DELIVERING RECYCLED WATER TO SE QUEENSLAND

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Abstract

In 2008, the Queensland Government completed the delivery of the Western Corridor Recycled Water Project to bring high-quality recycled water to industry and to supplement drinking water supplies for the region. At a cost of some $2.5B, this includes three advanced water treatment plants and over 200km of large-diameter pipelines with the capacity to deliver up to 232ML/day of recycled water to the region. This paper considers key achievements and issues affecting the delivery of the project, which was completed in 2008, including project delivery strategies and challenges; issues associated with recycled water use (particularly for drinking water) and public perception of water recycling for drinking water use; energy consumption and the overall sustainability of large-scale water recycling projects relative to other solutions like desalination and new dams.

Key Words: indirect potable reuse, advanced treatment, water recycling

Introduction

South East Queensland (SEQ), Australia, is experiencing significant population growth, with a projected increase of 1.2 million residents to a total of 4.0 million by 2026. Combined with industry growth, this is leading to significant increases in demand for water.

Assessments of yield from existing major sources are also declining as service standards are reconsidered and the impacts of the current drought and potential for long-term climate change are taken into account. As a result, there is a shortfall in overall supply availability in the next ten years and there has been a more acute short-term requirement to address security of supply in recent drought conditions – the worst in over 100 years of record.

The Queensland Government responded with a major capital works program to secure the future water supply for the region. This includes the 125ML/day Tugun Desalination Plant on the Gold Coast and the 232ML/day Western Corridor Recycled Water Project (WCRWP). Part of the strategy is to augment surface water supplies in the major storage, Wivenhoe Dam, with purified recycled water from the WCRWP.

The Project

The $2.5 billion Western Corridor Recycled Water Project (WCRWP) extends over about 160km around Brisbane, as shown in Figure 1. Secondary treated wastewater is collected from six wastewater treatment plants and further treated at three advanced water treatment (AWT) plants incorporating micro-filtration, reverse osmosis, advanced oxidation and residual disinfection. The initial treatment capacity will be 232ML/day. The project includes approximately 200km of large-diameter pipelines and pump stations to transfer the treated water from the AWT plants to end users and Wivenhoe Dam.

In February 2007, the Queensland Government committed to an indirect potable reuse (IPR) scheme using the purified recycled water produced by the AWT plants. Up to that time, the project had been progressing on the basis that it should neither include nor preclude the use of the water for IPR. The February 2007 decision committed to IPR supply by December 2008.

Subsequently, the Queensland Government has determined that purified recycled water will not be added to Wivenhoe Dam for IPR purposes unless the storage levels in the region drop below 40%. As at June 2009, the storages are at nearly 75% and it is unlikely that water will be added to Wivenhoe Dam until at least 2011, and probably longer.

