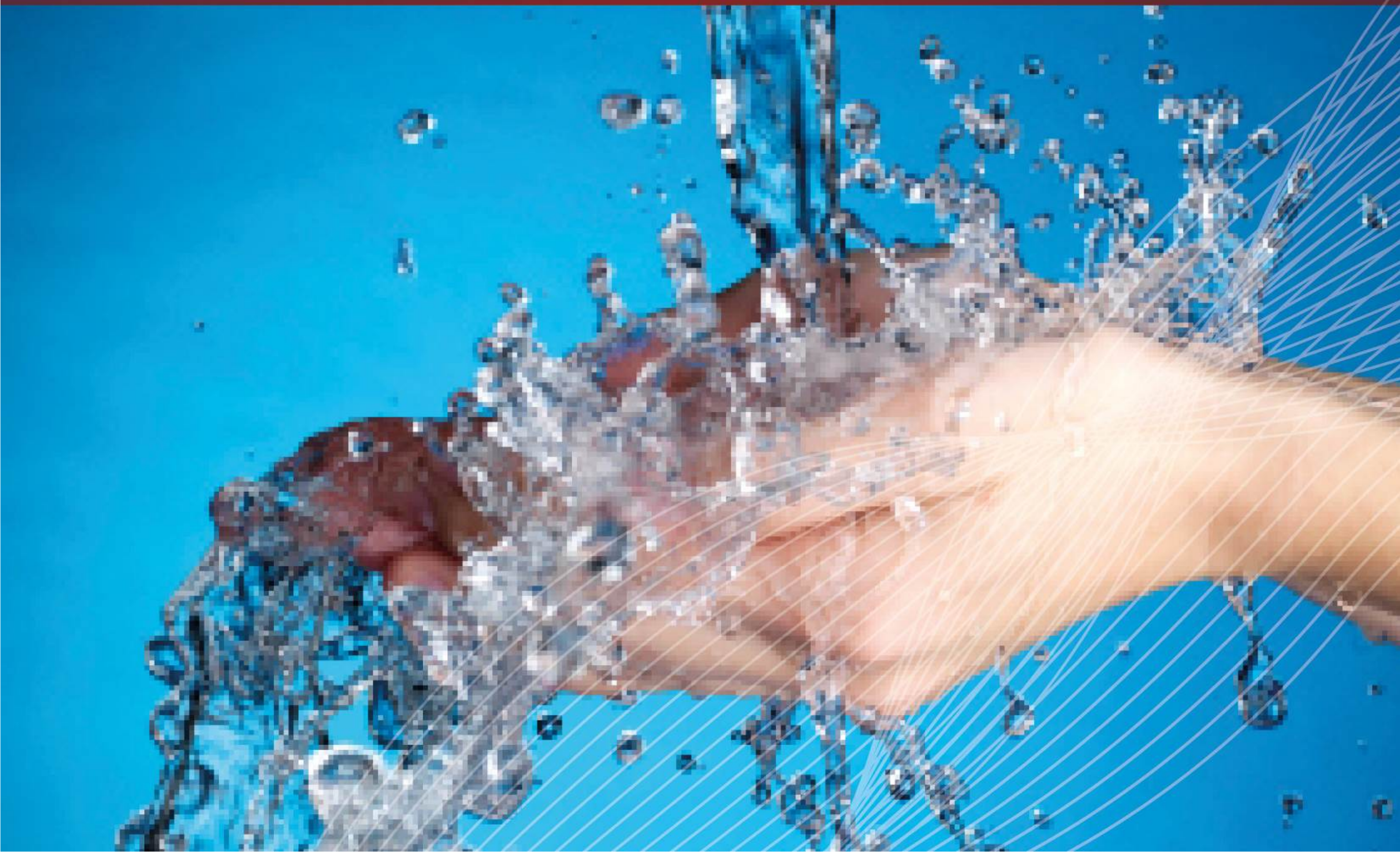
Australian Water Recycling
Centre of Excellence

Project Report

Potable Reuse: Practises, Water Quality & Public Health, A Global Perspective

A report of a study funded by the
Australian Water Recycling Centre of Excellence

University of New South Wales, November 2014



Potable Reuse: Practises, Water Quality & Public Health, A Global Perspective

This report has been prepared as part of the National Demonstration Education and Engagement Program (NDEEP). This Program has developed a suite of high quality, evidence-based information, tools and engagement strategies that can be used by the water industry when considering water recycling for drinking purposes. The products are fully integrated and can be used at different phases of project development commencing at "just thinking about water recycling for drinking water purposes as an option" to "nearly implemented".

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About the Australian Water Recycling Centre of Excellence

The mission of the Australian Water Recycling Centre of Excellence is to enhance management and use of water recycling through industry partnerships, build capacity and capability within the recycled water industry, and promote water recycling as a socially, environmentally and economically sustainable option for future water security.

The Australian Government has provided $20 million to the Centre through its National Urban Water and Desalination Plan to support applied research and development projects which meet water recycling challenges for Australia's irrigation, urban development, food processing, heavy industry and water utility sectors. This funding has levered an additional $40 million investment from more than 80 private and public organisations, in Australia and overseas.

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ABBREVIATIONS & ACRONYMS

AGWR	Australian Guidelines for Water Recycling
COW	City of Windhoek
DPR	Direct potable reuse
FPW	Finished product water
GDP	Gross domestic product
HACCP	Hazard analysis and critical control points
IPR	Indirect potable reuse
IWVA	Intermunicipal Water Company of the Veurne Region
OCWD	Orange County Water District
NDEEP	National Demonstration Education and Engagement Program
PUB	Public Utilities Board
SEQ	South-east Queensland
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation

EXECUTIVE SUMMARY

Criticism of potable reuse schemes from a medical and public health perspective has been seen as a contributing factor in the failures of potable reuse schemes to gain acceptance in the Australian context. The research conducted by Sub-stream 1.1 was intended to address these concerns through establishment of potable reuse case studies, reviews of regulation and literature and engagement with public health experts in refining the products for the public health wiki. In particular, 5 key milestones were established in relation to these goals, which were completed in amended form within a 2-year timeframe.

