21 April 2022

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CRC221846 – Marriott-Haugh

Hi Rachael

This letter responds to your email requesting further analysis of the effects of the onsite wastewater discharge Karen Marriot-Haugh and Stephen Haugh 46 McGrath Road, Ashburton. I delayed sending this to you as I was waiting for new drawings from Environmental Technology (ET) for the recirculating version of their AES wastewater treatment system.

1 Introduction

Mark Trewartha from ECan groundwater has reviewed the information we provided regarding effects of nitrate-nitrogen and pathogens on groundwater for the discharge of onsite wastewater from the proposed subdivision. The questions asked by Mark Trewartha are addressed in this report.

The applicants have decided they will install the AES recirculating advanced treatment system (including UV disinfection) with discharge to land through a sand bed to reduce the concentrations of contaminants to below the long term groundwater quality targets of the Land and Water Regional Plan (LWRP), considering the issues with groundwater nitrate concentrations in this location, and the fact that residents in this area typically source drinking water from private bores.

In the initial RMA s92 request for further information we provided an assessment of an alternative treatment system, the AES with recirculation. The applicant now proposes using this system, or an alternative system that will provide at least the same treatment level, on the land area.

AES is a passive, on-site advanced secondary wastewater treatment system supplied by Environmental Technology Ltd (ET) from Nelson. The domestic wastewater is pump or gravity fed from a septic tank to be treated within specially designed, passively aerated pipes laid in a sand bed, using naturally occurring microbes. The highly-treated effluent is then evenly dispersed via perforations in the AES pipes into the sand bed for further treatment. See appendices5 & 6 for graphics of the AES system.

The AES system is typically used as a single pass bottomless sand filter; however it can also operate in a recirculation mode to increase the level of contaminant removal. In recirculation mode the AES sand bed is contained so the effluent can be recirculated back to the septic tank a number of times to achieve higher levels of denitrification of nitrate-N to N_2 gas. The denitrification is enhanced as the denitrification microbes use the carbon rich effluent in the low oxygen environment in the septic tank to convert the nitrate. The OSET NTP Trial for this system in 2017/18 achieved a nitrate-N concentration of 7.8 mg/L using a recirculation factor of 500% (OSET Performance Certificate in appendix 4). ET have recorded higher levels of N reduction with increased recirculation factors in short test periods.

The OSET test summary notes that In terms of effluent quality, the Environment Technology AES-38 plant performed consistently well overall, with low and stable BOD, TSS, and TN results throughout, including through the geothermal influent event. There was no impact upon performance due to varying influent concentrations, cold winter temperatures, or the high flow test, apart from a minor increase in TN for the first week after high flows, which immediately returned to normal. Overall, the plant achieved total nitrification with no NH_4-N throughout, resulting in low total nitrogen concentration of <12mg/L, and a median of only 7.7mg/L. The OSET NTP test summary table is shown below, and the full report is appended.

Benchmark Ratings

The Environment Technology AES-38 R & R/UV treatment plant achieved the following effluent quality ratings:

Indicator Parameters	Median	Std Dev	Rating	Rating System				
				A+	*A*	*B*	*C*	*D*
BOD (mg/L)	*2*	*0*	A+	*<5*	*<10*	*<20*	*<30*	*≥30*
TSS (mg/L)	*1*	*1.1*	A+	*<5*	*<10*	*<20*	*<30*	*≥30*
Total Nitrogen (mg/L)	*7.7*	*1.6*	A	*<5*	*<15*	*<25*	*<30*	*≥30*
NH_4- Nitrogen (mg/L)	*0*	*0*	A+	*<1*	*<5*	*<10*	*<20*	*≥20*
Total phosphorus (mg/L)	*3.5*	*0.4*	B	*<1*	*<2*	*<5*	*<7*	*≥7*
E.coli (cfu/100mL)[1]	*2*[1]	*16*	A+	*<10*	*<200*	*<10,000*	*<100,000*	*≥100,000*
Energy (kWh/d) (mean)	*1.98*[1]	*0.14*	B	*0*	*<1*	*<2*	*<5*	*≥5*

[1]The *E.coli and Power* results are whilst UV disinfection was operating.

For this proposal the treated effluent is discharged to land via a second sand bed. As the sand bed option utilises two sand beds, there is potential for higher reductions in both nitrogen and microbial concentrations. The sand bed that discharges the treated wastewater to land is the same design as that provided with the application.

The treatment system, which includes UV disinfection, also results in a low concentration of microbes, with E. coli median concentration in the trial of 2 cfu/100 ml. The assessment of microbial removal estimates a 5.7 Log_{10} removal rate by the time the groundwater reaches the nearest down gradient bore located about 80 metres distance (assessment in appendix 1).

