IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for consents (**APP-2005011178.01**) by the **TARARUA DISTRICT COUNCIL** to the **HORIZONS REGIONAL COUNCIL** for resource consents associated with the operation of the Ekatahuna Wastewater Treatment Plant, including a discharge into the Makahi River, a discharge to air, and a discharge to landvia pond seepage, Bridge St, Ekatahuna

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STATEMENT OF EVIDENCE OF JOHN MILTON CRAWFORD

WASTEWATER ENGINEER

14 MARCH 2017

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1 INTRODUCTION

1.1 My full name is John Milton Crawford.

1.2 I am currently a self-employed engineering consultant. My technical speciality is in wastewater treatment systems, re-use and disposal schemes.

1.3 Prior to this self-employed role, I was employed by Opus International Consultants Ltd (Opus) for a period of 31 years. At Opus, I held the position of Principal Environmental Engineer based in Hamilton. For a period of 10 years, I was also the Technical Leader for Environmental Engineering at Opus.

1.4 My evidence is given in relation to the application for resource consents for the discharges from the Eketahuna Wastewater Treatment Plant ("EWWTP") lodged by Tararua District Council (TDC).

2 QUALIFICATIONS AND EXPERIENCE

2.1 I hold the degree of Bachelor of Engineering (Hons) in Agriculture from the University of Canterbury (1986).

2.2 I am a Chartered Professional Engineer (NZ) and a UK Chartered Engineer. I am a Fellow of the Institution of Professional Engineers New Zealand. I am a member of Water New Zealand, the Institution of Civil Engineers (UK) and the Chartered Institution of Water and Environmental management (UK).

2.3 I have 31 years research and practical experience in the investigation, design and implementation of water and environmental engineering facilities including treatment and disposal systems for municipal and industrial wastewater. I have been responsible for the development of options and design of upgrading for many municipal and industrial clients in New Zealand and overseas. Apart from the subject treatment plant, I have been involved in investigations for, resource consenting, implementation or trouble shooting of wastewater treatment and disposal schemes at some 52 wastewater treatment plants in New Zealand, Singapore, England and Fiji.

2.4 I am currently the lead wastewater consultant for Project Shotover, a project transitioning treatment of the wastes from Queenstown, Arrowtown, Frankton and Lake Hayes areas from oxidation ponds to activated sludge based treatment with disinfection. Prior to that, I was lead wastewater consultant on the Thames Coromandel District Council's Eastern Seaboard Project which involved transitioning the coastal resort towns of Pauanui, Tairua, Whitianga and Whangamata from pond based treatment to activated sludge based treatment with tertiary scrubbing and disinfection.

2.5 In recent years, I have advised on troubleshooting of, upgrading of and or consenting of discharges from oxidation pond based treatment plants at Thames, Porangahau, Porangahau Beach, Ratana, Martin, Leeston, Blenheim, Bulls, Seddon, Havelock, Queenstown, Gore, Kaiapoi, Ashburton, Rangiora and Woodend.

2.6 Because of this experience, I am familiar with very small to very large wastewater schemes and am qualified to comment on issues relevant to the wastewater treatment process currently used in the Ekatahuna Wastewater Treatment Plant ("EWWTP") and, in that context, systems and methodologies that could be used for the EWWTP.

2.7 I am familiar with RMA processes and have completed (in 2006) the certification course 'Making Good Decisions' for RMA Decision makers and have completed the 2008 and 2014 recertification modules.

3 EXPERT WITNESS CODE OF CONDUCT

3.1 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express. The opinions expressed are my own

4 INVOLVEMENT IN THE PROJECT

4.1 I was engaged as Technical Advisor for this project in 2014 as Opus was already assisting TDC with applications for renewal of discharge consents at Woodville, Pahiatua.

4.2 As far as EWWTP is concerned, my role in the project has been limited and has included providing advice to the consent renewal team on the performance improvements that are likely to be gained from the proposed upgrading and advising on wastewater characterisation sampling and testing that should be undertaken to better define loading on and performance of the treatment plant.

5 PURPOSE AND SCOPE OF EVIDENCE

5.1 The purpose of my evidence is to comment on the proposed effluent standards as they affect selection of treatment processes and to identify wastewater treatment processes or combinations of processes that would be suitable for provision of the effluent standards proposed for the EWWTP. My evidence will cover the following topics:

(a) Description of the existing wastewater treatment system (Section 3).

(b) Current levels of performance (Section 4).

(c) Future flows and loading (Section 5).

(d) Proposed levels of performance (Section 6).

(e) Proposed treatment plant upgrading (Section 7).

(g) Discharges to air (Section 8).

(h) Comment on issues raised in the Horizons Regional Council technical officer’s report, and the conditions recommended in that report (Section 9).

5.2 There are a number of technical terms, abbreviations and units used in my evidence. A glossary explaining these is attached as **Appendix 2** to my evidence.

5.3 A summary of my evidence is set out in Section 2 below.

6 SUMMARY OF MY EVIDENCE

6.1 EWWTP consists of a 0.33ha facultative pond followed by a 0.12ha maturation pond. Fine screens provide preliminary treatment. Discharge is via an outfall pipe to the Makakahi River adjacent to the treatment plant.

6.2 EWWTP performance is good in comparison to typical pond based systems in New Zealand with mean $scBOD_5$ and Total Nitrogen at 4 mg/l and 10 mg/l respectively and mean E.coli of 1,0000 MPN/100ml (1,750 MPN/100ml in summer).

6.3 Average day inflow is approximately 638 $m^{3/}$d. However, the true dry weather flow is 144 m^3/d and the peak wet weather flow (from one year of data), appears to be approximately 1900 m^3/d, a multiplier of 13 times. If this data is correct, it represents a reasonably extreme case of inflow and infiltration.

6.4 Considering the treatment plant type and the very limited actual or likely effects of the discharge, I consider the discharge standards proposed herein to be reasonable, sensible and achievable albeit with some additional hydraulic control, clarification and disinfection required to reliably meet these conditions.

6.5 Further works to complete the upgrading necessary to achieve the proposed consent conditions include completion of the inlet screening facility and addition of a chemically assisted clarification device and a UV disinfection system.

6.6 I have reviewed the Horizons Officer's report and generally made comments, where I felt appropriate, throughout the body of my evidence.

7 DESCRIPTION OF THE EXISTING WASTEWATER TREATMENT SYSTEM

Treatment plant

7.1 The Ekatahuna wastewater system includes a reticulation system throughout the town and an oxidation pond based wastewater treatment plant. The reticulation was installed around the year 1910. In the 1970's an oxidation pond system was constructed on the present treatment plant site, discharging the treated wastewater into the Makakahi River. A Ffne screening system has been added to remove gross solids from the incoming raw wastewater and prevent these from causing nuisance and unsightly mess within the treatment plant and downstream of the discharge. However, this screening system has not yet been put into service. A 3kW supplementary aeration device (a Reliant) was added c2014.

7.2 The EWWTP is about 250m north-west of Ekatahuna township at coordinate reference 40°38'35"S and 175°41'53"E on Lot 1 DP 47463 and Lot 2 DP 246.

7.3 The existing EWWTP consists of:

(a) Inlet pump station (currently unused).

(b) Influent fine screening (not yet used).

