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Barriers and Acceptability of Water Reuse

M. Kim Fries



Re-Fresh - The Confluence of Ideas and Opportunities on Water Reuse
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Agenda

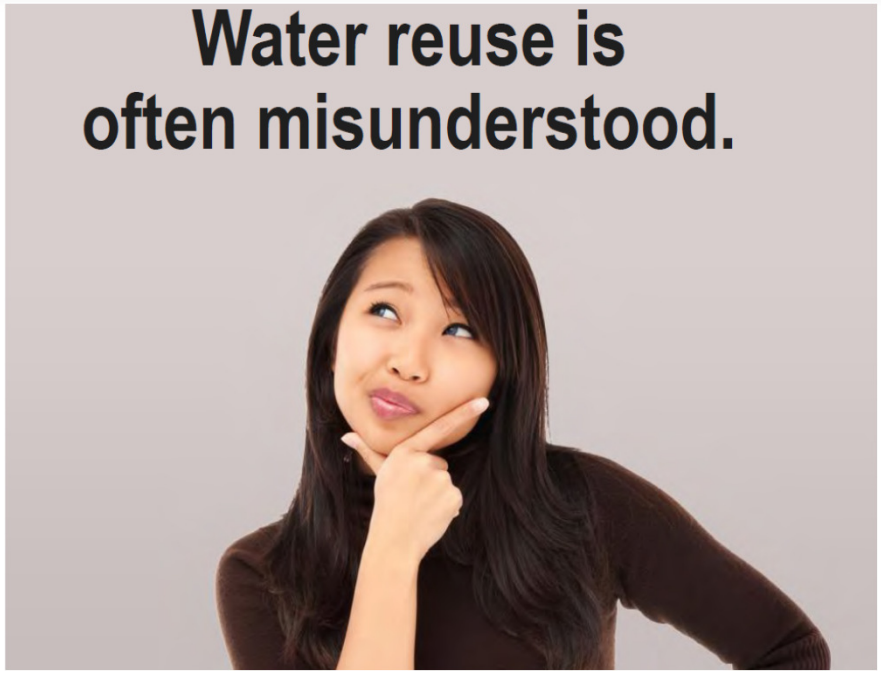
- Water reuse and its negative connotation
- Water reuse put into context
- How do we generate reusable water – the technology
- Economic realities of water reuse
- Public reaction to water reuse
- Regulatory constraints related to water reuse

Negative Context of Water Reuse

The negative connotations of water reuse

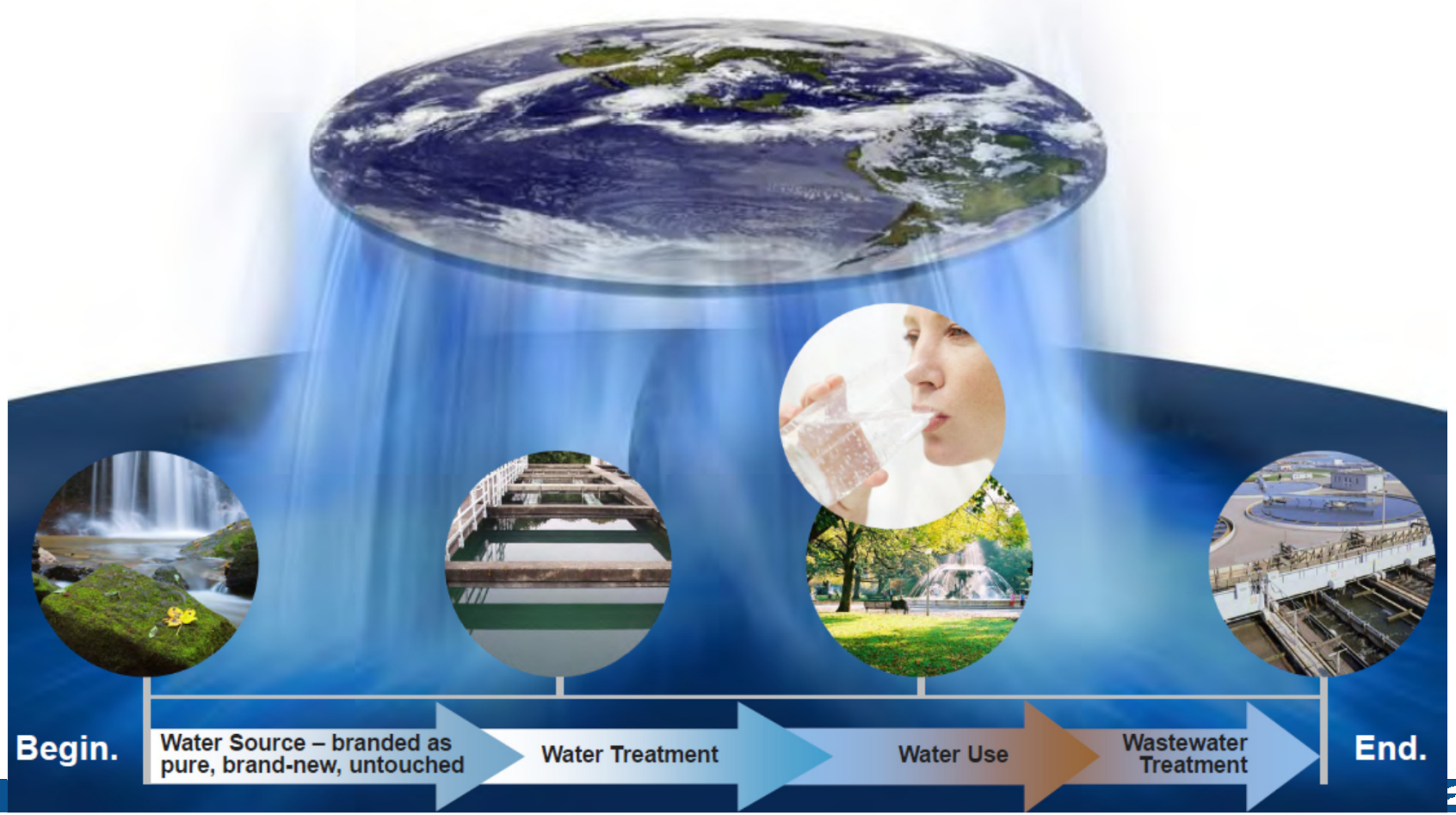
- A common perception is that reused water has just recently been used and presents hazards to the consumer
- “Stigmatized perceptions and negative associations limit our capacity to tap into these valuable resources” (MacPherson, 2013)

What is Water Reuse



What is water reuse

We think of the Water Cycle as linear as though the world is flat. Wastewater flows "away"…



But the reality is, there's an interconnected system that cycles and reuses water.

