Knights Stream and Prestons Stormwater Facility Monitoring 2022 – 2023 Annual Report

Prepared for

Christchurch City Council

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PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Office +64 3 **345 7100**
Website **http://www.pdp.co.nz**
Auckland Tauranga **Hamilton** Wellington
Christchurch Invercargill

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Prepared by		Reviewed by	Approved by
SIGNATURE			
	Liam Allan	Ingrid Cooper	Eoghan O'Neill
	Ella Harris		

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Executive Summary

Background

Pattle Delamore Partners Limited (PDP) has been undertaking water quality monitoring of the Knights Stream and Prestons stormwater facilities for Christchurch City Council (CCC) since 2018. The purpose of this monitoring has been to determine the treatment efficiency of the stormwater facilities and to assess the quality of stormwater that is discharging from these facilities into the receiving environment.

Methodology

Nine targeted rainfall events have been sampled by PDP at these facilities since 2018. Three of these events were within the 2022-2023 monitoring period, four were in the 2021 – 2022 reporting period, and two were in 2018. Five sampling sites were established at both the Knights Stream and Prestons subdivision stormwater facilities. Four of the sampling sites at Knights Stream utilised automatic samplers (autosamplers) for collection, with the remaining site using an in-sump first flush bottle. Three of the sites at Prestons used autosamplers, while the remaining two sites used in-sump first flush bottles. Following a successful round of sampling, composite samples were prepared for each autosampler site and were subsequently delivered alongside the first flush samples to Hill Laboratories Limited for analysis.

In the 2021 monitoring period, the sampling methodology was updated based on the recommendations provided by Dr Jennifer Gadd from NIWA. The number of samples taken from each autosampler was increased from 24 to 72 for each rainfall event (i.e., three samples per bottle). Additionally, at each of the stormwater facilities, an autosampler upstream of the first flush basin was used to collect a first flush sample. This methodology was implemented for two of the four monitoring rounds in the 2020-2021 monitoring period.

The water quality results were analysed to determine the approximate reduction in contaminant concentration across each of the stormwater facilities. This reduction was compared to the expected ranges of treatment efficiencies by contaminant type from Chapter 6 of CCC's Waterways, Wetlands and Drainage Guide (WWDG). The water quality discharged into the receiving environment from the outlets of each wetland was compared to the in-stream water quality standards.

Knights Stream Results Summary

Knights Stream is a small development located between Halswell and Prebbleton. The stormwater system for Knights Stream consists of a dry detention basin/first flush basin (FFB), and a wetland system. A portion of the contributing catchment is conveyed through a grassed swale prior to discharging into the first flush basin. The dry detention basin is a multifunctional space that is utilised as a park during dry weather. The water quality of the dry first flush pond and wetland was analysed for the purpose of this study (referred to as the system/facility).

The Knights Stream discharge results were compared to the Environment Canterbury (ECan) Land and Water Regional Plan (LWRP) 95% level of protection (LoP) guidelines. The guidelines have been applied to assess the contaminant levels of the stormwater discharges.

The Knights Stream results show that the median discharge water quality from the wetland exceeded the in-stream guidelines for copper, zinc, Dissolved Reactive Phosphorus (DRP), and total phosphorus post-treatment. All other contaminant levels meet the guidelines post-treatment; however, these contaminants predominantly met guideline concentrations prior to treatment.

There was a slight increase in particulate metals through the Knights Stream FFB. This is reflected in an increase in Total Suspend Solids (TSS). Increased TSS and decreased dissolved contaminants indicate that adsorption may be occurring.

The intermediate sampling location between the first flush basin and wetland inlet was located next to the wetland pump well; which may have stirred up sediment. The pump well may need to be investigated, to determine whether it is contributing to elevated TSS concentrations. However, as TSS and heavy metal concentrations predominantly met the ECan LWRP guidelines, an investigation is not a priority.

Knights Stream wetland removal efficiency results showed:

- poor dissolved copper, and dissolved lead removal efficiencies; and
- effective removal of TSS, total lead, and zinc (total and dissolved).

The results obtained from Knights Stream appear to indicate that first flush ponds provided the highest treatment efficiency; while the wetlands served to provide light polishing treatment. The dry detention first flush basin appeared to provide less reliable treatment than the wet pond at Prestons.

PDP recommends that further research should focus on first flush basins, or wetlands with a higher contaminant loading. Wetland sediment sampling may also be beneficial, to ensure wetland maintenance and upkeep are suitable. An investigation into the phosphorus and copper content of wetland media may also be beneficial.

Prestons Results Summary

Prestons is a 200 ha development located on flat, low-lying land. The stormwater management system in this study was designed to integrate with the site's recreational park. It is comprised of a wet first flush basin and a wetland. These systems are connected by a stormwater swale (Norton & Raynor, 2019). The water quality of the wet first flush pond and wetland was analysed for the purpose of this study (referred to as the system/facility).

The Prestons discharge results were compared to ECan LWRP 95% LoP guidelines. The guidelines were met for all contaminants, post-treatment, except phosphorous. It should be noted that the Prestons stormwater treatment system is hydraulically connected to the groundwater. This groundwater may act to dilute results. Therefore, it is unclear how much "treatment" the facility is undertaking. A detailed investigation into dry basins and wet ponds across different groundwater zones could be an asset to councils looking to provide guidance on stormwater treatment.

DRP, total copper, total zinc, dissolved copper, and dissolved zinc contaminant concentrations all exceeded guideline values before treatment through the FFB. The FFB appears to have reduced these contaminants to below-guideline values.

No contaminants were reduced below guideline values between the inlet to the wetland and the outlet of the wetland. This indicates that the function of Prestons wetland within the treatment system is primarily polishing treatment and not bulk contaminant removal which occurs through the Prestons FFB.

The results obtained from the sampling at Prestons appear to indicate that first flush ponds provided the highest treatment efficiency; while the Preston wetlands served to provide light polishing treatment. PDP recommends that further research should focus on first flush basins, or wetlands with a high contaminant loading. Wetland sediment sampling may also be beneficial, to ensure wetland maintenance and upkeep are suitable.

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1.0 Introduction

Pattle Delamore Partners Limited (PDP) has been engaged by Christchurch City Council (CCC) to provide ongoing stormwater quality monitoring at the Prestons and Knights Stream stormwater facilities. The primary objective of this stormwater quality monitoring is to determine treatment efficiencies and evaluate the discharge quality of these stormwater facilities. Stormwater quality monitoring was undertaken in three separate stages, as described below:

- Stage 1 – Two rainfall events sampled in 2018:
  - Event 1 – 24/09/2018; and
  - Event 2 – 11/10/2018.
- Stage 2 – Four rainfall events sampled between May 2020 and May 2021:
  - Event 3 – 25/05/2020;
  - Event 4 – 7/11/2020;
  - Event 5 – 11/05/2021; and
  - Event 6 – 29/05/2021.
- Stage 3 – Three rainfall events sampled between November 2022 and April 2023:
  - Event 7 – 17/11/2022;
  - Event 8 – 22/02/2023; and
  - Event 9 – 21/04/2023.

This report includes the results from nine rainfall events between September 2018 and April 2023. It includes details of the methodology used to monitor the facilities, the rainfall events captured over the reporting period, and an analysis of the sampling results to date. The analysis includes an assessment of the treatment provided by the sumps, first flush basins, and wetlands at both facilities, as well as a comparison of the discharge quality to receiving water standards.

2.0 Methodology

The methodology used to collect stormwater samples is mostly consistent with the previous sampling carried out as part of Stages 1-2 and has been described below. Updates to the methodology since Stage 1 are discussed in Section 2.2.

2.1 Receiving Environment Standards

2.1.1 Treatment Efficiency Standards

Observed treatment efficiencies for the stormwater facilities have been estimated from the sampled contaminant concentrations and have been compared to treatment efficiencies in Chapter 6 of CCC's Waterways, Wetlands and Drainage Guide (WWDG). WWDG efficiencies have been adopted from studies in Auckland and overseas and are used as a design basis for estimating treatment efficiencies for new treatment devices in Christchurch. The relevant standards have been summarised in Table 1.

Table 1: Summary of relevant CCC WWDG representative removal capability information (Table 6-6) (CCC, 2012) .

