Northern Corridor Improvements

Assessment of Surface Water Quality Effects

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Executive summary

Monitoring of six sites within the Oteha Valley, Alexandra Stream and Lucas Creek catchments was carried out on five occasions in May and June 2016 in order to establish a baseline dataset of surface water quality within the area of the Northern Corridor Improvement Project (the Project).

Sites were monitored for a range of field and laboratory parameters. The results were compared with Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) guidelines in order to gain an understanding of the current condition of the Oteha Valley Stream, Alexandra Stream and Lucas Creek. A further aim was to establish whether the nearby Rosedale Landfill was having an influence on surface water quality.

Field and laboratory measurements were compared with those previously collected by Auckland Council at two nearby long-term monitoring sites. The purpose of this comparison was to validate the water quality datasets collected in this study. The water quality results obtained will be used as a baseline to compare with future results in order to establish whether construction and/or operation effects associated with the Project are occurring.

Flow data within each waterway was collected so that it could be determined whether there was a relationship between flow and contaminant loads within the waterway. Overall the study findings were:

- Results collected were very similar to the Auckland Council's long-term monitoring record, with the exception of Total Zinc which was more elevated at Site 1. This may be due to the upstream location of Site 1 being in closer proximity to high-yielding sources of zinc such as industrial roofs and road land uses, while the zinc levels at the Auckland Council monitoring site located downstream are likely to have been diluted by land uses that discharge lower zinc yields;
- In comparison to the ANZECC (2000) guidelines, all physical stressors were within all relevant guideline values. Nutrient concentrations were mostly within guideline values with the exception of one elevated Nitrate-N result. Dissolved metals – Calcium, Magnesium, Potassium and Sodium were all below the ANZECC (2000) 95% environmental protection guideline values, as was Total Lead. However, Total Zinc and Total Copper results exceeded the ANZECC (2000) 95% environmental protection guideline values. This is likely to be due to the existing industrial and road land uses within the relatively urbanised catchments;
- Obtained contaminant concentrations were all well below typical mature landfill leachate values as prescribed by Davis and Cornwell (1991). From the water quality results obtained, it can be concluded that there is no measureable influence of landfill leachate on the surface waters monitored for the events assessed. During the Project construction phase leachate is to be fully contained and discharged to sewer - there is no discharge of land fill associated contaminants therefore expected. Monitoring will be carried out to confirm this containment and discharge is operating as intended – and will be addressed by way of a management plan and the proposed consent conditions;
- Based upon the water quality data obtained, it is not possible at this stage to establish whether a relationship exists between flow and contaminant loads due to a lack of variability in the flow conditions assessed. Further monitoring is to be carried out from December 2016 to February 2017 to allow an assessment of seasonal based variability in contaminant concentrations. This

monitoring will also provide further data to assess the relationship between rainfall, flow and contaminant concentrations;

- The effects of sediment discharges from erosion and sediment controls during the construction phase are expected to be no more than minor during typical operation of those controls. There is potential for elevated concentrations of sediment within discharges to the Oteha Stream. Proactive and diligent adaptive monitoring will be required to ensure that the best performance is achieved during the construction phase. The Erosion and Sediment Control Plans will ensure that compliance is achieved with TP90 and the NZTA Guidelines; and
- During the operational phase, the proposed enhanced stormwater quality treatment of existing impervious areas will result in the overall loads of key metals from the Project's impervious areas being reduced. This means the Project will have a net beneficial effect on stormwater quality and the downstream water quality.

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Glossary of Abbreviations

Item	Description
AEE	Assessment of Environmental Effects
ADV	Acoustic Doppler Velocimeter
ANZECC	Australian and New Zealand Environment and Conservation Council
AUP	Auckland Unitary Plan Operative in Part (15 November 2016)
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DRP	Dissolved Reactive Phosphorus
EC	Electrical Conductivity
ESCP	Erosion and Sediment Control Plans
GPS	Global Positioning System
HUR	High Use Road
NOEC	No observable effect concentrations
ORP	Oxidation Reduction Potential
PDP	Pattle Delamore Partners
RMA	Resource Management Act
RWWTP	Rosedale Wastewater Treatment Plant
SEA	Significant Ecological Area
SUP	Shared Use Path
SH x	State Highway (number)
TSS	Total Suspended Solids
UHH	Upper Harbour Highway
vpd	Vehicles per day

Terms and Definitions

Item	Description
Bicarbonate	Sodium bicarbonate (HCO_3^-)
Chemical Oxygen Demand	A measurement of the oxygen required to oxidise soluble and particulate organic matter in water
Chloride	A compound of chlorine with another element or group, especially a salt of the anion Cl− or an organic compound with chlorine bonded to an alkyl group
Digests	Preservatives placed in sample bottles in order to maintain the integrity of the sample
Dissolved Calcium	Calcium in dissolved form
Dissolved Magnesium	Magnesium in dissolved form
Dissolved Potassium	Potassium in dissolved form
Dissolved Reactive Phosphorus	Phosphorus in dissolved form
Dissolved Sodium	Sodium in dissolved form
Electrical Conductivity	A measure of how well water accommodates the movement of an electric charge
Nitrate-N + Nitrite-N	The sum of nitrogen present as nitrate and nitrogen present as nitrite
Nitrite-N	Nitrogen present as nitrate
Oxidation Reduction Potential	A measure of the tendency of a chemical species to acquire electrons and thereby be reduced
pH	A measure of how acidic/basic water is
Dissolved Oxygen	Oxygen that is dissolved in water
Sulphate	A salt or ester of sulphuric acid
Sum of Anions	The sum of negative ions in solution
Sum of Cations	The sum of positive ions in solution
Total Alkalinity	A measure of water’s resistance to change in pH
Total Antimony	Total antimony including dissolved and particulate forms
Total Arsenic	The sum of arsenic in both organic and inorganic forms
Total Boron	Total boron in a solution, including boric acid and borate
Total Cadmium	Total cadium including dissolved and particulate forms
Total Chromium	Total chromium including dissolved and particulate forms
Total Copper	Total copper including dissolved and particulate forms
Total Hardness	The concentration of calcium and magnesium ions

Item	Description
Total Kjeldahl Nitrogen	The sum of organic nitrogen, ammonia and ammonium
Total Lead	Total lead including dissolved and particulate forms
Total Mercury	Total mercury including dissolved and particulate forms
Total Nickel	Total nickel including dissolved and particulate forms
Total Suspended Solids	The dry weight of particles trapped by a filter
Total Zinc	Total zinc including dissolved and particulate forms

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1 Introduction

Pattle Delamore Partners (PDP) was engaged by Aurecon on behalf of the NZ Transport Agency to conduct baseline surface water monitoring within the footprint of the Northern Corridor Improvement Project near Albany, Auckland.

The objective of this assessment was to provide baseline stream water quality data for the assessment of effects associated with earthworks during construction (including discharges from works within the Rosedale Landfill) and stormwater discharges during operation. The parameters measured were also chosen to look for existing influences of landfill leachate.

With time, the catchment conditions and environmental standards could change so that the reported assessment and conclusions are no longer valid. Accordingly, the report should not be used to refer to site conditions and environmental standards applying at a later date without first confirming the validity of the report's information at that time.

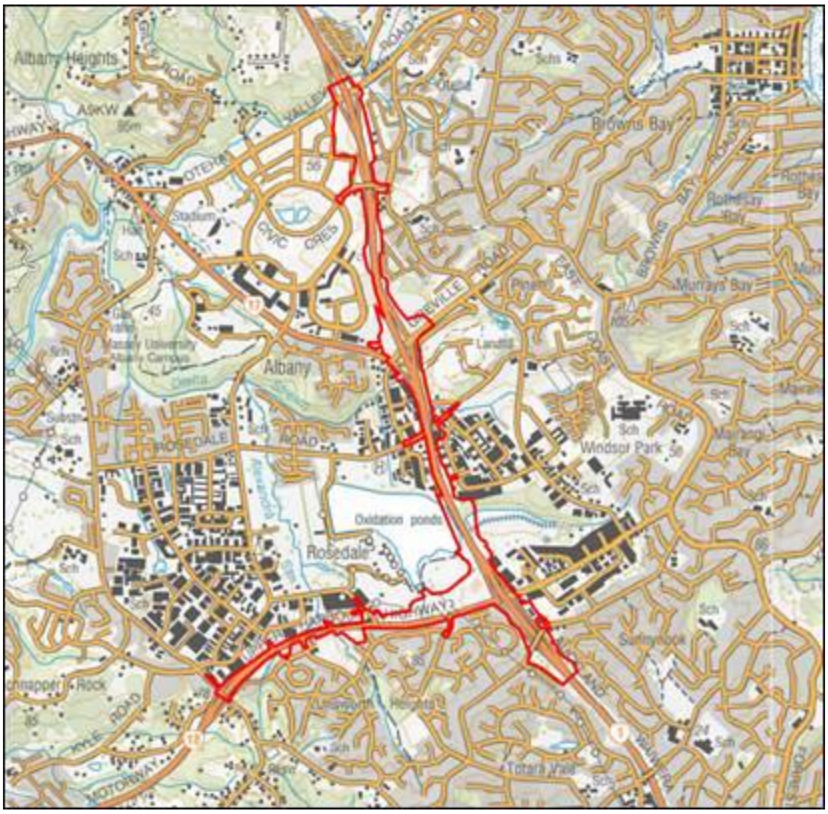
The selected baseline monitoring sites are also used as locations for an assessment of the effects of the Project on the freshwater receiving environment.

2 Background Information

2.1 Project Background

The Northern Corridor Improvements Project (the Project) is an accelerated project. The Project area covers the area of SH18 between Albany Highway and Constellation Drive, and SH1 between Upper Harbour Highway (UHH) interchange to just beyond the Oteha Valley Road Interchange as indicated on **Figure 1** below and set out in the suite of plans provided in **Volume 5**.

Figure 1 Extent of Project area



Source: Base Map from LINZ

The Project proposes to upgrade the existing State highways within the Project area. In summary, the key elements of the Project are as follows:

- North and West Motorway Interchange connections – SH1/SH18;
- State highway capacity and safety improvements;
- Northern busway extension from Constellation Bus Station and connection to Albany Bus Station;
- Reconfiguration of Constellation Bus Station converting it from a terminus station to a dual direction station;
- Shared Use Path (SUP) provision along existing SH1 and SH18 routes for the full extent of the Project corridor:

- Constellation Bus Station to Oteha Valley Road;
- Constellation Drive to Albany Highway; and
- Intermediate linkages to local network.

A full description of the Project, including its components and construction, is contained in section 5 of the Assessment of Environmental Effects (AEE).

2.2 Purpose of this Report

This report is one of a suite of technical reports that has been prepared to inform the AEE for the Project.

The construction and operation of the Project has the potential to adversely affect water quality in the streams within the Project area. Construction of the Project will involve earthworks, which have the potential to increase sediment runoff into streams. During construction, works will also be required within the Rosedale Landfill. Operation of the Project has the potential to increase contaminant levels in streams associated with stormwater from road surfaces.

The purpose of this report is to outline the results of the baseline water quality and hydrological monitoring and assess the potential effects of construction phase and operational phase stormwater discharges on freshwater quality.

2.3 Catchment Information

The Project area spans three catchments, namely:

- Alexandra Stream Catchment to the west,
- Oteha Valley Catchment to the east, and
- Lucas Creek Catchment to the north.

Table 1 below provides a summary of the characteristics of each catchment.

Table 1 Catchment Information

Name	Size and Vegetation	Land Use
Alexandra Stream Catchment	270 Hectares (Morphum, 2013)	The catchment is made up of approximately $^{1}/_{3}$ urban land use, with road and industrial land uses also dominant.
Oteha Valley Catchment	1311 Hectares (Auckland Council, 2013)	The catchment is approximately $^{1}/_{3}$ pasture and bush, with the remainder made up of urban, industrial, commercial and road land uses.
Lucas Creek Catchment	626 Hectares (Auckland Council, 2016)	The catchment is predominately urbanised, with over three quarters made up of urban, industrial, business and road land uses.

2.4 Surface Water Receiving Environments

The streams within the Project area are shown in **Figure 2**.

The Project area traverses three streams; Lucas Creek, Oteha Stream and Alexandra Stream. The Alexandra Stream is a sub-catchment of the Oteha Stream. The three streams are referred to separately in this report as they each represent a different local receiving environment for discharges to surface water from the Project area.

The Oteha Valley catchment is located in the centre of the former North Shore City. Oteha Valley Stream is 11.5km long and is joined by the Alexandra Stream approximately halfway along the channel. At 1311ha, the Oteha Valley catchment is the second largest stormwater catchment in the North Shore area, taking up approximately 10% of the city area. The Rosedale Landfill and the Rosedale Wastewater Treatment Plant are within the catchment (Auckland Council, 2013).

The Lucas Creek catchment is located to the north-east of Albany. Lucas Stream is 16.3km long, flowing from the north-east to the south-west and has eight main tributaries feeding into it. Lucas Creek discharges into the Lucas Creek estuary along with eight other streams from other stormwater catchments.

