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MORE THAN SEWAGE TREATMENT SERVICES

Adding value to the Maleny Community

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ABSTRACT

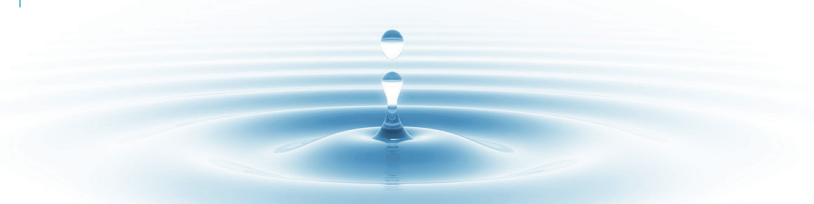
The Maleny community is well known for being passionate about social, environmental and local business values within the region. Unitywater – a water retailer-distributor authority in South-East Queensland is mindful of community interests, population growth, tourism, environmentally sensitive areas, water security zones and water supply sources to the region. Unitywater engaged in partnership with the local community, Sunshine Coast Regional Council (SCRC), state regulators, indigenous people and contractors in developing an innovative infrastructure solution to provide sewage treatment services to the community. Comprising a modern immersed membrane bioreactor (IMBR) treatment technology, and a natural purification process of irrigated forest and treatment wetland. This case study outlines the achievements over the last three years, and highlights the challenges Unitywater continues to face. This study also explores how Unitywater, working with the local community, has added broader value in delivering sewage treatment services to the residents of Maleny.

Keywords: Community participation/engagement, membrane bioreactor, irrigated forest and treatment wetland

INTRODUCTION

Maleny is a scenic town, located in the hinterland of the Sunshine Coast. In 2010, Unitywater inherited a sewage treatment plant (STP) from the then Sunshine Coast Regional Council (SCRC), which provided sewage treatment services to the 2,000 Equivalent Persons (EP), community living in Maleny township. Located on Landsborough-Maleny Road, the STP is comprised of an extended aeration system followed by chlorination and a single balancing lagoon, and was operating beyond its hydraulic and biological capacity. Treated effluent was spray irrigated onto a small Kikuyu (*Pennisetum clandestinum*) pasture grass block (cut and carry system) near the STP when the soil was dry enough to allow infiltration, otherwise it was discharged under an environmental licence to Obi Obi Creek. This was a sensitive issue for the community, due to the presence of recreational sites downstream such as Gardners Falls and Baroon Pocket Dam – a major tourist attraction and an important water supply reservoir for the Sunshine Coast region, respectively.

The Maleny community is well known for being passionate about social, environmental and local business values within their region, as evidenced by widespread community resistance to the establishment of a Woolworths supermarket on the banks of the Obi Obi Creek in the early 2000s. Realising people power can have significant impact on decision-making processes during infrastructure development,



Unitywater engaged early into partnership with the local community, SCRC, state regulators, bush care groups, indigenous people and contractors in developing an innovative sustainable solution for sewage treatment services for the Maleny community. In 2014, Unitywater constructed an immersed membrane bioreactor (IMBR) STP and undertook reforestation of 13.8 ha on a nearby old dairy farm (part of the Maleny Community Precinct, MCP) to create a rainforest community for disposal of treated effluent. The irrigated forest linked to an engineered wetland, with an all up-capital cost (IMBR + irrigated forest+ treatment wetland) of $17 million.

Approximately 39 ML in 2015 and 62 ML in 2016 of treated effluent was supplied to the Maleny Golf Club to keep its tees and greens healthy. The remaining effluent was irrigated throughout the 13.8 ha of irrigated forest. Excess groundwater percolates through 3.0 ha of treatment wetland to produce a low-nutrient 'naturalised water', and discharges through a narrow and short tributary into Obi Obi Creek - an important upland waterway in the hinterland.

The Maleny Golf Club, irrigated forest and treatment wetland are located in the Maleny Community Precinct (MCP). The local community has a keen interest in the development of the precinct. Given the "need" for the irrigated forest and treatment wetland, the additional benefits created through the project included community recreation and increased biodiversity in the precinct. To help foster community ownership of the sewerage infrastructure development, Unitywater spent considerable effort in stakeholder engagement and community activities in the precinct. This case study outlines achievements over the last three years and highlights the challenges still facing Unitywater. The study also explores how a water utility, working with various stakeholders can add broader-value to the social, economic and environmental aspects of its service area.

MATERIALS AND METHODS

Maleny Community Precinct (MCP) Development

Defined by the Obi Obi Creek and Blackall Range, the MCP master plan sets out to develop 126 ha of SCRC land. The irrigated forest and treatment wetland site is located within the northern portion of the precinct (Figure 1). Staged development within the MCP is managed by the SCRC and its development is overseen by the MCP Advisory Group. The MCP includes sub-precincts comprising:-

- An 18-hole community standard golf course (currently open with 12 holes) with temporary club house;
- Three to four full size sports fields (under construction) and a multi-purpose amenity building;
- Pedestrian network access, cycle trails and walking trails to signposted Gardners Falls;
- Environmental protection areas; and
- Parklands and a landcare nursery.