Sub-stream 1.1 completed the planned work in a 2-year timeframe beginning in October 2012. During the project, the key component was the potable reuse case studies, which combined water quality with demographic and qualitative data and were presented through the public health wiki. Additional components included incorporation of a summary of bio-monitoring tools and uses, existing epidemiological studies, a summary of regulatory frameworks pertaining to the case study sites. The accuracy and credibility of the material presented was guided by a public health advisory panel and assessed through external review on a near-final version of the wiki (details of these available in Appendix A below).

This project focussed on addressing the milestones through presentation for a professional audience in public or environmental health, with additional details available for water quality professionals. The main product generated through Sub-stream 1.1 is the set of seven case studies of implemented potable reuse schemes. These schemes, in general, had similar characteristics but differed to a greater degree in terms of engagement with the public around potable reuse. The New Goreangab scheme involved a lower cost approach that avoided use of reverse osmosis technology and was the only scheme that practiced direct potable reuse.

Regulatory practices were fairly consistent across the schemes, with most based on the WHO or USEPA guidelines but with some practical differences in terms of implementation. Our review of Health Assessments incorporated detailed summaries of available biomonitoring tools. The research also reviewed epidemiological and toxicological studies that have been conducted.

There was no evidence to suggest incidences of waterborne outbreaks in any of the potable reuse locations. The research concluded that the practise of potable reuse did not expose consumers to elevated health risks above what is found in traditional water supply. Moreover, assessments of the water quality data and in particular those parameters of public health concern showed that the prescribed targets were consistently met with the finished product water (FPW) being of high quality, which in most cases exceeded the quality of existing drinking water standards for traditional sources.

We also conducted an additional review of outbreaks from conventional water schemes in developed countries from 2003-2012 in order to ascertain common factors in these events. The categories of scheme failure identified through this study fed into the monte-carlo analysis of scheme resilience conducted under sub-stream 1.3 and reported on elsewhere. This work is being separately written up for publication in a scientific journal.

In terms of limitations, the project underwent some modifications due to the withdrawal of key researchers from the project, with the decision taken to scale-back Milestone 4 to the role taken by our expert advisory panel. More consultation within the public health and medical communities is likely to be helpful, including engagement with the Public Health Association of Australia, which has been effective in public health advocacy around a number of issues including cigarette smoking.

In addition, despite extensive efforts, we were unable to obtain as much data as desired from several of the schemes. In some instances, the schemes were happy to provide us with the data but limited representation in the public domain on the wiki, while in the case of the Namibian facility, despite assurances that data would be provided, we were unable to achieve this. In our view, more complete representation of the testing data would be very helpful, both in terms of enhancing the credibility of the wiki but also in relation to providing strong public evidence of the effectiveness of existing schemes.

This document summarises the work and findings of Sub-stream 1.1 and is intended to accompany the Public Health pages of the NDEEP wiki.

1. Introduction

Wastewater reuse has gained acceptance and prominence in many regions of the globe as a sustainable alternative water source especially in those locations that experience increasing water demand amidst dwindling natural reserves and unpredictable precipitation patterns. The practise of potable reuse is one such application for which treated wastewater has been implemented in these regions either directly into the distribution system (direct potable reuse - DPR) or indirectly through aquifer or groundwater recharge (indirect potable reuse - IPR). Australia has responded through the development of water conservation strategies and use of alternative waters mainly for non-potable purposes.

Some communities have been reluctant to accept potable reuse as a viable, alternative source despite the increased demand for water resources and the need to conserve and augment strained potable supplies. Potable reuse proposals have been met with strong opposition in some communities, evidenced by failed proposals such as in Toowoomba, Queensland. This has been due in part to criticisms by health and water professionals, negative media branding, and concerns over exposure to potential health risks. Given that great gains in public health in developed countries has been established through the provision of potable water sources kept separate from contaminated sources including urban wastewater, the concerns expressed are valid and require addressing. Global studies suggest that publics are more inclined to accept alternative water sources where engagement initiatives address community attitudes, educate audiences on reuse processes, demonstrate the efficacy of treatment and protective barriers, thereby addressing the perception of microbial and chemical risk exposure.

The research conducted by Sub-stream 1.1 was intended to provide a critical evaluation of the practise of potable reuse, examine the claims regarding disease transmission, and comment on the safety of this reuse option as a viable alternative for augmenting drinking water sources. The research aimed to address the following questions:

1. What data is currently available globally on the practise of potable reuse?
2. Are the regulations and guidelines from different jurisdictions practicing potable reuse adequate to provide information required to assess the impact on public health?
3. What public health information (incidences of water borne or other infectious disease contagion) exists for communities that have implemented potable reuse for the period before and after the schemes have been in operation?
4. Does the data that is currently collected from potable reuse provide appropriate information for public health professionals to comment on both the risks associated with potable recycling and the efficacy of the process barriers and preventative measures in mitigating these risks?

2. Milestones

The research questions were translated into a set of 5 explicit milestones, constituting the project. Sub-stream 1.1 milestone tasks were originally five-fold:

1. Build a database comprising available water quality information provided by water utilities
2. Collect demographic and health information (before and after) for those communities that have implemented potable reuse
3. Identify any gaps in the regulatory framework of jurisdictions practising potable reuse
4. Critically review current practises in water quality data collection and presentation and the public health impacts of reuse schemes
5. Develop a public centric program identifying areas of importance to the public health community

Following preliminary research into the practise of potable reuse, some of these milestones were amended to reflect the data that was available and relevant to the research developed by the sub-stream. The final version of the Milestones is presented in Appendix B.

3. Research Undertaken

Milestone 1 – Build a Database

To critically assess the safety of potable reuse and provide a more comprehensive public health assessment, data collection was extended beyond water quality information to encompass other scheme characteristics and practises pertinent to the production of high quality water. Information was compiled under the following major categories:

Scheme overview: scheme history, drivers of potable reuse, population served, amount of water reclaimed and blended, intended uses, and pilot testing initiatives.
Critical infrastructure: scheme specific operational processes such as permit guidelines, multiple barriers, trade waste policy, advanced treatments, regulatory elements, employee skills & training, breach management protocols, and maintenance regimens.
Water quality: range of assessments & parameters analysed (past 5 years), permit limits, water quality approval authority, on-going water quality research, and compliance testing of final product water (FPW).
Public health elements: water safety standards and protocols, corrective actions, multidisciplinary (public health) collaboration, and community health surveillance strategies.
Engagement & Education: initial & on-going stakeholder engagement strategies employed.