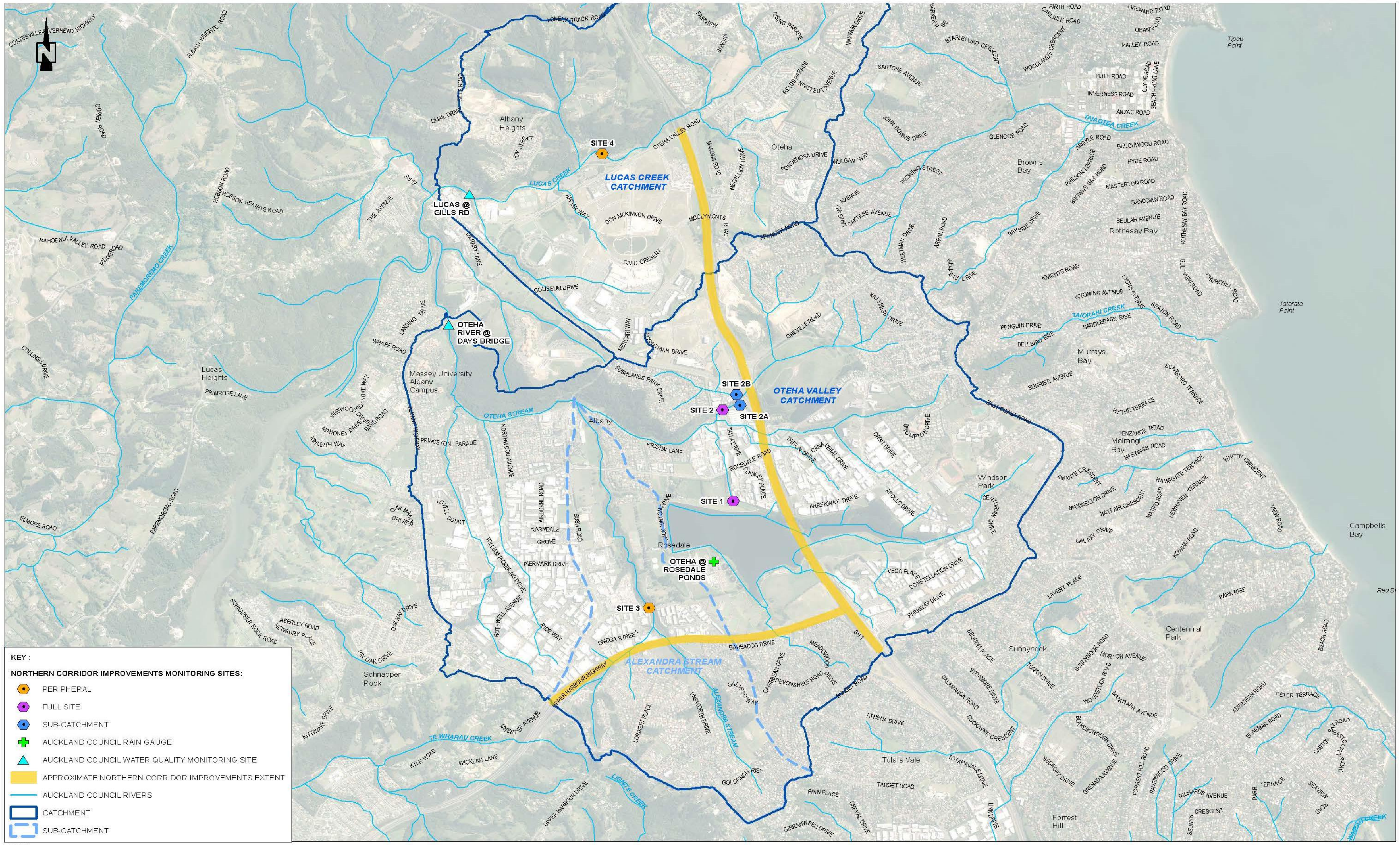
The Alexandra Stream catchment is a sub-catchment of the Oteha Valley catchment. Alexandra Stream is 5km long and flows in a south-north direction from the headwaters in the Unsworth Reserve through to its confluence with Oteha Valley Stream.

Whilst not a ‘stream’ in the traditional sense of the word, the stormwater drainage channels within the Rosedale Wastewater Treatment Plant to the south of Watercare’s Pond 1 fall within the definition of ‘stream’ within the Auckland Unitary Plan Operative in Part (15 November 2016).

The streams all meet near the Albany Village commercial area and flow west to the Lucas Creek estuary. This area is a sheltered depositional environment where most of the contaminants carried by the stream systems will eventually accumulate.

Figure 2 **Map of Sampling Sites**

AURECON/NZTA: NCI SURFACE WATER QUALITY MONITORING



SOURCE:
1. AERIAL IMAGERY (FLOWN 2012), RAIN GAUGE, WATER QUALITY MONITORING SITE AND RIVERS PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL WHO MAKES NO CLAIMS AS TO ITS RELIABILITY, ACCURACY OR ADEQUACY FOR ANY PARTICULAR PURPOSE.
2. APPROXIMATE NORTHERN CORRIDOR IMPROVEMENTS CORRIDOR LOCATION SUPPLIED BY AURECON.
3. TOPOGRAPHICAL INFORMATION DERIVED FROM LINZ DATA.

FIGURE 19: SURFACE WATER QUALITY MONITORING SITES

SCALE: 1:25,000 (A3)

0 250 500 1,000
Meters

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3 Summary of Existing Information

Auckland Council has two water quality sites downstream of the sites monitored called Lucas @ Gills Rd and Oteha @ Days Bridge. These two monitoring sites are located outside of the Project area and are shown on **Figure 2**. However, these monitoring sites provide useful information for the Lucas Creek and Oteha Valley Catchments. A summary of data for relevant parameters from January 2014 – June 2016 has been downloaded from the Auckland Council website and is presented in **Table 2** below.

Table 2 Auckland Council Data

Parameter	Statistic	Oteha @ Days Bridge	Lucas @ Gills Rd
pH	Mean	7.19	7.23
	Standard Deviation	0.29	0.24
	Minimum	6.65	6.71
	Maximum	7.8	7.95
Dissolved Oxygen	Mean	7.87	8.61
	Standard Deviation	1.86	1.29
	Minimum	4.11	6.23
	Maximum	10.55	10.46
Conductivity	Mean	0.23	0.27
	Standard Deviation	0.04	0.03
	Minimum	0.11	0.19
	Maximum	0.29	0.35
Total Kjeldahl Nitrogen	Mean	0.34	0.27
	Standard Deviation	0.29	0.13
	Minimum	0.16	0.05
	Maximum	1.8	0.65
Dissolved Reactive Phosphorus	Mean	0.016	0.014
	Standard Deviation	0.006	0.004
	Minimum	0.006	0.006
	Maximum	0.041	0.026
Total Suspended Solids	Mean	10.99	7.10
	Standard Deviation	15.82	6.01
	Minimum	1.60	1.80
	Maximum	77.00	24.00
Total Copper	Mean	0.0022	0.0017
	Standard Deviation	0.0011	0.0008
	Minimum	0.0011	0.0007
	Maximum	0.0055	0.0036
Total Lead	Mean	0.00044	0.00020
	Standard Deviation	0.00051	0.00021
	Minimum	0.00006	0.00005
	Maximum	0.00200	0.00070
Total Zinc	Mean	0.04007	0.00644
	Standard Deviation	0.02243	0.00539
	Minimum	0.01300	0.00130

Parameter	Statistic	Oteha @ Days Bridge	Lucas @ Gills Rd
	Maximum	0.08500	0.02500

1. All values are in g/m^3, except for pH and conductivity.

These results show that pH ranges between 6.65-7.80 with a mean value of 7.19 at Oteha @ Days Bridge, and 6.71-7.95 with a mean of 7.23 at Lucas @ Gills Rd. All of these values are within the ANZECC (2000) guideline values for pH of 6.5-8.5.

Dissolved oxygen mean values are 7.97 g/m^3 and 8.61 g/m^3 for Oteha and Lucas respectively, placing them above the ANZECC (2000) guideline minimum value of 6 g/m^3. The minimum value recorded for Oteha is outside of this guideline at 4.11g/m^3.

Total Lead results are all well below the ANZECC (2000) guideline of 0.0034 g/m^3 at both sites. Total Zinc results are mostly within the guideline value of 0.008 g/m^3 at Lucas, however the maximum value recorded exceeds this. The mean value for Oteha exceeds this guideline value, as does the minimum value recorded indicating that Zinc levels within this catchment are quite high. This may be due to the urban, industrial and road land uses within the Oteha Valley catchment.

Table 3 below shows seasonal averages for the two Auckland Council monitoring sites for a selection of parameters.

Table 3 Seasonal Averages

Parameter	Season	Oteha @ Days Bridge	Lucas @ Gills Rd
Conductivity	Summer	0.235	0.277
	Autumn	0.218	0.268
	Winter	0.231	0.254
	Spring	0.230	0.257
Dissolved Oxygen	Summer	6.49	7.22
	Autumn	7.65	8.82
	Winter	9.86	10.02
	Spring	8.27	8.96
Dissolved Reactive Phosphorus	Summer	0.015	0.016
	Autumn	0.018	0.014
	Winter	0.013	0.013
	Spring	0.015	0.014
Total Suspended Solids	Summer	6.07	7.24
	Autumn	9.58	5.49
	Winter	20.07	9.90
	Spring	11.43	6.48
Total Zinc	Summer	0.021	0.004
	Autumn	0.041	0.005
	Winter	0.071	0.012
	Spring	0.037	0.006

1. All values are in g/m^3, except for pH.
2. Summer: Jan-Mar, Autumn: Apr-Jun, Winter: Jul-Sept, Spring: Oct-Dec

These results show that there is some variation in results across seasons. Dissolved Oxygen and Total Zinc values (at both monitoring sites) and TSS (at the Oteha @ Days Bridge site) are higher during the winter months, and lower during summer. The other parameters show less significant differences between seasons.

4 Baseline Monitoring Methodology

4.1 Field Sampling Locations

Six monitoring sites were selected at four different locations across the three catchments within the footprint of the Project as shown in **Figure 2** along with **Table A1** in **Appendix A** which shows the GPS locations. The sites were selected to obtain representative data across the three catchments. The sampling sites selected and the parameters that were monitored are summarised in **Table 4** below.

Table 4 Baseline Monitoring Sites

Name	Location	Parameters
Site 1	Oteha Stream – South tributary (access from Rosedale Rd)	Full catchment monitoring: Laboratory analysis, field measurements, flow monitoring
Site 2	Oteha Stream – Tawa Reserve (access from Tawa Drive)	Full catchment monitoring: Laboratory analysis, field measurements, flow monitoring
Site 2A (2.4mØ Pipe)	Oteha Stream – Greville (access from Tawa Drive) – 2.4m Pipe	Sub-catchment monitoring: field measurements
Site 2B (3.0mØ Pipe)	Oteha Stream – Greville (access from Tawa Drive) – 3.0m Pipe	Sub-catchment monitoring: field measurements
Site 3	Alexandra Stream	Peripheral catchment: field measurements
Site 4	Lucas Creek	Peripheral catchment: field measurements

Sites 1 and 2 cover the majority of discharges from within the Project area. These sites catch flow from the existing SH1 motorway near Spencer Rd, south to the intersection with the Upper Harbour Highway and then west to near Barbados Drive. Outside this area, the Project only includes minor changes to the carriageway. A suite of laboratory water quality testing and in situ parameters were carried out for Sites 1 and 2. These sites were identified for more detailed assessment as they cover the majority of the Project area and receive flows from a significantly larger extent of new high use road than Sites 3 and 4.

Site 3 for the Alexandra Stream and Site 4 for Lucas Creek were assessed using in situ water quality parameters.

Site 1 represents the upper part of the catchment, including stormwater discharges from part of the existing SH1 and SH18, the industrial land east of SH1 and the Rosedale Wastewater Treatment Plant (RWWTP) site which is piped into the Oteha Stream just upstream of the sampling site.

Site 2 is split into three sites; the main Site 2 shows the combined effects of upstream activities, while Sites 2A and 2B immediately downstream of the 2.4m and 3.0m diameter pipe sites represent parts of the Oteha Valley catchment draining on either side of the Rosedale Landfill. Site 2A drains the northern end of the catchment, which is predominantly residential around Greville Rd, while Site 2B includes the landfill site and drains the southern end around the industrial areas surrounding Triton Drive and Orbit Drive.

The Alexandra Stream (Site 3) and Lucas Creek (Site 4) sites represent the peripheral catchments of the same name. These catchments will be influenced by the Project to a lesser extent than the Oteha Valley Catchment, which is why only field measurements were taken rather than full catchment monitoring. The sites were sampled across five monitoring rounds, beginning on 6 May 2016 and ending on the 17 June 2016. Each round was 10 -11 days apart.

The testing parameters were selected on the basis of the expected potential effects to surface water quality in each catchment. Sites 1 and 2 will receive the largest increases in impervious area and therefore metals were assessed so that effects from operational phase stormwater discharges could be assessed if required. Parameters associated with landfill leachate were also assessed at Sites 1 and 2 so that the potential influence of the landfill could be checked. Apart from this, the effects on surface water were considered likely to come from sediment generation during the construction phase – field parameters were considered appropriate to characterise water quality in this respect and have therefore been carried out at all sites.

Sites 2A and 2B were also monitored for field parameters so that any potential sediment discharges could be differentiated to one of these key sub-catchments.

The water quality parameters tested for are listed below.

Laboratory analysis:

Sum of Anions
Sum of Cations
pH
Total Alkalinity
Bicarbonate
Total Hardness
Electrical Conductivity
Total Suspended Solids (TSS)
Total Antimony
Total Boron
Dissolved Calcium
Dissolved Magnesium
Total Mercury
Dissolved Potassium
Dissolved Sodium

Chloride
Nitrite-N
Nitrate-N
Nitrate-N + Nitrite-N
Total Kjeldahl Nitrogen
Dissolved Reactive Phosphorus
Sulphate
Chemical Oxygen Demand (COD)
Total Arsenic
Total Cadmium
Total Chromium
Total Copper
Total Lead
Total Nickel
Total Zinc

Field measurements:

Turbidity
pH
Temperature

Electrical Conductivity (EC)
Oxidation Reduction Potential (ORP)
Dissolved Oxygen (DO)

4.2 Chemical Field Sampling Procedures

4.2.1 Order of sampling

The sites were visited in their numbered order, starting with Site 1 at Rosedale Rd. Following this, Site 2 was visited from Tawa Rd, then Site 3 at Alexandra Stream, and finally Site 4 at Lucas Creek.

At each site, the laboratory water samples were collected first to ensure that there was no disturbance of the water quality in the stream. Following this, the field measurements were taken, and lastly, the flow gauging was carried out.

4.3 Water Grab Samples Collection Procedures

A Mighty Gripper was used to collect water samples, so that water from the centre of the stream could be collected, without having to enter the stream potentially disturbing sediments and contaminating the sample.

Samples were collected directly into the appropriate sample bottles which had been supplied and certified clean by the analysing laboratory. The exception to this was the sample bottles containing digests, which were filled from the bulk bottle so that they were not over-filled. Each sample bottle was uniquely identified in accordance with the PDP chain of custody and sampling labelling procedure.

