ENVIRONMENTAL MONITORING ANNUAL REPORT

PREPARED FOR T&T LANDFILL LTD.

July 2018

Stantec

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T&T Landfill Ltd.

Environmental Monitoring Annual Report

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1. Introduction

T&T Landfills Ltd. holds a resource consent for the discharge of contaminants to a tributary of the Owhiro Stream. Condition 9 of the discharge permit WGN070260 [30627] (attached in full as Appendix 1) states that:

"*The permit holder shall ensure that a person suitably qualified to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council prepares and submits a report by 30 June each year detailing the items required by conditions 6 and 7 and the approved DMP.*

The report shall include, but not be limited to:

- The results and comparison of the contaminants sampled for with the relevant limits approved under the DMP and condition 8 of this permit.
- A comparison of the concentration of contaminants of the latest year of sampling with the baseline ecology survey results as required by condition 12 of this permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge.
- Any other relevant information; and
- Any recommendations for approval to the Manager, Environmental Regulation, Wellington Regional Council to remedy or mitigate any significant adverse effects that have occurred, or to avoid unforeseen significant adverse effects as a result of the discharge of contaminants from the landfill area to the tributaries of Owhiro Stream. Examples of these could be:
    - Changes to the management or site protocols;
    - Methods to remedy adverse effects that may have been transported into the Owhiro Stream catchment; and
    - Mitigation measures to offset or minimize the significant adverse effects."

This report covers monitoring undertaken in the year ending 30th June 2018 (note, the requirement to submit this report by the end of June was not achieved because results from the June monitoring round were not received until part way through July).

Conditions 6 details the requirement to provide a Discharge Management Plan (DMP), which was approved and subsequently amended in 2012 and again in 2017.

Condition 7 details the minimum groundwater and surface water sampling parameters, timeframes and locations.

2. Adaptive Management Overview

The adaptive management arrangement for surface water samples, as outlined in conditions 6 to 14 of the consent, includes the following steps:

a) Determination, on a quarterly basis, of contaminant levels in surface water of the two tributaries upstream of the landfill at TTE & TTW, and in the combined stream flow downstream of the landfill at TTD, and in Owhiro Stream at OSU and OSD;

b) Comparison of results with ANZECC (2000) trigger values;

c) Determination of contaminant contribution from the landfill;

d) Comparison of that contribution with pre-determined tolerance limits;

e) Identification of any determinand which exceeds both the relevant ANZECC (2000) trigger value at TTD and the relevant tolerance limit;

f) In the event that a result exceeds both a tolerance limit and trigger value, undertake two rounds of follow-up sampling testing (these are called 'Additional Monitoring Rounds');

g) In the event that the average of these two follow-up values continues to exceed the relevant tolerance limit and the ANZECC trigger values the permit holder is required to implement the adaptive management conditions as required by conditions 13 and 14 of the discharge consent.

The adaptive management conditions triggered during the previous monitoring year (in the last quarter of 2016) prompted an assessment of the ecological effects of the discharges from the site as stated in Condition 13. This assessment was carried out in 2016 and discussed in Section 4.

The adaptive management response also included bringing forward construction of stream diversion channels, construction a treatment wetland, and updating the DMP to provide a stronger focus on wet weather events. The updated DMP (updated 2017) details changes to the monitoring including:

- Monthly surface water monitoring for the duration until stream diversion works are operating effectively, quarterly for groundwater. (These are called 'Monthly Monitoring Rounds' and replace the 'Quarterly' and 'Additional Monitoring Rounds' while in place)
- Analysis of both dissolved and total concentrations of surface water metals
- Addition of COD to the suite of parameters analysed.
- Additional surface water monitoring triggered by high rainfall events (>45 mm with 24 hrs at Karori Reservoir)
- A follow up ecological survey during summer once diversion works are complete.

Works to complete a stream diversion and construction of the wetland treatment system (condition 17) had been partially implemented but not completed by the end of June 2018. Currently the channels effectively divert wet weather flows over the landfill but a significant proportion of the dry weather baseflow continues to seep under the landfill and exits out into the wetland. The wetland has been constructed and planted but additional planting is planned over the late winter/spring period. Monthly monitoring will continue until such time as these works have been completed.

An additional trend analysis covering the last two reporting periods (from June 2016) has been included in this report at the request of GWRC.

3. Water Quality Monitoring Results

3.1 Methods

The routine sampling methodology is described in the Discharge Management Plan (DMP).

3.2 Surface Water Monitoring Results

This annual report covers ten sampling rounds at five surface water quality monitoring sites and four sampling round at one groundwater quality monitoring site. The sampling sites are provided in Appendix B and described as:

- TTW western gully stream (true right branch) at the northern end of the landfill
- TTE eastern gully stream (true left branch) at the northern end of the landfill
- TTD lower stream, 100 m downstream from the toe of the landfill
- TTG groundwater bore 100 m downstream from the toe of the landfill
- OSU Owhiro Stream upstream of the T&T landfill stream
- OSD Owhiro Stream downstream of the T&T landfill stream

It is noted that sites TTW and TTE are now inundated by ponded water. Samples are collected at the outlet from the dam overflow structure, or if there is no flow at the outlet, from ponded water.

Figure 3-1 shows the transition from quarterly monitoring to monthly monitoring along with the daily rainfall at Kaori Reservoir. Most sampling was carried out during dry weather, only one sample, February 2018, was captured during a rainfall triggered event. The rainfall trigger was also activated in March 2018, which should have triggered a second round of wet weather sampling but that opportunity was missed.

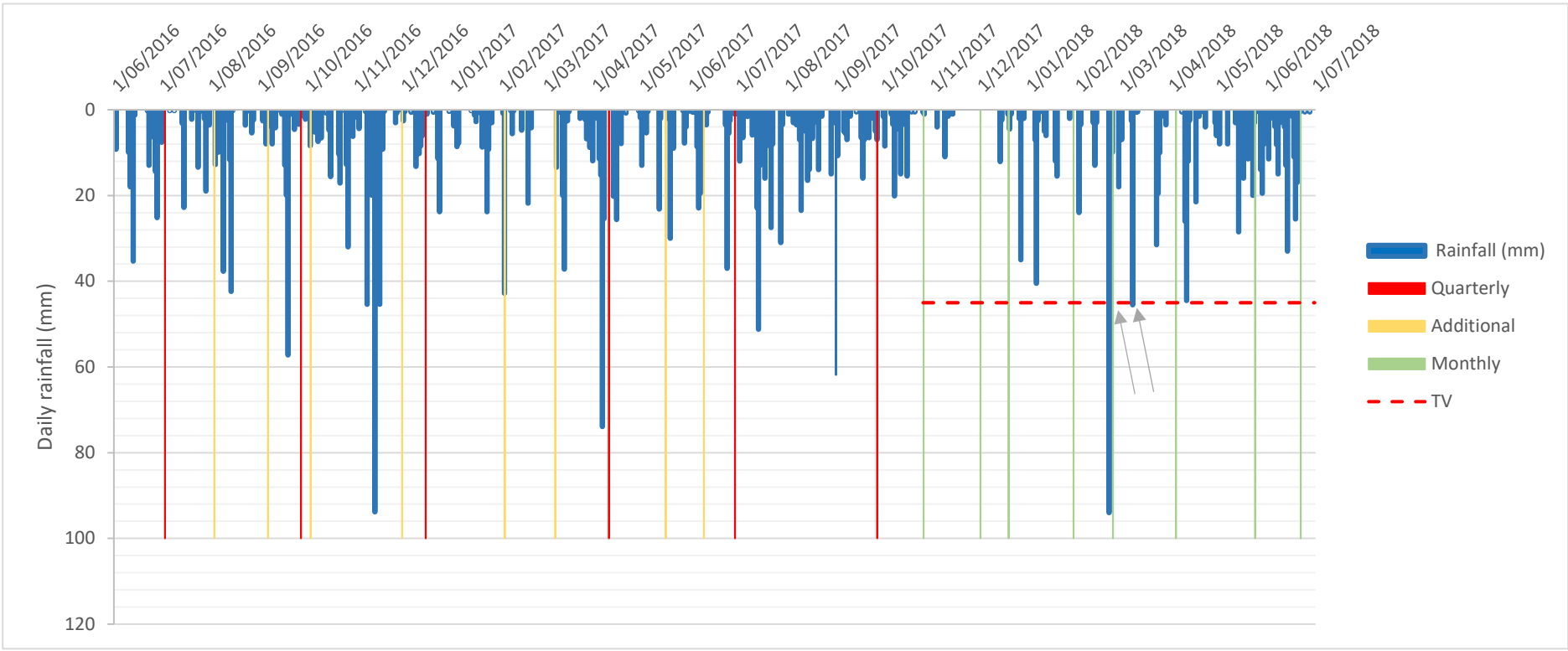

Figure 3-1: Daily rainfall at Karori Reservoir and the types of monitoring from June 2016 to June 2018. Vertical bars indicated quarterly, monthly of additional sampling event; grey arrows represent rainfall triggered sampling.

3.2.1 Surface Water Field Observations

Consent condition 11 states that the discharges shall not give rise to any of the following effects after reasonable mixing:

- The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials
- Any copious change in colour or visual clarity
- Any emission of objectionable odour
- The rendering of freshwater unsuitable for consumption by farm animals
- Any significant adverse effects on aquatic life; or
- Any visible deposition of iron oxide or other heavy metals

Site photographs, provided in Appendix E, were taken at each site during each monitoring round. A summary of the field observations are noted:

- Occasional notes on oil or grease films, scums or foams, or floatable or suspended were made throughout the reporting period. Foaming and/or a surface sheen were observed at sites TTD and OSD during February 2018. Debris, mostly leaves and sticks, was observed to be accumulating at locations within the ponds at TTW and TTE.
- Rubbish was observed throughout the reporting period at most sites, including the upstream control site (OSU).
- Some increase in water turbidity and reduced water clarity was occasionally observed at sites TTD and OSD when compared to the upstream sites, however this change was not conspicuous on any sampling occasion.
- A strong 'metallic' odour was detected at site TTD in February 2018. No odour was detected on any other sampling round at any sampling site. The ANZECC 2000 recommendations for water quality trigger values for heavy metals and metalloids in livestock drinking water and ANZECC 2000 recommendations for major ions of concern for livestock (TDS and dissolved magnesium) were used to identify risk of consumption by farm animals. No sampling round, for any site, exhibited concentrations that rendered the freshwater unsuitable for consumption by farm animals (Table 3-1).

Table 3-1: ANZECC 2000 recommendations for water quality trigger values for livestock drinking water.

Determinand	Trigger value (mg/L)	26/10/2017	01/12/2017	19/12/2017	29/01/2018	23/02/2018	04/04/2018	27/04/2018	24/05/2018	22/06/2018
Dissolved Arsenic	0.5	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Cadmium	0.01	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Copper[1]	0.4	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Lead	0.1	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Zinc	20	✓	✓	✓	✓	✓	✓	✓	✓	✓
TDS[2]	2000	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Magnesium	2000	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] Most conservative tolerance - Sheep

[2] Using electrical conductivity (µS/cm *0.67). Most conservative tolerance – Poultry: No adverse effects on animals expected between 0 and limit.

Significant adverse effects on aquatic life were not specifically tested during the reporting period, however, are discussed in Section 4.

The development of a conspicuous orange colouration in the pond (now constructed wetland) at the toe of the landfill and in the stream further downstream has been evident since approximately 2009 and has continued through the current reporting period. The orange colouration is caused by elevated concentrations of iron and/or manganese in stream water below the landfill leading to precipitation of iron floc. An iron oxide-accumulating bacterium (*Leptothrix*) facilitates the precipitation of iron floc and formation of the gelatinous masses observed in the stream. *Leptothrix* are non-disease producing bacteria which commonly colonise the transition zone where deoxygenated water from an anaerobic environment flows into an aerobic environment, i.e., where the stream emerges at the surface after passing more than 1km under the landfill. The area affected by iron floc became extensive during 2009 and 2010, probably indicating the onset of anoxic conditions in the landfill at that time.

Visible deposition of iron oxide was noted throughout most of the reporting period at TTD (100 m downstream of the landfill) and occasionally further downstream at OSD. Table 3-2 shows that very low or no orange precipitation was present on the stream bed during the November 2017 and January 2018 sampling rounds. However, during all other sampling rounds moderate to high levels of orange precipitation were observed at TTD. The requirement of Consent Condition 11 that the discharge shall cause no "*visible deposition of iron oxide or other heavy metals*" has not been consistently achieved during this reporting period.

Should any of the effects in Condition 11 occur, the permit holder shall commission an updated DMP exploring the relevant methodologies as require by condition 6. Accordingly, the DMP was updated on October 2017 and put into action in September 2017.

Table 3-2: Visual deposition of iron oxide at TTD over the reporting period.

Date/Assessment	Photo
September 2017	No Image
October 2017 High levels of orange precipitation on stream bed	
November 2017 Low / no orange precipitation on stream bed. Bed dark brown.	

December 2017 Moderate levels of orange precipitation on stream bed.	
January 2018 Very low levels of orange precipitation, mostly brown stream bed.	
February 2018 High levels of orange precipitation on stream bed.	
March 2018 High levels of orange precipitation on stream bed.	

April 2018 High levels of orange precipitation on stream bed.	
May 2018 High levels of orange precipitation on stream bed.	
June 2018 High levels of orange precipitation on stream bed.	

3.3 Comparison with Tolerance Limits and Trigger Values

3.3.1 Tolerance limits

The eastern and western branches of the T&T gully are each drained by headwater streams which have historically joined beneath the landfill, flowing out from the toe of the landfill as a single watercourse above site TTD. The two gullies are now dammed upstream of the landfill so as to divert surface water into constructed channels which run across the surface of the landfill re-joining the stream downstream of landfill and constructed wetland, approximately 80m upstream of TTD.

The contamination recorded at TTD is derived from sources upstream of the landfill (measured at TTE and TTW) and from the landfill itself. For each parameter the contribution derived from the landfill can be calculated by subtracting the average concentration upstream of the landfill from that recorded downstream of the landfill:

$$\text{Contaminant increment from landfill} = TTD - (TTE + TTW)/2$$

The contaminant increments from the landfill were determined from all monitoring rounds (using the total metal concentrations) and are compared against the specified tolerance limits in Table 3-3 below[3].

Ammoniacal nitrogen and total manganese exceeded the upper tolerance limit on all ten sampling occasions. Total Iron exceeded the upper tolerance limits in seven of ten samples. These results indicate that the ammoniacal nitrogen, total manganese, and total iron contribution from the landfill was high during the 2017/18 year compared with the 2004 to 2008 baseline period.

Electrical conductivity, pH, and alkalinity all exceeded the upper tolerance limit on 1 to 4 occasions.

3.3.2 Trigger values

Condition 8 of the consent requires that any monitoring result which exceeds a relevant tolerance limit must be compared with 'the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels'. Results for all monitoring sites are included in Appendix C and graphed in Appendix D.

Results for site TTD, 100m downstream of the landfill, are compared against ANZECC (2000) 90% protection default trigger levels and calculated site specific values in Figure 3-4. Note that ANZECC provides 90% trigger values only for stressors which are considered to be directly toxic to biota (such as ammonia, lead, copper and zinc). Table 3-4 also includes a trigger value for the sum of dissolved iron and manganese recommended by Hickey (2012) to prevent bed smothering.

The results in Table 3-4 show that the ANZECC default trigger value for ammonia was exceeded at site TTD in two of ten samples, but the calculated site specific trigger value was not exceeded in any sample. ANZECC trigger values for dissolved arsenic, lead, copper, chromium and zinc were not exceeded in any of the ten samples. These results indicate that the risk of direct toxicity due to ammonia, arsenic, lead, copper, chromium or zinc is low in aquatic habitats downstream of the landfill.

However, the trigger value for dissolved iron and manganese was consistently exceeded at Site TTD. High concentrations of dissolved iron and/or manganese have resulted in extensive covering of the streambed by an orange coloured precipitate at TTD on most sampling occasions, potentially degrading the habitat of invertebrates and fish.

[3] The tolerance limits are specified in condition 8 of the discharge permit and have been calculated from monitoring data collected between March 2004 and November 2008, inclusive except for total hardness and total suspended solids (TSS) which were calculated using monitoring data collected between December 2009 and January 2012. These tolerance intervals have been calculated on the difference between the downstream and upstream samples such that they contain 95% of the data distribution with 95% probability. Arsenic and chromium 'tolerance limits' were not derived from previous monitoring results but were arbitrarily selected in the 2011 consent variation.

Table 3-3: Contaminant increments from the landfill compared with specified tolerance limits (exceedences are red).

Parameter	TTD – (TTE + TTW)/2 Results										Lower Tolerance Limit (LTL)	Upper Tolerance Limit (UTL)
	22/06/18	24/05/18	27/04/18	04/04/18	23/02/18	29/01/18	19/12/17	01/12/17	26/10/17	27/09/17		
pH	-0.05	-0.30	0.25	-0.65	0.20	0.00	0.05	-0.10	-0.15	-0.10	-0.4	0.4
Electrical Conductivity (mS/m)	81.25	59.70	49.80	54.95	89.05	45.80	45.65	44.90	52.45	59.25		72.4
Alkalinity (g/m^3 $CaCO_3$)	288.00	229.50	214.50	226.00	334.50	223.00	212.50	215.00	222.50	244.50		226
Total suspended solids (g/m^3)	11.50	9.75	7.50	21.75	21.00	8.00	5.25	8.50	4.50	-46.25		32
COD (g O2/m^3)	17	16	7	11	17	-9	1	9	10	10		21
Total Hardness (g/m^3 $CaCO_3$)	392.50	296.50	249.00	264.50	427.50	215.00	225.00	219.00	238.00	315.00		465
Ammoniacal Nitrogen (g/m^3)	1.55	0.95	0.99	1.10	1.92	0.65	0.41	0.46	1.09	1.78		0.346
Total Iron (g/m^3)	4.90	4.59	4.91	6.74	7.65	4.70	2.85	2.49	2.46	2.58		2.748
Total Manganese (g/m^3)	2.56	2.20	2.23	2.46	2.16	1.91	1.68	1.76	1.84	1.77		1.461
Total Lead (g/m^3)	0.000275	0.000090	0.000275	0.000715	0.001350	0.000275	0.000195	0.000460	0.000130	-0.001045		0.0059
Total Copper (g/m^3)	0.000348	0.001208	-0.000228	0.000393	0.000665	-0.000208	-0.000705	0.000193	-0.000238	-0.000535		0.004
Total Zinc (g/m^3)	0.001650	0.001350	-0.000650	0.003250	0.012700	0.001775	-0.001000	-0.000350	0.002900	0.002800		0.130
Total Arsenic (g/m^3)	-0.000325	-0.002500	0.002550	0.003250	0.003375	0.002150	0.000750	0.000850	0.001150	0.001550		0.013
Total Chromium (g/m^3)	0.000883	0.000878	0.000665	0.000923	0.001000	0.000558	0.000675	0.000515	0.000435	0.000468		0.001

Table 3-4: Monthly sampling results compared with ANZECC trigger values (exceedences are red).

Parameter	Site TTD										ANZECC 90% TV
	22/06/18	24/05/18	27/04/18	04/04/18	23/02/18	29/01/18	19/12/17	01/12/17	26/10/17	27/09/17	
pH	7.2	7.3	7.5	7.5	7.3	7.5	7.7	7.6	7.6	7.5	Not specified
Electrical Conductivity (mS/m)	105.5	84.2	77.5	80.7	109.6	75.5	79.2	78.9	82.9	90.0	Not specified
Alkalinity (g/m^3 $CaCO_3$)	320	270	260	270	360	280	270	270	270	290	Not specified
Total suspended solids (g/m^3)	13.0	14.0	15.0	28.0	25.0	16.0	11.0	10.0	6.0	9.0	Not specified
COD (g O2/m^3)	22	21	14	16	27	7	11	12	13	13	Not specified
Total Hardness (g/m^3 $CaCO_3$)	430	340	300	310	460	270	290	280	290	370	Not specified
Ammoniacal Nitrogen (g/m^3)	1.570	1.030	1.020	1.100	1.980	0.700	0.460	0.490	1.090	1.78	2.34[1] (1.43)[2]
Dissolved manganese (g/m^3)	2.700	2.300	2.400	2.400	2.100	1.850	1.750	1.700	1.171	-	2.5
Dissolved Iron+Manganese (g/m^3)	2.720	2.320	2.440	2.440	2.150	1.890	1.770	1.730	1.720	-	1.0[3]
Dissolved Lead (g/m^3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	-	0.011[1] (0.0056)[2]
Dissolved Copper (g/m^3)	0.00003	0.00003	0.00003	0.00095	0.00050	0.00027	0.00003	0.00003	0.0011	-	0.0028[1] (0.0018)[2]
Dissolved Zinc (g/m^3)	0.00580	0.00210	0.00110	0.00650	0.00720	0.00050	0.00050	0.00440	0.00440	-	0.027[1] (0.015)[2]
Dissolved Arsenic (g/m^3)	0.00120	0.00300	0.00140	0.00140	0.00050	0.00050	0.00130	0.00050	0.0005	-	0.042[2]
Dissolved Chromium (g/m^3)	0.00080	0.00003	0.00050	0.00003	0.00090	0.00003	0.00003	0.00003	0.00003	-	0.006[2]

Notes: [1]Calculated site specific 90% protection trigger values based on a methodology from ANZECC 2000: ammoniacal-N is calculated for pH 7.6 which is the maximum value at TTD; hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m^3 CaCo.