(d) Facultative pond (0.33ha and approximately 1.5m deep)

(e) 3Kw of mechanical aeration added around 2014.

(f) Maturation pond (0.12 ha and 1.2 m deep).

(g) Outfall pipe directly into the Makakahi River

7.4 The treatment plant services a population of approximately 441 persons. With a reticulated water supply, a typical per capita discharge to the sewer would be approximately 250 l/hd/day, yielding a theoretical dry weather flow of 110m^3/day

7.5 Only plant effluent flow data is available. This data has only been made available to the consent renewal team subsequent to s92 responses being provided to HRC officers.

Flows

7.6 Effluent flow data from EWWTP from January 2016 to January 2017 has recently been made available to me.

7.7 Effluent flow data records from January to April 2016 give a good indication that the average dry weather flow (ADWF = flow after 10 days without rainfall), without significant impact from ground water infiltration is 144m^3/d.

7.8 However, when the entire 2016 record is considered the ADWF is 256 m^3/day. The flow record indicates that, in winter, the plant flows remain significantly elevated for periods of longer than 10 days after rainfall, suggesting a significant influence of infiltration from a seasonally elevated ground water table and inflow from direct connections from roofs or low gulley traps to the wastewater system.

7.9 From the 2016 record, the following statistics are drawn:

(a) True dry weather flow: $144m^3/d$

(b) Annual Average Dry Weather Flow: $256m^3/d$

(c) Average Day Flow: $638m^3/d$

(d) Maximum Day Flow: $1,877m^3/d$

The multiplier from dry to peak wet weather is a multiplier of 13 times. If this data is correct, it represents a reasonably extreme case of inflow and infiltration.

7.10 It is understood that there was considerable damage done to the Ekatahuna sewerage during the large 20 January 2014 earthquake. TDC has done considerable work since to undertake repairs. But there are likely areas still requiring attention. Further, because the reticulation was installed so early in the twentieth century, it is very likely that there are also stormwater connections, such as downpipes, direct to the sanitary sewer system that contribute to the high recorded flows.

Loads

7.11 Because there is no influent characterisation of the wastewater stream available and because the flows are so variable, I have based an assessment of the loading onto the EWWTP on per capita waste production figures. I have used a census derived population of 441 people. This is understood to be reasonably stable.

The following per capita loads, shown in Table 1 below, have been derived from Metcalf & Eddy, 5th Edition, Table 3-13. I have assumed that 50% of homes use a kitchen waste grinder of some form. I have also applied a factor of safety of 15% to allow for loading sources other than just the domestic population.

Table 1: Calculated Plant Loading

Pollutant	Per Capita Load	Total Daily Load
	g/hd/d	Kg/d (allows 15% FS)
COD	205	104
BOD5	80	41
TSS	78.5	40
NH3-N	7.8	3.9
TKN	13.5	6.8
TP	2.2	1.1
FOG	30	15

7.12 The treatment plant will likely have been designed for a nominal loading on the facultative pond of 84 kg BOD_5/ha/day. That was the prevailing Ministry of Works and Development standard at the time and the loading to which most facultative pond systems in New Zealand were designed. Given the area of 0.33ha and estimated loading of 41kg/day, the loading rate on the facultative pond would be approximately 124 kg/ha/d.

7.13 The more recent work of Mara and others has determined that, temperature and hydraulic conditions permitting, normal loads higher than 84kg/ha/day can readily be managed by these pond systems.

7.14 Addition of supplementary aeration systems such as the 3kW Reliant installed at Ekatahuna are a viable method of increasing the load carrying capacity of the facultative pond. We do not have specific data on the Reliant aerator. However, if we consider that it has a standard oxygen transfer efficiency of 0.9 kgO_2/kw.hr, an actual transfer efficiency in this waste of 0.6 kgO_2/kWhr and that 1.1kg of oxygen is required to oxidise 1kg of BOD_5, then the Reliant machine as installed could provide for a further 39kg of oxygen demand per day. This combined with the nominal pond capacity would increase the total BOD processing capacity of the facultative pond to 67 kg BOD_5/day (being 0.33 x 84 + 39). Therefore, I conclude that the treatment plant is operating well within its nominal loading capability. This is particularly important in managing the risk of odour generation – which I understand, has not raised any particular concerns at Ekatahuna.

7.15 Recent (since commencement of this consent renewal process) upgrades have already been carried out to the Ekatahuna wastewater reticulation system. These have included manhole repairs and relining of approximately 4.5km of sewer.

Effluent disposal system

7.16 Effluent from the maturation pond is piped out directly to the Makakahi River.

8 CURRENT LEVELS OF PERFORMANCE

8.1 This section describes the recent historical performance of the EWWTP in terms of effluent quality. This is shown in Table 2, which shows the current performance (based on sample analyses) and HRC proposed performance for comparison.

Table 2: Historic Effluent Quality Indicators

Analyte	**2013-16 Performance**		**HRC Proposed conditions** (Post July 2018)	
	Mean	90th %ile	Mean*	90th %ile**
scBOD$_5$ (mg/L)	2.7	5.0	<3	<6
Suspended Solids (mg/L)	26	53	<15	<30
Ammonia (mg/L)	4.4	8.2	<4	<11
Total Nitrogen (mg/l)	8.4	14.9		
D.R phosphorus (mg/l)	0.76	1.80	<0.5	<0.7
Microbiological				
E.coli (MPN/100ml)	1,800	3,600	<50	<200

* No more than 8 exceedances in 12 samples

** No more than 2 exceedances in 12 samples

8.2 At face value, these performance figures appear better than most two pond systems of this type. However, as discussed in paragraphs 3.6 to 3.8 above, average inflow does appear to be significantly elevated above what would normally be expected of a community this size. Therefore, dilutions do need to be considered in this respect.

8.3 If we consider the 11-month period of 2016, when we do have flow data, we can consider both effluent concentrations and loads under the different flow regimes. The comparison of 2016 concentrations is provided in Table 2, while the 2016 effluent loads are presented in Table 3.

8.4 During the period January to April 2016, flows appeared to have regressed to a stable low level. From May to November, when there was significantly higher rainfall, the inflows became elevated and never really regressed to the dry weather condition apart from a few very short periods.

Table 3: Year 2016 Daily Effluent Flows and Concentrations

	Flow	e.coli	TSS	NH4	SIN	TN	DRP	$scBOD_5$
	m^3/d	MPN/100ml	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3
Annual								
Mean	704	946	17	5.5	5.9	9.5	0.9	3.8
90%ile	1268	3240	29	13.0	13.1	19.4	1.8	7.4
Summer								
Mean	161	1743	19	9.2	9.4	14.9	1.8	5.5
90%ile	195	3150	29	13.9	14.0	21.7	2.4	7.1
Winter								
Mean	1014	593	16	3.9	4.4	7.2	0.5	3.1
90%ile	1376	1292	31	6.2	6.2	9.7	0.9	4.8

Table 4: Year 2016 Daily Effluent Flows and Loads

	Flow	e.coli	TSS	NH4	SIN	TN	DRP	$scBOD_5$
	m^3/d	MPN/d	kg/d	kg/d	kg/d	kg/d	kg/d	kg/d
Annual		$x 10^9$						
Mean	704	3.1	7	2.3	2.8	4.4	0.3	2
90%ile	1268	8.7	15	3.4	4.1	5.9	0.4	3
Summer								
Mean	161	2.6	3	1.5	1.5	2.3	0.3	1
90%ile	195	4.3	4	2.5	2.5	3.3	0.4	1
Winter								
Mean	1014	3.4	9	2.8	3.5	5.5	0.3	2
90%ile	1376	8.7	17	4.0	4.6	6.8	0.5	3

8.5 Based on the calculated plant loadings presented in Table 1, the following waste removal performance has been calculated.