Treatment System	Solids	Phosphorus	Nitrogen	BOD_5	Trace Metals
Dry Detention Basin	40-80	40-60	20-40	20-40	20-60
Extended Wet Detention Basin	60-80	40-80	40-60	20-60	40-80
Wetlands	60-80	40-80	20-60	20-40	40-80

Notes:

1. *The level of pollutant removal will be subject to the level of provisions of treatment system volume or surface areas relative to catchment runoff.*
2. *As a general rule, the higher the concentration of in-flowing pollutants, the greater the degree of removal*

2.1.2 Water Quality Standards

Knights Stream and the Styx River are both classified as spring-fed (plains) streams, under the LWRP. This means they require a 95% level of protection (LoP) for aquatic organisms (ECan, 2018). A 95% LoP means that adverse effects on aquatic organisms must be less than minor. This LoP has associated limits for contaminant concentrations to maintain protection for 95% of the aquatic organisms that are expected to be found in a specific classification of the waterway.

Based on this information, samples were compared to the LWRP Schedule 5, 95% LoP where possible (ECan, 2018). For TSS, LWRP Rule 5.95A Condition 2 (a) was used for comparison. The guideline used for each contaminant has been outlined in Table 2.

Table 2: Receiving Water Standards

Standard Applied	Contaminants
ECan LWRP Rule 5.95A, Condition 2 (a)	TSS
ECan LWRP Schedule 5 Table S5A	Nutrients
ECan LWRP Schedule 5 Table S5B	Heavy Metals

The LWRP standards are for chronic (longer term) exposure and, with the exception of Rule 5.95A, Condition 2 (a) of the LWRP, are intended to be applied to a discharge following reasonable mixing with the receiving waterway. Therefore, results must be interpreted with caution and are intended to be used as a guide for comparison. Additionally, they should aid in identifying which contaminants may be of concern for the receiving waterway.

LWRP does not distinguish between dissolved metals and total metals. Therefore, their values were applied to both dissolved and total metals. However, the LWRP does distinguish between different forms of arsenic and the arsenic VI limit was conservatively applied to the results.

2.2 Sampling Equipment and Methodology

The sampling programme uses six ISCO 6712 automatic samplers and one Liquiport 2000 automatic sampler (referred to as autosamplers in this report) as well as three Thermo Scientific Nalgene Storm Water Samplers (referred to as first flush bottles in this report) in the locations described in Section 2.3. Samples from the ISCO 6712 autosamplers are collected in 1 L ISCO Propak single-use plastic sample bags. The Liquiport 2000 autosampler is not compatible with single-use plastic sample bags. Instead, 1 L reusable plastic bottles were used to collect samples in the Liquiport autosampler. The reusable plastic bottles from the Liquiport autosampler and the first flush bottles were rinsed with deionised water following each sampling event to remove the contaminants remaining in the bottles.

The ISCO autosamplers use ISCO 730 Bubbler Flow Modules to measure the water depth at each sampling location, whilst the Liquiport 2000 autosampler uses a PS98i pressure transducer to measure water depth. A trigger water level is set for each of the samplers, and when the Bubbler Flow Module or PS98i detects a level greater than the trigger level the sampling program begins. In some cases, due to damaged Bubbler Flow Module tubing or issues with the Liquiport programming, the samplers have been triggered manually or based on a programmed start time.

The National Institute of Water and Atmospheric Research's (NIWA) guidance for developing stormwater monitoring programmes (NIWA, 2014) recommends that only rainfall events with a rainfall accumulation exceeding 2.5 mm per day should be considered runoff-generating events. This is because the effects of evaporation and depression storage result in little (if any) runoff generation from such an event. As such, antecedent dry days are also defined as days having less than 2.5 mm of rainfall.

Due to the inability to measure flow at some of the sample locations time-weighted composite samples were the chosen sample type for this sampling programme. This method of sampling is not as accurate as flow-based sampling; however, as discussed in Section 2.2.1 below, collecting a large number of

samples at each site per rainfall event can produce similar results to flow-based sampling.

Following a storm event that is sufficient to trigger the autosamplers, three 1 L composite samples were prepared from each autosampler. All three composite samples were sent to Hill Laboratories for testing. Two were analysed (duplicate samples), and the final sample was held cold until the results of the other samples were reported. If there were major discrepancies in the two samples, the third sample was analysed. Otherwise, the average concentration between the two duplicate samples was reported. As the first flush bottles only have a capacity of 1 L, no composite sample was made for these samples and the full 1 L of the sample was transferred into a Hill Laboratories 1 L sample bottle for analysis.

2.2.1 2021 Updates to Methodology

Dr Jennifer Gadd from NIWA conducted a review of the methodologies for the various stormwater monitoring projects that CCC are currently carrying out to inform CCC's Global Stormwater Consent monitoring (Gadd, 2020). This review acknowledged the limitations in measuring flow rates at the sampling sites and recommended that a suitable alternative solution was to increase the number of samples collected for each composite sample per site.

Dr Gadd's review recommends collecting at least 30 samples per storm event for each composite sample as this can provide an estimate of the event mean concentration (EMC) within a 20% error, with greater sample numbers further reducing this error. EMCs are calculated from flow-based samples and are recommended for estimating treatment efficiencies in stormwater treatment facilities as they allow more accurate comparisons between inlet and outlet sites.

A meeting was held between PDP, CCC, and Dr Jennifer Gadd on 10 February 2021 to discuss the existing sampling methodology and suggested modifications to the methodology. The meeting concluded that the number of samples taken per sampling round should be increased by allowing multiple smaller-volume samples to be placed in each bottle, which would increase the number of "snapshots" of stormwater quality that the sampling covered and allow the composite samples to be more representative of the EMC. In addition, it was suggested that first-flush samples should be taken from the autosamplers upstream of first-flush basins to compare their water quality with samples from the first-flush bottles.

The autosamplers were recalibrated prior to the May 2021 sampling round to prevent the sample bottles from overflowing. Prior to recalibration, the autosamplers were reprogrammed to take samples at a third of their original timesteps (e.g., hourly sampling became one sample every 20 minutes) and to take three 330 mL samples per bottle. The maximum number of samples an autosampler could now take increased from 24 to 72.

2.2.2 2022 Updates to Methodology

Prior to 2022, the autosampler situated at the outlet of Preston's wetland collected stormwater samples from within the double sump in Wetland Cell 4, with the exception of the 24 September 2018 rainfall event where the autosampler intake was located within the valve chamber. In 2022, the autosampler intake was relocated to be situated on the concrete lip at the inlet of the double sump in Wetland Cell 4. This relocation occurred as water falling into the sump may have been resuspending settled solids, and therefore undermining the quality of the samples taken.

2.3 Site Selection

2.3.1 Knights Stream

The sampling layout at Knights Stream is shown in Figure 1 in Appendix A and Figure 1 below.

Below is a brief description of each sampling site:

- K_FFSwale: At this site, an autosampler within a security housing collects samples from the inlet of a culvert that drains the swale and discharges into the first flush basin. The upstream catchment is currently undergoing development, and at times construction dewatering discharges enter the swale. The swale provides some treatment of stormwater, so the sampled stormwater is partially treated. Two samples will be taken at this location:
  - K_FFSwale: this sample should approximate an EMC for this location.
  - K_FFSwale_FF: this sample is generated by combining only the first 2-3 sample bottles. This location should therefore approximate the "first flush" contaminant concentration.
- K_FFB_Sump: At this site, samples are collected from a double sump using a first flush bottle near the intersection of Kruger Road and Elba Crescent. The first flush bottle collects raw stormwater runoff from the road channel and provides a sample of the untreated stormwater that enters the Knights Stream stormwater treatment system.
- K_FFB: Sampling at this site occurs for storm events from 11 October 2018 onwards. It uses the Liquiport 2000 autosampler to collect samples from within a large bubble-up sump that serves as an inlet into the first flush basin. The stormwater retrieved at this location will have received some treatment from sumps and manholes, as well as undergoing some pollutant removal via settling in the bubble-up sump. Two samples will be taken at this location:
  - K_FFB: this sample should approximate an EMC for this location.

- K_FFB_FF: this sample is generated by combining only the first 2-3 sample bottles. This location should therefore approximate the "first flush" contaminant concentration.

- K_Int: This site uses an autosampler to take samples from near the piped inlet to the wetland. Stormwater is pumped into the wetland from a pump chamber just prior to the inlet. Samples from this site serve as a baseline for pre-wetland treatment stormwater quality to allow the effectiveness of the wetland as a treatment device to be determined.