Table 13(i): Limits/Targets for Groundwater

Contaminant	Measurement	Limits/Targets
Nitrate-N	Annual average concentration[1]	6.9 mg /L (Target to be met by 2035)
E. coli	Annual median concentration[1]	< 1 organism/100 millilitres (Limit)
Other contaminants [2]	Any sample[1]	<50% MAV [3] (Limit)

1 *Groundwater quality is determined as the median concentration across the Canterbury Regional Council's quarterly groundwater monitoring bores (screened <30 m below the ground level).*

2 *Other contaminants of health significance as listed in NZ Drinking-water Standards*

3 *Maximum acceptable value (as listed [2] above)*

2 Nitrogen

The review of the nitrogen modelling identified areas where more information and clarification is required. We have answered these questions for the revised system proposed to treat the wastewater on this site.

OSET Performance Certificate – AES -38 R

The On-site Effluent Treatment National Testing Programme (OSET-NTP) Performance Certificate for the AES-38 R secondary wastewater treatment system is appended.

Nitrogen reduction through a recirculating intermittent sand filter

The standard AES recirculating system is a single pass recirculating intermittent sand filter. There have been a number of studies worldwide looking at nitrogen reduction through this type of filter, some of which we comment on following.

A study by Converse et al[1] evaluated 47 sand filters in Wisconsin where primary septic tanks discharge domestic wastewater to single pass sand filters. The median total nitrogen (TN) concentration of the septic tank effluent was 55 mg-N/L, reducing to 32.7 mg-N/L at the bottom of the sand trench, a reduction of 40.5%. Nitrate-N made up most of the N in the wastewater after passing through the sand filter. This study shows that on average over 22 mg-N/L of the TN at the top of the sand filter had been transformed through the sand trench and lost to the environment, typically as N_2 gas, while passing through the sand filter. This requires the nitrification of the ammonia to nitrate as well as denitrification of the nitrate to N_2 gas as the wastewater passes through the filter.

The difference between the wastewater treatment systems in this study with only primary treatment in a septic tank and the secondary system proposed for the applicant is that in the wastewater from septic tanks the majority of the N discharging to the sand filters is in non-mineral forms such as ammonia (NH3), which is converted to nitrate in the sand filter.

Almost all of the N discharging from a secondary treatment system to the sand filter will be in the form of nitrate. This suggests that there is a transformation of the NO_3-N to N_2 gas as the wastewater moves through the sand filter, as was shown in the studies mentioned. The question is how much. The study referenced showed a 40% reduction in N concentration on average.

Pell and Nyberg (1989)[2] found typical nitrogen removals of 18 to 33 percent with their intermittent sand filter study.

USEPA Onsite Wastewater Treatment Systems Manual in table 4-16 noted a range in N reduction of 9.64% – 47.3% for single pass sand filters, and 45.22% - 75.72% for recirculating sand filters over number of studies. This table is appended.

EPA: Wastewater Technology Fact Sheet - Intermittent Sand Filters (1999) states that a study of 30 systems showed average reduction in total nitrogen from 61.8 mg-N/L down to 37.4 mg-N/L, a decrease in concentration of 40%, through single pass intermittent sand filters. The majority of the TN had been nitrified to NO_3. The following table summarises those results.

[1] Authors are Matthew M. Converse, M.S. former Graduate Research Assistant, and James C. Converse Ph.D. P.E. Professor, Biological Systems Engineering, College of Agriculture and Life Sciences, University of Wisconsin Madison. Research funded by Small Scale Waste Management Project (SSWMP). Department of Soil Science, 1525 Observatory Drive, Madison, WI 53706. www.wisc.edu/sswmp/

[2] Pell, M., and F. Nyberg. 1989. Infiltration of wastewater in a newly started pit sand filter system. Journal of Environmental Quality 18(4):451-467.

TABLE 3 COMPARISON OF EFFLUENTS FROM SINGLE-FAMILY, RESIDENTIAL SEPTIC TANKS AND ISFs FOR 30 SYSTEMS IN PLACER COUNTY

Effluent Characteristic	Septic Tank Effluent	ISF Effluent	% Change
$CBOD_5$	160.2 (15)*	2.17 (44)*	98
TSS	72.9 (15)*	16.2 (44)*	78
NO_3-N	0.1 (15)*	31.1 (44)*	99
NH_3-N	47.8 (15)*	4.6 (44)*	90
TKN	61.8 (15)*	5.9 (44)*	90
TN	61.8 (15)*	37.4 (44)*	40
TC	6.82 x 105 (13)*	7.30 x 102 (45)*	99 (3 logs)
FC	1.14 x 105 (13)*	1.11 x 102 (43)*	99 (3 logs)

*Number of samples

$CBOD_5$, TSS, and nitrogen expressed as mg/L; arithmetic mean. Fecal and total coliform expressed as geometric mean of MPN/100 mL.

Source: Cagle and Johnson (1994), used with permission from the American Society of Agricultural Engineers.