The research reviewed the practise of potable reuse by evaluating published literature, online resources, and personal communication received from the following seven global potable reuse sites:

i. New Goreangab water reclamation plant, Windhoek, Namibia - DPR
ii. Groundwater replenishment system, Orange County, CA, USA - IPR
iii. Western Corridor Recycled Water Scheme, Queensland, Australia - IPR
iv. NEWater, Singapore - IPR
v. Upper Occoquan Service Authority, Fairfax, VA, USA - IPR
vi. Torreele/St. Andre water reclamation plant, Wulpen, Belgium - IPR
vii. Groundwater replenishment trial, Perth, Western Australia – IPR

Milestone 2 - Collect demographic and health information

The process of collecting demographic information for communities practising potable reuse did not yield sufficient data to adequately inform the public health status of these communities (before and after) based on just the provision of water. Numerous factors are known to affect the health of a population beyond adequate water supply and thus collection of demographic data (GDP, life expectancy, etc) was not performed. Rather, this milestone addressed concerns of increased disease contagion by investigating whether there have been incidences of disease outbreaks in communities implementing potable reuse, and the public health outcomes of such incidences.

In many communities where potable reuse is practiced, epidemiological and toxicological studies have been conducted to investigate whether consumption of recycled water has had any related adverse health effects. Epidemiological studies in particular have compared populations utilising recycled water with control groups on parameters such as enteric infections, respiratory infections, reproductive & birth defects, carcinogenic effects etc. Bio-monitoring studies on the other hand provide some evidence of the combined toxicological effects of reclaimed water by using various cell lines (bacterial or mammalian) and whole organisms (eg. mice and fish) to evaluate reclaimed wastewater for endocrine, toxicological, and carcinogenic effects. Bio-monitoring data was compiled by Sub-stream 1.2 and a detailed report of their findings has been provided separately.

Milestone 3 - Identification of gaps in the regulatory framework

The objective of this task was to compare and contrast regulatory frameworks from different jurisdictions practicing potable recycling to identify specific areas of importance to recycled water regulation, with reference to the Australian Guidelines for Water Recycling (AGWR) framework that is based on a risk management approach with a strong focus on minimising adverse public health impacts. Rather than provide a prescriptive approach to regulation, the aim of this processes was to compile a list of the best practises in potable reuse that form the basis of permits and regulation pertinent to public health protection. Assessments included investigating existing protocols, regulatory bodies and standards, HACCP programs, operational standards, corrective actions, and water safety plans implemented by these utilities. This data was compiled in a table showing the various characteristics of the seven case studies.

Milestone 4 - Critical review of current practices in water quality data collection and presentation

The objective of this task was to identify whether the data that is available provides appropriate information for public health professionals to adequately comment on both the risks associated with potable recycling and the efficacy of the process barriers and preventative measures in mitigating these risks. To achieve this, a panel comprising four water and public health professionals was appointed with the role of providing guidance and comment on the level of data collected, its presentation, and relevance. The panel were consulted throughout the duration of this project and their recommendations incorporated in the development of the outputs. In addition, three external reviewers in health and water were invited to review a draft of the wiki and provide feedback.

Milestone 5 - Develop "public centric" program

The main objective of this task was to communicate the performance of potable recycling schemes based on a public health perspective. The emphasis was on identifying the parameters that are of most importance to the public health community and general public and ensuring that this data and information is presented in a form that the public understands. The NDEEP team developed a wiki to collectively house the findings from each of the three streams. The work developed by Sub-stream 1.1 is housed under the Public Health icon on the wiki.

4. Wiki

The information collated in the database was transformed into wiki pages housed under the Public Health icon of the NDEEP wiki. The Public health home page (Figure 1) provides a brief introduction of the global need for potable reuse, presents the Australian perspective on potable reuse, and the questions the research topic aims to address.

The information is presented in four main pages:

Risks & Prevention page

Urban (domestic and commercial) wastewater contains elevated levels of both chemical and microbiological contaminants, some of which are known to affect human health and propagate disease. This page has identified the range of chemical (eg. pharmaceuticals, personal care products, endocrine disruptors, etc) and microbiological (enteric pathogens) components of concern associated with wastewater reuse, their public health impacts (where known) and the various strategies that are implemented to prevent these risks from affecting human health. The research explored treatment technologies in reuse, the use of multiple barriers, and the practise of pilot testing of processes, and provides a summary of their efficacy in meeting health targets.

Regulation & Public health page

Regulation forms an important element of public health protection in industry. This page briefly describes the guidelines in Australia (based on the AGWR) and identifies the 12 key elements described in this document. The latter part of this page presents a summary table of the regulatory elements of seven global reuse schemes including those of two Australian sites. Data was presented without necessarily taking a prescriptive approach on the ideal framework. While the common elements have been provided, the approach was to highlight important elements of each jurisdiction that are considered pertinent to regulation and protection of public health such as permit guidelines, regulatory surveillance standards, validation of operational processes, breach management and reporting, HACCP approach and water safety plans.

Health Assessments page

This section summaries additional approaches that have been undertaken to assess water quality and health impacts of wastewater reuse in communities that go beyond stipulated regulation. Included is the review conducted by Sub-stream 1.2 highlighting global bio-monitoring applications including those performed at the seven case studies sites. This section also provides information on the range of epidemiological studies that have been conducted worldwide to investigate acute and chronic disease rise in populations utilising recycled water. Incidences of waterborne disease outbreaks in potable reuse were also explored and compared to those that have occurred in conventional water systems in developed nations in the past decade.

Because there was no evidence to suggest incidences of outbreaks in reuse communities, the approach taken here was to investigate failure events which have led to community outbreaks in traditional water settings and how the potable reuse case studies prevent these faults in their systems. The analysis of failure events was performed in collaboration with Sub-stream 1.3 and that data has been presented in their section of the wiki. Sub-stream 1.1 presents a summary of the public health impacts of outbreak scenarios.

Potable reuse case studies page

This page presents information via a global map (Figure 2) depicting 28 locales where potable reuse is currently implemented, the type of reuse application (DPR/IPR; surface recharge/groundwater recharge) and provides detailed information about the aforementioned seven case studies (see example in Figure 3 and Figure 4). Included in the pages is information pertaining to their operational processes, water quality and public health, and engagement strategies.

