MAGNETIC ISLAND WATER RECLAMATION PLANT

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Abstract

The first full scale Membrane Bioreactor (MBR) in Australia, the Magnetic Island Water Reclamation (MIWR) Plant, was commissioned in late 2002.

Citiwater Townsville owns and operates the MIWR plant. The plant was designed by GHD and constructed via two contracts. Mineforce were responsible for civil and electrical whilst Aquatec Maxcon (AM) did the mechanical installation. Kubota membrane technology was provided by Aquatec Maxcon via Aquator of the United Kingdom. GHD have supplied on-going technical support to Citiwater since that time.

The MIWR has consistently produced effluent quality below licence requirements. *Inter alia* since commissioning in 2002 up to January 2006 the treated effluent has achieved BOD and suspended solids each < 5 mg/L (80th %ile) and turbidity <0.3, ammonia-N <1, Total N <2 and Total P < 0.2 mg/L (50th %ile).

This paper summarises the performance of the plant since the introduction of raw sewage.

The results of three years operation summarised.

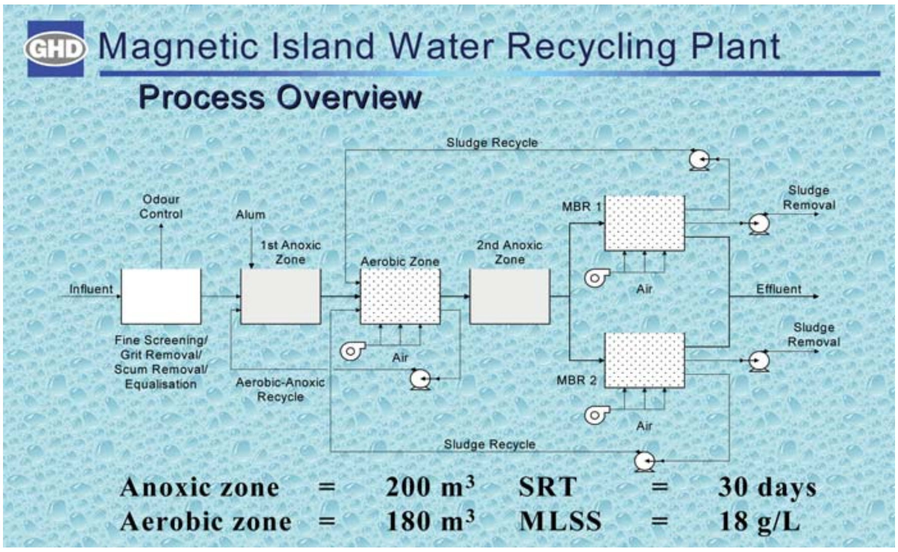

Figure 1. Process Flow Diagram.

Introduction

Magnetic Island, a popular tourist destination located approximately 8 km north of Townsville, Queensland, is comprised mostly of national parkland and is located within the State Marine Park of Queensland and the Great Barrier Reef Marine Park.

With an increasing population and development, and concerns for environmental protection, the Picnic Bay STP was upgraded to a wastewater reclamation facility, with an MBR BNR process, in the year 2002.

The Magnetic Island Water Reclamation Plant

The MBR BNR plant was commissioned in October 2002. The process, as installed, consists of:

- Fine screening (3 mm), grit and scum removal;
- Inlet storage and dry weather flow balancing tank;
- 4 stage Bardenpho-type activated sludge process (Primary anoxic - Primary aerobic - Secondary anoxic - Secondary aerobic) configured in MBR format, where the secondary aerobic stage is a highly aerated reactor containing the membranes;
- Membrane separation using flat sheet Kubota microfiltration membranes (nominal pore size 0.4 mm; actual pore size in operation ~0.01mm);
- Recycle and wasting pumps and aeration blowers;
- Drying beds for sludge drying;
- Alum dosing for P removal;
- Caustic soda for pH correction;
- Dosing facility for supplementary carbon source (e.g. sugar solution substrate);
- Sodium hypochlorite for providing residual chlorine;
- Storage and pumping of treated water; and
- Standby generator.