The nitrogen reduction modelling submitted in the request for further information used a total N reduction factor of 35%, citing Crites et al 1998 Table 11-13 p 743 noted a total N reduction factor of 35% in recirculating sand filters.

The proposed AES recirculating treatment system will comprise two sand beds. The first sand bed contains the AES pipes, through which the wastewater will be recirculated a number of times. The treated effluent is then discharged to ground through the second sand bed, in which there is expected to be further reductions in both nitrate-N and microbial concentrations.

We consider that using a reduction in TN concentration of 25% through the sand filters (one recirculating and one single pass) is supported by these studies and is appropriate for this proposal.

N loss in the soil below the sand filter

The nitrogen reduction modelling in the application assumed that 20% of the TN would be denitrified to N_2 gas below the land application system.

The USEPA Manual notes that several studies indicate that denitrification in the soil can be significant. Jenssen and Siegrist (1990)[3] found in their review of several laboratory and field studies that approximately 20 percent of nitrogen is lost from wastewater percolating through soil.

As there is limited local evidence that of denitrification in the subsoil we have removed this potential reduction from the modelling of nitrogen losses..

Revised nitrogen loss calculation

Reducing the TN reduction through the sand filter and removing N reduction in the sub-soil below the sand filter from the calculation leaves the TN concentration when the wastewater enters the groundwater reduces the TN of the treated wastewater from 7.8 mg/L to 5.9 mg/L (assessment in appendix 2). The calculation is appended, and

[3] Jenssen, P.D., and R.L. Siegrist. 1990. Technology Assessment of Wastewater Treatment by Soil Infiltration Systems. Water Science Technology, Vol. 22.

spreadsheet attached electronically. For this proposal the design daily wastewater volume is calculated to result in a discharge to land of 3.0 kg N/year.

N mixing in the groundwater

We have included a calculation of the effect of this wastewater on the TN concentration of the groundwater flowing under the site (appendix 3). A reduction in groundwater N concentration will be expected when the treated wastewater is mixed with groundwater that has a higher N concentration. This assessment estimates that change in groundwater N concentration.

When the treated wastewater reaches groundwater, it mixes with the groundwater. This assessment uses a mass mixing model to assess the potential change in groundwater nitrogen concentration. The mass mixing model is detailed in Environment Canterbury publication "Guidelines For Determining Significance Of Environmental Impacts Resulting From Use Of Water For Irrigation" (appended). This model calculates the volume of ground water that will flow under the land application system over a year, and the volume of wastewater that will be added to this system under the sand filter. The model calculates the concentration of the TN in the groundwater after mixing in the aquifer.

Mark Trewartha noted that the parameters in the model were different to those in the example provided with the ECan report on the model. The changes are:

- Concentration of N in groundwater –model uses the highest GW nitrate concentration in neighbouring bores
- Transmissivity – calculated using the geomean of transmissivity from nearby aquifer tests (bores listed in the analysis)
- Mixing depth – we initially used a 10m aquifer depth with an 8m mixing depth (aquifer depth less water level). In this assessment we retained the 2m mixing depth of the model.

AES-38 R to sand bed

Assumptions

Design wastewater volume	1,400 L/day	
Treatment	AES-38 R or similar	
Land application system	Sand bed – 28 m^2	
Concentration of N in groundwater	15 mg/L	From groundwater quality tests
Concentration of N in treated wastewater	5.9 mg/L	Assessment
Transmissivity	4372 m/day	Geomean of aquifer tests
Aquifer depth	10 m	
Mixing depth	2 m	Aquifer depth less base water level
Hydraulic gradient	0.00059	Piezometric contours
Drainage from land application system	20.86 m^3	Calculated in model

Results

N concentration of groundwater after mixing	14.95 mg/L
Change in N concentration of groundwater	-0.05 mg/L

The model estimates that there will be a reduction in groundwater N concentration after the treated wastewater is mixed with the groundwater flowing under the sand bed land application system.

3 Impacts of the proposed activity on groundwater limits and targets

Table 13(i) of the LWRP refers to limits and target for groundwater in the Ashburton sub-region. The limit for nitrate-N is an annual average concentration of 6.9 mg/L to be met by 2035.

Table 13(i): Limits/Targets for Groundwater

Contaminant	Measurement	Limits/Targets
Nitrate-N	Annual average concentration[1]	6.9 mg /L (Target to be met by 2035)
E. coli	Annual median concentration[1]	< 1 organism/100 millilitres (Limit)
Other contaminants [2]	Any sample[1]	<50% MAV [3] (Limit)

[1] *Groundwater quality is determined as the median concentration across the Canterbury Regional Council's quarterly groundwater monitoring bores (screened <30 m below the ground level).*

[2] *Other contaminants of health significance as listed in NZ Drinking-water Standards*

[3] *Maximum acceptable value (as listed [2] above)*

The treatment system proposed for this on-site wastewater system is predicted to reduce the N concentration in the wastewater from the dwelling from about 60 mg/L to about 5.9 mg/L by the stage the wastewater intercepts groundwater. This N concentration is less than that expected in the groundwater in this location and is also less than the limit average concentration for 2035.