- We have the technology to treat wastewater to the point that its quality exceeds that of potable water – ask the astronauts

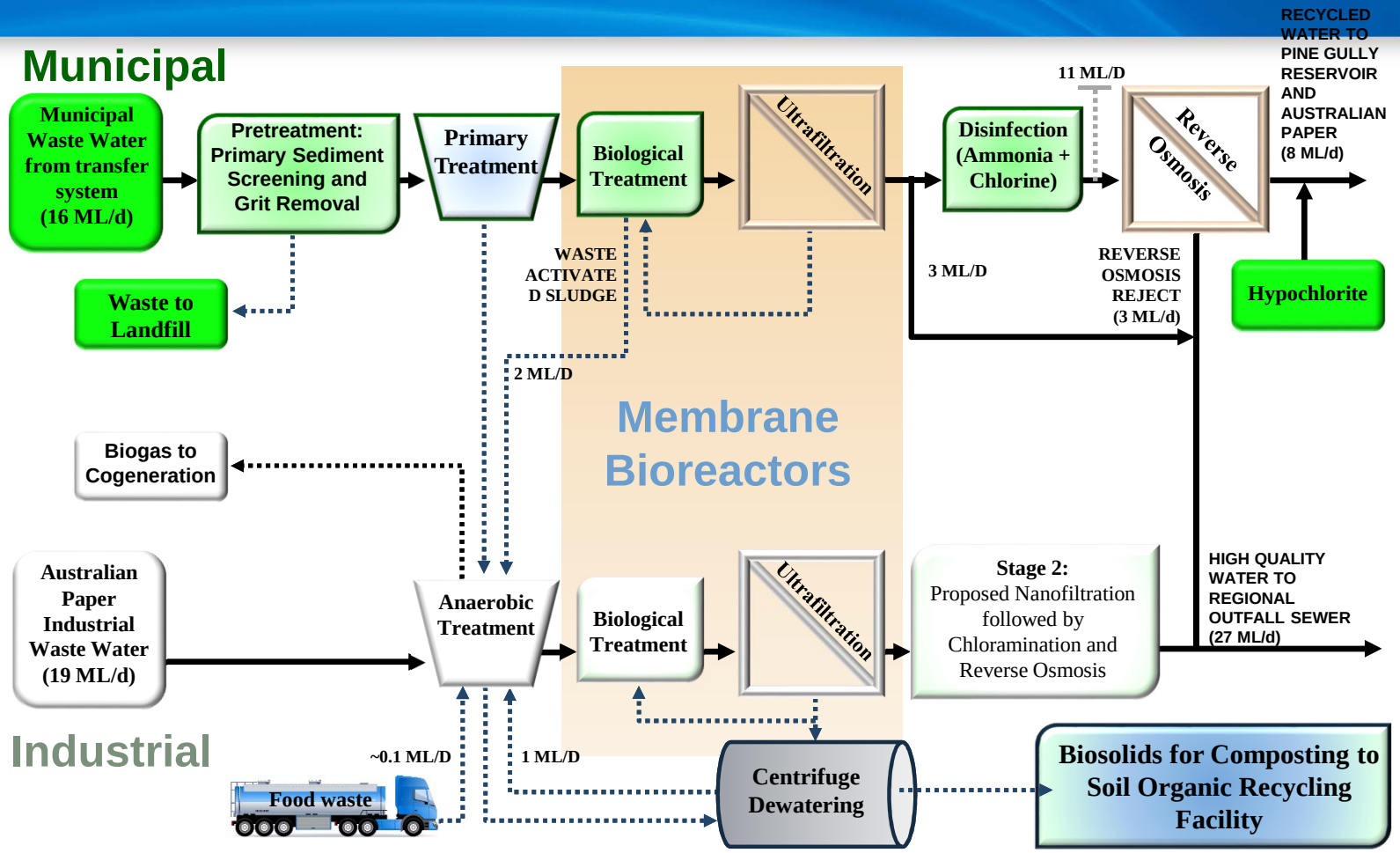
Buzz Aldrin walking on the moon – see any water bottle?

How technology is used to generate Reusable Water

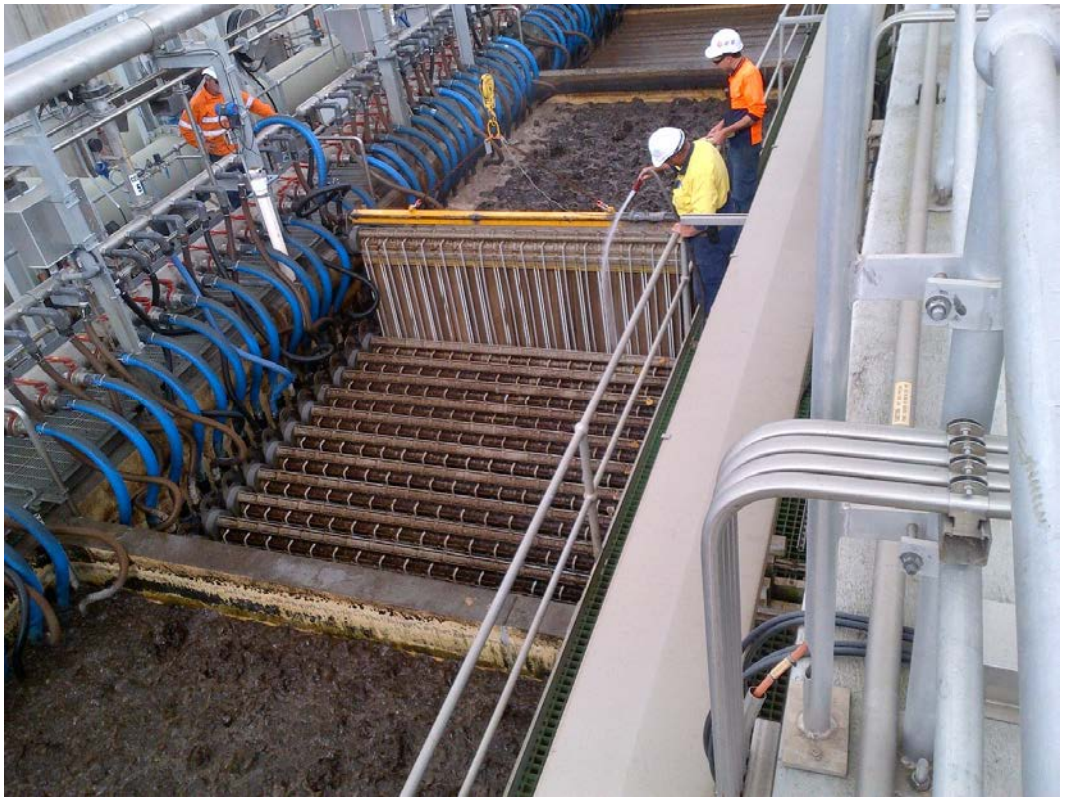
Gippsland Water Factory

- 15 ML/d of domestic wastewater
- Generate 8 to 10 ML/d of high quality water for reuse at a nearby paper mill for process water
- Also treats the high strength wastewater from the paper mill (20 ML/d)