- K_Outlet: This site is the final sampling location in the Knights Stream treatment system and collects samples of treated stormwater using an autosampler within the wetland outlet structure. The sampler intake is secured to the grate in the intake of the outlet structure, upstream of the notched weir that controls the outflow from the outlet.

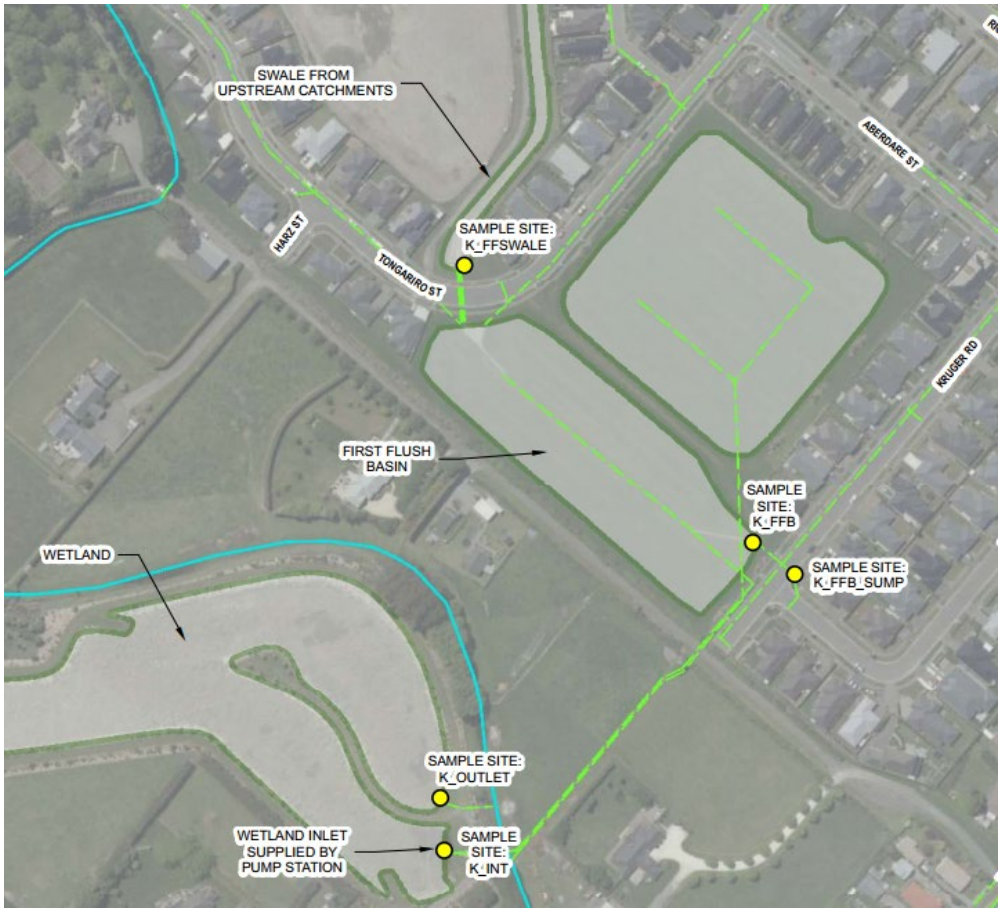

Figure 1. Knights Stream sampling locations. Refer to Appendix A for complete figure.

2.3.2 Prestons

Figure 2 in Appendix A and Figure 2 below shows the sampling layout at Prestons.

Descriptions of each sampled site are described below.

- P_FFBD_Sump: This site uses a first flush bottle to collect stormwater at the inlet to a double sump located on Makawe-Roa Street that contributes stormwater to First Flush Basin D. The stormwater is sampled directly from the road channel and is untreated.
- P_FFBF_Sump: This site collects stormwater from a single sump on Te Whenu Crescent using a first flush bottle. The sump contributes stormwater to First Flush Basin F, and the collected stormwater is untreated.
- P_FFBF Inlet: An autosampler located in a security housing is used to collect stormwater samples directly from a manhole located just upstream of the discharge into First Flush Basin F. The stormwater that is collected has received some prior treatment from sumps and manholes but is representative of the stormwater that discharges to the first flush basin. Two samples will be taken at this location:
  - P_FFBF Inlet: this sample should approximate an EMC for this location.
  - P_FFBF Inlet_FF: this sample is generated by combining only the first 2-3 sample bottles. This location should therefore approximate the "first flush" contaminant concentration.
- P_Int: The stormwater samples for this site are collected from the wetland forebay cell. An autosampler situated in a security housing is used to collect stormwater from the wetland forebay, which is considered to be partially treated via the first flush basins and the sumps and manholes prior to them. Note that during the 24 September 2018 rainfall event the autosampler intake was located within the valve chamber upstream of the wetland forebay.
- P_Outlet: This site also consists of a valve chamber where the bubbler module is installed, which receives wetland-treated stormwater from Wetland Cells 3 and 4. An autosampler within a security housing collects stormwater from a concrete lip adjacent to the inlet of the double sump in Wetland Cell 4 which is connected via a 225 mm diameter pipe to the valve chamber. The samples represent the final treated stormwater from the treatment system. Note that prior to 2022, the autosampler intake was located within the sump and for the 2018 samples, the intake was located in the valve chamber.

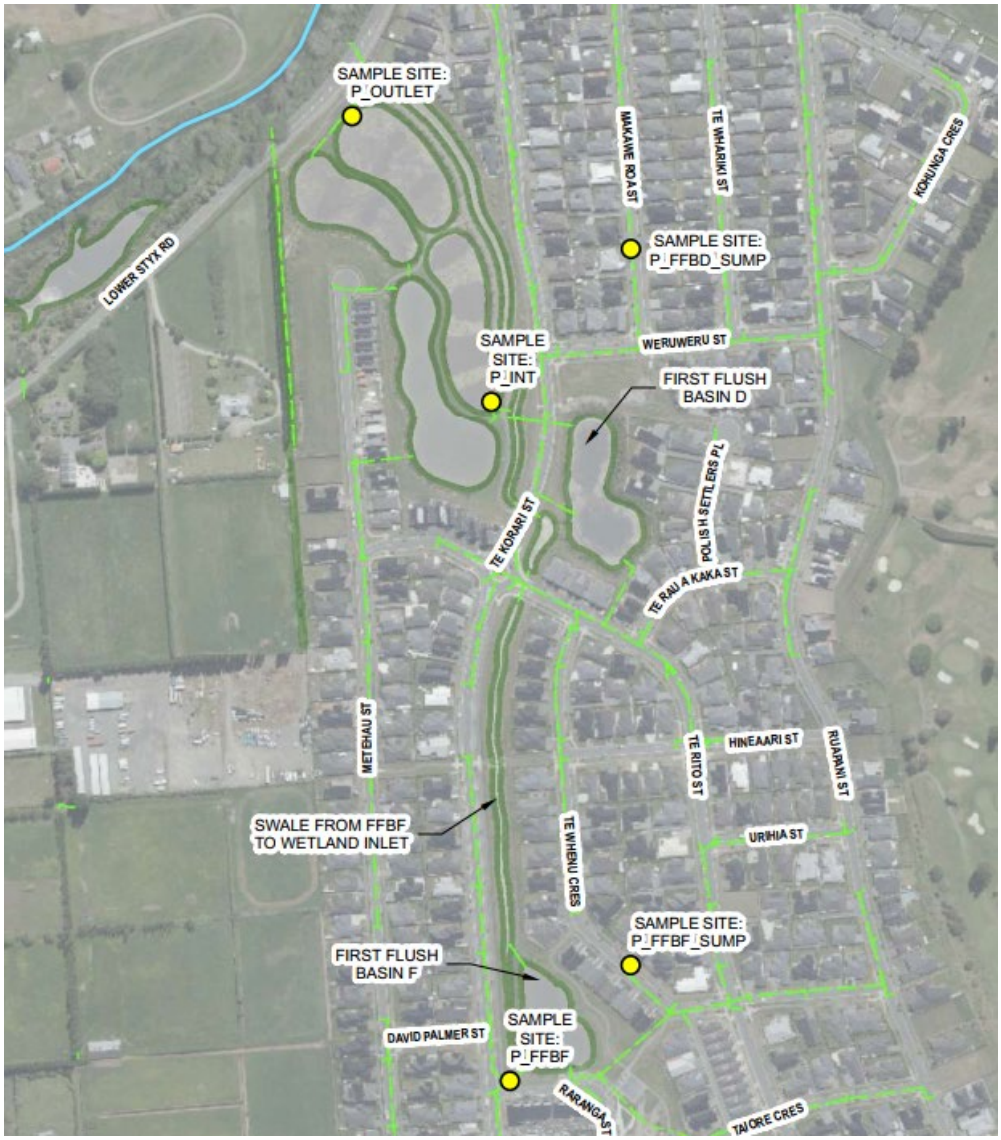

Figure 2. Prestons sampling locations. Refer to Appendix A for complete figure.