An overview of the process is provided in Figure 1.

The ultimate design capacity of the plant is 8000 EP (Average Dry Weather Flow, ADWF = 2160 kL/d). Only the inlet works, however, was designed for the full flow at 8000 EP. The remainder of the plant was designed for 2000 EP (540 kL/d or 6.25 L/s). The full plant process capacity for 2000 EP was installed, except for the membrane bioreactor MBR tanks where so far only one of two tanks has been fitted out.

The MIWR was designed to achieve very low nutrient (TN<3 and TP<0.1 mg/L) and faecal coliform levels (essentially zero). The plant is also flexible enough to allow less stringent criteria to be met. This allows for discharge to a sensitive environment during extreme wet weather events or reuse on an adjacent golf course in dry weather.

Licence Requirements and Historical Performance

Driven by concerns for the long-term protection of the sensitive marine waters of the Great Barrier Reef, which is a UNESCO Natural World Heritage Site, the environmental protection licence for this plant set stringent effluent quality standards. Inter alia the treated effluent is required to achieve BOD and suspended solids each < 5 mg/L (80th %ile) and ammonia-N <1, Total N <3 and Total P <0.1 mg/L (50th %ile). Citiwater Townsville had further opted to conform to the South Australia reuse guidelines, targeting a clear effluent with <2 NTU turbidity (50%ile). At least 80% of the effluent was to be reused for irrigation of a local golf course adjoining the treatment plant near Picnic Bay. This required low faecal coliform counts (5 no./ 100 mL, geometric mean) for land application of the effluent. The effluent requirements are summarised in Table 1.

Three years of operational data has been recorded for the MIWR. Daily on-site tests (>1000 test days) and fortnightly laboratory tests (89 test days) have been conducted from October 2002 until January 2006. The raw sewage data is summarised in Table 2 and effluent results are summarised in Table 3. Data presented in these tables excludes the commissioning period from October 2002 to January 2003.

The influent sewage is characterised by low actual influent BOD and COD, relative to design values (partly due to hot climate and characteristics of the collection and pumping system).

Trends for effluent quality data are shown in Figures 2 to 5. Performance has exceeded licence requirements since commissioning was completed (January 2003). The plant has produced consistent excellent BOD, TSS, TN, TP, turbidity and faecal coliform removal.

Removal of indicator bacteria (faecal coliforms, FC) has been good with only nine out of eighty-nine samples (up to July 2003) exceeding 0 FC/ 100 mL. Six samples exceeded the maximum licence requirement (> 25 FC/ 100 mL). There is no clear explanation for these sporadic spikes in faecal coliform levels; however it is suggested that it may be due to sampling collection issues (ie dirty bottles). In theory there should be no transfer of faecal coliforms through membranes (unless there is an integrity breach, which would show up in turbidity data).

Effluent turbidity has been very good for a reclaimed wastewater, with no results exceeding 1.8 NTU.

Nitrogen removal is often constrained by raw sewage characteristics, with a low ratio of COD (or BOD) to TKN being unfavourable. This problem has occurred at Magnetic Island and is exacerbated by the relatively long retention time in the sewage collection and pumping system. To achieve Total N requirements operations have focused on sugar solution dose rates, improved control of recycle rates and aeration (DO) settings.

P removal using simultaneous precipitation with alum has been very successful, aided by the long SRTs (giving efficient use of alum) as well as the excellent solids separation performance of the membranes. The plant is most likely operating at or very close to the solubility limit of phosphorus,

Table 1. MIWR Treated Effluent Quality Requirements.

Parameter	Units	Effluent Quality Requirement	Requirement Type	Maximum Value
BOD_5	mg/L	<5	80 %ile	10
Suspended Solids	mg/L	<5	80 %ile	10
Ammonia – N	mg/L	1	50 %ile	3
Total – N	mg/L	3	50 %ile	10
Total – P (new)	mg/L		50 %ile	1
pH	-	6.5 - 8.0	range	-
Turbidity	NTU	<2	50 %ile	5
Faecal Coliforms	No. per 100 mL	5	geomean	25

Table 2. MIWR Raw Sewage Data (Feb 2003 – Jan 2006).