Gippsland Water Factory Schematic



Gippsland Water Factory



MBR – Membrane Tanks

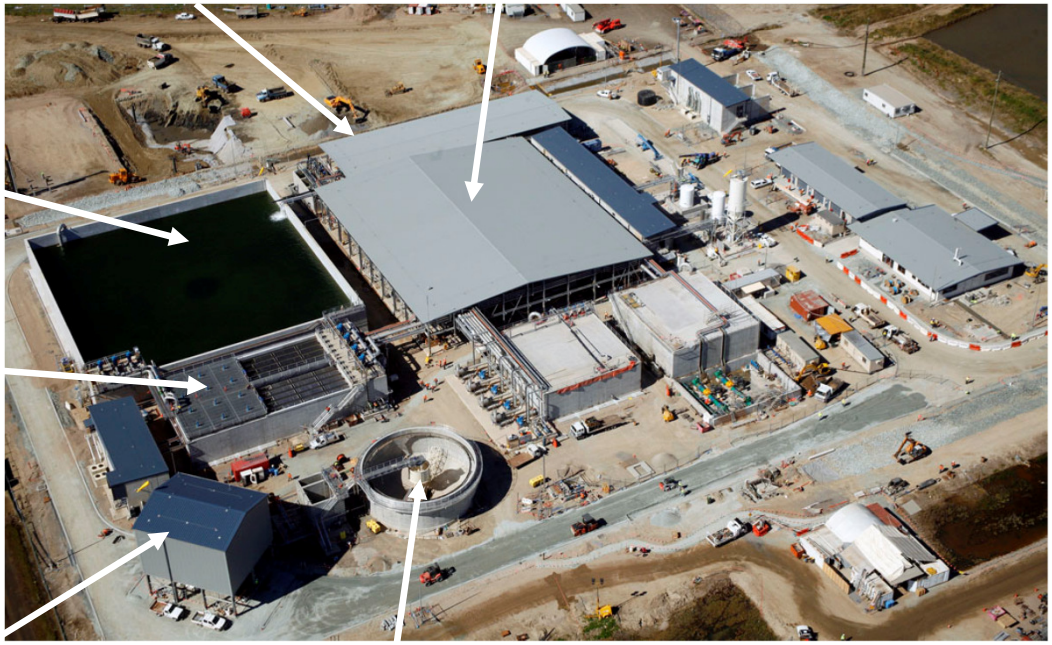
Reverse Osmosis

Western Corridor Recycled Water Project - Background

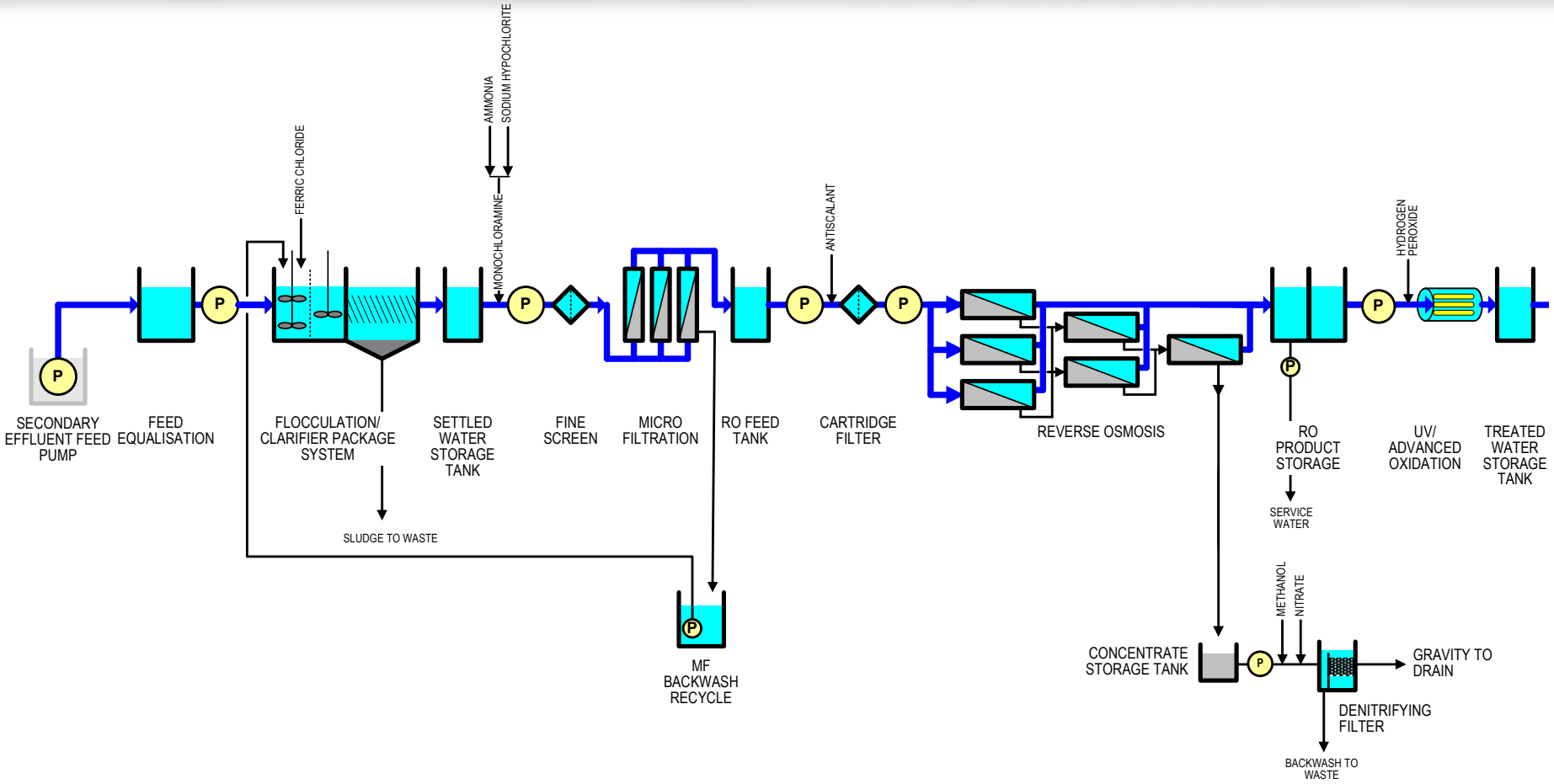
- Southeast Queensland had the worst drought on record from 2001 - 2008
- Water restrictions progressively enforced
- ‘Target 140’ campaign during extreme drought (140 L/c/d)
- Currently at ‘Target 170’ (170 L/c/d)
- Capital cost of program – $2.5 billion

