incomplete recoveries from recharged aquifers.

“Where there are high losses from the environmental buffer.”

“By avoiding the large storage it would avoid loss due to evaporation.”

“Use less water.”

“DPR may also be considered if there is an excessive loss of treated water from the environment before it is able to be recovered. This may occur is other users are able to access the water before it is recovered.”

“Does not suffer from losses to the same extent as an IPR solution.”

“Reduces evaporation loss.”

“Higher yields, as there is no loss of the recycled water produced through evaporation or hydraulic loss.”

“Due to losses in environmental storages, DPR may also provide a more efficient climate resilient form of water supply.”

Opportunity for decentralisation

A few respondents identified DPR as an opportunity for decentralisation of urban water systems, particularly where centralised supply was costly.

"Ability to use intermediate storage in cities as the collection point for recycled water, significantly reducing the size of the supply infrastructure."

"Primary benefit would be in inner city supply augmentations - when the transfer pipelines are at capacity and there is significant cost from transfer augmentation and local / decentralised supply sources become more attractive."

"DPR also facilitates multiple decentralised inputs of treated wastewater back into the potable supply."

"Development of dedicated decentralised water supply networks"

"Where a community does not have easy access to a WTP and is costly to establish."

Improved flood mitigation capacity

One respondent noted that a switch to DPR from IPR could free up capacity in environmental buffers for use in flood mitigation.

"DPR also offers a noticeable advantage in flood mitigation capacity, where the volume saved in the environmental buffer (often a dam with a dual water supply and flood mitigation role) can be used fully for flood mitigation. Khan has shown that had this been the case in Queensland in 2011, the Brisbane floods may have been averted."

Avoidance of contamination of environmental buffer/environment with contaminants in recycled water

Several respondents viewed DPR as a solution to the potential problem of contaminating environmental buffers with poorly treated water.

"Where the nutrients in the return flow are a problem: presumably DPR has to stricter in removing them also?"

"A further benefit of DPR over IPR when surface reservoirs or dams serve as the environmental buffer, is the impact of the residual nutrients in the reclaimed water could have on the quality of water in the dam. Considerable effort (and hence cost and time) was expended in investigating this aspect for the Cotter Reservoir in Canberra and the Wivenhoe Dam in Brisbane."

"No impact of contaminated water on general environment (i.e. the buffer) No impact of contaminated water on other water body it would have been mixed with under IPR (more control)."

"Lower environmental considerations associated with adding recycled water to receiving waters. This could include promotion of growth of cyanobacteria."

"Reduced outfall"

"No impact on the environmental buffer, such as a potential increase in risk of cyanobacterial bloom occurrence that may adversely affect the drinking water storages."

"Less concerns about discharges of recycle water to rivers."

More logical public communication message

Two respondents considered that DPR was easier to explain to the public.

"It provides an answer to the question about cleaning it up only to make it dirty again."

"Simpler system to explain to the public - DPR makes the water recycling system just like desalination, which the public can understand and has no trouble accepting from a quality and health point of view."

More responsive supply-demand profile

Two respondents considered that DPR could deliver timelier water supply in response to changing demand.

> *"The biggest drawback to IPR is the time required for residence of the treated wastewater in the natural environment. While, with good planning and availability of suitable 'environmental buffers', this should typically not be a problem, one can envisage instances where either time or a suitable environmental buffer are not available."*

> *"A more responsive supply-demand profile, i.e. the volume of water production and availability are directly correlated with the water demands."*

No benefits identified

Several respondents did not see any benefits from DPR.

> *"Possibly for industrial use but don't see it being acceptable for a long time for domestic use."*

> *"There are significant water efficiency benefits that can be achieved through energy efficiency, sustainable building design, and operational retrofits. The [Local Government Area] has also identified that approximately 50 per cent of potable water demand is for non-drinking water uses such as toilet flushing, air conditioning cooling towers and irrigation of parks and gardens which could be supported through a decentralised water network derived from local recycled and alternative water resources. At this stage, [Local Government Area] is unable to identify any perceivable benefits of DPR compared to IPR."*

> *"At this stage I would suggest that we would never consider DPR above IPR as there are too many risks associated with DPR above those posed by IPR, as described in the section above regarding the environmental buffer. The other issue is the hydraulic/mixing dynamics related to direct injection, which would need to be overcome by greater expense on infrastructure."*

> *"No"*

> *"Have not thought about it. I like the idea of indirect as it provides a buffer against possible contamination oversights due to breakdown in the treatment systems."*

> *"Nil."*

> *"No. Managing entities are rightly risk adverse to potential litigation should contamination occur, and governments equally risk adverse to adverse community response."*

> *"No. It should be noted though that systems unrelated to waste water treatment are suitable. Coal seam gas water is being used directly."*

Two respondents did not see any benefits either from DPR or IPR.

> *"I cannot perceive any benefits for either DPR or IPR."*

> *"None. Both are world firsts as are planned here. The introduction of DIRECT reuse, while involving all Australians as guinea pigs for research purposes, is great for [multinational companies], partners and the management of the 'Australian Water Recycling Centre of Excellence' that are funding this survey. DIRECT reuse will also benefit engineers, scientists, members of the Australian Water Association with [multinational companies] as members and the members of the Australian Water Industry, both professionally and financially by being involved in a world first. I think that it is a waste of time to even talk about IPR as every attempt to force its introduction since 1994 has been DIRECT. In other words, proponents have always stated that INDIRECT (through a dam) was to be introduced when in fact DIRECT (pipe to pipe after treatment) reuse was planned. Toowoomba in 1996, Caboolture in 1996, Caloundra/ Maroochy in 1997, Sydney in 2004, Toowoomba again in 2005-6 and SE Queensland in 2008*

were all promoted as being INDIRECT when in-fact DIRECT was planned. I have those documents. Universities, including Monash, University of Qld, their UniQuest Pty Ltd, Griffith, UNSW will continue to benefit by obtaining research money thrown at them by the Federal Government."

Perceivable Obstacles to DPR

QUESTION: Can you identify any perceivable obstacles to DPR (compared to IPR) that may apply in some (hypothetical) future circumstances? In other words, why might DPR be less attractive or more difficult to implement than IPR?

The diversity of opinion about perceivable obstacles to DPR illustrates the complex interaction between the issues involved (e.g. health, safety, cost, and regulation), perceptions, and individual and group responses. A large number of respondents commented on the public's negative perceptions about consuming recycled water and the public's lack of confidence in the safety of treatment technologies and the trustworthiness of operators. Some respondents noted that these sentiments appeared to be shared by some policy makers, water managers, and regulators.

Public acceptance (as distinct to perception)

A number of respondents noted that DPR lacked community acceptance and/or wider public acceptance. Explanations for the poor acceptability of DPR included consumer's clear preference for traditional water supplies and a lack of public confidence in advanced treatment technologies. DPR was also seen as an unproven approach. One respondent saw potable reuse as a forced solution.

"The only reason that IPR is not used in Australia more is the social and political stigma and lack of confidence the community has in advanced water treatment. This has been exacerbated by negative media reporting, community action groups opposed to purified recycled water, a number of outspoken scientists and water professionals, and politicians. There are few examples worldwide of DPR schemes operating successfully on a large scale. There is a strong public sentiment that traditional water treatment systems should be the first and only water supply source for drinking purposes."

"But the principal obstacle (public support) remains, and until Australians can see other Australians safely drinking DPR water, it is difficult to see this improving."

"Community perception and acceptance."

"Greatest risk would be community acceptance."

"Community acceptance"

"The lack of the 'environment buffer' will make the community acceptance much harder"

"Consumer sentiment"

"Despite the Commonwealth Government driving the forced introduction of DIRECT potable reuse of treated sewage effluent, political parties from all sides obtaining funding from transnational water companies, the fact that the WWF's National Water Commission was set in place to force the implementation of DIRECT reuse, the government's use of the Productivity Commission, COAG, NCP, CSIRO, NHMRC to drive home DIRECT reuse under the title INDIRECT reuse, there may be problems. The Australian public has rejected what they though was INDIRECT Potable Reuse a number of time since 1994 at all above mentioned locations. With that in mind DIRECT may be even harder or impossible to sell but don't worry because as we saw in the Productivity Commission's 2011 Inquiry, the Commission, working with the NWC, removed policy and legal impediments standing in the way of DIRECT reuse, sorry INDIRECT, and recommended that a 'GROUP' be selected of water industry members, proponents of potable reuse to remove community consultations and make decisions on water supply

augmentations. The main obstacle though is involving Australian citizens as guinea pigs for research purposes in a world first intergenerational experiment, without consent."

"Public acceptance."

"The acceptability of DPR to the community is a significant obstacle."

"A key obstacle would be public acceptance of a DPR scheme."

"Community/Public acceptance"

"The main obstacle remains community resistance to accept drinking water that does not go through an environmental buffer."

Public perception – the yuck factor

As discussed above, several respondents noted the public's disgust — 'yuck' — at the thought of directly consuming treated water. An environmental buffer was seen as an (at-least partially) effective way to overcome the public's first impressions of treated water as having been sewage. This is aligned with earlier comments regarding the role of the environmental buffer in providing a 'disconnect' between wastewater as the source and drinking water as the product.

"Public perception issues, yuck factor. As noted above, the environmental buffer appears to be 'magic' in some people's minds."

"Recognition of source."

"DPR is not well accepted by the Western Australian community although IPR has about 70% support. From my own experience in canvassing opinions on water recycling, DPR has a significant 'yuck' stigma. This appeared to arise mainly because there is not yet sufficient understanding of or confidence in the treatment processes involved, to accept DPR."

"Public perception of drinking something that has only recently been sewage and therefore more a political problem."

"Principal issue is public perception (the 'yuk' factor)"

"I suspect that the yuck factor is the main one to overcome."

"The public perception that they are drinking 'purified water' neat (100%)"

"DPR is seen less favourably by the public - the 'yuk factor'."

"Public perception of 'yuk' factor."

"The main obstacle is undoubtedly public perception. The 'yucch factor' is orders of magnitude greater."

Public perception – inherent poor water quality or lack of safety

A number of respondents noted a lack of public confidence in the safety of advanced treatment technologies and in the trustworthiness of operators. Although these concerns may also apply to IPR schemes, it was suggested by some that they may be magnified for DPR. This was attributed to the absence of an environmental buffer as an additional treatment barrier as well as an opportunity to mitigate treatment failures (i.e. 'time to respond'), should failures occur.

Several respondents pointed to the need for strategic public education campaigns in order to demonstrate the safety and efficacy of DPR. However other respondents noted that the public interpreted adequate safety as being necessarily ‘fail-safe’. In particular, human error was a risk that the public was unwilling to tolerate.

“The public may see it as a 'higher risk' alternative option, compared with IPR.”

“Fear of the new and distrust of science facilitate scare campaigns.”

“Public perception of the risk to health, rational or not.”

“It is very difficult to overcome the yuk factor. There are plenty of examples where treated effluent are discharged upstream of extraction points for water treatment plants.”

“Public perception- a lot of effort has gone into the Do's and Dont's (ie. Do NOT drink recycled water) campaign- there will be difficulties in overcoming the information flow to the public and convincing them that the water is safe to drink.”

“The main perceived obstacle to DPR is that of public perceptions. The environmental buffer has significant appeal to many members of the public. In circumstances where there has been high profile major operational failings in publicly provided infrastructure, even infrastructure not involving water, (for example the nuclear accident at Fukushima), public acceptance of DPR will be difficult. There is a body of literature which argues that public confidence in the integrity and standards of the operator is really important. On occasions, even the identity of the operator is unclear to the public, so confidence and trust is, unsurprisingly, low.”

“A key obstacle would be community perception even if technologies and governance/accountability is deemed appropriate from a health regulators perspective. This obstacle would likely be greater for DPR however it is also a significant issue for IPR.”

“Public acceptance is clearly the higher risk for the implementation of DPR over IPR and to be honest, it is true that one safety barrier is removed, one that is completely useless or even costly when things are well managed, but one that could prove vital if the AWTP and other barriers were to fail significantly. This risk will be perceived as extremely high by water utilities and even higher by politics. Therefore a significant effort will be required in terms of public education to enable the implementation of a DPR scheme. This effort should be conducted over many years, starting with children at a young age, and preferably over a complete generation to be effective when required.”

“Lack of trust in technology. Lack of trust in sufficient regulation.”

“Public perception - consider Toowoomba. Also recognise that the public increasingly distrusts water companies - consider the recent controversy in NSW over biosolids reuse. This challenge is not solved yet nor are risks yet to be fully defined. As resource availability gets more strained I would expect it to become still harder to sell DPR whereas IPR has been with us arguably forever (though this still does not seem to be publicised with pride to judge by uninformed media comments some years back when IPR was more on the table in NSW).”

“Enough scientific information to ensure that the public is comfortable that all the necessary safe guards to ensure the sewage is treated to an adequate level, that the online monitoring to ensure the processes are working and that all bypass mechanisms are in place.”

“The perception that further barriers are required for acceptability to the users, like a second round of treatment. To be acceptable any treatment scheme would have to demonstrate that it operated on a robust fail-safe mechanism.”

“There is public concern with perceived health risks of IPR, so removal of the environmental buffer may be much harder to convince the public that there are no health risks from chemicals (hormones, etc) associated with DPR.”

“The only obstacles are community perception being used as a political football. Scaremongering without any scientific base, as is the case in proposed IPR schemes and more recently the fluoride debate

in Queensland, will be greater in any proposal for DPR. Education of the opinion makers is paramount. Opinion makers are in my opinion journalists, politicians, and commentators."

"To discuss or introduce the concept of DPR, there is a need to demonstrate, over the long term, that the current recycling plants (with the treatment technologies) are reliable and consistently deliver water of drinking standards at all times. A system of regular audit by independent panels to be in place to 'confirm and reconfirm' that recycled water is safe and meets drinking water standards and must be communicated regularly. There is need for long term public education and communication programme involving all stakeholders starting from IPR."

"Public perception of uncontrolled risk to public health. Fear factor."

"Only that it does mean fewer barriers and will therefore generate even more concern than IPR."

"Public perception…of human error in treating the water for DPR"

"The negative public perception (i.e. "Yuck' factor) of health issues associated with reclaimed water and the lingering memory of the failed IPR proposal for Toowoomba."

"How can you reassure the public that if a malfunction occurs in the treatment train, it is discovered quickly & appropriate steps taken to reroute the reclaimed water. Technology is replete with examples of human error/machine failure. Eg. plane crashes, nuclear power plants, oil drilling rigs and fluoridating water supplies."

"Public perception plays a critical role in the final implementation of any IPR or DPR scheme. As IPR contains an environmental treatment and barrier, DPR is less attractive to the public. It may be easier to convince the public that DPR is a viable option following the successful demonstration of a full scale IPR scheme as safe."

"I think the main obstacle is the public's perception of the health consequences of sewage-associated water. John Snow did a great job starting the public health effort to convince people not to drink sewage-tainted water - and after 100+ years the public has finally accepted that message. Convincing them to drink IPR runs counter to that original message - to a degree. The public are being asked to trust that the treatment is effective, and more importantly the people running it can do it without failure. We have issues in Queensland with many drinking water supplies who can't operate them appropriately, much less adding the additional risk of returning recycled water into the system. The strong public health message originating with John Snow is actually a good thing, and it's up to the industry to demonstrate they can be trusted."

One respondent offered an observation as to why, alternatively, DPR might be perceived more favourably by the public in terms of water quality and risk than IPR. The use of an environmental buffer in IPR could give the impression that the treated water was not yet of an adequate standard for consumption.