4 Summary

The proposed use of an AES-38 R recirculating sand filter to treat the wastewater to a secondary standard and sand bed to discharge the treated wastewater to land will ensure that the effects of the activity on the groundwater and on surrounding groundwater users will be less than minor. The predicted N concentration of less than 6 mg/L leaving the base of the system will help meet the 2035 target groundwater N concentration of 6.9 mg/L.

Gary Rae
Environmental Consultant
21 April 2022

Appendices

1. Microbial Loss Calculation
2. Nitrogen Concentration Calculation
3. Nitrogen Mass Mixing Model Calculation
4. OSET NTP Performance Certificate for AES-R System
5. AES Components
6. AES-R Drawing
7. Sand Filter Evaluation – Converse et al
8. USEPA – Sand Filter Performance

Appendix 1: Microbial Loss Calculation

Microbial Removal in Subsurface Media

Marriott-Haugh, McGrath Road Ashburton

Contaminant source On-site treatment system - AES Recirculating Sand Filter to Sand Bed LAS

Subsurface Media	Description	Depth/Length (m)	Removal Rate (log/m)	Total Log_{10} reduction	Source (Pang)
Soil				0.0	Table 10
AES-R sand bed	2A Sand (single pass, will pass 5X)	0.6	4.2	2.5	Table 10
LAS Sand bed	2A Sand	0.6	4.2	2.5	Table 8
Vadose zone	Sandy gravels	1.1	0.36	0.4	Table 11
Aquifer	to nearest downgradient dwelling	78	0.004	0.3	Table 12
Total Microbial Log_{10} Reduction				5.7	
Percentage reduction				100.000%	

Notes
Assumes 78 metres from land treatment system to the nearest down gradient bore
Minimum separation distance to groundwater of 500 mm

Appendix 2: Nitrate-Concentration Reduction Calculation

Nitrogen discharge to land

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Treatment system	AES Recirculation
Treatment level	Advanced secondary treatment with recirculation (500%)
Land application system	Sand bed (600mm)
Land area	5,000 m^2

Table 1: Total Nitrogen Assessment

Calculation of Total N in the Domestic Effluent			
Daily occupancy	7	persons	Maximum design occupancy
Daily volume	200	L/person/day	Environment Canterbury - no reeduction fixtures
	1400	L/day	
Days occupancy/year	365	days	
Total N Concentration of influent	60	mg/L	Average concentration from AS/NZS 1547:2012, Table S1
Total N in wastewater	12	g/person/day	
	4.38	kg/person/year	
	30.7	kg/house/year	
Calculation of N reduction in treatment system			
Total N reduction in treatment plant	87%		Calculation to achieve OSET average N concentration
Total N concentration after treatment plant	7.8	mg/L	OSET NTP Trial 13 - AES-R discharge mean N concentration
Total N reduction in sand column	25%		EPA[2], Converse, Crites[3]
Total N concentration after sand column	5.85	mg/L	
Total N reduction over untreated effluent	90%		Calculated N reduction
Total N load exiting sand trench	**3.0**	kg/yr	5.85 mg/L * 1400 L/day *365 days/year
Total N exiting sand trench	**6.0**	kg/ha/yr	Over the total land area of 5000m2
N concentration below LAS	**5.9**	mg/L	Calculated N concentration ignoring rainfall
Calculation of N reduction below land application system			
Total N reduction by denitrification	0%		No reduction modelled
N concentration at groundwater	**5.9**	mg/L	
Total N load to groundwater	**3.0**	kg/yr	5.85 mg/L * 1400 L/day *365 days/year
	6.0	kg/ha/yr	Over the total land area of 5000m2

Notes:
(1) OSET Trials
(2) US EPA (2002) suggests 18 -33% TN reduction for primary treated effluent in a sand bed, Converse suggests 40%.
(3) Crites at al 1998 suggests 28 -50% TN reduction for secondary treated effluent in a sand bed. 25% has been used in this assessment

Appendix 3: Nitrogen Mass Mixing Model Calculation

Nitrogen concentration in groundwater after mixing

Marriott-Haugh & Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Design wastewater volume	1600 L/day
Treatment system	AES - Recirculating
Treatment level	Advanced secondary treatment
Land application system	Sand bed (600mm)
Land area	5,000 m2