In 2012, Unitywater negotiated the long-term lease of 30 ha of farm land from SCRC, which provided the foundations to develop an irrigated forest and treatment wetland site for land application of effluent within the precinct. The irrigated forest and treatment wetland, in combination with other facilities in the precinct, is set to become a centrepiece of biodiversity improvements for the whole community to enjoy. This was made possible due to keen participation shown by the local community and vested stakeholders in a supportive geographic location like Maleny. After all, an example is better than just the concept.

Figure 1: Aerial view of the 126 ha Maleny Community Precinct showing the irrigated forest and treatment wetland (top left) and the upgraded STP at bottom right (inset). The Maleny Golf Club is also shown.

IMBR Construction

Unitywater constructed an immersed membrane bioreactor (IMBR) process based STP (5,000 EP capacity) under a 'Design and Construct (D&C) Contract'. The upgraded STP is now capable of treating ~1ML/d of sewage to meet the expected population growth in next 30–35 years in the Maleny township.

Irrigated forest establishment

The site for the irrigated forest and treatment wetland was previously a dairy farm with a monoculture of Kikuyu grass (*Pennisetum clandestinum*). Reforestation was undertaken by planting native species, which were considered to be the best option for restoration and to create a healthy and diverse rainforest ecosystem. Thus far, Unitywater has established over 80,000 plants spanning 140 different types, grown on a contour-based pattern. Mixed forest planting included Moreton Bay Chestnut or Blackbean (*Castospermum australe*), Pepperberry (*Crytopcarya obovate*), Moreton Bay Fig (*Ficus macrophylla*), Lilly Pilly (*Syzygium smithii*), Giant Water Gum (*Syzygium francisii*), Plum Pine or Illawarra Plum (*Podocarpus elatus*), Bangalow Palm (*Archontophoenix cunninghamiana*) and many others.

Treatment wetland (Northern Wetland) establishment

The treatment wetland site consists of a free water surface system having three cells with individual rock diffuser inlets beneath boardwalks and vertical riser outlets. The wetland is located at a low point of the gully along spring fed tributaries of Obi Obi Creek, and absorbs residual nutrients and traps sediment from the high-quality effluent.

Over one hundred thousand emergent macrophytes were planted within the wetland due to their high nutrient bioaccumulation rates, including the Grey Rush (*Lepironia articulata*), Twig Rush (*Baumea articulata*), Soft Twig Rush (*Baumea rubiginosa*), and Lakeshore Bul Rush (*Schoenoplectus*), which has resulted in a dense coverage of 80% of the wetland water surface.

RESULTS

Effluent concentrations and compliance

Table 1 shows the sample results of the treated effluent following membrane treatment. Comparing the results with the licence conditions show 100% full compliance, with nil odour issues. The STP is operated remotely and demonstrates a 'stable performance' under a range of dynamic conditions during its period of operation (*Kulkarni, 2017*).

Table 1: Quality of treated effluent exported from the IMBR plant over 3 years of operation. Release limits to Obi Obi Creek are also shown.

Parameter	Release limits	2014	2015	2016
5-day BOD, mg/L	20*	4.5	<3.0	NA
Suspended solids, mg/L	10*	4.0	5.0	4.0
Turbidity, NTU	*<0.2***$$ *<0.5****$$	(UF1/UF2) 0.03/0.13 0.1/0.2	(UF1/UF2) 0.03/0.11 0.1/0.2	(UF1/UF2) 0.03/0.03 0.04/0.04
Total Nitrogen, mg/L	5**	3.3	2.5	1.8
Total Phosphorus, mg/L	1**	0.1	0.4	0.4
Escherichia coli[(a)], [1] CFU per 100mL	<100**	<1	<1	<1
Intestinal enterococci[#], [1] CFU per 100mL	40** 150****	<1 230	<1 <1	<1 45

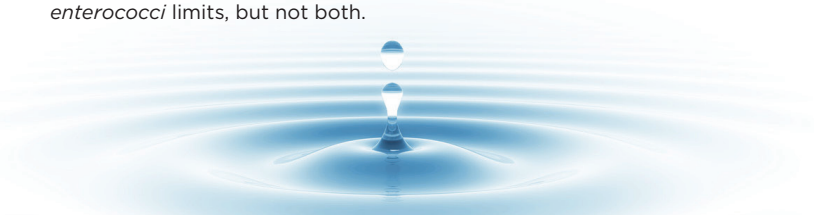
* 80th%ile; **50th%ile; ***95th%ile; ****Maximum.