[2]Default 90% protection trigger values from ANZECC (2000)

[3]Hickey (2012) recommended that the sum of dissolved iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3.3.3 Adaptive management response

In the event that a sample collected at TTD exceeds the relevant tolerance limit ***and*** also exceeds the ANZECC trigger value listed in Table 3-4, two further sampling rounds are required within two months. In these samples, the dissolved fraction of metals are tested and compared to the ANZECC (2000) 90% trigger values set out in the DMP to confirm exceedances. Note, for most of the 2017/18 monitoring year the requirement to test quarterly samples plus two additional samples if an exceedance occurs has been replaced by a requirement to sample every month regardless of the results of the previous sample. If the average of the two recoveries continues to exceed the relevant tolerance limit and TVs, the permit holder is required to implement the adaptive management actions under conditions 13 and 14 of the discharge permit (refer Appendix A). The results of this assessment are summarised below in Table 3-5.

Ammoniacal nitrogen exceeded the upper tolerance limits for all ten samples, however, none of the samples exceeded the site specific ANZECC (2000) 90% trigger value during the reporting period. Nevertheless, adaptive management actions are currently being implemented due the trigger having been exceeded in the 2016/17 monitoring year. These works, including diversion channels and a constructed wetland, appear to have reduced ammonia to within acceptable limits. Completion of those works will potentially deliver further ammonia reductions in the watercourse downstream of the landfill.

Total manganese exceeded tolerance limits in all ten samples, and dissolved manganese exceeded the site specific ANZECC trigger value in one sample, indicating the need for a management response.

A dissolved iron + dissolved manganese trigger value was added to the DMP in the 2017 review. Hickey (2012) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering. During this reporting period, all nine samples exceeded this limit, due largely to elevated manganese levels. It is expected that completion of the diversion channels will further reduce the volume of water passing under the landfill and increase the volume being diverted around the landfill which, in combination with the wetland treatment system, should achieve further reductions in stream concentrations of iron and manganese.

At this stage it is not clear whether the works currently underway will achieve sufficiently low iron and manganese levels to prevent iron oxide precipitation on the streambed. A readily achievable target would be to ensure that oxide precipitation of the streambed is limited to the landfill tributary and does not extend into Owhiro Stream. Photographs of the stream diversion system and constructed wetland are shown in Figure 3-2 to Figure 3-4. The channel diversion works are shown in Appendix E.

Table 3-5: Compliance record from four sampling rounds for the year to June 2018

Parameter	Tolerance limit exceeded?[4]	ANZECC 90% TV Exceeded at TTD?	Additional sampling required?	Adaptive Management action required?
pH	**1/10**	Not Applicable	Not Applicable	no
Electrical conductivity (mS/m)	**2/10**	Not Applicable	Not Applicable	no
Alkalinity (g/m^3 $CaCO_3$)	**4/10**	Not Applicable	Not Applicable	no
TSS (g/m^3)	0/10	Not Applicable	Not Applicable	no
COD (g O2/m^3)	0/10	Not Applicable	Not Applicable	no
Total Hardness (g/m^3 $CaCO_3$)	0/10	Not Applicable	Not Applicable	no
Total ammoniacal N (g/m^3)	**10/10**	0/9	Not Applicable	**In progress from 2016/17**
Dissolved Iron (g/m^3)	**7/10**	Not Applicable	Not Applicable	no
Dissolved Manganese (g/m^3)	**10/10**	**1/9**	Not Applicable	**Yes, in progress**
Dissolved Iron + Manganese (g/m^3)[5]	N/A	**9/9**	Not Applicable	**Yes, in progress**
Dissolved Lead (g/m^3)	0/10	0/9	Not Applicable	no
Dissolved Copper (g/m^3)	0/10	0/9	Not Applicable	no
Dissolved Zinc (g/m^3)	0/10	0/9	Not Applicable	no
Dissolved Chromium (g/m^3)	0/10	0/9	Not Applicable	no
Dissolved Arsenic (g/m^3)	0/10	0/9	Not Applicable	no

[4] Tolerance limits are assessed against totals, while ANZECC (2000) 90% trigger values are assessed against dissolved.

[5] Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

Figure 3-2: Western dam and diversion flow as of June 2018

Figure 3-3: Eastern dam and diversion flow as of June 2018

Figure 3-4: Diversion channel downstream (left) and wetland as of June 2018 (right)

By the end of June 2018 is was apparent that the diversion channels were effectively diverting wet weather stream flows around the landfill, however considerable quantities of water continued to seep through the base of both dams into the landfill, eventually exiting from the toe of the landfill into the wetland treatment system. It is our observation that in dry weather the entire base flow seeps under the landfill, with no surface flow in the diversion channels.

3.4 Surface water spatial and temporal trends

The surface water quality results for the year to 30 June 2018, together with historical results collected previously since December 2009, are graphed in Appendix D.

Temporal trends within this section also assessed for the period June 2016 through to June 2018 (the last two reporting periods) to show the benefits achieved by the diversion channels and the constructed wetland system.

3.4.1 Trends not associated with T & T Landfill operations.

No temporal trends were observed for pH, TSS and DOC and total lead. pH values were consistently between 6.5 and 9 and Owhiro Stream concentrations (OSU, OSD) were slightly more acidic than samples at the landfill.

Total and dissolved copper and zinc, and dissolved lead concentrations were all highest in Owhiro Stream upstream of the landfill tributary, at site OSU. The likely source of these contaminants is stormwater runoff from road and roofs from the urban area of Brooklyn. Concentration of these contaminants in the landfill tributary at site TTD are consistently lower than in Owhiro Stream. Over the last two years no clear trend can be discerned for these constituent at any of the monitoring sites. The results for dissolved copper are shown in Figure 3-5.

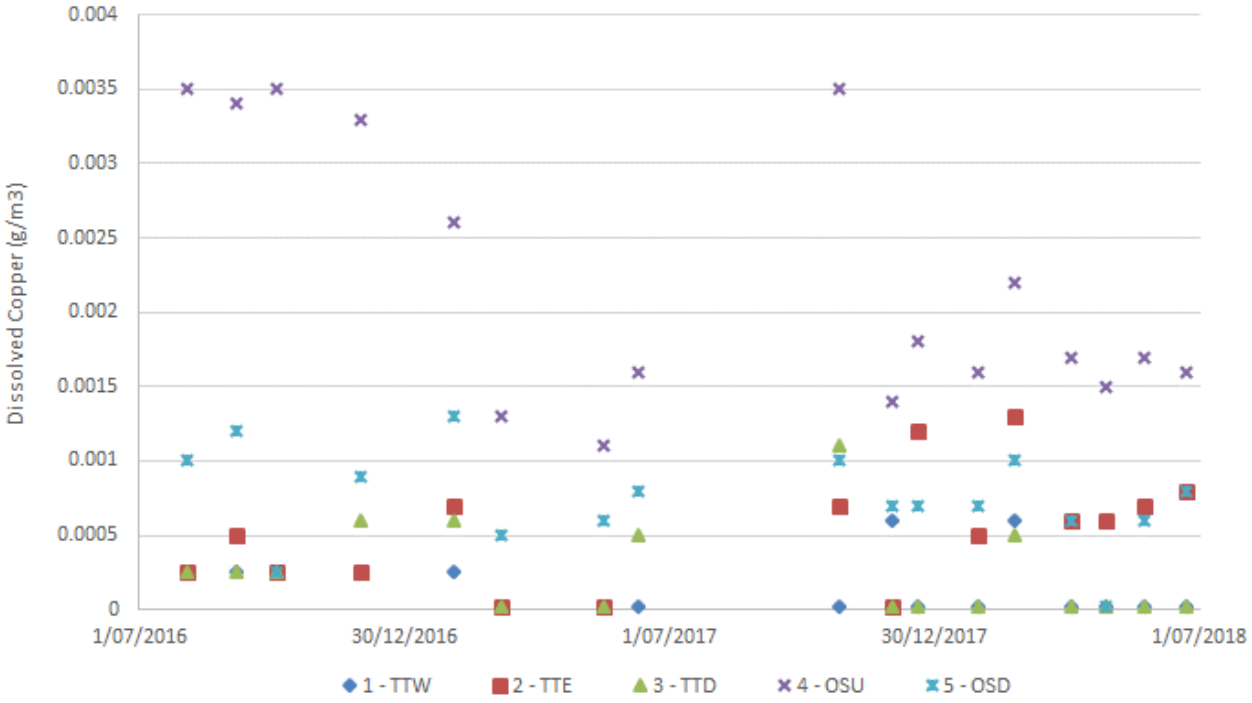

Figure 3-5: Dissolved copper from June 2016 through to July 2018.

3.4.2 Trends likely associated with T & T Landfill operations

General temporal trends

The general trend for most constituents at sites TTD and OSD is for a sharp increase through the third and fourth quarters of 2016 followed by a decline in the first quarter of 2017, and mostly stable results through 2017 and the first half of 2018. The spike in the second half of 2016 appears to have been triggered by a series of high rainfall events at that time.

Increased water hardness below landfill

The monitoring results for the two years to June 2018 show that the headwater tributaries (TTW and TTE) upstream of the landfill had generally high water quality and low contaminant levels. Concentrations of some contaminants increased in the watercourse during its passage through the French Drain network under the landfill, through the wetland and downstream to site TTD. The diversion channels are designed to direct stream water flow around the landfill thereby reducing the quantity of leachate generated within the landfill and passing through the constructed wetland.

The changes include a slight pH reduction and a marked increase in alkalinity, electrical conductivity (EC), dissolved magnesium and calcium concentrations, and an associated increase in water hardness (Figure 3-6). These changes are consistent with water passing slowly through a large volume of crushed concrete within the landfill. There is a clear reduction in water hardness in the year to June 2018 compared with the year to June 2017 which is attributed to the channel diversion and wetland construction works. It is expected that completion of these works so as to divert a greater proportion of the stream flow around the landfill would further reduce leachate quantities and consequent impacts on downstream habitats.

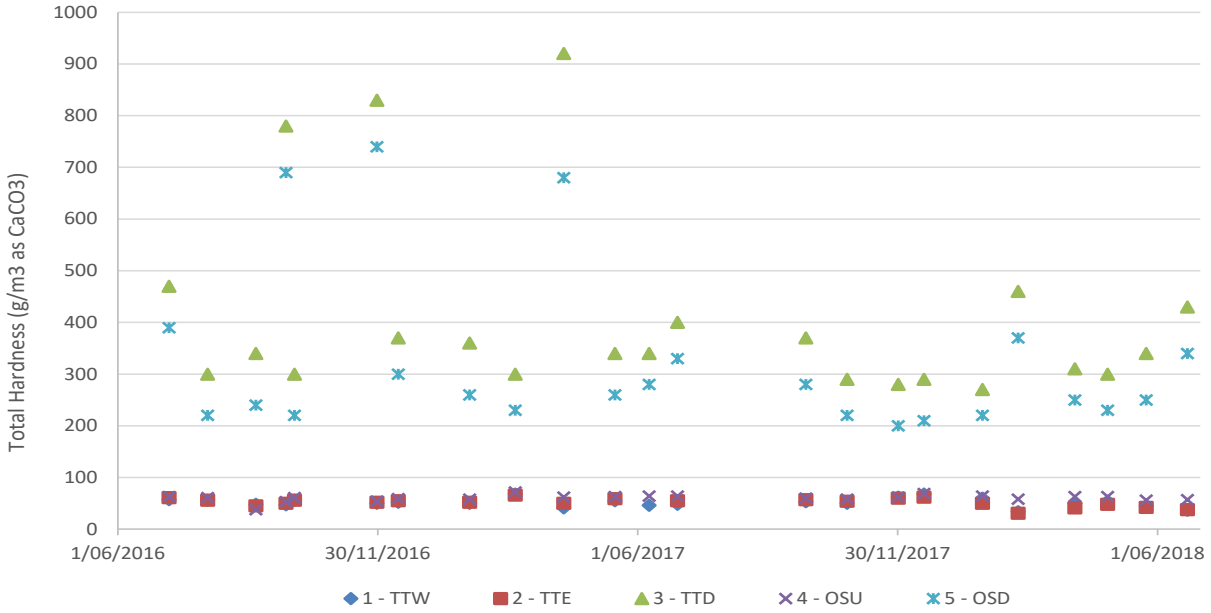

Figure 3-6: Total hardness June 2016 through to July 2018.

Ammoniacal-nitrogen

A trend of increasing ammoniacal nitrogen levels at TTD began during 2011 and is characterised by a series of peaks (in mid-2012, mid-2013 and mid/late 2016) which coincide with heavy rainfall (Figure 3-7). During 2016 ammoniacal nitrogen concentrations increased sharply after a heavy rainfall event and then remained high until a decline in the first quarter 2017. Throughout 2017 and 2018 ammonia concentrations remained below the site specific ANZECC (2000) 90% trigger level despite significant rainfall events in that period (Figure 3-8).

It is likely that the diversion works and constructed wetland have contributed to lower ammoniacal nitrogen concentrations, and that there is scope for achieving further reductions by diverting a high proportion of stream flow around the landfill.

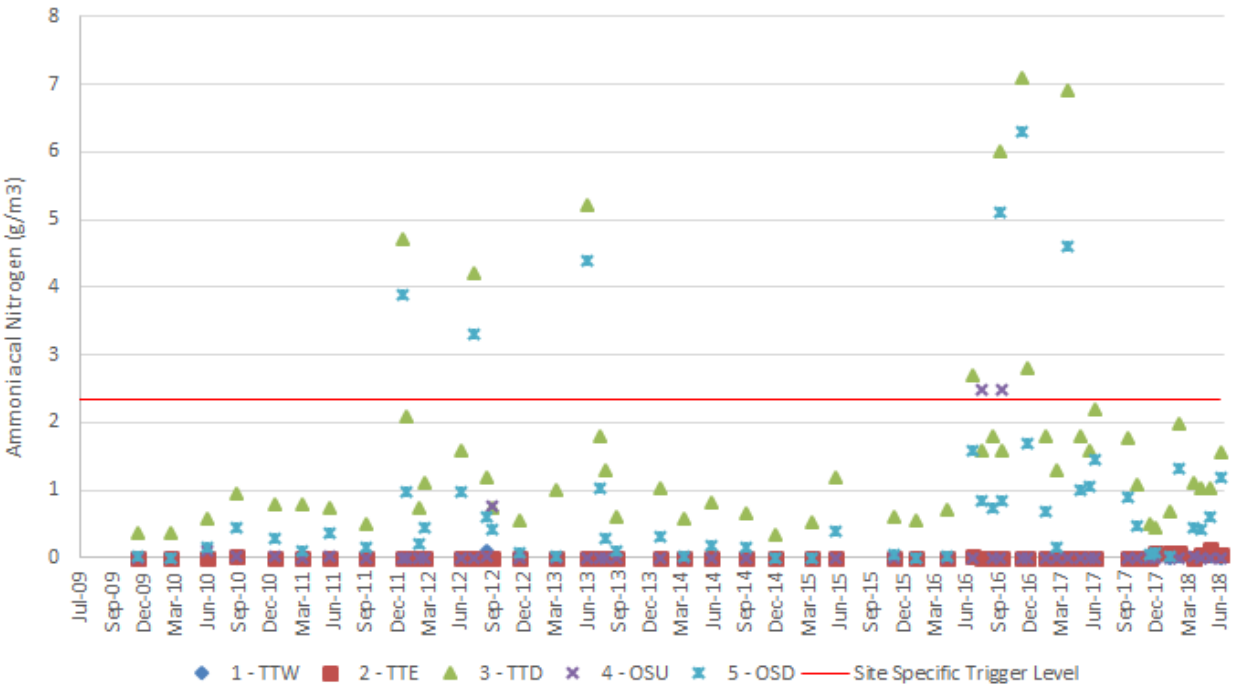

Figure 3-7: Historical ammoniacal nitrogen from Dec 2010 through to June 2018.

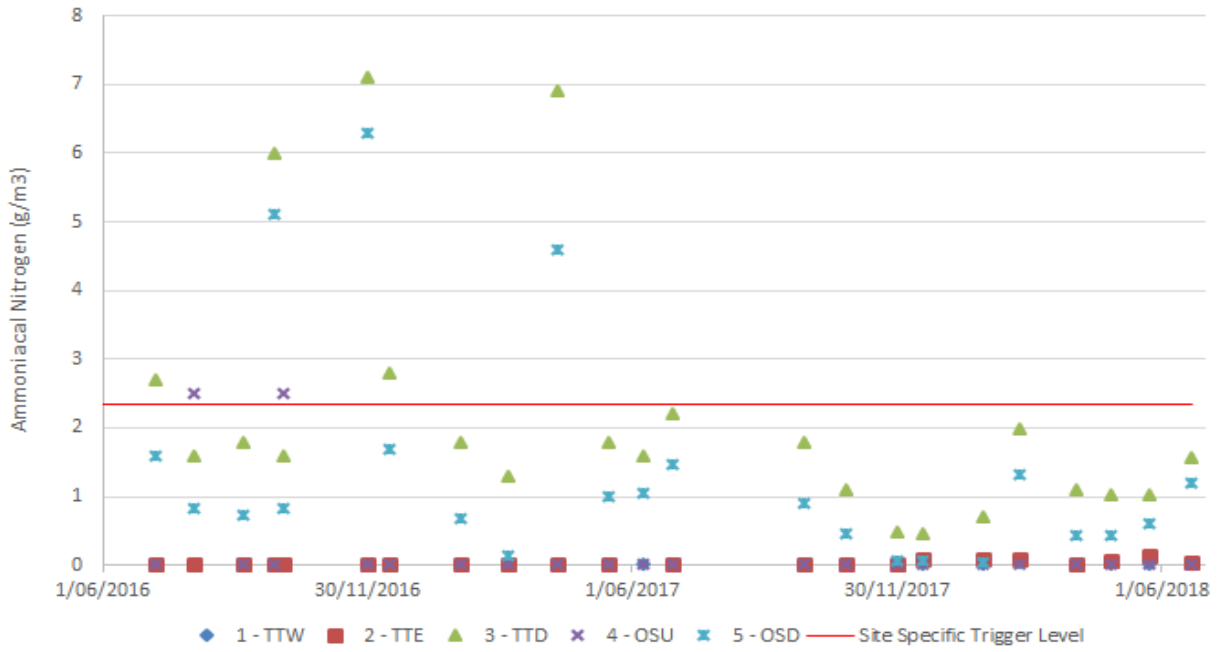

Figure 3-8: Ammoniacal nitrogen over last two reporting periods (June 2016 – June 2018)

Iron and Manganese

Historically, total manganese has remained consistently above 1.0 g/m³ in all samples collected at TTD (Figure 3-9). Subsequent monitoring has shown that the majority of manganese at TTD is in the dissolved form (Figure 3-11). In the case of Iron, the dissolved fraction is virtually absent at TTD, with all iron present in the particulate form (Figure 3-12). During the current reporting period the sum of dissolved iron and manganese exceeded the trigger limit of 1.0 g/m³ in all ten samples collected. From June 2016 to June 2018 dissolved manganese levels spiked in November 2016 followed by a rapid decline and then a slow gradual increase through to June 2018 Figure 3-10). There is no clear evidence from monitoring results to date that the diversion channels and constructed wetland have reduced stream concentrations of manganese. Nevertheless, it is expected that some reduction can be achieved by diverting a greater proportion of the stream flow around the landfill and reducing seepage through the landfill.

