FLOATING WETLANDS – NATURE IMPROVED – AN END USER'S EXPERIENCE

F Pratt & A Twose Whangarei District Council

ABSTRACT

In 1988, Whangarei District Council (WDC) constructed an eight hectare, surface flow wetland system to act as a final wastewater effluent polishing system and was a culturally sensitive option. Wastewater from Whangarei is treated at the treatment plant in Kioreroa Road before discharging to the wetland system, prior to Limeburners Creek and subsequently the Whangarei Harbour.

In 2011, public pressure and WDC's inability to consistently meet Resource Consent conditions around effluent quality discharge, gave impetus to plans to upgrade the treatment plant and wetland. Options for the wetland upgrade were investigated and consideration was given to: consent requirements, minimization of wetland downtime during construction, long term water quality objectives, aesthetics & operational costs.

WDC has completed two further conversions of surface flow to floating wetlands at Hikurangi & Waipu. Unlike Kioreroa Rd, where the wetland is the final process before discharge, the installation of the floating wetlands at these locations was to aid downstream processes. At Hikurangi the intention was to improve the effluent being presented to a membrane plant, and at Waipu to aid the performance of the rapid sand infiltration basins.

This paper discusses the drivers for the installation of the floating wetland system and the actual performance achieved to date.

KEYWORDS

Surface Flow Wetlands, Floating Treatment Media, Cultural Sensitivity, Wastewater Treatment

1 INTRODUCTION

1.1 USE OF WETLANDS FOR SEWAGE TREATMENT

Most 'western' literature detailing wastewater treatment processes focuses on high energy and civil intensive structures. This direction has been driven by the conditions experienced; high populations, expensive land prices, large flow volumes and the regulatory requirements to meet stringent effluent parameter conditions. The notable absence of wetlands being used as any form of treatment stage in Metcalf & Eddy's 'Wastewater Engineering', (considered to be the fundamental text in the field of sewage treatment), is an excellent example of this.

United Utilities, the water and sewage provider for the whole of the North West of England has close to 600 wastewater treatment plants catering for approximately 7 million people. Wetlands, as a sewage treatment process feature on only one of these sites. In New Zealand however, the use of wetlands for wastewater treatment is far more prevalent. For example, Whangarei District Council (WDC) operates nine Wastewater Treatment Plants (WWTP's), eight of which use wetlands as a treatment process.

The prevalence of wetlands in New Zealand is due in part to cultural consideration. Land treatment is the favoured method for achieving the cultural objectives for human waste management by the majority of Māori *iwi*. In a purely physical sense this reflects the idea that water can be cleansed of many pollutants by passing through vegetation and the earth before entering the sea.

In the natural environment, wetlands are one of nature's most effective and efficient treatment process for cleaning a multitude of contaminants from water. Engineers have sought to replicate and enhance the performance of natural wetlands through constructed wetland systems for a wide range of applications; from treating agricultural waste & urban run-off to industrial & municipal wastewater treatment plants (WWTP's). The aim for all applications is essentially identical; to reduce the level of contamination in the water being discharged before it reaches the receiving environment.

In New Zealand, the balancing act is to complement the cultural considerations against the need to achieve the necessary performance to meet the regulatory requirements (typically the resource consent for the site). Furthermore, the operation and maintenance needs to be taken into consideration, as well as the associated financial and health and safety requirements.

1.2 FLOATING WETLANDS

Floating Wetlands utilise Floating Treatment Media (FTM) technology to offer an alternative to the constructed surface flow wetland systems currently employed in the Whangarei District. It is effectively wetland plants grown on a buoyant pod structure that sits in a pond 1.0 to 1.2m deep. The roots of the wetland plants dangle in the water, providing a contact zone for bacteria to grow and "consume" contaminants from the wastewater as it passes by. The pods are wired together and can be moved to allow de-sludging. The FTM installation at Kioreroa Road WWTP twelve months after completion is shown in Photograph 1.

Photograph 1: Floating wetland systems installed at Kioreroa Road WWTP

The FTM system also includes a baffle system on the downstream side of each pod that directs water up towards the roots structure. Figure 1, (provided by Waterclean, the supplier of the FTM), illustrates the flow paths created by the baffles. The FTM system is deigned to remove a range of pollutants, the principals behind each pollutant removal process is detailed below;

- Total Suspended Sediment (TSS) is removed through accumulation of the sediment onto the biomass on the wetland plant roots, pods & baffles, which is sloughed over time and settles below the pods in front of the baffles.

- Ammonia (and total nitrogen) is removed through nitrification (by nitrifying bacteria in the biomass on the roots, pods & baffles) to nitrites and nitrates before being taken up by de-nitrifying bacteria in the biomass or the plants and subsequently releases as nitrous oxide or nitrogen.

- Phosphorus is removed through uptake by the wetland plant roots into the plants and by the biomass on the plant roots, pods and baffles which is sloughed over time and settles below the pods in front of the baffles.