UF1/UF2 refer to Ultrafiltration membrane trains 1 and 2

[$$] *data in italics refers to suppliers guarantees*

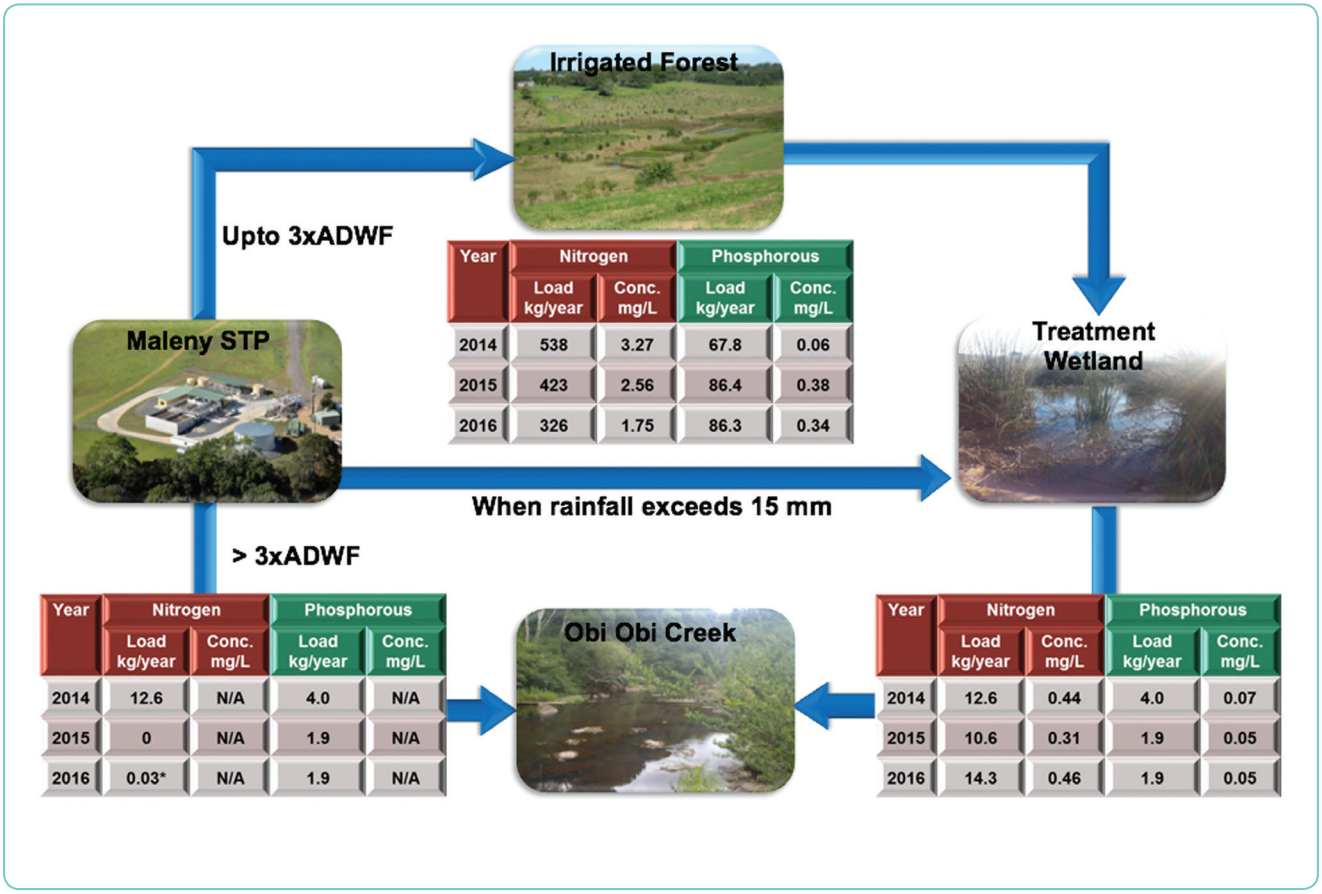
[#] Preferred faecal indicator bacteria for assessing recreational water quality determined in accordance to AS/NZS 4276.9:2007.

[1] The licence requires compliance with *E.coli* or *Intestinal enterococci* limits, but not both.



Nutrient loads

Figure 2 shows a mass balance schematic of the effluent composition and nutrient load as it exits the IMBR STP and outflows from the treatment wetland to Obi Obi Creek. The 0.5 ML of effluent produced each day is preferentially applied daily to the irrigated forest using under tree pop up sprinklers. Deep drainage from the irrigated forest is intercepted by the wetland cells. If daily rain exceeds 15 mm, treated effluent is discharged directly to the treatment wetland to avoid innundating the forest and to prevent harming the tree planting. In some situations during wet-weather event (> 3xADWF), screened effluent is discharged directly into Obi Obi Creek. Apprroximately 300 to 500 kg/yr of total nitrogen exiting the IMBR STP is reduced through natural treatment to about 10 kg/yr before it enters Obi Obi Creek, a reduction of > 95%. Similarly, the total phosphorus load exiting the IMBR STP reduces from around 85 kg/yr to <2 kg/yr entering the Obi Obi Creek, a reduction of around 98%. The nutrient load directly discharged into the Obi Obi Creek from the IMBR STP is minor. Based on these results, the irrigated forest and treatment wetland is very effective in removing nutrients from the treated effluent, which commences its natural treatment at tertiary treatment standards (*i.e.*, TN < 3mg/L and TP < 0.4 mg/L). By way of comparison, the estimated load to the Obi Obi Creek before the STP upgrade and establishment of the irrigated forest and treatment weland, was 380 kg/yr of total nitrogen and 115 kg/yr of total phosphorous. Clearly the operation of the new treatment system has made a substantial reduction in the nutrient loads of Obi Obi Creek, and as such, might be expected to be reflected in an improvement in the condition of the creek ecosystem.