Table 5: Pollutant Removal Performance 2016

	TSS	**NH4**	**SIN**	**TN**	**DRP**	**scBOD$_5$**
	kg/d	kg/d	kg/d	kg/d	kg/d	kg/d
Influent	40	3.9	3.9	6.8	1.1*	41
Annual						
Effluent	7	2.3	2.8	4.4	0.3	2
% Removal	82.5%	41%	28%	35%		95%
Summer						
Effluent	3	1.5	1.5	2.3	0.3	1
% Removal	92.5%	62%	62%	34%		98%
Winter						
Effluent	9	2.8	3.5	5.5	0.3	2
% Removal	78%	28%	10%	19%	73%	95%

* TP

Biochemical-parameters

8.6 **Carbon:** The treatment plant is principally configured to reliably remove carbon-based wastes and provide rudimentary effluent disinfection. Reduction of cBOD$_5$ is approximately 95% on a load basis.

8.7 **Nitrogen:** The main forms of nitrogen in domestic wastewater are organic-N (bound in organic substances), ammonia-N, nitrate and nitrite. Organic N and ammonia together make up what is known as TKN (Total Kjeldahl Nitrogen). TKN is of most interest as an influent determinand because it represents almost all of the influent nitrogen to be assimilated or nitrified. Ammonia-N, nitrate and nitrite make up what is known as SIN (soluble organic nitrogen). SIN is an important determinand because it is these forms of soluble nitrogen that contribute most to eutrophic effects in receiving waters. The ammonia-N component is also important because it can contribute to both acute and chronic toxicity effects in the receiving water.

8.8 The EWWTP is not specifically configured to remove nitrogen. Most nitrogen arriving at the plant is in the form of TKN. A certain amount of nitrogen (19 – 35% for 2016 in this case) is removed by one or more of three processes described by Middlebooks[1]. These are i) assimilation into the growing algal biomass as organic-N, ii) biological nitrification (to nitrite and nitrate) and ii) ammonia volatilization due to pH and temperature changes and thence equilibrium shifts between gaseous ammonia and liquid phase ammonium. For the nitrogen assimilation route to have an effect, the algal solids produced need to be removed from the process stream. However, this is not normally the case and, over time some of the organically bound nitrogen is mineralised in the cold digestion process occurring at the bottom of the pond and re-released as ammonia/ammonium.

8.9 Most of the SIN leaving the treatment plant is in the form of ammonia-N. There is very little nitrate or nitrite. This is typical of oxidation pond systems. In his evidence, Dr Ausseil has concluded that effluent SIN from EWWTP is not having any measurable negative effects on the receiving water.

8.10 It is difficult to formalize and formally control the nitrogen removal processes in an oxidation pond system. Measures such as removal of short circuiting, addition of supplementary aeration (and or pond area), addition of tertiary clarification devices and reduction in wet weather flows are some ways in which the level of total nitrogen removal can be enhanced and or made more reliable.

8.11 To have a plant where ammonia and total nitrogen can be guaranteed to be reduced to very low levels would require changing to a fundamentally different form of treatment (i.e higher rate fixed film or activated sludge style processes). From new plant build costs that I have accumulated over many years and kept update using cost indices, I am able to give an indication that the cost of such a facility at Ekatahuna would be of the order of $1 to $1.2M. I do not believe that such expenditure is justified unless there is significant negative environmental effect that needs to be mitigated. From Dr Ausseil's evidence, I conclude that is not the case.

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[1] Middlebrooks et al 1999.

Therefore no significant upgrade targeting improved nitrogen removal is proposed.

8.12 **Phosphorus**: There is no specifically designed process for removing phosphorus from the wastewater. As with nitrogen, a small amount is removed in the generation of active biomass and algae in the ponds. Active biomass is simply a group of living micro-organisms respiring and reproducing on food and oxygen supplied by external sources. As with nitrogen, some of this organically bound phosphorus will eventually be re-released into the water column due to the solids digestion process.

Micro-Biological

8.13 Under dry weather flow conditions influent to EWWTP will generally contain E-coli (EC) of the order of 5×10^6 MPN/100ml. Mean dry weather effluent EC level is approximately 1.7×10^3 MPN/100ml. This represents roughly a $3.5 \times \log_{10}$ reduction (from raw sewage) which is quite acceptable performance for a basic oxidation pond configuration.

8.14 The current performance would not be adequate to meet the performance E.coli levels anticipated by HRC. To reach the <50MPN/100ml level suggested would require a 1.8 $\log_{10}$ inactivation from the current 1,700 MPN/100ml or a 5.0 $\log_{10}$ inactivation from the likely influent concentration in dry weather. Wet weather dilution would make the situation slightly, but not significantly (at most $0.4\log_{10}$) better.

9 FUTURE FLOWS AND LOADING

9.1 The population at Ekatahuna is expected to remain reasonably stable, or even to decline slightly over time. Therefore, apart from any flow changes due to changes to the water tightness of the sewer system and or climate change effects, the flows and loading to EWWTP are likely to remain reasonably static.

10 PROPOSED LEVELS OF PERFORMANCE

10.1 Target effluent quality figures have been derived from:

(a) Preferred disposal option - continued discharge to the Makakahi River.

(b) Allowance for reasonable mixing.

(c) What the river can assimilate with minimal effect.

(d) Fiscal prudence, namely what reasonably affordable technology can achieve based around upgrading of the existing asset.

10.2 The proposed effluent quality standards are presented in the following table:

Table 6: Proposed Effluent Quality Standards

	Following implementation of proposed upgrades	
	Mean	90th %ile[1]*
$scBOD_5$ *(g/m³)*[2]	≤5	≤8
Total suspended solids *(g/m³)*	≤15	≤30
Ammoniacal nitrogen *(g/m³)*	≤10	≤15
DRP (g/m³)	≤0.5	≤1.0
	Median	90^{th}%ile.
E.coli (MPN/100*ml*)	260	1,000

10.3 **Soluble Inorganic Nitrogen (SIN) / Ammonia:** The proposed mean effluent target for ammonia is 10 mg/l. This represents a value that the river can assimilate without significant effect. Because this is pond technology, some high results will inevitably appear from time to time.

10.4 **Dissolved Reactive Phosphorus**: An annual mean of 0.5mg/l is proposed. This will be achieved via chemical dosing and use of a tertiary clarifier. To a certain extent, the amount of DRP removal can be tuned by adjustment of the chemical dose. However, there are direct implications for operational cost

10.5 **scBOD5:** The proposed effluent target of 5 mg/l $scBOD_5$ should be achievable as a mean with the proposed technology. It is unlikely to be achieved as a 90^{th} percentile. 'Jar' and or pilot testing should be undertaken, in conjunction with a reputable chemicals supplier, to confirm this. It is not a critical discharge parameter in this case. Using the measure of soluble $cBOD_5$ removes most influence of high summer spikes due to the proliferation of algal blooms. The proposed plant upgrades of a lamella clarifier and UV disinfection are unlikely to improve the $scBOD_5$

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2 $scBOD_5$ is Soluble Carbonaceous Biochemical Oxygen Demand.

performance significantly. However, the use of a coagulant in the clarifier to amalgamate the particulates may result in some soluble BOD being removed. The likely extent of this, if any, could only be assessed by pilot trialling or by experimenting with the full-scale installation during the post installation monitoring period suggested by Dr Ausseil.