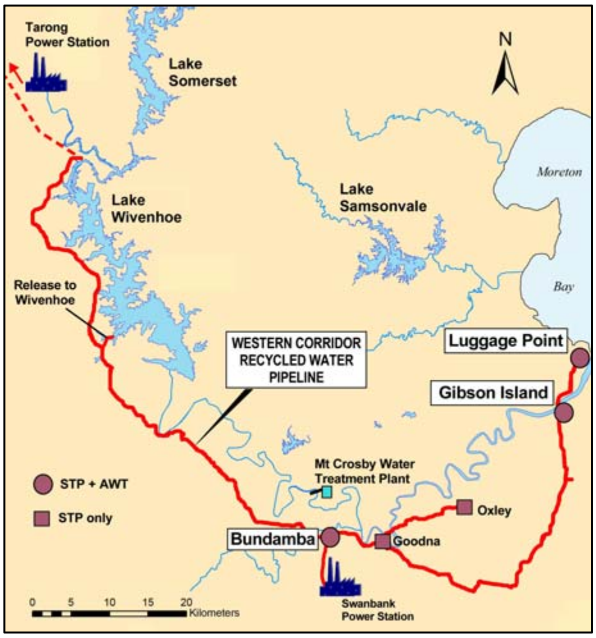

Figure 1: Location of Project *(Source: WaterSecure)*

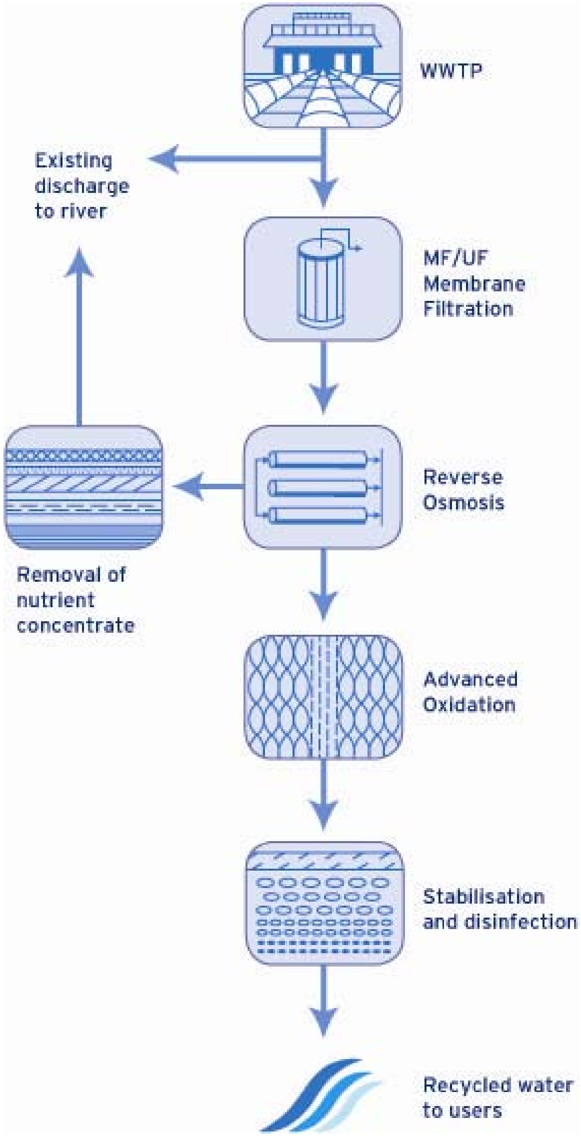

Figure 2: Treatment Process *(Source: WaterSecure)*

Treatment Process

The water treatment strategy is shown in Figure 2. Key constraints that have been taken into account in the development of the strategy include:

- Treatment must deliver water that is suitable for indirect potable reuse.
- As far as possible, salts should be removed and managed at their source.
- Water quality in the Brisbane River and Moreton Bay should be improved if possible.
- The treatment process is to be considered as part of the overall management of the water cycle.

The water received into the AWT plants is secondary treated wastewater from existing wastewater treatment plants. All of the plants are activated sludge plants using a biological nutrient removal (BNR) process. Some of the plants are designed for both nitrogen and phosphorus removal, while others target nitrogen removal only. They have relatively long sludge ages (around 20 days) which contributes to contaminant removal before the water is received at the AWT plant

Immediately prior to the major treatment steps, the secondary treated wastewater goes through a coagulation process using ferric chloride. The primary purposes of the coagulation are to remove phosphates from the feed water and to reduce the solids load. Phosphates tend to cause membrane fouling. Coagulation also has a significant benefit in reducing total phosphorus and contributes significantly to the environmental benefits achieved by the project.

The water is then taken through a membrane filtration process. This comprises microfiltration (MF) and reverse osmosis (RO).

MF has become the accepted pre-treatment process for reclaimed water. MF also provides a microbial barrier, and has been shown to provide around 4-log removal of the protozoans cryptosporidium and giardia. It is the first of three “barriers” in the treatment process.

The next barrier is the RO membrane which removes dissolved solutes including nutrients, inorganic salts, organic molecules as well as viruses. The nominal pore size (0.0001-0.001µm range) is one to two orders of magnitude smaller than virus particles.

For the WCRWP, salt removal was a key objective. The salinity of the water arriving at the major water wastewater treatment plants is towards the limit of what can be used for irrigation, and the water is too saline for use in many industrial cooling applications, including power stations. RO was therefore an essential process for both industrial reuse and indirect potable reuse.

The third barrier is advanced oxidation. Some advanced water treatment processes use only ultraviolet (UV) radiation at this point for disinfection, but to provide assurance in the removal of low molecular weight organic chemicals such as NDMA, advanced oxidation has been used in more recent plants. Advanced oxidation variously includes UV radiation, hydrogen peroxide and ozone. In the case of the WCRWP, hydrogen peroxide and UV radiation are used.

The final step in the process is stabilisation and residual disinfection. Stabilisation using lime brings the alkalinity and hardness of the water to a stable point; water from RO plants is otherwise aggressive. Carbon dioxide is used for pH correction.