After collection, the water samples were kept chilled, and sent under standard PDP chain of custody documentation to the appropriate laboratories within 24 hours of sampling. This was to ensure the laboratories received the samples within the required hold times and to ensure sample integrity was maintained.

4.3.1 Field Measurements

Three pieces of equipment were used to measure the field parameters. A Hach 2100Q Turbidimeter was used to measure field turbidity. A YSI Multi Meter was used to measure temperature, pH, Electrical Conductivity and Oxidation Reduction Potential, while a YSI Dissolved Oxygen meter was used to measure Dissolved Oxygen.

4.4 Flow Monitoring Procedures

Flow monitoring was carried out using a SonTek FlowTracker Handheld-ADV® (Acoustic Doppler Velocimeter). On the first visit to Sites 1 and 2, the cross-sections to measure were selected. Cross-sections were chosen in a straight reach of the channel with uniform streamlines and relatively free of slack water, eddies and turbulence. Sections with abrupt changes in bed topography due to large rocks and cobbles were avoided. At Site 1 there was a lot of weed present, so this was removed from upstream and downstream of the chosen cross-section to eliminate effects on flow.

Once the cross-sections were selected, landmarks defining the locations were recorded in the field notes so that the same cross-section would be measured in the following monitoring rounds.

To undertake the gauging, a measuring tape was secured across the section, and a minimum of 20 stations across the stream were measured, at a depth of 0.6 of the water depth at each station. Upon returning to the office, the flow data was downloaded onto the computer and saved.

The FlowTracker was calibrated in the field, prior to measurements being undertaken. PDP owned handheld water quality meters were calibrated in the field prior to use following relevant calibration procedures supplied in the instrument user manuals. Rented handheld water quality meters were calibrated by the rental suppliers.

5 Results

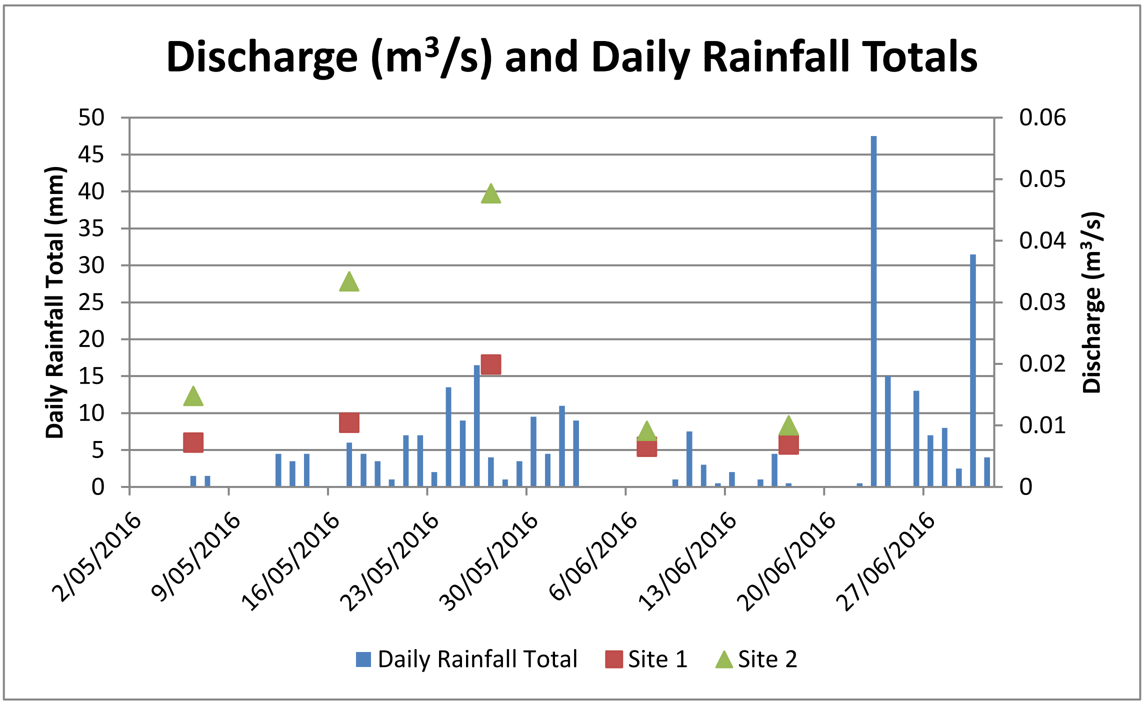
5.1 Flow Results

The results of the flow gaugings are shown below in **Figure 3** for the five monitoring rounds for Sites 1 and 2. The daily rainfall totals recorded at the nearby Oteha @ Rosedale Ponds Auckland Council rain gauge are also shown, to show the antecedent conditions for each event. **Figure 3** shows that the stream discharge recorded was similar for four of the five events, with an elevated discharge recorded on the 27 May 2016 gauging. This was due to the 10 days of rainfall that were recorded prior to this gauging, which would have increased the amount of stormwater and groundwater reaching the stream system.

Flow gauging was carried out in order to establish whether there was a relationship between the amount of flow and the concentration of contaminants. Due to the lack of variation in flow data, it is not possible to draw a conclusion regarding this relationship from the results obtained. Low flow data would be required, which is most likely to be present throughout the summer months. Further flow monitoring will be undertaken from December 2016 to February 2017 in order to supplement the data collected to date. The data collected to date is considered sufficient for this phase of the assessment and with the additional data to be collected will form a robust baseline dataset.

Measured flow for events 1, 4 and 5 is considered not affected by rainfall. Flows were between 6.5 and 7.2 L/s for Site 1 and 9.1 and 14.8 L/s for Site 2.

Figure 3 **Discharge and Rainfall**



5.2 Water Quality Evaluation Criteria

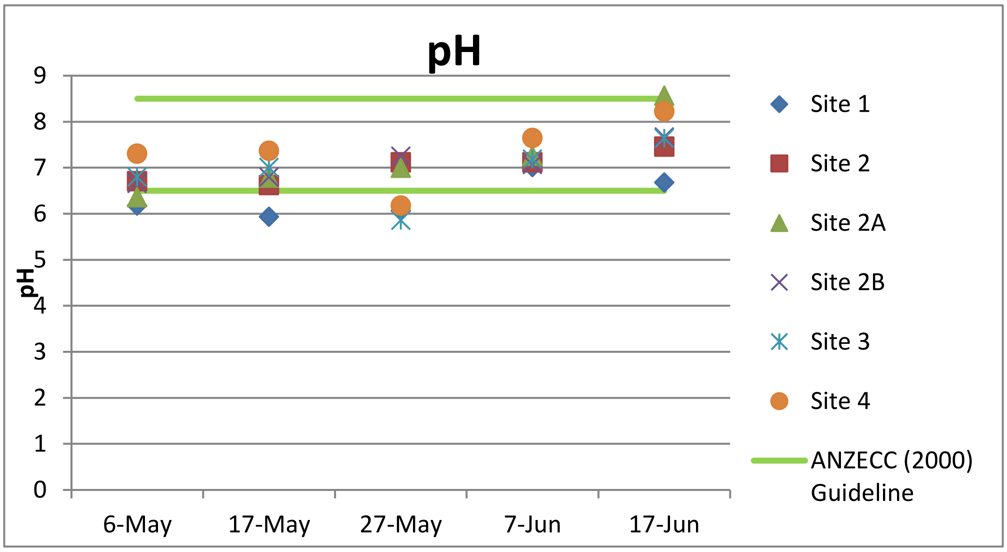
The ANZECC (2000) guidelines have been used as the primary water quality guidelines to assess the current health of surface water within the area of the Project. These guidelines have been derived using data from single species toxicity tests on a range of test species. High-reliability trigger values were calculated from ‘chronic no observable effect concentrations’ (NOEC) data. A statistical distribution method has been used to calculate four different protection levels (99%, 95%, 90% and 80% ecosystem protection) for high-reliability trigger values. In this assessment the 95% protection trigger values have been used as the default values.

5.3 Water Quality Monitoring Results

5.3.1 Physical Stressors

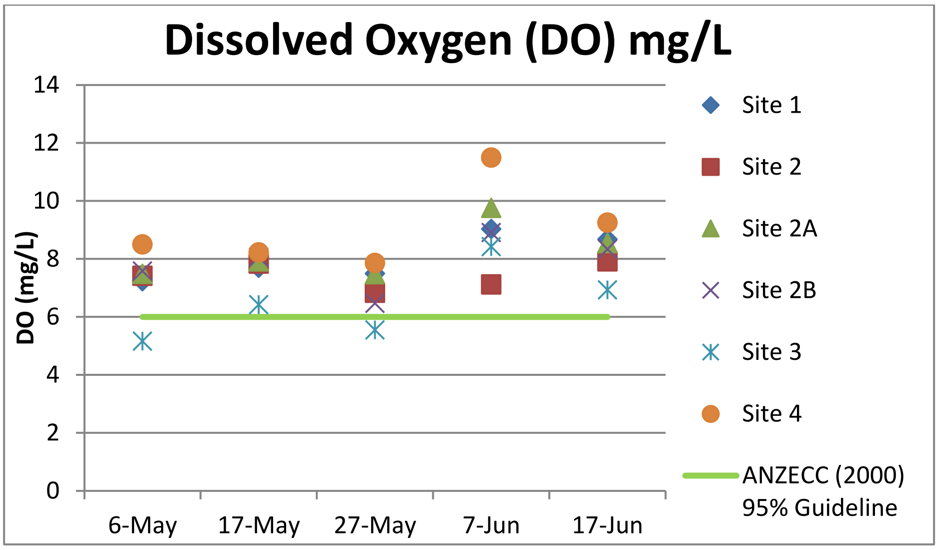
The pH results and the ANZECC (2000) guideline values of 6.5-8.5 are shown below in **Figure 4**. The results are consistent with those collected by Auckland Council at the Oteha @ Days Bridge and Lucas @ Gills Road monitoring sites which range from 6.65-7.80 and 6.71-7.95 respectively.

Figure 4 pH measured in the field compared with ANZECC (2000) guidelines



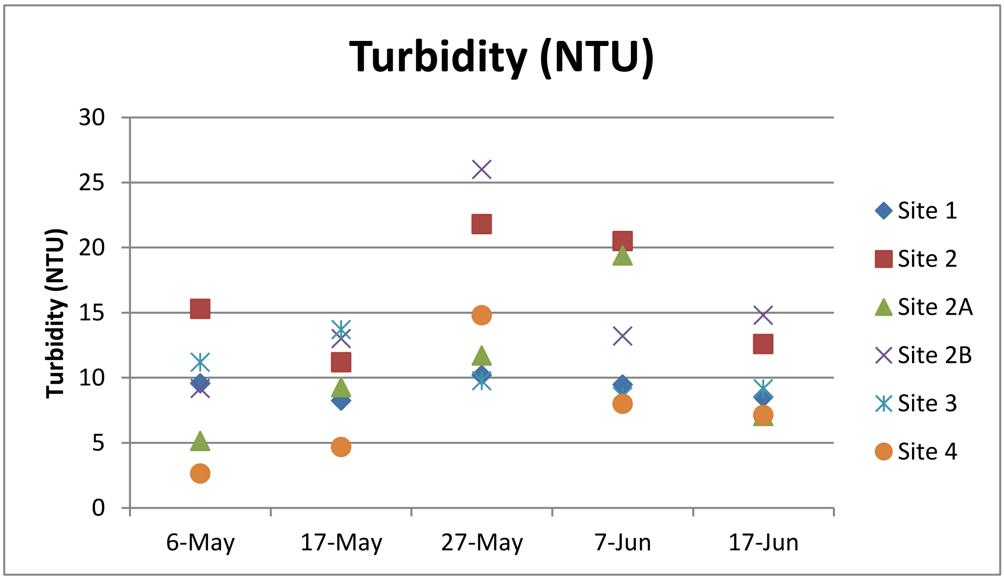
The majority of Dissolved Oxygen results recorded were above the ANZECC (2000) guideline value, as shown in **Figure 5**. The results are consistent with those collected by Auckland Council at the Oteha @ Days Bridge and Lucas @ Gills Road monitoring sites which range from 4.11-10.55 and 6.23-10.46 respectively.

Figure 5 Dissolved Oxygen measured in the field compared with ANZECC (2000) 95% guidelines



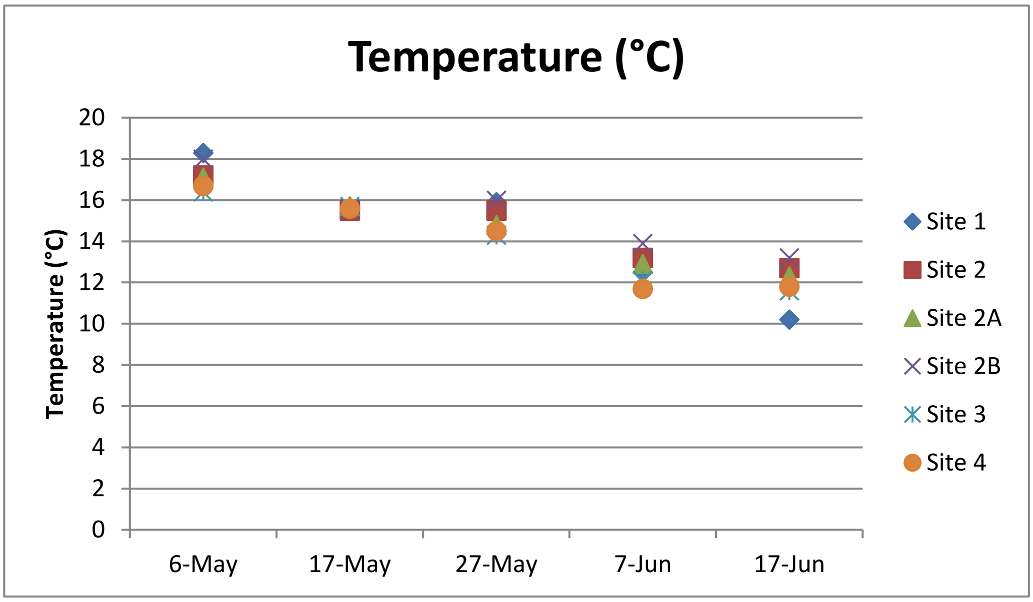
No guidelines are available for Turbidity, but the values recorded were all relatively low, indicative of clear water (**Figure 6**).