Year	Nitrogen		Phosphorous	
	Load kg/year	Conc. mg/L	Load kg/year	Conc. mg/L
2014	538	3.27	67.8	0.06
2015	423	2.56	86.4	0.38
2016	326	1.75	86.3	0.34

Year	Nitrogen		Phosphorous	
	Load kg/year	Conc. mg/L	Load kg/year	Conc. mg/L
2014	12.6	N/A	4.0	N/A
2015	0	N/A	1.9	N/A
2016	0.03*	N/A	1.9	N/A

Year	Nitrogen		Phosphorous	
	Load kg/year	Conc. mg/L	Load kg/year	Conc. mg/L
2014	12.6	0.44	4.0	0.07
2015	10.6	0.31	1.9	0.05
2016	14.3	0.46	1.9	0.05

Figure 2: Annual mass load and average concentrations of nitrogen and phosphorus as treated effluent exits the STP and the irrigated forest/ treatment wetland system. Three years of data is shown.

Water quality monitoring

Water quality monitoring has been conducted at three sites to identify any changes in the creek under the Obi Obi Creek Monitoring Program. The monitoring includes two periods: Pre-upgrade from 2010 to 2013 and post-upgrade from 2014 to 2016. Table 2 provides the results of the water quality parameters measured and its statistical analysis with an indication of change in the data using Students' t-test. This determines if results from pre- and post-upgrade are significantly different from each other.

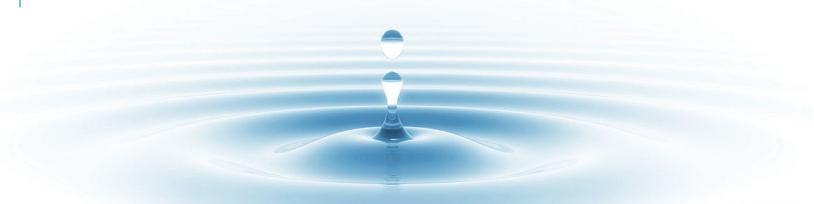
Table 2: Water quality parameter concentrations (Mean ± SD) including Student t-test (ρ-value) during pre- and post-upgrade monitoring period.

Monitoring sites → / Parameter ↓	No. of samples		Maleny township (3 km upstream of outfall)			20 m upstream of outfall			200 m downstream of outfall		
	Pre-upgrade	Post-upgrade	Pre-upgrade Mean ± SD	Post-upgrade Mean ± SD	T-Test (ρ-value)	Pre-upgrade Mean ± SD	Post-upgrade Mean ± SD	T-Test (ρ-value)	Pre-upgrade Mean ± SD	Post-upgrade Mean ± SD	T-Test (ρ-value)
E.coli, CFU/100 mL	75	78	569 ± 1,673	384 ± 522	0.361	574 ± 1,125	507 ± 1,031	0.701	600 ± 1,331	377 ± 604	0.189
Thermo-tolerant Coliforms, CFU/100 mL	75	78	1,151 ± 3,685	487 ± 611	0.128	1,019 ± 3,274	623 ± 1,311	0.332	1,019 ± 3,975	284 ± 829	0.257
pH	76	78	7.4 ± 0.4	7.0 ± 0.15	9.10E-14	7.4 ± 0.3	7.1 ± 0.18	1.30E-10	7.4 ± 0.3	7.1 ± 1.5	9.90E-09
Conductivity, µg/cm³	76	78	100 ± 58	101 ± 12	0.824	88 ± 20	102 ± 14	1.10E-06	99 ± 51	103 ± 15	0.54
Total Dissolved Salts, mg/L	76	78	58 ± 34	68 ± 7.9	0.01	51 ± 11.7	69 ± 9.6	3.50E-19	57 ± 29	69 ± 9.9	0.001
Turbidity, NTU	75	78	6.5 ± 17	3.5 ± 1.6	0.135	5.7 ± 9.6	3.5 ± 1.2	0.046	5.7 ± 9.6	3.1 ± 1.2	0.02
Ammonia, mg/L	75	78	0.04 ± 0.13	0.01 ± 0.01	0.146	0.02 ± 0.05	0.01 ± 0.01	0.219	0.04 ± 0.08	0.01 ± 0.01	0.009
Nitrate & Nitrite, mg/L	75	78	0.3 ± 0.23	0.13 ± 0.16	5.70E-07	0.26 ± 0.19	0.12 ± 0.13	3.90E-07	0.28 ± 0.18	0.13 ± 0.13	3.90E-08
Phospate, mg/L	74	78	0.02 ± 0.06	0.005 ± 0.0	0.133	0.01 ± 0.01	0.005 ± 0.0	0.033	0.015 ± 0.03	0.005 ± 0.0	0.009
Total Nitrogen, mg/L	75	78	0.6 ± 0.37	0.38 ± 0.13	5.70E-06	0.53 ± 0.19	0.37 ± 0.11	2.70E-09	0.59 ± 0.27	0.37 ± 0.11	1.80E-09
Total Phosphorus, mg/L	75	78	0.05 ± 0.08	0.03 ± 0.01	0.025	0.04 ± 0.03	0.04 ± 0.04	0.378	0.06 ± 0.05	0.04 ± 0.04	0.005

Note:

1. Statistically significant decrease between pre- and post-upgrade values represented in 'green' cells
2. Statistically significant increase between pre- and post-upgrade values represented in 'white' and 'grey' cells