Residual disinfection is achieved using sodium hypochlorite. This is an important step in ensuring that the water meets the Australian Drinking Water Guidelines (ADWG) and the Australian Guidelines for Water Recycling Phase 2 (AGWR2), but residual chlorine is not necessarily sought by, or desirable for, end users.

Validation and Assurance

The production of purified recycled water is subject to regulation under regulations introduced by the Queensland Government in May 2008. Notably, this requires the preparation of a Recycled Water Management Plan and a Validation Plan. The validation plan is necessary if the water is to be used for drinking supply.

There has been significant effort from many parties to develop the relevant plans. This work has been led by Queensland’s Department of Infrastructure and Planning and considers each step in the water recycling process, starting with wastewater catchment management.

Validation of the AWT plants involves the successful operation of each treatment facility for a period of 90 days. During this time, it must be demonstrated that (a) the AWT plants produce water that complies with ADWG and AGWR2 and (b) effective monitoring is in place at each of the critical control points.

There are five key critical control points in the AWT process. These steps are:

- feed water compliance;
- MF integrity;
- RO integrity;
- Advanced oxidation performance; and
- Residual disinfection.

Continuous monitoring is used at each location to verify performance. Each barrier is only relied upon to the extent that their performance can be continuously verified.

The Queensland Water Commission has recently reported publicly on the performance of the treatment processes at the first AWT plant, Bundamba. Performance is overseen by an independent Expert Panel established by the Queensland Government. The report provides details of the treated water performance of the AWT plant, and commentary from the Expert Panel is also provided.

In essence, the report shows that the water quality objectives – compliance with ADWG and AGWR2 – are consistently achieved. There have been a few minor departures from the guidelines and these are described and explained in the report. All of the departures are a result of post-treatment of the RO water, and relate to physical or chemical properties of the water.

Recycled Water for Industry

Recycled water has been supplied for power station use since August 2007. The first water was sent to the Swanbank Power Station south of Ipswich. Since that time, more than 10,000ML of water has been supplied for power station cooling at a typical supply rate of 20ML/day.

The second stage of the project, Stage 1B, commenced delivery to the two power stations at Tarong in June 2008, via the existing pumping system that runs between Caboonbah (at the northern end of Wivenhoe Dam) and Tarong. Typically, 40ML/day is being supplied to Tarong.

In both cases the project has removed the power stations from reliance on South East Queensland's drinking water supplies for cooling water.

It is worth remembering that water that meets the guideline values set out in ADWG or AGWR2 is not necessarily suitable for industrial application. This is particularly relevant for cooling circuits at industrial plants such as power stations, where metal concentrations need to be significantly lower than would otherwise be acceptable under the guidelines.

Indirect Potable Reuse

Indirect potable reuse is planned to be achieved via release to Wivenhoe Dam, the largest of South East Queensland's water supply dams. The location of the release is Logan's Inlet, which is about a third of the distance from the dam wall to the Caboonbah intake for Tarong Power Station.

Release will be achieved via a sub-surface up-flow manifold, under gravity from the balance storage some 7km south at Lowood. The challenges of releasing water into a dam should not be underestimated. Numerous configurations were considered before the final arrangement was adopted.

Key considerations include:

- the circulation time in the dam before the water is released to the Brisbane River and from there to the water treatment plants;
- mixing in the dam, including propensity of the water to sink or float across the surface;
- the impact of purified recycled water on dam water quality.

At first glance, the introduction of purified recycled water to the dam would not appear to be an issue. However, there are two key matters for consideration.

The first is that the water must have zero or a very low concentration of chlorine. This is inconsistent with the treatment objectives set out earlier in this paper, and de-chlorination is therefore necessary prior to release. Residual chlorine has the potential to affect local biota, and the potential to create chlorination by-products when released into the natural, organic-rich lake water.

The second matter is that the water, despite the high levels of treatment, is still potentially relatively high in nitrogen and phosphorus compared to the natural waters. To help avoid potential algal blooms, key elements of the treatment process – particularly RO membrane selection – are designed around nitrogen removal. The purified recycled water typically has a nitrogen concentration of around 1mg/L. On the other hand phosphorus is removed to limits of normal measurement by the treatment process. Significant proportions of the phosphorus are removed in coagulation, and phosphorus is also very effectively removed by RO membranes.