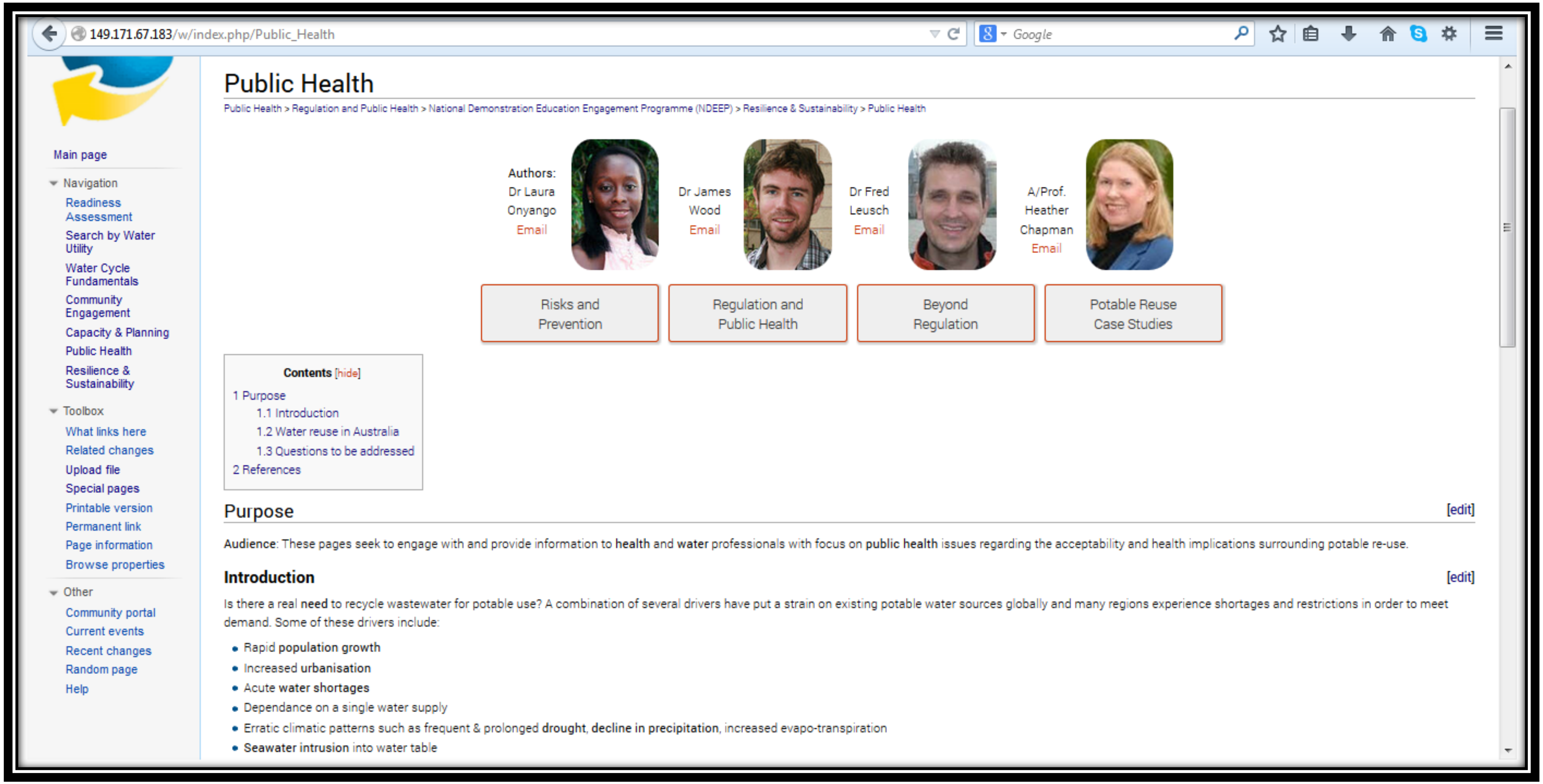


Figure 1: Public Health pages of the NDEEP wiki.

Exploring successful potable re-use schemes in more detail

Below are some examples of current global potable re-use schemes. By hovering over a location identified by the coloured circles, you can access a brief description of the corresponding potable reuse scheme. For a set of **seven** case studies circles), detailed information has been compiled including (**scheme overview, operational infrastructure, water quality data & public health factors, and a portfolio of engagement and educational strategies**), which can be accesse clicking on the respective dots. These schemes are chosen either reflecting their international importance, or in the Australian context to illustrate the performance of existing pilot schemes and are as follows:

International Schemes:

- Groundwater replenishment system, Orange county, California, USA.
- Upper Occoquan Service Authority, Fairfax, Virginia, USA.
- NEWater, Singapore
- New Goreangab water reclamation plant, Windhoek, Namibia
- Torreele/St. Andre Water Reclamation Plant, Wulpen, Belgium

Australian Schemes:

- Western Corridor Recycled Water Scheme, Queensland
- Groundwater Replenishment Trial, Western Australia