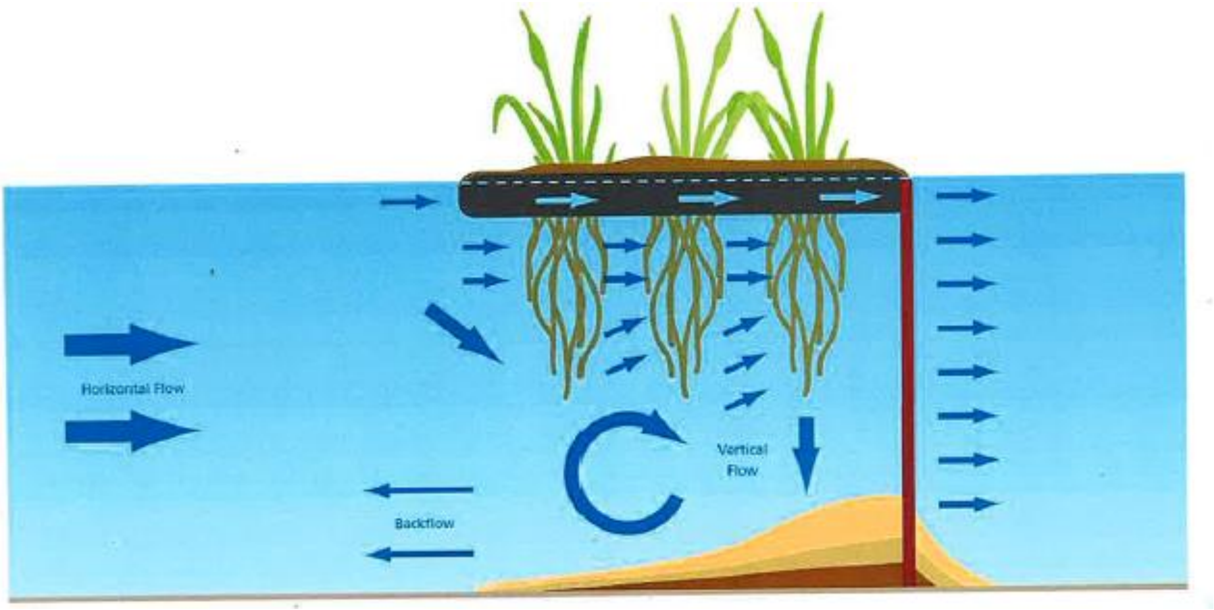


Figure 1: The flow paths created by the baffle system on the FTM pods.

The advantages of FTM systems include:

- De-sludging (recommended every 10 years) is manageable without the need to replant – move baffles and floating media – hence de-sludging cost is reduced;
- Large surface area for biofilm formation (1000m^2 per 1m^2 of plant);
- Easier management and control with reduced operating and maintenance costs;
- Less susceptible to minor water level changes;
- Less susceptible to minor bird damage;
- Less likelihood of short circuiting;

The FTM also offer some benefits in water quality, particularly when the wetland plants are harvested. Test results from other districts indicated phosphorous and nutrient reductions are possible.

1.3 DRIVERS FOR THE FLOATING TREATMENT MEDIA INSTALLATION

WDC undertook a risk assessment and costing for surface flow wetlands and measured this against the installation of FTM. The cost of a surface flow wetland was less than FTM but the risks were higher. From this final analysis, it was decided that the following risks were unacceptable;

- Inadequate water level management while young plants are trying to establish and once they are established
- The establishment of invasive weed species which intertwine with the desired wetland species making it impossible to eradicate either by hand or chemical
- Damage to plants by water fowl particularly during establishment
- Inadequate base substrate as a growth media

WDC was of the opinion that FTM technology is an environmentally sound process that leverages the use of various natural and artificial media. These systems are robust and able to cope with dramatic changes in flow rate and influent characteristics due to the diversity of micro-organisms. Table 1 discusses the other significant site specific drivers relevant to each of the three WDC WWTP's.