TSS

10.6 The existing effluent TSS levels from EWWTP are low, even in summer, dry weather conditions when we normally expect algal blooming to elevate the effluent TSS levels. There is little that can be done in an oxidation pond system itself to restrict the TSS to low levels without major partitioning into segments of, nominally, less than 3 days' hydraulic retention time. At Ekatahuna the scale of works would mean that the bunds forming the partitions would take up a major portion of the volume of the pond. By adding in a lamella style clarifier, or similar tertiary treatment device, with appropriate coagulation and flocculation by chemical addition, an equivalent improvement in TSS removal can be achieved, with the added benefit of additional DRP removal

10.7 A similar solution involving installation of a lamella clarifier has been applied at Pahiatua. No apparent improvement in DRP or TSS levels have been observed at Pahiatua. However, we have no information as to the level of design, sizing or process tuning that has been undertaken at Pahiatua or, for that matter whether the clarifier system was actually running at the time samples were taken. We know such systems work in removing algae in water treatment plants so there would not appear to be a good reason why they won't work on wastewater algae. It should be possible to take the existing effluent and consistently reduce TSS to less than 15mg/l.

10.8 My recommendation is that a formal design, procurement and commissioning process is followed to implement the tertiary process additions at Ekatahuna as an integrated and optimised system.

Disinfection

10.9 E. coli type bacteria enter the EWWTP in raw sewage at the rate of approximately 5,000,000 (5×10^6) per 100ml. Protozoan cysts may or may not be present. Human enteric viruses of some kind will normally be present in raw sewage, but numbers are typically relatively low unless there is some form of outbreak condition in the community. However, e.coli has been adopted as the key indicator criterion for this site and this discharge consent.

10.10 Current performance (13 samples to date for 2016/17) is a mean EC of 946 MPN /100ml and a 90^{th} percentile of 3,240 MPN/100ml. The performance appears better in winter and worse in summer (low flows), but this effect is likely due to dilution effects.

10.11 Key parameters in achieving wastewater disinfection targets using UV irradiation are UV transmissivity (%UVT) and TSS. No UVT testing has been undertaken. However, in a pond with relatively low TSS, the UVT can be as high as 40%, while it can get to as low as 15% for ponds with an algal bloom. The effect of a clarifier would likely be to make UVT more consistent and at the higher range of what would be expected from a pond system.

10.12 At Thames, without clarification, the large maturation pond produced UVT at around 40%, at Queenstown 13 – 17% and at Gore, using an Actiflo process post maturation pond, the UVT is typically between 54 and 65%.

10.13 To achieve the HRC suggested limit of 50 MPN is numerically possible if a clarifier and UV reactor are installed. This would, in effect, require a 2 x log10 further inactivation in the UV system. It is, as yet, uncertain whether an affordable, lamella style clarifier will be sufficiently reliable to provide a consistent enough UVT to achieve this as nominal mean (no more than 8 exceedances in 12 samples). As per advice given in the s92 response, I would recommend that the target mean is revised to 260 MPN/100ml in line with a 1 x $\log_{10}$ further inactivation in a UV reactor and the MfE and MoH Safe Bathing Guidelines. 1000 MPN/100ml would be a suitable nominal 90^{th}%ile limit (no more than 2 in 12 exceedances)

Summary

10.14 In summary, and with reference to the evidence of Dr Ausseil the proposed effluent quality targets for the EWWTP recommended above represent, in my view a pragmatic standard that will result in no more than minor effects on the receiving water and that is achievable with a level of expenditure that is fiscally prudent for TDC.

11 PROPOSED TREATMENT PLANT UPGRADING

General

11.1 The levels of treatment required by the effluent targets will require additional treatment capacity to be added to EWWTP, particularly if there are further significant reductions made to sewer inflow and infiltration.

11.2 Three further upgrades are intended for EWWTP. These all involve addition of what are known as 'Tertiary' treatment processes: addition of a chemically assisted clarifier (probably a Lamella Style), a UV disinfection reactor (could be a channel or an enclosed reactor style) and a wetland (this could be of the surface flow or subsurface flow style or a combination). My evidence covers only the clarifier and UV system. The wetland is discussed in the evidence of Mr MacGibbon.

Prior Upgrades

11.3 Several improvement works have already been implemented at EWWTP since this consent renewal process commenced. These include:

(a) Installation of influent fine screening to remove most deleterious materials from the system.

(b) Installation of a new 3kW aerator in the oxidation pond.

(c) Desludging of the maturation pond to increase its working volume.

11.4 The desludging programme, undertaken in 2015 has removed over 30 years' accumulation of organic and inert solids from the base of the ponds. This has provided extra volume to the process and hence a greater nominal hydraulic retention time processes, particularly for disinfection and nitrification to take place

11.5 The fine screening works to omit synthetic and bulky objects that otherwise:

(a) Foul the deposited sludge materials;

(b) Wrap around machinery to cause rapid failures; and

(c) Deposit on the lagoon embankments to cause an unsightly mess.

(d) Exit with the effluent to create an unsightly mess in the downstream waterway.

While the screen has been installed it is not yet in use. A lift pump station has been installed to lift the raw sewage flows up into the screen chamber. It is not clear if the capacity of the lift station matches the maximum incoming flow rate. This pump and screen needs to be commissioned as a system, or alternatively, the screen lowered into the ground to work 'at grade' in the sewer, thereby eliminating the need to a pump. Siting of the electrical components of the screen below ground level creates potential issues with failure due to flooding. In conjunction with this work in commissioning the screen, the influent flow meter set up needs to be adjusted correctly to ensure that the end distances from pipe bends are appropriate and that the flow measurement device remains completely submerged at all times, with no air bubbles entrained in the flow.

Further Upgrading

11.6 Further upgrading is required to the site to achieve the proposed consent requirements:

- Reduce effluent DRP
- Reduce suspended solids
- Improve the level of disinfection provided by the treatment plant

11.7 DRP could potentially be reduced by direct addition of a coagulant such as alum to one or both ponds. The coagulated material, with chemically bound phosphorus then settles out on the base of the ponds. However, this method uses large quantities of alum as there are many other compounds for the alum to complex with, particularly if introduced to the facultative pond. The conditions for coagulation are also not as ideal as those that can be created in a formal reactor tank.

11.8 Installation of a clarifier on the outlet from the maturation pond, on the other hand, would allow for: more accurate and effective chemical dosing; assisting in TSS removal; and improved clarity of the final effluent for disinfection.

11.9 Works that have yet to be implemented are as follows (described in further detail in the following paragraphs):

(a) Installation of lamella clarifier (and coagulation tank and mixer) or similar;

(b) Installation of UV disinfection system;

(c) Installation of wetland.