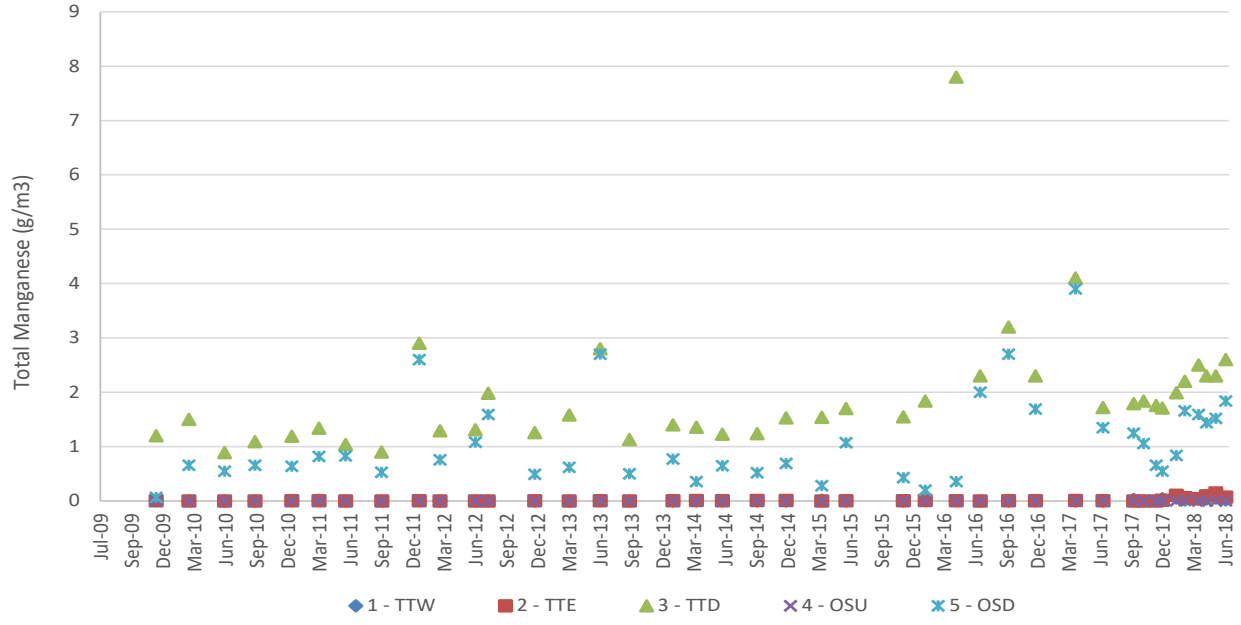

Figure 3-9: Total Manganese from Dec 2010 through to June 2018

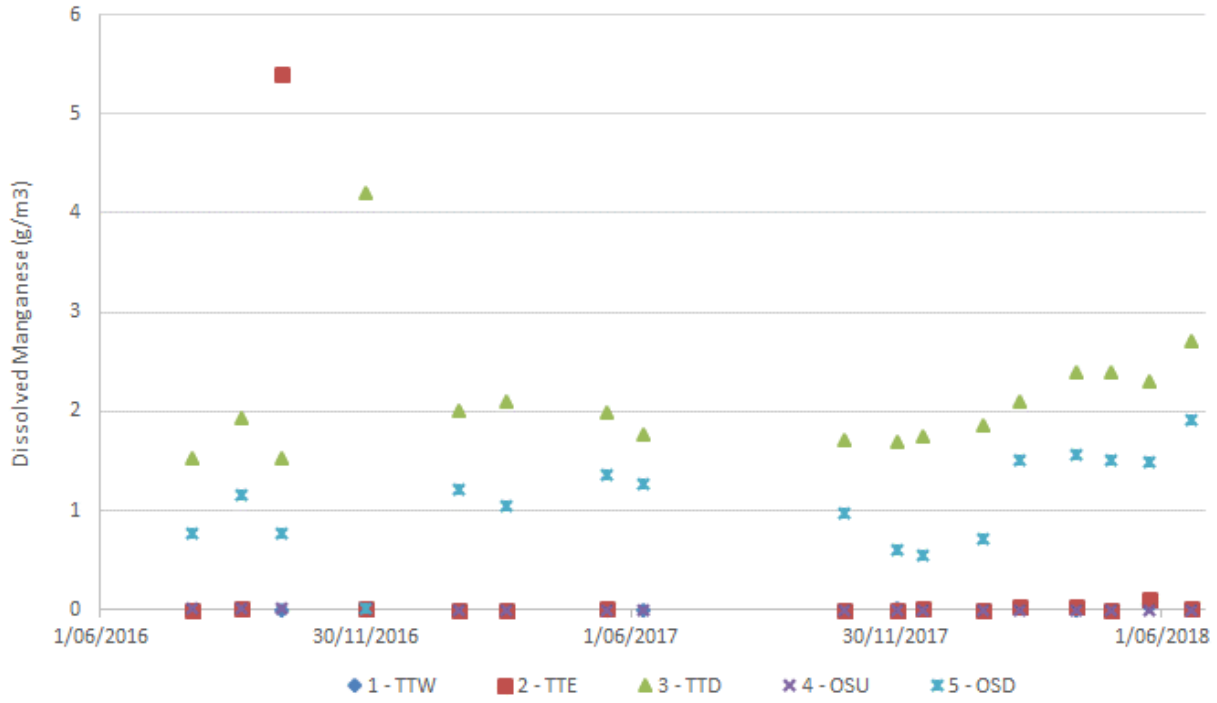

Figure 3-10: Dissolved Manganese over last two reporting periods (June 2016 – June 2018)

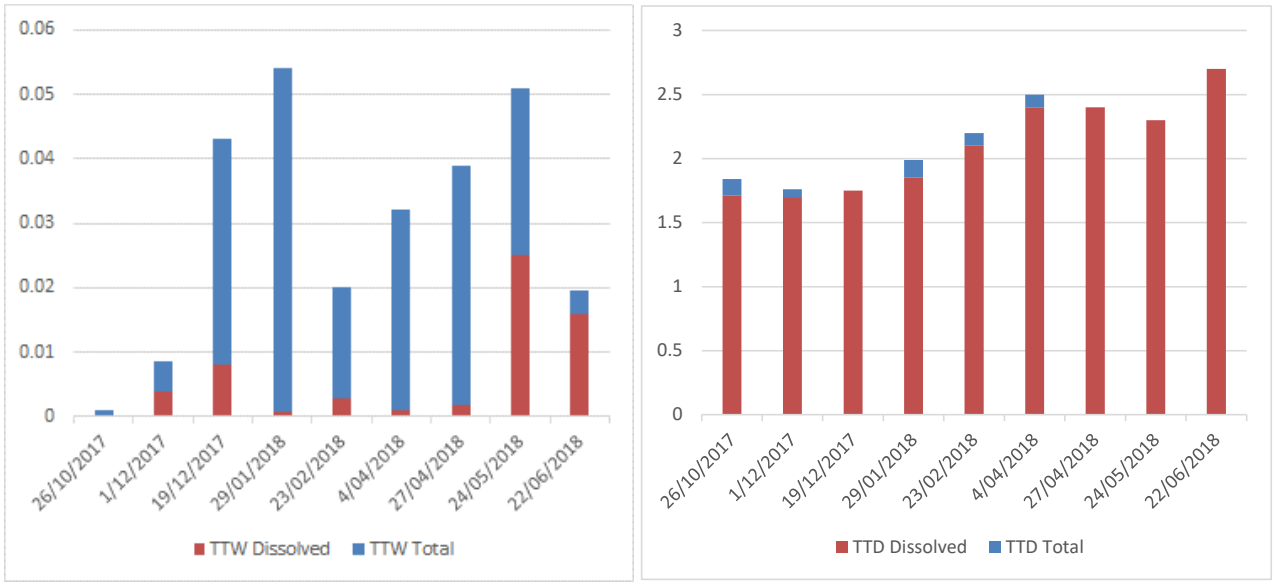

Figure 3-11: Total manganese vs. dissolved manganese at TTW and TTD.

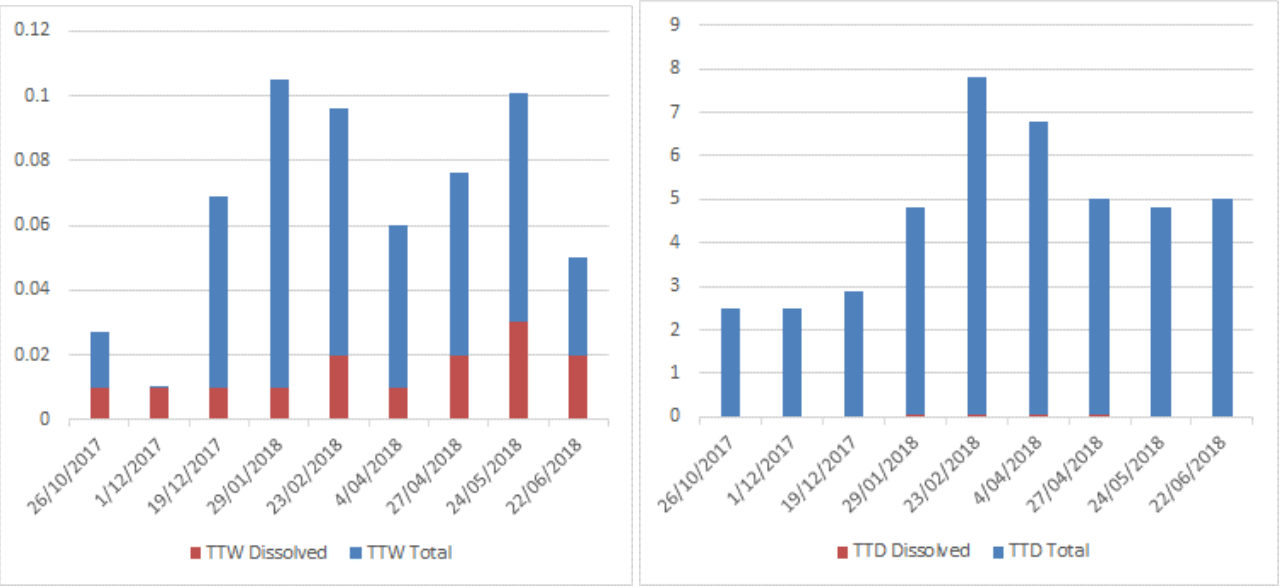

Figure 3-12: Total iron and dissolved iron at TTW and TTD

3.5 Groundwater Monitoring Results

Groundwater quality monitoring results summarized in Table 3-6 show contaminant concentrations were variable through the monitoring year. Over the longer term there has been considerable variation in concentrations of iron and manganese in particular, and to a lesser extent copper, zinc and lead Figure 3-13 and Figure 3-14. There is very little correlation between groundwater and surface water concentrations of these metals.

Table 3-6: Groundwater monitoring results for the year to June 2018

Parameter	Unit	TTG Results			
		22/06/2018	04/04/2018	19/12/2017	27/09/2017
pH	pH	6.7	7	7	6.5
Chloride	g/m3	98	109	106	103
Conductivity	µS/m	47.8	52.2	53.6	55.1
Nitrate Nitrogen	g/m3	1.93	2	2.1	2.1
Ammoniacal Nitrogen	g/m3	0.63	0.005	0.005	0.005
Total Lead	g/m3	0.12	0.125	0.65	0.0191
Total Zinc	g/m3	0.24	0.28	1.26	0.039
Total Iron	g/m3	50	48	260	9.5
Total Manganese	g/m3	4.8	7.2	30	1.2
Total Copper	g/m3	0.058	0.075	0.32	0.0076

Note: Results below detection limits are halved.

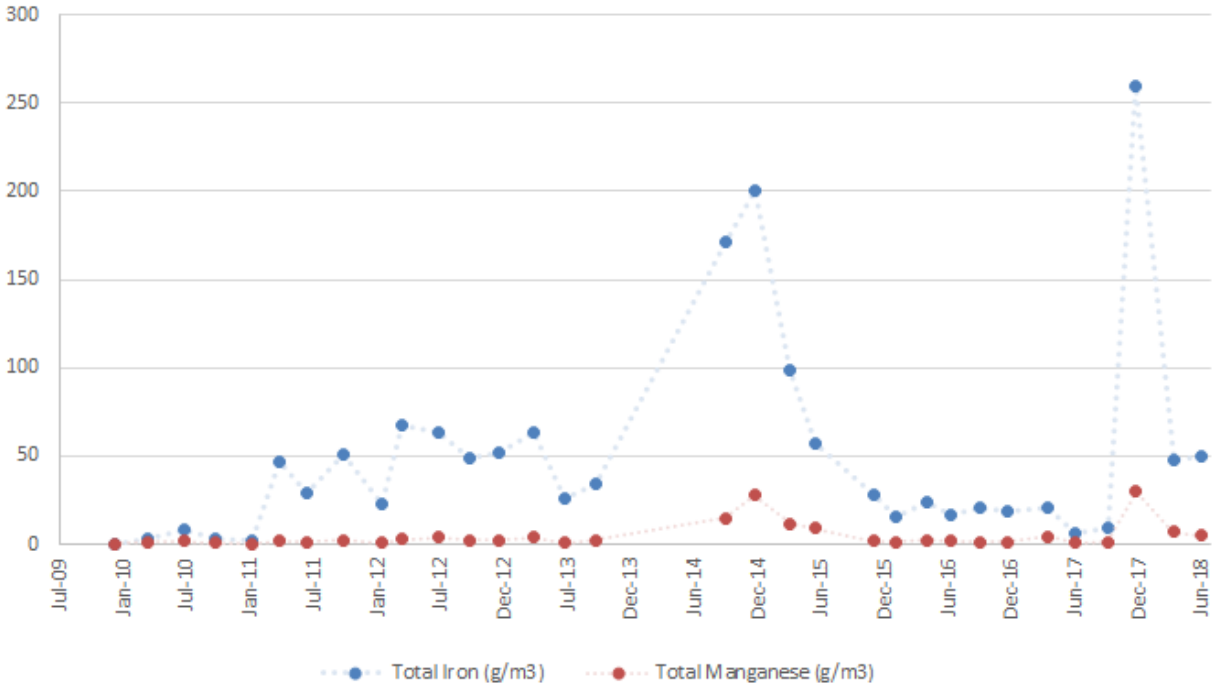

Figure 3-13: Total Iron and Total manganese concentrations in groundwater samples collected downstream of the landfill at site TTG

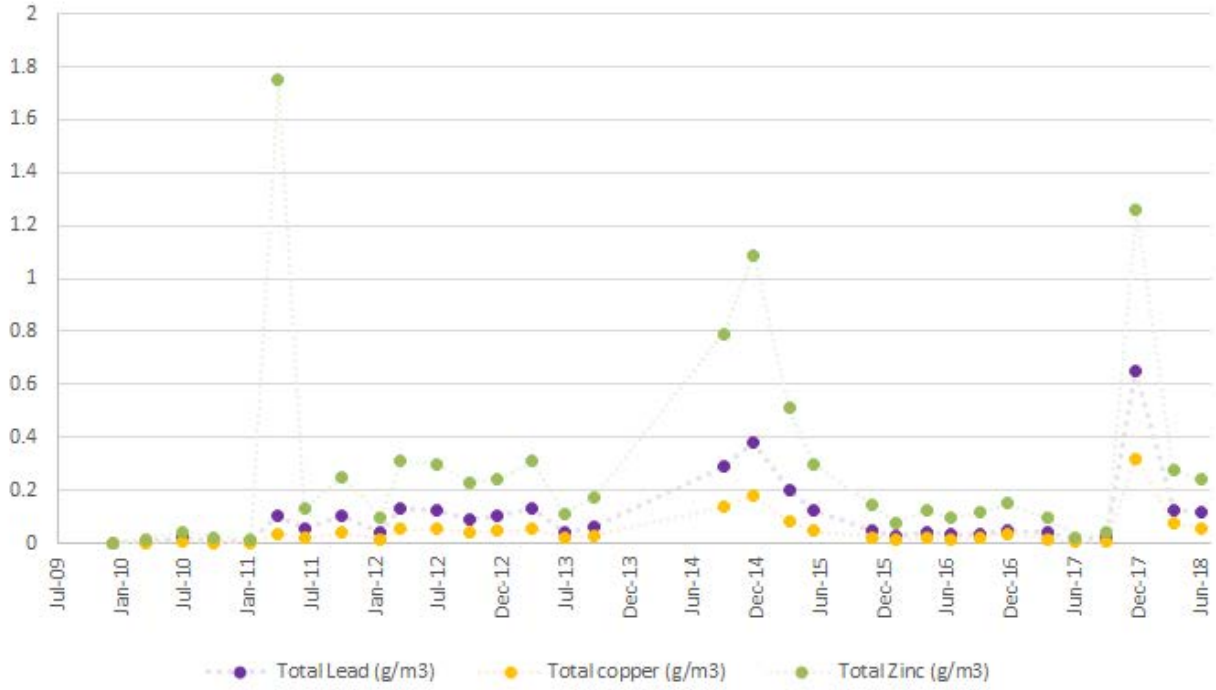

Figure 3-14: Total lead, total copper and total zinc concentrations in groundwater samples collected downstream of the landfill at site TTG

4. Annual Discharges in Relation to Ecology Assessment 2016

Condition 9 of the discharge consent requires that the annual report include:

"A comparison of the concentration of contaminants of the latest year of sampling with the baseline ecology survey results as required by condition 12 of this permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge."

T&T Landfills commissioned an ecological study of the tributary stream upstream and downstream of the landfill during 2010 pursuant to condition 12 of the consent. A second ecological survey was conducted in December 2016 following an exceedance of trigger values during the last quarter of 2016. The next survey is due to be completed during the summer of 2018-19. A comparison between results of the 2010 and 2016 surveys show that:

- Concentrations of a number of contaminants at site TTD including EC, alkalinity, hardness, calcium, magnesium, ammonia, iron and manganese have increased since 2010, possibly associated with the gradual development of the landfill over that period. By contrast total copper, total lead and total zinc show a decreasing trend at TTD over that period. Metals that show no measurable change during passage under the landfill include dissolved arsenic, dissolved copper, dissolved chromium, total chromium and dissolved lead.
- The contaminants of most concern at TTD are iron, manganese and ammonia, all of which have significantly exceeded recommended TVs. High levels of iron and manganese have, in combination with elevated levels of dissolved organic matter (DOM), resulted in ferric iron precipitation covering streambed substrates in the reach below the landfill, extending downstream beyond site OSD. The extent of streambed affected by iron bacteria has gradually increased between 2010 and 2016. Similarly, TSS has gradually increased at TTD due in part to increased iron bacteria growths. It is noted that iron precipitation may have direct or indirect effects on stream biota but also has an adverse effect on water clarity, TSS, and the visual appearance of the streambed.
- Invertebrate metric scores are lower in 2016 than in 2010 at all monitoring sites. The reason for differences at upstream sites TTE and TTW is not clear, but may be related to a major flood event that occurred approximately 5 weeks prior to the 2016 survey.
- Adverse effects in the tributary below the landfill appear to have been more pronounced in 2010 than in 2016; and
- Adverse effects in Owhiro Stream were slightly more pronounced in 2016 than in 2010.

The 2016 ecological study (Cameron, 2017) concluded that landfill discharges had caused significant deposition of iron oxide on the streambed and consequent changes in the colour and/or visual clarity of the stream water, and the magnitude of those effects had increased since the baseline survey was conducted in 2010. These effect appear to have stabilised during the 2017-18 reporting period.

Ammoniacal nitrogen concentrations were markedly lower during the 2017/18 year compared to the last half of 2016. These results suggest that the risk of ammonia toxicity was substantially lower in 2017/18 compared with late 2016 and that the quality of the benthic community may well have improved over that period.

A benthic ecology survey proposed for the 2018/19 summer will confirm the extent of any improvements that may have occurred since late 2016.

5. Conclusion and Recommendation

Leachate generation in the landfill continues to have some impact on downstream water quality in the unnamed tributary and Owhiro Stream through elevated levels of ammonia, dissolved iron and dissolved manganese. High levels of dissolved iron and manganese have formed a conspicuous orange precipitate on the streambed downstream of the landfill, which has the potential to adversely affect the quality of habitat for invertebrates and fish, and to reduce amenity values.

The diversion of stream water and local stormwater around the landfill has already reduced leachate volumes, but diversion of a greater proportion of the stream flow is needed. It is recommended that mitigation actions should include the following:

- Reduced seepage through the base of dams at TTW and TTE, and in the stream reach immediately upstream of the dam, to ensure that dry weather base flows are diverted in the constructed channels and that flow under the landfill is minimised.
- Replanting of the constructed wetland with appropriate, locally sourced wetland plants to ensure a substrate (roots, stems leaves) upon which microorganisms can grow and break down organic materials.
- A benthic ecology survey to be conducted during the 2018/19 summer that is comparable to the survey conducted in December 2016 (Cameron, 2016) in order to assess the condition of Owhiro Stream following completion of stream diversion works and constructed wetland.
- No change should be made to the daily rainfall trigger of 45mm, but an increased level of vigilance is required to ensure that a water quality survey is conducted within seven days of each trigger level exceedance.