Figure 6 Turbidity measured in the field



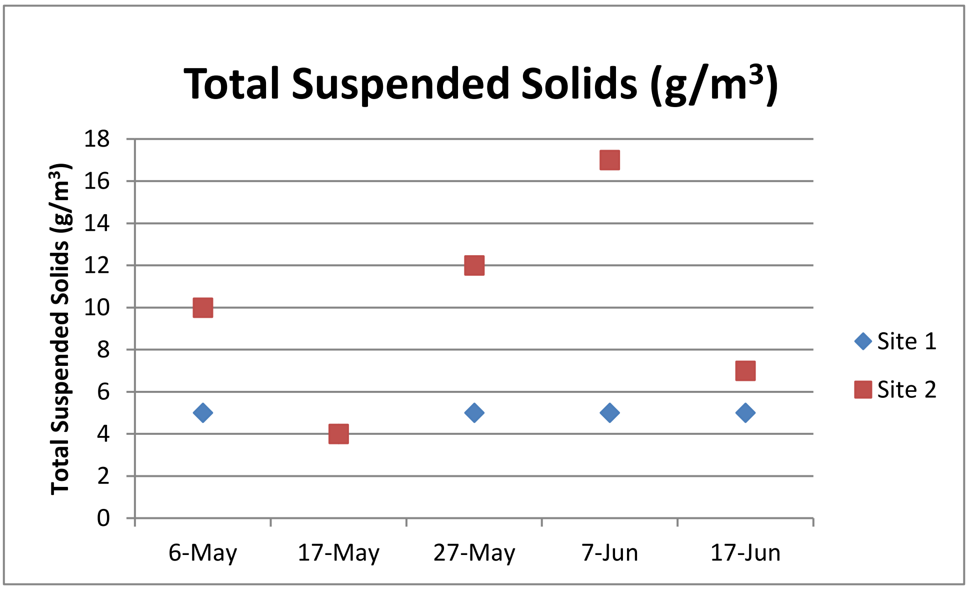
Temperature recorded in the field decreased with each monitoring round as shown in **Figure 7** below. This is likely due to seasonal changes in weather conditions, as it moved into winter. Overall, the water temperatures are considered consistent with an urban stream catchment and the riparian conditions present.

Figure 7 Temperature measured in the field



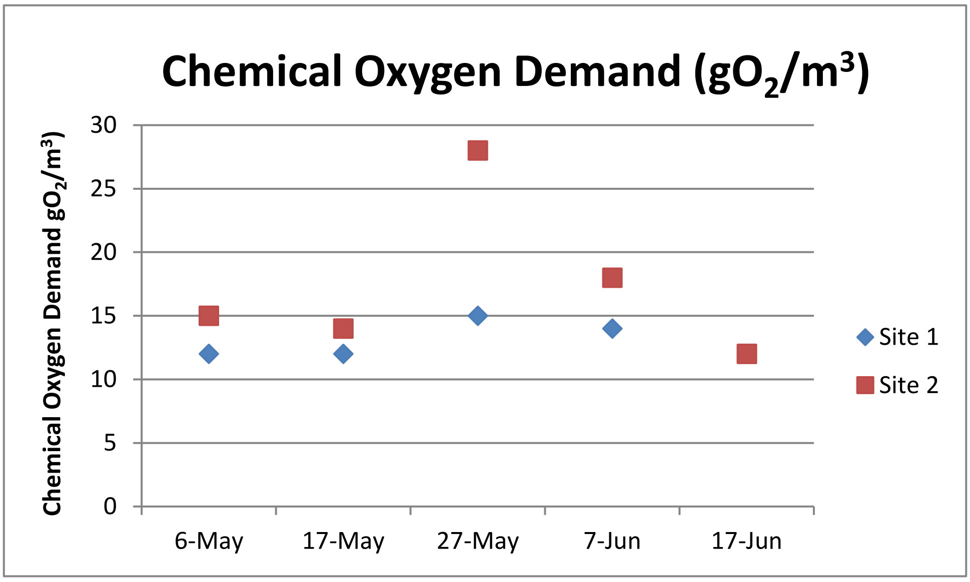
Total Suspended Solids (TSS) results are shown in **Figure 8** below. The results for Site 1 were consistent across the five monitoring rounds, while Site 2 was more varied. The higher TSS results recorded on 27 May and 7 June were following several days of rainfall, which is likely to transport higher sediment loads into the waterways. Overall, the TSS levels measured are considered to be relatively low.

Figure 8 Total Suspended Solids results for Site 1 and 2



Chemical Oxygen Demand results are shown in **Figure 9** below. No guidelines are available for Chemical Oxygen Demand, however, the range of COD values measured within this study are within the range observed in stormwater runoff. Elevated COD concentrations up to 100 mg/kg can be observed during first flush events as a result of petroleum residues being mobilised from carparks and road surfaces.

Figure 9 Chemical Oxygen Demand (COD) results for Site 1 and 2

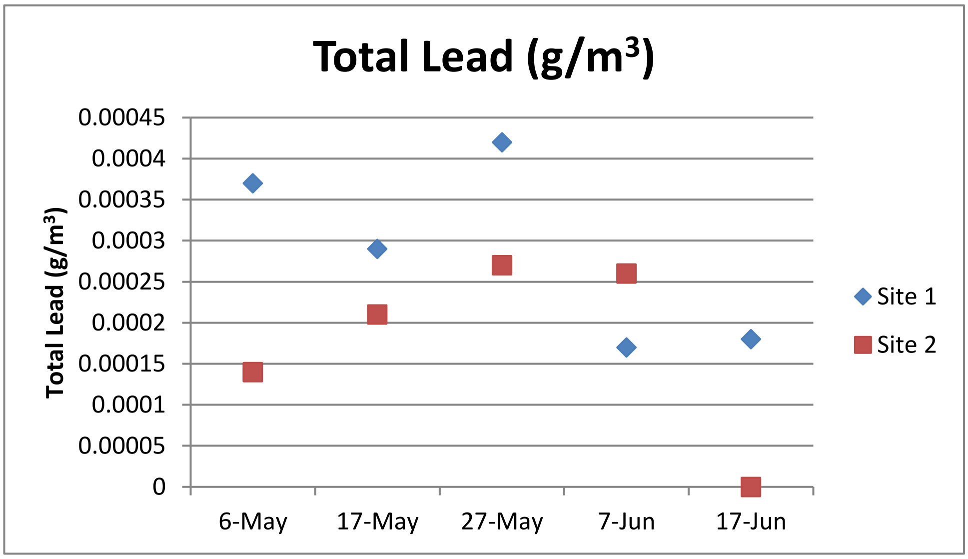


5.3.2 Metals

5.3.2.1 Total Metals

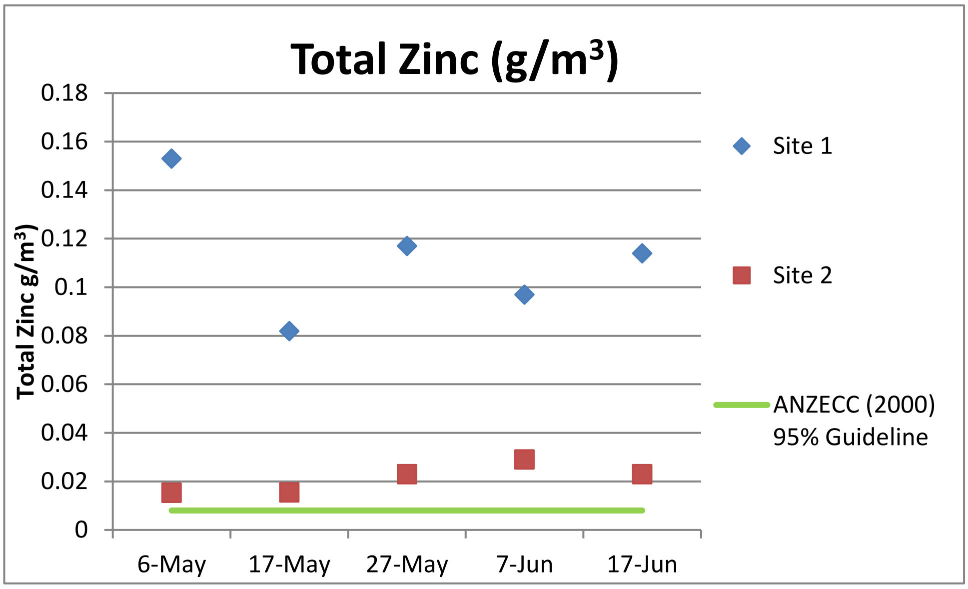
Total Lead results are shown in **Figure 10** below. The result for Site 2 on 17 June 2016 was below laboratory detection limits. All results are well below the ANZECC (2000) 95% guideline value of 0.0034 g/m^3. (This limit is not shown on the figure below as it is tenfold greater than the results and would not allow the differences between sites to be shown.)

Figure 10 Total Lead results for Site 1 and 2



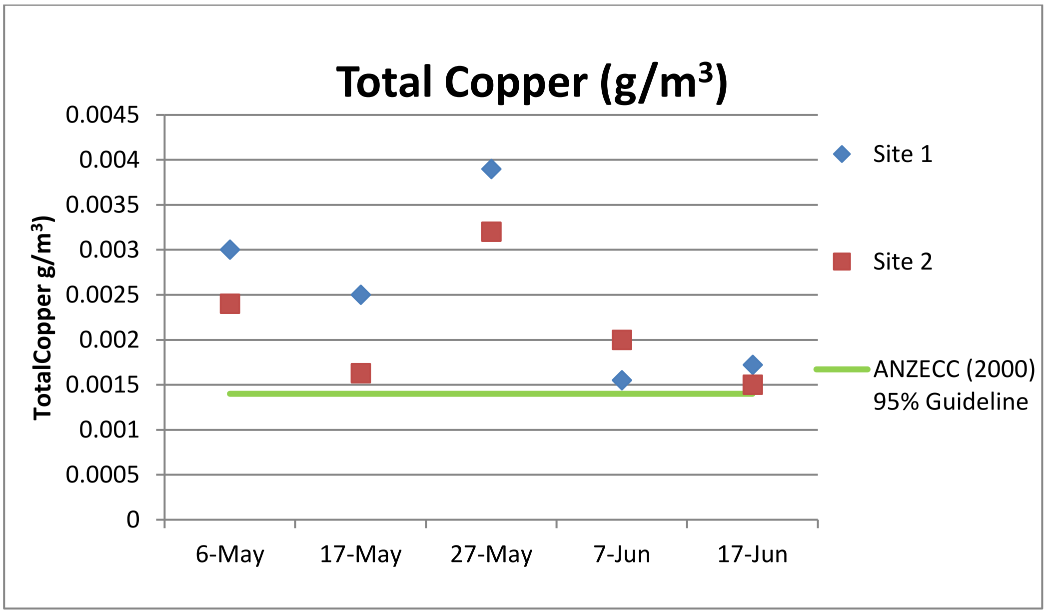
Total Zinc results all exceed the ANZECC (2000) 95% guideline value of 0.008 g/m3 as shown in **Figure 11** below.

Figure 11 **Total Zinc results for Site 1 and 2**



Total Copper results all exceed the ANZECC (2000) 95% guideline value of 0.0014 g/m3 as shown in **Figure 12** below. There is a spike in results on 27 May 2016. This aligns with the heavy rainfall in the days preceeding sampling which increased flows to the river, likely causing the increase in copper levels.

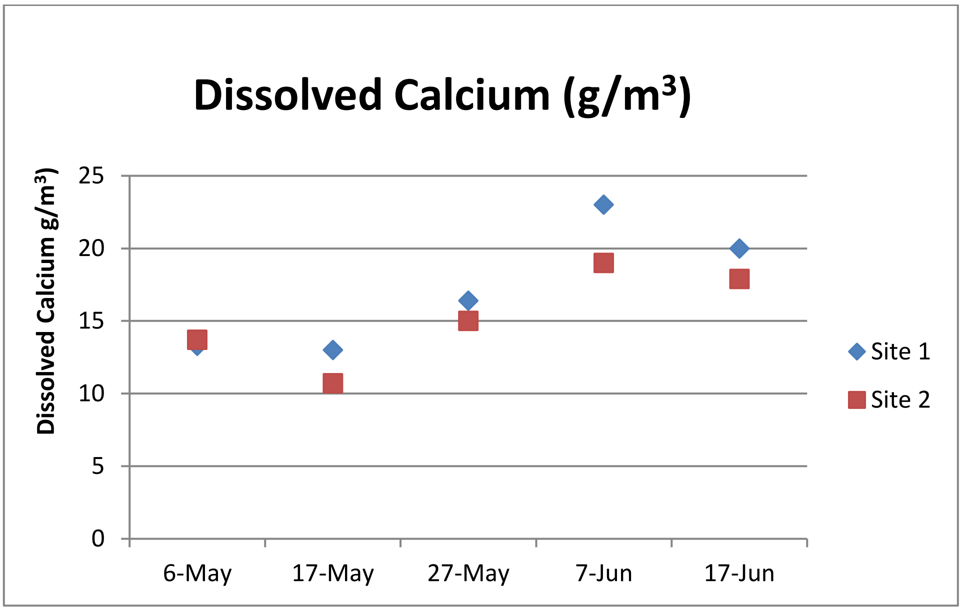
Figure 12 **Total Copper results for Site 1 and 2**



5.3.2.2 Dissolved Metals

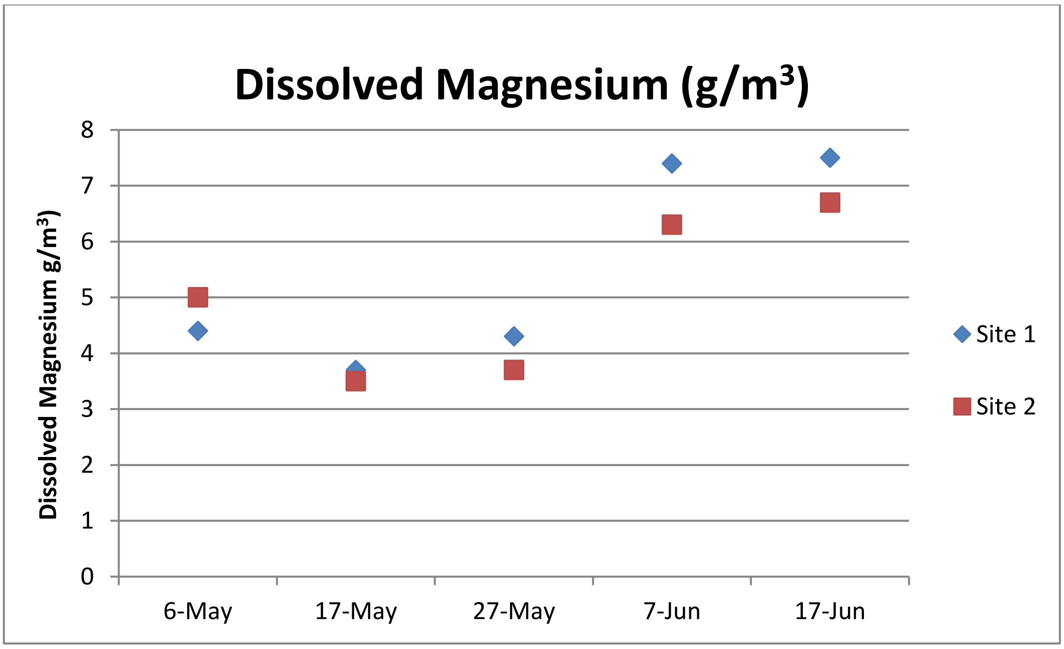
Dissolved Calcium results are shown in **Figure 13** below. Dissolved calcium is within the range typically found within urban stormwater.