Initially I would have thought IPR would be easier to 'sell' to the public but in my experience over four years of trying to do this I would say it is not. The same objections you hear about IPR would apply to DPR, but at least the system is much easier to explain and also it shows you have confidence in the technology and the monitoring if you're going to go the DPR route - the IPR route unfortunately implies you don't really have that confidence. One of the big problems with the Western Corridor project was that the water was planned to go into a dam rather than a river. I hadn't anticipated this being a problem when I started work in the area but over the years I found people had an aversion to what they thought of as slightly off water going into a stagnant storage and festering, as opposed to going into a running river where presumably natural processes would clean it up. The experience with Sydney Water's St Mary's water recycling plant bears this out. It also helps that this is an undeclared IPR scheme and is instead badged as 'environmental flows'."

Public perception regarding non-equal distribution of recycled water

One respondent considered that the relative proportions of recycled water delivered to specific sections of the distribution system could have an impact on public perception. That is, negative perception may be generated if it were the case (or perceived to be the case) that some areas received high concentrations of recycled water, while others received conventionally sourced water. In this case, more favourable public perception would depend upon recycled water being relatively evenly distributed within a distribution system. This would include even levels of distribution to both high and low socio-economic communities.

> *"The public perception that they are drinking 'purified water' neat (100%) and it is only supplied to some areas (which is more of nature of the distribution network). So, need to ensure that it is 'well distributed' and is blind to economic status."*

Public perception – no further explanation provided

Numerous respondents also identified "public perception" or "community perception" as an obstacle but without further explanation.

> *"Apart from public prejudice - none!"*
>
> *"There is a perception that the public is generally supportive of water recycling, but not DPR (preferring instead IPR). I would be curious to see the actual numbers, from surveys, rather than 'our perception' of the situation. People are always surprised to hear that most Australians actually support water recycling - perhaps we might be surprised to find how many support DPR, WHEN IT HAS BEEN PROPERLY EXPLAINED. The latter is crucial - and hints at the way forward for water recycling in Australia: public education is critical. The general public barely understands the water cycle, let alone complicated water treatment. The wrong message of 'you'll be drinking your own sewage' is easy to spread and visual - proponents of DPR need to come up with an equally catchy sound bite."*
>
> *"Negative public perceptions"*
>
> *"Community perceptions and fear mongering. Ignorance."*
>
> *"Perception"*
>
> *"Community perceptions"*
>
> *"Public perception."*
>
> *"Public perception is the number 1 risk."*
>
> *"Public perception"*
>
> *"Public perception is the main problem with adoption of a DPR solution"*
>
> *"Public perception"*
>
> *"Primarily public perception issues"*
>
> *"Public perception will probably be a bigger issue."*
>
> *"The main barrier is potential negative public perception."*
>
> *"Community perception"*
>
> *"Largest is the negative public perception"*

"The attractiveness [of IPR] is that it seems more palatable for the general community."

"Community perception"

Lack of political will

Several respondents saw DPR as a difficult and unpopular political issue.

"The political support (or rather lack of political strength on potentially unpopular and difficult decision, even if these are necessary to the sustainable and continued growth of the Australian society) and public uncertainty are, as always, most likely to be the most important obstacles to DPR."

"The second obstacle is political. Politicians will look for the most cost effective, politically palatable solution."

"In Noosa in 1992/3 the Community Reference Group opted for DPR - supported by many members of the community who had attended information days. These didn't include some of the Councillors and it was lost by 1 vote. (See paper by Uhlmann and Head)."

"The only obstacles are community perception being used as a political football."

"Political pragmatism makes DPR problematic"

"The main barrier is potential negative public perception and political paralysis."

"political anxiety"

Lack of global precedents

One respondent though that local acceptance of DPR depended on DPR's global acceptance. It was noted that the few current global examples of DPR did not provide a large basis for global acceptance.

"There are less global examples of DPR than IPR and global acceptance will be a big driver of local acceptance"

Lack of regulatory framework and/or regulatory competency or regulatory acceptance

Several respondents suggested that existing regulatory gaps would need to be addressed before DPR was more widely accepted or could be implemented. Some comments noted that local regulators might lack the technical capacity to deal with the necessary approvals for DPR schemes.

"Lack of regulatory framework. Regulatory and industry competency to manage risk management plan."

"Current Health and Environment regulatory frameworks…make DPR problematic"

"The lack of national guidelines/standards, and public health legislation specific to the management of a DPR. Any regulatory conflicts between environmental legislation (i.e. wastewater discharged) and public health legislation (i.e. drinking water quality) would need to be overcome."

"Regulators' skills set gaps and the general lack of capacity by regulators to approve DPRs, particularly in smaller jurisdictions such as the Northern Territory."

"Regulatory acceptance."

"Regulatory issues"

"In both IPR and DPR, drinking water quality standards will need to be expanded to accommodate the different water source compared with the traditional water sources. The water quality constituents to be tested will need to be expanded from the current list to include a wider list of contaminants including anthropogenic micro-pollutants. The use of an environmental buffer to facilitate the use of recycled water for potable purposes through an IPR scheme is only an interim measure. In essence, further developments in both IPR and DPR schemes must be accompanied by a more rigorous and expanded water quality treatment and monitoring regime. A DPR scheme merely highlights the current deficiency by the 'premature' removal of the environmental buffer."

"The perceived obstacles in this circumstance would be lack of regulation. Development of regulation would be contingent upon defining performance criteria for the operation of the system (AWT + drinking water system) that the perceived role of 'the environmental buffer' have been included in the proposed action (i.e. pathogens, % content recycled water, WQ targets for salt, nutrients), fate of TIC's (Tentatively identified un-regulated compounds). It is important to note that these obstacles only apply in jurisdictions where IPR is accepted and practiced. DPR in jurisdictions where IPR is not on the table would be attended by the same obstacles as IPR."

Lack of industry competency

One respondent suggested that the water industry might lack the competence to manage the risks of DPR.

"Industry competency to manage risk management plan".

Risks of poor water quality

Some respondents indicated a concern that the treatment barriers to be used for a DPR project may not be sufficient to remove all important contaminants to below safe levels in drinking water. Endocrine disrupting chemicals were specifically mentioned, as were issues associated with 'mixture effects' of complex low concentration mixtures of chemicals. Furthermore, treatment process by-products (e.g.disinfection by-products) were mentioned including those that may be particular to some advanced water treatment processes (e.g., ozonation).

"Lack of trust regarding the process to remove all chemicals (waste and treatment chemicals). Don't know the long term implications of highly treated water or manufactured water on human health."

"As a stop gap it has few drawbacks. As a permanent water supply option, there may be concerns about long-term exposure of the population to trace or ultra-trace concentrations of certain chemicals (e.g. endocrine disrupters) or from mixture effects of different chemicals with a similar mode of action. As long as IPR keeps the contribution to drinking water from recycled water below a certain threshold, these risks will be lower."

"Public health concerns, meeting potable water quality."

"Also source control of what is discharged to the sewerage network. There are so many new compounds and chemicals developed each day. It will be a challenge and potentially expensive to keep treatment technologies matched."

"The lack of the 'environment buffer'…places a greater emphasis on ensuring effective treatment processes, since additional barriers are not present."

"Technology to remove chemical hazards"

"Uncertainty. While treatment technologies can remove contaminants to desired levels, there is often a 'downside' to technology. For example, chlorination kills pathogenic organisms but may introduce carcinogens in the form of chlorinated organic compounds; ozone may also kill pathogenic organisms but may lead to formation of bromate, etc."

"The fear factor of contamination"

Risk of a water quality incident and loss of 'time to react'

A number of respondents suggested that risks associated with water quality incidents may be more significant for DPR schemes than for IPR. Particular modes of water quality incidents identified included accidental contamination, treatment process failure, sabotage and terrorism. To these respondents, the absence of an environmental buffer implied both a loss of treatment redundancy ('multiple barriers') as well as the loss of 'time to react' to incidents.

"Benefits small relative to risk of accidental or contamination."

"Risk of failure in treatment plants ending up in my mouth."

"Treatment reliability assurance"

"IPR potentially has benefits due to longer lag time between treatment and tap in case there is an out-of-spec event that is not identified immediately."

"DPR is clearly more vulnerable to sabotage and terrorism as the latter would have trouble with two plants. If DPR takes place at effectively a single location this probably makes it more vulnerable."

"If another event, such as the case in Queensland where an automated fluoridation system failed and continued to pump elevated concentrations of fluoride into the water for several days, was allowed to occur, this will seriously damage the claims and assertions that the Advanced Water Treatment system is so advanced that it would shut down immediately that a fault occurred."

"Greater risk of breakthrough due to less barriers, less time to react to an issue, more monitoring required, greater emphasis on mechanical/chemical treatment infrastructure, and not taking advantage of natural ecosystem processes that could do the same work (passively) as a mechanical plant."

"We need multiple redundancies & barriers to make sure we get it right or the loss of confidence will take a decade or longer to rebuild."

"The lack of an environmental buffer will mean that much tighter controls will be required in the event of incidents or variations in treatment. Operator responsibilities will be greater. If incidents are not controlled quickly the likelihood of public health impacts will be higher. Dilution and detention will not be a safety feature/barrier."

"Risk. While treatment technologies are relatively robust, accidents can happen (membranes can break, advanced oxidation processes can fail, inappropriate chemicals may be added, etc)."

"Health authorities, water suppliers and water quality professionals value multiple preventive measures as contributing to a more resilient source of supply."

DPR would obviously become more difficult to implement in the wake of any documented incidence of adverse health effects traceable to any form of IPR, or valid adverse research outcomes.

"Corporate Governance requirements. Regulator confidence and requirements. Safety of supply"

Belief that the environmental buffer is necessary

Two respondents felt that the public commonly believed that an environmental buffer was simply necessary for potable reuse. This belief was also attributed to some water industry professionals.

"One major obstacle to the wide scale acceptance of DPR as an option for consideration is the belief by many - including some water industry professionals - that the environmental buffer is necessary. This is now being challenged. Much of this water industry belief is its own belief that the community will be

more accepting of PR if the environmental buffer is included. There is now evidence to show that once the community understands that [unplanned] IPR already occurs, that the levels of treatment afforded in the AWTP and the resulting quality of water produced are very high and that these facilities are reliable in operation, many will change their minds about the need to inclusion."

"It can prove difficult to generate public acceptance of an IPR scheme and there has been communication (including in Australian Guidelines explicitly requiring an appropriate time buffer) that a 'natural barrier' is of importance. It may therefore be difficult to overcome the public perception that an environmental buffer is not required, without the technical improvements mentioned above."

High costs associated with DPR

As discussed above, a number of respondents thought that DPR would result in cost savings. However, a smaller number of respondents thought that DPR would result in higher costs, particularly higher water treatment and monitoring costs.

"The major obstacle is cost of delivering DPR with the same or better risk profile than IPR or other sources. The economics of recycled water treated to a standard that is fit for purpose and used as close as possible to its point of origin as a substitute for potable supply (e.g. parks, gardens, industry) would need to be measured against the economics of DPR, IPR or other sources. The volume of water that can be produced would also need to be considered in the cost benefit analysis. During periods of water shortage, there is also a reduction in the amount of waste water generated and possibly its quality (particularly salinity). It may therefore require additional costly treatment."

"Energy use increase/ treatment cost increase- these costs would probably be passed on to the customers"

"Cost"

"Removal of the environmental barrier/buffer will require higher log removals (or more stringent validation, monitoring) for other steps in the treatment train, which may not be economically attractive to implement. This is exacerbated by the fact that there are relatively few barriers involved (two filters and AOP). Increased cost of energy production (carbon constraints) may mean that it will become more attractive to avoid relatively energy intensive advanced treatment of WW: Instead an 'engineered natural' solution could be implemented, by which I mean WWTP effluent flows into a stream/river, then reservoir (though not necessarily), then to DWTP. Oh, but wait, isn't that what we do now?"

"Treatment costs may be higher as natural treatment is free."

"Water for IPR can be treated to a lower standard before the environmental buffer (as it will be treated again) and as such could be cheaper than DPR"

"Cost. Treatment of wastewaters to a level that is acceptable to particular consumers may well be very costly (though this will of course depend on what is considered 'acceptable') compared to the alternate 'passive' treatment in an environmental buffer."

"The costs of DPR and IPR are likely to be similar, taking account of the enhanced risk management practices that are likely to be required for DPR to give the same level of protection as IPR."

"Treatment & monitoring"

"Cost"

Need for additional risk management measures compared to IPR

Some respondents reported that DPR would require more sophisticated risk management. Although generally not explicitly stated, it may be assumed that the obstacles identified here may be the additional costs associated with increased risk management and/or the possibility that sufficiently sophisticated techniques are not currently available.

> *"Fail safe will need to be higher than IPR because of the lack of a 'magic mile' where the public can alert water managers to a problem in addition to water company management arrangements."*

> *"Risk management in competitive market for water supply (see WICA in NSW)"*

> *"DPR would need higher levels of operational control (risk-based management plan)"*

> *"Water quality monitoring requirements (although this is likely to be comparable for both options)"*

> *"I imagine that the risk management responses (eg log reductions) required of DPR would be considerably more than IPR, because IPR usually involves further treatment before re-use, but I'm not sure about what the implications would be for life cycle impacts - it may go either way - that is, in some cases, life cycle impacts (environmental, economic, and social) may be greater for DPR and in others, greater for IPR."*

Need for real-time monitoring exceeding current capabilities.

Two respondents noted the need for real-time monitoring of DPR and expressed concern about whether this could be achieved in practice.

> *"With full DPR prevention of health problems relies completely on real time monitoring. This field is developing but it has a long way to go."*

> *"A key aspect would to be to improve monitoring technologies so as to reduce costs and turnaround times. Ideally, online monitoring would alleviate the need for any buffering, environmental or otherwise."*

The need to manage different source waters or impacts to distribution system

A few respondents considered that there may be some challenging issues associated with mixing highly treated recycled water with water from conventional sources within distribution systems. Potential issues included variations in water quality, as well as changing pressures in some sections of distribution systems.

> *"Managing differences in source inputs- variable quality requirements for different utilities due to differ source inputs, colour, taste, odour"*

> *"DPR may also be constrained by any limitations that might apply to distribution systems that were not intended or designed for DPR. Relevant factors for consideration could include pumping/pressure related issues; potential for issues associated with fluctuating water quality if there is much variability in recycled wastewater/water from other sources; potential issues associated with mixing of different water sources/qualities which would require consideration of potential impacts to both supplier distribution pipelines and customers (plumbing, appliances etc)."*

> *"Issues associated with mixing of different water types will need to be addressed for either type of DPR arrangement but more significant for injection after drinking water treatment plants."*

Stranding of existing water supply infrastructure after significant investment

Two respondents thought that existing underutilised water infrastructure, namely desalination plants, should be put to use before implementing DPR.

"Water saving attitudes shift due to construction of desalination plant in Victoria- why invest in recycled water when Vic government has already spent significant costs on the construction of the Desalination Plant (our Water Corporation is located 30 km from the Desal Plant)."

"The costly construction of desalination plants in some capital cities and the subsequent expectation that they will be used and not mothballed."

Centralised nature of existing water supply and sewage treatment infrastructure

One respondent thought that it would be difficult to implement DPR in established urban areas with existing centralised, rather than distributed, water infrastructure.

"Supply and sewage treatment infrastructure that is centralised rather than distributed represents a key obstacle in large cities since DPR infill will almost certainly be distributed."

Loss of advantage from using environmental buffer as a means of transporting (distributing) water

It was noted that the advantages of some environmental buffers includes transportation or distribution to various extraction points. A DPR scheme would need to include new water distribution infrastructure to replicate these processes.

"IPR can be used as a means of transporting or distributing water between a number of extraction points reducing the distribution infrastructure requirements of DPR. In WA managed aquifer recharge by IPR will enable the water to be extracted by existing infrastructure at other points in the aquifer remote from the treatment plant. This will negate the need to retrofit new water distribution infrastructure into the existing network and existing urban environment."

Lack of a storage buffer

The need for storage to balance supply and demand of treated water was identified. Two respondents found DPR to be lacking in storage capabilities.

"There is no storage buffer in DPR balancing supply and demand"

"In a more variable climate, need for buffer storages will increase, and aquifer storage in particular offers evaporation free storage. The availability of a continuous feed of water to aquifer storages can therefore increase drought resilience at a very low cost."