2.4 Laboratory Analysis

The sampling programme targets key pollutants of concern which are typically found in urban catchments. Stormwater samples are analysed for the following analytes:

- Turbidity;
- Total Suspended Solids (TSS);
- Suite of dissolved and total heavy metals (including arsenic (Prestons only), copper, lead, and zinc);
- Total nitrogen (TN);

- Dissolved inorganic nitrogen (DIN);
- Total phosphorus (TP); and
- Dissolved reactive phosphorus (DRP).

Due to the volatility of petroleum hydrocarbons and the extended periods that the samples would spend in the samplers without being sealed, it was decided that these would not be included in the analysis. *E. coli* analysis was also not included due to the period between sample collection and analysis.

TSS is sourced from atmospheric deposition, vehicle traffic, and erosion during overland flow. TSS can decrease water clarity, smother the benthic layer of streambeds, and form a binding surface for heavy metals and other contaminants (Charters, Cochrane, & O'Sullivan, 2015). It is therefore an important pollutant for determining the effectiveness of a treatment facility.

Dissolved metals are more bioavailable and therefore more toxic to the aquatic environment (ANZECC, 2000). However, particulate metals can accumulate in streambeds and can dissolve or become re-suspended over time. Therefore, it is important to analyse the samples for both total and dissolved metals.

DIN and DRP are the dissolved inorganic forms of nitrogen and phosphorus that are available for immediate uptake by plants. TN and TP include bound forms of nutrients that are less bioavailable. Environment Canterbury's (ECan) current guideline for receiving water bodies includes guideline values for DIN and DRP in rivers and artificial water courses, and TN and TP in lakes. Both DIN and DRP can influence the growth of periphyton in rivers which can lead to excessive algae growth. This growth can cause issues such as a reduction in habitat for aquatic life, altered water chemistry, and obstruct the flow in waterways (ANZECC, 2000). Therefore, it is important to establish the level of nutrient treatment provided by the stormwater facilities.

The raw laboratory results data for the Stages 1, 2 and 3 sampling is presented in Appendix D.

2.5 Assumptions and Limitations

The samples are taken at pre-programmed intervals and therefore do not account for the volume of water that has passed through the sampling point between each sample. However, as discussed in Section 2.2.1, having a high number of samples for each sampling location per rainfall event enables an approximation of the EMC to be made based on composite sampling. The ability to make this approximation is a key assumption for this study, as EMCs are required to calculate treatment efficiencies across stormwater facilities.

3.0 Knights Stream

3.1 Event Summary

Rainfall data was obtained from the Sparks Rd rainfall station. This monitoring location is situated approximately 5 km from the Knights Stream autosampler sites. This monitoring station is the closest monitoring station with available data.

Data was used to generate figures and find the intensity and duration of the event, as shown in Figure 3. Graph legends include the number of antecedent dry days (ADDs) that preceded each event. The relative steepness of each graph shows the relative storm event intensities.

Nine rainfall events have been sampled at the Knights Stream monitoring site (2018 – 2023). These events are shown in Figure 3.

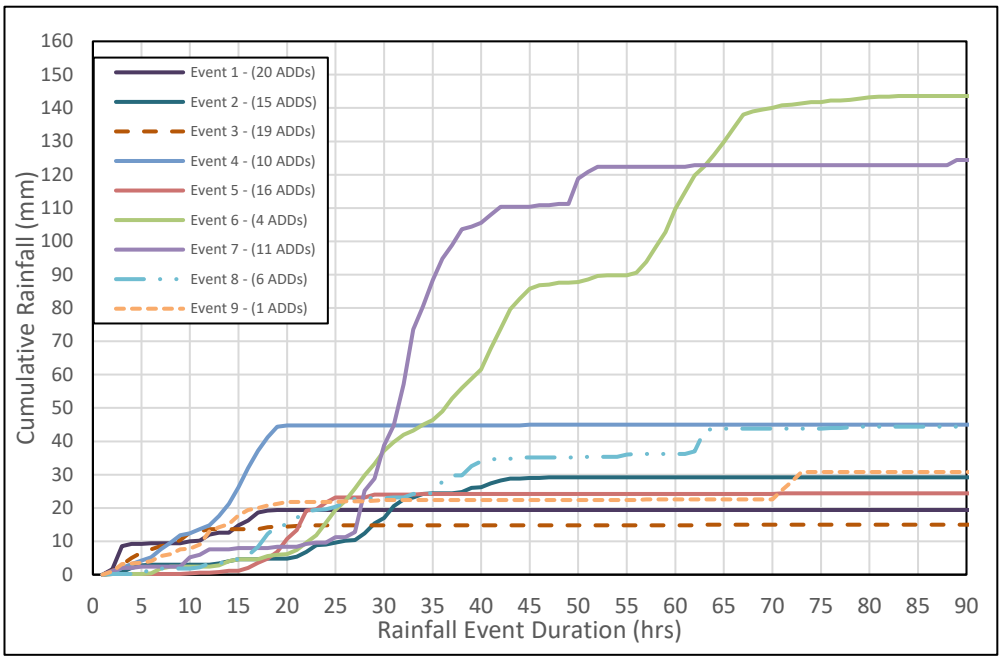

Figure 3. Sparks road rainfall from all sampled events (2018 - 2023)

The ISCO autosamplers at both Knights Stream and Prestons had their internal batteries replaced following Event 3, where depleted internal batteries resulted in the autosampler pump programming being incorrectly implemented at Prestons. However, no issues occurred at the Knights Stream site.

The laboratory diluted the samples from Event 6 prior to analysis, resulting in a high number of samples being beneath the laboratory detection limit and subsequently deemed non-detect samples. Triplicate samples were analysed for the sites that had samples diluted (K_FFSwale, K_FFB, K_Int, K_Outlet). However, first-flush samples were unable to be re-analysed. The laboratory carried out

this additional analysis free of charge as they acknowledged the error in diluting the samples.

During Events 1, 5, 8 and 9 there were issues with the Liquiport autosampler at the K_FFB sampling location that resulted in incorrect triggering. Due to this error, samples were not collected from location K_FFB during these events.

During Event 8, the K_FFSwale location experienced maintenance issues that may impact the validity of the results. The swale was blocked by grass clippings, partially preventing flow from exiting the swale, as shown in Figure 4.

Figure 4. K_FFSwale location during Event 8.

During Event 9, the ISCO autosampler at the K_Int sampling location did not collect any samples due to insufficient suction head. Pump calibration should be undertaken between each sampling round.

During Events 7, 8 and 9, a development was being constructed in a lot adjacent to K_FFB_Sump. During event 8, PDP staff attended the site near the beginning of the rainfall event. Contractors advised PDP staff that their sump protection had been removed. This may have impacted the K_FFB_Sump results during this event.

3.2 Results

Approximate removal efficiencies of the Knights Stream stormwater facility have been plotted in box and whisker graphs displayed in the following sections. The treatment facility removal efficiency has been compared to the removal efficiency ranges outlined in the Waterways, Wetlands and Drainage Guide (WWDG) (CCC, 2012), shown as a red dotted line in Figure 5 through to Figure 11. The red dotted line shown in Figure 12 and Figure 13 shows the comparable receiving water quality guideline value. Values displayed in the box and whisker plots have been tabulated in Appendix B and Appendix C.

3.2.1 First Flush Basin Removal Efficiency

Removal efficiencies for the Knights Stream first flush basin have been estimated between the K_FFSwale and K_Int sites for each event. The removal efficiencies were estimated by subtracting the concentration at the downstream (K_Int) site from the upstream (K_FFSwale) site and dividing this by the concentration at the upstream site.

The K_FFB site was not chosen for this assessment as the site has only been sampled in five out of the nine events. It is difficult to determine contaminant removals across the FFB due to potential contaminant resuspension and/or transformation between dissolved or particulate forms (in the case of metals and nutrients) between the FFB and the wetland inlet. To more accurately assess the removal efficiency of the FFB an additional sampling location would need to be established at the outlet from the FFB. Based on the sample analysis undertaken, the heavy metal removal efficiency of the Knights Stream First Flush Basin (FFB) is displayed in Figure 5. The red lines on this graph show the WWDG removal efficiencies.