Based on Table 2, it can be inferred that the results at downstream of the outfall showed a statistically significant decrease especially in the concentration of ammonia and total phosphorus including other forms of nitrogen (ρ<0.01), indicating a water quality improvement in Obi Obi Creek. The data also shows a significant decrease of total dissolved salts (ρ<0.01) and pH (ρ<0.01). A significant increase (ρ>0.01) for other water quality parameters such as microbiological and conductivity could be as-a-result of broader activities in the catchment. Changes in the diffuse inputs from the catchment play a key role in influencing a reduction in the nutrient concentrations over time, both upstream and downstream of the creek. While there has been a dramatic reduction in the nutrient loads released due to irrigated forest and treatment wetland, the decline in the receiving environment cannot solely be attributable to the new sewage treatment and new effluent disposal system. In summary, significant reductions in the nutrients concentrations have occurred at all sites within the Obi Obi Creek Monitoring Program, with exception being concentrations of ammonia and total phosphorous.



Treatment wetland and Obi Obi Creek ecosystem health

Constructed wetlands provides a variety of social and environmental values and goods and services, including: processing nutrients (a service that is important for this project), decreasing sedimentation, flood mitigation, storing carbon, providing links to food webs, and habitats for a diverse community of aquatic organisms (Costanza *et al.*, 1997; Chen et al., 2009; Horwitz and Finlayson, 2011; Mitsch *et al.*, 2015).

A four-year biodiversity study in collaboration with the University of The Sunshine Coast (USC) is currently underway (Walker et al., 2016, 2017 & 2018) to assess changes in the aquatic biodiversity in and surrounding the treatment wetland site and comparing it with nearby reference sites (farm dams) on private property within a 5 km radius including in Obi Obi Creek (Figure 3), which is conducted biannually.

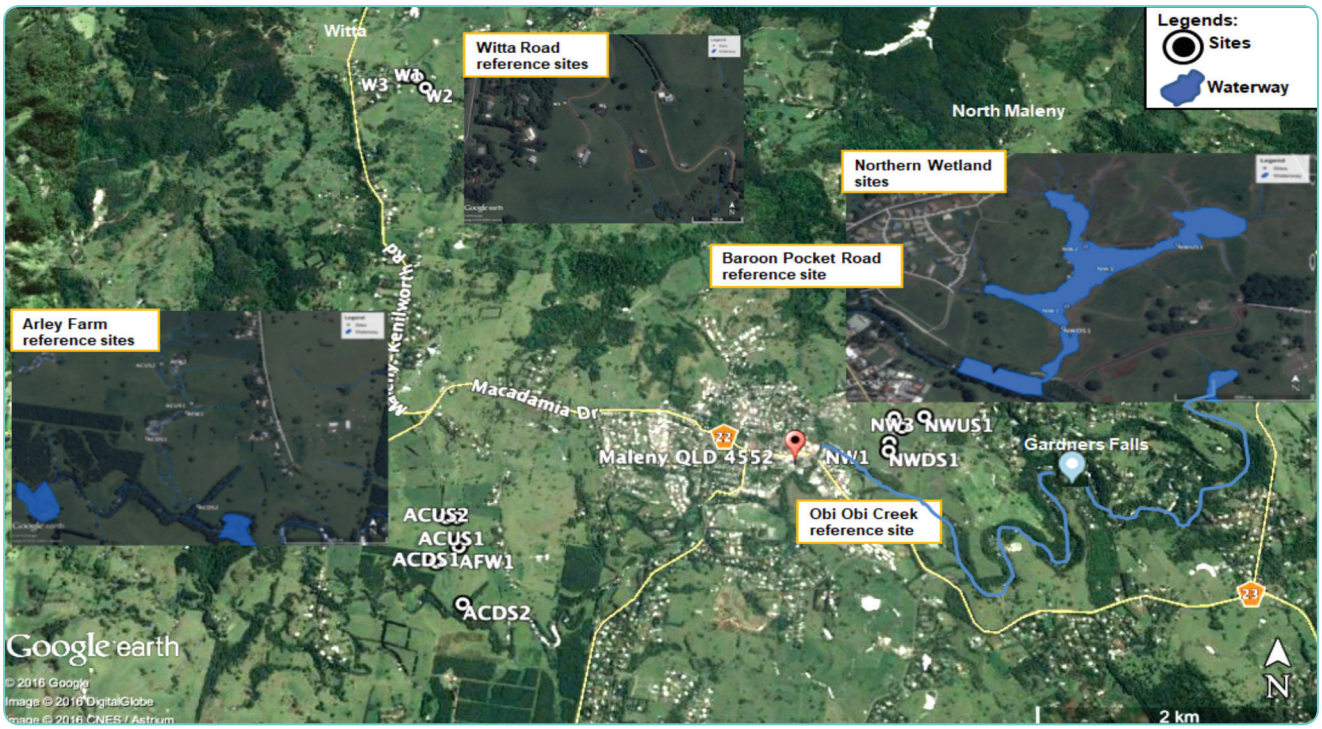


Figure 3: Location of Northern Wetland and reference sites of Witta Rd, Arley Farm, Baroon Pocket Rd and Obi Obi Creek