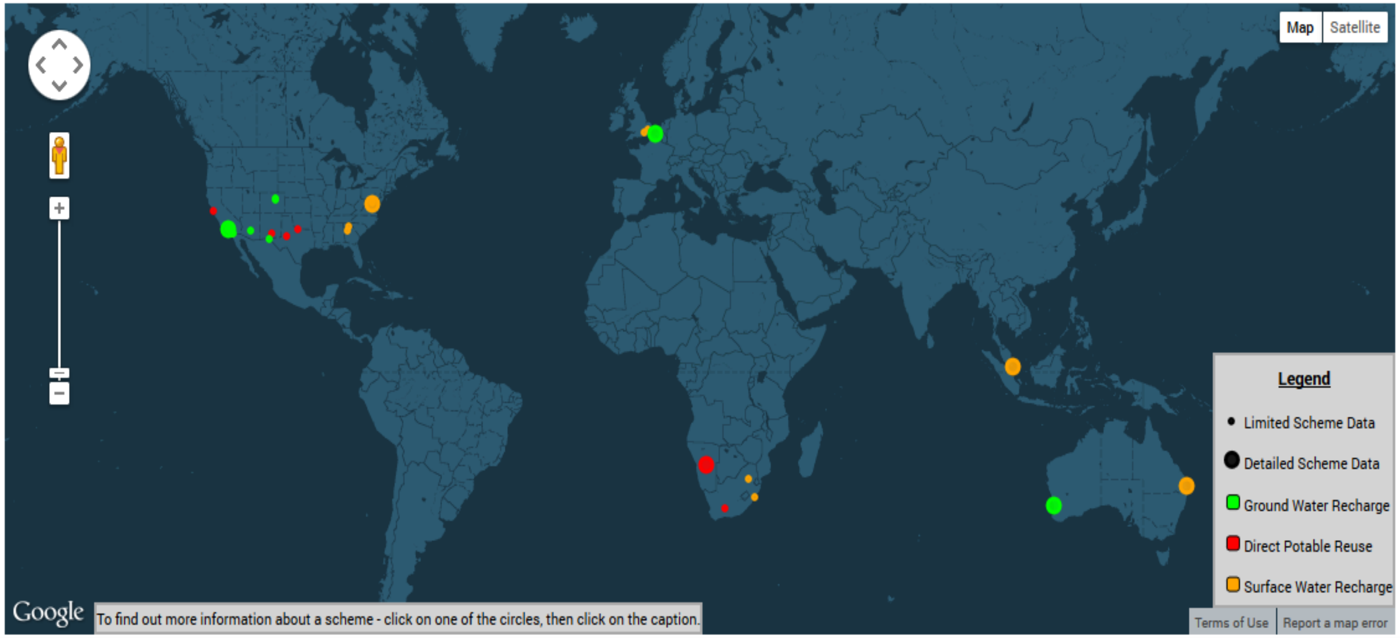


Figure 2: Global map showing locations of potable reuse practise.

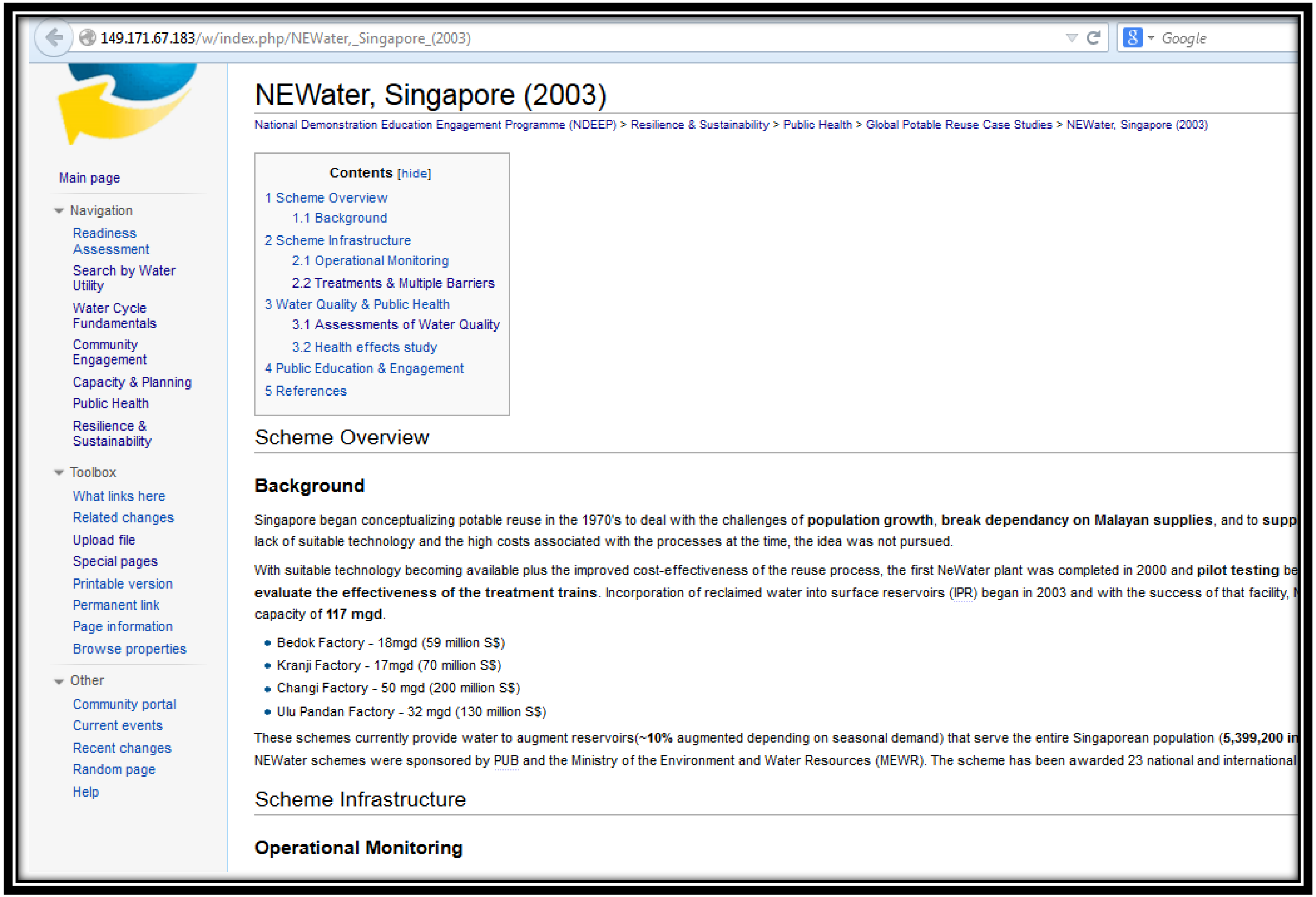
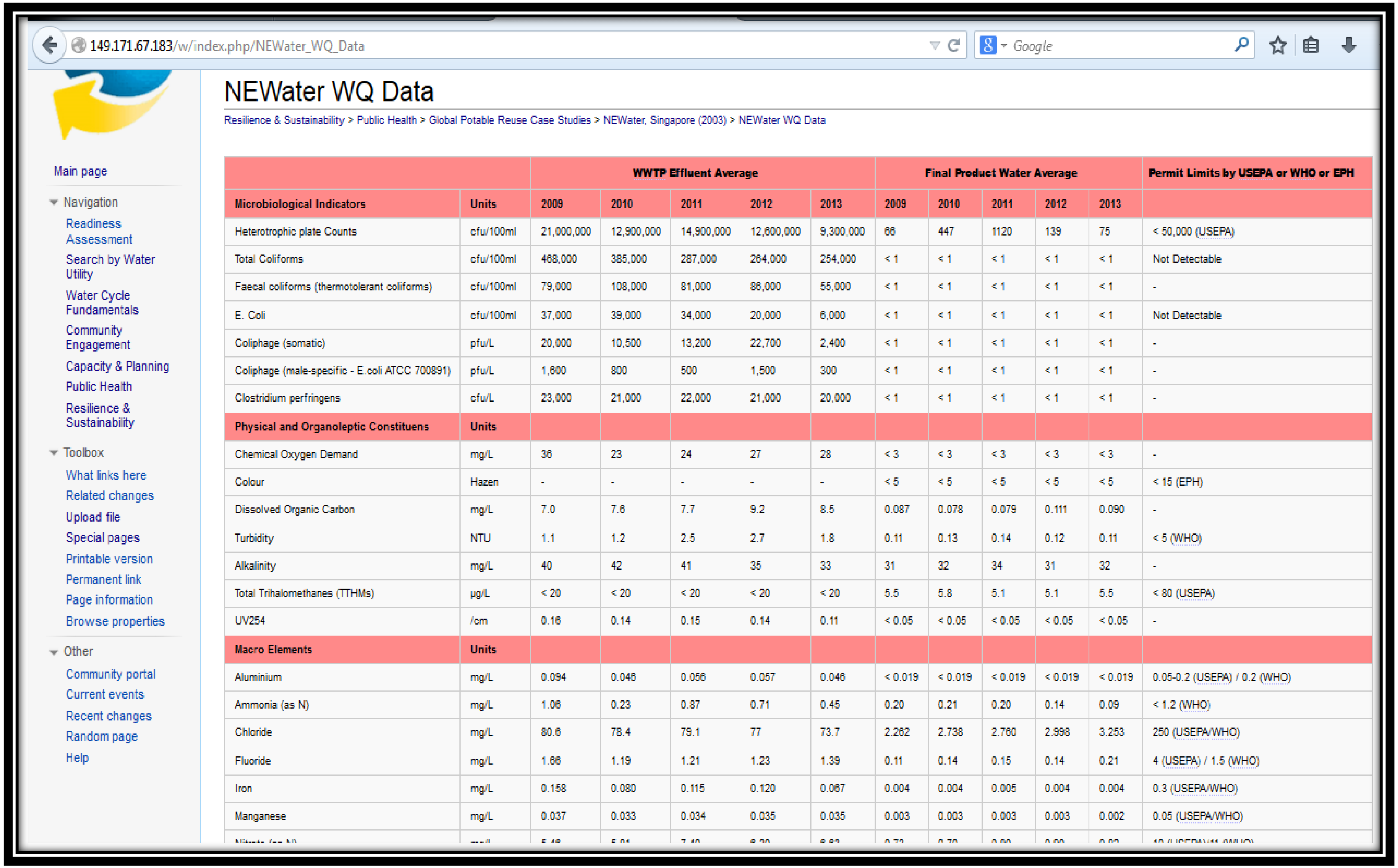