All raw statistical data related to these removal efficiencies can be found in Appendix B.

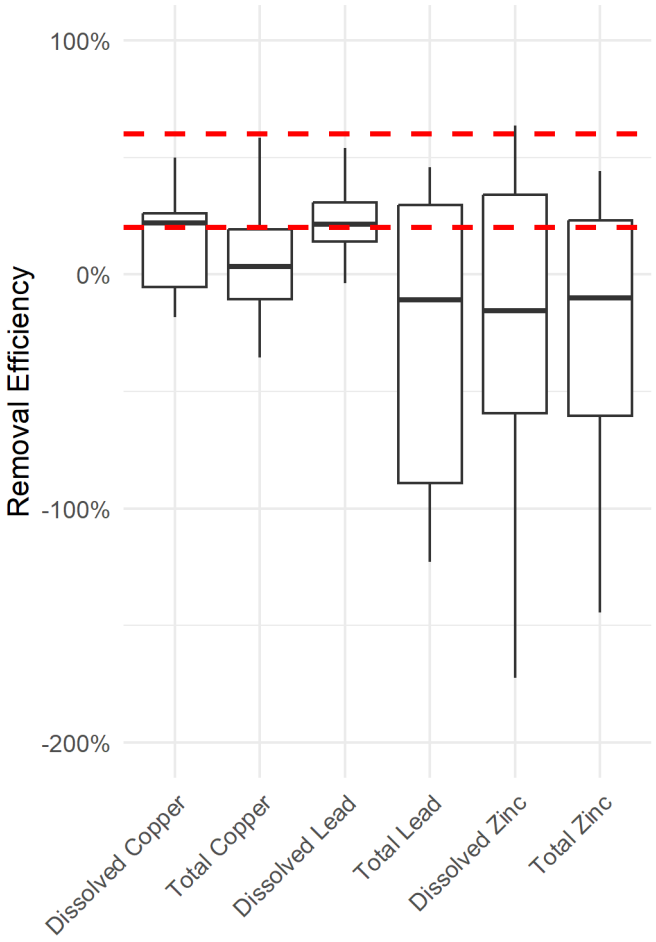

Figure 5. Heavy metals removal efficiencies for the Knights Stream first flush basin. CCC WWDG Table 6-6 removal efficiency range for a "Dry Detention Basin" shown with red dashed lines.

Based on the samples taken, the nutrient removal efficiency of the Knights Stream FFB was calculated and has been displayed in Figure 6. The TSS removal efficiency of the FFB is displayed in Figure 7.

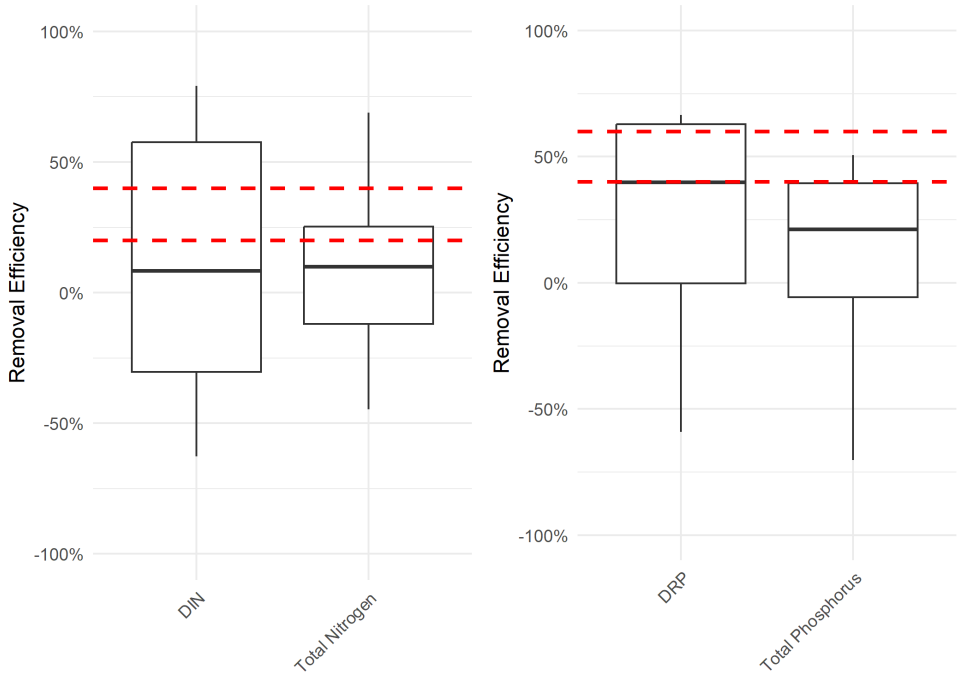

Figure 6. Nitrogen and phosphorus removal efficiencies for the Knights Stream first flush basin. CCC WWDG Table 6-6 removal efficiency range for a "Dry Detention Basin" shown with red dashed lines.

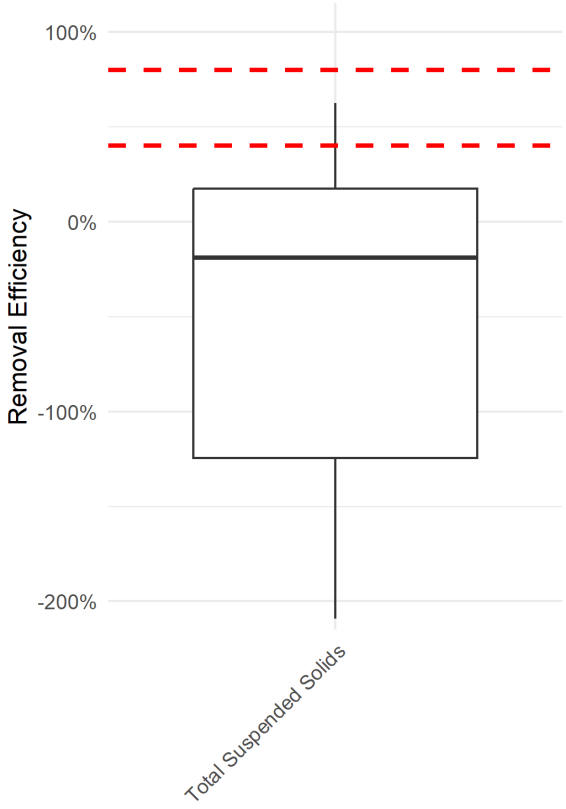

Figure 7. Total suspended solids removal efficiency for the Knights Stream first flush basin. CCC WWDG Table 6-6 removal efficiency range for a "Dry Detention Basin" shown with red dashed lines.

3.2.2 Wetland Removal Efficiency

Figure 8, Figure 9, and Figure 10 shows the removal efficiency of the Knights Stream Wetland. Removal efficiencies have been calculated between the K_Int and K_Outlet sampling locations. All raw statistical data related to these removal efficiencies can be found in Appendix B. These removal efficiencies have been compared to the removal efficiency ranges outlined in the Waterways, Wetlands and Drainage Guide (CCC, 2012). WWDG values are shown as dashed red lines.

