Ticking all the Boxes – A Cost Effective Installation, Low Running Costs, High Quality Effluent and Consent Compliance! Achieved using a Textile Packed Bed Reactor

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ABSTRACT

In 2009, the Auckland Regional Council received a number of odour complaints from a wastewater treatment and disposal system servicing a mixed use residential/commercial block in Kumeu, West Auckland. Andrew.Stewart Ltd were engaged by the client to provide engineering and planning services which included a 'fit for purpose' assessment of the existing treatment system, a new resource consent application and a new upgraded treatment plant and disposal system. The client wanted a solution that was cost effective due to the proposed reticulation of Kumeu Township, due to be completed in the next 2 years.

The residential/commercial block includes a cafe, a Chinese restaurant, offices, a small dairy/grocery store and a residential accommodation for 5 people. In 2001, a Bioflow 2000 system was installed to treat the wastewater to secondary standard prior to disposal via a PCDI disposal system. For a number of reasons the system was unable to treat the strong wastewater generated from the commercial block and partially treated wastewater was discharged to land resulting in regular odour complaints from neighbouring businesses.

Refurbishing/upgrading the existing treatment system was uneconomic due to the small tank sizes and lack of space for a grease trap and buffer tank. Andrew.Stewart Ltd presented the client with a number of options to produce secondary effluent quality prior to land application of treated wastewater.

Following a period of flow monitoring to determine the average and peak wastewater flows and influent sampling, a robust treatment process based on textile recirculating packed reactors was chosen. Two providers of this technology were asked to submit proposals based on a performance based specification; the installation and maintenance contract was subsequently awarded to Jet Water and Waste Systems Ltd. The Jet commercial packed bed reactor had been under development for a number of years and this was the first system installed within the Auckland Region.

The treatment plant was designed to treat peak flows of up to 1,600 litres per day and to produce advanced secondary treated effluent.

The paper covers wastewater treatment and disposal, engineering design, installation and plant performance.

KEYWORDS

Compliance, on site wastewater, textile packed bed reactors

1 INTRODUCTION

The rural West Auckland towns of Kumeu, Huapai and Riverhead are not reticulated for sewage and rely on on-site treatment and land disposal. The performance of some treatment systems are poor, they are often undersized, often cause odour nuisance and poor effluent quality has a cumulative effect on the receiving environment.

Watercare is constructing a public water and wastewater system to support the growing populations of Kumeu, Huapai and Riverhead; Phase 3 of the project is currently underway. The construction of the Kumeu, Huapai and Riverhead local wastewater reticulation and connections to the wastewater system will be available from July 2012. When complete, the north western trunk sewer and pump stations will carry wastewater for treatment from Kumeu, Huapai and Riverhead to either the Mangere or Rosedale wastewater treatment plants.

In 2009, the Auckland Regional Council received a number of odour complaints from a wastewater treatment and disposal system servicing a mixed use residential/commercial block in Kumeu. Andrew.Stewart Ltd were engaged by the client to provide engineering and planning services which included a 'fit for purpose' assessment of the existing treatment system, a new resource consent application and a new upgraded treatment and disposal system. The client wanted a solution that was cost effective due to the proposed reticulation of Kumeu Township, had low operating costs (power, maintenance), produced a high quality effluent and a modular system that could be decommissioned and relocated to another site.

The residential/commercial block includes a cafe, a Chinese restaurant, offices and a small dairy/grocery store. In 2001, a Bioflow 2000 system was installed to treat the wastewater to secondary standard prior to disposal via a PCDI disposal system. For a number of reasons the system was unable to treat the strong wastewater generated from the commercial block and partially treated wastewater was discharged to land resulting in regular odour complaints from neighbouring businesses.

It was quickly determined that refurbishing/upgrading the existing treatment system was uneconomic due to the small tank sizes and lack of space for a grease trap and buffer tank. Andrew.Stewart Ltd presented the client with a number of options to produce secondary effluent quality prior to land application of treated wastewater.