Parameter	Units	50th %ile	80 %ile	Maximum Value
COD	mg/L	245	351	1010
BOD_5	mg/L	86	125	255
BOD_5 + sugar	mg/L	428	498	758
Suspended Solids	mg/L	57	123	428
Ammonia – N	mg/L	47.2	54.7	72.0
Total – N	mg/L	59.9	69.5	84.0
Total – P	mg/L	7.4	8.7	10.2
pH	-	7.2	7.4	7.9
Conductivity	uS/cm	1045	1181	3020
Alkalinity	mg/L	323	362	990

Table 3. MIWR Performance (Feb 2003 - Jan 2006).

Parameter	Units	50th %ile	80 %ile	Maximum Value
BOD_5	mg/L	1	3	9
Suspended Solids	mg/L	2	5	25
Ammonia – N	mg/L	0.15	0.54	2
Total – N	mg/L	2.0	10.0	26.6
Total – P	mg/L	0.20	0.48	7.7
pH	-	7.4	8.7	10.2
Turbidity	NTU	0.2	0.5	1.8
Faecal Coliforms	No. per 100 mL	0	0	3000

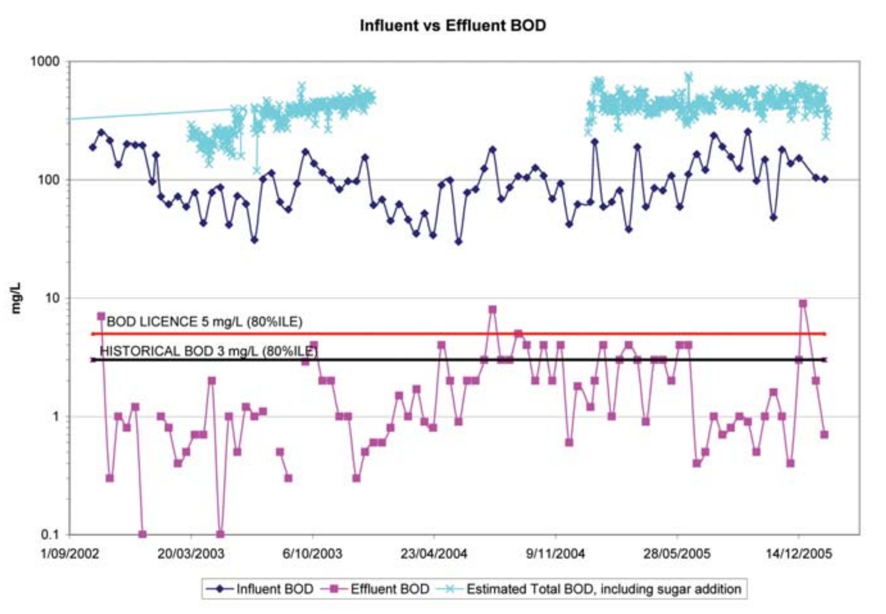

Figure 2. BOD removal performance at MIWR plant (October 2002- January 2006).

taking chemical equilibrium into considerations. The high alum dose may be contributing significantly to sludge production in the system and may be impacting on mixing performance and membrane flux rates.

The TP licence is currently being renegotiated from 0.1 mg/L to 1 mg/L (as noted in Table 1) due to the high levels of reuse on the golf course, where the nutrient content has value.

Membrane performance to date has been excellent. The trans-membrane pressure (TMP) has been consistently lower than the design value. Similarly, membrane flux has consistently exceeded the design value. It appears that membrane performance has been aided by the warm temperatures at Magnetic Island (water temp range approx. 25 to 32°C), relative to plants operating in the temperate climates of UK, Europe or Japan.