Figure 13 Dissolved Calcium results for Site 1 and 2



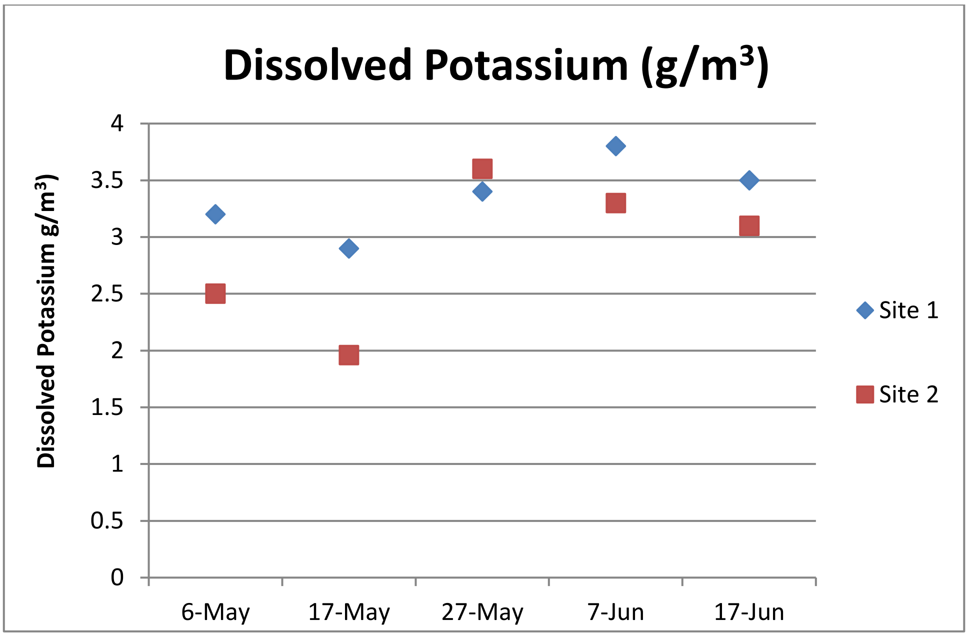
Dissolved Magnesium results are shown in **Figure 14** below. Dissolved magnesium is within the range typically found within urban stormwater.

Figure 14 Dissolved Magnesium results for Site 1 and 2



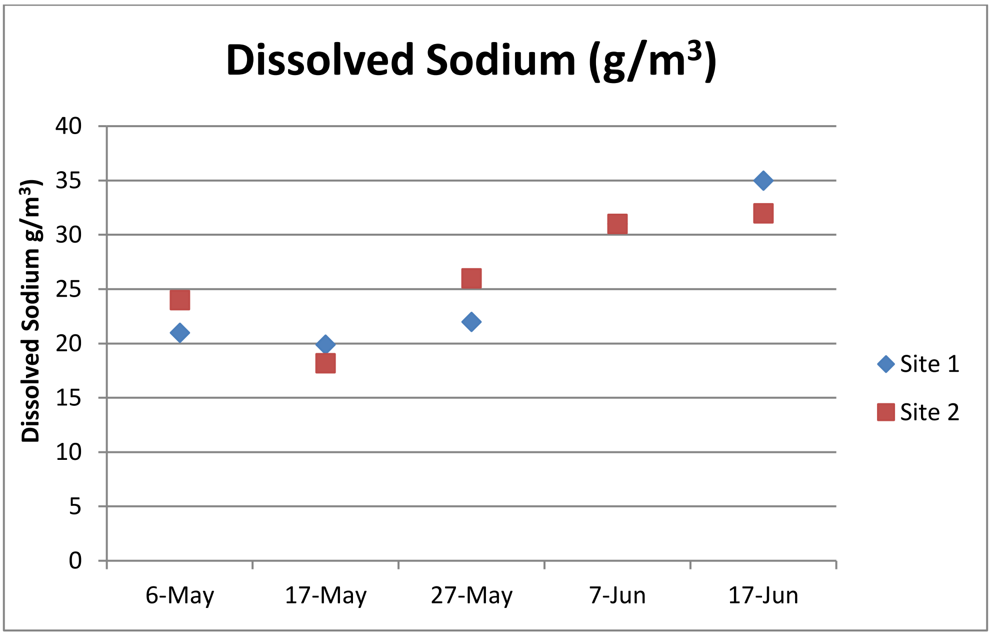
Dissolved Potassium results are shown in **Figure 15** below. Dissolved potassium is within the range typically found within urban stormwater.

Figure 15 Dissolved Potassium results for Site 1 and 2



Dissolved Sodium results are shown in **Figure 16** below. Dissolved sodium is within the range typically found within urban stormwater.

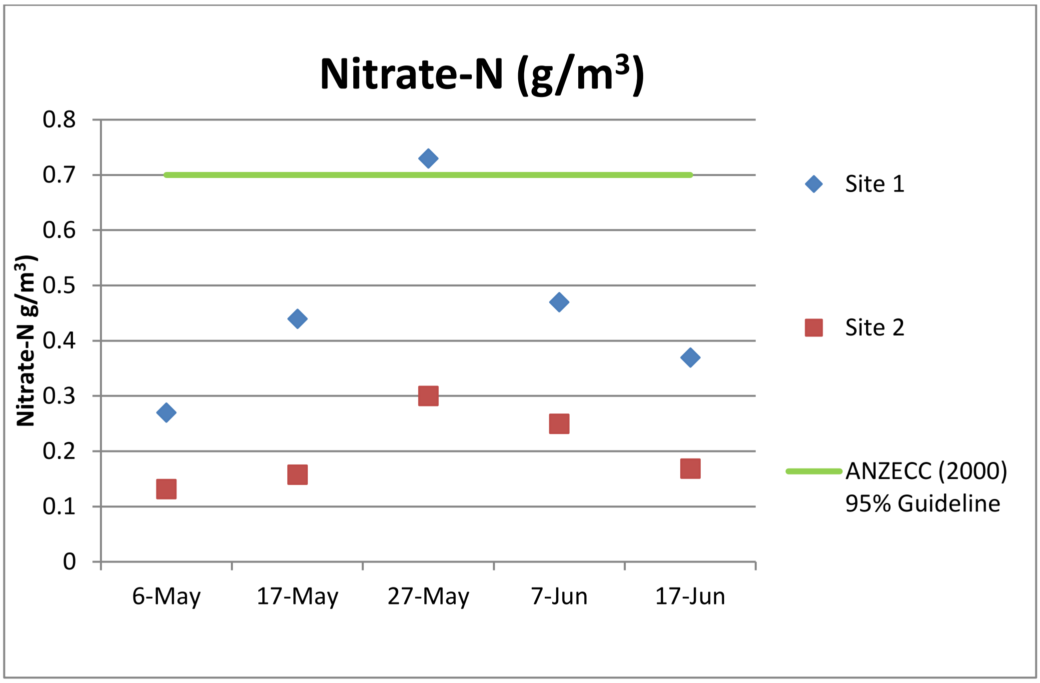
Figure 16 Dissolved Sodium results for Site 1 and 2



5.3.3 Nutrients

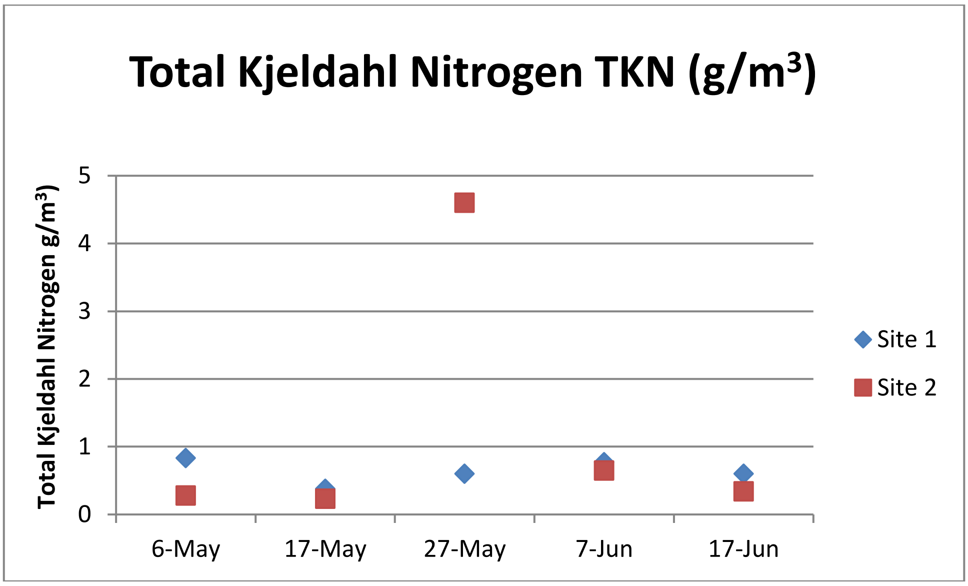
Nitrate-N results and the ANZECC (2000) 95% guideline value of 0.7 g/m^3 are shown in **Figure 17** below. The results are within the guideline value with the exception of one result recorded at Site 1 on 27 May 2016 which slightly exceeded this value.

Figure 17 Nitrate-N results for Site 1 and 2



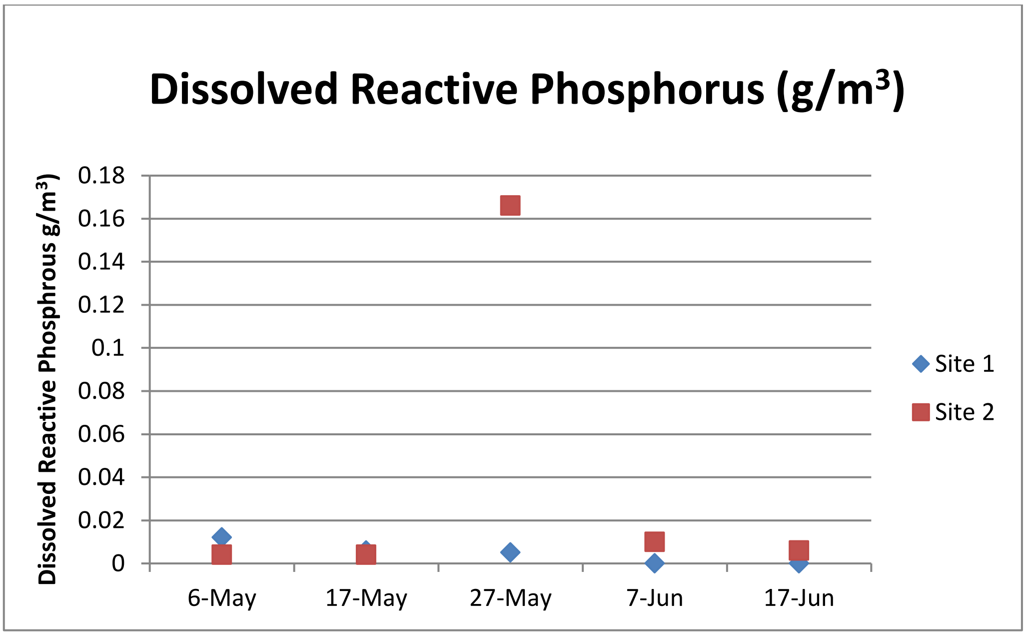
Total Kjeldahl Nitrogen results are shown in **Figure 18** below. The TKN concentration measured at Site 2 on 27 May 2016 is elevated compared to the other results. This sample was collected following rainfall and elevated TKN concentrations are typically recorded during first flush events due to the runoff of petroleum compounds (which contain urea), animal excrement and fertilisers from landscaping areas. Slightly elevated levels were also seen in other parameters such as Total Copper and Nitrate-N on this sampling date.

Figure 18 Total Kjeldahl Nitrogen results for Site 1 and 2



Dissolved Reactive Phosphorus results are shown below in **Figure 19.** There is an elevated concentration measured for Site 2 on 27 May 2016. As discussed previously, this aligns with increased rainfall and is consistent with trends seen in other parameters.