Public Acceptance

The introduction of purified recycled water into the drinking water supply has been a matter of great public interest. There is still a significant stigma attached to the deliberate re-use of water for drinking purposes, despite a significant lack of scientific evidence to support such a position.

Many of those reading this paper would be aware of circumstances where treated wastewaters are discharged into rivers and streams upstream of water treatment plant intakes. There is any number of examples across Australia and overseas, some very prominent, yet the concept of deliberately adding highly-treated water to our supplies is still stigmatised. All of the evidence to date from the WCRWP supports the proposition that the use of purified recycled water to supplement drinking water supplies is extremely safe and low-risk.

Much misinformation is in circulation regarding the imagined impacts of recycled water on drinking supplies. Without exception, the horror stories have been shown to be either false or not comparable with the processes that have been put in place in South East Queensland.

Public acceptance of purified recycled water to supplement drinking water supplies in South East Queensland has generally been good, despite the outcome of the referendum in Toowoomba in mid-2006. There is sufficient public mistrust, however, that the opinions expressed by a relatively small proportion of the population continues to influence government policy, leading to decisions to delay the introduction of purified recycled water to the drinking water supply until supply levels drop below 40%.

Energy Use and Sustainability

In considering alternatives to “conventional” surface or ground water, energy consumption in the production of the water is an increasingly important consideration. Recycled water uses around 1kWh/kL to process, compared to about 4kWh/kL for seawater desalination and around 0.2-0.3kWh/kL for conventional sources. Recycled water also has a conveyance energy cost, because the water needs to be taken back to the supply dam. This can be contrasted with desalination where the water can be sent directly to the distribution system. Nonetheless, water recycled through the WCRWP uses about half the energy of desalination.

It is worth comparing these figures to the energy consumption arising from pumps connected to domestic rainwater tanks. It is not widely recognised that these pumps are remarkably inefficient, and the energy cost per kilolitre is generally higher than for water recycling.

Project Delivery

The WCRWP is an enormous project that has been delivered from start to finish in just over two-and-a-half years. The concept was finalised in June 2006, and the project was substantially complete by the end of 2008. During construction, average expenditure was nearly $100 million per month.

Delivery dates for the project were enshrined in legislation. Queensland’s *Water Act* defined the dates for completion of the project, reflecting the urgency associated with the project and the determination of the Queensland Government to combat the drought that was then gripping South East Queensland.

Construction targets were achieved by splitting the project into five project alliances. These comprised three treatment plant alliances and two transfer system alliances. These were complemented by the early engagement of the Scheme Operator, who has been on board since the early months of design and construction.

The individual alliances were further separated into parts. At last count, there were some 15 target completion dates, each with associated milestones and handover processes.

The alliances have proven to be an effective way of delivering a very large project in a defined timeframe.

Some aspects of the project delivery were centralised to minimise project risks and reduce timeframes. These included:

- pipe supply, where the Queensland Government established a "pipe procurement centre" to manage the delivery of pipes and fittings to numerous pipeline projects across the region;
- environmental approvals, which were centralised to streamline application processes and also to initiate key approvals prior to establishment of the alliances to avoid project delays; and
- land acquisition and access, which needed to be controlled centrally because of the Government's role in the process, including compulsory acquisition where this was necessary.

Conclusion

The Western Corridor Recycled Water Project has been a major achievement, as a project in itself and as a landmark in water recycling in Australia. It is a project that has generated a great deal of international interest and it is fair to say that it is a flagship of the Australian water industry.

The project uses state-of-the-art treatment and monitoring technologies to ensure that the product water meets the stringent guidelines for water quality and process performance.

Although the Queensland Government has decided to defer the introduction of purified recycled water to the drinking water supply until dam storage levels drop below 40%, extensive monitoring and testing since August 2007 has shown that purified recycled water is a safe source of water to supplement our drinking water.

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Author Biography

Warren Traves has recently been appointed as GHD's Global Leader, Water. He has been working in the water industry in Australia and internationally for 20 years. He has been involved in a wide range of water supply, sewerage and recycling projects predominantly for state and local government across the State of Queensland.

Recent roles include Project Manager for Stage 1 of the South East Queensland (SEQ) Regional Water Supply Strategy, Interim Project Manager for the SEQ Regional Drought Strategy and Design Manager for the BMP Alliance on the Gold Coast.

For three years, Warren was Concept Design Manager and later Engineering Manager for the $2.5B Western Corridor Recycled Water Project (WCRWP), working as a member of the Project Management Group.

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