Calculation of Nitrogen concentration in groundwater after mixing				Calculation Co = (CiQn + CnQn)/(Qi + Qn) - Note 1
Concentration of N in groundwater	**Cn**	15	mg/L	Assumed
Concentration of N in wastewater input	C_1	5.9	mg/L	N reduction calculation spreadsheet
Flow of groundwater				
Transmissivity		4372		Geomean of aquifer tests in surrounding bores (see calculation)
Aquifer depth		10	m	
Hydraulic conductivity (T/Depth)		437		
Mixing zone	(z)	7	m	Aquifer depth = 10 m, water level = 2 m, mixing zone = 8 m)
Hydraulic gradient (i)		0.0059		Rangitata Hinds Sallow 2006 (15m/2555m)
Q_n		6557.481	m^3	GW flow over year
Flow of input (drainage)				
Length of LAS parallel to direction of GW flow		1.8	m	
Additional drainage		20.86	m	Drainage from wastewater applied to LAS - see calculation
Q_i	(L * 1m * additional drainage)	37.548	m3	Annual drainage through LAS
N Concentration of groundwater after mixing		14.95	mg/L	N concentration of drainage mixed with groundwater
change in N concentration		-0.05	mg/L	

Bores for Transmissivity		
L37/0720	41.2	9000
L37/0030	38	8500
L37/1171	30	1600
L37/1430	50.79	3574
BY21/0068	90	3650
Geomean		4372

Note 1: Ecan document - GUIDELINES FOR DETERMINING SIGNIFICANCE OF ENVIRONMENTAL IMPACTS RESULTING FROM USE OF WATER FOR IRRIGATION

Appendix 4: OSET NTP Performance Certificate for AES-R

ROTORUA LAKES COUNCIL | water NEW ZEALAND The New Zealand Water & Wastes Association Wairoa Aotearoa | Bay of Plenty REGIONAL COUNCIL

On-site Effluent Treatment National Testing Programme (OSET NTP)

General Performance

There were no equipment failures (apart from a discharge pump replacement prior to commencement of testing) or attendance other than an inspection in Week 20 to turn the UV system on and clean the UV Teflon tube, during which neither plant nor control settings were modified.

In terms of effluent quality, the Environment Technology AES-38 plant performed consistently well overall, with low and stable BOD, TSS, and TN results throughout, including through the geothermal influent event. There was no impact upon performance due to varying influent concentrations, cold winter temperatures, or the high flow test, apart from a minor increase in TN for the first week after high flows, which immediately returned to normal. Overall, the plant achieved total nitrification with no NH_4-N throughout, and low levels of TOXN, resulting in low Total Nitrogen of <12mg/L, and a mean of only 7.8mg/L.

Bacteria reduction was also good, with the AES-38 R plant effluent containing 1,900-18,000cfu/100mL faecal coliforms. After the UV unit was switched on in Week 20, low *E.coli* results were achieved with a median of 2cfu/100mL and 80% <3cfu/100mL.

The plant's power usage was around 0.9kWh/day in the AES-38 R mode, and 2.1kWh/day in the AES-38 R/UV mode.

AS/NZS 1547:2012 Secondary Effluent Quality Requirements

These requirements are that 90% of all test samples must achieve a BOD_5 of $\leq$ 20 g/m^3 and TSS of $\leq$ 30 g/m^3 with no one result for BOD_5 being >30 g/m^3 and no one result for TSS being >45 g/m^3.

The Environment Technology AES-38 R & R/UV treatment plant had **100% of BOD_5** results and **100% of TSS** results within the **Secondary Effluent Quality** requirements for both the 90 percentile and maximum limits above. **The AES-38 R & R/UV plants therefore achieved AS/NZS 1547 secondary effluent quality performance requirements** when operated at 1,000 L/day, which is the manufacturer's advised operational flow design capacity.

AS/NZS 1547:2012 Secondary Effluent Quality with disinfection Requirements

These requirements are additional to the secondary effluent quality requirements and require the plant to achieve *E.coli* levels comprising a median ≤10cfu/100mL, with 80% of samples ≤20cfu/100mL, and no sample to exceed 100cfu/100mL

The UV unit was turned on in Week 20 from when the plant performed as an AES-38 R/UV system. Transmissivity, and Turbidity were tested from Week 25 and *E.coli* from Week 28. The results showed that the effluent had high Transmissivity with a median of 72%, and low Turbidity with a median of 2NTU. *E.coli* results varied from 1 to 34cfu/100mL, with 80% of samples ≤5cfu/100mL, and a mean of 1cfu/100mL. **The Environment Technology AES-38 R/UV plant therefore had 100% compliance with the requirements of this standard for secondary treatment plants with disinfection.**

On-site Effluent Treatment National Testing Programme (OSET NTP)

PERFORMANCE CERTIFICATE
Environment Technology AES-38 R & AES-38 R/UV
OSET NTP Trial 13, 2017/2018