Currently, the irrigated forest and treatment wetland site provides habitat for a variety of native fauna including water birds, small mammals and marsupials, aquatic macroinvertebrates and amphibians. The presence and condition of the various aquatic habitats was assessed using standard methods adapted from the Wetland Assessment Techniques Manual for Australian Wetland and Australian River Assessment System (AusRivas) (DNRM, 2001; Parsons *et al.*, 2004; Price *et al.*, 2008). The treatment wetland (Northern Wetland) currently has a habitat condition rating of 'moderate' and a conservation value rating of 'low to moderate' relative to the reference sites based on the combination of factors assessed and presence of animals and plants including those of state and federal conservation significance (Table 3). The habitat condition rating compares favourably with the nearby reference sites, particularly with sites containing farm dams (Witta Rd) that are poorly connected and provide habitat for a low diversity of aquatic species. It is a substantial improvement from the wet paddock, with sediment clogged spring fed tributaries present within the precinct prior to restoration works. The rating is expected to improve as the site matures.

Table 3: Aquatic habitat characteristics

Location	Water Quality	Connectivity Index [a] (%)	Human Disturbance Index [b] (%)	AusRivas Bioassessment Score	Overall Habitat Condition	Conservation Value
Treatment Wetland (Northern Wetland: NW)						
NW site 1	Moderate	21	30	46	Moderate	Low–Moderate
NW site 2	Moderate	18	30	46	Moderate	Low–Moderate
NW site 3	Good	18	20	45	Moderate	Low–Moderate
Reference Sites						
NW upstream site 1	Good	21	40	52	Moderate	Low–Moderate
NW upstream site 2	Good	21	40	48	Moderate	Low–Moderate
NW upstream site 3	–	21	40	–	Moderate	Low–Moderate
Arley Farm wetland 1	Good	43	50	85	Good	High
Arley Farm wetland 2	Good	43	50	65	Moderate–Good	Moderate
Witta Rd site 1	Moderate	29	20	44	Poor–Moderate	Low
Witta Rd site 2	Moderate	32	20	36	Poor	Low
Baroon Pocket Rd Dam 1	Moderate	21	20	50	Moderate	Moderate
Obi Obi Creek	Good		60	100	Good	High

Note:

[a] 0% = nil or very low connectivity with aquatic ecosystems and 100% = completely connected.

[b] 0% = very high human induced disturbance and 100% = nil or or very low disturbance.

Biodiversity improvements – Flora and Fauna

The planted vegetation has adapted well to the local site conditions, as evidenced by the increase in plant canopy cover in the irrigated forest from 2015 to 2017 (Figure 4a1 compared with 4a2 and Figure 4b1 compared with 4b2). There have been some emerging weeds observed such as Prickly smartweed (*Persicaria strigosa*) and some wetland plants have been reduced by the impact of swamp hens nesting in the sedge clumps. The smartweed is a problem for many waterways in the area, quickly encroaching on the channel. It is currently being managed on the site using targeted herbicide spraying.

Twenty-three native birds have been observed at the site. Three amphibian species have been observed, the Striped Marsh Frog (*Limnodynastes peronii*), the Eastern Sedge Frog (*Litoria fallax*) and the Wallum Froglet (*Crinia tinnula*).

Fish assemblages in the catchment typically have low diversity (Pusey *et al.*, 2004). At this stage, native freshwater fish are under-represented in the treatment wetland with assemblages dominated by introduced Eastern Gambusia (*Gambusia holbrooki*). The native fish - Empire Gudgeon (*Hypseleotris compressa*), Firetail Gudgeon (*Hypseleotris galii*) and Purple Spotted Gudgeon (*Mogurnda adspersa*) have been caught downstream of the treatment wetland site. These and other native fish dominate within the reference sites which have higher habitat diversity and conservation values (*i.e.* Arley Farm Wetlands and Obi Obi Creek). Obi Obi Creek has a diverse fish assemblage (10 species). Native fish diversity may improve where overland flow and fish passage is improved; however, this must be balanced with the treatment performance of the wetland, which is of primary concern and benefits higher value aquatic habitats downstream. Feral species have also been recorded including Red Foxes (*Vulpes vulpes*), Brown Hares (*Lepus europaeus*) and Black Rats (*Rattus rattus*).

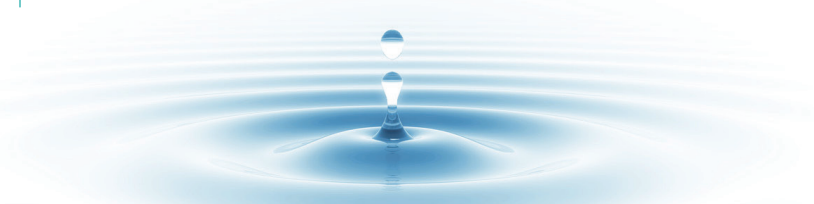


Figure 4: Images showing plant/tree canopy improvement at the irrigated forest and treatment wetland sites.