2 WASTEWATER TREATMENT OPTIONS

Following a period of flow monitoring the average and peak wastewater volume generated by the residential/commercial block was determined to be 1,600 litres/day. A number of grab samples from the existing septic tank were also collected to determine the strength of the wastewater. Following discussions with the ARC, it was agreed that a minimum effluent quality of 30:30 (BOD:SS) was required prior to land disposal.

As part of the process design, a number of treatment processes were considered. The following alternative treatment options are discussed below:

- Conventional aeration plants
- Membrane Bioreactors (MBR's)
- Textile packed bed reactors

CONVENTIONAL AERATED TREATMENT PLANT

Conventional aerated treatment systems have been installed throughout New Zealand to treat wastewaters of similar origin, volume and strength. They can be designed to meet the effluent quality of 10:10 (BOD:SS). However, when compared to the existing technology, aeration plants rely on more mechanical equipment, utilise more power and their performance can often be compromised by wide swings in load (hydraulic and organic).

MEMBRANE BIOREACTORS (MBR'S)

MBR's are a variant of the conventional aerated treatment plant but utilise a membrane for solid liquid separation instead of a gravity settlement process. MBR's produce a very high quality effluent but in this situation they were not considered to be suitable because of the following reasons:

- sludge management – although they produce low volumes of sludge, they require desludging on a frequent basis
- power – high power usage when compared to the existing technology
- membrane replacement every 7-10 years
- complex control and regular maintenance required
- highly mechanical treatment plant
- very high capital costs

TEXTILE PACKED BED REACTORS

Textile packed bed reactors (rPBR's) are a variant of the recirculating sand filter (RSF) and have a very good track record for treating wastewater from facilities where there is a high seasonal change in organic load or flow. In this case, textile filters also had the following benefits:

- well known to the current service provider
- consistently high quality effluent is produced
- low power users
- small footprint
- sludge production is kept to a minimum

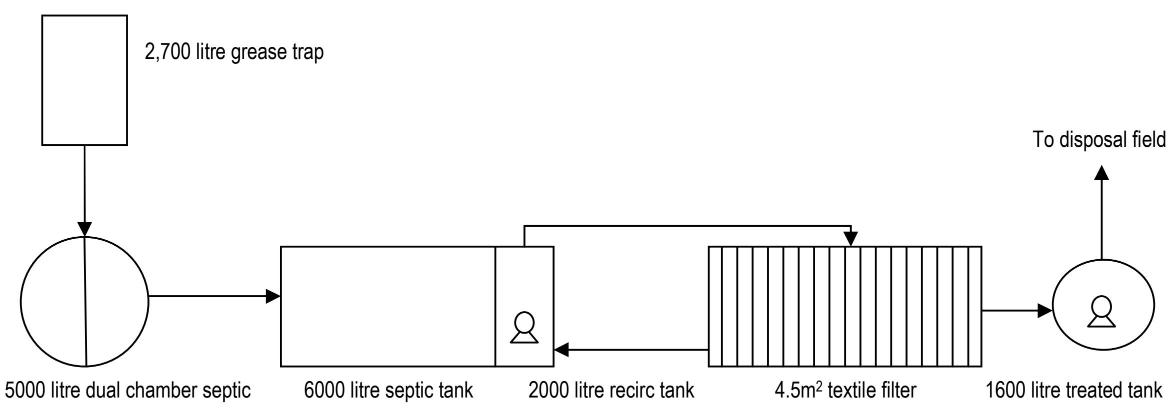
2.1 TREATMENT PLANT UPGRADE

A recirculating packed bed reactor was selected, as it was determined to be the most stable treatment system capable of handling fluctuating loads while having the smallest footprint. Two providers of this technology were asked to provide proposals based on a performance based specification and the installation and maintenance contract was awarded to Jet Water and Waste Systems Ltd. The Jet treatment system had been under development for a number of years and this was the first commercial system installed within the Auckland Region.