Driver	Whangarei	Hikurangi	Waipu
Is a wetland system a consent requirement?	Yes	Yes	Yes
Is minimising downtime during construction an issue?	Yes. Flow > 12,000 m^3/d would need to be diverted direct to Limeburners during construction and plant establishment	Less of an issue	Yes
Does a FTM fit into long term water quality objectives;	Yes. It is likely that nutrient reduction will be a consideration during 2021 consent renewal. There is potential for the reduction in phosphorous and nitrogen through wetland would reduce capital to upgrade main treatment process.	Yes. Depending on the final performance of the wetland the way the Hikurangi scheme is operated will be reviewed. The membrane system requires periodic membrane replacement at significant cost. Better wetland effluent quality would offer alternatives to the membrane (e.g. UV)	Yes. The removal of suspended solids is critical to the continuing performance abilities of the Rapid Sand Infiltration Basins to dispose of the effluent.
Will an FTM reduce long term maintenance costs	Yes. Sludge accumulation in the wetland is reduced (due to less algae growth and plant matter), hence de-sludging costs are reduced.	Yes. Sludge accumulation in the wetland is reduced (due to less algae growth and plant matter), hence de-sludging costs are reduced.	Yes. The removal of suspended solids will result in a reduction in the number of occasions that 'clogged' sand will need to be removed and replaced in the Rapid Sand Infiltration Basins
Are aesthetics an issue	Yes. Wetland area is visited by many people on a daily basis.	No	No
Does an FTM fit in with WDC’s programme to manage wet weather overflows in Whangarei;	Yes. Council is in the process of directing all flows through the wetland (currently limited to 57,000 m^3/d). The floating system can offer polishing during high flows.	N/A	N/A
Will an FTM affect operation costs	There will be a requirement to maintain the floating system on an annual basis, though this will be offset by reduced de-sludging costs.	Operation of the membrane system is affected by influent water quality. Reduction in suspended solids as the water passes through the FTM will reduce backwash times resulting in less chemical use and less solids in the oxidation pond.	Operation of the Rapid Sand infiltration Basins is affected by influent water quality. Reduction in suspended solids as the water passes through the FTM will reduce the number of occasions that 'clogged' sand will need to be removed and replaced.
Reliability	Yes. There is a reduction in effluent quality as the wastewater passes through the existing wetland system. This will be improved with and FTM system.	A stable water quality going through the membrane system will improve the membranes' reliability.	A stable water quality going into the Rapid Sand Infiltration Basins will improve the reliability.

Table 1: Assessment of FTM in relation to the Kioreroa Road, Hikurangi and Waipu WWTP’s

2 KIOREROA ROAD WWTP WETLAND

2.1 OVERVIEW

In 1988, an eight hectare, surface flow wetland system was constructed in two distinct areas. Wetland one has an area of 40,000m^2, is gravity fed and receives up to 25,000m^3 (ADWF) of treated effluent per day and wetland two has an area of 25,000m^2 and receives 10,000m^3 (ADWF) of treated effluent from a rising main. The wetlands were constructed to act as a final wastewater effluent polishing system and environmental buffer between the treatment plant and Whangarei harbour. This land based, natural component is particularly important to Maori, making it a culturally sensitive option.

Treated effluent from the WWTP passes through the wetlands and discharges into Limeburners Creek which flows to the harbour. The retention time was approximately four days. These wetlands were designed to be cleaned on a ten year cycle with a plant replacement regime as required but this programme was never adhered to, hence there was a high level of sludge build up in areas with weeds growing level with the top of the water. This had the effect of reducing the effective depth of the ponds and reducing retention times, both of which resulted in reduced effluent polishing.

In 2011, public pressure and WDC's inability to consistently meet the Resource Consent conditions around effluent quality discharge, gave impetus to plans to upgrade the WWTP and wetland. Options for the upgrade of the wetland were investigated and consideration was given to: consent requirements, minimization of wetland downtime during construction, long term water quality objectives, aesthetics & operational costs.

The WWTP itself underwent significant upgrading in 2013 to enable treatment of storm flows of up to 125,000m^3 per day. The wetlands were the last part of this upgrade, which included a proposed de-sludging and replanting. A technical review of the capacity of the wetlands to receive these higher discharges was also undertaken. This showed that by deepening wetland one, the full 125,000m^3 per day could be discharged into this wetland. This meant that wetland two could become redundant and potentially retired, thereby providing a cost saving for WDC. As a result of this review, no work has been undertaken on wetland two.

In 2013, all sludge and plant material was removed from wetland one, the depth was increased to 1.2m, overflow weirs were constructed at three of the discharge outlets to Limeburners Creek, and the FTM was installed.

Photograph 2: Kioreroa Road WWTP Wetland Sept 2013 prior to de-sludge and FTM system installation

2.2 DESIGN CRITERIA

Table 2 notes the design influent and effluent water quality parameters of the FTM wetland at Kioreroa Rd WWTP which were required when designing the system.

	Influent Quality	Effluent Quality (when flow 12,000m3/d)
BOD (mg/l)	13	<7
TSS (mg/l)	19	<10
Total Nitrogen (mg/l)	8	<5

Table 2: Design influent and effluent water quality parameters for Kioreroa Road WWTP FTM wetland

2.3 PLANT ESTABLISHMENT

Within 2 – 3 months of completing the floating wetlands, it was evident that the vast majority of the plants which had been planted on the floating pods had survived. The health of the plants was uniform, with no noticeable difference in growth rate and size between those at the inlet of the wetland and those closest to the outfall. The number of plant losses and required replacement was also minimal.