Brisbane – Luggage Point

- Key component of Western Corridor project was Luggage Point project
- Sized to provide 70 ML/d for indirect potable water use
- Capital – $270M



Luggage Point Schematic



Key Design Criteria of Full-Scale Plant

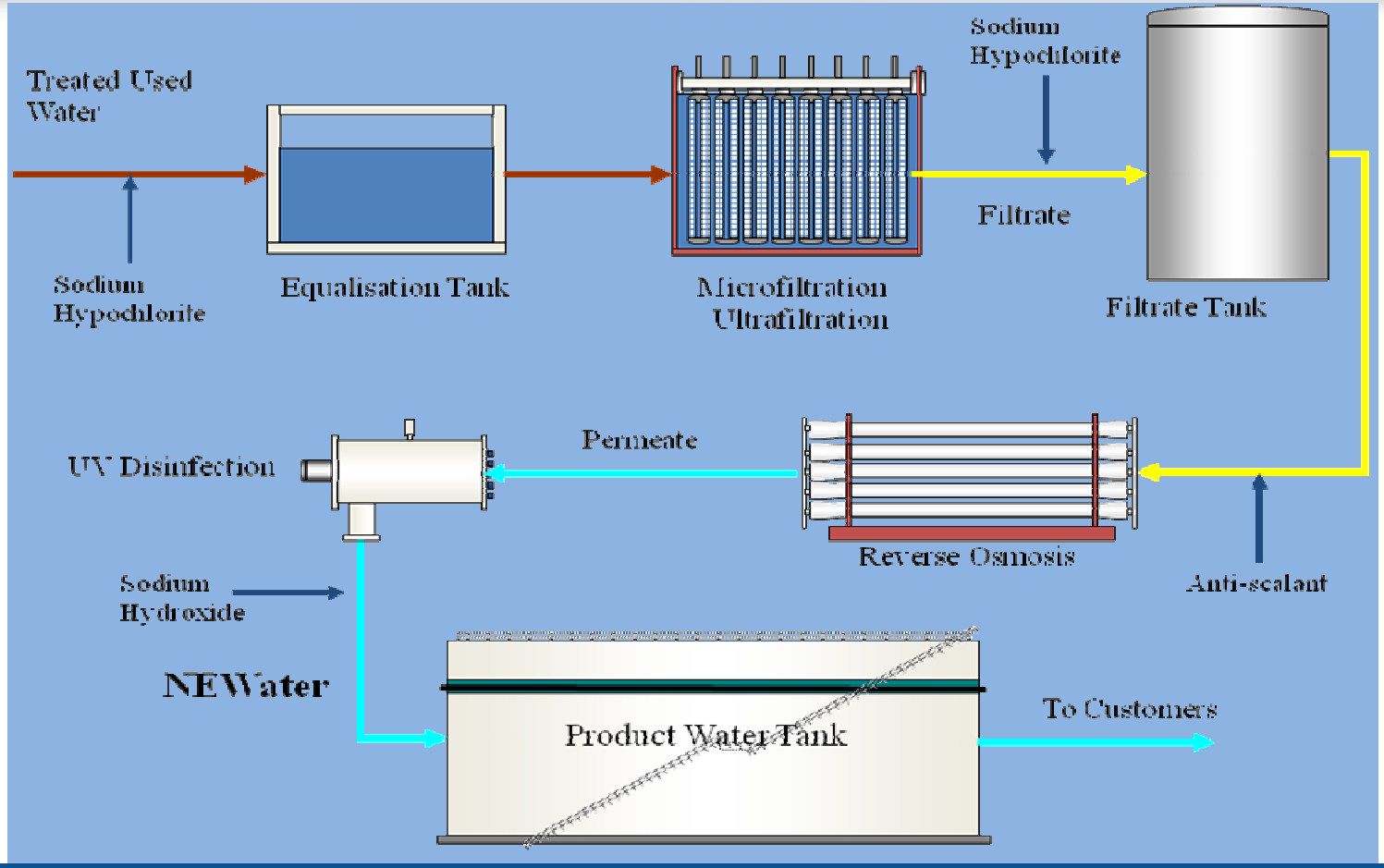
- Production capacity of 70 ML/d
- Provide multi-barrier treatment process
- Meet all water quality requirements
- Meet all Australian drinking water guidelines
  - Total Nitrogen < 1.2 mg/L as N
  - Total Phosphorus < 0.13 mg/L
  - NDMA < 10 ng/L

RO and Advanced Oxidation Modules

Singapore – Changi WRC/NEWater

- Due to the shortage of new supplies of potable water, Singapore decided to aggressively pursue water reuse to meet many of its demands.
- There are four NEWater plants, co-located with WWTPs throughout Singapore – Bedok, Kranji, Ulu Pandan, and Changi
- The Changi Water Recovery Centre (WRC) is the largest of the wastewater plants, with a capacity of about 800 ML/d.
- The initial stage of the Changi NEWater facility was 145 ML/d. Other NEWater facilities have a total capacity of about 390 ML/d
- The majority of the NEWater product is delivered to industry for their use. The product that is not used by industry discharges into the City's drinking water reservoirs (indirect potable use)