Appendices

Appendix A Consent Conditions

Conditions to Resource Consent WGN070260 [30627]

1[1]. The location, design, implementation and operation of the discharge shall be in general accordance with the application, associated documents and further information lodged with Wellington Regional Council on:

- 14 June 2007 (consent application)
- 14 June 2007 (plans, including final stormwater discharge plan E04-1000-FL)
- 21 June 2007 (microalgae investigation report)
- 6 September 2007 (second microalgae investigation report)
- 7 September 2007 (executive summary)
- 4 June 2008 (Wellington City Council application)
- 27 February 2009 (Further information)
- 18 August 2010 (change of conditions application); and
- 14 June 2011 (Further information)

Where there may be contradictions or inconsistencies between the application and further information provided by the applicant, the most recent information applies. In addition, where there may be inconsistencies between information provided by the applicant and conditions of consent, the conditions apply.

Note: Any change from the location, design concepts and parameters implemented and/or operation may require a change in consent conditions pursuant to Section 127 of the Resource Management Act 1991.

2. The permit holder shall provide a copy of this permit and any documents referred to in this permit to each operator or contractor undertaking works authorised by this permit before that operator or contractor starts any works.

Note: It is recommended that the contractor(s) undertaking the works be verbally briefed on the conditions of this and all other associated permits prior to the works being undertaken.

3. The permit holder shall ensure that a copy of this permit and all other permits granted under the Wellington Regional Council resource consent suite WGN070260 is kept within the site office, and presented to any Wellington Regional Council officer on request.

4. The permit holder shall keep a permanent record of any complaints received alleging adverse effects from the permit holder's operations. The complaints record shall contain the following where practicable:

- The name and address of the complainant, if supplied
- Identification of the nature of the complaint
- Date and time of the complaint and alleged event
- Weather conditions at the time of the alleged event
- Results of the permit holder's investigations; and
- Any mitigation measures adopted.

The complaints record shall be made available to the Wellington Regional Council on request.

Site Operations and Maintenance Condition

5. The permit holder shall, at all times, operate, maintain, supervise and control all processes and equipment on site to ensure compliance with all conditions of this permit and the Operations Management Plan required by condition 6 of permit WGN070260 [26122].

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[1] Condition changed under section 127 of the Act, granted 28/07/11

Monitoring of Discharge

6. Within six months of the grant of this permit, the permit holder shall engage a suitably qualified person to prepare and submit a **Discharge Management Plan (DMP)** for approval, to the Manager, Environmental Regulation, Wellington Regional Council.

The purpose of the DMP is to establish and implement a more scientifically robust quantification at representative locations of the effects of the discharge coming from the landfill, and the effects of the discharge to the downstream unnamed tributaries of Owhiro Stream.

The DMP shall include, but not be limited to, the following:

- The provision of maps and monitoring locations (GPS locations or NZMS 260 grid references) that provide for an upstream control sample from both the eastern (TTE) and western arm (TTW) tributaries, downstream of the discharge point (TTD/TTG) and the main trunk of Owhiro Stream (upstream and downstream of the confluence of the landfill tributary with the main trunk of Owhiro Stream); and
- A monitoring methodology for surface and ground water quality sampling, including, but not limited to:
  - The technique used to recover the contaminants from the samples
  - The location and area the sampling will be undertaken over; and
  - A comparison with relevant tolerance limits (including method of calculation) and guidelines (e.g. surface water quality values against the ANZECC 2000 90% ecosystem protection values for freshwater quality) and the upstream control samples for the protection and maintenance of ecosystem services within the Owhiro Stream

Note: The DMP is to be included in the OMP alongside the other required plans under condition 6 of permit WGN070260 [26122].

7[2]. At a minimum, the groundwater contaminants at the location TTG (as total recoveries) to be sampled in March, June, October and December of each year shall include, but not be limited to:

• pH	
• Conductivity	µS/m
• Chloride	g/m^3
• Ammoniacal Nitrogen	g/m^3
• Nitrate Nitrogen	g/m^3
• Iron	mg/m^3
• Manganese	mg/m^3
• Lead	mg/m^3
• Copper	mg/m^3
• Zinc	mg/m^3
• Chromium	µg/L
• arsenic	µg/L

At a minimum, the **surface water** contaminants at the locations TTW, TTE, TTD and the two new locations on the main branch of the Owhiro Stream (as total recoveries) to be sampled in March, June, October and December of each year shall include, but not be limited to:

• pH	
• Conductivity	µS/m
• Alkalinity	g/m^3
• Total suspended solids	g/m^3
• COD	
• Total Hardness	g/m^3
• Ammoniacal Nitrogen	g/m^3
• Iron	mg/m^3
• Manganese	mg/m^3

[2] Condition changed under section 127 of the Act, granted 28/07/11

- Lead mg/m³
- Copper mg/m³
- Zinc mg/m³
- Chromium µg/L
- Arsenic µg/L

All sampling techniques employed in respect of the conditions of this permit shall be to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council. All analyses shall be performed by an International Accreditation New Zealand (IANZ) registered laboratory or otherwise as specifically approved by the Manager, Environmental Regulation, Wellington Regional Council.

8[3]. The quality of the surface water discharge as sampled under condition 7 of this permit shall be compared with the following tolerance range, determined from *total recoveries*:

Contaminant and unit		**Lower tolerance range**	**Upper tolerance range**
pH		-0.4	0.4
Conductivity	µS/m		72.4
Alkalinity	g/m³		226
Total suspended solids	g/m³		
COD	g/m³		21
Total Hardness	g/m³		
Ammoniacal Nitrogen	g/m³		0.346
Total Iron	mg/m³		2748
Total Manganese	mg/m³		1461
Total Lead	mg/m³		5.9
Total Copper	mg/m³		4.0
Total Zinc	mg/m³		130
Total Arsenic	µg/L		13.0
Total Chromium	µg/L		1.0

The limits for Total Suspended Solids and Total Hardness shall be calculated once the number of samples reaches 10. The same calculations to determine the upper and lower tolerance limits shall be applied as is detailed in the DMP in condition 6 of this permit.

Should the tolerance limit for any parameter be exceeded, and where that parameter also exceeds the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels, the permit holder shall, within one month of the receipt of the laboratory report:

- Undertake a second sample and analyse this for the exceeded parameter, and
- Undertake a third sample within one month of the second sample being taken, and analyse this for the exceeded parameter
- In these instances, the *dissolved metal* fraction, rather than the total metal fraction shall be tested for
- If the average of these two samples continues to exceed the relevant tolerance limits and the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels, the permit holder shall implement the **adaptive management** conditions as required by conditions 13 and 14 of this permit.

9. The permit holder shall ensure that a person suitably qualified to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council prepares and submits a report by 30 June of each year detailing the items as required by conditions 6 and 7 and the approved DMP.

The report shall include, but not be limited to:

- The results and comparisons of the contaminants sampled for with the relevant limits approved under the DMP and condition 8 of this permit

[3] Condition changed under section 127 of the Act, granted 28/07/11

- A comparison of the concentration of contaminants of the latest year of sampling with the base line ecology survey results as required by condition 12 of this permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge
- Any other relevant information; and
- Any recommendations for approval to the Manager, Environmental Regulation, Wellington Regional Council, to remedy or mitigate any significant adverse effects that have occurred, or to avoid foreseen significant adverse effects as a result of the discharge of contaminants from the landfill area to the tributaries of Owhiro Stream. Examples of these could be:

  Changes to the management or site acceptance protocols;
  - Methods to remedy adverse effects that may have been transported into the Owhiro Stream catchment; and
  - Mitigation measures to offset or minimise the significant adverse effects.

Note 1: For the purposes of this condition, 'significant adverse effects' are those effects which are determined to be significant in the professional opinion of the engaged independent expert.

Note 2: Annual reports can be bundled and submitted as one large report, providing that the relevant sections are clearly defined within the one document.

10. Should any recommendations arise from the report produced under condition 9 of this permit, the permit holder shall undertake to provide for the recommendations in a manner and timeframe that meets the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council.

Note: These activities may require further resource consents.

Mixing zones

11. The discharges shall not give rise to any of the following effects after reasonable mixing:

- The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials
- Any conspicuous change in colour or visual clarity
- Any emission of objectionable odour
- The rendering of fresh water unsuitable for consumption by farm animals
- Any significant adverse effects on aquatic life; or
- Any visible deposition of iron oxide or other heavy metals

For the purposes of this condition and permit, the discharges shall be reasonably mixed at 100 metres downstream of the discharge point from the stilling basin within the unnamed tributary of Owhiro Stream.

Should any of these effects occur, the permit holder shall commission an updated DMP exploring the relevant treatment methodologies as required by condition 6 of this permit.

Baseline Ecological Survey Condition

12. During the period 1 December 2009 to 30 April 2010 inclusive, and following at least a two week period without a significant flood event (defined as 3x median stream flow) the permit holder shall have an appropriately experienced and qualified freshwater ecologist that meets the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council carry out a semi-quantitative ecological survey of the landfill tributary upstream and downstream of the landfill discharge and the Owhiro Stream upstream and downstream of the confluence of the landfill tributary.

The survey shall comprise as a minimum:

- A macroinvertebrate survey following protocols C1 and P2 from the Ministry for the Environment's report on protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001) involving the collection of a 3 replicate samples (a minimum of 5 kicknet samples per replicate) within riffle habitat at each site, fixed count of macroinvertebrate taxa to the taxonomic resolution specified for use of the MCI and enumeration of the results as taxa richness, MCI, SQMCI, number of EPT taxa, %EPT taxa and %EPT individuals

- Macroinvertebrate surveys should also be accompanied by visual assessment of periphyton cover and substrate characteristics. Survey sites should share similar habitat characteristics in terms of substrate, flow and depth; and
- A full fish survey including electrofishing and spotlighting within the unnamed tributaries of the Owhiro Stream downstream of the landfill, and within the western and eastern arms of the tributaries upstream of the landfill

Note: The results of the Baseline Ecological Survey are to be included in the OMP alongside the other required plans under condition 6 of permit WGN070260 [26122].

Adaptive Management Conditions

13[4]. Should the tolerance limits, the latest ANZECC Guidelines for the protection of aquatic ecosystems (90%) trigger levels and additional sampling show an increase in the level of any one contaminant as described in condition 8 of this permit, the permit holder shall engage a suitably qualified, independent ecologist to provide an assessment of the ecological effects of the discharges from the site.

The qualifications of and methods employed by the ecologist or other suitably qualified person (in the case of recommendations on the practicable treatment of the discharged contaminants) shall meet the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council.

The ecologist or other suitably qualified person shall provide specific assessment recommendation and implementation of the following:

- A monitoring methodology for *macroinvertebrate* sampling, including, but not limited to:
  - The techniques that will be used to carry out the surveys;
  - The location and area the sampling will be undertaken over;
  - The analysis methodology used to record and present the data; and
  - Other physical habitat quantifications used to assess the local ecosystem.
- An assessment of the potential effects of the discharge of contaminants to the unnamed tributary of Owhiro Stream;
- A recommendation of the number of sampling events that need to be undertaken (along with timeframes) to adequately gauge the effects of the discharges from the site;
- An assessment, once the invertebrate sampling has been undertaken, whether the existing treatment methodology for the discharge to the unnamed tributary of Owhiro Stream is the best practicable option for the treatment of the contaminants arising from either the historical or current land use of the area (i.e. both the fill placed by the permit holder, and the fill that existed on site prior to the operator's activities at the site) to feed back into the DMP as approved under condition 6 of this permit; and
- Provide recommendations on methods that could be used to further treat the discharge to ensure they remain within the tolerance limits specified in condition 8 of this permit.
- In the case of the limits for Total Chromium and /or Total Arsenic being exceeded, provide a recommendation as to whether or not the consent holder should cease the disposal of processed timber (both treated and untreated) to the landfill.

Note: Some recommended viable adaptive management measures could include the installation of a treatment wetland, sand filter system or enlargement of the stilling basin.

Note: The consent holder may store treated timber on site in the event arsenic and/or chromium tolerance limits are exceeded; however, all in-ground disposal must cease until informed otherwise.

14. The recommendations approved from the report prepared under the DMP and ecological assessment undertaken under conditions 6, 12 and 13 of this permit shall be undertaken by the permit holder to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council and within timeframes specified by the manager, Environmental Regulation, Wellington Regional Council.

Note: Further resource consents may be required to undertake the works recommended.

[4] Condition changed under section 127 of the Act, granted 28/07/11

Long term Management Conditions

15. The permit holder shall, no less than **twelve** months prior to the expiry or surrender of this permit for the closure of the landfill, make application(s) for such consent(s) as are required for the future management of the site.

This requirement shall also be complied with should filling activities at the site cease for a continuous twelve month period.

16. The permit holder shall continue to sample and provide monitoring results as required by conditions 6, 7, 8 and 9 until the expiry of this permit.

Water quality management - wetland creation

17[5]. The permit holder shall lodge application(s) for such consent(s) as are required for the creation of a wetland area at the location as shown on drawing numbers S02-0752-41 Rev.A and S02-0752-42 Rev.A, submitted as evidence at the change of conditions application hearing on 7 July 2011. The application must be lodged with and accepted by the Wellington Regional Council by **31 October 2011**.

The application(s) for such consent(s) shall provide information on, but not be limited to:

Design

- The wetland shall be designed in accordance with NIWA's '*New Zealand Constructed Wetland Planting Guidelines, 2006*'.
- Evidence to show how the wetland will improve the water quality of the discharges from the landfill.
- Details of how the proposed wetland will treat the following list of contaminants:
  - Ammoniacal Nitrogen
  - Iron
  - Manganese
  - Lead
  - Copper
  - Zinc
  - Chromium
  - Arsenic

Construction

- A 'step by step' construction methodology and timeline for the creation of the wetland
- Details of the amount of earthworks required to increase the size of the stilling basin (volumes of cut and fill)
- How any unsuitable material from the stream bed will be removed from the site and disposed of
- Erosion and sediment control measures to be implemented prior to works starting
- Erosion and sediment control measures to be used during construction to ensure sedimentation effects on the unnamed tributary of Owhiro Stream will be mitigated while works are occurring;, and
- Identifying person(s) who will be responsible for managing each part of the construction operation (including sediment control).

Planting

- Details of pre-planting site preparation;
- A to scale design plan(s) clearly showing:
  - The location and extent where planting will be undertaken around the stilling basin; and
  - The browse resistant native wetland plants species (sedges and rushes etc) that are proposed to be planted to aid in the treatment of the landfill's discharge, the size of the plants and the density of planting.
- A Monitoring and Maintenance Plan which shall be undertaken for the first 12 months upon completion of the planting, including, but not be limited to, the following:
  - Details of how plants will be irrigated during their establishment;

[5] Condition changed under section 127 of the Act, granted 28/07/11

  - Details of how the site will be maintained and how often, including the ongoing replacement of plants that do not survive and eradication of evasive weeds from the planting site to ensure adequate growth (e.g. weeding, spraying, mulching); and
  - Details of how plants will be protected from animal pests (e.g. goats).
- A list of the key responsibilities and identification of the suitably experienced persons responsible for implementing the wetland planting.

Note 1: The intent of the wetland area is to improve water quality downstream of the landfill. The wetland is expected to help treat the heavy metals and other contaminants that will percolate through and discharge from the landfill.

Note 2: The wetland area shall be made a large as possible.

Note 3: The construction of the wetland shall be completed within two years of the grant of the resource consent(s) required from the Wellington Regional Council, or within a different timeframe on assessment of the consent application.

Note 4: The approved RMP as required under condition 9 of WGN070260 [26129] and ongoing ecological assessment as required under various conditions of WGN070260 [26124] may provide information that is helpful to the development of the wetland.

Review Conditions

18. The Wellington Regional Council may review any or all conditions of this permit by giving notice of its intention to do so, pursuant to section 128 of the Resource Management Act 1991 at any time within the life of the landfill for any of the following purposes:

- To deal with any adverse effects on the environment which may arise from the exercise of this permit, and which it is appropriate to deal with at a later stage;
- To review the adequacy of any plan prepared for this permit and/or the monitoring requirements so as to incorporate into the permit any modification to any plan or monitoring which may be necessary to deal with any adverse effects on the environment arising from the management or operation of the landfill and recycling centre;
- To impose limits on the discharge of contaminants in light of the results obtained from previous monitoring; or
- To enable consistency with any relevant Regional Plans or any National Environmental Standards.

Note: Following review, conditions or restrictions on the use of the site may be set by the Council if deemed necessary.

19. Wellington Regional Council shall be entitled to recover from the permit holder the costs of the conduct of any review, calculated in accordance with and limited to the council's scale of charges in force and application at the time, pursuant to section 36 of the Resource Management Act 1991.

Appendix B Monitoring Locations

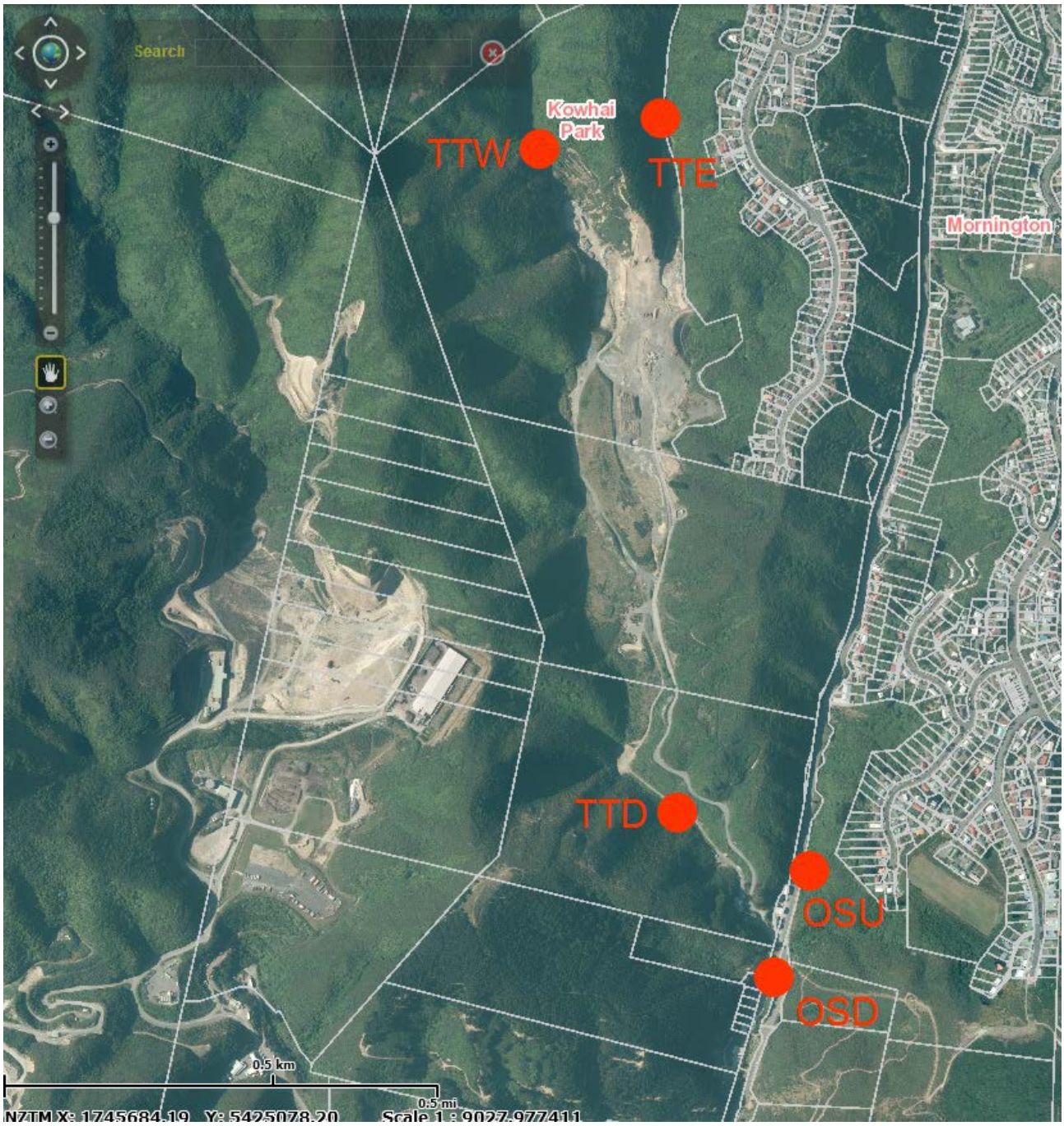


Figure 5-1: Location of T&T Landfill monitoring sites (TTG is located at TTD)