In August 2016, the floating pods on the FTM wetland were lifted by a crane truck to allow an inspection of the root system, (an invasive investigation undertaken whereby the plants were physically extracted from the floating pods proved inconclusive, with little root remaining on the plant once removed). Photograph 3 below shows the floating pods at the inlet end of the wetland. The figure clearly shows the well developed root structure, with the length of the roots being controlled by the depth of the water beneath the raft; short roots on the left where the water depth was minimal, much longer on the right where the water depth increases.

Photograph 3: Lifting of one of the floating pods at the inlet end of the Kioreroa Rd wetland.

Photograph 4 shows the root structure below the floating pod located near the wetland outfall. At this location the underwater sides of the wetland dropped away much quicker, thereby not restricting the growth of the roots. The Photograph shows the roots, unrestricted by depth, as being uniformly well developed and extensive.

Photograph 4: Lifting of one of the floating pods close to the outlet of Kioreroa Rd WWTP wetland.

2.4 WATER QUALITY MONITORING

Inter-stage water quality samples have been undertaken across the wastewater treatment processes at Kioreroa Rd WWTP for a number of years. This includes the common influent to both wetlands and the effluent from each wetland. This sampling was continued after wetland one was de-sludged and FTM installed. As noted above, only wetland one was converted to floating treatment media in 2014, with wetland two remaining untouched and can for all intents and purposes can be regarded as a 'control' (albeit of a smaller size and receiving less flow).

Table 3 details the average annual results for the three effluent parameters against which the WWTP is required to perform to meet the conditions of the resource consent. When comparing the performance of wetland one pre- & post- upgrade, it can be seen there is a very minor reduction in both the BOD & TSS concentrations after the upgrade. This minor increase in performance could be considered to be greater than initially anticipated as it should also be noted that the influent concentrations of BOD & TSS to the wetlands has also marginally increased post- upgrade. However, it is interesting to note that this increase in performance is mirrored within wetland two (control).

Whilst the wetlands are not specifically designed to remove ammonia (NH_3), the removal of the significant quantities of sludge as part of the upgrade could be expected to have a reducing influence. Typically in wastewater treatment processes, the less sludge there is 'hanging' around in the system, the lower the ammonia levels are. Whilst the ammonia concentration of the effluent from the upgraded wetland one does appear to have been reduced across the process, it can be regarded as not any better than before the upgrade and is on a par with the performance achieved across wetland two.

Year	Wetland Influent			Type of Wetland	Wetland 1 Effluent			Type of Wetland	Wetland 2 Effluent		
	NH3 (mg/l)	BOD (mg/l)	TSS (mg/l)		NH3 (mg/l)	BOD (mg/l)	TSS (mg/l)		NH3 (mg/l)	BOD (mg/l)	TSS (mg/l)
2011	11.7	17.7	18.1	Surface Flow Wetland	9.3	4.2	4.2	Surface Flow Wetland	8.2	4.6	4.7
2012	2.4	9.7	13.3		2.0	4.7	4.6		1.2	4.0	4.2
2013	2.4	6.5	9.1		1.7	3.8	4.0		1.0	3.8	4.4
2014	3.1	8.6	14.5	Transition	2.9	5.4	30.7		1.1	3.1	3.8
2015	3.7	10.1	13.2	Floating Media	2.9	4.0	3.3		2.4	3.8	4.1
2016	3.3	10.1	12.8		1.2	4.0	3.3		1.3	3.0	3.5

Table 3: Laboratory sample analysis as annual averages of the water quality influent and effluent across the two wetlands at Kioreroa Rd WWTP

Table 4 illustrates the performance of the wetlands in terms of percentage removed based on the data detailed in Table 3. Whilst the variation in percentage figures could be viewed as significant, when compared with the scale of the actual concentrations which are being considered, the overall level of effectiveness can be considered low. It should also be noted that the percentage removal performance figures for the upgraded wetland one are not that dissimilar to wetland two (control).

Percentage Removal								
Year	Type of Wetland	Across Wetland 1			Type of Wetland	Across Wetland 2		
		NH3 (mg/l)	BOD (mg/l)	TSS (mg/l)		NH3 (mg/l)	BOD (mg/l)	TSS (mg/l)
2011	Surface Flow Wetland	20%	76%	77%	Surface Flow Wetland	30%	74%	74%
2012		16%	51%	65%		52%	59%	68%
2013		30%	43%	56%		60%	43%	51%
2014	Transition	7%	37%	-111%		66%	64%	74%
2015	Floating Media	22%	60%	75%		36%	63%	69%
2016		62%	60%	74%		61%	70%	73%

Table 4: Analysis of the laboratory sample data displayed as percentage removed across the two wetlands at Kioreroa Rd WWTP

2.5 SITE SPECIFIC ISSUES

Following the completion of the Kioreroa Rd WWTP FTM wetland it was observed that there was a difference in the distribution of duckweed (or lemnoideae) between the lines of the pods. This can clearly be seen in Photograph 1. Whilst the distribution of the duckweed itself is not believed to be detrimental to the performance of the wetland, it did raise the question of why. On investigation it was found that short-circuiting was occurring around an island that had been left during the construction. This channel was allowing the majority of the flow to by-pass eight lines of pods. This channel has only recently been filled in and the water quality sample results will continue to be monitored.