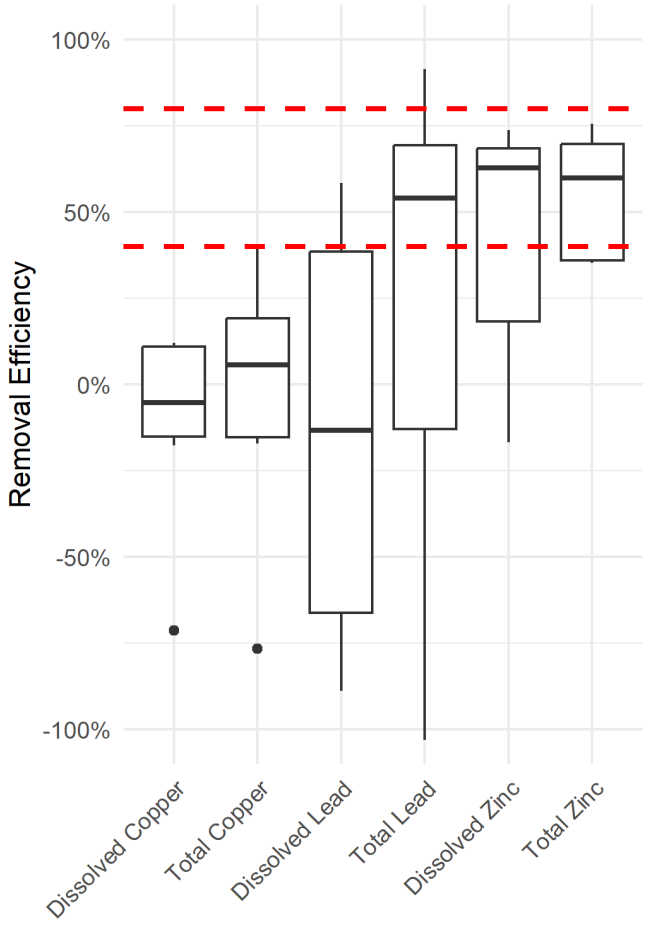

Figure 8. Heavy metals removal efficiencies for the Knights Stream wetland. CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

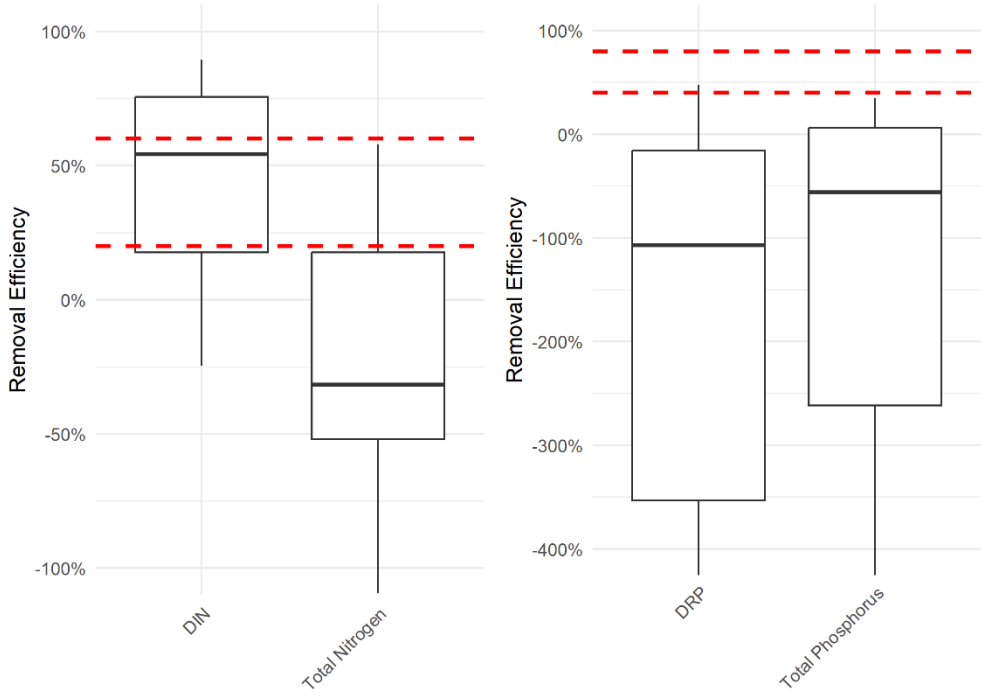

Figure 9. Nitrogen and phosphorus removal efficiencies for the Knights Stream wetland. CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

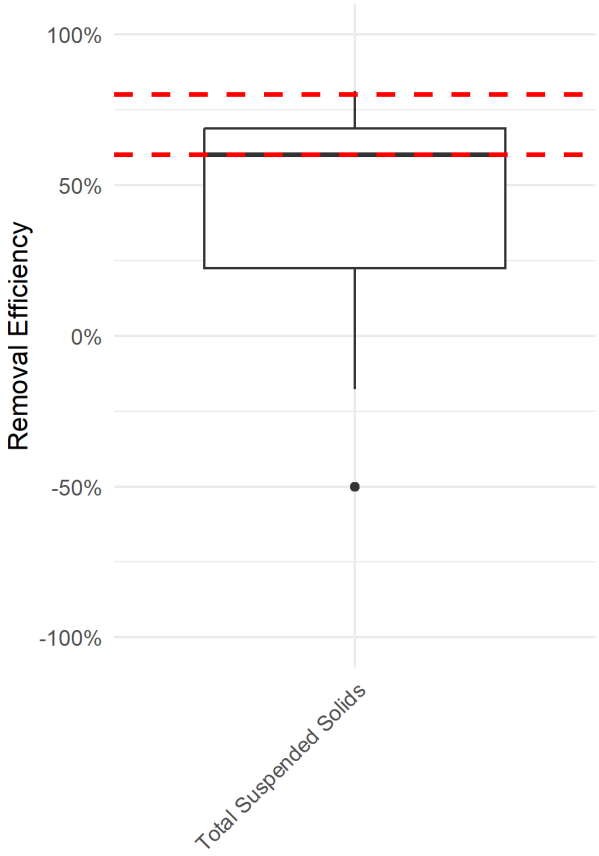

Figure 10. Total suspended solids removal efficiencies for the Knights Stream wetland. CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

3.2.3 System Removal Efficiency

Removal efficiencies across the entire treatment system have been estimated for each contaminant. This was carried out by comparing the K_FFSwale results to the K_Outlet results for each event. Based on the sample analysis, the removal efficiency of the entire Knights Stream Treatment Facility is displayed in Figure 11. DRP and TP extend off this figure due to the large interquartile range (IQR) of both contaminants. The IQR of DRP and TP ranged from 25% to -341% and 24 to -272% respectively. All raw statistical data related to these removal efficiencies can be found in Appendix B.

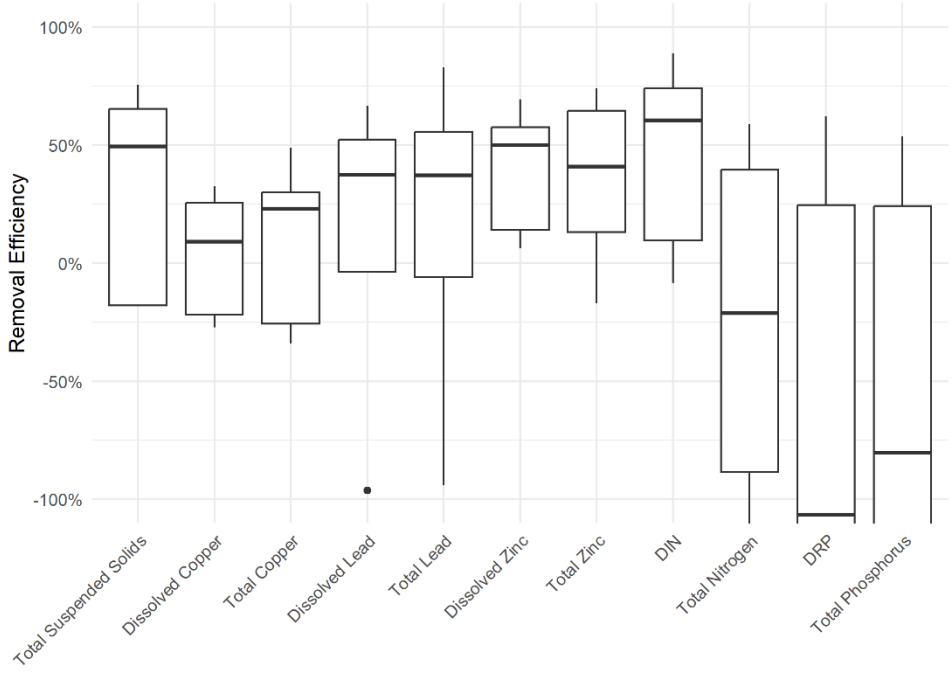

Figure 11. The removal efficiency of the Knights Stream stormwater facility.

3.2.4 Water Quality

Average contaminant concentrations across the entire treatment system have been plotted in box and whisker plots for analysis, as shown in Figure 12, and Figure 13. All raw statistical data related to pollutant influent and effluent concentrations can be found in Appendix C. The water quality standards discussed in Section 2.1.2 are shown as red dashed lines.

The concentration of lead in the single sampling round undertaken at K_FFB_FF was affected by the laboratory over-diluting the samples in this event (Event 6). There is therefore no data point in the box and whisker plot in Figure 12 for lead at K_FFB_FF, but the site label has been left on the plot for consistency.