Appendix C Comparison with ANZECC 2000 Guidelines

Table C1: October 2017 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.6	7.6	7.9	7.7	8
Conductivity	mS/m	NA	82.9	32.1	28.8	34.4	66.6
Total Alkalinity	g/m^{3}CaCO$_3$	NA	270	51	44	48	192
TSS	g/m^3	NA	6.0	1.5	1.5	1.5	4.0
COD	g O2/m^3	NA	13	3	3	7	13
Total Hardness	g/m^{3}CaCO$_3$	NA	290	54	50	58	220
Ammoniacal-N	g/m^3	1.430 (2.34)	1.090	0.005	0.005	0.005	0.470
Total Iron	g/m^3	NA	2.50	0.05	0.03	0.06	1.20
Dissolved Iron	g/m^3	NA	0.01	0.01	0.01	0.02000	0.03
Total Manganese	g/m^3	NA	1.84000	0.00157	0.00111	0.00260	1.06000
Dissolved Manganese	g/m^3	2.5	1.71000	0.00003	0.00003	0.00170	0.97000
Dissolved iron + Dissolved manganese	g/m^3	1.0	1.72	0.01	0.01	0.02	1.00
Total Lead	g/m^3	NA	0.00018	0.00005	0.00005	0.00052	0.00028
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00023	0.00005	0.00022	0.00010
Total Copper	g/m^3	NA	0.00027	0.00074	0.00027	0.00370	0.00119
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00110	0.00070	0.00003	0.00350	0.00100
Total Zinc	g/m^3	NA	0.00530	0.00370	0.00110	0.01700	0.00860
Dissolved Zinc	g/m^3	0.015 (0.027)	0.00410	0.00380	0.00050	0.01590	0.00410
Total Arsenic	g/m^3	NA	0.00170	0.00055	0.00055	0.00055	0.00130
Dissolved Arsenic	g/m^3	0.042	0.00050	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m^3	NA	0.00070	0.00027	0.00027	0.00027	0.00027
Dissolved Chromium	g/m^3	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m$_3$CaCO$_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C2: November 2017 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.6	7.7	7.7	7.9	8.1
Conductivity	mS/m	NA	78.9	34.0	34.0	36.3	63.9
Total Alkalinity	g/m³CaCO₃	NA	270	55	55	57	193
TSS	g/m³	NA	10.0	1.5	1.5	4.0	1.5
COD	g O2/m³	NA	12	3	3	3	11
Total Hardness	g/m³CaCO₃	NA	280	60	62	62	200
Ammoniacal-N	g/m³	1.430 (2.34)	0.490	0.005	0.050	0.005	0.058
Total Iron	g/m³	NA	2.50	0.01	0.01	0.03	0.48
Dissolved Iron	g/m³	NA	0.03	0.01	0.01	0.01000	0.02
Total Manganese	g/m³	NA	1.76000	0.00142	0.00850	0.00260	0.66000
Dissolved Manganese	g/m³	2.5	1.70000	0.00003	0.00390	0.00120	0.61000
Dissolved iron + manganese	g/m³	1.0	1.73	0.01	0.01	0.01	0.63
Total Lead	g/m³	NA	0.00051	0.00005	0.00005	0.00016	0.00014
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.00082	0.00027	0.00099	0.00195	0.00092
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00003	0.00060	0.00140	0.00070
Total Zinc	g/m³	NA	0.00440	0.00460	0.00490	0.00800	0.00420
Dissolved Zinc	g/m³	0.015 (0.027)	0.00160	0.00340	0.00300	0.00720	0.00240
Total Arsenic	g/m³	NA	0.00140	0.00055	0.00055	0.00055	0.00055
Dissolved Arsenic	g/m³	0.042	0.00050	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00078	0.00027	0.00027	0.00027	0.00027
Dissolved Chromium	g/m³	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C3: December 2017 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.7	7.5	7.8	7.7	8
Conductivity	mS/m	NA	79.2	32.7	34.4	37.2	66.4
Total Alkalinity	g/m³CaCO₃	NA	270	56	59	59	198
TSS	g/m³	NA	11.0	1.5	10.0	1.5	1.5
COD	g O2/m³	NA	11	8	12	3	7
Total Hardness	g/m³CaCO₃	NA	290	62	68	69	210
Ammoniacal-N	g/m³	1.430 (2.34)	0.460	0.084	0.018	0.005	0.067
Total Iron	g/m³	NA	2.90	0.04	0.07	0.05	0.39
Dissolved Iron	g/m³	NA	0.02	0.01	0.01	0.01000	0.01
Total Manganese	g/m³	NA	1.71000	0.01270	0.04300	0.00550	0.55000
Dissolved Manganese	g/m³	2.5	1.75000	0.00670	0.00800	0.00180	0.55000
Dissolved iron + manganese	g/m³	1.0	1.77	0.02	0.02	0.01	0.56
Total Lead	g/m³	NA	0.00039	0.00014	0.00025	0.00039	0.00006
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.00027	0.00140	0.00054	0.00240	0.00092
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00120	0.00003	0.00180	0.00070
Total Zinc	g/m³	NA	0.00300	0.00530	0.00270	0.01150	0.00370
Dissolved Zinc	g/m³	0.015 (0.027)	0.00050	0.00400	0.00050	0.00920	0.00250
Total Arsenic	g/m³	NA	0.00130	0.00055	0.00055	0.00055	0.00055
Dissolved Arsenic	g/m³	0.042	0.00050	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00094	0.00027	0.00027	0.00027	0.00027
Dissolved Chromium	g/m³	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C4: January 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	7.2	7.8	7.7	7.9
Conductivity	mS/m	NA	75.5	27.5	31.9	35.6	65.5
Total Alkalinity	g/m³CaCO₃	NA	280	56	58	59	220
TSS	g/m³	NA	16.0	6.0	10.0	1.5	6.0
COD	g O2/m³	NA	7	16	16	3	8
Total Hardness	g/m³CaCO₃	NA	270	50	60	64	220
Ammoniacal-N	g/m³	1.430 (2.34)	0.700	0.086	0.005	0.005	0.034
Total Iron	g/m³	NA	4.80	0.10	0.11	0.05	1.32
Dissolved Iron	g/m³	NA	0.04	0.01	0.01	0.01000	0.01
Total Manganese	g/m³	NA	1.990	0.106	0.054	0.007	0.840
Dissolved Manganese	g/m³	2.5	1.850	0.001	0.001	0.001	0.710
Dissolved iron + Dissolved manganese	g/m³	1.0	1.890	0.011	0.011	0.011	0.720
Total Lead	g/m³	NA	0.00033	0.00006	0.00006	0.00063	0.00018
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.00027	0.00068	0.00027	0.00240	0.00093
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00050	0.00003	0.00160	0.00070
Total Zinc	g/m³	NA	0.00330	0.00250	0.00055	0.01190	0.00370
Dissolved Zinc	g/m³	0.015 (0.027)	0.00050	0.00050	0.00050	0.00750	0.00130
Total Arsenic	g/m³	NA	0.00270	0.00055	0.00055	0.00055	0.00055
Dissolved Arsenic	g/m³	0.042	0.00050	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00098	0.00058	0.00027	0.00027	0.00027
Dissolved Chromium	g/m³	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C5: February 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	6.8	7.4	7.5	7.6
Conductivity	mS/m	NA	109.6	18.7	22.4	32.2	93.6
Total Alkalinity	g/m³CaCO₃	NA	360	25	26	45	290
TSS	g/m³	NA	25.0	5.0	3.0	3.0	12.0
COD	g O2/m³	NA	27	12	8	6	22
Total Hardness	g/m³CaCO₃	NA	460	31	34	58	370
Ammoniacal-N	g/m³	1.430 (2.34)	**1.980**	0.088	0.036	0.005	1.320
Total Iron	g/m³	NA	7.80	0.20	0.10	0.20	3.10
Dissolved Iron	g/m³	NA	0.05	0.08	0.02	0.05000	0.06
Total Manganese	g/m³	NA	2.200	0.063	0.020	0.008	1.660
Dissolved Manganese	g/m³	2.5	2.100	0.036	0.003	0.002	1.510
Dissolved iron + manganese	g/m³	1.0	2.150	0.116	0.023	0.052	1.570
Total Lead	g/m³	NA	0.00168	0.00052	0.00014	0.00069	0.00103
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00015	0.00005	0.00013	0.00005
Total Copper	g/m³	NA	0.00192	0.00171	0.00080	0.00260	0.00200
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00050	0.00130	0.00060	**0.00220**	0.00100
Total Zinc	g/m³	NA	0.02300	0.01760	0.00300	0.01950	0.01800
Dissolved Zinc	g/m³	0.015 (0.027)	0.00720	**0.01510**	0.00210	0.01450	0.00630
Total Arsenic	g/m³	NA	0.00430	0.00130	0.00055	0.00055	0.00240
Dissolved Arsenic	g/m³	0.042	0.00050	0.00110	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00194	0.00128	0.00060	0.00070	0.00154
Dissolved Chromium	g/m³	0.006	0.00090	0.00060	0.00003	0.00003	0.00070

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C6: March 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	7.7	8.6	7.2	8
Conductivity	mS/m	NA	80.7	23.6	27.9	35.1	71.1
Total Alkalinity	g/m³CaCO₃	NA	270	42	46	53	220
TSS	g/m³	NA	28.0	1.5	11.0	1.5	8.0
COD	g O2/m³	NA	16	8	3	3	12
Total Hardness	g/m³CaCO₃	NA	310	41	50	63	250
Ammoniacal-N	g/m³	1.430 (2.34)	1.100	0.005	0.005	0.016	0.440
Total Iron	g/m³	NA	6.80	0.06	0.06	0.03	2.80
Dissolved Iron	g/m³	NA	0.04	0.03	0.01	0.01000	0.04
Total Manganese	g/m³	NA	2.500	0.043	0.032	0.002	1.590
Dissolved Manganese	g/m³	2.5	2.400	0.022	0.001	0.001	1.570
Dissolved iron + manganese	g/m³	1.0	2.440	0.052	0.011	0.011	1.610
Total Lead	g/m³	NA	0.00077	0.00006	0.00006	0.00017	0.00036
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.00095	0.00085	0.00027	0.00220	0.00097
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00060	0.00003	0.00170	0.00060
Total Zinc	g/m³	NA	0.00650	0.00510	0.00140	0.01260	0.00570
Dissolved Zinc	g/m³	0.015 (0.027)	0.00050	0.00430	0.00050	0.01200	0.00190
Total Arsenic	g/m³	NA	0.00380	0.00055	0.00055	0.00055	0.00180
Dissolved Arsenic	g/m³	0.042	0.00140	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00147	0.00083	0.00027	0.00027	0.00108
Dissolved Chromium	g/m³	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C7: April 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	6.8	7.7	7.9	7.9
Conductivity	mS/m	NA	77.5	26.5	28.9	33.5	65.5
Total Alkalinity	g/m^3CaCO_3	NA	260	46	45	52	199
TSS	g/m^3	NA	15.0	5.0	10.0	1.5	7.0
COD	g O2/m^3	NA	14	12	3	3	8
Total Hardness	g/m^3CaCO_3	NA	300	48	54	63	230
Ammoniacal-N	g/m^3	1.430 (2.34)	1.020	0.060	0.005	0.005	0.430
Total Iron	g/m^3	NA	5.00	0.11	0.08	0.01	2.50
Dissolved Iron	g/m^3	NA	0.04	0.01	0.02	0.01000	0.06
Total Manganese	g/m^3	NA	2.300	0.094	0.039	0.001	1.440
Dissolved Manganese	g/m^3	2.5	2.400	0.000	0.002	0.001	1.500
Dissolved iron + manganese	g/m^3	1.0	2.440	0.010	0.022	0.011	1.560
Total Lead	g/m^3	NA	0.00033	0.00006	0.00006	0.00012	0.00032
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.00027	0.00072	0.00027	0.00144	0.00069
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00003	0.00060	0.00003	0.00150	0.00003
Total Zinc	g/m^3	NA	0.00250	0.00500	0.00130	0.01140	0.00590
Dissolved Zinc	g/m^3	0.015 (0.027)	0.00110	0.00230	0.00050	0.01220	0.00200
Total Arsenic	g/m^3	NA	0.00310	0.00055	0.00055	0.00055	0.00190
Dissolved Arsenic	g/m^3	0.042	0.00140	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m^3	NA	0.00093	0.00027	0.00027	0.00027	0.00081
Dissolved Chromium	g/m^3	0.006	0.00050	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C8: May 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	7.6	7.6	7.6	7.8
Conductivity	mS/m	NA	84.2	23.5	25.5	3.3	69.1
Total Alkalinity	g/m³CaCO₃	NA	270	42	39	45	200
TSS	g/m³	NA	14.0	7.0	1.5	1.5	7.0
COD	g O2/m³	NA	21	8	3	3	13
Total Hardness	g/m³CaCO₃	NA	340	42	45	56	250
Ammoniacal-N	g/m³	1.430 (2.34)	1.030	0.140	0.027	0.005	0.600
Total Iron	g/m³	NA	4.80	0.31	0.10	0.09	2.20
Dissolved Iron	g/m³	NA	0.02	0.05	0.03	0.03000	0.04
Total Manganese	g/m³	NA	2.300	0.147	0.051	0.002	1.520
Dissolved Manganese	g/m³	2.5	2.300	0.098	0.025	0.002	1.480
Dissolved iron + manganese	g/m³	1.0	2.320	0.148	0.055	0.032	1.520
Total Lead	g/m³	NA	0.00043	0.00056	0.00012	0.00040	0.00039
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00015	0.00005
Total Copper	g/m³	NA	0.00189	0.00110	0.00027	0.00250	0.00104
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00070	0.00003	0.00170	0.00060
Total Zinc	g/m³	NA	0.00820	0.01200	0.00170	0.01580	0.00930
Dissolved Zinc	g/m³	0.015 (0.027)	0.00210	0.00830	0.00050	0.01470	0.00390
Total Arsenic	g/m³	NA	0.00300	0.00550	0.00550	0.00550	0.00170
Dissolved Arsenic	g/m³	0.042	0.00140	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00134	0.00066	0.00027	0.00027	0.00077
Dissolved Chromium	g/m³	0.006	0.00003	0.00003	0.00003	0.00003	0.00003

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Table C9: June 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.2	7.4	7.1	7.3	7.7
Conductivity	mS/m	NA	105.5	23.9	24.6	33.8	87.9
Total Alkalinity	g/m³CaCO₃	NA	320	33	31	41	240
TSS	g/m³	NA	13.0	1.5	1.5	1.5	7.0
COD	g O2/m³	NA	22	3	8	3	24
Total Hardness	g/m³CaCO₃	NA	430	38	37	57	340
Ammoniacal-N	g/m³	1.430 (2.34)	**1.570**	0.041	0.005	0.005	1.190
Total Iron	g/m³	NA	5.00	0.15	0.05	0.06	2.60
Dissolved Iron	g/m³	NA	0.02	0.04	0.02	0.02000	0.03
Total Manganese	g/m³	NA	2.600	0.070	0.020	0.003	1.840
Dissolved Manganese	g/m³	2.5	2.700	0.010	0.016	0.003	1.910
Dissolved iron + manganese	g/m³	1.0	2.720	0.050	0.036	0.023	1.940
Total Lead	g/m³	NA	0.00070	0.00030	0.00055	0.00028	0.00059
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00011	0.00005
Total Copper	g/m³	NA	0.00098	0.00100	0.00027	0.00194	0.00124
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00003	0.00080	0.00003	0.00160	0.00080
Total Zinc	g/m³	NA	0.01130	0.01380	0.00550	0.02300	0.01440
Dissolved Zinc	g/m³	0.015 (0.027)	0.00580	0.01130	0.00050	0.02200	0.00720
Total Arsenic	g/m³	NA	0.00270	0.00550	0.00055	0.00055	0.00160
Dissolved Arsenic	g/m³	0.042	0.00120	0.00050	0.00050	0.00050	0.00050
Total Chromium	g/m³	NA	0.00139	0.00075	0.00027	0.00059	0.00106
Dissolved Chromium	g/m³	0.006	0.00080	0.00003	0.00003	0.00003	0.00060

* Notes: 1. Site specific ammoniacal-N is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as detection limit

Appendix D Additional Monitoring Graphs

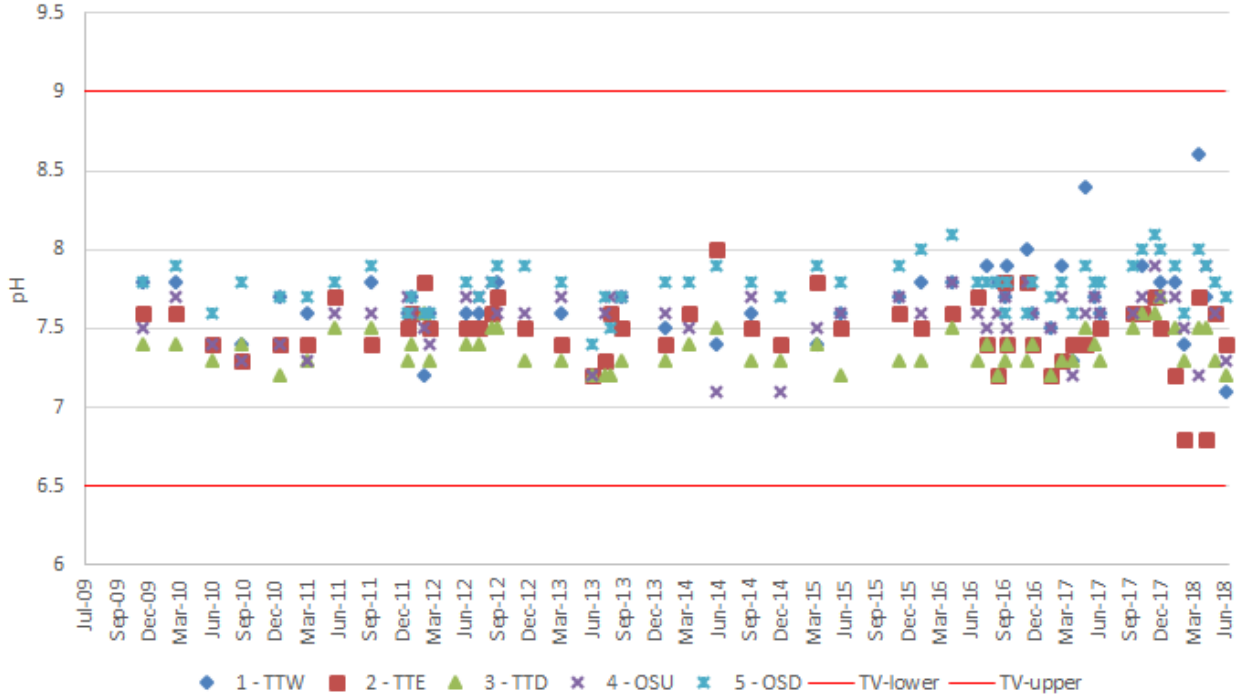


Figure D1: pH for quarterly surface water quality monitoring sites. The red lines indicates GWRC recommended guideline levels (Perrie et al, 2012).

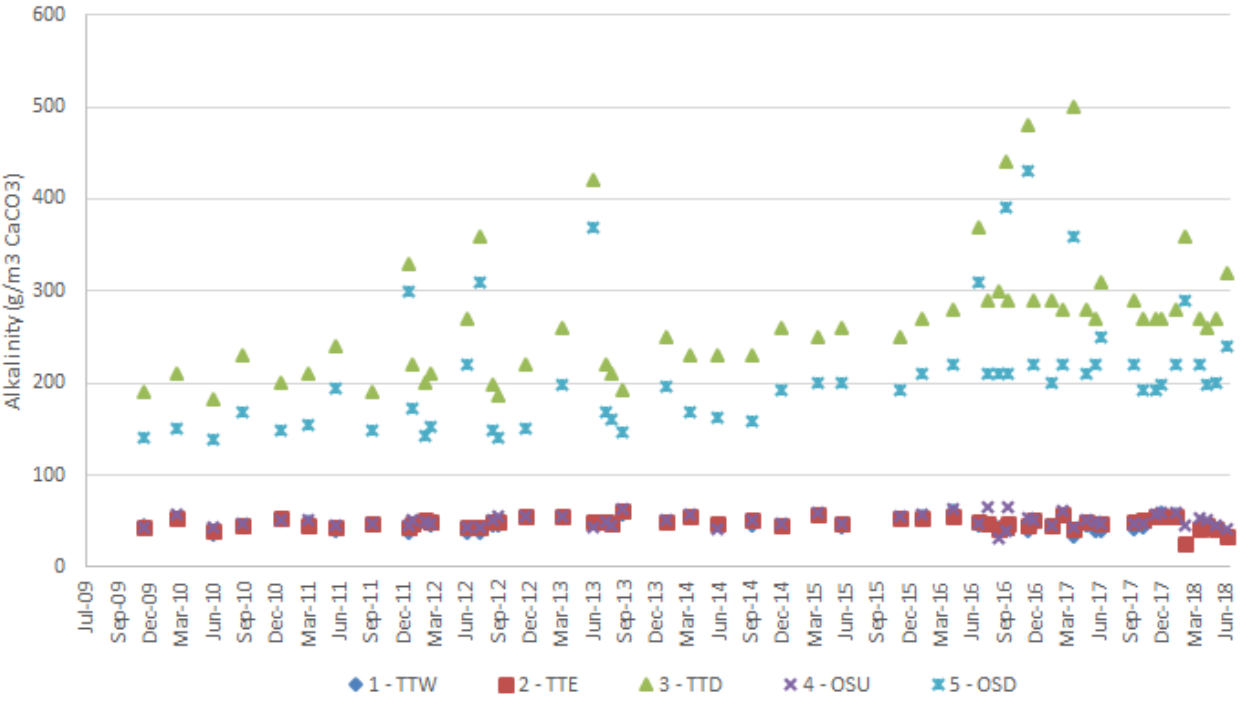


Figure D2: Alkalinity for quarterly surface water quality monitoring sites.