System Tested

The Environment Technology AES-38 R & R/UV treatment plant comprising a passive aerobic proprietary bed treatment system with treated effluent recirculation through the septic tank, plus a phosphorus reduction filter and UV disinfection (turned on from Week 20 of the testing program) participated in Trial 13 of the On-site Effluent Treatment National Testing Programme (OSET NTP). This commenced on 23 October 2017 and ran over ten months (44 weeks) during which the treated effluent discharge was monitored generally every six days. The Environment Technology AES-38 R & R/UV treatment system tested had a rated capacity of 1,026L/day (38L/m/day of AES pipe) and a maximum capacity of 2,025/day (75L/m/day of AES pipe). The plant comprised a 5,000L septic tank, a 2.25m wide x 8m long x 0.9m deep AES bed configured as a Combination System comprising two lines supplied via a distribution box, with each line comprising a Basic Serial Pipeline in accordance with ET's installation manual, followed by a 630L recirculation tank with a Waste-180VA 2,000L/h recirculation pump (operated 144 min/day discharging to the septic tank), plus a 200L phosphorous reduction chamber, a Salcor UV-3G unit and a 45L effluent pump station. The emergency storage below the bed and in the pump station is 1,307L.

The service requirement is annual for the R/UV plant and 4 yearly for the R plant for septic tank cleaning.

Test Flow Rate

The Environment Technology AES-38 R & R/UV treatment system was tested at 1,000L/day (equivalent to servicing a 3-bedroom 5 to 6 person household) over an 10 month (40 week) period November 2017 to August 2018 including a 1 month (4 week) high load effects test involving 5 days at 2,000L/day then 1,000L/day over the following 3 weeks. Note that the manufacturer's advised design capacity for this plant is 1,400L/day.

Testing and Evaluation Procedures

A two-month (8 week) media development and settling-in period was initially proposed, but this was extended to 12 weeks due to an unscheduled geothermal waste influent flow on 23 November, followed by extreme weather events in Rotorua, resulting in widespread flooding and high infiltration into the sewerage system, along with an electrical storm impacting on the testing facility control system in early December. Ten samples were taken during this period (Weeks 4 to 12). The Environment Technology AES-38 R & R/UV treatment system did not appear to be affected by either the geothermal influent or weather events.

The performance evaluation testing programme followed involving a three-month pre-benchmarking period (20 samples over Weeks 13 to 28), and a three-month benchmarking period (19 samples over Weeks 29 to 40). Within each block, a five-day consecutive sample period occurred (Weeks 25 and 34). A one-month high load assessment period followed in Weeks 42 to 44 (three samples).

The 39 samples taken through the pre-benchmarking and benchmarking periods were used to assess treatment performance against the **Secondary Effluent Quality** requirements for biochemical oxygen demand (BOD_5) and total suspended solids (TSS) defined by AS/NZS 1547:2012 as set out in AS/NZS 1546.3:2008

A total of 19 treated effluent samples of organic matter (BOD_5), total suspended solids (TSS), total nitrogen (TN), ammonia nitrogen (NH_4-N), total phosphorus (TP) and faecal coliforms (FC) at generally six day intervals during weeks 28 through 40 were tested and the results benchmarked and rated on their median values.

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Bay of Plenty REGIONAL COUNCIL

On-site Effluent Treatment National Testing Programme (OSET NTP)

Benchmark Ratings

The Environment Technology AES-38 R & R/UV treatment plant achieved the following effluent quality ratings:

Indicator Parameters	Median	Std Dev	Rating	Rating System				
				A+	*A*	*B*	*C*	*D*
BOD (mg/L)	2	0	A+	<5	<10	<20	<30	≥30
TSS (mg/L)	1	1.1	A+	<5	<10	<20	<30	≥30
Total Nitrogen (mg/L)	7.7	1.6	A	<5	<15	<25	<30	≥30
NH_4- Nitrogen (mg/L)	0	0	A+	<1	<5	<10	<20	≥20
Total phosphorus (mg/L)	3.5	0.4	B	<1	<2	<5	<7	≥7
E.coli (cfu/100mL)[1]	2[1]	16	A+	<10	<200	<10,000	<100,000	≥100,000
Energy (kWh/d) (mean)	1.98[1]	0.14	B	0	<1	<2	<5	≥5

[1]The *E.coli and Power* results are whilst UV disinfection was operating.

This Certificate of Performance only applies to the Environment Technology AES-38 R & R/UV treatment plants as described in the 'System Tested' above when operated at 1,000 L/day, which the manufacturers advise is normal flow design capacity.