NEWater Treatment Schematic



Treatment Technologies

Ultra Filtration System at Kranji WRC

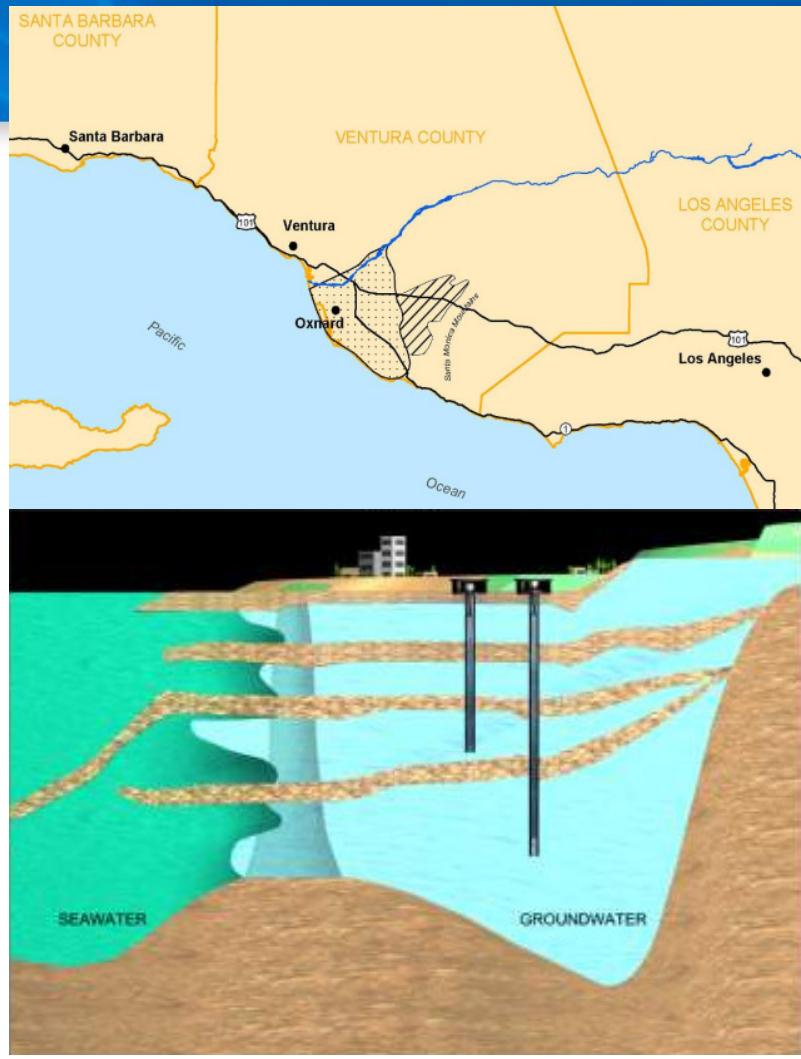
RO System at Kranji WRC

NEWater Visitor Centre

- To reinforce the positive message associated with the benefits of reused water, substantial amounts have been expended to build visitor centres at all of the plants

Advanced Water Purification Facility, Oxnard, California

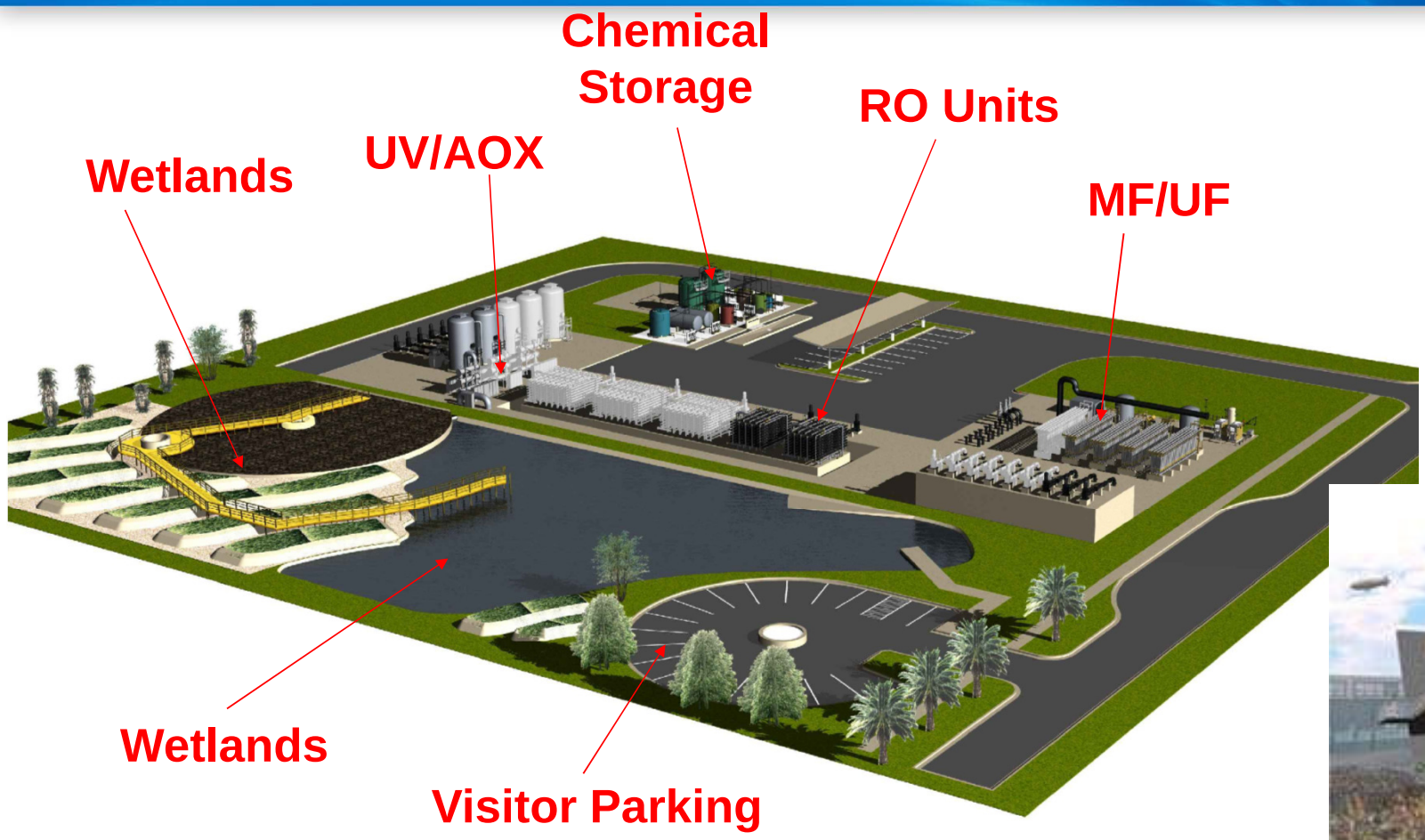
- Seawater intrusion into aquifer was progressively contaminating the drinking water supply of the City and the surrounding agricultural community that drew from the aquifer for irrigation supplies