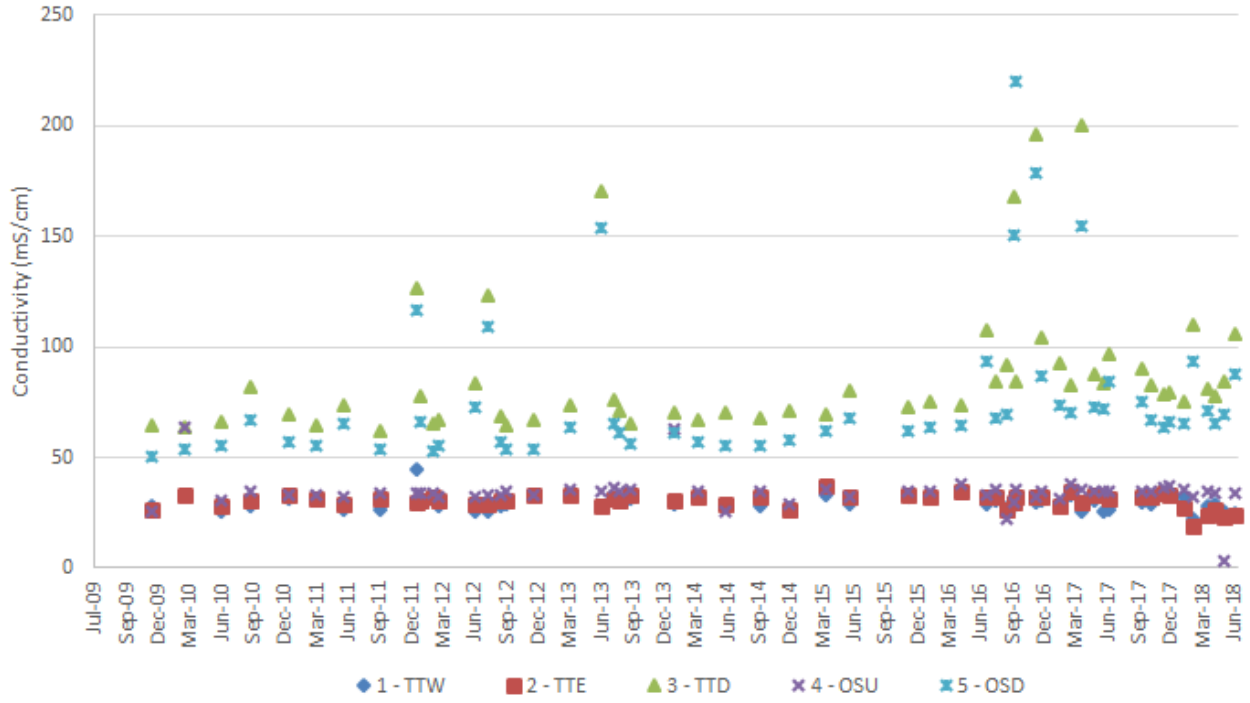


Figure D3: Conductivity for quarterly surface water quality monitoring sites.

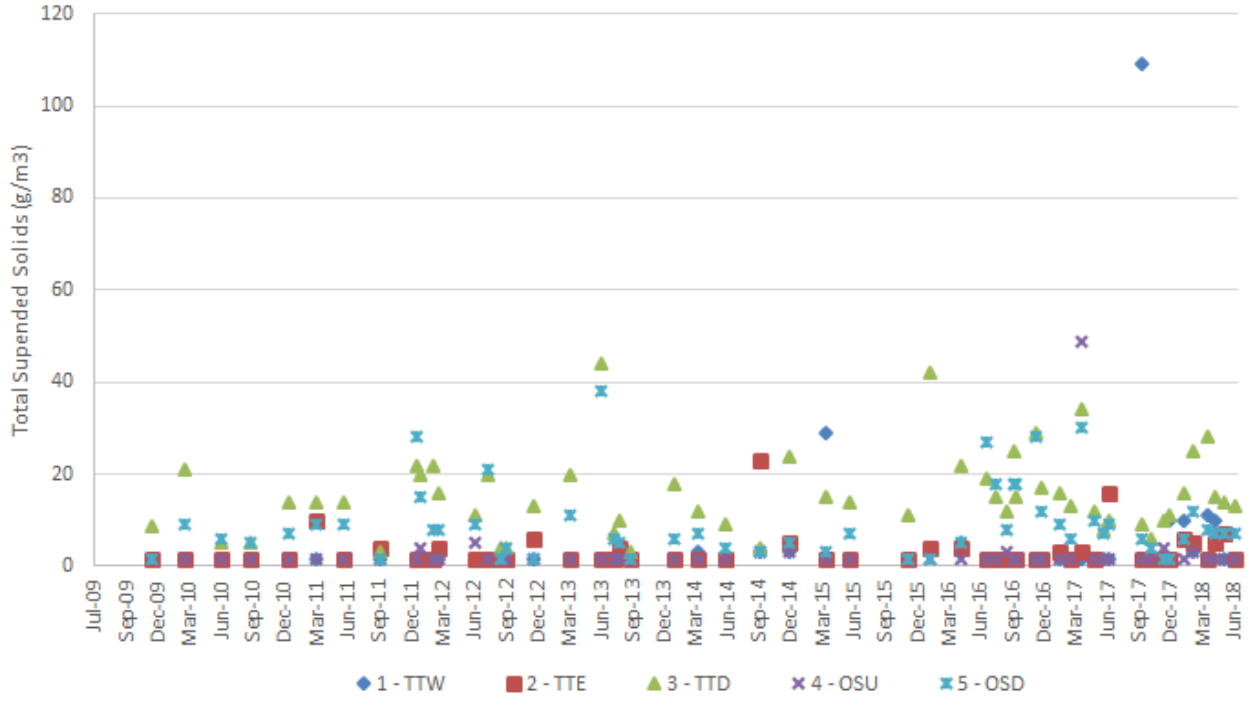


Figure D4: Total Suspended Solids for quarterly surface water quality monitoring sites.

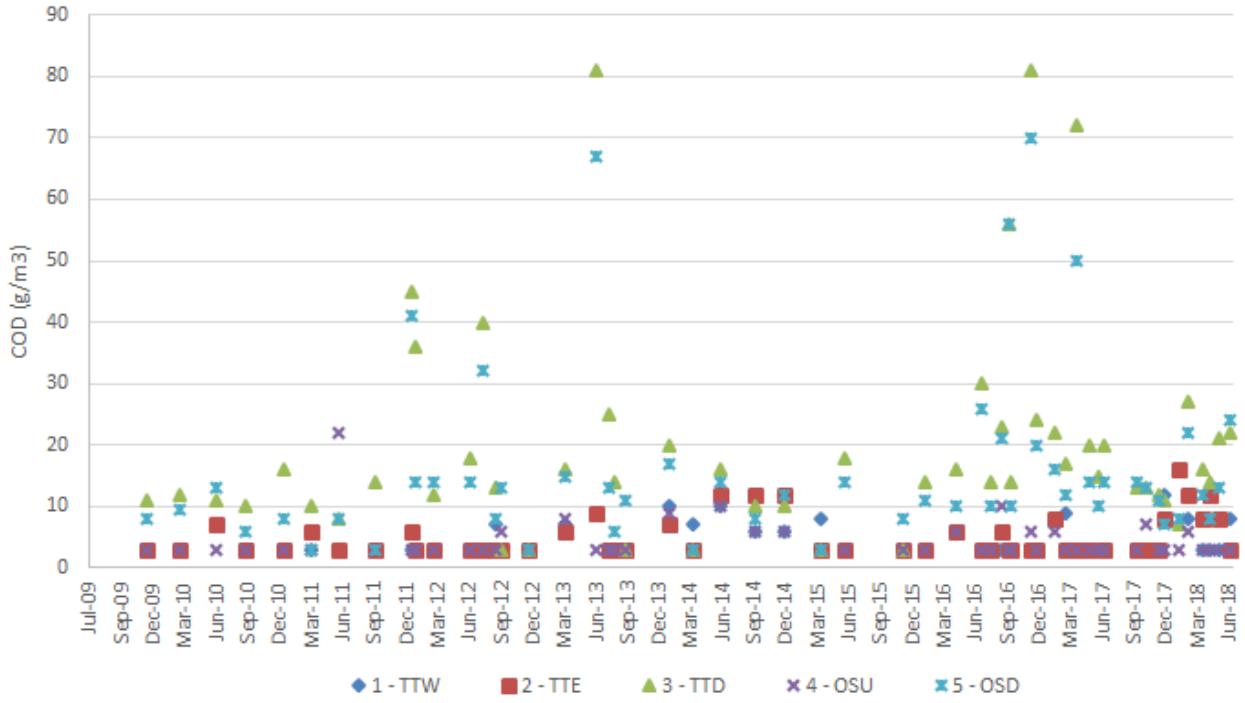


Figure D5: COD for quarterly surface water quality monitoring sites.

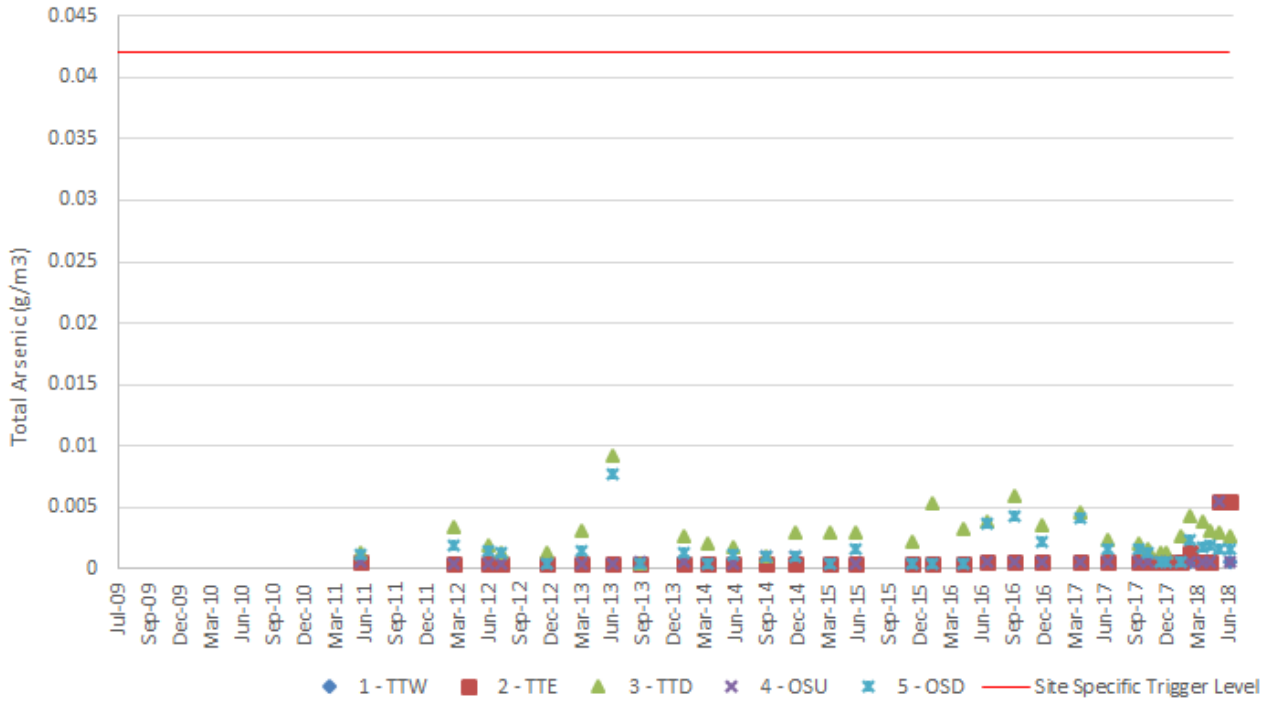


Figure D6: Total arsenic for quarterly surface water quality monitoring sites. The red line indicates the ANZECC 90% protection TV as dissolved arsenic V.

Note: Results are shown for total arsenic, while TV is based on dissolved arsenic V.

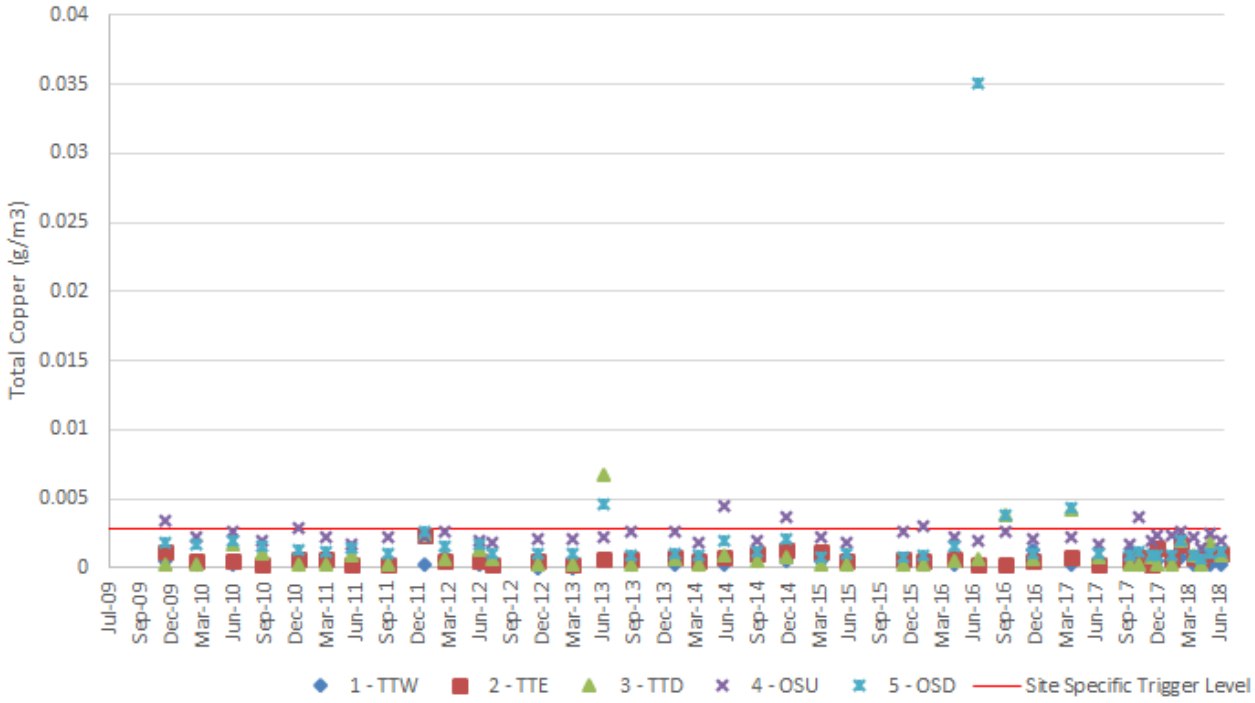


Figure D7: Total copper for quarterly surface water quality monitoring sites. The red line indicates site specific TV.

Note: Results are shown for total copper, while TV is based on site specific dissolved copper. One outlier removed in 2011.

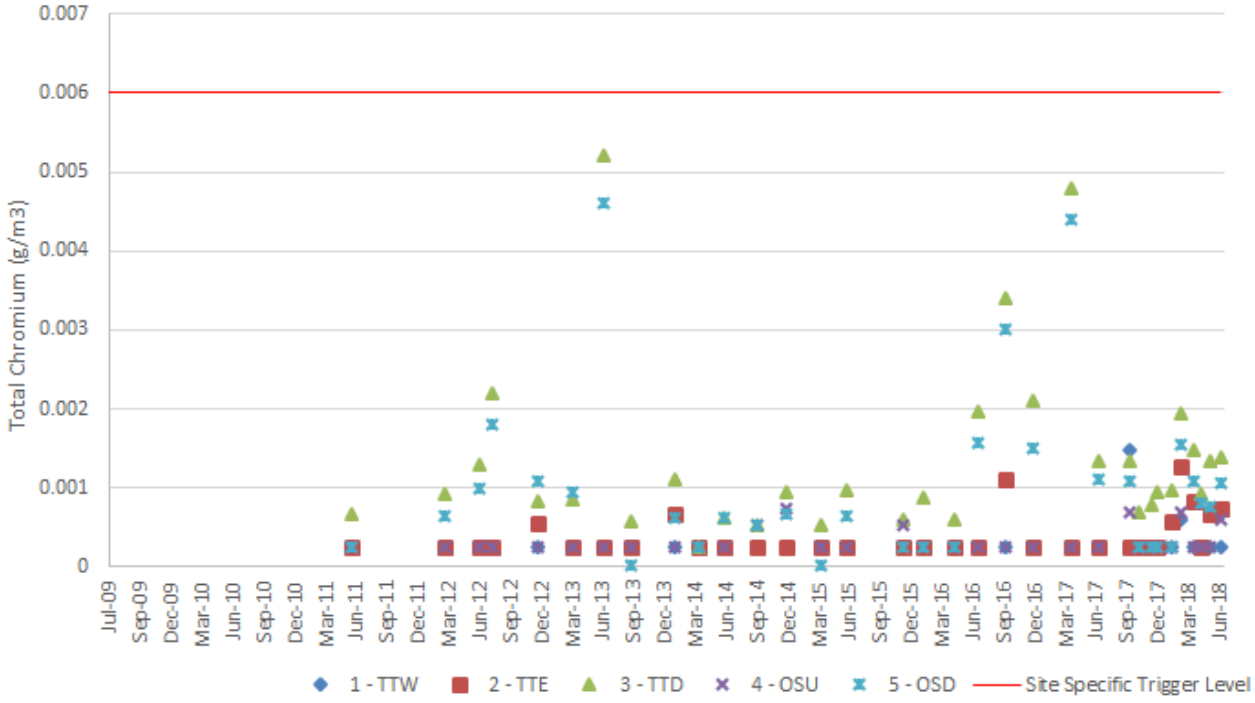


Figure D8: Total chromium for quarterly surface water quality monitoring sites. The red line indicates ANZECC 90% protection TVs.

Note: Results are shown for total chromium while TV is based on dissolved chromium.

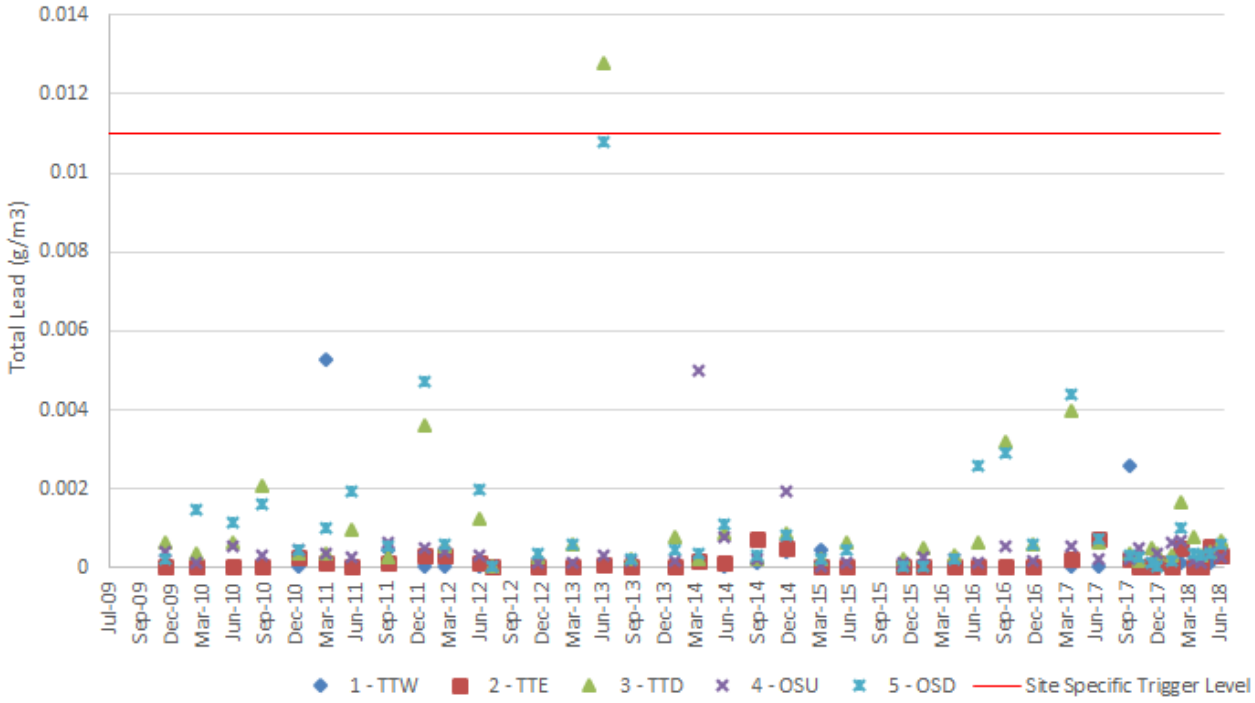


Figure D9: Total Lead for quarterly surface water quality monitoring sites. The red line indicates site specific TVs.