Figure 3: Example of a data collected for NEWater, Singapore.



149.171.67.183/w/index.php/NEWater_WQ_Data

Main page
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Community Engagement
Capacity & Planning
Public Health
Resilience & Sustainability
Toolbox
What links here
Related changes
Upload file
Special pages
Printable version
Permanent link
Page information
Browse properties
Other
Community portal
Current events
Recent changes
Random page
Help

NEWater WQ Data

Resilience & Sustainability > Public Health > Global Potable Reuse Case Studies > NEWater, Singapore (2003) > NEWater WQ Data

		WWTP Effluent Average					Final Product Water Average					Permit Limits by USEPA or WHO or EPH
Microbiological Indicators	**Units**	**2009**	**2010**	**2011**	**2012**	**2013**	**2009**	**2010**	**2011**	**2012**	**2013**	
Heterotrophic plate Counts	cfu/100ml	21,000,000	12,900,000	14,900,000	12,600,000	9,300,000	66	447	1120	139	75	< 50,000 (USEPA)
Total Coliforms	cfu/100ml	468,000	385,000	287,000	264,000	254,000	< 1	< 1	< 1	< 1	< 1	Not Detectable
Faecal coliforms (thermotolerant coliforms)	cfu/100ml	79,000	108,000	81,000	86,000	55,000	< 1	< 1	< 1	< 1	< 1	-
E. Coli	cfu/100ml	37,000	39,000	34,000	20,000	6,000	< 1	< 1	< 1	< 1	< 1	Not Detectable
Coliphage (somatic)	pfu/L	20,000	10,500	13,200	22,700	2,400	< 1	< 1	< 1	< 1	< 1	-
Coliphage (male-specific - E.coli ATCC 700891)	pfu/L	1,600	800	500	1,500	300	< 1	< 1	< 1	< 1	< 1	-
Clostridium perfringens	cfu/L	23,000	21,000	22,000	21,000	20,000	< 1	< 1	< 1	< 1	< 1	-
Physical and Organoleptic Constituens	**Units**											
Chemical Oxygen Demand	mg/L	36	23	24	27	28	< 3	< 3	< 3	< 3	< 3	-
Colour	Hazen	-	-	-	-	-	< 5	< 5	< 5	< 5	< 5	< 15 (EPH)
Dissolved Organic Carbon	mg/L	7.0	7.6	7.7	9.2	8.5	0.087	0.078	0.079	0.111	0.090	-
Turbidity	NTU	1.1	1.2	2.5	2.7	1.8	0.11	0.13	0.14	0.12	0.11	< 5 (WHO)
Alkalinity	mg/L	40	42	41	35	33	31	32	34	31	32	-
Total Trihalomethanes (TTHMs)	µg/L	< 20	< 20	< 20	< 20	< 20	5.5	5.8	5.1	5.1	5.5	< 80 (USEPA)
UV254	/cm	0.16	0.14	0.15	0.14	0.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-
Macro Elements	**Units**											
Aluminium	mg/L	0.094	0.046	0.056	0.057	0.046	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	0.05-0.2 (USEPA) / 0.2 (WHO)
Ammonia (as N)	mg/L	1.06	0.23	0.87	0.71	0.45	0.20	0.21	0.20	0.14	0.09	< 1.2 (WHO)
Chloride	mg/L	80.6	78.4	79.1	77	73.7	2.262	2.738	2.760	2.998	3.253	250 (USEPA/WHO)
Fluoride	mg/L	1.66	1.19	1.21	1.23	1.39	0.11	0.14	0.15	0.14	0.21	4 (USEPA) / 1.5 (WHO)
Iron	mg/L	0.158	0.080	0.115	0.120	0.067	0.004	0.004	0.005	0.004	0.004	0.3 (USEPA/WHO)
Manganese	mg/L	0.037	0.033	0.034	0.035	0.035	0.003	0.003	0.003	0.003	0.002	0.05 (USEPA/WHO)