3 HIKURANGI WETLAND

3.1 OVERVIEW

The Hikurangi WWTP comprises a two stage facultative pond system followed by a wetland which feeds effluent into a membrane plant. Average dry weather flow is approximately 500m^3 per day. The wetland receives effluent from an aeration pond.

The Hikurangi WWTP wetland was in a poor state of repair, largely due to accumulation of sludge being carried through from the aeration pond and die off of wetland plants due to water level changes. These uncontrolled water level changes are due to difficulties with the operation of the membrane plant and the "leaky" reticulation which results in volumes as high as 1,200m^3/day entering the WWTP. The poor effluent quality that resulted was further impacting the membrane operation and making it very difficult to comply with consent requirements. Algal and daphnia (water fleas) blooms that passed through the wetlands were also believed to be having a significant impact on the operation of the membrane plant.

3.2 DESIGN CRITERIA

Table 5 notes the design effluent water quality parameters of the FTM wetland at Hikurangi WWTP considered when designing the system.

	Effluent Quality
TSS (mg/l)	< 25mg/l
pH	6.5 – 8.5

Table 5: Design effluent water quality parameters for Hikurangi WWTP FTM wetland

3.3 PLANT ESTABLISHMENT

Plant establishment on the Hikurangi FTM, by all accounts from the supplier/installer, required the most assistance compared to their other installations. The Hikurangi WWTP is located on the fringes of the Hikurangi Swamp, a vast arable area with a very high density of farm drains. As a result of this, the site is home to hundreds of wild fowl over the course of the year, including Pukekos (Australasian Swamphens). WDC's WWTP operators found during their routine checks that significant numbers of the plants had been pulled out by the birds, laid down on the pods and had their roots eaten. On one occasion, the operator estimated up to 25% had been pulled out over one weekend alone. A cull of the Pukekos and the replacement of plants with a different species allowed the plants to become established on the pods.

Photographs 5 & 6 below depict the size of the plants when they were first planted and again after two years once they had fully established.

Photograph 5: Photograph of the newly installed and planted FTM wetland at Hikurangi WWTP.

Photograph 6: Photograph of the established FTM wetland at Hikurangi WWTP.

In August 2016, the floating pods were lifted by a crane truck to allow an inspection of the root system, (again an invasive investigation whereby the plants were physically extracted from the floating pods proved inconclusive with little root remaining on the plant once removed). Photograph 7 below shows the well established roots hanging down, as well as a number of unidentified fungus/mould growths as seen in the top left. There was no notable difference in root growth between pods at the inlet and the outlet of the wetland.

Photograph 7: Lifting of one of the floating pods on the Hikurangi WWTP wetland.

3.4 WATER QUALITY MONITORING

Inter-stage water quality samples were not frequently taken across the wastewater treatment processes at Hikurangi WWTP prior to the FTM installation. The only regular set of inter-stage samples were taken in 2011 when the previous upgrade on site was undertaken (addition of the membrane plant as the final treatment process). However, as can be seen in Table 6, which shows the pre- and post- upgrade results, it did highlight the issue of additional TSS load being generated through the existing surface flow wetland.

Following the installation of the FTM, there has been a notable turn around in performance compared to the prior surface flow wetland. However, it must be noted that even thought the wetland has had close to two years to establish, the TSS in the wetland effluent continue to exceed the design concentration of <25mg/l despite the wetland influent being below the influent design concentration.

Type of Wetland	Year	Wetland Influent Results	Wetland Influent Design Parameters	Wetland Effluent Results	Wetland Effluent Design Parameters
		TSS (mg/l)		TSS (mg/l)	
Surface Flow Wetland	2011	21.5	-	34.7	-
Floating Media Wetlands	2014	52.8	75	32.7	<25
	2015	49.1		35.7	
	2016	70.3		49.3	

Table 6: Laboratory sample analysis as annual averages of the water quality influent and effluent across the wetland at Hikurangi WWTP

Table 7 details the percentage removal performance of the Hikurangi wetland pre- and post- upgrade. As discussed above, although the post-upgraded wetland has reversed the trend of additional TSS load being generated through the process, the percentage removal is still below the required performance to meet the design effluent parameters.

Type of Wetland	Year	Actual removal across wetlands	Required removal to meet design parameters
		TSS Removed (%)	
Surface Flow Wetland	2011	-61%	-
Floating Media Wetlands	2014	38%	53%
	2015	27%	49%
	2016	30%	64%

Table 7: Analysis of the laboratory sample data displayed as percentage removed across the wetland at Hikurangi WWTP

3.5 SITE SPECIFIC ISSUES

During the design and installation it was made clear by the supplier that it was essential to keep the water level in the FTM wetland as close to a set level as possible. This was to ensure that the Shaded Algae Mitigation (SAM) (see Photograph 11) and the pods covered the whole of the water surface to mitigate against both algal and water flea (or daphnia) blooms which were known to significantly influence the previous surface flow wetland's effluent TSS's. The correct water level is also essential to have the baffles at the correct height, thereby ensuring the correct flow paths and retention time by preventing short-circuiting.