Clarifier

11.10 TDC intends to install some form of tertiary clarifier on the outlet from the maturation pond. My understanding is that this is likely to be a lamella type clarifier similar to those installed at Woodville and Pahiatua.

11.11 Unlike conventional wastewater clarifiers, lamella clarifiers contain a ‘pack’ of inclined (45 – 60° from horizontal) plates that the coagulated water travels through in an upwards direction., Rather than having to fall through the entire clarifier depth, the coagulated solids only need to fall through a depth equal to the vertical distance (60 – 240mm) between adjacent plates. The settled solids then slide, counter-current, down the top of the plate upon which they have ‘settled’, to a sludge collection system at the base. This greatly enhances the allowable up-flow volume through the clarifier and allows a much greater throughput per unit area compared to a conventional up-flow gravity clarifier. Typical overflow rates are between 5 and 12 $m^3/m^2/hr$ without sand ballasting, whereas conventional circular or rectangular clarifiers have an operating range of 1 and possibly up to 2 $m^3/m^2/hr$.

11.12 A specific design process will be required to ensure the clarifier is appropriately sized for the range of flows experienced at EWWTP. Similarly, a chemical trialling and optimisation process will be required following installation, to ensure that both the chemicals (coagulant and polymer) and their dose rates are optimised. The design process needs to ensure that the clarifier and associated chemical dosing system, mix tank, and UV disinfection work as an integrated system and not as isolated components of the plant

11.13 Ideally a location can be found on the site that allows for gravity flow into the clarifier and then to the UV system. If gravity flow is not possible, a submersible pump system will be required in the maturation pond outlet to lift the effluent up into the clarifier.

11.14 Ideally the algal sludge accumulated in the base of the clarifier would extracted from the system, dried and applied to land or another beneficial reuse or landfill. However, where land disposal is not possible the chemically bound sludge is returned to the ‘head of works’ in order for it to be settled out in the facultative pond. Such systems are used at, Waihi and Gore. The practice of returning the algal sludge to the head of the plant does not appear to be to the detriment of effluent quality, but will result in pond desludging being required on a slightly more frequent basis.

11.15 Chemical dosing to condition effluent for clarification would be continued on a year round basis to ensure that optimal conditions are maintained for carrying out the disinfection function. Within that constraint, some dosing adjustment may be appropriate if high levels of DRP removal are not required all year round. This would be to mitigate operational costs.

11.16 The clarifier will remove suspended solids (TSS) from the effluent. The primary benefit of this is that disinfection is facilitated. However additional benefits of reducing effluent TSS are that total nitrogen loading is reduced by an equivalent of 9 to 11% of the solids mass removed. This is organic nitrogen, which, longer term, also contributes to eutrophic effects downstream. And removal of TSS aids in reducing the build-up of organic solids on the bed of the receiving water which can contribute to degradation of fish and macro-invertebrate habitat.

Disinfection

11.17 The existing plant is producing a variable effluent of variable microbiological quality with a median E.coli level of approximately 1,000 MPN/100ml (summer 1,750) and 90th%ile of 3,200 MPN/100ml. This will typically increase in summer as effluent suspended solids levels increase and flows decrease. Therefore, at least 1 x log_{10} (and possibly up to 2x log_{10}) further coliform inactivation will be required to meet the proposed standard.

11.18 A UV disinfection process is proposed for installation downstream of the maturation pond and upstream of a possible future wetland.

11.19 The UV disinfection process works by inactivation of microbes through exposure to UV light irradiation and, therefore, requires relatively good quality effluent in order to be effective, if very high UV dose rates are to be avoided.

11.20 Disinfection by UV light irradiation is not normally regarded as appropriate for achieving very high levels of disinfection of waste stabilisation pond ("WSP") effluent (in high rate plants UV systems readily provide about 4 to 5 x log_{10} bacteria inactivation). However, since only a single log (or thereabouts) reduction is required in this case, UV disinfection can be considered, if it comes at a reasonable capital and operating cost.

11.21 Key parameters in achieving wastewater disinfection targets using UV irradiation are UV transmissivity (%UVT) and suspended solids. If a pond effluent UVT of 40% can be reliably achieved downstream of the clarifier, a 2 x log10 inactivation should be reliably achievable. If the UVT achieved is less than 40 %UVT and or is inconsistent, then a 1 x log_{10} inactivation is the likely outcome. At 40%UVT, a rudimentary UV disinfection is feasible to the extent that the additional disinfection required from 1,750 down to 260 (mean) and maintaining around 1,000 MPN/100ml (90^{th} %ile) should be reasonably achieved.

11.22 As well as UV transmissivity, effluent suspended solids concentration is also relevant in determining appropriate limits to be achieved by effluent disinfection. The work of various researchers has shown (refer Beltram & USEPA work in Appendix 3, Figure 3) that for any given residual effluent suspended solids level, there is a practical limit as to the minimum level of disinfection that can be achieved. This is due to the phenomena of bacterial particles being shielded from the UV light either due to embedment in the solid particle or hidden in its shadow. This was also reported by Gail Sakamoto in her paper on UV Disinfection to the NZWWA annual conference in 1998.

11.23 The target disinfected water quality is shown in Table 7.

Table 7: Current and Target Effluent Disinfection Quality

Raw Sewage (Generally)	E.coli (MPN/100mL)	5,000,000 ($5x10^6$)	Very approx
Current performance	E.coli (MPN/100mL)	1,743	Mean
Current performance	E.coli (MPN/100mL)	3,150	90th %iles
Target - Interim	E.coli (MPN/100mL)	As is	
Target - Final	E.coli (MPN/100mL)	1000	
Target - Final	E.coli (MPN/100mL)	260	Mean

11.24 All flows (apart from very high flow events bypassed to prevent a pond overflow) would be passed through the UV system. It is not clear yet whether a reactor or channel UV system would be used. Irrespective of which system is chosen, with a pond system upstream, the UV installation can be configured to be shut down for maintenance without undisinfected flows passing to the wetland.

11.25 Because a wetland is proposed downstream of the UV disinfection system, the point of compliance, at least for disinfection, should be upstream of the wetland. This is because non-human sourced e.coli and e.coli mimics (Ishii & Sadowski 2008) will be reintroduced to the effluent stream within the wetland. These additional e-coli come from the soil, plant material, birds, rats, opossums and the like and disinfection control has effectively been lost.

Pond Lining

11.26 It has been suggested in draft conditions for the pond seepage consent that the ponds should be lined. I do not think that is a appropriate unless there it can be shown there is considerable leakage from the ponds which is shown to be causing groundwater or other effects such as reducing pond integrity by creating 'tomos' underneath or reducing general slope stability below the ponds. I have not been engaged to assess those risks and they are not within my area of speciality.

11.27 Further, the process of lining the ponds would be very disruptive to operation at the plant and it is likely that the primary pond would need be enlarged and divided in two prior to the pond being lined to retain a degree of treatment to the flow while the empty cell of the pond is being lined. The enlargement would be to counter the volume taken up by the dividing bund and to ensure there was sufficient capacity to provide rudimentary treatment in one half at a time. Once the two halves of the facultative pond were lined, they would then be used in series while the maturation pond was lined.

11.28 Further, because the site is already in use as an oxidation pond, the soil under the base will be contaminated with organic material. When the liner is placed and the pond put back into service, the underside of the liners will become anaerobic, methane and CO_2 will be generated and, unless a gas relief system is also installed, large 'whales' will form in the liner due to the gas not being able to escape. Thus, under drainage and gas relief would need to be installed in each of the three cells prior to placing the liner.