Figure 4: Example of NEWater water quality data (before and after treatment) compiled for 5 years showing categories of parameters analysed, and permit limits.

5. Findings & Conclusions

The practise of intentional potable reuse has successfully been implemented in many global regions with over 25 schemes identified practising either DPR or IPR applications, the majority of these located in the USA. In Australia, potable reuse acceptance has been hampered in part due to criticism by health and water professionals, negative media branding, and public perceptions of disease risks. Nonetheless, two potable reuse projects have been introduced in the past decade: the Western Corridor Recycled Water Scheme (WCRWS) in South-east Queensland (SEQ), and the Groundwater Replenishment Trial (GWRT) in Western Australian in response to the water needs in these regions.

Data available on potable reuse

The research found that the practise of potable reuse has been well documented in published and grey literature, with information available for a vast number of audiences on topics such as:

i. types of potable reuse options,
ii. drivers / need for alternative water sources,
iii. water treatments available,
iv. practise guidelines,
v. system configurations,
vi. water quality,
vii. associated public and environmental health issues,
viii. community attitudes,
ix. engagement strategies, and much more.

The research performed in Sub-stream 1.1 aimed to provide the health and water community with comprehensive information on potable reuse practise with focus on public health aspects. Initial research analysed the health risks associated with wastewater reuse and focused on those of concern to the general public, and the health and water professionals. While waterborne disease contagion from enteric pathogens (bacteria, viruses and protozoa) was the primary concern, apprehension surrounding the toxicological effects of a growing list of chemical compounds was also noted. Chemicals of concern included:

i. Household and personal-care products
ii. Pharmaceuticals
iii. Endocrine disrupting compounds
iv. Disinfection by-products
v. Industrial products
vi. Other unknown/emerging pollutants.

Past research studies document instances where these compounds have been found in environmental settings including in traditional drinking water sources. Since municipal wastewater sources contain elevated levels of these compounds, concern over health effects was heightened especially surrounding the efficacy of monitoring techniques to detect these compounds and the reliability of treatment technologies to remove them. To prevent consumers from exposure to these risks, potable reuse schemes indeed require treatments and processes that go beyond those employed in traditional systems for potable reuse to be considered safe.

Investigations focused on the practises of seven global case studies (1 DPR; 6 IPR) and reviewed their operational processes from source water acquisition all the way to water delivery, regulatory elements, public health concerns, risk mitigation strategies, and supporting water quality data. Data for these case studies was compiled primarily from personal communication with contacts at these sites, and from additional published literature. Evaluations found the following practises were commonly employed by reuse system as part of their risk management plan:

1. Well-developed water policies incorporated into operational permits
2. Pilot testing of the system under different operating scenarios

3. Use of multiple barriers incorporated throughout the system including source water protection strategies, trade waste management, advanced treatments, blending and passage in an environmental buffer, etc
4. Comprehensive water quality monitoring practises
5. Incorporation of critical control points (CCPs) where operational processes are monitored for quality assurance
6. Multiagency collaboration in developing rigorous regulatory surveillance
7. In-built corrective actions and well-developed water safety plans

Each scheme uses a combination of these best practises tailored to their specific needs and jurisdictional requirements in the production of high quality reuse water and were found to be effective in preventing incidences of waterborne outbreaks and other ill health effects.

Regulations & Guidelines

Research found that the practises of each reuse system was governed by specific scheme permits developed from local, national, and in some instances international guidelines compiled through the collaborative efforts of multidisciplinary consultation with experts in the various fields of water production. These permits are comprehensive documents that stipulate the configurations of the reuse systems; conditions under which they should operate; specify the water quality monitoring parameters (what is analysed), schedule (how often they are analysed), and quality of the FPW; breach management protocols, and subsequent water safety plans. The stipulations of these permits were found to be stringent in their nature often taking a conservative approach with an equally rigorous regulatory monitoring framework that is deemed paramount in the protection of public health.

As an example, the NGWRP permit has been considered. Being the longest running potable reuse scheme in the world and the only one practising DPR at the time, their permit was based on a combination of Namibian, WHO, USEPA, and South African guidelines. The criteria in this agreement outline a very conservative approach in water production, which includes imposing hefty fines on the operator should water quality targets and operational standards not be met at the stipulated check points of the water purification process. The plant is regulated yearly by an independent international regulatory body which includes certification of scheme operations which include the skills of its operators.

Public Health Information

Investigating concerns of perceived ill health outcomes owing to potable reuse, the research initially set out to examine whether there was before and after data characterising the health of communities as well as any reports of increased waterborne disease outbreaks in jurisdictions implementing this resource. There was no evidence to suggest incidences of waterborne outbreaks in any of the potable reuse locations. The research also reviewed epidemiological and toxicological studies that have been conducted in these settings to capture acute and long term health implications. Although the range of epidemiological studies were mostly outdated, the findings of these studies concluded that the practise of potable reuse did not expose consumers to elevated health risks above what is found in traditional water supply. Moreover, assessments of the water quality data and in particular those parameters of public health concern showed that the prescribed targets were consistently met with the FPW being of high quality, which in most cases exceeded the quality of existing drinking water standards for traditional sources. Because of this, most jurisdictions did not see the need for follow-up epidemiological studies especially where improvements in water treatment and monitoring technologies have been applied.