Photograph 5 shows the FTM being installed when the water level is at the correct height, with Photograph 6 illustrating what occurs when flows to the WWTP are high following wet weather, (due to inflow & infiltration on the reticulation). This issue of 'uncontrolled' flows into Hikurangi WWTP is proposed to be addressed in the 2016/17 & 2017/18 financial years through major upgrades to the reticulated network. Only once this work has been completed, with the flows and levels much more carefully managed, can the effect of the FTM and the SAM be considered to be effective. This will continue to be monitored through the water quality sampling.

Hikurangi WWTP's main pond, unlike Waipu WWTP's which was de-sludged immediately prior to the FTM installation, has not been de-sludged according to known records. These known elevated sludge levels could also be a contributor to the poor water quality influent to the wetland. However, it must be noted that the water quality of the influent into the FTM is under the required design limit as detailed in table 6. A de-sludge of the main pond to improve the water quality into the FTM could be considered to try and improve the effluent from the FTM.

4 WAIPU WETLAND

4.1 OVERVIEW

The Waipu WWTP comprises a single stage facultative pond followed by a wetland which discharges to rapid sand infiltration basins. The wetland itself comprises three separate ponds which all receive an equal amount of effluent from the oxidation pond. Large accumulation of TSS from the pond and die off of the plants (one pond was almost plant free) meant that the discharge to the rapid sand infiltration basins was of poor quality and these basins were starting to blind up hence requiring continual maintenance in an effort to comply with the Resource Consent conditions. The decision was made to install FTM to reduce the amount of TSS being passed to the rapid sand infiltration basins

4.2 DESIGN CRITERIA

	Influent Quality	Effluent Quality
BOD (mg/l)	65	30
TSS (mg/l)	60	30

Table 8: Design influent and effluent water quality parameters Waipu WWTP FTM wetland

4.3 PLANT ESTABLISHMENT

At Waipu, as with Kioreroa Rd, within 2 – 3 months of completing the installation of the FTM, it was evident that the vast majority of the plants had survived. Initially the health of the plants was uniform, with no noticeable difference in growth rate and size between those at the inlet of the wetland and those closest to the outfall. The number of plant losses and required replacement were also minimal.

Photograph 8: Overview photograph of the floating wetlands at Waipu WWTP.

In August 2016, during an inspection it was evident that a variation in the growth of the plants between pods had developed. This variation is clearly illustrated in Photograph 8. This stunted plant development could not have been associated with depth (as noted in the root development at Kioreroa Road WWTP), as the depth was known to be constant beneath all the pods. The distribution of variations in healthy growing plants and those appearing to be displaying stunted growth and lost plants did not appear to be random, nor correlate with proximity to the inlet or outlet of the wetlands. What is evident is that there appears to be clear zones of healthy plant, zones of plants displaying stunted growth and areas of transition.

The results of a closer inspection are illustrated in Photographs 9 & 10. Whilst there has been no visual confirmation, a preliminary assessment of the extensive amount of feces indicates that the plants are being extensively grazed by Leporidae (the family of mammals that include rabbits and hares).

Photograph 9: Close-up photograph of the plants displaying stunted growth (including losses) on the FTM wetlands at Waipu WWTP.

Photograph 10: Close-up photograph of the plants displaying stunted growth on the FTM wetlands at Waipu WWTP and the associated Leporidae droppings.

4.4 WATER QUALITY MONITORING

With the Waipu FTM installation only being completed in March 2016, the amount of sample data is very limited. Table 9 details all the available sample analysis, which does not allow any direct comparison between the pre-and post- upgrade. What the data does reveal is that the pre-upgrade wetland was performing reasonably well removing a significant proportion of both BOD & TSS.

Type of Wetland	Year	Wetland Influent		Wetland Effluent	
		BOD (mg/l)	TSS (mg/l)	BOD (mg/l)	TSS (mg/l)
Surface Flow Wetland	2011	-	-	25.5	-
	2012	-	-	25.3	-
	2013	-	-	26.0	-
	2014	50.2	113.0	30.9	41.0
	2015	53.2	87.6	28.1	48.1
Floating Media Wetlands	2016	-	-	-	52.2

Table 9: Laboratory sample analysis as annual averages of the water quality influent and effluent across the wetland at Waipu WWTP

4.5 SITE SPECIFIC ISSUES

Due to the recent completion of the Waipu WWTP FTM wetlands, other than the aforementioned *Leporidae* grazing, no site specific issues have been noted. However, the effect on the plants will be monitored to ensure that excessive plant loss does not occur. The supplier recommends that 8-12 months from installation is allowed for the plants to reach their full size and treatment capacity. It is therefore proposed that the performance of the wetland is assessed at that time.