11.29 I estimate that the cost of lining would be of the order of $330,000. This was based on the rates for lining the brand new Himatangi wastewater ponds around 2012. Expenditure of such a magnitude could, in my view only be justified if it can be shown the seepage from the ponds is having a detrimental effect on groundwater or nearby bores.

11.30 Initially, in my opinion, I think that a seepage test should be carried out on each of the two ponds to determine if there is any appreciable loss. If there is, then an appropriate monitoring programme can be put in place to determine if any of the issues discussed in paragraph 11.26 above is significant.

11.31 The draft conditions suggest that suitably calibrated meters should be installed to enable water balance calculations to be made for the treatment plant. I agree that this is a reasonable requirement. The site already has two flow meters.one on the inlet and one on the outlet. The inlet flow meter is understood to be incorrectly installed (as the pipe is only partially full of flow). This needs to be corrected and the flow measurement checked by a technician using appropriate instrumentation. As a further check the pump curves of the lift station should also be examined. Installation of the effluent flow meter should also be checked to ensure that it meets the manufacturer's requirements for delivering the specified level of accuracy.

11.32 In obtaining the hydraulic mass balance for the site, the measurements of the two flow meters can be supplemented with rainfall and evaporation data and results of the seepage test described above. This mass balance exercise should only need to be completed infrequently.

Dissolved Oxygen Monitoring

11.33 It has been suggested by the HRC Planning officer in proposed conditions 6 & 7 of the air discharge consent, that a permanent continuous dissolved oxygen (DO) monitoring system should be installed in the maturation pond to measure effluent dissolved oxygen. I would not be in favour of this addition. I would however be in favour of use of a hand held dissolved oxygen meter, for the reasons set out below.

11.34 A permanently fixed DO sensor is a precision instrument requiring a robust mounting system and frequent cleaning along with regular recalibration to maintain accuracy and to provide a reliable signal. Often when such DO meters are installed at remote locations cleaning and maintenance is neglected and the instrument becomes an expensive memory.

11.35 I estimate that the cost of installation of a permanent DO sensor would be of the order of $12,000 (excl GST) capital cost allowing for purchase, manufacture of a robust mounting device, cabling and some minor SCADA programming.

11.36 In my opinion, it would be more appropriate to achieve the desired objective using a hand held DO meter. Because the pond is a photo-synthetic system with algae as the plants, the dissolved oxygen will vary significantly throughout any given 24 hour period, simply due to the intensity of sunlight interacting with the algae.

11.37 Also, DO is generally at a maximum around mid-afternoon on during hot summer days at which time super-saturated DO levels will frequently be achieved. Likewise DO will be at its lowest, and most depleted levels during early hours of the morning, before sunrise.

11.38 Thus, a hand held meter can easily, and at relatively low cost, be used to develop diurnal DO profiles for the pond at various times of the year. After developing the diurnal DO profile, DO can then simply be measured and logged by the operators during each visit to the site – although each visit and measurement would preferably be at a similar time of day. The measurement taken on any particular day could then be referenced against DO profiles for the site to determine if there is a risk of the desired minimum of 0.5 being reached.

11.39 The additional benefits of provision of a hand held DO meter are that it can likewise be used on all the other oxidation ponds operated by TDC. Accordingly it is likely to be used almost daily and cleaning, checks and calibration are able to be done quickly, frequently and safely in a controlled environment.

Timing

11.40 I estimate that TDC requires approximately 32 months from the date of commencement of the consent (if granted) to complete the proposed upgrading work. This will provide the time necessary to:

(a) Engage a consultant to manage data acquisition and procurement processes (2 months);

(b) Complete a monitoring programme targeting influent flow and characteristics, pond seepage, effluent TSS, DRP, scBOD5, algal characteristics, 'jar testing' and changes in maturation pond temperature, pH and alkalinity (12 months);

(c) Prepare procurement documentation (2 months – but included in the time frame for (b) above);

(d) Procure the appropriate implementation contract/s including tendering, evaluation, due diligence and seeking approval from Council for awarding contracts (4 months)

(e) Design and construction of the works, including establishment, hydraulic design, equipment sizing and configuration, ordering, delivery and installation (12 months).

(f) Commissioning of the works (2 months).

Following commissioning a further period will be required to undertake performance testing, make seasonal adjustments and undertake parallel receiving water investigations (36 months).

11.41 TDC has funding identified in its budgets as follows to complete the work:

(a) 2017/18 $ 810k

Summary

11.42 TDC is proposing to design and implement a series of pragmatic upgrade measures that are commensurate with the water quality requirements of a medium-term consent and which are able to be implemented without major upheaval or fundamental changes to the treatment plant, and which are affordable to the community at this time.

12 DISCHARGES TO AIR

12.1 Four types of discharges to air are potentially produced during wastewater treatment as takes place at the EWWTP. These comprise:

(a) Carbon dioxide produced from the biological breakdown of organic matter in the wastewater.

(b) Nitrogen gas discharged during the denitrification process when nitrates (formed during the oxidation of ammonia and organic N to nitrate) are reduced as heterotrophic bacteria scavenge the bound oxygen during daily cycles of low dissolved oxygen in the water column.

(c) Odour in the form of chemicals such as amines and hydrogen sulphide, which are generated when insufficient oxygen is available to sustain aerobic (oxygen-rich) biological breakdown and anaerobic (lacking oxygen) conditions develop.

(d) Odour produced by decay of natural organisms such as algae that may grow to excess numbers and then die off when nutrients limitations or climatic conditions fail to support their growth (algal blooms).

Carbon dioxide

12.2 Carbon dioxide is a harmless non-toxic gas, which is normally present in the atmosphere. Discharges of carbon dioxide from the EWWTP will not be of such magnitude to result in any detectable changes to the natural carbon dioxide concentration in the air above the site. Some of the carbon dioxide generated will be utilised by the algae in the oxidation pond and converted to oxygen for supply to the bacteria in the pond.

Nitrogen gas

12.3 Nitrogen gas is also a harmless and non-toxic gas which comprises approximately 70% of the atmosphere. Discharges of nitrogen gas from the EWWTP will not be of such magnitude to result in any detectable changes to the natural concentration in the air above the site.

Odour

12.4 Odour generation has not been an issue at the EWWTP in the past.

12.5 It cannot be guaranteed that an unusual load event will not occur that is larger than the aeration capability in the ponds. In this case, anaerobic conditions and associated odour could occur. The best mitigation for this type of event is strict trade waste control.

12.6 It is not possible to eliminate the risk of an algal bloom occurring in the maturation pond, because algal blooms also occur in natural ponds and estuaries. However, should an algal bloom occur an electrically-driven mixer / aerator can be installed in the maturation pond at short notice to provide improved mixing to assist to break up or prevent the formation of algal “mats” and the risk of odour from the “mats” rotting in the sun.

13 COMMENT ON THE OFFICERS REPORT

13.1 Through my evidence, I have already made comment, at relevant places, on matters raised in the HRC Officer’s report that were directly applicable to issues I was discussing in my evidence.