California Groundwater Recharge Regulations

- Requires advanced treatment with RO and advanced oxidation (NDMA and 1,4 dioxane removal)
- Requires 1-year retention time in groundwater prior to withdrawal from drinking water well
- Maximum groundwater recharge contribution from recycled water is 50%; can be increased with low TOC treated water
- Control of nitrogen compounds (TN < 5 mg/L or 10 mg/L if monitoring DO)
- Compliance with MCLs for regulated drinking water chemicals
- Monitoring of Unregulated Compounds and Pharmaceutical and EDCs

Oxnard Water Purification Facility



- Ultimate Capacity – 95 ML/d

The Economics of Reused Water

Economic Context - Calgary

- In Calgary, retail water rates are approximately $1.70/m^3. Marginal water costs are likely $2.0 to $3 per m^3 (What does it cost for the next m^3/d capacity). Wastewater treatment costs are similar - $1.50/m^3. These rates are near the average for larger communities in Canada (***2011 Water Pricing Report***, Environment Canada, 2011)
- In the developed world, reused water treatment adds between $1 to $5 per m^3 to conventional wastewater treatment, depending on scale, end use (quality requirements), and local market conditions

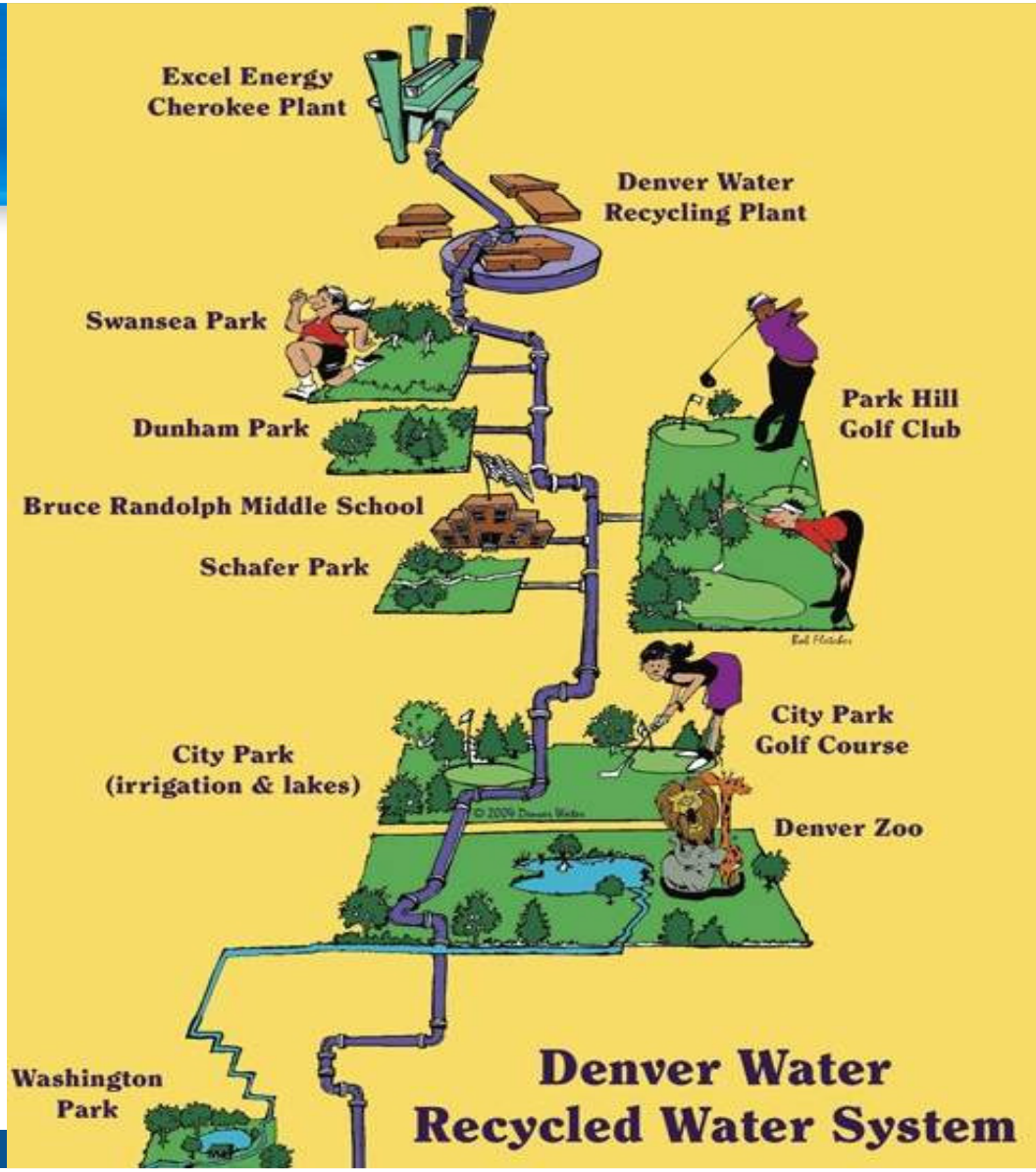
In Calgary, reuse does not appear economically justifiable, at least in the short term

Economic Context - Singapore

- In Singapore, the retail cost of water is similar to that of Calgary $1.2/m^3. However, the marginal cost is much higher because there are no readily available sources (much of their water is imported from Malaysia).
- For this reason, they are working toward self sufficiency by aggressively pursuing reused water. The NEWater facility treats about 200 ML/d of wastewater effluent from the Changi WRC (800 ML/d capacity) and returns it to the City for mostly non-potable use.
- Planning is proceeding to expand the Changi WRC to 2400 ML/d and the NEWater facility to as large as 1,800 ML/d
- Other wastewater treatment plants/reuse facilities are being planned to generate up to another 800 ML/d of reused water.

Economic Context - Denver

- In Denver, retail water rates are approximately \$1.5/m^3. New water sources are extremely difficult to source, so marginal water costs are likely \$3 to \$5 per m^3
- Because of the high marginal costs, Denver and its environs are aggressively pursuing reused water strategies, which at the present time aim to replace non-potable uses
- Since the reuse is non-potable, the supplemental treatment costs are lower. However, dual distribution systems (purple pipe systems) add to capital costs



The role of Public Education in Reused Water

Public Reaction to Reuse Strategies

The time has come to look squarely at
'the yuck factor' –
an irrational fear contributed to by the
absence of critically important context.