a1) January 2010 (pre-upgrade)

a2) July 2017 (post-upgrade)

b1) 2015 – Irrigated forest site

b2) 2017 – Irrigated forest site

Stakeholder's participation and community engagement

Sustainability values are deeply rooted in stakeholders' participation and community engagement. The key to successful delivery lies in managing stakeholder communication from inception to completion, and on-going operation. Unitywater's first step was to develop a Stakeholder Management Plan (SMP) incorporating local community groups and referral agencies that have vested interests in the project. The key elements in the SMP included:

- Identification of key stakeholders.
- Consultation with environmental regulators, SCRC, SEQ Water, MCP Advisory Group, and Maleny District Sport & Recreation Club Inc. to gain development approval and where possible mitigate their issues/ concerns when they arise.
- Working closely with the Jinibara People to ensure the heritage of the land and its traditional owners was respected.
- Development of key messages and presenting project vision at 2012 and 2013 Maleny Agricultural Shows and at the Maleny RSL in 2012 (Figure 5).
- Establishing an appropriate community engagement and communication plan for public consultation about future water challenges.
- News articles published in *Maleny Range News* in 2011 and *Suncoast Daily* in 2013.
- Partnership with local community groups, including:
  - Maleny Green Hills Environment Group
  - Maleny Golf Club

Figure 5: Maleny locals Dr Max Whitten and Dr Penny Edwards discuss the proposed sewage treatment plant upgrade and effluent irrigation scheme with Andrew Mills (Project Manager) of Unitywater and Rob McKenzie at the 2012 Maleny Agricultural Show.

- Friends of Pattemore House (Maleny Historical Society)
- Barung Landcare
- Lake Baroon Catchment Group

Under the Caloundra City Plan, 2014, the development application required public notification due to the impact of the project site being in a rural zone. As a result of community consultation, there was only one notification received from a local environmental group that favoured the proposed development.

An engageing site

Unitywater has held several tree planting day events with the local communities and conducted educational tours to promote interest in the 'green engineering' solution. Some key promotional events organised to-date include:

› March 2013, Unitywater staff joined Jinibara elder – Uncle Kenny Murphy in celebrating the collaborative approach by planting the last native wetland plants in the MCP in conjunction with the World Water Day (Figure 6a).

› World Environment Day – June 2013, nearly 2,500 native seedlings were planted by local community members, bush-care volunteers including school children from Maleny River School under the Maleny Creekside Greening Event. This initiative gave the local public an opportunity to take some ownership of the community asset (Figure 6b).

› September 2013, under the SCRC's initiative 'Kids in Action Program' (Figure 6c) another 350 students became involved in a hands-on learning exercise focusing on waterway health, sustainability and protecting the environment within the precinct. It was considered important to engage the students to build a healthy landscape, given the local community was passionate about preserving and securing the natural values of the region. The students explored the precinct and showed a keen interest in the future of native plants and animals on the banks of Obi Obi Creek. Approximately 1,000 native seedlings were planted. Water testing of inlet/outlet samples at the irrigated forest and treatment wetland site was also undertaken.

› May 2015, Goulburn Malwaree Council staff visited the site to share technology and ideas that would help achieve greater benefits and savings to both the businesses and the communities they serve in.

› In June 2015 and May 2016, further seedlings were planted on either side of newly constructed walkway with the help from local communities (Figure 6d).

The events included the planting of Richmond birdwing vines (*Pararistolochia praevenosa*) to support the vulnerable Richmond birdwing butterfly (*Ornithoptera richmondia*), which is endemic to the broader region.

- October 2015, Conference delegates from the International Union of Forest Research Organisations (IUFRO) Small-scale Forestry Group undertook a tour of the site (Figure 6e).
- April 2016, 2017 and 2018, environmental science students from University of the Sunshine Coast undertook an annual fieldtrip to learn about the environmental management of the site.
- October 2016, water industry delegates undertook a bus tour as part of IWA World Water Congress and Exhibition held in Brisbane (Figure 6f).

It is estimated that over 1,000 visitors have visited the site since commissioning. The events provided educational opportunities for the attendees.

The irrigated forest and treatment wetland site has significantly improved local aesthetics and provides social, economic and environmental aspects for the local community and visitors to enjoy. The facility, along with the other components in the precinct, enhances 'liveability' in its neighbourhood.

Figure 6: Images showing planting days and educational events within the precinct.

2013 – Unitywater CEO George Theo, Jinibara Elder Ken Murphy and Unitywater Chairman Jim Soorley planting the final wetland plants on World Water Day.

2013 – 'Kids in Action' Field Day.

2013 – Community tree planting day.

2016 – Community tree planting on either side of newly constructed walkway.

2015 – IUFRO Forestry Group site tour.

2016 – World Water Congress participants walking on the new wooden bridge in the treatment wetland site.

DISCUSSION

Benefits realised

Community benefits

The combination of membrane-based treatment technology and nature-based technology, coupled with effective community engagement and stakeholder participation, has delivered a much reduced nutrient load discharged to Obi Obi Creek and has improved terrestrial and aquatic ecosystems that are home to a varitey of native animals and plants. Walking trails through the irrigated forest and around the treatment wetland cells (yet to be opened) will provide an additional nature based recreational activity for residents and visitors. Moreover, school children have been exposed to real world nature restoration activities which have developed their conservation values that may carry over into their adult lives.