John M Crawford
Principal Environmental Engineer
March 2017

APPENDIX 1: REFERENCES

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APPENDIX 2: GLOSSARY OF TERMS AND ABBREVIATIONS

Term or Abbreviation	**Meaning**
Activated Sludge	A generic description for a wide range of generally similar treatment processes using vast numbers of specifically selected and cultivated natural microbes to break down particular components of wastewater, normally in a compact, mechanically aerated reactor vessel.
ADWF	Average Dry Weather Flow (Non-peak period) – A measure of the average flow to the treatment plant after dry weather periods of 7 days or more.
ADF	Average Day Flow. The average daily flow taking into account the full yearly flow record.
AEE	Assessment of Environmental Effects
Alum	Aluminium sulphate – an acidic metal salt used in water treatment processes to precipitate out soluble pollutants into a particulate form for settlement or filtration and removal.
aerobic	Containing free oxygen
anaerobic	Devoid of oxygen
anoxic	Devoid of free oxygen but containing molecular oxygen
autotrophic	An autotrophic organism is one "capable of synthesizing its own food from inorganic substances, using light or chemical energy"
BC	Business Case
Beneficial Reuse	Reuse of treated wastewater or biosolids for beneficial purposes
Black noise	Noise created by mechanical sources
BNR	Biological Nutrient Removal – Generic description of a group of wastewater treatment processes that remove nitrogen and or phosphorus biologically.
BOD_5 or $cBOD_5$	Five day carbonaceous biochemical oxygen demand. Used as a measure of carbon based wastes.
BOI	Bay of Islands
BNR	Biological Nutrient Removal. The removal of nitrogen and or phosphorus from wastewater using biological methods.
Brownfields	A development site that has been previously been built on
BTF	Biological Trickling Filter
Buffer Zone	Area between point of application (e.g. irrigation) and potentially sensitive location (e.g. house, road, waterway) to avoid adverse effects
CAPEX	Capital cost of a project or product

Term or Abbreviation	Meaning
Caustic	Caustic Soda or Sodium Hydroxide – a strong Base chemical
CCI	Construction Cost Index
CDTCC	Crafted Design and Traditional Construction Contract
CMA	Coastal Marine Area
DBC	Design and Build Contract
DBO	Design, Build, Operate
Denitrification	The separation of nitrate into oxygen and nitrogen gas. The oxygen is scavenged from the molecule by heterotrophic bacteria and the nitrogen is given off to the atmosphere.
DIL	Development Impact Levy
DNA	Deoxyribonucleic acid – Molecular building block for biological tissue.
DS	Dry solids
DWF	Dry weather flow
DWS	Drinking Water Standard (Proposed) 2005. The standard that it is proposed that suppliers of water target for delivery into a Potable water reticulation. The standard is not mandatory and has not been encapsulated in an Act of Parliament.
EBPR	Enhanced biological phosphorus removal
EWWTP	Ekatahuna Wastewater Treatment Plant
Exogenous	means ‘originating externally’
FAST	Fixed Activated Sludge Treatment. Activated sludge process that includes fixed growth media.
floc	A small grouping of (normally visible) particles often attracted by opposite electrical charges or some chemical affiliation
FRP	Fiber Reinforced Plastic (Fiberglass)
HAZNO	Hazardous Substances and New Organisms regulations
Heterotrophic	An organism that, unlike an autotroph, cannot derive energy directly from light or from inorganic chemicals, and so must feed on other life-forms. They obtain chemical energy by breaking down the organic molecules they consume.
HR	High Rate
HRT	Hydraulic Retention Time
IDEA	Intermittently Decanted Extended Aeration. One particular hybrid configuration of Sequencing Batch Reactor

Term or Abbreviation	Meaning
I & I	Inflow and Infiltration – flows of clean water from rainfall and ground water to the sewerage.
LGA	Local Government Act 2002
l/hd/day	Litres per head per day. A measure of the per capita discharge of wastewater to the sewer system.
log	Means '1 exponent of 10' or 1 'order of magnitude'
LTCCP	Long Term Council Community Plan – A requirement of the Local Government Act including 10 year council infrastructure budgetary requirements.
MBR	Membrane Bioreactor
MCI	Macro-invertebrate Community Index
Methylotrophic	A type of heterotrophic organism that can only metabolize on substrate molecules that include a methyl group attached to another atom (usually but not necessarily carbon) e.g methanol.
N	Nitrogen
NH_4-N	Ammoniacal nitrogen
nitrification	Oxidation of ammonia and organic nitrogen to nitrate
nm	nanometer or 10^{-9} meters – used for measuring the size of molecules or the wavelength of different types of light.
NO_3-N	Nitrate
NO_x	Oxidised nitrogen = $NO + NO_2 + NO_3$
NPV	Net Present Value – The present day value of a series of future costs.
Nitrogen limited	
OPEX	Operational expenditure
Ozone	O_3 , A toxic and unstable form of oxygen molecule used as a strong oxidising agent for water disinfection.
P	Phosphorus
PCE	Parliamentary Commissioner for the Environment
PDWF	Peak Dry Weather Flow – is the peak flow part of the day (normally early to mid morning) during the peak summer holiday period and during a period of dry weather where I&I are minimal.
Peaking factor	Difference between peak load and off peak load
PET	Proposal Evaluation Team
PI	Precipitation Index – provides a relative measure of recent rainfall to the irrigation zones for management of application rates.

Term or Abbreviation	Meaning
PIF	Peak instantaneous flow
Plant	Wastewater treatment plant / facility.
Practical Completion	The point in the Contract at which a treatment plant has been built, commissioned, tested and is ready for compliant operation
Proposal	A tender for work that contains options and alternatives and where the tender rules provide for negotiation of price and conditions of Contract with individual ‘Proposers’
PWWF	Peak Wet Weather Flow
RFT	Request for Tender
RI	Rapid Infiltration
RMA	Resource Management Act 1991 and subsequent amendments.
RNA	Ribonucleic acid
RO	Reverse Osmosis – the finest form of membrane filtration, capable of filtering particles at a molecular scale including aqueous salts.
SBNR	Simultaneous Biological Nutrient Removal
SBR	Sequenced Batch Reactor
SCADA	Supervision, Control and Data Acquisition system.
SDI	Subsurface Drip Irrigation
SH	State Highway
Specific gravity	The density of a substance relative to the density of fresh, cold water at sea level. e.g, sewage flocs may be around 1.03
SWOT	Strengths Weaknesses Opportunities and Threats
TKN	Total Kjeldahl Nitrogen. Represents the sum of organic nitrogen plus ammonia in a substance.
TN	Total Nitrogen
T/P	Tairua / Pauanui
TP	Total Phosphorous
TPS	Terminal Pump Station: Refers to the last pump station before the treatment plant in a sewage reticulation.
TSS	Total suspended solids
Turn down ratio	Required treatment capacity range to treat high peak load and low off peak load
TWAS	Thickened waste activated sludge