Note: Results are shown for total lead, while TV is based on site specific dissolved lead.

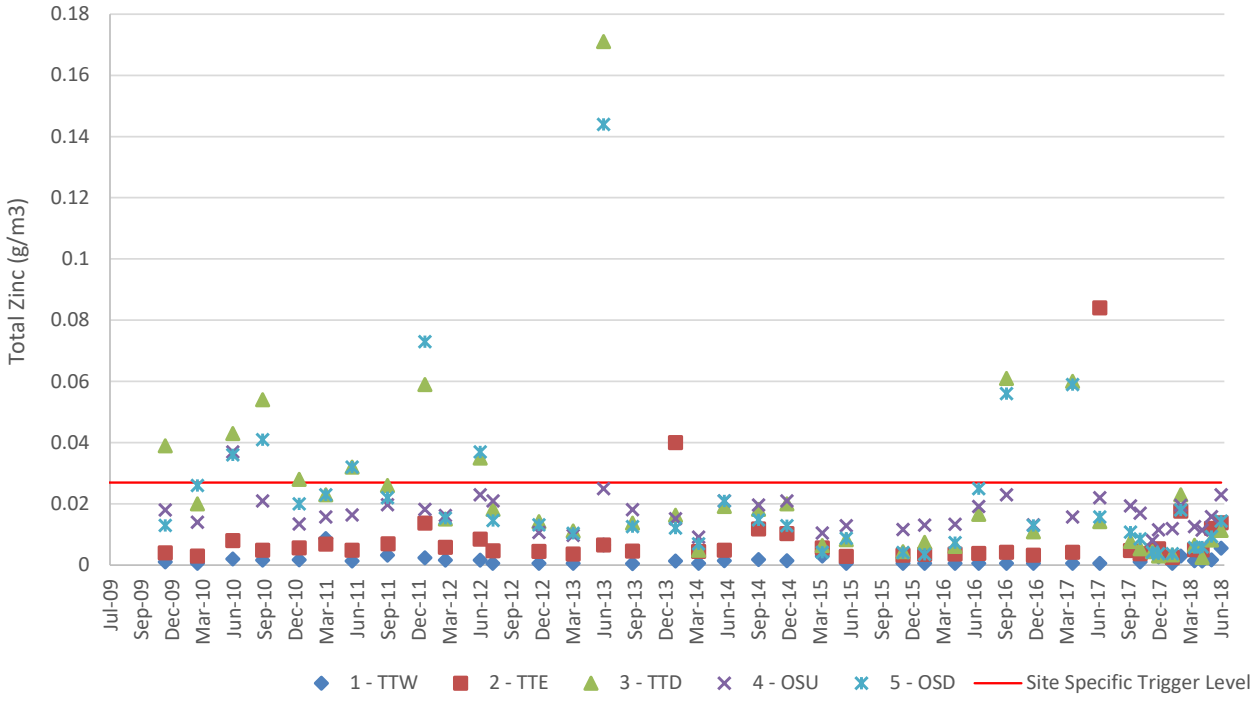


Figure D10: Total zinc for quarterly surface water quality monitoring sites. The red line indicates site specific TVs.

Note: Results are shown for total zinc, while TV is based on site specific dissolved zinc.

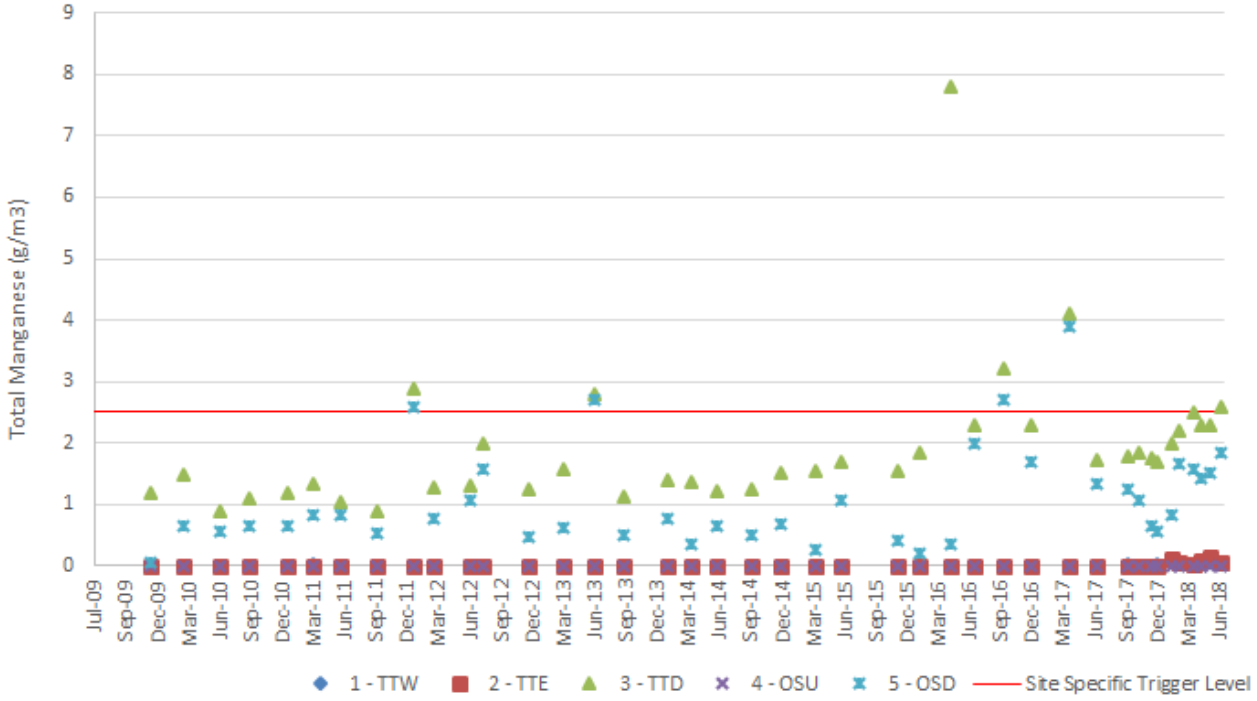


Figure D11: Dissolved manganese for quarterly surface water quality monitoring sites. The red line indicates ANZECC 90% protection TVs.

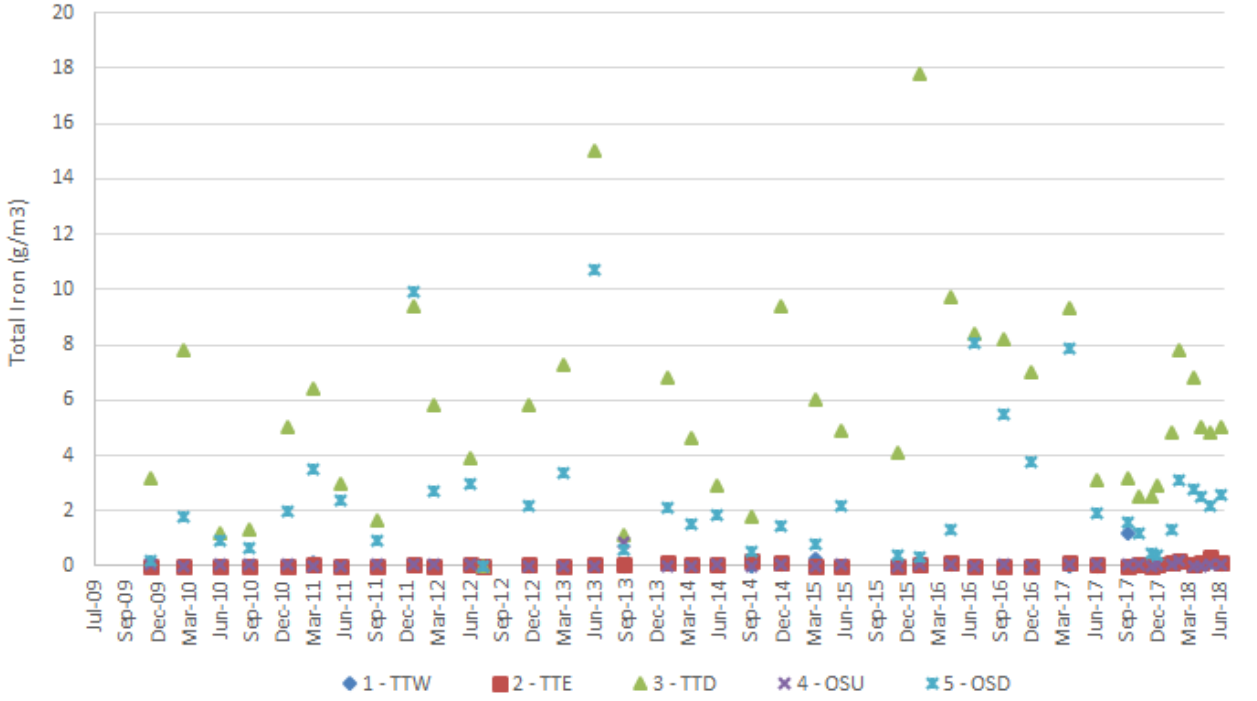


Figure D12: Total iron for quarterly surface water quality monitoring sites.

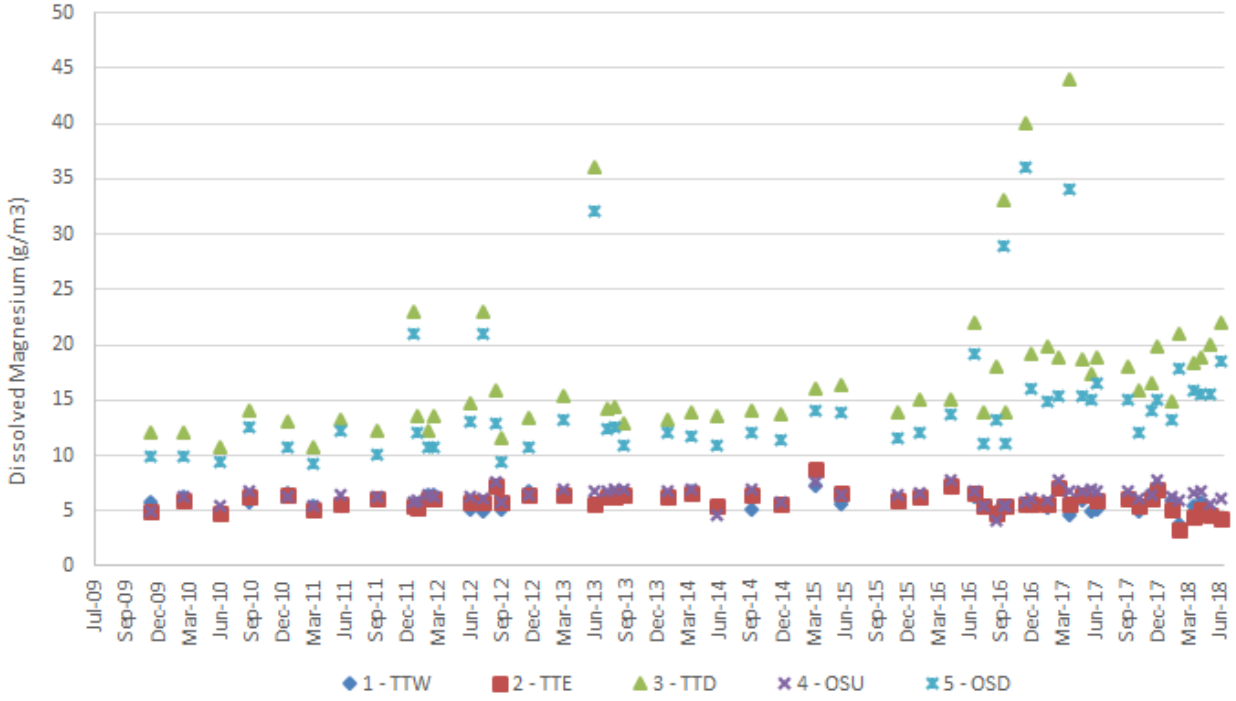


Figure D13: Dissolved Magnesium for quarterly surface water quality monitoring sites.

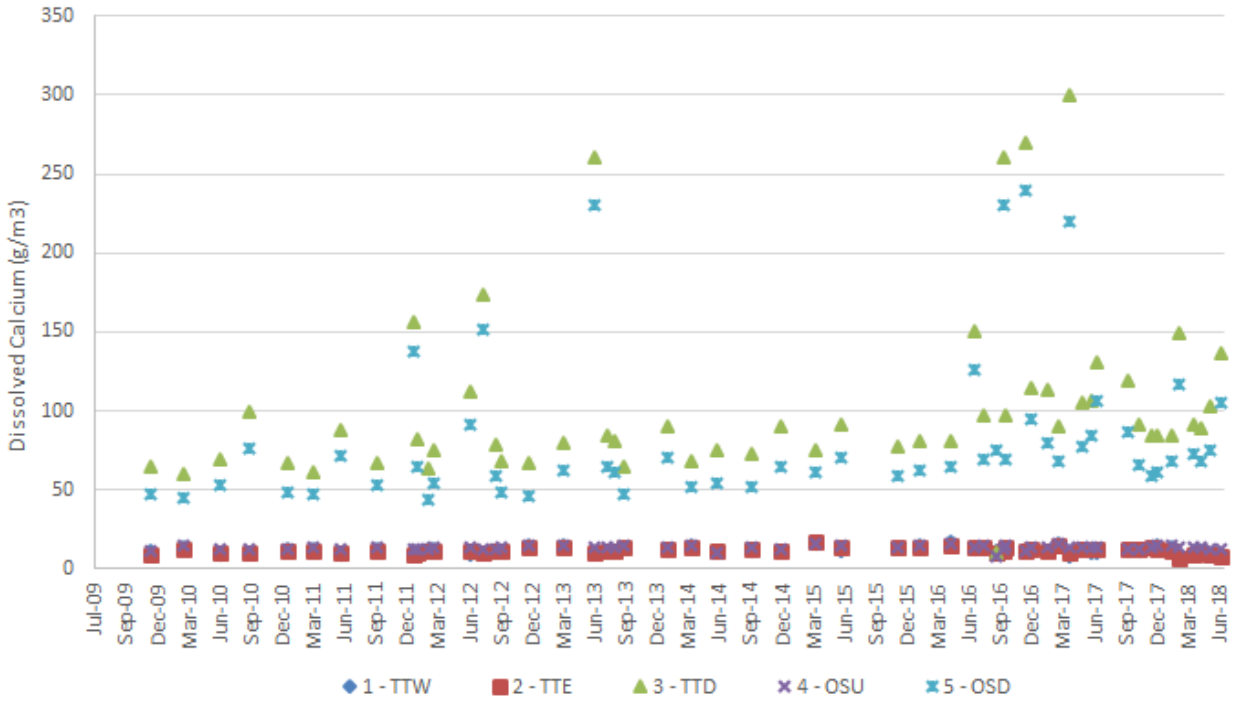


Figure D14: Dissolved Calcium for quarterly surface water quality monitoring sites.

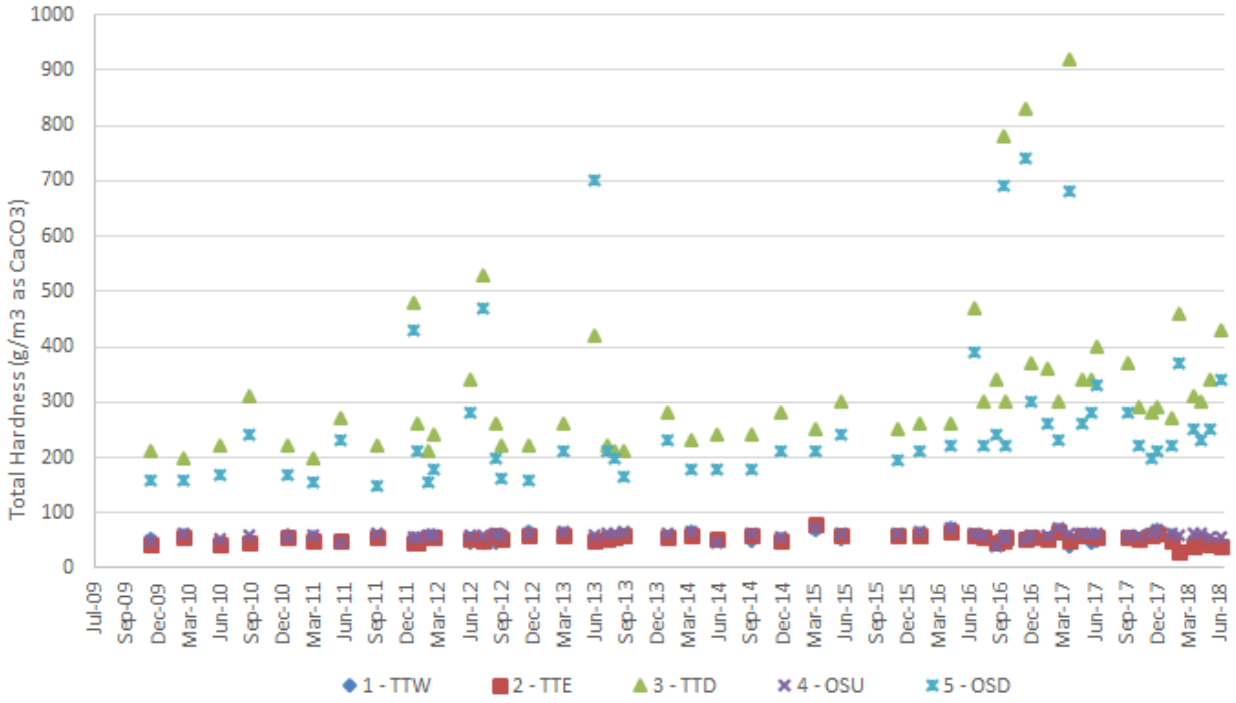


Figure D15: Total hardness for quarterly surface water quality monitoring sites.