Role of Public Education

- Research of Macpherson and Slovic 2011 and Macpherson and Snyder, 2013 have shown that public education enhances the understanding of the water cycle, the appreciation of technology, and leads to accepting the safety of reused water when produced in accordance with appropriate regulations

Trust and Acceptance is Related

There are also studies which have shown that risk perception is lower when perceived knowledge is higher. Since risk and benefit are inversely related, it is critical to increase perceived knowledge of benefit.

- Dolnicar and Hurlimann, 2009,
- Lohman
- Marks 2008
- Nancarrow, 2009

Visitors Centers with transparent and imaginative water information have generated acceptance

- Singapore's NEWater Visitor Centre, Perth's Water Cycle Center, San Diego's PURE Water Demonstration Project and Orange County's Tour of Water Factory 21 and now the Groundwater Replenishment Program have all lead to successful project

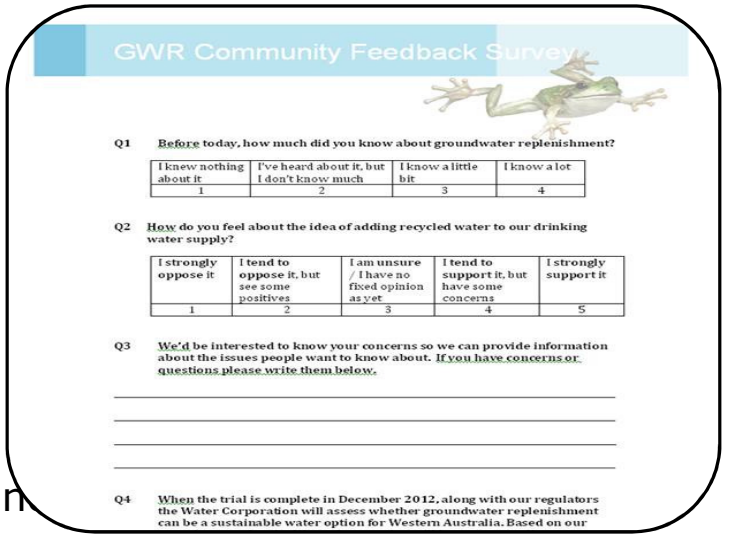
- Water education matters but, too frequently, is ignored or receives minimal investment

A survey from Water Corporation of Western Australia shows the effectiveness of visitor experiences as a means to create impact, understanding and change mental models.

Water Corp Tracked Community Attitudes

- Community attitudes have been tracked since 2007 through a variety of channels:

- Annual telephone surveys
- Focus groups
- Online pulse surveys
- Community event surveys
- Tour surveys



GWR Community Feedback Survey

Q1 Before today, how much did you know about groundwater replenishment?

I knew nothing about it	I've heard about it, but I don't know much	I know a little bit	I know a lot
1	2	3	4

Q2 How do you feel about the idea of adding recycled water to our drinking water supply?

I strongly oppose it	I tend to oppose it, but see some positives	I am unsure / I have no fixed opinion as yet	I tend to support it, but have some concerns	I strongly support it
1	2	3	4	5

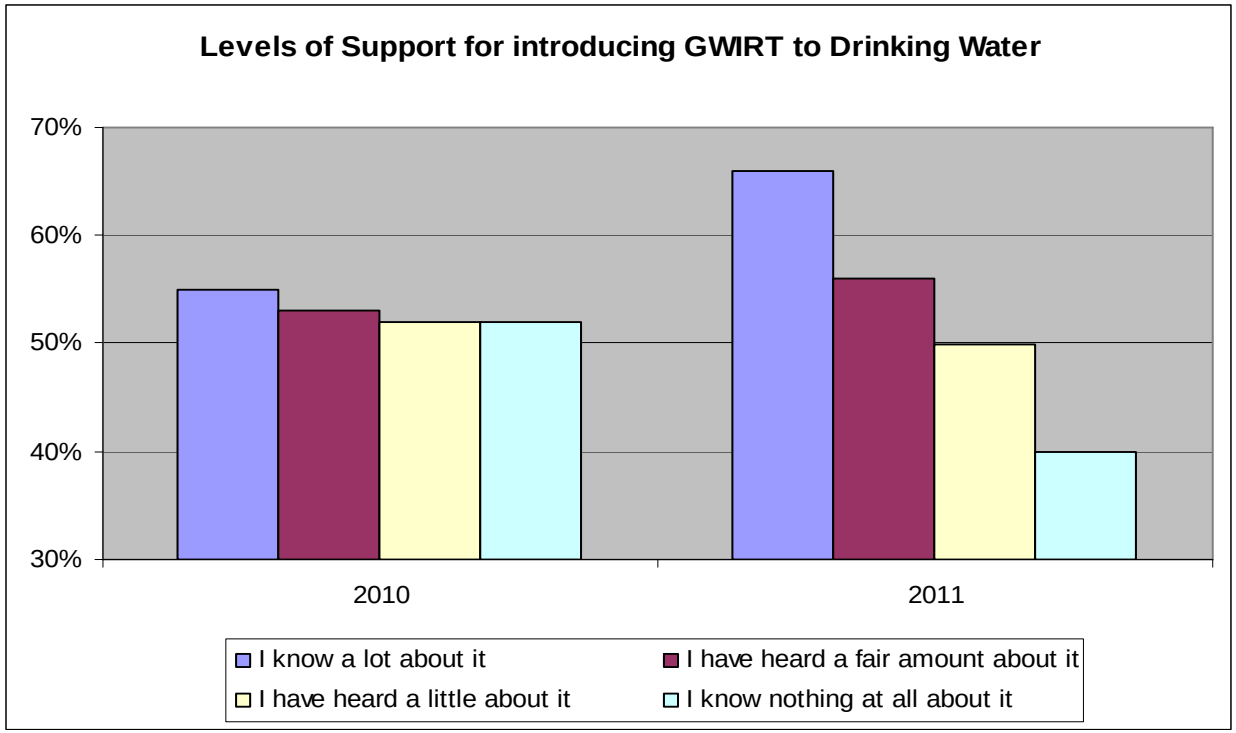
Q3 We'd be interested to know your concerns so we can provide information about the issues people want to know about. If you have concerns or questions please write them below.