Figure 19 Dissolved Reactive Phosphorus results for Site 1 and 2



5.4 Comparison with Existing Data

Auckland Council has water quality monitoring sites on both Oteha Stream and Lucas Creek that are monitored monthly. When comparing this data with that collected during the baseline monitoring rounds conducted by PDP, it can be seen that results for physical stressors such as pH, Dissolved Oxygen and Total Suspended Solids are very similar.

Total Kjeldahl Nitrogen results in the baseline monitoring rounds were also similar to the Council record, with the exception of the spike recorded on 27 May 2016. Dissolved Reactive Phosphorus results were very similar to the Council record and were within the range of minimum and maximum results recorded.

In general the Auckland Council data for metals (Total Copper, Zinc and Lead) is consistent with the results from the baseline monitoring results with the exception of Total Zinc at Site 1, where results were more elevated. This is likely due to Site 1 being further upstream in the catchment, closer to the sources of Zinc and before dilution and mixing has occurred. As all results were collected during Autumn (based on the hydrological year), it is not possible to draw conclusions regarding the effects of seasonality on the results collected. However, the results are consistent with the Autumn averages calculated for the Auckland Council dataset (see **Table 4** in Section **4** above).

6 Summary of Baseline Results

6.1 Physical Stressors

The majority of physical stressors were within guideline values.

pH values recorded were all close to or within ANZECC (2000) guideline values of 6.5-8.5, while the majority of Dissolved Oxygen results recorded were above the recommended minimum value of 6 mg/L. There were some differences in pH results recorded in the field and those from the laboratory, which is being investigated further.

Temperature recorded in the field decreased with each monitoring round, likely due to seasonal changes in weather conditions, as it moved into winter.

No guidelines are available for Turbidity, but the values recorded were all relatively low, indicative of clear water. An increase in Turbidity values was recorded on 27 May 2016, likely due to the increased flows during this period following 10 days of rainfall. This would mean more runoff would reach the stream system, increasing turbidity.

Chemical Oxygen Demand results showed no sign of influence from landfill leachate. Mature landfill leachate typically has COD results of 100-500 gO_2/m^3 (Davis and Cornwell, 1991) which is 10 fold greater than results recorded for Sites 1 and 2.

6.2 Metals

Total Zinc and Copper results all exceed the 95% ANZECC (2000) guideline value of 0.008 g/m^3 0.0014 g/m^3 respectively. This is to be expected due to the existing industrial and road land uses in the catchment.

Total Lead results were well below the 95% ANZECC (2000) guideline of 0.0034 g/m^3. There was a spike in lead concentrations on 27 May 2016 which aligns with the increased flow recorded on this date as discussed previously.

Dissolved metals results for Calcium, Magnesium, Potassium and Sodium were all low; at least four to tenfold less than the typical landfill leachate values.

6.3 Nutrients

Nitrate-N results were mostly below the ANZECC (2000) guideline value of 0.7 g/m^3, with the exception of one result recorded at Site 1 on 27 May 2016 which slightly exceeded this value. Typical landfill leachate values of 5-10 g/m^3 are 10 fold greater than this.

Dissolved Reactive Phosphorus results are over 20 fold less than the typical values in mature landfill leachate of 4-8 g/m^3. There is an elevated value for Site 2 on 27 May 2016 that is over ten times greater than other results recorded.

There was also an elevated value for Total Kjeldahl Nitrogen of over 4 times greater than the other results recorded at Site 2 on 27 May 2016. The elevated value in both TKN and Dissolved Reactive Phosphorus (DRP) on this date suggests there was a source of contamination related to these higher nutrient values, such as bird excrement washing into the stream system during the period of elevated flow.

7 Characterisation of the discharges

7.1 Construction phase - sediment

Sediment is the key contaminant expected to be discharged to surface water during the construction phase of the Project. Other potential contaminants during the construction phase, such as landfill leachate, hydrocarbons from asphalt and refuelling operations and pH from concrete works are expected to be fully contained and management procedures will be in place to avoid discharges occurring. Details of the proposed management approaches are set out in the Assessment of Construction Water Management (**Volume 3 – Technical Assessment 4**) and the Landfill (**Volume 3 – Technical Assessment 7**).

The assessment of, and proposed management approach for, construction phase sediment discharges is set out in Sections 1.3, 4 (Sediment Control Design Philosophy) and 5.2 (Monitoring) of the Assessment of Construction Water Management.

The proposed management approach follows a Best Practical Option approach and is summarised as follows:

- Detailed erosion and sediment control plans (which will include a range of erosion and sediment control measures) are proposed to be developed, certified by Auckland Council and implemented to manage the amount of sediment discharged;
- The erosion and sediment control measures are to be designed and implemented in accordance with **best practice** as outlined in relevant erosion and sediment control guidelines (including Auckland Council's TP90 and NZ Transport Agency's Erosion and Sediment Control Guidelines for State Highway Infrastructure, Construction Stormwater Management (dated September 2014)). Where there is a difference between these documents the more stringent approach is to be adopted;
- "Adaptive monitoring" of the discharges from representative devices will be carried out to confirm the sediment retention ponds and controls are performing as intended and any trends indicating a deterioration in device performance are identified as soon as practicable; and
- Various assessment responses and actions result from these triggers to proactively check and improve the device performance and discharge quality.

The Project has some 61 hectares of areas that will be "worked" at some point. However much of this area is pavement regrading where the surface exposed will be aggregate and therefore it will be inherently resistant to erosion and low loads of sediment are expected to be generated. The larger, more "traditional", bulk earthworks surfaces and the use of chemical treatment sediment retention ponds is focussed in the south around State Highway 1 and the Constellation Drive interchange.

The proposed earthworks management approach is therefore expected to manage and treat the concentrations of sediment in discharges to a high standard. Flocculation is to be used on all sediment treatment devices. Use of organic flocculants is to be considered provided that the most effective flocculant in terms of sediment removal will be selected. As an indication of the discharge quality expected from chemically flocculated ponds, Auckland Regional Council testing recorded a median sediment concentration discharge of 118 g/m^3 (Performance of a Sediment Retention Pond Receiving Chemical Treatment, AC TR 2008/021). Note it is not possible to state that such a quality will actually be achieved in any given event (as rainfall is a key input to any stormwater treatment system and is inherently variable with no practical upper limit). Notwithstanding this point, the performance of flocculation treatment for sediment retention ponds is the best available technology and provides significantly better performance than untreated ponds. On an operational basis the detention volume component of sediment retention devices typically provides enough storage to contain runoff from a 2 year rainfall event.   Events larger than this will overtop the service spillway and are likely to discharge higher concentrations of sediment.

7.2 Operational phase - metals

Metals are expected to be the key contaminant to be discharged with stormwater from the Project area during the operational phase. Other potential contaminants such as from the landfill drainage system are considered to be fully contained in the long term and assumed to not affect surface water quality. Zinc and copper are identified as key metals for consideration.

The assessment of, and proposed management approach for, operational phase stormwater discharges is set out in the Assessment of Stormwater Management **(Volume 3 – Technical Assessment 11**). Sections 4 (Project Design) and 9 (Summary and Conclusions) are of particular note.

Stormwater quality acute effects on the local freshwater environment are typically transitory as runoff moves through the catchment following a storm. Longer term chronic effects require more consistent water quality concentrations; or for metals to settle out, adsorb to sediment particles and accumulate within streams. Sediment within streams is usually moving through the catchment to some extent and therefore long term effects associated with stormwater quality are considered in the estuarine environment where sediment and metals have longer retention times which allow settlement and much lower energy hydrodynamic processes which allow accumulation.

The Assessment of Stormwater Management report has followed a Best Practical Option approach and has carried out a detailed options assessment to arrive at the stormwater management approach, which includes:

- A treatment train series of controls;
- Extensive retrofitting of stormwater treatment to existing high use roads;
- Treating all new high use roads to design guidelines set out in relevant Auckland Council and NZTA documents; and
- The use of wetlands as the primary means of stormwater treatment – which targets metals for treatment.

The baseline monitoring sites have been adopted as locations to assess the effects of Project discharges on the freshwater receiving environment. As all the streams discharge to the downstream Lucas Creek Estuary and contaminants will accumulate there, the estuary is identified as the representative downstream marine receiving environment.

The extent of impervious area within the Project area and the extent of treatment provided to that impervious area provides a useful means of assessing the potential for effects in terms of operational stormwater discharges. Treatment is currently provided for 10.97 ha of the 21.07 ha of existing high use roads (HUR) within the Project area. Following construction, 28.94 ha of the 29.36 ha of high use road will be treated.

Table 5 **Stormwater catchments**

Monitoring Site / Receiving environment	Catchment	Motorway sub catchment	Motorway HUR Impervious Area (existing and proposed)	Motorway Impervious Area	Motorway Pervious Area	Monitoring Site Catchment Area
1	Oteha – south trib	M2S	1.59	2.21	0.27	212
		S2R	9.42	12.13	4.65	
2	Oteha – Tawa Reserve	R2C	6.54	8.43	4.62	252
		C2PM	3.79	3.79	2.59	
3	Alexandra	PM2AH	4.57	4.89	1.73	179
4	Lucas Creek	OV2M	3.45	4.44	1.21	306
		All	29.36	35.89	15.07	
	Lucas Creek Estuary					2500 approx

Notes:

1. All areas in ha

8 Receiving Environment Characteristics

8.1 Freshwater

A range of fresh water aquatic values are identified in the Assessment of Freshwater Ecological Effects (**Volume 3 – Technical Assessment 5**). Table 5 of that report summarises the sites assessed and their ecological values and identifies that they range from moderate to very low. Moderate values are identified at Lucas Creek, a tributary on the northern side of the Oteha stream and the Alexandra Stream. Baseline water quality monitoring Site 1 is assumed to have a low value – although no assessment was carried out it is similar in appearance (a straight engineered channel with sections of armoured bed and banks and limited riparian vegetation) to some upstream sites assessed within the Project area as having low to very low values.

Table 6 Ecological Values

Baseline Water Quality Monitoring Site	Freshwater Ecological Site	Catchment Area to Monitoring Site	Ecological Value
Oteha – south tributary (Site 1)	None	212	Assumed Low
Oteha – Tawa (Site 2)	Tawa Reserve	252	Low
Alexandra (Site 3)	Alexandra Stream – North	179	Moderate
Lucas (Site 4)	Lucas Creek	306	Moderate

Note:

1. All areas in hectares.
2. Refer to the Assessment of Freshwater Ecological Effects for more detailed assessments of the ecological assessments undertaken near Sites 2, 3, 4

8.2 Marine

All of the freshwater streams eventually join and discharge to the Lucas Creek estuary to the west of Albany. The catchment to the estuary is approximately 2500ha with an estuary size of 178ha (ARC, Regional Maps of Settling and Outer Zones, TP170, 2002). Lucas Creek estuary is identified in the Auckland Unitary Plan as a Significant Ecological Area (SEA): Marine 1.

9 Effects Assessment

9.1 Construction phase

The Assessment of Construction Water Management identifies the maximum extents of earthworks areas in Table 3. These have been reviewed and approximately divided into the relevant surface water catchments so that effects on each catchment can be assessed – refer **Table 7**.

Table 7 Project Zone Earthwork Areas

Construction Zone	Monitoring Site 1 (Oteha Stream –South trib)	Monitoring Site 2 (Oteha Stream- Tawa Reserve)	Monitoring Site 3 (Alexandra Stream)	Monitoring Site 4 (Lucas)	Total Area (ha)
Zone 1 – SH1/SH18 Interchange	10.5				10.5
Zone 2 – SH18 to Constellation Drive	5.3		5.3		10.5
Zone 3 – SH1 Northbound	3.5	7.0		3.5	13.9
Zone 4 – SH1 Southbound	3.9	6.7		0.5	11.2
Zone 5 – SH1 Median	0.7	1.3		0.1	2.1
Zone 6 – Albany Park and Ride				0.9	0.9
Zone 7 – Busway Albany to Greville		2.9		1.4	4.3
Zone 8 – Busway Greville to Constellation	5.5	1.8			7.3
Totals	29.4	19.7	5.3	6.4	

Notes:

1. Construction zone areas are taken from the Assessment of Construction Water Management and broadly split into the relevant catchments.
2. All areas are in hectares and have been rounded to 1 dp.

A qualitative assessment of factors relating to sediment loads from the Project construction zone areas has been carried out (refer **Table 8**). The assessment broadly splits the construction zone areas into bulk earthworks areas treated by sediment retention ponds, earthworks areas treated by other erosion and sediment controls (such as check dams and silt fences) and the remaining working area. The assessment shows that both the absolute extent of earthworks area and the ratio of earthworks areas to upstream catchment area will be smaller at Alexandra Stream and Lucas Creek than those to the Oteha Stream via Tawa Reserve and the Oteha southern tributary.

Table 8 Construction phase sediment load risks

Monitoring site	Catchment	Catchment area	Catchment pervious area	Working zone area	Working zone area / catchment area, %	Earth-works area	Earthworks area / Catchment Area, %	Ecological value
1	Oteha – South trib	212	58	29.4	13.9%	10.9	5.1%	Assumed low
2	Oteha – Tawa Reserve	252	87	19.7	7.8%	6.4	2.5%	Low
3	Alexandra	179	66.7	5.3	3.0%	1.0	0.5%	Moderate
4	Lucas	306	122	6.4	2.1%	1.2	0.4%	Moderate

Notes:

1. All areas are in hectares
2. Catchment pervious area is for the maximum development of land use under the Auckland Unitary Plan (AUP).
3. Earthworks areas are broadly estimated from the Assessment of Construction Water Management Erosion and Sediment Control drawings and assume all identified earthworks areas are open simultaneously.

The assessment indicates that there is the most potential for increases in the instream sediment concentration at Site 1 and the least potential at Sites 3 and 4.

It will be important that the erosion and sediment controls, including progressive stabilisation, for the Project are managed and monitored proactively and diligently so that the best practice performance can be achieved, discharge concentrations are minimised and the potential for adverse effects is minimised.