Likewise, toxicological studies examining the biological effect of FPW quality on cell lines and whole organisms in parameters such as reproduction, carcinogenic effects, morphology changes and behavioural patterns found no evidence to suggest mutagenicity from reclaimed water use. Although types of studies have limitations in capturing a complete picture of human health effects, this research found no evidence to suggest an increase in public health risks whether acute or long-term owing to potable reuse practise. In fact, it is the confidence in high water quality production that has prompted some jurisdictions previously practising IPR to consider moving to a DPR option. This would see the purified water distributed directly to consumers rather than blended with surface water sources which in some jurisdictions is of poor quality to begin with. The efficacy of the NGWRP for example, demonstrates that passage through an environmental buffer prior to distribution is not always required provided adequate measures of public health protection are in place.

Public Health comment

The data collected through the course of the research was presented to a panel of four water and health professionals for comment on the appropriateness of the information to a wider public health audience. The feedback received from the panellists approved of the range of data collected by the research team and agreed that the analyses carried out would provide appropriate information for water and health professionals to comment on both the risks associated with potable recycling and the efficacy of the process barriers and preventative measures in mitigating these risks.

In conclusion, the research found that the practise of potable reuse is growing worldwide mainly to meet the water needs of communities with limited supplies. The availability and affordability of water treatment technologies has enabled the growth of this practice. However, safe implementation goes beyond the application of robust treatments and requires that communities have adequate critical infrastructure and use best industry practises aimed at protecting the health of consumers. Despite differences in capacities, operational, treatment, and regulatory configurations, and water delivery options, the review of seven case studies found that the practise is a viable alternative to augmenting potable supplies in water stressed locations.

Appendix A: Membership of advisory panel and external reviewers

The public health advisory group was established to provide guidance and feedback on progress in relation to the respective milestones. We asked the group to focus on providing feedback on the wiki representation of the work, and this was done via meetings (at about bimonthly frequency) and in addition through written response to emails. The group was chosen to strike a balance between general and specific health expertise and convenience (in terms of arranging meetings). The panel members were:

A/Prof Martyn Kirk (ANU – expert in epidemiology of food and waterborne infectious diseases)
Dr Paul Byleveld (NSW Ministry of Health – Water Unit Manager)
A/Prof Melissa Haswell (UNSW – expert in environmental and public health)
Prof Nicholas Buckley (Medical Toxicologist - Prince of Wales Hospital, Randwick NSW).

We also invited external reviewers to provide comment on the final draft of the public health wiki. The two reviewers who accepted the task were:

Dr David Cunliffe (SA Health – Water regulator); and
A/Prof Patrick Gurian (Drexel University, USA – Expert in environmental health and risk analysis of infrastructure systems).

Appendix B: Project Milestones

The original milestones underwent some revision during the course of the project, with the finalised versions presented below:

Milestone 1. - Build database

The project will develop a comprehensive water quality database using information provided by partner utilities in Australia, the United States and Singapore. The project will review the regulation, guidelines and standards that each scheme is working under and compared them to Australian water guidelines, showing the threshold parameters they are working under.

The data will be sourced from the various water utilities and authorities that are either operating advanced water treatment systems used in potable recycling schemes, or are operating potable recycling schemes. The database will be built by the School Public Health and Community Medicine under the direction of Dr. James Wood using techniques developed for the modelling of infectious diseases. Construction of the database and review of the data quality will be completed in the first six months of the first year of the project.

Milestone 2. - Collect demographic and health information

Assemble detailed case studies on the schemes-provided water quality data, which reflect the reasons for introducing potable reuse, summarises scheme infrastructure including operational processes, and public health engagement. This includes detailed descriptions of barriers employed, operational procedures and summaries of health promotion and education activities. This data is sourced from the schemes, reports from local authorities, government documents and the peer review process. Demographic information will be sourced from recent census data and government sources equivalent to the Australian Bureau of Statistics. Public health information will be sourced from health stream reports, public health records and the medical literature. Construction of the demographic database will be completed in 6 months commencing in the second quarter of year 1.

Milestone 3. - Identification of gaps in the regulatory framework

Compare and contrast the regulations and guidelines from different jurisdictions practicing potable recycling to identify specific areas, with reference to the Australian Water Recycling Guidelines. The data that will be analysed will include compliance monitoring as well as the role of preventative measures such as trade waste policy, environmental buffers and operational practices and audits such as HACCP. In addition, the project will summarise non-regulation approaches to assessing water quality, including the use of biomonitoring in potable reuse sites, findings from the epidemiological studies conducted during potable reuse introduction and a research study investigating factors underlying disease outbreaks in conventional drinking water systems in high resource countries. The gap analysis will run over three months in the third quarter of the project.

Milestone 4. - Critical review of current practices in water quality data collection and presentation

To advise on the current practices used to assess water quality and monitor public health impacts in potable recycling schemes and how these are reflected in the public health wiki. The objective is to identify if the data that is currently collected in potable recycling schemes provides appropriate information for public health professionals to comment on both the risks associated with potable recycling and the efficacy of the process barriers and preventative measures in mitigating these risks. The process will be coordinated by the School of Public Health and Community Medicine and advised by a committee involving representative from the National Water Regulators forum as well as public health professionals specialising in environmental health impacts. The panel will focus on translation and communication of public health information and water quality data in relation to public health. The critical review will be coordinated in the final quarter of the first year of the project.

Milestone 5. - Develop "public centric" program

The main objective of stream 1.1 is to help develop a monitoring and reporting programme that is specifically designed to communicate the performance of potable recycling schemes based on a public health perspective. The monitoring and reporting program will be developed with strong community consultation in stream 2 with the intent of identifying the parameters that are of most concern to the public. The key risk factors, mitigation measures and likely impact on public health for potable recycling scheme will be reported in a way that resonates with the public. This task will be delivered by working closely with the team delivering stream 2. Information on the concerns of both the health profession and general public will be collected and analysed. Possible reporting scenarios will be tested through activities planned for stream 2. This task will also draw on outcomes from stream 1.2 on bioassays and toxicology monitoring and stream 1.3 on operational reliability. The emphasis will be on identifying the parameters that are of most importance to the public health community and general public and ensuring that a monitoring scheme collects this data and presents the information in a form that the public understands.

The consultation with stream 2 will commence at the beginning of quarter 3 in year one and extend to the end of year 2 (total time 18 months).