Risks Associated with DPR

QUESTION: Can you identify any risks associated with DPR relative to those that apply to IPR? Please consider a broad range of risks such as environmental, social and economic risks.

Many respondents simply referred back to answers that they had already provided to earlier questions, particularly the previous question relating to 'obstacles' for DPR relative to IPR.

A significant number of responses indicated that respondents could not identify any risks associated with DPR relative to those that apply to IPR. Many respondents simply answered "no" to this question. Others left the answer field blank. Furthermore, some participants provided an (unsolicited) opinion that there are likely to be fewer risks with DPR than with IPR.

"I can't see any extra risks with DPR - in fact I think there are fewer risks. The environmental and economic cases are straight forward. As long as there are multiple barriers and fail safes that shut a plant down if a barrier fails then I think any social risks can be overcome".

"No I suggest the same risks apply to both DPR and IPR. In the case of DPR I believe the environmental and economic risks in theory should be less than the IPR case. Social risks in some way depend on the climate cycle at the time, -a greater acceptance of both IPR and DPR when a community is facing severe water shortage in the case of droughts. Political parties need to take a bi partisan approach to such issues".

"Generally I think the risk associated with IPR are greater than those associated with DPR, where there systems are managed appropriately".

Social risks

A number of respondents saw social risk as a significant management challenge because of the complexity of individual and group perceptions and responses to DPR, as well as to water recycling more generally. However some respondents also noted the opportunity to improve public participation and transparency in the DPR decision-making process.

"Social only"

"Public perception risk...they do not trust that you will get it right!"

"The public and the politicians need to be convinced and supportive, otherwise a scheme could be built and validated, but not actually become operational despite the expense (can you say 'Western Corridor scheme' anyone?)."

"There is a social risk of doing away with the buffer - partially discussed above - and steps are being taken to address/understand this."

"Social - clear risks on acceptance in a large community where the drivers for recycle are not well articulated. It is hard to see that the entire community will support DPR or even IPR without significant climate or environmental drivers where the potable supply from traditional and desalination sources is secure."

"Perceived risks for DPR include mistrust in new technology to operate effectively, mistrust that there will be a plant operator 'human error' fault which leads to contamination in the water quality, and lack of capacity to overcome the 'yuck' factor".

"Social Risks- public perceptions from recycled water campaigns/ information flow"

"There is a higher risk for public acceptance as I expect a more challenging (less objective, more emotive) debate with opponents to potable reuse schemes fuelled by the political scene and the local press with selling and evocative titles."

"Social risks - related to perceptions."

"The social risks for DPR are clearly higher. Most surveys on potable reuse show a preference for use of an environmental buffer."

"Social - community having sufficient knowledge to make an informed decision."

"Adverse public perception or lack of confidence in the process can result in the rejection of DPR as a water supply option."

"Community acceptance"

"Social risks - community acceptance and the 'yuck' factor."

"Much greater [health and] PR consequence of DPR treatment failure - potential for more people to be affected more severely."

"[Human error] would seriously damage the social acceptance of a DPR scheme. As IPR has the buffer of the natural system, public confidence could be maintained despite any human error."

"The main difference is social acceptance."

"Socially, I believe that the environmental buffer is a selling point to those opposed to any recycled water entering the drinking water supply."

"Community outrage. Political intervention. Serious risk to corporate reputation and stability. Any event can incur this regardless of whether the event is serious or minor."

"There is a greater chance of public rejection of DPR subsequent to commissioning, whether as a result of a real or perceived non-conformance or adverse public health outcome, or by change of government, resulting in stranded assets and/or loss of water security."

"The only risk is public perception"

"Social risks are all to do with perception and emotion"

"Social risks - public seem less likely to accept DPR"

"The main risks are public perception and political."

"Community engagement"

"There are risks that a DPR scheme would lose public acceptance as a result of a process upset."

"Public scrutiny related to any plant non-performance etc."

"Also, perception issues related to the adverse result in Toowoomba, where the public voted against IPR to augment water supplies."

"The risk of non-acceptance by public would be higher for DPR than IPR. Utilities would need to have much more transparent water quality reporting than at present. An excellent example of transparency in public reporting is for the Beenyup groundwater replenishment project."

"With utilities being seen as corporations that need to make a profit, shifting to DPR from IPR may be perceived as a step taken primarily as a cost saving measure, with public safety possibly compromised to some degree in doing so."

"Community acceptance"

"It is likely that it would require only one event of this nature to significantly impact on social acceptability of DPR."

"The complexity surrounds all of the social issues. It is very easy to turn a debate on DPR and referencing drinking sewage."

"I think that community acceptance is still the largest risk. We still need to bring the community along, teaching them, and proving to them, that we can produce safe water."

"The greatest challenge is not the technical capacity to provide DPR or IPR, but the social barriers, originating from the public health message discussed in the previous question."

"The main risk is that if the water is being used for drinking or will have close contact with the body, then it may be more problematic to gain acceptance of a DPR scheme."

"The social licence to operate risk is stronger"

"DPR in particular would require an unprecedented public education campaign that allays the fears of the public to overcome the 'Yuck' factor."

Political risks

A few respondents thought that DPR was a difficult political issue that was unlikely to be championed by governments while alternative water supplies were available.

"Political - no government will approve it in the absence of strong drivers (i.e. we would need to be running out of every other source option)"

"The social risks largely translate into non-re-election of governments who introduce either DPR or IPR without due preparation of the electorate."

"Continuing political interference will hamper all recycling schemes but in particular DPR."

"Political 'guts' to implement DPR and detraction of the area using DPR as a place to attract people to live."

"Government support, such as the Western Corridor scheme in Queensland where the advanced water treatment plant was built, but not 'switched on' due to the 'yuck factor'."

Water quality/safety/public health risks

A large number of respondents noted the public health risks associated with treatment system failures, as well as the potential for unknown long-term risks associated with consuming treated water. The environmental buffer was typically viewed a providing an important layer of safety, particularly in the context of new chemical hazards and technology failures.

"One less treatment barrier, which may add a risk if parts of the system or its management fail."

"There is, of course, always the risk of catastrophic failure of the AWTP in extreme events and the ensuing health risks. In a well-designed scheme with multiple control points and an action plan to deal with emergencies, this risk should be almost nil (although I am sure that is what they thought at Fukushima ...)."

"Margin for error smaller. We know Queanbeyan sewerage flows from time to time into the Molongolo and Lake Burley Griffin, but water drinkers downstream of the Lake never seem to complain (although recreational Lake users do). Can we be sure DPR handles all the new chemicals (eg medicines, reagents) likely to be found in water in the future. IPR would always be a buffer for such unknowns, and resident animals may tell us something has gone wrong before too much other damage is done."

"Inadequately treated [advanced treatment plant water] will be introduced into the drinking water stream. This can be addressed with a range of treatment reliability enhancements [that are currently under development]."

"Health risks are my main concern. At what cost can you provide certainty and how does it stack up against other sources of supply?"

"Social & Environmental Risk- Increased public health risk due to source water that is not diluted".

"Chemicals, chemotherapeutic agents, etc in water. Human error in the design, construction and operation of system".

"The Australian Water industry appears to be driven these days primarily by pursuit of profit, minimization of investment, privatization and outsourcing. Environmental and ecological health are, as a result, becoming secondary considerations. While there is no malice in this development, I see it as encouraging the building of recycling systems with the minimum treatment specifications and fail safe

arrangements to match i.e. the minimum necessary to satisfy regulators whose resources are very thin. This increases the potential that eventually something will go wrong. The precise likelihood of hazardous events being severe or catastrophic is unclear but it is higher with DPR than IPR and any large event will discredit water reuse more broadly. And the more schemes that are brought in the more opportunity there will be for problems. This is not an issue unique to water recycling but it does deserve extensive consideration. A familiar analogy is the challenge of flood damage prevention. Historically building down to the 1 in 100 year flood recurrence line has been the norm. However with climate change and increasing 'build to the limit' and simply the march of time means hazardous events will happen which were predictable conceptually but still cause catastrophes. The examples of the recent times Queensland floods indicate the issue in principle. Water recycling should not be based on analogous 'build to the limit' policies."

"There may be increased health risks with DPR if the barrier technology is compromised."

"Public health"

"Much greater health…consequence of DPR treatment failure - potential for more people to be affected more severely."

"EDCs at current AGWR levels may cause adverse effects in fish if the water was used in aquaria or aquaculture. Dialysis water treatment and similar systems may need to be revalidated for exclusion of potential contaminants of DPR water (AGWR assumes oral and perhaps dermal exposure)."

"Primary risk is breakdown of processes with releases of untreated or under-treated water into potable supply systems."

"Human failings remain the greatest risk for all recycling systems and could have a much higher impact in a DPR system than an IPR or any other recycled water scheme."

"Risk of contamination of drinking water supply"

"Public health risks arising from inadequate risk assessment, design, validation or operation of the DPR system. These risks would be similar in nature, but greater in consequence than those applying to IPR. A non-conformance event could result in significant widespread contamination and the need to provide alternate water supplies, possibly resulting in severe water shortages and/or loss of supply over an extended period. Clean-up costs would be significant."

"Greater water quality risks due to greater emphasis on reduced number of treatment barriers."

"If there is a treatment upset and inadequate contingency is in place, a DPR facility would be more likely to cause health risks in the community."

"Detention ('batching') theoretically provides greater time for quality testing and assurance."

"The WHO (& NHMRC) identify source control as the primary barrier. This is intrinsically compromised with both IPR and DPR. IPR & DPR are inherently high risk activities. Furthermore, the risks associated with unintentional and intentional sabotage are far greater, as there is increased opportunity. DPR further elevates the risk profile (as it relates to consequence) via exclusion of an environmental buffer."

"Human health - any treatment failure could result in water going directly to consumers. There is little chance to intervene prior to exposure."

"More than I can hope to include here. I can only wonder why 'HEALTH RISKS' are not included in this survey. Why would anyone want to purposely add contaminates to our existing dams, rivers and streams (IPR). Why would anyone want to add chemicals, pathogens, bacteria and other contaminants DIRECTLY into our drinking water supply mains. The treatment processes fail to remove all contaminants, one can't test for many of those contaminants, plant failures, poor management, technology not up to scratch, we don't know what happens when two or more contaminants combine. The only way to detect short term health impacts is to monitor local hospitals and medical centres (After

the fact). There are no ways to detect long term or intergenerational health impacts of consuming treated sewage effluent."

"The ongoing reliability of the technology to achieve drinking water standards poses a major risk especially in areas where there are questions about the reliability of the power supply."

"Verification of the performance of both DPR and IPR schemes servicing regional areas will be problematic for small water authorities that lack sufficient expertise and ready access to water laboratories."

"Risk of failure of technology (and the consequences of failure more severe) will be higher for DPR than IPR."

"Given the greater reliance on technology, there is more uncertainty as to whether specialists have 'got it right' with DPR than with IPR."

"There is the issue of 'unknown unknown chemicals' that have chronic health effects. Dilution & transit in an environmental buffer is partial protection against ingesting this stuff."

"The consequences of not detecting treatment failure in real time are less in IPR schemes."

"Potential human health risks are greater with DPR as the additional barrier that the 'environmental buffer' provides has been removed."

"Water quality"

"There is a risk that out of specification water is produced that may end up in the reticulation network more rapidly than it would with in IPR scheme."

"The risk of a new chemical hazard passing through the AWTP and impacting on public health is likely to be higher for DPR then IPR. This is twofold as, water is delivered quicker to the population in DPR schemes (the water may reach the community before test results are obtained) and at least two barriers which may have an impact on the hazard have been removed from the treatment train (i.e. the Environmental Barrier and the Drinking Water Treatment Plant)."

"The main risk is that process control barriers fail to prevent contamination."

"The risk associated with failure of treatment processes is greater with DPR simply due to the absence of a buffer. This simply requires a different risk management response compare with that for an IPR scheme."

"From a technological perspective, the greatest risk is ensuring that all monitoring is suitably operating. Then comes the potential for human error."

"Harder to manage catastrophic technical failure."

"Puts greater reliance on the recycled water treatment plant operations and gives less time between production and consumption to identify and deal with any public health issues."

Economic risks

A number of respondents commented on the uncertain economic feasibility of implementing DPR. DPR schemes might ultimately be deemed unacceptable, leaving stranded assets. The perceived increased treatment and monitoring costs of DPR were often seen as being prohibitive.

"The primary risk stems, in my view, from the economics of IPR and DPR. If enough funds are put into either system, safety can be assured. However, infrastructure funding will increasingly be challenging, and while early schemes will receive significant investment, there is a risk, over time of reducing the

controls. This is particularly so in an environment of deregulation. The benefits of the environmental buffer should not be underestimated."

"Economic - its dearer than dam water, and therefore, you could only make the economic argument if there is no other (cheaper water) alternative."

"Economic - the public are already complaining about water pricing"

"The social 'licence to operate' is dependent on very high standards of performance. Engineering a DPR plant to acceptable risk levels may prove to be costly."

"The greatest risk as I see it is the belief that by doing away with the environmental buffer, there will need to be an increased level of treatment and monitoring required at the AWTP. This is based on the belief that the buffer affords a level of treatment that has not been proven in any shape or form. This could well reduce the likely cost advantage of DPR over IPR."

"Economic - cost of infrastructure to implement is high"

"An economic risk is that, after public investment to reconfigure urban water supply infrastructure for DPR with new plants, pipelines and pumping stations, there may no need for the system due to an improvement in water security from water efficiency measures and traditional dam sources. This situation is happening now after our massive public investment in constructing desalination plants in all Australian capital cities."

"Economic Risk/Social/Environment- Infrastructure required to connect wastewater treatment plants to a water treatment plant & back into distribution system"

"By its nature DPR would likely require specific monitoring/safeguards due to (presumably) lesser storage time that would be available prior to reuse that would differ (but probably more onerous overall) than for IPR."

"The economic risks for DPR are probably even greater than for IPR, in Qld at least, where political decision-making effectively resulted in billions of dollars in investment being rendered unusable (for the foreseeable future anyway)."

"Economic - cost, feasibility"

"Economic risks - the extent of buffer systems required may be more expensive."

"Related economic cost of such failure to plant operators (usually government of some sort), industry and community"

"Potential on-going community cost of people choosing alternative DW supplies such as bottled water (may be a consequence of DPR implementation even without any adverse incidents)."

"Any reuse is economically of higher cost than other traditional sources of water such as from groundwater or precipitation."

"Higher economic costs due to the need for greater levels of treatment (more infrastructure). Greater energy usage associated with the higher level of infrastructure."

"Economic risk is mainly associated with community risk being higher."

"Economic - potentially higher costs."

"The economic risks include the fact that INDIRECT and DIRECT Potable Reuse are so expensive and inefficient, cost much more than dams, that Australian companies can't compete with overseas companies that rely on dams and cheaper water supply options. Why do you think Singapore, USA, Japan, South Africa are involved in this strategy to have Australia introduce DIRECT reuse, not to mention tourism. The introduction of DIRECT reuse will force the privatisation of Australia's $80 billion of

water and wastewater infrastructure and the residents ability to pay for water which is already strained by the use of desalinated water will increase dramatically as will health impacts."

"Economically: the cost of monitoring to routinely verify DPR and the impact on attracting people to live in area with DPR."

"Cost of DPR is likely to be substantially higher than IPR"

"DPR would rely on a higher degree of monitoring and control to ensure treated water quality."

"Huge costs associated with excessive monitoring requirements."

"The cost of such [process control] barriers in the short term could be very high, though they would reduce over time."

"This is also loosely related to the cost of providing such a system, which in Australia's current environment just adds to the cost of a system that is already weighed down by the costs of so much change."

Environmental risks

Several respondents were concerned about the environmental impacts associated with advanced water treatment in DPR, including increased energy requirements and disposal of treatment by-products. A few respondents noted the valuable contribution that discharges into environmental buffers could make towards environmental risk management.