The instream TSS concentration measured during the baseline monitoring round on 27 May is the only baseline event that was carried out following several days of rainfall - instream TSS concentrations of 5 and 12 g/m^3 of sediment were recorded at Sites 1 and 2 respectively. The Auckland Council monitoring site Oteha @ Gills recorded seasonal TSS averages between 6 and 20 g/m^3. However, there could be a wide variation between the baseline value used and the actual instream concentration in response to rainfall and upstream earthworks and stream erosion. More baseline monitoring is required to address this potential variation and establish the likely instream sediment concentrations at the baseline monitoring sites. This monitoring is planned for December 2016 to February 2017.

Effects from the construction phase sediment discharges have considered the above factors and the Resource Management Act (RMA) section 107 matters. Overall the effects on the receiving environment are assessed as follows:

- Within the Alexandra and Lucas catchments, the extent of the work is predominately pavement re-grading with limited bulk earthworking of soils. Treatment will be provided mainly by silt fences and checks dams. Earthworks areas are small compared to the upstream catchments and therefore significant dilution is available. Therefore, the effects from potential sediment discharges from the site are expected to be no more than minor;
- In the centre of the Project area, discharges from the causeway will be directed to the Watercare ponds and therefore the earthworks will not cause any effects on freshwater quality; and
- Much of the works on SH1 that will drain to the Oteha Stream via Tawa Reserve or the Oteha southern tributary is also pavement regrading, and therefore the extent of bulk earthworks is

significantly smaller than the actual area of the Project's physical works. However, the bulk earthworks areas are larger than those in Lucas and Alexandra catchments and constitute a slightly greater proportion of the receiving environment's upstream catchment area. Treatment will be provided by a combination of flocculation treated sediment retention ponds and other methods such as silt fences and check dams. Management by progressive stablilisation will prevent the release of sediment. The treatment and management methods proposed are considered best practice. It is expected that there will be no more than minor effects as a result of the site's sediment discharges on the receiving environment.

It is recommended that water quality monitoring is undertaken at the baseline monitoring sites during the construction phase to check the actual level of receiving environment effects due to sediment discharges and ensure that the best practicable performance is achieved by the erosion and sediment controls. This will be developed as part of the erosion and sediment control plans.

9.2 Stormwater quality long term

The annual stormwater loads have been estimated for the current level of development within the Project area and compared to the proposed development plus treatment. This clearly shows the effect of the stormwater management approach whereby untreated existing high use roads are now to be treated. Annual loads of TSS, zinc and copper from the Project area all decrease. It is, therefore, expected that overall quality of stormwater discharged from the Project area will improve following development. However, given the larger existing loads of contaminants from the wider catchments, any net positive change in water quality at the baseline monitoring sites is likely to be minor.

Table 9 Assessment of Proposed Stormwater Treatment

Scenario	Impervious Area	Pervious Area	Untreated HUR Area	Treated HUR Area	TSS, t/annum	Zn, kg/annum	Cu, kg/annum
Existing	21.08	29.90	10.09	10.97	48	162	47
Proposed Project : operational phase	35.89	15.07	0.42	28.94	28	152	35

Notes:

1. All areas are in hectares.
2. All HUR roads are assumed to have 20,000 to 50,000 vpd.
3. In post Project scenario other impervious areas are assumed equivalent to roads with up to 5000 vpd.
4. Loads have been estimated using the ARC's 2006 Contaminant Load Model.
5. Treatment is assumed to occur by a wetland in all cases.

10 Additional Baseline Monitoring

Additional monitoring is to undertaken for all three catchments over the months of December 2016 to February 2017, consisting of:

- Lucas Creek and Alexandra Stream catchments
  - Targeted at baseline monitoring for sediment effects during construction; and
  - Includes field measurements only.
- Oteha Stream catchments
  - Targeted at baseline monitoring for sediment effects during construction;
  - Includes field measurements;
  - Laboratory analysis; and
  - Flow monitoring to understand the seasonal variation in flow and contaminant concentrations.

The additional baseline monitoring will be carried out to:

- Provide more data for instream sediment concentrations in response to rainfall events and thereby provide the baseline for understanding potential effects from sediment discharges during construction.
- Understand the seasonal variations in baseflow and contaminant concentrations that will be used to check for changes in landfill related contaminants during the construction phase.

11 Monitoring During The Works

The baseline sediment, contaminant and flow monitoring will be used to inform the development of the Erosion and Sediment Control Plans (ESCP).

During the construction phase, monitoring for the management of surface water discharges and freshwater quality will include:

1. “Adaptive monitoring” of the erosion and sediment controls and discharges from sediment retention ponds to confirm they are performing as intended and any trends indicating a deterioration in performance are identified as soon as practicable;
2. Water quality monitoring at baseline Sites 1, 2, 3 and 4 to check for effects related to site discharges. This monitoring and response and action criteria for these results should be included in the ESCPs.

12 Summary

Overall, based on the data collected and assessments carried out;

- There are no physical stressors of concern at the monitoring sites and these are consistent with the level of urban development in the catchments.
- Elevated values were recorded for Zinc and Copper, although this is to be expected of the existing urbanised stormwater catchments.
- From the water quality results obtained to date, there is no measureable influence of landfill leachate on the surface waters monitored within this study.
- The monitoring carried out to date is considered suitable for the assessment in the report to date. Further monitoring to be undertaken over the summer months (Dec 16 to Feb 17) will provide more water quality and flow data to better understand the seasonal and rainfall related variations in baseline water quality and inform the range of instream water quality conditions likely to be present during the construction phase.
- Effects from construction phase sediment discharges are expected to be no more than minor for the Lucas and Alexandra receiving environments. Higher loads of sediment could occur to the Oteha Stream, particularly from the southern tributary, but will be managed by best practice erosion and sediment controls such as flocculation treatment and progressive stabilisation. Effects are expected to be no more than minor during typical operation of the erosion and sediment controls. Proactive and diligent monitoring will be required to ensure that the best performance of sediment control devices is achieved during the construction phase.
- Monitoring is recommended at baseline Sites 1, 2, 3 and 4 during the construction phase to check for effects related to site discharges and provide feedback into the operation of the erosion and sediment controls. This monitoring and response and action criteria for these results should be included in the ESCPs.
- During the operational phase, the proposed stormwater quality treatment of existing impervious areas will allow the loads of key metals to be reduced. This means the Project will have a net beneficial effect on stormwater quality and the receiving environments in terms of stormwater discharges during its operational phase. However, given the larger loads of contaminants from the wider catchments, any net positive change in water quality at the baseline monitoring sites is likely to be minor.

13 References

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Appendices

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Appendix A

Photos, GPS Locations, Map of Sites

Site 1: Oteha Stream at Rosedale Rd on 6 May 2016

Site 2: Oteha Stream at Tawa Dr on 6 May 2016

Site 3: Alexandra Stream on 17 May 2016

Site 4: Lucas Creek on 27 May 2016

Table A1 GPS Locations of Sampling Sites

Site	X	Y
Site 1	1753284	5932235
Site 2	1753292	5932929
Site 2A	1753326	5932949
Site 2B	1753324	5932952
Site 3	1752696	5931442
Site 4	1752660	5934882

Note: Locations are approximate to within 5 metres.

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Appendix B
Lab Results

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Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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Hamilton 3240, New Zealand

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Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

SUPv1

Client:	Pattle Delamore Partners Limited	**Lab No:**	1580378
Contact:	Leena Khong	**Date Registered:**	07-May-2016
	C/- Pattle Delamore Partners Limited	**Date Reported:**	16-May-2016
	PO Box 9528	**Quote No:**	76345
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02951700
		Submitted By:	G Sheridan

Sample Type: Aqueous

	Sample Name:	SW1 06-May-2016 10:25 am	SW2 06-May-2016 1:00 pm		
	Lab Number:	1580378.1	1580378.2		
Individual Tests					
Sum of Anions	meq/L	1.835 ± 0.060	2.002 ± 0.063	-	-
Sum of Cations	meq/L	2.03 ± 0.12	2.19 ± 0.13	-	-
pH	pH Units	7.2 ± 0.2	7.2 ± 0.2	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	40.6 ± 1.8	51.0 ± 2.2	-	-
Bicarbonate	g/m^3 at 25°C	49.4 ± 2.7	62.1 ± 3.2	-	-
Total Hardness	g/m^3 as $CaCO_3$	51.2 ± 2.5	55.0 ± 2.6	-	-
Electrical Conductivity (EC)	mS/m	20.7 ± 0.5	21.8 ± 0.5	-	-
Total Suspended Solids	g/m^3	5.0 ± 2.1	10.2 ± 2.5	-	-
Total Antimony	g/m^3	0.00044 ± 0.00026	< 0.00021 ± 0.00014	-	-
Total Boron	g/m^3	0.0439 ± 0.0071	0.0552 ± 0.0085	-	-
Dissolved Calcium	g/m^3	13.30 ± 0.84	13.70 ± 0.86	-	-
Dissolved Magnesium	g/m^3	4.37 ± 0.30	5.05 ± 0.34	-	-
Total Mercury	g/m^3	< 0.00008 ± 0.000053	< 0.00008 ± 0.000053	-	-
Dissolved Potassium	g/m^3	3.16 ± 0.24	2.49 ± 0.19	-	-
Dissolved Sodium	g/m^3	21.3 ± 2.3	23.6 ± 2.6	-	-
Chloride	g/m^3	26.1 ± 1.7	23.3 ± 1.5	-	-
Nitrite-N	g/m^3	0.0118 ± 0.0022	0.0025 ± 0.0014	-	-
Nitrate-N	g/m^3	0.268 ± 0.034	0.132 ± 0.017	-	-
Nitrate-N + Nitrite-N	g/m^3	0.279 ± 0.034	0.134 ± 0.017	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.829 ± 0.080	0.276 ± 0.068	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0125 ± 0.0032	0.0045 ± 0.0027	-	-
Sulphate	g/m^3	12.81 ± 0.85	15.18 ± 0.98	-	-
Chemical Oxygen Demand (COD)	g O_2/m^3	12.0 ± 4.8	15.0 ± 5.2	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m^3	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	-	-
Total Cadmium	g/m^3	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	-	-
Total Chromium	g/m^3	0.00056 ± 0.00036	< 0.00053 ± 0.00036	-	-
Total Copper	g/m^3	0.00299 ± 0.00046	0.00240 ± 0.00043	-	-
Total Lead	g/m^3	0.000369 ± 0.000077	0.000136 ± 0.000074	-	-
Total Nickel	g/m^3	0.00210 ± 0.00043	0.00248 ± 0.00046	-	-
Total Zinc	g/m^3	0.153 ± 0.013	0.0154 ± 0.0015	-	-

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IANZ
ACCREDITED LABORATORY

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

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ANALYSIS REPORT

Client:	Pattle Delamore Partners Limited	**Lab No:**	1585552	SUPv1
Contact:	Leena Khong	**Date Registered:**	18-May-2016	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	25-May-2016	
	PO Box 9528	**Quote No:**	76345	
	Newmarket	**Order No:**		
	Auckland 1149	**Client Reference:**	A02951800	
		Submitted By:	G Sheridan	

Sample Type: Aqueous

Sample Name:		SW1 17-May-2016	SW2 17-May-2016		
Lab Number:		1585552.1	1585552.2		
Individual Tests					
Sum of Anions	meq/L	1.913 ± 0.063	1.672 ± 0.053	-	-
Sum of Cations	meq/L	1.89 ± 0.11	1.660 ± 0.094	-	-
pH	pH Units	7.2 ± 0.2	7.5 ± 0.2	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	36.6 ± 1.7	40.0 ± 1.8	-	-
Bicarbonate	g/m^3 at 25°C	44.6 ± 2.4	48.6 ± 2.6	-	-
Total Hardness	g/m^3 as $CaCO_3$	47.6 ± 2.3	41.0 ± 2.0	-	-
Electrical Conductivity (EC)	mS/m	20.9 ± 0.5	18.0 ± 0.4	-	-
Total Suspended Solids	g/m^3	4.2 ± 2.1	4.0 ± 2.1	-	-
Total Antimony	g/m^3	0.00034 ± 0.00021	0.00028 ± 0.00018	-	-
Total Boron	g/m^3	0.0299 ± 0.0055	0.0534 ± 0.0083	-	-
Dissolved Calcium	g/m^3	13.04 ± 0.82	10.71 ± 0.68	-	-
Dissolved Magnesium	g/m^3	3.66 ± 0.25	3.47 ± 0.24	-	-
Total Mercury	g/m^3	< 0.00008 ± 0.000053	< 0.00008 ± 0.000053	-	-
Dissolved Potassium	g/m^3	2.86 ± 0.22	1.96 ± 0.15	-	-
Dissolved Sodium	g/m^3	19.9 ± 2.2	18.2 ± 2.0	-	-
Chloride	g/m^3	28.0 ± 1.8	20.1 ± 1.3	-	-
Nitrite-N	g/m^3	0.0081 ± 0.0018	0.0021 ± 0.0014	-	-
Nitrate-N	g/m^3	0.443 ± 0.055	0.158 ± 0.020	-	-
Nitrate-N + Nitrite-N	g/m^3	0.452 ± 0.055	0.160 ± 0.020	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.376 ± 0.070	0.234 ± 0.068	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0060 ± 0.0028	0.0040 ± 0.0027	-	-
Sulphate	g/m^3	17.3 ± 1.1	14.08 ± 0.92	-	-
Chemical Oxygen Demand (COD)	g O_2/m^3	12.5 ± 4.8	13.5 ± 5.0	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m^3	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	-	-
Total Cadmium	g/m^3	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	-	-
Total Chromium	g/m^3	0.00065 ± 0.00036	< 0.00053 ± 0.00036	-	-
Total Copper	g/m^3	0.00249 ± 0.00043	0.00163 ± 0.00039	-	-
Total Lead	g/m^3	0.000290 ± 0.000076	0.000213 ± 0.000075	-	-
Total Nickel	g/m^3	0.00215 ± 0.00044	0.00131 ± 0.00039	-	-
Total Zinc	g/m^3	0.0822 ± 0.0067	0.0155 ± 0.0015	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

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The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

ANALYS

R J Hill Laboratories Ltd
1 Clyde Street,
Private Bag 3205,
Hamilton 3240, NEW ZEALA

Job No: Date Recv: 18-May-16 05:33
158 5552
Received by: Jennifer Singlewood

Office use Job
3115855526

Client

Name Pattle Delamore Partners Limited 59

Address PO Box 9528, Newmarket
Auckland 1149

Phone 09 523 6900 Fax 09 523 6901

Client Reference ~~A02951700~~ A02981.SW

Quote No 76345 Order No

Primary Contact Leena Khong 220393

Submitted By Leena Khong 220393

Charge To Pattle Delamore Partners Limited 59

Results To ☑ Mail Primary Contact ☑ Mail Submitter

☐ Fax Results

☑ Email Results Grant Sheridan.