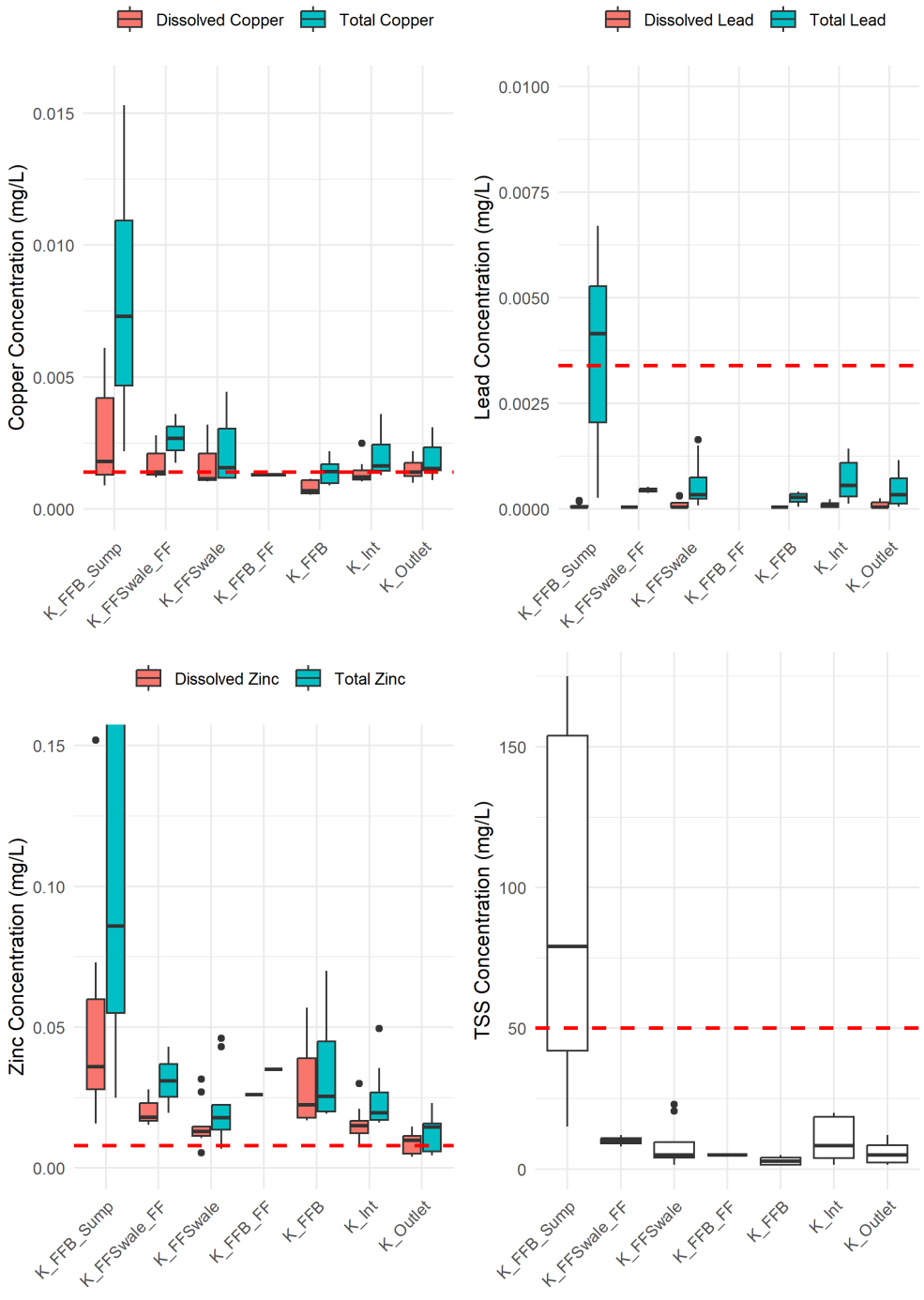

Figure 12. Knights Stream stormwater detention facility - Heavy metal and TSS concentrations

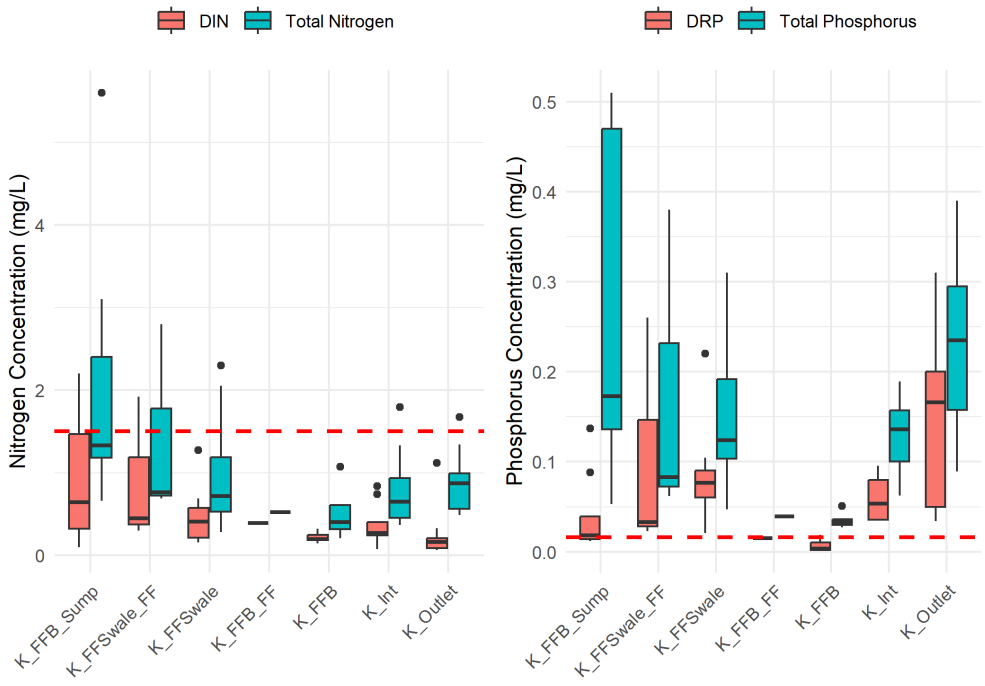

Figure 13. Knights Stream stormwater detention facility – Phosphorus and Nitrogen concentrations

3.3 Discussion

3.3.1 First Flush Bottle Results

First flush samples were collected from a sump adjacent to Knights Stream First Flush Basin, using a Nalgene bottle. This bottle collected the first litre of runoff generated during each rainfall. The results show that this first flush had significantly higher heavy metal concentrations than the first flush autosampler results.

It should be noted that separate first-flush sampling methodologies were implemented at the different sampling locations. The first flush bottle collects the first litre of stormwater that flows into the sump, whereas the autosampler collects a more approximate first flush, due to the triggering mechanism and sampling frequency. K_FFSwale_FF is also located downstream of a treatment swale; therefore, the first flush has already undergone treatment. This may contribute to the differences between the sample results. Additionally, a development was occurring adjacent to K_FFB_Sump during the 2022/2023 sampling events. This may have increased the TSS loading at the sump during these sampling events.

3.3.2 First Flush Autosampler Results

The first flush composite sample taken from the Knights Stream Swale Autosampler (K_FFSwale_FF) generally had higher contaminant concentrations

than the K_FFSwale sample. However, median concentrations for total ammoniacal-N, TKN, DRP, total phosphorus, dissolved arsenic, dissolved lead, total arsenic and particulate arsenic were all higher in the K_FFSwale sample. The reasons behind this are unclear and could be an area for further research.

3.3.3 First Flush Basin Removal Efficiency

The Knights Stream first flush basin removal efficiency shown in Section 3.2.1 indicates that the system has poor heavy metal removal efficiency when compared to the CCC WWDG range.

The first flush basin appeared to perform better at dissolved contaminant removal, in comparison to total contaminant removals. "Dissolved" contaminants refer to particles smaller than 0.45 µm, whilst "totals" includes all contaminants found in the sample and particulate metals make up the balance (Charters et al. 2016).

The key FFB results were as follows:

- Poor TSS removal, with a mean of less than -50% and an interquartile range (IQR) spanning from approximately 17% to -125% removal efficiency;
- All median total heavy metal removal efficiencies sat below the CCC WWDG trace metals removal efficiency range of 20 – 60%, with the exception of dissolved copper and dissolved lead. These contaminants had median removal efficiencies of 22%;
- Dissolved zinc and total zinc had median removal efficiencies of -16% and -10% respectively. This is particularly poor in comparison to the WWDG range; and
- Dissolved nutrient removal efficiencies appeared greater than total nutrient removal efficiencies.