"Wastewater, while a valuable resource for water recycling, also plays a role in environmental flow. The environmental cost of abstracting a large volume of water from the natural water cycle needs to be determined."

"There are a whole range of issues that would need to be considered such as the safe disposal of waste by products and impact on the environment."

"Environmental Risks- energy use, increase in consumption"

"Environmental - impacts on water cycle - surface and groundwater quality and quantity"

"There are environmental risks associated with the residues of treatment."

"Environmental risks due to inappropriate management of DPR purification system by-products and/or release of non-conforming product water. Energy consumption might also be an issue. These risks would be generally similar in magnitude to those associated with IPR."

"Environmental: use of RO and management of the brine and use of ozone and the associated electricity"

"Lack of broad environmental benefits of IPR."

"It is conceivable that in some coastal aquifers and in dams of drying catchments the topping up by recycled water assists in protecting the existing natural resource from coastal saline intrusion or anoxia or acid-sulphate conditions, that could have longer-lasting effects on the ability to use the natural resource."

Other risks

Other risks identified included a potential lack of locations for storage of treated water and whether or not DPR could operate as a stand-alone option.

"Land availability for storage of treated water."

"Whether or not DPR can provide a sufficient quantity of water for potable or even agriculture purposes without supplementation by another water source or technology such as desalination. Increasing utilities costs may be an important driver that encourages water conservation thus reducing the water supply for DPR."

Knowledge Gaps for DPR

QUESTION: Are there important 'knowledge gaps' that should be addressed prior to proceeding with DPR in Australia? Please elaborate as much as possible.

A diverse range of knowledge gaps was identified by the respondents. These included some relatively technical knowledge gaps relating to scheme design, assessment, operation and validation. Regulatory gaps and lack of information regarding economic and environmental impacts were also identified.

Water quality and process performance objectives

Two respondents believed that the existing Australian standards for water recycling were deficient in key areas including 'reliability' standards and source water management.

"Treatment performance/reliability standards"

"Best practices for source water quality control"

Treatment plant design

Three respondents stated that there were knowledge gaps regarding the treatment performance capabilities of key processes or treatment trains for the effective removal of contaminants.

"An evaluation of which treatment trains could meet such standards"

"Improved models to predict chemical removal/transformation through advanced oxidation processes would be beneficial. Models of rejection of chemicals by reverse osmosis are reasonably robust and processes well understood. However, to the exception of some specific chemicals, there appears to be limited knowledge around predicting removal through advanced oxidation processes."

"Technologies for effective removal of contaminants"

Treatment plant operation

A few respondents suggested knowledge gaps or deficiencies in current advanced treatment plant operation and control. Improved training for plant operators was an identified need.

"I don't think there are 'knowledge gaps' as such to run these schemes, but there is definitely a deficiency in our management / operation of some treatment plants. We would need to have very robust systems in place to ensure they are operated effectively and robustly."

"Better training for AWTP operators."

"Process control. This is being addressed with WateReuse Research Foundation Project 11-01 3-operator reliability and certification requirements."

Health risk assessment

A number of respondents indicated that there are knowledge gaps in our ability to undertake comprehensive risk assessment in order to fully quantify risks posed to human health.

“Do we know what concentration of contaminants may cause harm to any particular sensitive group? AGWR only provides examples of how such concentrations may be derived - some of the sources of tox data used in AGWR may not be applicable for some sensitive groups (eg estrogen numbers derived from cancer incidence related to HRT use). Do we have a good enough understanding of mixture effects to derive protective guidelines? Do we know all of the enteric viruses of concern? Is it valid to use MS2 virus or similar surrogates if, say, 8 or greater log removals need to be validated?”

“Proper [human health risk assessment] and consideration of likely/possible breakdowns - possibly using HACCP principles.”

“Understanding the risk associated with chemicals in raw sewage need to be further explored.”

“In a scientific sense, the greatest knowledge gap still lies in the area of quantitating the impacts of ‘contaminants’ present in the treated recycled water, and moving the community beyond the presence/absence of contaminants argument to the health effect argument. I believe that while we are making progress in this direction, we are still lacking in a definitive, economical and rapid method of assessing ‘whole of effluent’ toxicity which can be easily and directly related to potential adverse health effects.”

“Possibly a need to do more research in terms of contaminants (the unknown unknowns)”

“Quantification of failure risks of system components in wastewater and water treatment plants, and of failure to detect failure.”

“The outcomes of full quantitative human health risk assessments specific to each scheme is an important knowledge gap.”

Assessment and management of hazardous substances in wastewater

A large number of respondents expressed concern about current levels of uncertainty in relation to the assessment and management of hazardous substances present in wastewaters. In particular, respondents identified industrial waste discharge, endocrine disrupting chemicals and hormones, radioactive and medical waste, disinfection by-products, and “undetectable/unknown contaminants”.

“More specifically, one of the most important gaps may be in terms of source control in the sewers, i.e. control on industrial waste discharge or warning systems on illegal dumps to the sewer.

“What weird and wonderful chemical risks will we face I wonder? The EDC issue is still not sorted.”

“My understanding is that the disposal of materials into the wastewaters that supply treatment plants in some other countries is controlled. This is done to ensure a reasonably uniform quality wastewater source and so protect the treatment process. I think more research needs to be done into the effects of hazardous materials found in wastewater such as radioactive and other medical waste, in the treatment process.”

“Variability of compounds in source water. The possible presence of spikes of components, which we have not quantified as occurring, that may impact on the efficiency of the treatment train. A good understanding of the concentration and types of these compounds in sewage.”

“What are the key contaminants (chemical and biological) in the source water that must not reach the product water?”

“Undetectable/unknown contaminants entering the system which are not removed (note that chemicals are increasingly being introduced for use at a rate greater than identification techniques, and for which there is no assessment of health risk for drinking purposes).”

"With policy drivers to reduce material to landfill, it is foreseeable that there will be a trend for 'hazardous' materials to be converted into a liquid form for discharge into the sewerage system. Furthermore, measures to conserve water will increase the concentration of contaminants into the sewerage system. Governance of the sewerage network and regulation of chemicals is not aligned with harvesting sewage for drinking water purposes. Improved rigour is needed in how chemicals are introduced into Australia and assessment of their fate & impact (alone & in combination) via drinking water. These issues are relevant to both DPR and IPR."

"Nobody knows what is in sewage, the effluent stream entering two sewerage treatment plants are never the same. If you do not know what is in sewage how do you know what to test for after it is treated? Hospital and medical centre wastes should NEVER be used for reuse as drinking water and yet, that is exactly what is proposed, including industrial wastes."

"Understanding within the broader water industry which new chemicals are entering the catchment. It is accepted that there is a disconnect between the regulatory agencies approving chemicals and the water utilities who need to measure and mitigate the risk to the catchment for recycled water, particularly in the case of DPR and IPR."

"Risks of different types of medicines and hormones entering the system."

"List of anthropogenic contaminants that are to be removed from reclaimed water"

"Long term impact of some of the disinfection by-products and EDC compounds on public health and the environment."

Treatment performance and water quality validation and monitoring

A large number of respondents identified knowledge gaps relating to effective monitoring and validation of water treatment performance and water quality. In particular, respondents suggested that there was a need to better understand the capabilities, as well as the 'reliability' and 'failure modes' of key treatment processes and trains. A commonly recurring theme was the need for 'continuous', 'online' or 'real-time' monitoring. The improved use of surrogates and indicators, and specific toxicity tests for recycled water was suggested. One respondent suggested the need for 'demonstrated long term health and environmental studies'.

"Better online monitoring endpoints to ensure that all steps of the AWTP are working properly, and that the water produced from the AWTP is of high quality and safe at all times."

"This is being addressed with WateReuse Research Foundation Project 11-02 2-real-time monitoring technology (esp. for pathogens)."

"I am not convinced that we have sufficient knowledge yet to enable us to be confident that we can manage risk to the same level as other sources of supply."

"There appear to be still significant regulatory issues, especially for plants that cannot supply continuous validation data. Given that it is our belief that the most likely initial implementation drivers will be in small and remote communities that have a key potable supply issues and environmental issues with discharge of effluent, how validation will be achieved in these environments is not well articulated."

"Demonstrated long term health and environmental studies particularly in removal of endocrine disruptors, cancer treating drugs etc."

"The industry might have to prove that they can consistently achieve this high level of recycled water quality for a much longer period of time before the most conservative people can be convinced and consider DPR over IPR."

"Another element that is currently not well understood is how to monitor the performance of biological treatment (wastewater treatment plants) in real time and how do develop efficient critical control points for this important barrier."

"We would like to see more use of specific toxicity tests on [purified recycled water] before it could be considered for DPR. There are new tests being developed all the time and once a sufficiently large battery of these tests could be implemented, on a routine basis that would provide considerable reassurance about health risk."

"Also, it would be useful to have more reassurance about the reliability of both the technological and human factors in advanced water treatment plants. We would need a substantial body of 'fail-safes' to be in place to be confident about safety of these plants."

"Chemicals, chemotherapeutic agents, etc in water - over a period of time (years) tested, reported and documented with support by a panel of medical doctors and other experts that the water is fit to drink."

"Events could be very localised - can monitoring cope with this?"

"There needs to be a better understanding of the limitations of the current membrane technologies and treatment processes used with respect to the range of quality waters they are subject to."

"We need to improve our understanding of the consequences of recycled water 'looping back' on its self a number of times, and the concentration affects that could occur. What might concentrate in the system and what proportions of fresh to recycled water should make up the supply?"

"Further understanding of the impact of the treatment train on the chemical compounds themselves e,g, UV and ozonation."

"Surrogates/indicators may need to be defined and validated that provide assurance that the key contaminants are not present in the product water if the contaminants themselves are not measurable, too complex (mixtures, transformation products), too numerous. How do we measure these at the concentrations of concern (probably required to do this on-line if there is minimal buffering in the system)."

"The changing efficiency of treatment systems within a DPR system as they age."

"The reliability and safety of new, less energy intensive treatment systems other than the current "gold standard" of dual membrane UV Ozone systems."

"The reliability of automated sensors to shut down a Treatment System in the event of a treatment failure."

"The selection of appropriate surrogates and indicators for the validation and verification of the different stages and barriers within a DPR treatment system."

"Better on-line monitoring sensors and systems to demonstrate effective removal of different chemical and biological contaminants and/or to rapidly detect treatment failures."

"The main knowledge gap would be how to deal with micro-pollutants and how to demonstrate (via monitoring) that these current and emerging pollutants/pathogens of concern are removed at all times under all operating conditions. The performance of all treatment barriers must be trackable, validated and robust."

"Concerns about what tests are done to ensure waste water is potable."

"Value of decentralised treatment and supply systems for overall network and water security management."

"There is a lack of information on failure mode analysis of DPR plants and the ability to design, install and operate on-line monitoring systems so that variations or failure in performance can be detected in

time to prevent delivery of unsafe water to customers (e.g with DALYs exceeding 10^{-5} -10^{-6} per person per year)."

"Risk management of DPR schemes. Currently risk management and communication plans are still in their infancy. There are very few (perhaps none) risk management plans that have been running for several years as per the Aust guidelines that are publically available, transparent and have dealt with a range of emergencies and incidents. there are no critical control points/ indicators or surrogates for many of the common hazards."

The Aust Recycling Guidelines Phase 2 relies on theoretical log reductions for some treatment techniques; these should be validated, such as influent pathogen levels and activated sludge treatment.

"The uncertainty of pathogen testing and indicators."

"Real time detection of treatment failure is the biggest challenge"

"Guaranteeing that the plant operators' response to treatment failure is rapid, unambiguous & appropriate"

"Making sure that the treatment process itself does not generate extra potentially harmful chemicals.eg disinfection by products"

"Demonstrating that in vitro bioassays can provide a useful warning of health effects of chemicals in recycled water without having to identify & quantify each chemical of interest. That is, their values are accepted by the heath regulators."

"What is the point at which the monitoring and treatment steps taken are sufficient? Excessive treatment/ monitoring are detrimental to efficiency."

"Instrumentation to improve reliability of detection of failure"

"Treatment & monitoring"

"A knowledge gaps exists on the long term effectiveness of membrane and other emerging treatment technologies. In lieu of this knowledge gap, it may be required to continually demonstrate the effectiveness of each treatment barrier. However, further emphasis will be placed on the effectiveness of the treatment barriers for a greater array of hazards as DPR has a reduced number of barriers in the total cycle."

"We need to be able to prove that we can manage the WQ, independent on it history. This is made the more difficult as we do not yet operate our water supply on instantaneous monitoring. HACCP has got us a step closer. It is part technology and part paradigm change. It is done in other industries. Each time a plane goes up, we need to know that it will not crash. Equally, we need to have a system in place to ensure that all WQ is safe."

Approaches for building or assessing stakeholder acceptance

A number of respondents pointed out that there was no proactive or strategic community education campaign in Australia to facilitate the acceptance of DPR. Effective approaches for doing so were seen as an important knowledge gap for a large number of respondents.

"Approach to achieve acceptance by key stakeholders (this is being addressed by the [Australian Centre of Excellence for Water Recycling] Goal 3 project in Australia. A similar project is starting in California)."

"How to convince opponents of DPR that, if managed correctly, it is safe, etc."

"Understanding of and communicating the risks. It is much easier to be fearful based on ignorance and/or receiving misinformation from (for example) the media. Decisions on water are often political."

"There needs to be careful study of why the public is opposed to DPR, and an education program to overcome the public's perceptions and concerns."

"Public acceptance and involvement in establishing DPR systems (as opposed to IPR, Desalination or other alternative water supplies)."

"Effective communication skills to demonstrate the safety and reliability of DPR (without any political interference)."

"Need to convince the public on the need for DPR since they have accepted and are 'happy' with IPR and [non-potable reuse].

"There is now much to be learnt from successful and unsuccessful community involvement processes both in Australia and overseas. Community consultation mechanisms need not be designed from scratch on each occasion."

"Education of the next generation who may not have the same availability of water we currently have and waste."

"The issue of public acceptance needs attention. In particular, involvement of consumers in the decision making process leading up to installation of a DPR scheme would be critical. That is, it is important that 'experts' not be the key decision makers with regard to installation of a DPR scheme."

"Tying performance to public HEALTH not PERCEPTION"

"Identification of what the community needs to accept DPR."

"Community/Public acceptance"

"Gaining community acceptance. That will require educational change"

"I view Singapore as the best example of DPR. They have done a lot to educate the community, and to invest in providing a good, cost-effective system. I'm not sure that Australia has done enough to engage the community properly. DPR is also a hard sell when there is sufficient water in the reservoirs. This option needs more than just technical statements supporting the ability of a STP to provide safe water, it needs a social justification."

"I can't think of any social research that has examined acceptance of a DPR scheme (although that's not to say that there isn't some research out there). If I'm right, though, then we need to know more about how people would respond to this type of scheme depending on what it would be used for."

"At this stage, we have really yet to win the community over in regard to IPR."

Regulatory gaps

Several respondents thought that regulatory gaps created uncertainty for operators and investors. In particular, it was suggested that there remain some unresolved questions in current guideline documents including issues around the regulation of chemicals of concern and plants that are unable to provide continuous validation. Some suggested that a clear definition of what constituted DPR would be required and questioned whether existing guideline documents would remain applicable to such projects. It was noted that the development of new guidelines for DPR would be a slow process as it would require extensive national stakeholder consultation.

"There appear to be still significant regulatory issues, especially for plants that cannot supply continuous validation data."

"There are also significant issues on the regulation of chemicals of concern. The potable water guidelines have not yet quantified the way in which we should deal with chemicals of concern."

"No point in having research support unless it is updated in current guidelines- which we find to not occur in a timely fashion particularly with regard to wastewater/recycled water."

"Clear, efficient, effective and stable approval processes for recycling schemes are needed to improve public confidence and investor certainty, and reduce regulatory burdens."