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☐ *Please tick if you require COC to be emailed back*
Date & Time: 3.30pm 17-5-16
Name: Grant Sheridan
Signature:

Received at Hill Laboratories
Date & Time: 18/5 12.43pm
Name: Jen Singlewood
Signature:

Condition ☐ Room Temp ☐ Chilled ☐ Frozen
Temp: 9.2

☐ Sample & Analysis details checked
Signature:

ADDITIONAL INFORMATION

Priority ☐ Low ☐ Normal ☑ High
☐ **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 5 working days following the day of receipt of the samples at the laboratory.

Quoted Sample Types

Requested Reporting Date:

Surface Water (SW)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	SW1	17-5-16	SW	landfill metals (trace) + TSS TKN, COD, ORP anions/cations.
2	SW2	17-5-16	SW	landfill metals (trace), TSS, TKN, COD, ORP, anions/cations
3				
4				
5				
6				
7				
8				
9				
10				

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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Job Information Summary

Page 1 of 2

Client:	Pattle Delamore Partners Limited	**Lab No:**	1585552
Contact:	Leena Khong	**Date Registered:**	18-May-2016 12:47 pm
	C/- Pattle Delamore Partners Limited	**Priority:**	High
	PO Box 9528	**Quote No:**	76345
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02951800
		Add. Client Ref:	
		Submitted By:	G Sheridan
		Charge To:	Pattle Delamore Partners Limited
		Target Date:	25-May-2016 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	SW1 17-May-2016	Surface Water	UP1L, S250, N100, FN100	Anion / Cation profile, dissolved metals trace level; Total Suspended Solids; Chemical Oxygen Demand (COD), High range Hach; Total Mercury; Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn; Total Antimony; Total Boron; Total Kjeldahl Nitrogen (TKN); Dissolved Reactive Phosphorus
2	SW2 17-May-2016	Surface Water	UP1L, S250, N100, cFN100	Anion / Cation profile, dissolved metals trace level; Total Suspended Solids; Chemical Oxygen Demand (COD), High range Hach; Total Mercury; Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn; Total Antimony; Total Boron; Total Kjeldahl Nitrogen (TKN); Dissolved Reactive Phosphorus

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not > 500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), High range Hach	Dichromate/sulphuric acid digestion, colorimetry. Screen Level method. APHA 5220 D 22nd ed. 2012.	40 g O_2/m^3	1-2

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ANALYSIS REPORT

SUPv1

Client:	Pattle Delamore Partners Limited	**Lab No:**	1591585
Contact:	Leena Khong	**Date Registered:**	30-May-2016
	C/- Pattle Delamore Partners Limited	**Date Reported:**	07-Jun-2016
	PO Box 9528	**Quote No:**	76345
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02951800
		Submitted By:	Jennifer Leslie

Sample Type: Aqueous

Sample Name:		SW1 27-May-2016	SW2 27-May-2016		
Lab Number:		1591585.1	1591585.2		
Individual Tests					
Sum of Anions	meq/L	2.205 ± 0.068	2.442 ± 0.073	-	-
Sum of Cations	meq/L	2.23 ± 0.12	2.27 ± 0.14	-	-
pH	pH Units	7.1 ± 0.2	7.1 ± 0.2	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	43.0 ± 1.9	56.9 ± 2.4	-	-
Bicarbonate	g/m^3 at 25°C	52.4 ± 2.8	69.3 ± 3.6	-	-
Total Hardness	g/m^3 as $CaCO_3$	58.8 ± 2.9	52.9 ± 2.6	-	-
Electrical Conductivity (EC)	mS/m	24.2 ± 0.5	26.6 ± 0.6	-	-
Total Suspended Solids	g/m^3	5.2 ± 2.1	12.0 ± 2.6	-	-
Total Antimony	g/m^3	0.00036 ± 0.00022	0.00025 ± 0.00016	-	-
Total Boron	g/m^3	0.0290 ± 0.0054	0.0495 ± 0.0078	-	-
Dissolved Calcium	g/m^3	16.4 ± 1.1	15.00 ± 0.94	-	-
Dissolved Magnesium	g/m^3	4.32 ± 0.30	3.75 ± 0.26	-	-
Total Mercury	g/m^3	< 0.00008 ± 0.000053	< 0.00008 ± 0.000053	-	-
Dissolved Potassium	g/m^3	3.42 ± 0.26	3.59 ± 0.27	-	-
Dissolved Sodium	g/m^3	22.2 ± 2.4	25.7 ± 2.8	-	-
Chloride	g/m^3	26.3 ± 1.7	23.7 ± 1.5	-	-
Nitrite-N	g/m^3	0.0104 ± 0.0020	0.0194 ± 0.0031	-	-
Nitrate-N	g/m^3	0.726 ± 0.089	0.301 ± 0.039	-	-
Nitrate-N + Nitrite-N	g/m^3	0.736 ± 0.089	0.321 ± 0.039	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.596 ± 0.074	4.58 ± 0.25	-	-
Dissolved Reactive Phosphorus	g/m^3	0.0050 ± 0.0028	0.166 ± 0.025	-	-
Sulphate	g/m^3	26.5 ± 1.7	28.7 ± 1.8	-	-
Chemical Oxygen Demand (COD)	$g\ O_2/m^3$	15.0 ± 5.2	28.0 ± 7.7	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m^3	0.00129 ± 0.00074	0.00194 ± 0.00074	-	-
Total Cadmium	g/m^3	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	-	-
Total Chromium	g/m^3	0.00109 ± 0.00037	0.00148 ± 0.00038	-	-
Total Copper	g/m^3	0.00391 ± 0.00053	0.00315 ± 0.00048	-	-
Total Lead	g/m^3	0.000415 ± 0.000078	0.000267 ± 0.000075	-	-
Total Nickel	g/m^3	0.00388 ± 0.00059	0.00271 ± 0.00048	-	-
Total Zinc	g/m^3	0.1169 ± 0.0094	0.0229 ± 0.0020	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

ilac-MRA IANZ ACCREDITED LABORATORY

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental

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BETTER TESTING **BETTER RESULTS**

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Pattle Delamore Partners Limited	**Lab No:**	1596409 SUPv1
Contact:	Leena Khong	**Date Registered:**	08-Jun-2016
	C/- Pattle Delamore Partners Limited	**Date Reported:**	14-Jun-2016
	PO Box 9528	**Quote No:**	76345
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02951800
		Submitted By:	G Sheridan

Sample Type: Aqueous

	Sample Name:	SW 1 07-Jun-2016	SW 2 07-Jun-2016		
	Lab Number:	1596409.1	1596409.2		
Individual Tests					
Sum of Anions	meq/L	3.29 ± 0.11	2.817 ± 0.086	-	-
Sum of Cations	meq/L	3.21 ± 0.17	2.89 ± 0.16	-	-
pH	pH Units	7.2 ± 0.2	7.5 ± 0.2	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	55.5 ± 2.4	59.5 ± 2.5	-	-
Bicarbonate	g/m^3 at 25°C	67.6 ± 3.5	72.3 ± 3.7	-	-
Total Hardness	g/m^3 as $CaCO_3$	87.1 ± 4.1	73.4 ± 3.5	-	-
Electrical Conductivity (EC)	mS/m	35.6 ± 0.8	30.6 ± 0.7	-	-
Total Suspended Solids	g/m^3	5.1 ± 2.1	17.3 ± 3.2	-	-
Total Antimony	g/m^3	< 0.00021 ± 0.00014	< 0.00021 ± 0.00014	-	-
Total Boron	g/m^3	0.0377 ± 0.0064	0.0421 ± 0.0069	-	-
Dissolved Calcium	g/m^3	22.6 ± 1.5	19.0 ± 1.2	-	-
Dissolved Magnesium	g/m^3	7.43 ± 0.50	6.31 ± 0.43	-	-
Total Mercury	g/m^3	< 0.00008 ± 0.000053	< 0.00008 ± 0.000053	-	-
Dissolved Potassium	g/m^3	3.83 ± 0.29	3.26 ± 0.24	-	-
Dissolved Sodium	g/m^3	31.4 ± 3.4	30.8 ± 3.3	-	-
Chloride	g/m^3	40.0 ± 2.5	29.5 ± 1.9	-	-
Nitrite-N	g/m^3	0.0083 ± 0.0018	0.0068 ± 0.0017	-	-
Nitrate-N	g/m^3	0.474 ± 0.058	0.254 ± 0.032	-	-
Nitrate-N + Nitrite-N	g/m^3	0.483 ± 0.058	0.261 ± 0.032	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.773 ± 0.078	0.647 ± 0.075	-	-
Dissolved Reactive Phosphorus	g/m^3	< 0.004 ± 0.0027	0.0095 ± 0.0030	-	-
Sulphate	g/m^3	49.0 ± 3.0	37.3 ± 2.3	-	-
Chemical Oxygen Demand (COD)	g O_2/m^3	14.5 ± 5.2	17.5 ± 5.7	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m^3	< 0.0011 ± 0.00074	0.00153 ± 0.00074	-	-
Total Cadmium	g/m^3	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	-	-
Total Chromium	g/m^3	< 0.00053 ± 0.00036	0.00092 ± 0.00036	-	-
Total Copper	g/m^3	0.00155 ± 0.00039	0.00201 ± 0.00041	-	-
Total Lead	g/m^3	0.000170 ± 0.000074	0.000259 ± 0.000075	-	-
Total Nickel	g/m^3	0.00590 ± 0.00079	0.00436 ± 0.00063	-	-
Total Zinc	g/m^3	0.0966 ± 0.0078	0.0287 ± 0.0025	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

ilac-MRA IANZ ACCREDITED LABORATORY

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SUMMARY OF METHODS

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Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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BETTER TESTING **BETTER RESULTS**

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ANALYSIS REPORT

Client:	Pattle Delamore Partners Limited	**Lab No:**	1602528 SUPv1
Contact:	Leena Khong	**Date Registered:**	18-Jun-2016
	C/- Pattle Delamore Partners Limited	**Date Reported:**	23-Jun-2016
	PO Box 9528	**Quote No:**	76345
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02951800
		Submitted By:	G Sheridan

Sample Type: Aqueous

Sample Name:		SW1 17-Jun-2016	SW2 17-Jun-2016		
Lab Number:		1602528.1	1602528.2		
Individual Tests					
Sum of Anions	meq/L	3.036 ± 0.097	2.684 ± 0.082	-	-
Sum of Cations	meq/L	3.27 ± 0.19	2.92 ± 0.17	-	-
pH	pH Units	7.1 ± 0.2	7.2 ± 0.2	-	-
Total Alkalinity	g/m^3 as CaCO$_3$	51.6 ± 2.2	58.4 ± 2.5	-	-
Bicarbonate	g/m^3 at 25°C	62.8 ± 3.3	71.1 ± 3.7	-	-
Total Hardness	g/m^3 as CaCO$_3$	81.7 ± 3.8	72.2 ± 3.4	-	-
Electrical Conductivity (EC)	mS/m	33.7 ± 0.7	29.0 ± 0.6	-	-
Total Suspended Solids	g/m^3	4.7 ± 2.1	7.1 ± 2.2	-	-
Total Antimony	g/m^3	< 0.00021 ± 0.00014	< 0.00021 ± 0.00014	-	-
Total Boron	g/m^3	0.0355 ± 0.0061	0.0505 ± 0.0079	-	-
Dissolved Calcium	g/m^3	20.4 ± 1.3	17.9 ± 1.2	-	-
Dissolved Magnesium	g/m^3	7.51 ± 0.51	6.67 ± 0.45	-	-
Total Mercury	g/m^3	< 0.00008 ± 0.000053	< 0.00008 ± 0.000053	-	-
Dissolved Potassium	g/m^3	3.53 ± 0.26	3.09 ± 0.23	-	-
Dissolved Sodium	g/m^3	35.4 ± 3.8	32.2 ± 3.5	-	-
Chloride	g/m^3	42.7 ± 2.6	29.8 ± 1.9	-	-
Nitrite-N	g/m^3	0.0067 ± 0.0017	0.0031 ± 0.0014	-	-
Nitrate-N	g/m^3	0.373 ± 0.046	0.169 ± 0.021	-	-
Nitrate-N + Nitrite-N	g/m^3	0.379 ± 0.046	0.172 ± 0.021	-	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	0.600 ± 0.074	0.345 ± 0.069	-	-
Dissolved Reactive Phosphorus	g/m^3	< 0.004 ± 0.0027	0.0060 ± 0.0028	-	-
Sulphate	g/m^3	37.1 ± 2.3	31.9 ± 2.0	-	-
Chemical Oxygen Demand (COD)	g O$_2$/m^3	12.5 ± 4.8	12.5 ± 4.8	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m^3	< 0.0011 ± 0.00074	0.00112 ± 0.00074	-	-
Total Cadmium	g/m^3	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	-	-
Total Chromium	g/m^3	0.00087 ± 0.00036	0.00089 ± 0.00036	-	-
Total Copper	g/m^3	0.00172 ± 0.00039	0.00150 ± 0.00039	-	-
Total Lead	g/m^3	0.000178 ± 0.000074	< 0.00011 ± 0.000074	-	-
Total Nickel	g/m^3	0.00619 ± 0.00083	0.00356 ± 0.00056	-	-
Total Zinc	g/m^3	0.1139 ± 0.0092	0.0232 ± 0.0020	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

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This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 22nd ed. 2012.	1.0 g/m^3 at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1-2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-2
Total Antimony	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.00021 g/m^3	1-2
Total Boron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0053 g/m^3	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 22nd ed. 2012.	6 g O_2/m^3	1-2

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