Jet have developed a number of unique features that assist in producing a high quality effluent: These are:

- the packed bed reactor has an inbuilt solids removal system incorporated into the unit that reduces biomass sloughed from the textile being returned to the recirculation tank. Accumulated solids are periodically returned to the septic tank
- textile bed depth is long to promote a diverse population of heterotrophic and autotrophic micro-organisms
- the plant has been designed to prevent textile bridging
- an increased reactor depth allows free drainage of wastewater from the textile and prevents continual saturation, thereby improving treatment efficiency

Figure 1:Schematic Drawing of the Wastewater Treatment System



The installed system is diagrammatically shown in Figure 1, and comprises of the following components:

- 2700 litre grease trap – constructed of fibreglass to resist attack from organic acids.
- 5000 litre dual chamber primary septic tank – receives untreated wastewater from the commercial development and is designed to buffer peak flows in excess of 1,600litres per day.
- 6000 litre septic tank fitted with effluent filter – this tank allows for more than 72 hours detention, sufficient for primary treatment. The effluent filter screens solid particles greater than 3mm in diameter reducing solids carryover to the secondary treatment system.
- 2000 litre recirculation tank – provides timer controlled dose loading to the packed bed reactor.
- 4.5 m^2 packed bed reactor – the primary treated effluent percolates through the packed bed textile and collects at the bottom of the reactor where it gravity feeds back into the recirculation tank. Depending on the flows 100% of the

secondary treated effluent is returned to the reactor for dilution and further treatment. Under constant flow conditions, 20% (4:1 ratio) is split off and directed to the treated effluent tank. The textile media provides a large surface area for biological attachment and growth. It is the biological activity that treats the wastewater.

- 1600 litre pump chamber – a float controlled pump delivers high quality advanced secondary treated effluent in controlled doses to land disposal.

There are a number of other benefits to the client from installing the treatment system:

- when the Kumeu Township is reticulated in 2012, the grease trap and pump station will be reused
- the grease trap and treatment system is manufactured from fibreglass which resists attack from organic acids generated in aggressive anaerobic conditions
- the system has been designed to treat high strength wastewater
- the plant can be removed and reinstalled elsewhere
- although not required by the resource consent, ammonia reduction/denitrification is achieved.

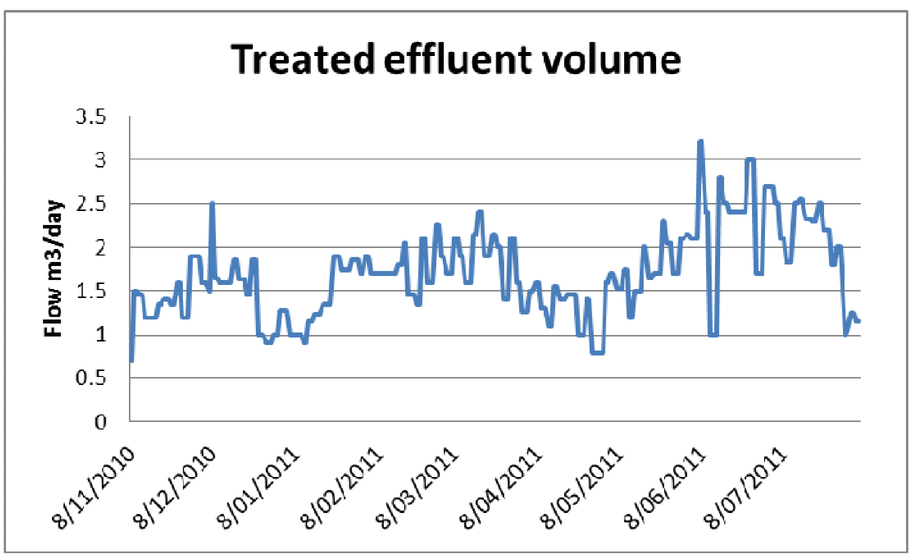
2.2 WASTEWATER DISPOSAL

As part of the initial site assessment, a subsurface assessment of the soils was carried out by a soil scientist. The soils were category 5/6 clay soils with "moderate to slow draining" characteristics and a low loading rate of 4mm/day used. Disposal of effluent is via approximately 400m^2 of UniRAAM pressure compensating dripper irrigation lines, which ensure an even thin dosing. The dosing lines are installed sub-surface and have been planted. The drippers have a mechanical seal to prevent root intrusion (which can result in disposal fields failing).