"Clear regulatory and legal liability arrangements are required. The assignment of responsibilities between agencies needs to be clear, transparent and coordinated across health and environmental regulation, water supply planning, land-use planning, and policy."

"There are currently no standards or guidelines in Australia applicable to DPR, and development of these guidelines will be a slow process as it will require extensive national stakeholder consultation. Upholding such standards or guidelines would be challenging for regulators and water authorities."

"Regulatory approvals"

"If current knowledge is based on the effect of an environmental barrier (as is the case for IPR) then a knowledge gap exists in regard to the required water quality standard if an even more conservative standard is required for DPR (i.e are standards derived from AGWR and ADWG still appropriate?)."

"A good definition of DPR. A clear distinction between DPR and IPR. What treatment is used for DPR as opposed to IPR, what really constitutes 'environmental buffer'?"

Environmental impacts

A few respondents though that the full range environmental impacts of DPR were not yet adequately understood, such as potential impacts of diverting water from environment flows, energy requirements and the disposal of treatment wastes.

"Consequence on the environment from abstraction of a large amount of water from the natural water cycle?"

"RO brine disposal challenges"

"and energy efficiency."

Mixing DPR-produced waters with other sources

Several respondents considered that the potential range of impacts associated with mixing highly treated water with traditional water supplies was poorly understood. These included issues relating to taste and odour, as well stabilities of disinfectant residuals. Furthermore, it was suggested that in cases where blending may occur prior to subsequent conventional treatment processes, the contribution of highly treated water may have an impact on the treatment performance of some processes.

"Issues associated with mixing, including initial interactions as well as impacts on stabilities of disinfectant residuals."

"Impact of DPR scheme on taste and odours in water supplies, due to blending and/or variability of wastewater effluent source water."

"Understanding the impact of mixing conventional drinking water with recycled water in terms of the transformation of chemicals (disinfection by-products) over the residence time that occurs in the specific drinking water network."

"If the DPR scheme involved the introduction of recycled water before a conventional WTP rather than directly into a drinking water network, then the impact on the treatment performance (e.g. coagulation

and settling) of introducing such a clean water source as one of the raw water supply options would have to be understood."

"An understanding of the water chemistry when manufactured water is placed directly into a anthropogenic structures (pipes, storages) and mixed in situ with water from traditional drinking water sources is also not completely understood."

Economic impacts

One respondent felt that economic feasibility of DPR had not yet been satisfactorily demonstrated.

"I would argue that the main knowledge gap relates to the economic impact, both capital and operational, of the use of DPR as opposed to IPR. The health risks have already been addressed above, but I would suggest that the economic impact (of implementing a mechanical/chemical barrier that performs to the same level as the environmental buffer) would also be detrimental to the supporting of a business case to implement DPR if IPR was also being considered."

Articulation of the need/business case

A few respondents noted that a comprehensive cost best analysis of DPR compared to IPR, as well as other decentralised water infrastructure options, was needed.

"Perhaps the primary knowledge gap concerns the articulation of the need/business case - I'm not aware that other than in a few cases the case for drinking water augmentation has been made (exceptions being where severe drought + lack of viable other alternatives has led to consideration of recycled water schemes for specific circumstances of drought)."

"The need for a DPR strategy, benefits over IPR, benefits over decentralised water infrastructure solutions."

"A knowledge gap is plain English review of the issues (including level of treatments required, risks, monitoring required, and costs) for policy makers would be of benefit. Also, some analysis of DPR/IPR vs other large-scale water supply augmentations would be of benefit to policy makers."

"Supply options need to be costed based on 'whole of water cycle management' principles, so that the costs of social and environmental externalities are also taken into account; this will ensure better comparison of recycling versus other sources of water supply. - Avoided costs can be significant and may disadvantage an otherwise viable proposal if not taken into account."

"Also, it would be vital that a detailed analysis of costs versus risks be undertaken."

"Need a rigorous comparison with seawater desalination plants on economic & environmental grounds"

Water storage

Two respondents though that DPR water storage needs had yet not been adequately quantified.

"Land availability for storage of treated water."

"If it is decided that a buffering storage is required it would be useful to determine the minimum storage time to increase confidence in timely intervention."

Knowledge gaps within the wider community

Several respondents felt that the community's lack of knowledge about water recycling impacted on the public acceptability of DPR. It was suggested that universities, the water industry, governments, have important, but currently unfulfilled roles in addressing this knowledge gap. Overall, it was suggested that more information should be provided to the community in a more transparent manner.

> *"As stated above [our cities] community are not aware we effectively have an IPR system because they have never turned their minds to this."*
>
> *"The different cost of water from different sources is not appreciated. The drive to keep water cheap and not to sell water of different security to retail customers means the cost of each sources may not be important in any case."*
>
> *"Why is wastewater and its treatment not included in the school curriculum and in very few TAFE or Uni courses? Why do the majority of educational websites – provided by water utilities and companies - not include info about what we put into water and how we take it out again? Why do utilities (eg Sydney Water) not tell their communities about the recycling that is already happening? How can water industry professionals be persuaded to take the lead in a campaign to stop using the term recycled wastewater (treated effluent, upgraded sewage, municipal wastes etc) and learn to reclaim WATER."*
>
> *"Need to make research more transparent with current results and for clear relations to change/alter regulatory requirements."*
>
> *"Improved policy from State and Federal Governments."*
>
> *"We need to know why Sydney does not have it and only does an extremely indirect IPR with poor levels of wastewater treatment with discharges to the sea followed by desalination."*
>
> *"Major gaps in the education of the community, politicians, commentators and journos that sensationalise issues. Trust in science needs to improve. Academics in the field of DPR/IPR need to challenge unscientific clap trap that other academics seem to be able to assault the airwaves with. For example [an individual community member] was able to be put up as the poster boy for the anti IPR proponents over recent years. He was not supportive of IPR except as a last resort. However if his concerns were taken on by water authorities we would have to put in place the same treatment trains used for IPR to counter his concerns re water quality that exist in nearly all raw water that enters conventional water treatment plants especially those downstream of wastewater treatment plants (non-planned IPR). The [community member] may be highly expert in infectious diseases but he was not qualified to comment on, nor did he have the understanding of the highly advanced treatment trains proposed for IPR which in fact removes the contaminants that he was most concerned about. His views by in large were unchallenged by the engineering profession and academia. Imagine the outcry from the medicos if a Professor of Chemical / Process Engineering provided expert opinion on Obstetrics and or Gynaecology."*
>
> *"The most significant knowledge gap is one of community perception and understanding of the proposal and science. There is also a 'credibility gap' that exists in the minds of the public, media and political leadership and I would suggest this is the greatest barrier and the most difficult to overcome."*
>
> *"Why have the results of the 2000 Qld Government's Advanced Mobile Water Recycling Demonstration Plant that was located at Pine Rivers not been made public? The plant has since disappeared. Why haven't the test results been made publicly available from the universities carrying out research into DIRECT potable reuse? What are they hiding? Why has the Western Australian Government Aquifer Recharge Trial failed to make public their test results, not a dot system, what has been tested for and what has been found in the treated sewage effluent. Is it a fact that they have not tested for any chemicals etc found below the level of reporting in previous associated tests?"*
>
> *"People will need to be assured that micro pollutants can be dealt with safely."*

Relevant national and international precedents

Several respondents pointed to the need for proven examples of DPR, both in Australia and worldwide.

“For me, overseas experience with DPR would be a big issue. We are not going to be the first in this.”

“Broad knowledge of how DPR schemes are operating in other parts of the world, disseminated to the wider public and decision makers”

“Demonstration of DPR performance. This will be addressed with a $2.1 million grant just obtained in California. This will demonstrate at an existing [advanced water treatment plant] facility the recommendations of [two current WateReuse Research Foundation projects] (and other relevant projects).”

“A significant gap is in the amount of scientific data, information and knowledge on the performance and reliability of IPR and DPR schemes worldwide. Not only is there a lack of credible scientific knowledge, there is a lack of public information in various forms which is easily accessible to the media, politicians, water professionals, regulators, planners and the general public. This leads to mistrust, pseudoscience, dogma and ill-informed public debate.”

“Pilot studies to prove that these schemes can deliver safe, reliable and cost effective solutions for water provision.”

“I am unaware of a full scale trial being undertaken to verify the technology. ie a full scale trial doesn't need to be supplied to customers directly but could be used for non-potable uses to test and verify the technology, costs and performance and required standards.”

“Perhaps we need some IPR projects up & running for some time before we consider DPR.”

Commitment to ongoing knowledge enhancement

One respondent felt that a commitment to continuous improvement was mandatory.

“Of course there should always be ongoing research”

Contaminants in existing drinking water systems

One respondent suggested that a better understanding of contaminants in conventional drinking water systems would support the improvement of monitoring requirements and public education.

“There is a lack of knowledge regarding the concentration and distribution in the drinking water system of some of the chemicals that are typically monitored in recycled water schemes. This would be important to establish monitoring requirements and support public education. “

Decision-making processes

One respondent reported that there are knowledge gaps within our current decision-making process. It was suggested that more effective public participation in the water planning process is required, as well as an even-handed participation of ‘enthusiasts’ and ‘skeptics’.

"Decision-making knowledge gaps. The two main things I would say is 1. that work needs to be done by both those who are skeptics, rather than only those who are enthusiasts. Enthusiasts, with the best of intention, are more likely to gloss over or fail to see and address concerns that others perceive as meaningful and realistic. 2. a really effective means of testing the waters with this idea and the Australian public would be a properly designed, representative, democratic, deliberative process. These words are bandied about more frequently now, but there are still few examples where the process is actually genuinely representative (ie those involved are randomly selected and statistically representative in meaningful dimensions of the wider population eg gender, age, ethnicity, socio-economic circumstances, educational achievements, etc etc); deliberative (ie provides a real opportunity for participants to engage with the issues on their terms, and to ask and find out about and learn from experts, rather than a mainly one-way information provision process).”

Skills Gaps for DPR

QUESTION: Are there important 'skills gaps' that should be addressed prior to proceeding with DPR in Australia? Please elaborate as much as possible.

Respondents identified a variety of skills gaps. One commonly identified skills gap related to the lack of adequate training of treatment plant operators. A number of respondents identified stakeholder communication and participation as areas where better community engagement skills could help overcome negative public perceptions about DPR.

DPR scheme design and implementation

Three respondents saw a need to up-skill in the broad areas of scheme design and implementation.

> *"Engineering experience in DPR to consult/ assist water authorities to achieve the scheme"*

> *"Human capabilities and experience in the design, construction, operation, maintenance and monitoring of system."*

> *"Its a question of volume. Certainly, Australia has the capacity to delivery a single DPR scheme. It may not have the capacity to manage multiple schemes."*

Treatment plant operations

A large number of respondents saw a need to up-skill treatment plant operators in DPR. Operator training and assurance of competency were seen to be important means for managing the occurrence of 'human error' at treatment plants. Two particular areas where it was suggested that skills could be improved were risk management and emergency response.

> *"There is a deficiency in trained operators at the moment. This has shone through with the increase in desalination plants. There would need to be an audit of current trained operators and future need to understand just how short we are in this regard."*

> *"Better operator training to minimise operator error."*

> *"There certainly must be the institutional capacity in place before consideration should be given to adopting any form of advanced treatment - be it for water treatment or water reclamation for PR. As our surface water qualities deteriorate and more advanced forms of treatment are required to safeguard the quality of water distributed to our communities, so we must have the necessary skills in place to manage, operate and maintain our facilities. We cannot afford to have another Walkerton or Brisbane event occurring. It will be absolutely critical that those responsible for a DPR facility are suitable trained in all matters of management, operation - both routine and emergency - and maintenance. Having said that, adherence to the concept of 'risk management' rather than 'risk avoidance' must still be there."*

> *"There are enormous skill gaps in the industry already, skill gaps for reuse will add to that."*

> *"One of the most important risks for failure in potable reuse is probably associated with human errors. Developing a robust scheme delivering high-level operator certificates would be a must to support a DPR scheme. Remuneration packages and evolution perspectives should also be developed accordingly to retain experienced staff on a scheme and prevent too high a rotation."*

> *"There is a general skills shortage in the Australian water industry for the management of water treatment plants, let alone advanced water treatment plants. This may not be a problem if we are not looking at the systems becoming common place. This will mean determining how to limit the processes to appropriately skilled organisations."*

"Compliance with standard operating procedures is critical to reliable production of safe drinking water. Training is critical to obtaining this compliance, as are effective systemic compliance checkpoints. However, there are numerous examples of staff taking actions, either deliberately, through negligence, or through lack of knowledge, that contravened [standard operating procedures]. Often these actions were not picked up until adverse consequences had occurred. Walkerton is the classic example. So for a relatively high risk activity such as DPR, the [standard operating procedures] will need to be well validated and defined, training will need to be extensive and on-going (the educational level of operators may need to be higher), and the systemic checking system will need to be comprehensive and have quite rapid response capability. Although some of these concerns can be addressed by greater treatment plant automation, I suspect staff skills/training/compliance will be the most difficult 'technical' aspect of DPR."

"There could be improvements in the training and skill base of treatment plant operators, particularly at the stage of the Wastewater Treatment plant to ensure that a consistent quality of water is provided to the Advanced Water Treatment plant."

"Operators and manager need to be skilled to operate system."

"Would require higher level of treatment process management - taking real time control and management of water spec within tight tolerances to the next level."

"Staff training and competency is key though it should also apply to water works operators. Staff should have a good understanding of the treatment technologies and good appreciation of instrumentation and ability to analyse and interpret the on-line readings. They must be confident to "shut down" the plant in the event of water quality breaches, trouble shoot and then put back the plant into operation when indications show everything is normal."

"Operator skills, performance and diligence together with appropriate formal management structures will be key components in ensuring safety of DPR schemes. These plants are likely to be more complex with narrower margins for error and lesser reaction/response times than IPR or Water Treatment Plants."

"Operators should be trained and certified to operate these plants. Training should include components directly relevant to DPR plants."

"There will need to be a greater confidence in systems and operator training."

"Organisational capability including operator competency (the reality is that human error is inevitable - this cannot be designed out, only minimised)."

"Possibilities of 'operator error' will be raised by opponents, so need strong focus on training and systems."

"The actions of operators that treat drinking water have a direct impact on water quality and consequently may impact on the public health risk to communities and consumers. The National Water Commission recently released a Proposed National Framework for Operators of Drinking Water Supply Schemes. The benefits of defining a nationally consistent minimum standard were highlighted in the Framework as; ensuring operators are appropriately trained, improving the national consistency of operator training, reducing the risk of events that may affect the quality and/or safety of drinking water, and providing greater assurance to water regulators and the community regarding the competency of operators."

"One only has to look at the number of spills, contamination etc from a number of state of the art Advanced DIRECT Water Recycling Plants in Brisbane, Caboolture's DIRECT Advanced Water Recycling Plant, cross connections from Dual Reticulation Schemes, Rose Hill a number of times, Gold Coast, which have contaminated drinking water, reuse schemes where treated sewage effluent is used for irrigation purposes on sporting fields used for contact sports where bacterial infections are reported, the Queensland Government's Fluoride bungle where the amount of fluoride exceeded the allowed limits, not to mention the toxic chemical and pathogenic pollutants in bio-solids."

"Operator skills in both treatment and validation/verification."

"Design of complex treatment rooms that ensure that instrument warning are not frequent false positives or ambiguous or otherwise difficult to interpret when operators are tired or bored or complacent etc. Treatment plant technicians need regular engineering/science oversight from appropriately trained people, -more so than occurs in STPs and water treatment plants."

"Training of staff of wastewater treatment plants in the same way as those at water treatment plants are trained, with an eye to upholding customer safety, failsafe system operation, risk management, documentation of operating procedures and reporting of incidents."