Conclusion

The MIWR has been operating successfully for over three years and has consistently met stringent licence requirements, with excellent removal of BOD, TSS, turbidity, TN, TP and faecal coliforms.

Notable characteristics of plant performance over the past three years have included:

- Continuous excellent BOD, TSS, TP, TN and faecal coliform removal;
- Compliance with all design parameters over the last 3 years of operation;
- Ability to operate under low loads;
- Reliable performance of the membranes;
- Ease of operability and maintainability;
- Ease of membrane cleaning;

Lessons learned have been:

- Highly intermittent flows have meant the balance tank is invaluable;
- Aeration control is important;
- Supplementary carbon source (sugar solution) has enabled low total N to be met consistently;
- High alum doses impact on sludge production, membranes and mixing;
- The need for more regular cleaning after 3 years of operation; and
- The importance of QA on nitrogen and phosphorus analyses at low levels.

Other positive aspects associated with plant operation have included:

- Client satisfaction through its performance, simplicity of operation and low maintenance of the plant;
- Minimal odour, it looks great and is easy to get around;

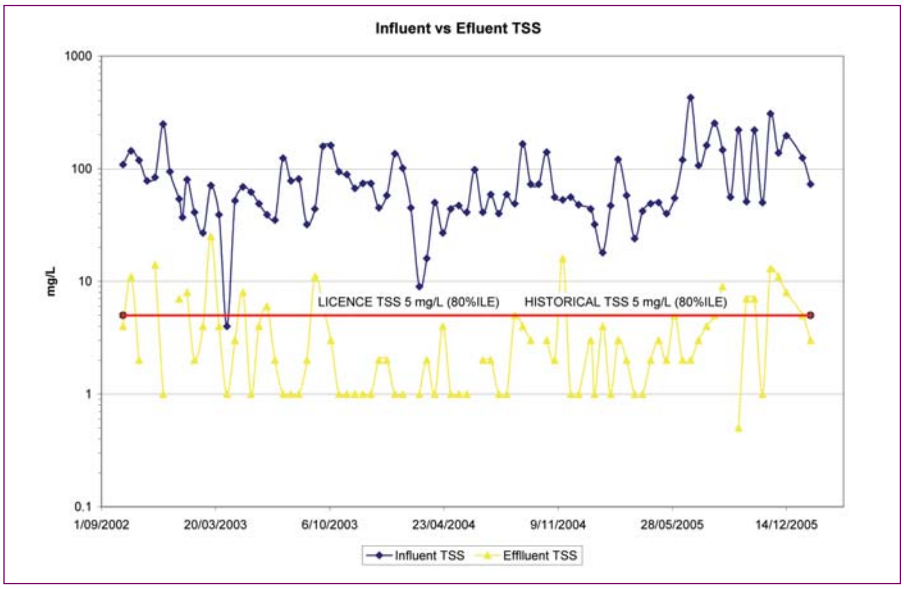

Figure 3. TSS removal performance at MIWR plant (October 2002- January 2006).