Q4 When the trial is complete in December 2012, along with our regulators the Water Corporation will assess whether groundwater replenishment can be a sustainable water option for Western Australia. Based on our

- Community support has been maintained at around 70% sin

The correlation between awareness and support is strong

High awareness = strong support



"Thorough information gives me confidence"

Community support increased by 23% After a Tour and Opposition Decreased by 5%

Pre Tour
Support for Ground Water Replenishment 71% Opposition for Ground Water Replenishment 7.4%

Post Tour
Support for Ground Water Replenishment 93% Opposition for Ground Water Replenishment < 2%

(Tour survey conducted by Water Corporation, results collated by Synovate Research)

NEWater Visitor Centre, acclaimed around the world, becomes a tourist destination

In the first year (2003) the Visitor Centre receives over 100,000 visitors

A decade later the number of visits exceeded 1.3 million

In 2014 Singapore won the UN Water for Life Best Award for Education and Engaging the Public about water reuse

Singapore is now looking to a future where 50% of their water needs will be meet by NEWater – a testament that education makes a difference

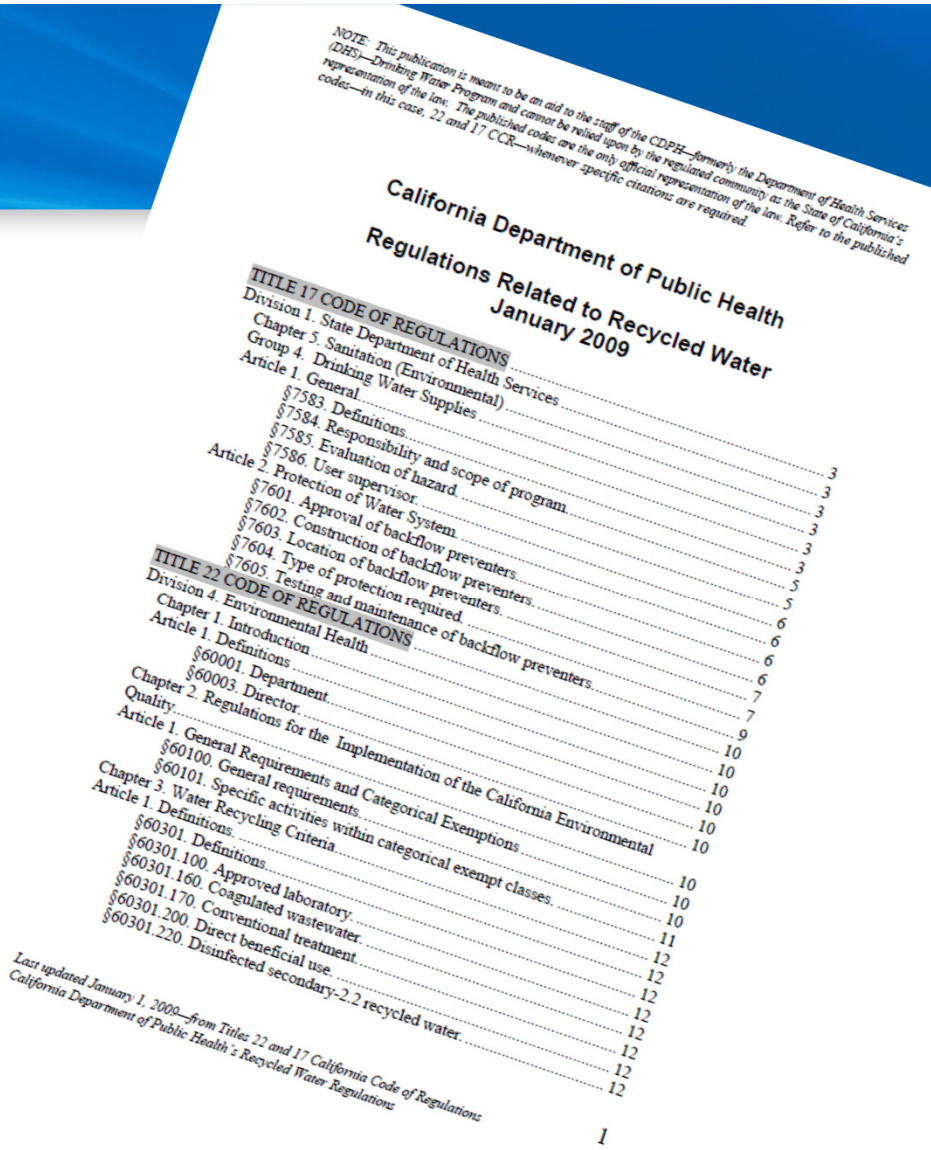
Regulatory requirements associated with Reused Water

Regulatory Considerations

- Regulations are put in place to protect public health.
- These regulations establish minimum levels of performance for treatment or set maximum concentration of certain constituents or both.
- Consumption of reused water produced in compliance with these regulations will not expose the consumer to an unacceptable risk
- Regulations do not form a barrier to reused water. Rather, scientifically based regulations that are believed by the community as being reliable and enforceable actually improves the acceptance of reused water.

California's Title 22 – The Original

- The Title 22 Regulations Related to Recycled Water were originally published in 1986 and have been updated and modified numerous times since.
- The regulations establish water quality standards applicable to different types of water reuse varying from irrigation to industrial use to aquifer recharge
- The regulations also set out methods that allow for certification of certain processes proven to be able to meet the quality requirements



NOTE: This publication is meant to be an aid to the staff of the CDPH—formerly the Department of Health Services (DHS)—Drinking Water Program and cannot be relied upon by the regulated community as the State of California's representation of the law. The published codes are the only official representation of the law. Refer to the published codes—in this case, 22 and 17 CCR—whenever specific citations are required.

California Department of Public Health

Regulations Related to Recycled Water

January 2009

Last updated January 1, 2009—from Titles 22 and 17 California Code of Regulations
California Department of Public Health's Recycled Water Regulations

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Reused Water Regulations in Alberta

- The Alberta Wastewater and Storm Drainage Regulation provides for site-specific approvals for reuse for irrigation on agricultural lands and other large facilities such as golf courses.
- Alberta has determined that there are risks associated with reused water in other applications. No regulations or codes are currently in place to mitigate these risks, which would ensure that reclaimed wastewater is safely used for non-irrigation applications. The Reclaimed Water Working Group has been established to develop appropriate regulations, and water quality and technical standards or guidelines to facilitate the safe use of reclaimed wastewater in Alberta.

Summary

- Reused water suffers from misconceptions based on a misunderstanding of the environment and technology
- Technology is available that can generate water suitable for almost any type of water reuse
- Public understanding of reused water is often jaundiced by misinformation, but can be moderated by well informed educational programs and public outreach
- Regulations are developed to protect public health and in doing so, reassure the public that the product is suitable for consumption.
- In Alberta, water reuse regulations are only in place for limited irrigation uses. However, updates to the regulations are expected in the future to provide for broader reuse.

Discussion/Questions