"The required skills for a DPR scheme are present in Australia (e.g. within the Ground Water Replenishment Trial in WA, St Mary's Scheme in Sydney, Western Corridor Recycled Water Scheme in Queensland). However, they are concentrated and there would be a need to ensure that the knowledge and skills (operational, management, maintenance, systems etc.) associated with these existing similar schemes is transferred to any DPR scheme."

"Further development of operator competency skills for certification of treatment plant operators is required to reduce errors at advanced water treatment plants. Advanced levels of operator competency at the water treatment plant would be required for DPR."

"When I look at the skills of operators at WQ treatment plants in Australia, i think that they are not as skilled as what I hear is now occurring internationally."

"I would assume that the worker shortages we observed in the drinking water industry are just as prominent in the recycled water industry. There is a need to capture workers earlier in education, and to make this career more socially valued. Being a water or recycled treatment plant operator should be appreciated more, as this work is vital for our existence."

Water distribution network management

One respondent called for better strategic modelling of drinking water networks ability to respond to possible incidents and emergencies.

"A greater modelling capability and understanding of drinking water networks is required for DPR. With reduced emergency and incident response timeframes it would be critical to have a detailed understanding of grid networks."

Broader organisational skills gaps

Some respondents felt that high level expertise in water management was being shed from organisations and governments, resulting in a lack of internal resources to deal with DPR schemes.

"Organisational skills gaps- capability to manage and keep abreast of research on increased risks associated with recycled water- there are increasingly more chemicals/ diversity of source inputs with little understanding of effect in recycled water, and the ability to address these risks/ remove/treat back to potable standard."

"Internal high level expertise in water management organizations is being slashed and burned. In one larger water supplier I believe there is only one person now in the recycling unit and more cuts are likely on the way."

"Even worse is the problem of small utilities and local government who are increasingly poorly resourced in environmental technical matters generally."

"Institutional & scientific capability"

"Any skills gaps may be subject to the location of a DPR scheme. It is important to consider the skills retention issues many remote and regional locations are currently facing with existing potable, wastewater and recycled water service provision."

Research

Two respondents commented on skills gaps relating to research to support DPR. While the research skill-base itself was seen to be sufficient, it was suggested that the key issue was 'resources to undertake the research'.

"I think the issue is more about resources to undertake the research into the technology, the risks and the cost benefit analysis compared to other sources of supply."

"The research skill base is sufficient, and in a number of areas world class."

Risk assessment and risk management

Several respondents saw a need to up-skill in areas of risk assessment and risk management for plant operators and for water managers.

"Risk identification and risk management."

"Also, advanced water treatment plants are complex technological undertakings and it would be helpful to have proper human factors analysis of how human performance might impact on the safety of these plants, once they are supplying directly to drinking water treatment plants."

"Inadequate training base for water professionals especially those conversant with risk (other than engineering) to health and the environment. Disciplines like biology, toxicology, social science, climate, environmental science need better representation in water supply organisations."

"Understanding the risk associated with chemicals in raw sewage need to be further explored."

"Risk management skills"

"As a result of new scientific and technological developments and the use of more diverse water sources, water managers are facing a broader range of water quality risks. These developments demand a more adaptive and skilled workforce."

"We still have to prove to independent bodies that we can provide instantaneous control of our water supply systems."

Stakeholder communication, engagement and consultation

Several respondents saw skills gaps in facilitated community education and engagement to explain DPR in a way that the public can readily understand and to change negative public perceptions about DPR.

"Lack of people who have both the knowledge and presentation skills to explain wastewater and it treatment and quality."

"Not a skills gap but a gap - terminology that the community can understand that relates to the quality of water and its uses as opposed to its source and degree of treatment (its history)."

"An important skills gap is in the area of the processes and institutions which can improve the quality of public consultation. This should not be confused with 'public education' which carries a patronising tone."

"Although not strictly speaking a 'skills gap', it would be desirable if a small group of respected 'national champions' for DPR could emerge to lead the public debate."

"Social skills - i.e. convincing the community."

"We focus a lot on the scientific and technical skill sets but seem to forget the skill sets of PR, marketing, psychology etc."

"Limited number of experts who are able to communicate the concepts in a way that is easy for policy makers and the community to understand."

"The skills gaps relate primarily to educators/promoters able to discuss the issues with the public."

"The communication skills of the proponents need work."

"The biggest single issue is developing the skills to overcome the 'credibility gap'. Water industry professionals and research scientists need to be provided with the skills to effectively communicate risk and safety concepts to the community, media and political leaders."

"Community and political stakeholder education and management."

"While the technological skills are available, Australia is deficient in 'public policy' aspects of such initiatives. This has been well demonstrated in failures of previously proposed IPR schemes. How do we best engage consumers?"

"Need people skilled in communicating heath risk & technologies to the lay public."

"Community engagement and public understanding of IPR and DPR and other water recycling options for different water grades."

"Communication and stakeholder engagement has failed in introducing IPR in Australia (i.e. Western Corridor). Even the Melbourne desalination project has been a good example of the poor management of public perception, the biggest skills gap is not technical but managing the message and engagement process of IPR/DPR."

"Improved communications with communities on water supply options, costs, benefits, reliability and safety"

"Enhanced communication is required between all entities involved in DPR Schemes."

"The social side of DPR."

Water quality analysis

A few respondents thought that there needed to be a greater number of accredited laboratories that could undertake the necessary water quality analysis. The need for improved analytical techniques was also identified.

"As noted above, specific tox tests have a lot to offer, but the expertise to conduct these are, at present, largely confined to a handful of universities. They need to be properly validated and rolled out to commercial labs to ensure there is sufficient expertise available to integrate this testing into routine monitoring."

"Monitoring systems are often poorly maintained. How do they monitor?"

"Laboratory facilitates for the testing of treated water."

"The ability monitor all analytes and to ensure efficient operation of all barriers all of the time under all conditions."

“Analytical and monitoring capability (including Quality Assurance)”

“The uncertainty of pathogen testing and indicators”

“[lack of current capacity for] laboratory testing may also be significant.”

Policy, planning, and regulation

A few respondents reflected the view that skills in policy, planning, assessment, and regulation of water recycling could be improved.

> *“Water recycling at the municipal level is specialised area with a general shortage of skilled staff especially in the regulatory area. The introduction of DPR will compound this issue as there is virtually no knowledge base in Australia of either DPR or IPR.”*
>
> *“Yes at industry policy/regulator consumer levels.”*
>
> *“As there are no public policies which support the use of DPR in Australia, indeed they generally oppose DPR as an option; there is a lack of professional skill development in this field. The skills gap appears to one of policy and planning than technical or scientific.”*
>
> *“A key skills gap that seems relevant here is our capacity to assess different kinds of options. We 'do' MCA, but usually badly, for a range of understandable but complex and nuanced psychological factors. So the skills gap is about developing the means for improving our assessment and comparison of seriously different options in terms of scale or output. For example, our current work for the AWRCoE shows that in fact most recycling investments have not been 'economically efficient' or 'financially efficient' but there were valid reasons for making the investment. Our current work for Sydney Water on the costs and benefits of decentralised systems is revealing fascinating unintentional biases that are built into State government policy and long-held practices of key stakeholders, ranging from engineering design considerations to risk management preferences. Relevant here also is the impact of one's professional worldview on what matters - the fact that engineers and scientists tend to view the world in a fairly black and white kind of way - a positivist epistemology - and it's beautifully evidenced in the introduction to this project about how it is seeking 'objective' information as if that is the only kind that matters, ignoring even our own experience that the world does not work on 'objective' information alone.”*

Source management

Two respondents thought better skills were needed to deal with source control, particularly trade waste.

> *“Source management (including trade waste) - improved capability in how the sewerage & trade waste system is managed and improved alignment.”*
>
> *“Skills gaps exist in the ‘source control’ area. Source control is generally only focused on sewer worker safety and impact on the biological process. If DPR (or IPR) was introduced the trade waste officers would potentially need to have a greater understanding of the potential impact of chemicals or chemical interactions on the quality of recycled water produced. This skill gap is around up-skilling of trade waste officers to have awareness of the issues relevant to these schemes.”*

Technological deficiencies for DPR

QUESTION: Are there important ‘technological deficiencies’ that should be addressed prior to proceeding with DPR in Australia? Please elaborate as much as possible.

A considerable number of respondents indicated that they could not identify and technical deficiencies that should be addr4essed prior to proceeding with DPR. Among those who could, monitoring and various aspects of risk management were the most common themes. For a smaller number, the broader uptake of DPR was seen as dependent on improved treatment technologies.

None

However, several respondents did not consider that technological deficiencies were hampering the uptake of DPR.

> *"No" (many occurrences of this response)*
>
> *"I think that the technology is sound."*
>
> *"I don't believe so."*
>
> *"Technology can always be improved and will continue to improve but the current technology can effectively be used to produce potable water from recycled water in a safe and sustainable manner (at least from municipal wastewater in a coastal area)."*
>
> *"I don't believe so."*
>
> *"Current technologies are more than adequate to deliver water of drinking standards."*
>
> *"Not really - sewage can be cleaned to an appropriate standard for drinking easily."*
>
> *"Not that I'm aware of."*
>
> *"My understanding is technology used in IPR and DPR is well proven"*
>
> *"I don't think there are technological problems, just social and economic ones."*

Treatment plant design

A few respondents suggested that improvements were required in overall plant design for local conditions. Some of these identified a need for a more sophisticated understanding of the 'multiple-barrier' approach to water quality management.

> *"Redundant systems to minimise operational failure"*
>
> *"More investigation (and promotion) of technology available to reclaim water that doesn't use membranes so the plant can be shut down when not needed."*
>
> *"Whether or not technologies where it's applied [internationally] will be deemed appropriate for use in Australia is a matter for relevant public health regulatory agencies."*
>
> *"Treatment and monitoring alternatives to the environmental buffer (i.e. the difference between IPR and DPR)."*
>
> *"The role each technology plays in a multibarrier approach needs to be further understood."*

Treatment capabilities

A few respondents felt that water treatment technologies were not yet sufficiently advanced to provide quality assurance.

> *"Assurance will be required that plants can be designed to deal with issues raised in the [question regarding 'knowledge gaps']."*
>
> *"Yes I don't believe we have technology to manage chemical hazards."*

“There is much to learn about the long-term efficacy of treatment processes. Specific deficiencies include: Treatment capability (all treatment processes individually & in combination have their limitations”.

“Rigour in the manufacturing of treatment processes including quality assurance”

“The technology is not up to scratch and has a long way to go. In fact, it will never be good enough to guarantee that NO contaminants pass through the processes and into the drinking water supply mains that can affect human health. It will never change while the sewage entering the Advanced Water Recycling Plants is 100% contaminated, 100% toxic, is the same effluent leaving the plant after treatment.”

Evaluation of treatment process reliability

A few respondents felt that there was a need for improved validation technology and data to ensure reliability treatment process performance.

“Reliability of the technology. I am unaware of a full scale trial being undertaken to verify the technology. ie a full scale trial doesn't need to be supplied to customers directly but could be used for non-potable uses to test and verify the technology, costs and performance and required standards.”

“Freely available, credible performance data relating to the removal of pathogens and chemicals of concern will be vital to improving assessments of alternative supply options and public confidence in the technologies.”

“The lack of consistent validation of technology presents a current challenge with regard to recycled water initiatives. This will hopefully be addressed through the national validation project. Extension of this project to drinking water technologies may benefit DPR as a water management strategy.”

“Greater emphasis will be placed on demonstrating through a validation program that a DPR scheme can consistently produce the required standard of recycled water.”

Evaluating natural treatment

One respondent felt that more research was needed to assess the benefits of natural treatment by environmental buffers. It was suggested that if this was shown to be deficient, a stronger case would be made for DPR.

“Does the quality of water improve the longer it has been in the river? This would seem doubtful, because generally water quality in rivers deteriorates as it progresses to the sea. How long is the ‘miracle mile’? Is there evidence to show that water quality in dams improves with longer storage? Would risk be managed better by using the money and energy required to pump the reclaimed water long distances to an environmental buffer to provide more treatment or safeguards at the reclamation plant? (such as batching storage as they do in Windhoek?).”

Monitoring

The need for improved monitoring technologies was commonly identified. A large number of respondents considered that there was a need for more sensitive and reliable real time and continuous monitoring technologies. Capabilities for monitoring a broader range of potential contaminants were also suggested. These included pathogen monitoring, chemical contaminants, and bioanalytical tools.

“Measuring membrane performance in real time, and aspects of monitoring could be improved, such as cheap, reliable surrogate technologies.”

“Dealing with all the new chemicals and malicious contamination by for example terrorists”

“Given that it is acknowledged that 'acute risks' are more relevant than those of a 'chronic' nature in any PR application, having an on-line monitoring tool for bacteria, virus and protozoa would be of immense value. This would then allow the validation of the treatment process to be continually verified and confidence gained in the LRVs achieved by the plant under all flow and temperature conditions. Having said that, I do not see this lack of on-line bug measurement as preventing the consideration of DPR today.”

“In our initial work on DPR, the manner in which validation of performance will be achieved with a low worker skill base in remote communities has been a challenge.”

“Not so much the technology but the sufficient ongoing monitoring and reporting.”

“Any technical deficiencies are more about water quality monitoring than treatment. Improved control, recording and monitoring systems need to be developed for all stages of a DPR scheme - from source to tap.”

“Techniques for rapid analysis of water quality (desirably in real time).”

“We need better monitoring of the performance of membranes and, in particular, RO membranes. There needs to be continuous monitoring to detect any failure of the membranes or seals so that non-compliant water is never supplied. “

“See comments above re use of bioanalytical tools.”

“Operating and monitoring of system will need to be much more sophisticated (including real time/ online) than currently used for drinking water and/or recycled water Class A+ systems.”

“There is a total lack of broad routine water virus testing capacity in this country or for bacterial pathogens especially opportunists which might develop - another one is pathogenic amoebae like Acanthamoebae in the recycled waters. As the population ages these lower grade pathogens will increase in importance.”

“On-line monitoring for membrane integrity”

“The level of detection of some micro-pollutants is a concern as the level of potential impact is often lower than the level of detection for long term exposure. “

“Also the tracking and monitoring of emerging chemicals, pathogens etc would need to be considered.”

“Sensitive, real time performance monitoring of advanced treatment processes such as [reverse osmosis] that indicate small reductions in performance and management of sewage quality (trade waste) to achieve influent specs.”

“Limitations in control system and monitoring techniques,- Uncertainty in measurement and analytical techniques.”

“There is no way to determine if all of the contaminants have been removed.”

“Real time treatment failure”

“Scientifically rigorous health implications of bioassays”

“I sense that there may be monitoring issues, although I am not across the detail of what these may be.”

“Capabilities for real time pathogen and trace organic detection would assist in giving confidence.”

“Better surrogates for operational monitoring of virus removal through membrane filtration and reverse osmosis systems. Surrogates that are more sensitive enabling earlier actions to be taken and higher levels of removal claimed. Ideally these could be monitored online to enable rapid detection and response to any issues.”

"Enhancing the procedures and reliability of bioassays, ecotox or generic toxicity testing of water from Advanced Water Treatment plants is required to address the risk of emerging contaminants."

"Online monitoring for a range of endpoints, to ensure both operational quality and quality of the final product."

Risk management controls

Several respondents thought that risk management controls should be improved.

"The technology exists but needs to have sufficient controls in place to ensure it operates correctly and that there is a contingency plan for when it does not."

"As the current development of risk based targets by NHMRC shows we haven't even got it right from a risk point of view for normal let alone recycled water supplied."

"It is well known from reticulation supply managers how often things go wrong."

"Sensors and automated monitoring systems that can rapidly detect failures in the treatment system and shut down or divert the DPR supply from the potable water grid."

"Rigorous, transparent and science-based risk management arrangements are imperative to ensure that the community can have the same confidence in the quality of recycled water produced by new technologies as it currently has in conventional sources."

"The reliability of advanced wastewater treatment systems could be problematic and so 'fail safe' technology inclusive of back-up power supplies will be need to be deployed."