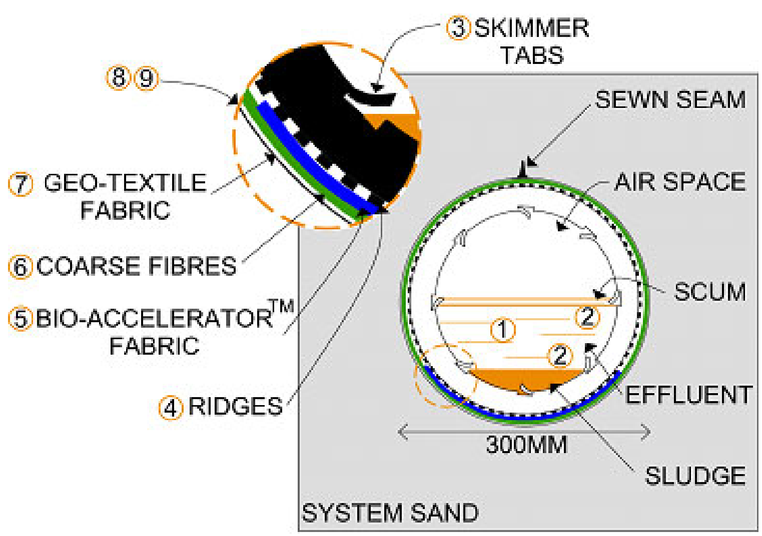
The certificate is valid for 5 years from the date below. For the full OSET NTP report on the performance of the Environment Technology AES-38 R & R/UV wastewater treatment plant contact Dick Lamb/Hazel Pearson, Phone: 03 970 7979, or Email: info@et.nz

Authorised By:

Ray Hedgland, Technical Manager, OSET NTP
27 November 2018

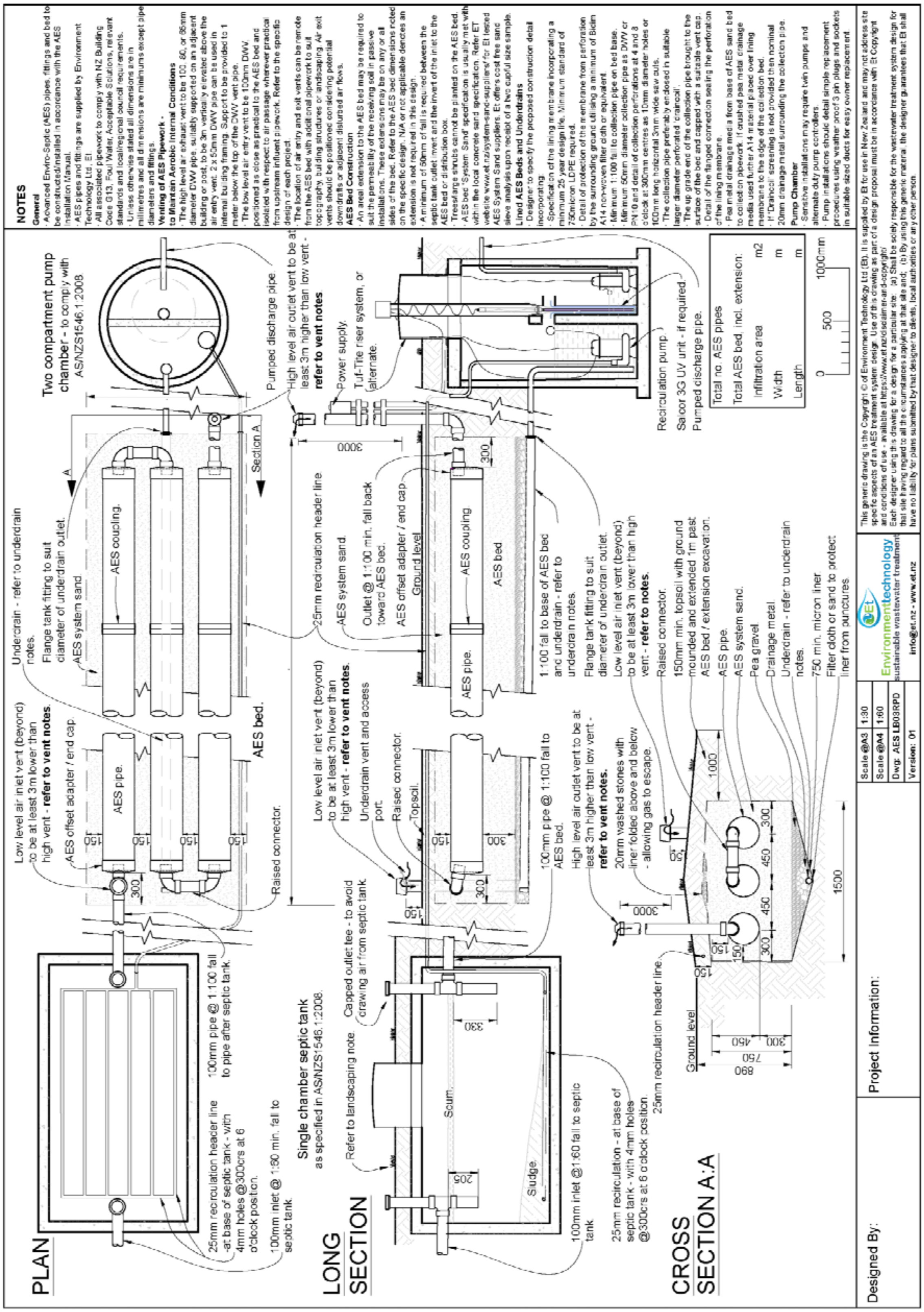
AES Components

AES Pipes



AES Pipes on the Sand Bed

Appendix 6: AES – R Drawing



Appendix 7: Sand Filter Evaluation – Converse et al

PDF of report attached to emailed report.