5 MAINTENANCE

5.1 MAINTENANCE

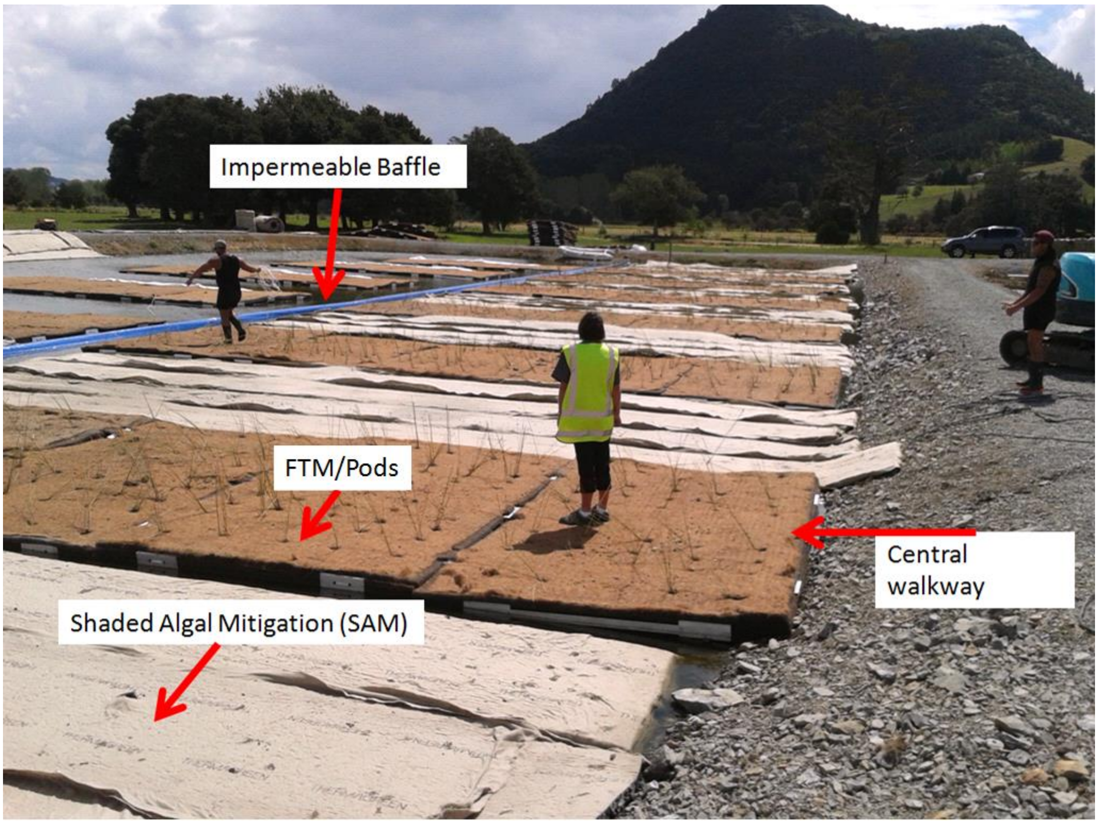
Maintenance of the FTM is a routine operation. It can be done by the treatment plant operators once training has been undertaken, or contracted out. The main components of the FTM (see Photograph 11) should undergo routine maintenance every three months.

The routine maintenance requires:

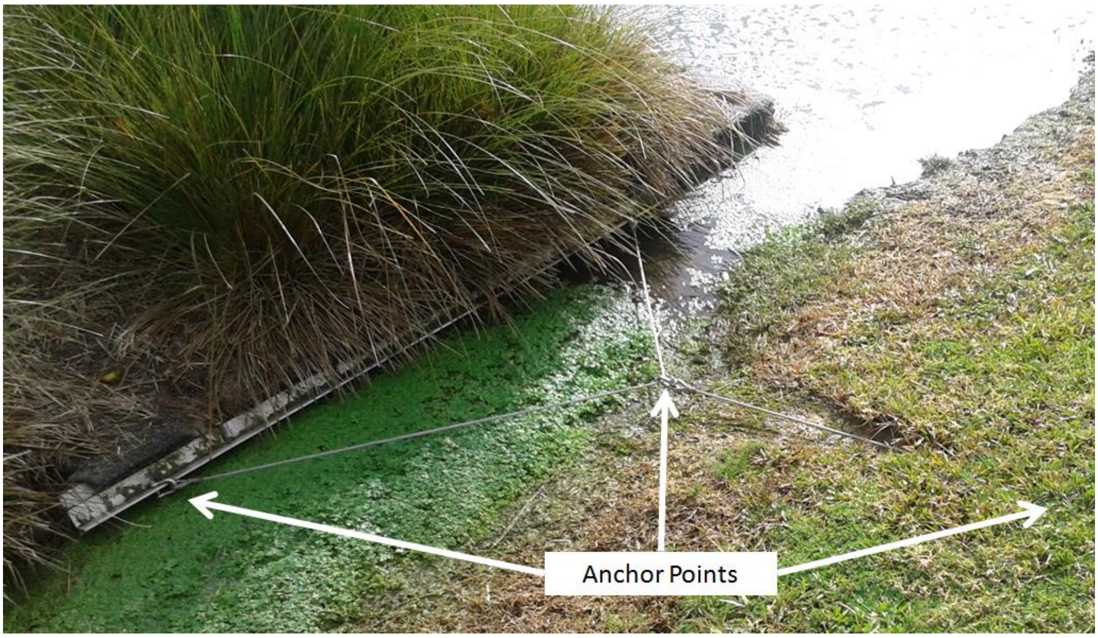
- Visual checks of all anchor points for wear and tear and rust at the points where the FTM is attached to the anchors on the banks of the wetland and the anchor plates and eye bolts on the FTM (see Photograph 12).
- Check for invasive weeds which, if present will need to be removed by hand or carefully sprayed.
- Check the alignment of the FTM is as per the original plan
- Ensure the FTM has 70 – 100mm freeboard
- Check any impermeable baffles are 100mm above the water level
- Check that all plants have a fresh green appearance (are healthy)
- Plants should be harvested to 500mm height above the FTM using a mechanical harvester. This will promote root and shoot growth

The FTM that was installed has a central platform which allows the maintenance crew to walk onto the pods (without getting wet) for ease of checking on and harvesting plants. This is a significant health and safety improvement when the similar task to harvesting wetland vegetation on surface flow wetlands is considered.

It is our belief that with training, the maintenance of the FTM can be performed by our treatment plant operators as part of the routine maintenance of the WWTP's without requiring additional staff hours.



Photograph 11; Showing the components of the FTM system



Photograph 12; Showing the anchor points of the FTM system

6 CONCLUSION

WDC has only two years experience with the installation and operation of FTM systems and as such is still working through a number of challenges to further improve and optimize the performance of the FTM. During this time WDC has gained a greater understanding of the importance between the design and the interaction with external influences.

The FTM systems were originally chosen over the surface flow wetlands they replaced to address perceived risks. Table 10 re-visits these risks and WDC's experience of the FTM in eliminating them.

Inadequate water level management while young plants are trying to establish and once they are established	The FTM system meant that flows could be restored effectively immediately following completion of the de-sludging and vegetation removal, meaning no protracted intensive flow and level control was required. This enabled WDC to work within the bounds of the Resource Consent Conditions required for each of the three WWTPs. Had this not been achievable, there would have been considerable costs and time associated with applying for a variation to each of the three consents.
The establishment of invasive weed species which intertwine with the desired wetland species making it impossible to eradicate either by hand or chemical	Invasive weed species can be easily dealt with. The rafts are able to be walked on hence weeds can be easily removed by hand or, if necessary, sprayed by the WWTP operators or maintenance crew. It has also proved to be an easy task to deal with any weeds which have appeared in the water between the rafts.
Damage to plants by water fowl particularly during establishment	Hikurangi was the biggest challenge however, once again the replacement of plants is an easy task as the rafts can be walked on and the plants planted within them. In a surface flow system, the operators would have needed special PPE to enter the water and planting of new plants would have been a difficult task with associated health and safety issues
Inadequate base substrate as a growth media	The floating pods provide the structure to support the plants, with the roots hanging down into the water column

Table 10: Perceived risk of surface flow wetlands and the elimination of these through the use of FTM.

The water quality monitoring revealed that the performance of the FTM systems was not as significant as originally anticipated, with negligible improvement compared to the surface flow wetlands they replaced. Where the FTM has been used as an inter-stage process at Hikurangi & Waipu WWTP’s this remains an issue. Further work is still required to improve the effluent from the FTM system to produce the required water quality parameters for the downstream processes.

As discussed, the performance of the FTM at Hikurangi WWTP has been compromised through an inability to control flows and levels critical to the design performance of the FTM. With proposed resolutions to be undertaken, monitoring will continue to assess whether the original design criteria can be achieved.

At Kioreroa Road WWTP, where the FTM is acting as a final effluent polisher, the lack of improvement is acceptable. As noted in the introduction, this wetland area is open to the public and seen as both a recreational and education resource. The FTM has satisfied this requirement by being visually appealing for people and providing a habitat for wildlife.

REFERENCES

Wastewater Engineering – Treatment & Re-use, Metcalf & Eddy (4^{th} Edition 2003)

Waterclean Technologies – Hikurangi WWTP Floating Media Treatment Document 2012

Waterclean Technologies – Kioreroa Road WWTP Floating Media Treatment Document 2012

Waterclean Technologies – Waipu WWTP Floating Media Treatment Document 2013