"Introduction of national validation protocols for commissioning and ongoing testing to ensure public support for such schemes."

Greenhouse gas emissions

One respondent called for the carbon footprint of DPR to be closely assessed and improved.

"The carbon intensity of water recycling is a concern and this needs to be constantly looked at to make in more environmentally and economically appealing."

Management of RO concentrates

A few respondents considered that the water treatment brine streams required improved management. One respondent called for the further investigation into the safety of beneficial reuse of brine.

"Brine management for inland areas is currently an issue and would require further technological development to make this an economically and/or environmentally sound option."

"Finally I have long standing concern about what to do about the brine stream other than ocean outfalls. I can't think of a much more useless form of toxic sludge. It has been argued that you can get useful by-products. I am unconvinced and will remain so until a high quality and comprehensive multicriteria decision analysis e.g. LCA QRA footprint analysis - shows otherwise."

"Lifecycle analysis including management of concentrated waste streams."

"Brine management on RO is an area of 'what do you do with it'."

Need for reduced-cost technologies

Two respondents felt that further technological developments were required to allow DPR to be economically feasible.

> *"The costs of implementing potable reuse schemes is generally a concern and while I expect the overall cost of a DPR scheme to be less than the cost of an IPR scheme, technological development will lead to a further reduction in costs."*

> *"There could be improvements in things like cleaning membranes efficiently"*

Regulator approaches

Two respondents felt that a more consistent and optimal approach to regulation was required.

> *"Sharing best practice regulation approaches and developing mutual recognition frameworks for the validation of recycling schemes and accreditation of operators and certifiers will help."*

> *"Optimal amount of regulation for public and environmental health"*

Lifecycle assessment and costing

A few respondents noted the need for lifecycle accounting to evaluate the costs and benefits of DPR.

> *"Often the long term life cycle costs are not factored into affordability and sustainability."*

> *"Lifecycle analysis including management of concentrated waste streams"*

> *"Not particularly but a proper accounting of ALL aspects of DPR (costs, risks, uncertainty, etc) need to be considered."*

Source water control

Three respondents thought that source control could be improved.

> *"Particularly with regard to new chemicals on the market/ variation/ changes to source input and inability for water Corps to control source inputs."*

> *"Understanding the risk associated with chemicals in raw sewage need to be further explored"*

> *"Improved monitoring for detecting 'trade waste dumps'. Currently [total organic carbon] in [reverse osmosis] permeate is used as a surrogate. This improved monitoring could be incorporated in the [supervisory control and data acquisition system] enabling alarming and/or triggering of automatic sampling for analysis. This would improve the reliability of a scheme by ensuring that during high risk periods water is not supplied for DPR"*

Mixing of water from various sources

Two respondents noted that improved technologies were needed to deal with the potential issues of mixing treated water with traditional water supplies.

> *"Potential issues associated with mixing should be resolved."*

> *"Existing water treatment systems would need significant modifications to accommodate DPR to take into account how reclaimed water can be blended with existing supplies.*

Social issues for DPR

QUESTION: Are there important 'social issues' that should be addressed prior to proceeding with DPR in Australia? Please elaborate as much as possible.

A range of social issues were identified, predominantly relating to public perception, acceptance and engagement. One respondent noted that there exists little support for proper evaluation of the social science.

> *"Social science evaluation of these issues is poorly supported."*

Negative public perception

A number of respondents nominated negative public perception as an obstacle that would need to be overcome.

> *"Perception that it is dirty or poo water is going to be difficult to change in some members of the community."*

> *"Perception - the yuk factor."*

> *"Public perception of source water - yuk factor"*

> *"Negative community perceptions"*

> *"Yuck factor."*

> *"This is a generation change issue, and until we are gripped by many more droughts/water shortages etc I don't think IPR and DPR will get full public support. With the impacts of climate change starting to show through in Australia, I would say that in the next couple of decades the public perception may change."*

> *"Public acceptance and understanding."*

> *"Additionally, by closing a loop 'drinking tap – wastewater – drinking tap', there may be a perception that some contaminants will never leave the system and may potentially be accumulated to an unacceptable high level."*

Need to advance risk communication and education

Several respondents saw a need for strategic community education and improved risk communication in order to address negative community perceptions about DPR.

> *"The whole field of risk communication would be a key area that needs to be advanced to assist with communicating these (and other e.g. health-based targets) discussions with water consumers."*

> *"The public needs to be better educated. Unobtrusive TV campaign? Special topic in school? Concerted effort to educate politicians on this issue?"*

> *"The public would need to be convinced that DPR poses no greater health risk than other sources of supply and that the same (or better) whole of system risk profile can be assured."*

> *"Also, there needs to be more attention to helping the general public understand the physics of water treatment (if this were possible) and that sewage is just dirty water and that, like anything else, when it gets dirty, it can then be cleaned."*

> *"The public needs to be better educated about potable reuse in general."*

"There is a degree of unacceptance in the community due to a lack of understanding of how wastewater can be treated."

"The public expectation of 'zero risk' needs to be addressed."

"YES - knowledge gaps in the community - educate the community about why DPR is ok and IPR is not needed"

"[There is a] need to raise public awareness and understanding of the urban water cycle in order that communities may have informed input into the selection of new water products."

"Education and information to overcome the 'yuk' factor."

"There needs to be a coordinated public education campaign coupled with a feasibility study about DPR that would easily translate across all jurisdictions."

"Communicating technical risk to the general public"

"Development of an agreed national education program on water recycling"

"The key social question is 'what is the level of perceived risk/acceptance of a DPR scheme for the different purposes that it could be used for'?"

Lack of public trust

Several respondents noted a lack of public trust in government and industry stakeholders in DPR.

"There is currently not enough trust by the general community in the governments, the technology, the water utilities… to guarantee a successful scheme."

"The social research undertaken to date indicates that the main social issues relate to 'trust' in decision-makers, regulators and water professionals."

"As noted above, we need to address the 'credibility gap'. The community simply does not trust the technical and scientific community, and remains highly susceptible to a well-orchestrated scare campaign."

"Public confidence in the implementing organisation to manage the risks."

"The community will never trust those involved in this industry for lying to them by stating that INDIRECT was to be introduced when they always intended introducing DIRECT reuse. How does one trust those with their drinking water who worked to have them and their families involved as guinea pigs for research purposes in a world first intergenerational experiment, without consent, to benefit themselves."

"All relates to the fact that many people have faith in the environment to ensure that all of the residual chemicals that people do not like will not harm public health."

Need for improved public engagement

A large number of respondents pointed to the need for better public engagement in water planning processes. Better public engagement would involve facilitating public participation allowed for a diversity of individual and group views. There was a need to develop consistent terminology for the various components of DPR that could be readily understood by the general public.

"There is a significant public engagement program needed to obtain a 'licence to operate'."

"Potable Reuse always creates emotive debate and discussion, often with the print media leading the way. It is important for there to be a means by which the public at large - from school kids up to water

industry professionals - have access to material that explains the concepts of IPR and DPR in a way that engenders interest that then leads to trust of those who are charged with delivering safe and wholesome water supplies. Once the community understands, they will tend not to be influenced as much by sensationalised media reports. A quote by Ghandi is relevant to this discussion: "If the people lead, the leaders follow". This applies to out political leaders who do look over their shoulders a lot. This work has started and there are now many reports out in the public arena that show progress is being made in these areas."

"Approach to achieve acceptance by key stakeholders"

"The economic and environmental drivers need to be far better articulated than previously. The technical issues do not come out high on surveys as being as important as the scientists and engineers would assume."

"Most people would say we need greater public awareness. But that is only the case because of the public sector involvement in the water industry. You never heard it said that bread manufacturers need to consult with the community about where the bread comes from! The water industry is likely to stay in the public sector, so the public needs to understand and be comfortable with the issues."

Talking about water "Waterlines report 49 - May 2011: http://archive.nwc.gov.au/library/waterlines/49 "Talking about water provides an insight into what drives this public perception and the effect terminology has on communities' acceptance of alternate water supplies, specifically recycled water for drinking. The research provides evidence on the importance of terminology to the acceptance of alternate water supplies".

"For the most part objections to water recycling are based on emotion, and therefore education has to work on the emotional level. In my experience and opinion the following are necessary to build public confidence: an open and accessible water treatment plant. An integrated education and communication campaign that includes providing samples of bottled water. A clear explanation of the water cycle, how all water is recycled water, how water should be judged by its quality, not its history, and by what you can do with it, not what's been done to it. This should also include an acknowledgement of where our current water supplies come from - ie that we are already drinking "recycled water". The campaign should also stress the environmental and sustainability benefits, building on the very high public acceptance of recycling of other materials - eg glass, cardboard, metals etc. Advocates from a range of areas to appeal to people from all walks of life eg scientists, environmentalists, doctors, the TV weatherman etc etc. Familiarisation tours for regulators and journalists to Singapore and the US to look at comparable water recycling schemes and how they are presented to the public."

"Requires huge campaign to get public to support the concept. Particularly, because of consultation around Class A recycled water NOT for drinking, etc."

"Additional difficulties are expected due to other water technologies such as desalination where decisions have already been made to adopt this technology-etc."

"The need to have a decision-making process which is sufficiently representative of the people to be accepted but is designed in a way to minimise illogical or irresponsible political campaigns. For example a referendum or plebiscite is a decision-making process which is very vulnerable to hijacking."

"The role of scientists and engineers in the public consultation and decision-making process needs to be carefully managed. On the one hand they can be highly credible sources of professional technical input. On the other hand they can be misrepresented as one – dimensional advocates."

"The place of environmental scientists and environmental community groups needs to be clarified in the DPR debate. The potential environmental costs, benefits and risks need to be brought out. It is possible that environmental interests could become strong advocates of well-designed DPR proposals"

"Where the public has been more 'on board' with drinking water augmentation has generally been in exceptional circumstances due to drought, where it might be argued there is a greater case for

augmentation. It might be of interest to assess whether attitudes for drinking augmentation (not necessarily just DPR) change following break in drought/'water security crisis'."

"It's also likely that communities may be more accepting of gradual adaptations to increased levels of use (increased contact) than to move from current situation in Australia straight into what is likely to be the most risky/controversial means of use."

"The management of communication around the ground water replenishment trials in WA seem to deliver positive outcomes."

"We still don't have a full-scale potable reuse scheme in operations in Australia. It will be a learning curve on how to engage and communicate with the general public, media, politics and a whole range of stakeholders to make these a success, either indirect or direct."

"Potable reuse will only be considered acceptable if it is seen as a necessary requirement for supply of adequate drinking water, with better alternatives exhausted. Hence the public needs to know more about where their water comes from so that they can make informed cost/benefit choices."

"But in practice, it seems that where IPR has been successfully implemented, the decision to do so was made by government and "sold" to the public rather than being put to a public vote. DPR will be a harder sell, whichever approach is taken, so the better educated the public is about water issues in general, the more understanding they may be of any future need to implement DPR."

"Unless the public can be convinced that DPR is safe, there will be little likelihood of successful implementation. Convincing the public of the safety on IPR would be a first step."

"I think we need to be honest with our customers about this topic and use very straight language. There hasn't been a mature un-politicised debate about this issue."

"I also recommend that in the next two decades we should be creating schemes that mimic a full scale DPR or IPR scheme, use the end product for irrigation or industrial use, and gather as much data and experience as possible."

"Concerted public relations campaign will be required to address the issue - perhaps pointing out the degree of 'uncontrolled' IPR going on, and looking at the water quality of a typical DW system compared to the output of a DPR scheme."

"Public perception/aversion of drinking waste water needs to be addressed (political issue). Explaining that we drink waste water anyway and that it is only about whether or not we have an environmental buffer might help."

"Community appears unlikely to accept DPR"

"Public acceptance is likely to remain an issue particularly if there limited examples of successful IPR."

"There remain several vocal and visible opponents in the medical sector in particular. Unless or until these voices are stilled (re-assured?) this issue will continue to be an easy target for media."

"Yes consumers are naturally reluctant to accept change especially one that forces the consumption of a recycled product."

"Australians have a special relationship with drinking water and a high degree of trust in utilities that deliver it. There is high degree of ownership by the community of their drinking water. A risk communication campaign would need to ensure that a proposal such as DPR does not undermine confidence in water utilities or drinking water."

"Engaging with stakeholders including the wacko ones."

"Public will not support at present. If we are serious, needs a long term national R&D program so that the science is indisputable and schemes can then be developed if/when needed - and that won't be for a few years. The questions will be, is this the best way to allocate scarce R&D dollars in the water sector?"

"Language and terminology has a key role to play in community engagements as it has been found to drive public perception and effect communities' acceptance of alternate water supplies, specifically recycled water for drinking."

"The development and use of nationally consistent and simple terminology would be an important step to resolving anomalies that currently give rise to conflicting messages on the use of alternate water supply schemes."

"Community and political stakeholder education and management"

"Need majority on side and open style of demonstration of treatment levels and barriers."

"We are woefully deficient in engaging potential consumers in the decision making process."

"Transparent treatment technologies at the recycling plant via a visitors centre"

"High cost of alternative water sources"

"The fact we are unable to launch IPR in Australia means we are unlikely to be ready for DPR."

"Very transparent approaches to selecting among water supply options, would assist in enabling the public to understand the consequences of each option. It is proposed that new institutions (to Australia) such as water banks, would assist in this process. For more on water banking see section 6.3 of: Dillon, P., Pavelic, P., Page, D., Beringen H. and Ward J. (2009) Managed Aquifer Recharge: An Introduction, Waterlines Report No 13, Feb 2009. http://www.nwc.gov.au/publications/waterlines/waterlines-13. and: Ward, J. and Dillon, P. (2011). Robust policy design for managed aquifer recharge. Waterlines Report Series No 38, January 2011, 28p. http://www.nwc.gov.au/publications/waterlines/robust-policy-design-for-managed-aquifer-recharge"

"The general education of the community regarding the value of water and resource management is a key element. A number of studies have considered or are considering these issues, in Australia and internationally."

"The 'Yuk factor' would need to be addressed. Comprehensive and sustained stakeholder engagement needs to be undertaken to have any success."

"One of the major drivers for public acceptance of direct potable reuse is a drought or other extreme emergency situation. It would be difficult to achieve public support, when most of the country is affected by the floods and dams are full 100%. Unless the public can be successfully educated that by implementing one of the schemes now, we are reducing the risk of an incident and it will safe guard our future water supply once drought re-occurs."

"There are many examples in the world of 'unplanned indirect potable reuse' because the town downstream is indirectly reusing the other town's sewage without planning. This in some ways may elevate public concern on IPR schemes. However, direct potable reuse currently is not practiced widespread throughout the world."

"[Water Corporation (WA)] is using the right approach by community involvement in groundwater IPR early on small scale. Other states (eg NSW) get the order wrong - they announce a policy then market test the reaction. The public need to be part of the journey, given all the information and make the final decision on whether DPR or IPR is used or not, given the implications for water security, health and costs."

"I do not think that the general community can see the need for it, nor understand, and accept that this is safe."

"We have yet to fully convince the community regarding the benefit of IPR."

Importance of considering community preferences and values in water supply decisions

Two respondents felt that consumer choice should be respected.

> *"Community consultation in delivering customers choice in water products is critical and mechanisms should be developed to ensure community values are adequately reflected in the determination on new water products."*

> *"There's also the blind spots I alluded to above, about how engineers and scientists have a particular worldview that is enormously valuable, but partial. When we (I have an engineering and a science degree) engage with professionals from the other side - humanities and social sciences - we tend to avoid qualitative information and research, and to focus instead on psychological statistics. Economics has taught us that the idea of a purely rational human-being (homo economicus) is only a partial view, but it's a lesson we are still to learn."*

Political unease

A few respondents noted that public acceptance of DPR would be difficult to achieve unless governments adopted a consistent approach of advocating for DPR schemes.