Table 4-16. Single pass and recirculating filter performance.

Reference	BOD Inf. (mg/L)	BOD Eff. (mg/L)	BOD % Rem.	TSS Inf. (mg/L)	TSS Eff. (mg/L)	TSS % Rem.	TKN Inf. (mg-N/L)	TKN Eff. (mg-N/L)	TKN % Rem.	TN Inf. (mg-N/L)	TN Eff. (mg-N/L)	TN % Rem.	Fecal Coliforms Inf. (#/100mL)	Fecal Coliforms Eff. (#/100mL)	Fecal Coliforms % Rem.	Comments [d,e]
Single Pass Filters																
Cagle & Johnson (1994)[a] California	160	2	98.75	73	16	78.08	61.8	5.9	90.45	61.8	37.4	39.48	1.14E+05	1.11E+02	99.90	Sand media: es=0.25-0.65 mm; uc=3-4. Design hydraulic loadings=1.2 gpd/ft² based on 150 gpd/bedroom. Actual flows not measured.
Effert, et al. (1985)[a] Ohio	127	4	96.85	53	17	67.92	--	--	--	41.5	37.5	9.64	2.19E+05	1.60E+03	99.27	Sand media: es=0.4 mm, uc=2.5. Average loadings=0.4 gpd/ft² / 0.42 lb BOD/1000ft Doses per day=3.3.
Ronayne, et al. (1982)[a] Oregon	217	3	98.62	146	10	93.15	57.1	1.7	97.02	57.5	30.3	47.30	2.60E+05	4.07E+02	99.84	Sand media: es=0.14-0.30 mm; uc=1.5-4.0. Average loadings=0.33-0.70 gpd/ft BOD/1000ft²-day.
Sievers (1998)[a] Missouri	297	3	98.99	44	3	93.18	37	0.5	98.65	37.1	27.5	25.88	4.56E+05	7.30E+01	99.98	Sand media: not reported. Design hydraulic loading=1 gpd/ft². Daily flows not reported.
Recirculating Filters																
Louden, et al. (1985)[a] Michigan	150	6	96.00	42	6	85.71	55	2.3	95.82	55	26	52.73	3.40E+03	1.40E+01	99.59	Sand media: es=0.3 mm, uc=4.0. Average loadings=0.9 gpd/ft²(forward flow) / 1.13 lb BOD/1000ft²-day. Recirculation ratio=3:1. Dosed 4-6 times per hour. Open surface, sprinkler
Piluk & Peters (1994)[a] Maryland	235	5	97.87	75	8	89.33	--	--	--	57	20	64.91	1.80E+06	9.20E+03	99.49	Sand media: es=1 mm, uc=<2.5. Design hydraulic loading3.54 gpd/ft²(forward flow). Actual flows not measured. Recirculation ratio=3:1. Doses per day=24.
Ronayne, et al. (1982)[a] Oregon	217	3	98.62	146	4	97.26	57.1	1.1	98.07	57.5	31.5	45.22	2.60E+05	8.50E+03	96.73	Sand media: es=1.2 mm, uc=2.0. Maximum hydraulic loading (forward flow)=3.1 gpd/ft Recirculation ratio=3:1-4:1. Doses/day=48.
Roy & Dube (1994)[a] Quebec	101	6	94.06	77	3	96.10	37.7	7.9	79.05	37.7	20.1	46.68	4.80E+05	1.30E+04	97.29	Gravel media: es=4.0, uc=<2/5. Design hydraulic loading (forward flow)=23.4 gpd/ft ratio=5:1. Doses per day=48. Open surface, winter operation.
Ayres Assoc. (1998a)[b] Wisconsin	601	10	98.34	546	9	98.35	65.9	3	95.45	65.9	16	75.72	>2500	6.20E+01	>98	Gravel media: pea gravel (3/8-in. dia.). Design hydraulic loading=15 gpd/ft² (forward flow). Recirculation ratio=3:1-5:1. Doses per day=72. Open surface, seasonal operation.
Owen & Bobb (1994)[c] Wisconsin	80	8	90.00	36	6	83.33	--	--	>95	--	--	--	--	--	--	Sand media: es=1.5 mm, uc=4-5. Design hydraulic loading=2.74 gpd/ft² (forward flow). Recirculation ratio=1:1 to 4:1. Open surface, winter operation.

[a] Single-family home filters. [b] Restaurant (grease and oil inf/eff = 119/<1 mg/L respectively). [c] Small community treating average 15,000 gpd of septic tank effluent. [d] 1 gpd/ft² = 4 cm/day = 0.04m³/m²×day. [e] 1 lb BOD/1000ft²×day = 0.00455 kg/m²×day