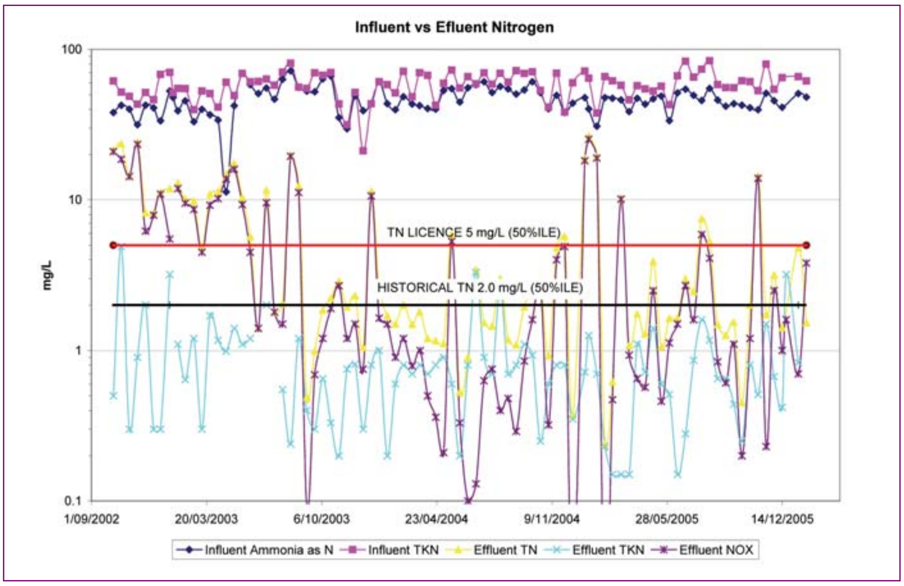

Figure 4. Nitrogen removal performance at MIWR plant (October 2002- January 2006).

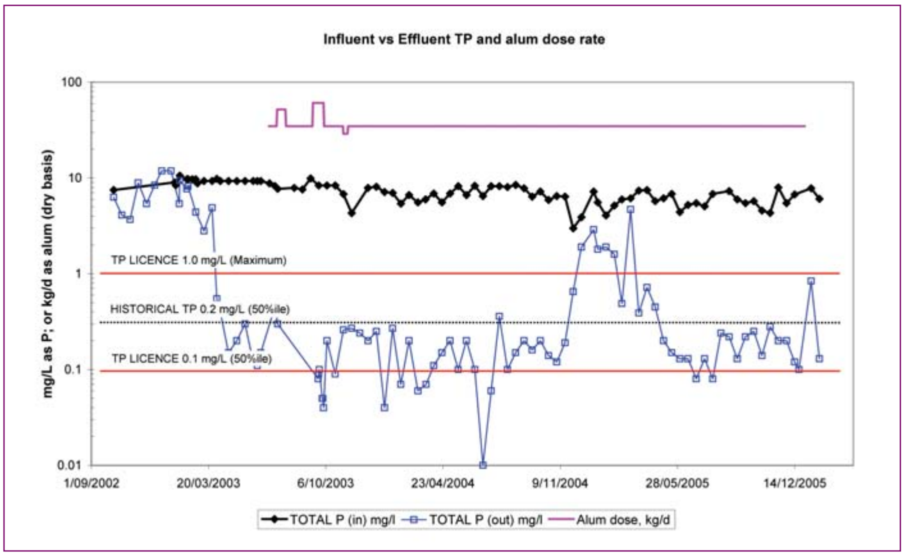

Figure 5. Total P removal performance at MIWR plant (October 2002- January 2006) (QLD EPA licence for TP is currently being renegotiated to 1 mg/L 50%ile).

- High profile, with lots of visitors;
- Supplier's design performance expectations exceeded; and
- The green-keeper of the adjacent golf course (who uses the water) proudly shows his before and after photos and can't get enough of the water!

Since the plant was constructed there has been a significant reduction in the cost of delivering this style of plant.

The proven performance of this facility combined with increasing stringent licence conditions and a significant reduction in the cost of membrane systems, is likely to result in a larger number of MBR facilities in Australia over the next decade

Postscript

As this paper is being written the Water Matters Alliance is about to install the second set of membranes in the second membrane tank. This will allow us to inspect the condition of membranes in tank 1 that have been in the water for over 3 years and subjected to a high dose of alum and addition of carbon to optimise nitrogen removal. The results of this investigation will be provided at in a separate paper at Enviro 06, May, 2006.

Citiwater is collaborating with James Cook University, Kubota and Aquatec-Maxcon, to design, build and run a pilot plant using the Kubota membrane to investigate flux efficiencies and biofouling control and management. Dr. Phil Schieder from JCU has been the principal technical force behind the study which is set to run for the next three years.

The Magnetic Island Water Reclamation (MIWR) Plant.

Acknowledgements

Many people have been involved in this project, from concept, to design, supply and commissioning. In particular, thanks are expressed to the following people:

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