Term or Abbreviation	Meaning
EWWTP	Thames Wastewater Treatment Plant
UAC	Uniform Annual Charges
UF	ultra-filtration in the range 0.004 to 0.1 microns
UV	Ultraviolet: Refers to disinfection by irradiation by ultraviolet light.
VSS	Volatile suspended solids
WAS	Waste Activated Sludge – Surplus biomass that grows in an activated sludge treatment plant due to the provision of food and oxygen.
WCP	Whangamata Community Plan
White noise	Noise created from non-mechanical sources such as water splashing or waves or trees rustling
WSP	Wastewater Stabilisation Pond
WWF	Wet weather flow
WWTP	Wastewater Treatment Plant
pH	a logarithmic measure of hydrogen ion concentration
HRT	Hydraulic retention time
Units	**Meaning**
%	percentage
%ile	Percentile. . 95th percentile is, nominally, the value below which 95% of sample test results will fall.
cfu/100ml	Colony forming units per one hundred millilitres
dBA	the sound level obtained when using a sound level meter having its frequency response A-weighted
g	gram
g/m^3	Grams per cubic metre (equivalent to mg/L)
h	Hour or head
ha	hectare
hd	Per head or per capita
kg	kilogram
kg N/ha.yr	Kilograms of Nitrogen per hectare per year
kg P/ha.yr	Kilograms of Phosphorous per hectare per year
kg/d	Kilograms per day
km^2	Square kilometers

Term or Abbreviation	Meaning
kW	kilowatt
kW.hr	Kilowatt hour. A measure of electric power consumption by a machine.
l/hd/d	Litres per head per day. A measure of the per capita discharge of wastewater to the sewer system.
l/s	Litres per second
L_{10}	means the noise level equaled or exceeded 10% of the time during the measuring period
L_{95}	means the noise level equaled or exceeded 95% of the time during the measuring period
L_{max}	means the maximum noise level (dBA) measured with a sound level meter having a "fast" response, or an equivalent method. Fast Response means:The time-weighting characteristic included in sound level meters by convention (See IEC651.)
m	metre
M	Million or Mega
m^3/day	Cubic metres per day
Mg/d	Mega (million) gallons per day
mg NO_3-N/Second/km^2	Milligram Nitrate Nitrogen per second per square kilometre
mg/l	Milligram per litre (equivalent to g/m^3)
micron	One one thousandth of one millimeter (10^{-6}m)
mm/day	Millimetre per day
mm/week	Millimetre per week
MPN/100ml	Most probable number per one hundred millilitres
mWs/cm^2	milli Watt seconds per square centimeter. A measure of UV dose rate
pfu	Plate forming unit – one method for enumerating the number of viral organisms in a sample.
UVT	Effluent ultraviolet light transmittance, typically measured at a light wavelength of 254 nanometers
yr	year
l/p/d	Litre/person/day
Organizations	
HBRC	Hawkes Bay Regional Council

Term or Abbreviation	Meaning
HPT	Historic Places Trust
HRC	Horizons Regional Council
MfE	Ministry for the Environment
MoH	Ministry of Health
MOH	Medical Officer of Health
NZWWA	New Zealand Water and Waste Association
Opus	Opus International Consultants Ltd
USEPA	United States Environmental Protection Authority

APPENDIX 3: ACCOMPANYING FIGURES

Figure 1: 2016 Rainfall and Effluent Flow Chart

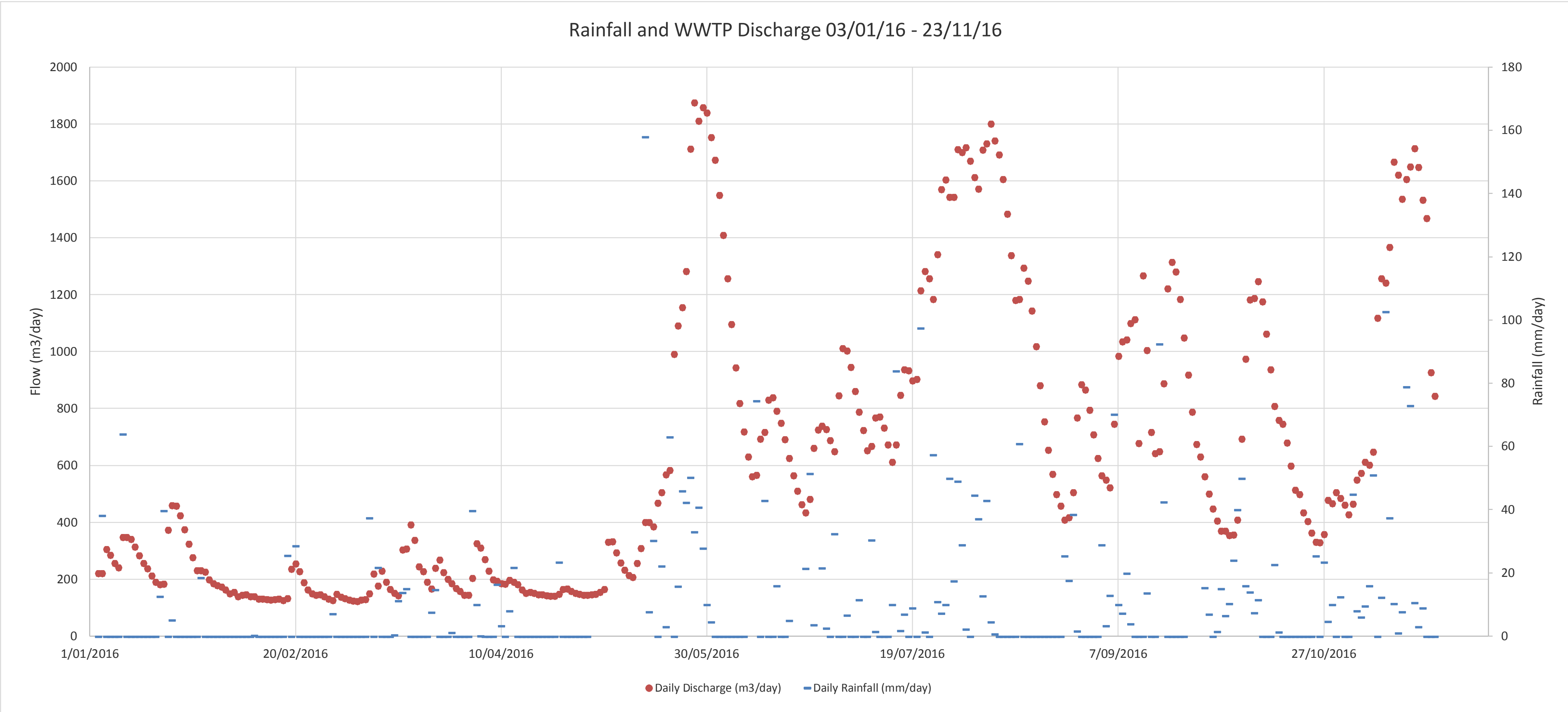

Figure. 2: Effluent UVT/TSS/Permit Relationships

Process Level	%UVT	TSS mg/L	Permit Level/100mL
Primary	5 – 25	30 – 150	Log reduction or <1,000 to <10,000 TC or FC.
Secondary	40 – 75	10 – 30	<200FC, <240TC <126 E.coli <35 enterococci
Secondary Filtered	60 – 75	5 – 10	<14FC, <23TC
Tertiary Filtered	65 – 80	1 – 5	<1FC, <2.2TC

(FC – fecal coliform, TC – total coliform)

Table 8: Effluent UVT/TSS/Permit Relationships: Sakamoto, NZWWA 1998

Figure 3: TSS vs Maximum Inactivation: Beltram 2008, USEPA 1986