> *"Public acceptance of IPR is reasonably high (despite political unacceptance). The acceptance of DPR is much less than IPR which will retard its uptake. This is particularly an issue in obtaining political approval where politicians react to the most vocal groups (always the opponents) and the demands to 'protect the government and/or minister' put on State Agencies prevents effective communication or appropriate, sensible guidelines and standards."*

> *"Opponents can run, fear, uncertainty and doubt to derail DPR."*

> *"Toowoomba example says it all"*

> *"Remember Toowoomba It is potentially a major political issue as the recent media about QLD Councils wanting to cease fluoridating water supplies will not help the cause of selling DPR or IPR to the general public. If regional water supply authorities are wavering about fluoridation then introducing DPR or IPR will possibly create significantly more consternation amongst communities."*

Effective and credible regulation

Two respondents saw improved regulation of DPR as a means to address public concerns.

> *"Independent regulation of the industry will go a long way towards addressing public concerns. Australians are now used to seeing public hospitals accredited, even public schools graded, but water treatment plants are not licenced, nor accredited. Accordingly, the public does not see 'water' as a licenced product as it would see 'bread' for instance."*

> *"Adjustments to legislation, regulation, political will and public support are all required for this type of scheme to occur."*

Need to evaluate DPR within a big-picture analysis of water management philosophy

Two respondents emphasised the need to evaluate DPR within a much broader 'big picture' analysis of water management philosophy. It was suggested that some important 'overriding' philosophies, including conservation, decentralisation and the need for source separation should be subjects of greater focus.

"The biggest problem I see is the drive to introduce it based on its technological feasibility rather than as part of a larger socially related package. The big question for me is should we first be changing our water system away from high per capita consumption not only of water itself but the wider infrastructure - if this were done we would not need to bother with DPR for a long time if ever. Conversely and perversely IPR and DPR promote 'business as usual' approaches to resource use but with various substantial energy, environmental and infrastructure costs."

"There may well be some situations where IPR or DPR make sense (ie are socially, environmentally, and economically preferable) for short or long term water supply. But I guess my question about this as a source starts from a different space. I used to teach thermodynamics, so I wonder about the fundamentals of starting with the dirtiest water available in order to make the cleanest water we require, and doing so on the largest possible scale ie popping back in to a centralised distribution system. This seems to be a recipe for maximising the environmental and social impact of our water systems - we simply have to invest enormous amounts of energy and chemicals to treat the water in order to manage the obvious social (microbiological and pharmaceutical) risk and then to move it around. We can be much cleverer than this, surely! Especially in a world we know we need to think differently about resource recovery in sewage. Which will inevitably lead us down a path of less mixing than we do now."

Costs

A few respondents commented that the cost of DPR would be socially unacceptable in the current economic climate and where there would always be competing uses for taxpayer's dollars.

"Cost"

"It would also need to be delivered at the same of lower cost than other sources to warrant the investment."

"Utility costs"

"Significant capital investment in the infrastructure is unlikely be supported by general public due to the current economic uncertainty."

"And then, it might be helpful to step back a little further, and look at the water system as just one of many necessary public investments - the scale of treatment required means that we end up 'gold-plating' in this service area, but at the expense of investing in other public infrastructures, such as public transport or hospitals or education."

Public safety

Several respondents identified public safety as a social issue in itself.

"Terrorism"

"Understanding and managing systems failures would provide more confidence to the wider community"

"Immuno-suppressed, dialysis members of the community may be more concerned than others."

"Assurances about the long-term public health impacts when we still do not have a full understanding of all the compounds in the water. Unknown unknowns."

"Public health concerns"

"It is also important to consider the increased risk profile of transporting, storing and handling of chemicals on communities and occupational safety for both IPR and DPR."

Potential religious concerns

A few respondents commented that DPR might conflict with some religious beliefs and practices both in Australia and in export countries.

> *"Potential religious concerns (e.g. Jewish and Islamic potential reservations about recycled water)."*

> *"Also it is import to understand different segments to the community and potentially religious beliefs associated with DPR and IPR"*

> *"Certainly cultural diversity needs to be considered, as does the life cycle chain as it relates to export markets."*

> *"There are also religious beliefs involved in this issue."*

Equity

Two respondents noted that DPR should be implemented with social equity in mind; socioeconomics should not be allowed to determine whether or not communities were forced to accept DPR.

> *"The undesirability of requiring one geographic area of the city to use DPR water, while other areas – especially wealthier areas – are not required."*

> *"The distribution of recycled water needs to be as equitable as possible throughout the scheme to increase its general acceptance. Already in Perth discussions are around that if you live in the southern suburbs you will drinking desalination and dam water, and if in the north you will get groundwater and wastewater. This is leading to a bit of an 'us and them' situation with the connotation being that if you live in the north you will be worse off because you will be drinking wastewater. Get the well-off/community leaders to accept the DPR water first."*

Critical issues to overcome for DPR

QUESTION: In your opinion, what is the most critical single issue (if any), which will need to be overcome before DPR could become broadly accepted as an aspect of water management in Australia?

A relatively broad range of issues were identified as 'the' critical issue among the various respondents. However, the vast majority of responses referred primarily to social, rather than technical, issues. The most common responses related to public acceptance.

Current lack of evidence for need

Several respondents noted that the need for DPR had not yet been established. Most of these suggested that either improved levels of water conservation or other sources of supply would provide to be adequate for some time in most cases.

> *"We would need to run out of all other sources of water. Like all of these things (and if you look globally at where IPR/DPR has been used) there was a severe water shortage driver in all cases...as the economics alone (not even considering the social / political issues) do not stack up."*

> *"Another drought would make it easier to be accepted. Currently in SEQ there is more than enough water so there would not be much of an appetite for DPR."*

"Social issues are paramount - water recycling being pushed as a technological reaction to a social problem - excess and unnecessary overuse of a natural resource. Its the latter which needs to be dealt with first."

"In my opinion I don't believe that IPR or DPR are necessary if we use our water resources wisely. The amount of water that is actually consumed or used for cooking/showering is minimal compared to that used in the laundry, the toilet and domestic outdoor use. Furthermore, the volume used by industry, councils and some agricultural enterprises far outweighs that used for consumption or primary contact. As a State we need to be looking at what is needed and where, and then treat the water to the standard required for that end use. The cost to retrofit a suburb with a third pipe solution is warranted when the true environmental and economic externalities are considered. The use of decentralised treatment systems will support the ability to treat as required instead of all water being treated for the highest end use (when the highest end use represents the lowest volume of use)."

"Need for [DPR] vis-a vis [IPR} and non-potable use of the water. It is not a technical or water quality issue."

"It would need another drought as bad as the last one."

"Overt need for new source of urban water."

Need for public and political education and acceptance/support

A large number of respondents indicated that improved public and political acceptance were the key obstacles to DPR. Many pointed to the need for proactive community education to build support.

"Public and political education"

"Water policy decision-making in Australia is highly politicized (more so than in California, which i wouldn't have thought possible). I believe strongly that the water industry needs to demonstrate leadership by amplifying the Goal 3 project results when they are available. The Goal 3 project and AWRCE alone will not persuade key stakeholders that DPR is safe and appropriate. The water industry must actively engage to educate key stakeholders."

"Political nervousness fuelled by negativity among some water industry professionals - particularly the regulators - and an ignorant community."

"Building political support. Political support usually follows public support, so you would need to do the above to convince politicians of the benefits of DPR - and that it's not going to cost them votes."

"Public acceptance"

"Social (see above) and (related) political."

"Social acceptance and trust in the technology and management systems."

"Community fears and misguided opposition."

"Broad social and institutional acceptance."

"Community education program"

"Practitioner acceptance. If the majority of people within the water industry or the associated research and regulatory establishments are not reasonably sure that DPR carries no greater risk than the alternatives, then you will not be able to present a consensus view that can convince politicians and the public."

“Public acceptance - and consequent political will. There will be little political consideration of reuse until the next drought strikes. It would be economically prudent to pursue the issue in the time of plenty than to follow past practice and throw money at the problem as the dams run out.”

“The need of appropriate, concrete political support.”

“There is a degree of unacceptance in the community due to a lack of understanding of how wastewater can be treated.”

“People have to learn that there is no zero risk (they accept that when going surfing)”

“Education with an emphasis of trust of science so that rational bi-partisan decisions can be made”

“Community acceptance is very very low.”

“Public understanding and acceptance”

“Consumer sentiment and political pragmatism make DPR problematic.”

“National political leadership is needed. Rejection of recycling in one jurisdiction makes acceptance in others more difficult. Conversely, acceptance in any jurisdiction assists consideration in others. Collaborative approaches by governments, such as the approach to drafting the national recycling guidelines, and the efforts of the Water Recycling Centre of Excellence will assist all.”

“Community and political stakeholder education and management.”

“Public acceptance.”

“Educating people about the relative chemical risk from recycled water compared with their exposure through other common pathways including traditional potable water treatment(eg DBPs)”

“Public acceptance that DPR don't increase health risk compared to existing drinking water supplies.”

“Acceptance by regulators, politicians and the public.”

“Social/community acceptance also acceptance by the Public Health sector”

“Social acceptance. Politicians need to be on-board. They are responsible for the failed schemes at Western Corridor, all to save a few votes. It shouldn’t be seen as a 'last resort' option. Putting recycled water into Wivenhoe when it’s full is better than when it is at 40%.”

“The general education of the community regarding the value of water and resource management is a key element.”

“Community acceptance and political support.”

“Public Confidence”

“Social acceptability”

“Managing the public's appreciate of this technology - increasing it's social value.”

“As we know in Australia, the key barrier to the introduction of recycled water schemes is public acceptance. If we are talking about using water from a DPR scheme for drinking or close personal use, then the social acceptability of the scheme remains a major & significant barrier.”

Media sensationalism and risk of a scare campaign

Respondents noted the ability of the media to derail DPR proposals for the sake of sensational headline and the ease with which an effective scare campaign may be waged against DPR.

“Media in search of a headline resulting in politicians avoiding the issue”

“It is very easy to develop a scare campaign that would destroy the reputation of recycle water.”

Need for improved public perception

A large number of respondents identified the key obstacle as ‘public perception’, including the use of terms such the ‘yuck factor’.

> *“Public perception. This is best done not by quoting risk figures and performance reviews, but by exposure to the perceptions of people who live daily in other parts of the world with DPR”*
>
> *“Public perception.”*
>
> *“Clearly the 'yuk' factor. It is a natural human response to feel revulsion at the idea of drinking water being contaminated with human waste. But if people could just see how clean PRW really is, this may help them overcome this feeling. Mind you, it is not clear how this is achieved in large populations when most people never give a thought to where their water comes from.”*
>
> *“Public perception.”*
>
> *“Psycho-social issues.”*
>
> *“Public perception resulting in strong negative reactions to wastewater reuse.”*
>
> *“Public acceptance or overcoming the yuk factors”*
>
> *“Changing public perception”*
>
> *“Social issues.”*
>
> *“Public Perception”*
>
> *“Public Perception”*
>
> *“Yuck factor due to the water industry's inability to provide a clear message & sell this”*
>
> *“Community perception.”*
>
> *“Overcoming the mindset that DPR is ‘linking toilet to tap’: i.e. people (professionals and community) need to understand more about water technology and the water cycle.”*
>
> *“Yuk' factor from consumers manipulated by opponents, the thought of drinking something that has directly originated from a toilet is a major hurdle.”*
>
> *“Public acceptance of DPR will be the main issue as there will always be doubt about the reliability of an engineering solution to continuously treat wastewater to a potable water quality.”*
>
> *“Community acceptance of IPR”.*

Improved regulatory environment

Three respondents saw a need to improve the regulation of DPR before significant progress could be made.

> *“The regulatory environment, which is already extremely onerous for IPR and has certainly discouraged water recycling schemes in Australia. While I agree that the health of the public should NOT be jeopardised to improve our approach to the urban water cycle, there is a need for more support from the regulators to help utilities develop safe water recycling alternatives without the extreme requirements currently placed solely on the utilities.”*

"Current Health and Environment regulatory frameworks…make DPR problematic"

"There will be a need for a revision to the drinking water standard for recycled water that captures the many anthropogenic contaminants not prevalent in traditional sources of raw water treated for drinking purposes."

Independence, stability, and leadership in public water bodies

Two respondents called for increased stability and leadership from public water management bodies.

"Water management organisations that are not changed every time there is a state or commonwealth election"

"Lack of autonomy, vision and leadership in our water authorities. IPR is successful in California, Singapore, Georgia, Virginia and Perth because implementation is the responsibility of one entity - the water authority. Water authorities are empowered to deliver IPR because they have gained the trust (or receive a mandate) of the local government (either National (Singapore), State (Water Corp), Regional (OCWD) or Municipal (Virginia, Texas, Georgia)."

Acceptance that DPR is safe and reliable

Several respondents argued that more work was required to prove the safety and reliability of DPR to the public or regulators.

"The belief by water industry professionals and the community at large that DPR is a safe and reliable option that should be considered in all supply option assessments. The journey has started but there is still a way to go."

"The risk profile from a whole of system perspective is critically important"

"Safety issue around use and perception about potable water sourced from treated effluent or wastewater."

"Proven, reliable, long-term reliability and performance"

"Risk management esp. governance and accountability will also be of concern."

"The incorporation of an adequate number of controls into the system to ensure contaminated water is not put into the system."

"Public health"

"The ability to ensure effective operational control to provide 'in-time' responses to variations in water quality that may threaten public health"

"Conclusive evidence that treatment systems are in fact fail-proof."

"Real time Identification & response to treatment failure."

"Trust and transparency in water quality management by utility"

"From a human health perspective, adequately addressing to the satisfaction of the community the risks identified by the quantitative human health risk assessment is crucial to the acceptance of DPR as an aspect of water management in Australia."

"Fundamental issues are the identification of key contaminants related to the source of water and the technologies available for their effective removal."

"Once we are able to bed down any contested science on the quality of treated water, the promotion of community receptivity to reclaimed water in IPR and DPR can commence off this firm foundation."

"We need to prove to the regulators that this is safe."

Cost

Several respondents considered that the economic feasibility of DPR had not yet been demonstrated.

"Cost"

"The cost benefit needs to stack up against other supply options."

"Economic and environmental drivers. The latter is also the case for IPR. The differential in the economic drivers between IPR and DPR need to be better articulated. In some cases, this will not be all that clear (see my comments on aquifers above)."

"The costing of water is a major determinant. Under the current arrangements the true cost of water is hidden by access charges, developer contributions, subsidies etc. If the customer was charged the true marginal cost, urban water consumption may drop to levels where reuse was no longer on the agenda. If customers had to pay the actual cost of DPR water, instead of having a pricing system that bundled it up with water of other sources, DPR would not proceed. The public are used to paying superior prices for a superior product. The idea of a superior price for an inferior product, due to higher risk, would not make any sense to customers."

"Additional treatment costs to make water comply with Aust. Drinking Water Guidelines."

"Community resistance to expenditure."

"We need to prove that it is the lowest community cost solution."

Improved public consultation and decision-making processes.

Three respondents called for greater public participation and transparency in the water decision-making process.

"Public consultation and decision-making processes."

"Trust and transparency in water source decision making process."

"I think the most critical issue might just be to treat our citizenry's views as if they matter. To develop meaningful engagement processes (see above about deliberative, democratic engagement) that allow us to have worthwhile conversations about whether our society really does want to go down the IPR/DPR path, what accommodations would be necessary, and what it would take to make that path sufficiently acceptable."

Successful trial/demonstration project

Two respondents pointed out the need for a proven example of DPR under Australian conditions.

"A well-functioning trial/demonstration project"

"Risk management - an established track record from demonstration suites across Australia."

Need for improved source control

One respondent called for improved governance of source control.

"Improved governance in how we manage the catchment - i.e. inputs into the sewerage network"

Risk of system failure

One respondent felt that the risk of failure was too great ('inevitable') and that such a failure would undermine public confidence in water recycling generally.

"An inevitable failure will occur, and undermine public confidence in recycling generally".