Other social, economic and environmental benefits include:

- STP upgrade meets the needs of future population growth and quality compliance with the regulators.
- Negligible odour from the new STP (zero odour complaints from nearby community).
- Environmental protection and improved water quality to the Obi Obi Creek via the multi-barrier effluent treatment.
- Reforestation using a variety of native plant species.
- Habitat creation for native animals – includes nesting boxes for bird shelters (Figure 7).
- Improvements in biodiversity and aesthetics to make Maleny a more 'liveable' rural town.

- Creation of multi-purpose community assets for locals and visitors to enjoy.
- Locally created artwork celebrating and acknowledging the nature-based treatment solution, associated partnerships in developing the Maleny Community Precinct (Figure 8).
- Reputational benefits for Unitywater from community and from stakeholders' positive engagement.
- One of the key target identified under Sustainable Development Goal SDG6: Clean Water and Sanitation on community engagement achieved through this project (Hall *et al.*, 2016).

Lessons learned and future challenges

- It is important to first recognise indigenous people's rights over their traditional lands and motivating them to become 'partners' based on mutual respect, understanding and a pro-active approach during any proposed development. In doing so, this will help utilities gain 'a social licence' to operate services and provide a degree of ownership for the traditional owners.
- Very early in the project, Unitywater was well-aware of the decade-old conflict engaged by the community in boycotting the Woolworths' development, and quickly realised people power can have a serious impact on the infrastructure development.
- A fast track development approval was gained by working closely with local council and regulators, the community, and other stakeholders.
- A multi-disciplinary approach where utility engineers co-operated with scientists, biologists, local bush-care groups, indigenous people, regulators, council staff and contractors has led to successful implementation.
- Developing walking tracks close to the irrigated forest and treatment wetland site is an excellent opportunity for visitors to understand its operations and maintenance. (Unitywater is proposing to open connecting footpaths in 2018-19).
- Opening the site to the public is likely to raise a few challenges around community 'perceptions' and 'expectations' such as:
  - People/pets coming in contact with treated effluent;
  - Easement access to allow pedestrian traversing through the centre of site;
  - Slope stability, landslips and erosion aspects;
  - Potential for vegetation fire;
  - Potential for wind logging by irrigated trees; and
  - Feral pests in tree plantings.
- A mechanism to track visitor numbers and collect feedback on their attitudes towards water and environmental issues.
- Identifying and improving the variety of aquatic habitat and biodiversity in the treatment wetland site. The USC's biodiversity study recommendations include:
  - Improving the connectivity and fish passage between the wetland and Obi Obi Creek;
  - Increasing shade across the wetland cells by planting riparian species in the wetland cells; and
  - Assessing opportunities for upstream and downstream weed removal and rehabilitation.

  Unitywater is currently reviewing these recommendations. A balanced approach is being taken in terms of making improvements to the wetland for aquatic biodiversity and maintaining

Figure 7: Bird nesting boxes with cavities for shelter.

Figure 8: Art-work sculpture.

effluent treatment performance and site operational management.

- Better engagement from the community in the decision-making processes will be the key for proper maintenance in the near future.
- A systematic approach in understanding reforestation failures, weed management, and designing intervention measures to improve outcomes of irrigated forest and treatment wetland are yet to be resolved.
- All ground/shrub plants (e.g. mat rushes (*Lomandras sp.*) be avoided in the establishment phase of future project. They require large amounts of time and effort to establish, and are often not suited to exposed conditions and frost. A planned introduction of ground plants at year four or five would improve budgetary and maintenance considerations.
- Open, shallow water encourages recontamination of the reuse water prior to release to the creek and promotes growth of algae, weeds and nesting bird species such as Purple swamphens (*Porphyrio melanotus*) that destroy wetland plants (Figures 9). Creating areas of deeper water, especially with some woody structure would provide a variety of microhabitat types for fish and bird species such as Cormorants (*Microcarbo melanoleucos*) which were common in reference wetlands in the area that have these habitats.

CONCLUSIONS

Figure 9: Weed growth in the treatment wetland site (left) and wetland plants destroyed by nesting birds (right).

- Increasing levels of sewage treatment, delivering higher effluent quality, and fostering a community-based-partnership has led to a solution where Unitywater and its stakeholders have benefitted from an ecosystem based approach for effluent disposal.
- The irrigated forest and treatment wetland site has led to an improvement in biodiversity, and provided a habitat for wildlife that would otherwise have been scarce in a cleared farm environment.
- The Northern Wetland continues to provide an aquatic habitat to a variety of native flora and fauna including numerous aquatic plants, water birds, small mammals, marsupials, and a variety of aquatic macroinvertebrates. In the time since surveying, there has been no substantial change in the overall quality of aquatic habitat at the wetland or elsewhere at reference sites, the exception is a small increase in the coverage native aquatic plants.
- Maleny has become a more liveable community with a higher-degree of recreational value for the local community to enjoy the regenerated natural environment.
- Average annual reduction between pre- and post-upgrade results indicate 525 kg of total nitrogen and 412 kg of total phosphorus has not been released to Obi Obi Creek.
- Using a cross-disciplinary, cross-institutional and a multiple-stakeholder approach, the project has been able to increase the sense of ownership by local communities. This has been largely attributable to co-operation between the future users and the water utility from an early stage.

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