3 PLANT PERFORMANCE SINCE COMMISSIONING

The treatment plant has been installed for approximately 12 months and during that time the wastewater treatment system has been operating effectively and well within the predicted effluent quality criteria of 30:30 (BOD:SS). For the period from the beginning of November 2010 to the end of July 2011, the average flow rate through the treatment system was 1700 litres per day, which exceeds the design flow. The wastewater system is consistently loaded and the flows have been exceeding 2000 litres per day regularly since May 2011. This has been attributed to a siphoning toilet and high water use. The treated effluent flows during this period are shown in Figure 2.

Figure 2:Treated Effluent Volume



The treated effluent is sampled (grab) and analysed on a monthly basis to determine plant performance. Table 1 below, shows the current performance of the treatment system.

Table 1: Influent and Effluent Quality

Date	BOD	TSS	Ammonia	Nitrate	pH
Influent (settled sewage prior to outlet filter and after grease removal)					
1st Mar 2010 (Raw)	640mg/l	72mg/l	73mg/l	-	-
10th Aug 2011	410mg/l	64mg/l	47.1mg/l	-	-
Effluent					
1st Dec 2010	5.9 mg/l	6 mg/l	0.7mg/l	0.16mg/l	7.3
19th Jan 2011	<2mg/l	3mg/l	<0.4mg/l	29.7mg/l	7.5
6th Apr 2011	5.7mg/l	10mg/l	1.8mg/l	5.44mg/l	7.3
4th May 2011	5.9 mg/l	6mg/l	2.8mg/l	8.65mg/l	7.5
15th June 2011	3.2mg/l	7mg/l	4.5mg/l	5.47mg/l	7.5
6th July 2011	8.5mg/l	1mg/l	3.5mg/l	8.2mg/l	6.5
10th Aug 2011	2.3mg/l	4mg/l	1.2 mg/l	9.63mg/l	7.0

The treatment plant is meeting its discharge consent requirements of 30:30 (BOD:SS) even though the hydraulic flow through the system is often well over the design flow rate. Indeed, the ammonia removal in the effluent is very good and complete removal is probably not achieved due to a lack of available carbon. Nitrate reduction is facilitated by diverting a portion of the effluent into the second septic tank where the anoxic conditions promote denitrification. It can also be seen that the pH of the treated effluent is consistent even though a large amount of alkalinity is being consumed via nitrification. This is due to regular doses of hydrated lime added to the system which improves effluent quality and facilitates Nitrogen removal.

Jet Water and Waste are monitoring the plant on a weekly basis to ensure that the effluent quality is consistently meeting 30:30. This is not part of the maintenance agreement with the client and allows Jet to collect performance information on their treatment system. Regular weekly measurement of D.O. and pH in the recirculation and treated effluent tanks, and adjusting the recirculation ratios has improved effluent quality. pH control and providing sufficient alkalinity is critical for biological treatment, especially nitrification and denitrification. Regular addition of hydrated lime and monitoring of the wastewater keeps the pH at 7.5, and provides sufficient alkalinity for nitrogen reduction.

4 CONCLUSIONS

Installing a new advanced secondary treatment plant and disposal system has enabled the owners of a small residential/commercial block to meet their discharge consent requirements following a series of odour complaints, poor effluent quality and the threat of abatement notices. The solution had to be cost effective, produce high quality effluent and also have the ability for the plant to be relocated to another site when the rural West Auckland township of Kumeu is reticulated for sewage in 2012.

The Jet Commercial textile plant has been developed to treat high strength wastewater generated from cafes, restaurants and takeaways. Smart engineering design and providing robust operation and maintenance as part of the package, ensures that the system works effectively, producing a very high quality effluent even when the design flows are being exceeded.

The quality of the treated effluent produced by the treatment plant is of a very high standard with very low residual BOD and TSS. Ammonia reduction via nitrification and nitrate reduction by denitrification are achieved by the regular monitoring of pH/alkalinity and dosing hydrated lime into the plant.

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