Appendix E Site Photographs

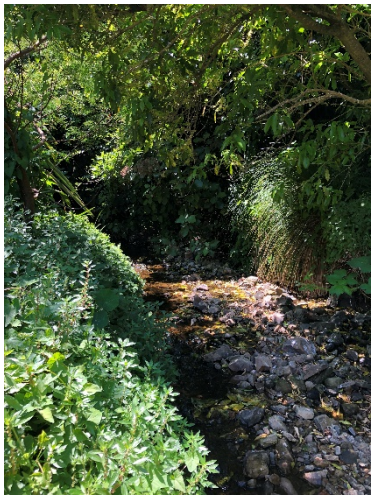
September 2017 ODS - Downstream	September 2017 ODS – Stream Bed	September 2017 ODS - Upstream
		
September 2017 OUS - Downstream	**September 2017 OUS – Stream Bed**	**September 2017 OUS - Upstream**
		
September 2017 - No photos were able to be obtained for TTD		

September 2017 TTE - Downstream	September 2017 TTE – Stream Bed	September 2017 TTE - Upstream
	N/A	
September 2017 TTW - Downstream	**September 2017 TTW – Stream Bed**	**September 2017 TTW - Upstream**
	N/A	

October 2017 ODS - Downstream	October 2017 ODS – Stream Bed	October 2017 ODS - Upstream
		
October 2017 OUS - Downstream	**October 2017 OUS – Stream Bed**	**October 2017 OUS - Upstream**
		

October 2017 TTD - Downstream	October 2017 TTD – Stream Bed	October 2017 TTD - Upstream
		
October 2017 TTE - Downstream	**October 2017 TTE – Stream Bed**	**October 2017 TTE - Upstream**
		

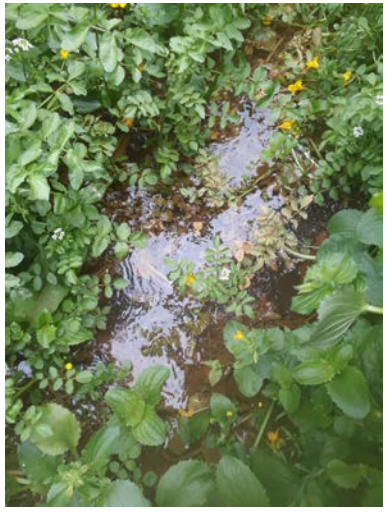
October 2017 TTW - Downstream	October 2017 TTW – Stream Bed	October 2017 TTW - Upstream
		
October 2017 - Wetland	**October 2017 - Wetland bed**	**October 2017 - Mitchel St Pond**
		
October 2017 - Diversion	**October 2017 - Diversion**	**October 2017 – Geotec liner in upper diversion**
		

November 2017 ODS - Downstream	November 2017 ODS – Stream Bed	November 2017 ODS - Upstream
		
November 2017 OUS - Downstream	**November 2017 OUS – Stream Bed**	**November 2017 OUS - Upstream**
		

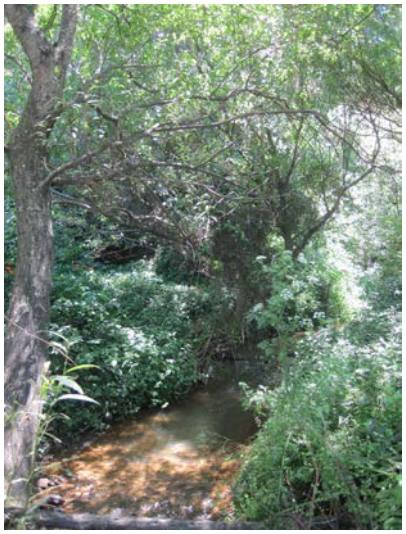
November 2017 TTD - Downstream	November 2017 TTD – Stream Bed	November 2017 TTD - Upstream
		
November 2017 TTE - Downstream	**November 2017 TTE – Stream Bed**	**November 2017 TTE - Upstream**
		

November 2017 TTW - Downstream	November 2017 TTW – Stream Bed	November 2017 TTW - Upstream
	N/A	
November 2017 - Wetland	**November 2017 - Wetland**	**November 2017 – Site from TTW**
		

November 2017 - Diversion	November 2017 - Diversion	
		

December 2017 ODS - Downstream	December 2017 ODS – Stream Bed	December 2017 ODS - Upstream
		
December 2017 OUS – N/A		
December 2017 TTD - Downstream	December 2017 TTD – Stream Bed	December 2017 TTD - Upstream
		

December 2017 TTE - Downstream	December 2017 TTE – Stream Bed	December 2017 TTE - Upstream
	N/A	
December 2017 TTW – N/A		

January 2018 ODS - Downstream	January 2018 ODS – Stream Bed	January 2018 ODS - Upstream
		
January 2018 OUS - Downstream	**January 2018 OUS – Stream Bed**	**January 2018 OUS - Upstream**
		

January 2018 TTD - Downstream	January 2018 TTD – Stream Bed	January 2018 TTD - Upstream
		
January 2018 TTE - Downstream	**January 2018 TTE – Stream Bed**	**January 2018 TTE - Upstream**
		

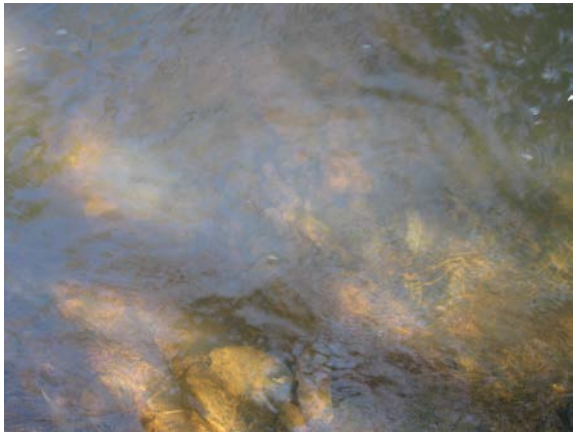
January 2018 TTW - Downstream	January 2018 TTW – Stream Bed	January 2018 TTW - Upstream
N/A	N/A	
January 2018 - Wetland	**January 2018 - Wetland**	**January 2018 – Wetland**
		

January 2018 - Diversion	January 2018 - Diversion	January 2018 - Diversion
		

February 2018 ODS - Downstream	February 2018 ODS – Stream Bed	February 2018 ODS - Upstream
		
February 2018 OUS - Downstream	**February 2018 OUS – Stream Bed**	**February 2018 OUS - Upstream**
		

February 2018 TTD - Downstream	February 2018 TTD – Stream Bed	February 2018 TTD - Upstream
		
February 2018 TTE - Downstream	**February 2018 TTE – Stream Bed**	**February 2018 TTE - Upstream**
		

February 2018 TTW - Downstream	February 2018 TTW – Stream Bed	February 2018 TTW - Upstream
		
February 2018 - Wetland	**February 2018 - Wetland**	**February 2018 – Diversion**
		

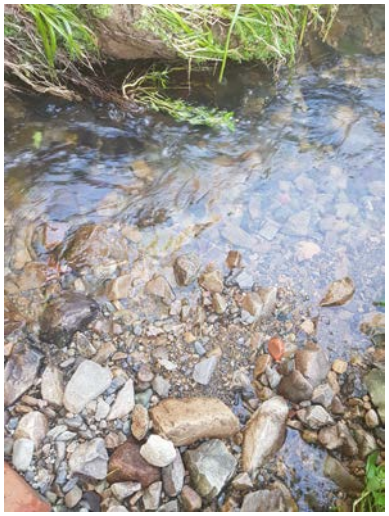
March 2018 ODS - Downstream	March 2018 ODS – Stream Bed	March 2018 ODS - Upstream
		
March 2018 OUS - Downstream	**March 2018 OUS – Stream Bed**	**March 2018 OUS - Upstream**
		

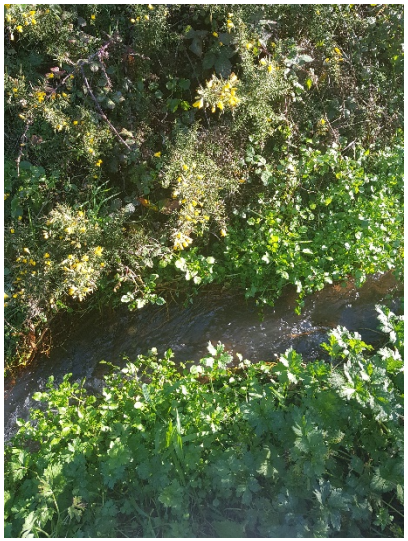
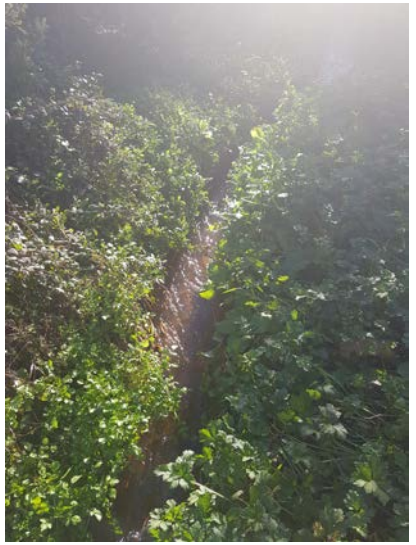
March 2018 TTD - Downstream	March 2018 TTD – Stream Bed	March 2018 TTD - Upstream
		
March 2018 TTE - Downstream	**March 2018 TTE – Stream Bed**	**March 2018 TTE - Upstream**
		

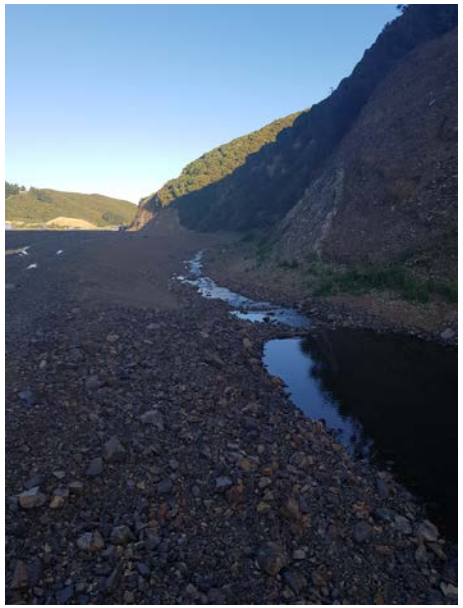
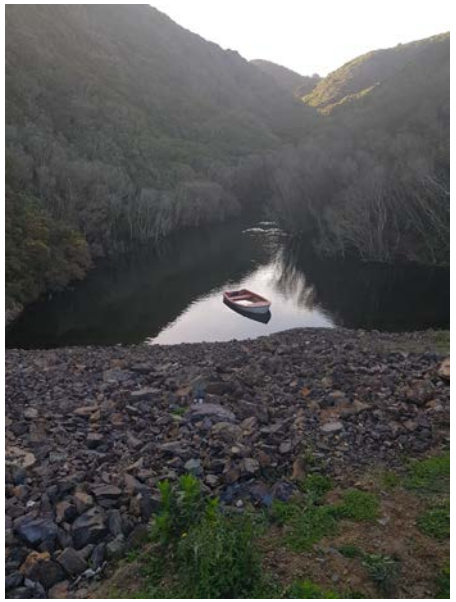
March 2018 TTW - Downstream	March 2018 TTW – Stream Bed	March 2018 TTW - Upstream
		

April 2018 ODS - Downstream	April 2018 ODS – Stream Bed	April 2018 ODS - Upstream
		
April 2018 OUS - Downstream	April 2018 OUS – Stream Bed	April 2018 OUS - Upstream
		
April 2018 TTD - Downstream	April 2018 TTD – Stream Bed	April 2018 TTD - Upstream
		

April 2018 TTE - Downstream	April 2018 TTE – Stream Bed	April 2018 TTE - Upstream
		
April 2018 TTW - Downstream	**April 2018 TTW – Stream Bed**	**April 2018 TTW - Upstream**
		
April 2018 - Wetland	**April 2018 - Wetland**	**April 2018 - Diversion**
		

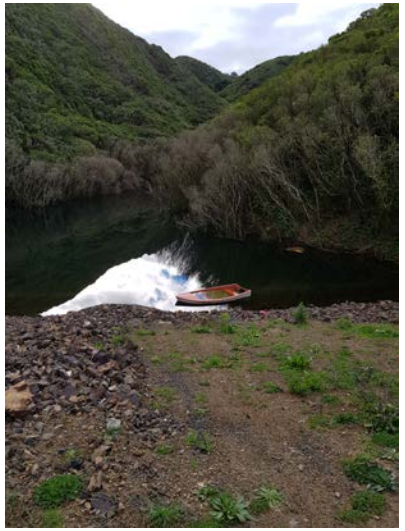
May 2018 ODS - Downstream	May 2018 ODS – Stream Bed	May 2018 ODS - Upstream
		
May 2018 OUS - Downstream	**May 2018 OUS – Stream Bed**	**May 2018 OUS - Upstream**
		

May 2018 TTD - Downstream	May 2018 TTD – Stream Bed	May 2018 TTD - Upstream
		
May 2018 TTE - Downstream	**May 2018 TTE – Stream Bed**	**May 2018 TTE - Upstream**
		

May 2018 TTW - Downstream	May 2018 TTW – Stream Bed	May 2018 TTW - Upstream
		

June 2018 ODS - Downstream	June 2018 ODS – Stream Bed	June 2018 ODS - Upstream
		
June 2018 OUS - Downstream	**June 2018 OUS – Stream Bed**	**June 2018 OUS - Upstream**
		

June 2018 TTD - Downstream	June 2018 TTD – Stream Bed	June 2018 TTD - Upstream
		
June 2018 TTE - Downstream	**June 2018 TTE – Stream Bed**	**June 2018 TTE - Upstream**
		

June 2018 TTW - Downstream	June 2018 TTW – Stream Bed	June 2018 TTW - Upstream
		
June 2018 - Wetland	**June 2018 - Wetland**	**June 2018 - Wetland**
		

Appendix F Field Notes

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Stream bed conditions			
Periphyton	Not assessed		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No odour, increased fill and debris		
Flow	Low, channelled under dam		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Stream bed conditions			
Periphyton	Not assessed		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No Odour, increased fill and debris		
Flow	Low, pond forming		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Stream bed conditions			
Periphyton	Not assessed		
Orange precipitate	Orange precipitate on the stream bed		
Water clarity	Clear		
Foam/bubbles	low amounts of bubbles/foam		
Rubbish/odour	Strong metallic odour		
Flow	Low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Stream bed conditions			
Periphyton	Yes		
Orange precipitate	No		
Water clarity	clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	mild orange precipitate		
Water clarity	slightly murky		
Foam/bubbles	low amounts of bubbles/foam		
Rubbish/odour	No		
Flow	low		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2017	-	No	-
Comments	Possibly sampling from old bore. Need to re-find new bore.		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
26/10/2017	9:00 am	No	-
Stream bed conditions			
Periphyton	Small amounts noted		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low in stream, pond forming		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
26/10/2017	9:20 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low in stream, pond forming		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
26/10/2017	8:45 am	No	-
Stream bed conditions			
Periphyton	no		
Orange precipitate	Yes, orange		
Water clarity	Slightly turbid		
Foam/bubbles	Some bubbles noted		
Rubbish/odour	No odour, no rubbish		
Flow	moderate		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
26/10/2017	9:45 am	No	-
Stream bed conditions			
Periphyton	Small amount noted		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No odour, rubbish noted		
Flow	moderate		
OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
26/10/2017	9:40 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No, brown		
Water clarity	Slightly turbid		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	moderate		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/12/2017	2:50 pm	No	-
Stream bed conditions			
Periphyton	Small amount noted		
Orange precipitate	no		
Water clarity	Clear		
Foam/bubbles	no		
Rubbish/odour	no		
Flow	Flow low upstream, Culvert not flowing		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/12/2017	2:35 pm	No	-
Stream bed conditions			
Periphyton	no		
Orange precipitate	no		
Water clarity	murky		
Foam/bubbles	no		
Rubbish/odour	no		
Flow	Dam level low, culvert not flowing		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/12/2017	2:20 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No, dark brown		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/12/2017	2:15 pm	No	-
Stream bed conditions			
Periphyton	Small amounts noted		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	None		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/12/2017	2:00 pm	No	-
Stream bed conditions			
Periphyton	Small amounts noted		
Orange precipitate	Orange at edges only.		
Water clarity	clear		
Foam/bubbles	None noted		
Rubbish/odour	None noted		
Flow	Moderate - low		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	-	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Murky		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Dam level low, culvert not flowing		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	-	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Murky		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Dam level low, culvert not flowing		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	-	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes, orange		
Water clarity	Cloudy		
Foam/bubbles	No		
Rubbish/odour	Very overgrown with vegetation		
Flow	Low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	-	No	-
Stream bed conditions			
Periphyton	Small amounts noted		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	3:30 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Only on edges, brown bed substrate where main flow		
Water clarity	Slightly turbid		
Foam/bubbles	No		
Rubbish/odour	None noted		
Flow	low		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
19/12/2017	-	No	-
Comments	Possibly sampling from old bore. Need to re-find new bore.		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/01/2018	2:00 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Murky		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low, culvert not flowing		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/01/2018	1:50 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Murky		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low, culvert not flowing		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/01/2018	1:30 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Only slight evidence of previous orange precipitation. Dark brown		
Water clarity	Slightly turbid		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/01/2018	1:15 pm	No	-
Stream bed conditions			
Periphyton	Small amounts noted		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	Rubbish noted		
Flow	low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/01/2018	1:20 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Traces of orange around edges, mostly grey/brown bed.		
Water clarity	clear		
Foam/bubbles	No		
Rubbish/odour	No, no odour		
Flow	low		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/02/2018	11:00 am	yes	
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Slightly Turbid		
Foam/bubbles	No		
Rubbish/odour	Rubbish present		
Flow	Dam level up to culvert, not flowing, Downstream culvert has washed out.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/02/2018	10:30 am	yes	
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear, slightly brown		
Foam/bubbles	No		
Rubbish/odour	Rubbish present		
Flow	Flowing through culvert, into pool, not reaching far down diversion.		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/02/2018	10:20 am	yes	
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes		
Water clarity	Slightly turbid, cloudy		
Foam/bubbles	Yes, petroleum sheen		
Rubbish/odour	Petroleum odour		
Flow	High		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/02/2018	10:00 am	yes	
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Slightly Turbid		
Foam/bubbles	No		
Rubbish/odour	Rubbish noted		
Flow	high		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/02/2018	10:10 am	yes	
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes, Orange/Brown		
Water clarity	Turbid and cloudy		
Foam/bubbles	Yes		
Rubbish/odour	Rubbish noted		
Flow	High		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	2:!5 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No – slightly orange??		
Water clarity	Clear, slightly brown		
Foam/bubbles	No		
Rubbish/odour	Scum accumulated in eastern corner of dam		
Flow	Low, well below culvert, culvert not flowing		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	2:00 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear, slightly Brown		
Foam/bubbles	No		
Rubbish/odour	Small amount of rubbish noted		
Flow	Low, Just below culvert, culvert not flowing.		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	1:15pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy, Brown/Orange		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low-moderate		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	12:45 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	Small amount of rubbish noted		
Flow	Low-moderate		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	1:00 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy		
Foam/bubbles	No		
Rubbish/odour	Small amount of rubbish noted		
Flow	Moderate		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
04/04/2018	1:15 pm	No	-
Comments	Possibly sampling from old bore. Need to re-find new bore.		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/04/2018	11:00 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear, slightly yellow, very muddy in downstream puddle		
Foam/bubbles	No		
Rubbish/odour	Scum accumulating in dam corner. mostly levees and sticks		
Flow	Dam level lower than culvert.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/04/2018	10:45 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear, muddy in downstream puddle.		
Foam/bubbles			
Rubbish/odour	Scum accumulating in dam corner. mostly levees and sticks, some rubbish		
Flow	Almost at culvert level, culvert not flowing		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/04/2018	10:25 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes. Orange		
Water clarity	Slightly cloudy		
Foam/bubbles	Small amount of bubbles		
Rubbish/odour	No		
Flow	Low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/04/2018	10:00 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	clear		
Foam/bubbles	No		
Rubbish/odour	Rubbish noted, no odour		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/04/2018	10:10 am	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Dark brown, slightly orange		
Water clarity	Slightly turbid, cloudy		
Foam/bubbles	Some bubbles		
Rubbish/odour	No odour, some rubbish noted		
Flow	moderate		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
24/05/2018	3:30 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Cloudy		
Foam/bubbles	Yes		
Rubbish/odour	No odour, rubbish noted, scum and lots of sticks		
Flow	Culvert full to headwall but flows creating hole, therefore, not flowing down channel.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
24/05/2018	3:10 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Cloudy		
Foam/bubbles	Yes		
Rubbish/odour	No odour, Rubbish noted, Scum in corner of dam		
Flow	Small amount of slow through culvert and down diversion		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
24/05/2018	2:50 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy		
Foam/bubbles	Small amount of bubbles		
Rubbish/odour	No odour, rubbish noted		
Flow	Moderate		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
24/05/2018	2:30 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No Odour, No rubbish. Recent restoration and planting noted.		
Flow	Low – moderate.		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
24/05/2018	2:40 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Small amount of precipitate		
Water clarity	Cloudy		
Foam/bubbles	Yes		
Rubbish/odour	No odour, rubbish noted		
Flow	Moderate		

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	2:40 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear but lightly yellow		
Foam/bubbles	No		
Rubbish/odour	Small amount of rubbish noted. No odour		
Flow	Downstream culvert completely submerged. Small flow down diversion.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	2:30 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	Small amount of rubbish noted. No odour.		
Flow	Dam level high, water flowing through culvert and down diversion		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	2:10 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes, orange		
Water clarity	clear		
Foam/bubbles	Small amount of bubbles noted		
Rubbish/odour	No odour, no rubbish noted		
Flow	moderate		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	1:40 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	1:50 pm	No	-
Stream bed conditions			
Periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy orange/grey		
Foam/bubbles	Yes		
Rubbish/odour	No odour, rubbish noted		
Flow	Moderate		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
22/06/2018	2:!0 pm	No	-
Comments	Possibly sampling from old bore. Need to re-find new bore.		

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