K_Int was located next to the wetland pump well. This pump well inflow to the wetland may have resuspended sediment at this location, increasing the average TSS concentrations at this location. The pump well may need to be investigated, to determine whether it is contributing to elevated TSS concentrations and decreasing the overall calculated removal efficiency result for the first flush basin. However, it should be noted that TSS concentrations predominantly met the LWRP guidelines. Investigation is therefore not a priority.

The International Stormwater BMP Database (2020) indicated that:

- detention basins provide a statistically significant reduction in TSS, total and dissolved zinc, total and dissolved copper, and total lead; the report also showed,
- detention basins do not significantly impact total dissolved solids concentrations (TDS), dissolved phosphorus, or dissolved nitrogen.

This contradicts the results from Knights Stream, which indicate poor TSS removal, and relatively effective dissolved contaminant (metals and nutrients) removal. This could be due to the low influent concentrations (CCC, 2012).

3.3.4 Wetland Removal Efficiency

The wetland had similarly variable results:

- Dissolved and total copper, and dissolved lead IQR removal efficiencies sat below the CCC WWDG range of 40 – 80%;
- Total lead, dissolved zinc, and total zinc median removal efficiencies sat within the CCC WWDG ranges;
- Phosphorus, DRP, and total nitrogen IQR removal efficiencies sat well below the CCC WWDG ranges. WWDG ranges for phosphorus and nitrogen are 40 – 80% and 20 – 60%, respectively; and
- The median DIN removal efficiency sat within the WWDG range.

This is consistent with the International Stormwater BMP Database (2020), in terms of:

- the poor dissolved copper, and dissolved lead removal efficiencies; and
- the effective removal of TSS, total lead, and zinc (total and dissolved);

However, the International Stormwater BMP (2020) states that based on 125 international studies, wetland basins significantly reduced total phosphorus and total copper. This is inconsistent with the results displayed in Section 3.2.2.

Studies indicate that some bioretention devices have high levels of phosphorus export. The International Stormwater BMP Database (2020) suggests that recent bioretention devices effectively remove phosphorus, as they are designed with low phosphorus content media. Conversely; it has been suggested that higher compost content may be required to support vegetation growth. This suggests that effluent phosphorus content can be reduced by replacing wetland media. However; this will negatively impact vegetation.

Relatively poor dissolved copper removal may also be attributed to wetland media. A study in Washington concluded that dissolved copper export was as high as 600% in bioretention cells containing 40% compost (Herrera Environmental Consultants, 2012).

There was a high percentage of non-detects for dissolved lead in this study and the International Stormwater BMP studies (2020). These low influent concentrations could impact the removal efficiencies calculated for this system.

3.3.5 System Removal Efficiency

The treatment system had the following notable characteristics:

- Poor phosphorus, total nitrogen, and DRP removal (median removal efficiencies of less than 0%);
- Relatively effective nitrogen removal (IQR > 25%);
- The removal efficiencies for total copper, dissolved copper, total lead, dissolved lead, and TSS were highly variable, with inconclusive results (IQR spanning both negative and positive removal efficiencies); and
- The IQR for dissolved zinc, total zinc, and dissolved reactive nitrogen removal all sat above 0%.

All results were highly variable. This may be attributed to the low influent concentrations. Low influent concentrations affect variability in the following ways:

- Removal efficiencies are generally lower when influent concentrations are low (CCC, 2012; Yang. et al, 2023); and
- The removal efficiency calculation is more sensitive when the concentrations in question are small. This means small changes in contaminant concentrations translate to large changes in removal efficiencies.

While it may appear that the majority of treatment is occurring between the stormwater sump (K_FFB_Sump) and the first flush basin (K_FFSwale, K_FFSwale_FF and K_Int), it should be noted that separate first-flush sampling methodologies were implemented at these different sampling locations. The first flush bottle (Located at K_FFB_Sump) collects the first litre of stormwater that flows into the sump, whereas the autosampler (K_FFSwale and K_FFSwale_FF) collects a more approximate first flush, due to the triggering mechanism and sampling frequency. K_FFSwale is also located downstream of a treatment swale; therefore, the first flush has already undergone treatment. This may contribute to the differences between the sample results.

3.3.6 Discharge Water Quality

The Knights Stream results show that the median discharge water quality exceeded the standards for:

- copper;
- zinc;
- DRP; and

- total phosphorus.

All other contaminant levels meet the guidelines post-treatment; however, the influent concentrations of these contaminants, were also below the receiving environment standards at K_FFSwale. As the influent water quality was high, it was hard to effectively assess the effectiveness of the treatment system.

4.0 Prestons

4.1 Event Summary

Rainfall data was obtained from the Lower Styx rainfall station. This monitoring location is situated approximately 2 km from Preston's autosampler sites and is the closest monitoring station with available data. Data was used to generate figures and find the intensity and duration of the sampled events.

Nine rainfall events have been sampled at the Prestons monitoring site (2018 – 2023). The sampled rainfall events have a range of rainfall characteristics as described in previous reports. This information is summarised in Figure 14. Graph legends include the number of antecedent dry days (ADDs) that preceded each event. The relative steepness of each graph shows the relative storm event intensities.

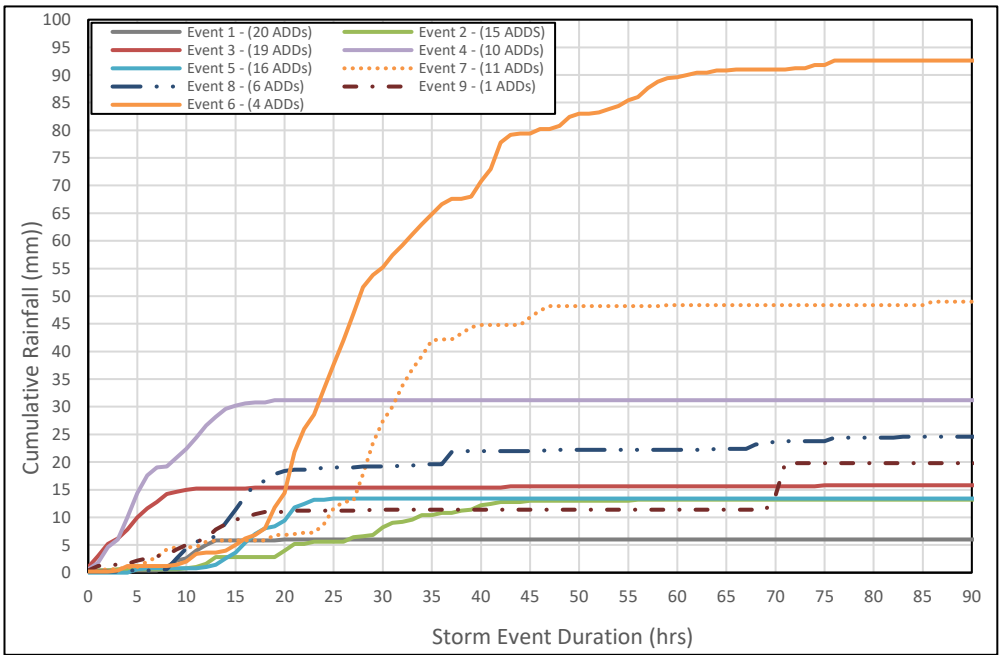

Figure 14. Lower Styx rainfall data for all sampled events (2018 - 2023)

The ISCO autosamplers at both Knights Stream and Prestons had their internal batteries replaced following Event 3, where depleted internal batteries had resulted in the autosampler pump programming being incorrect. This caused two of the Preston autosamplers to not collect any usable samples during this period.

During Event 8, P_Int and P_FFBF triggered early. It is unclear what caused this occurrence. It could be attributed to:

- Wave action;
- Atmospheric pressure changes; or
- Operator error.

This caused the first four samples to be collected by the autosampler prior to the storm event. However, the storm event was captured in the remaining 19 sample bottles, which were used for analysis. The first flush was collected from the first of the 19 bottles.

4.2 Results

Approximate removal efficiencies of the Prestons stormwater facility have been plotted in box and whisker graphs. The treatment facility removal efficiency has been compared to the removal efficiency ranges outlined in the Waterways, Wetlands and Drainage Guide (WWDG) (CCC, 2012), indicated by a dotted red line in graphs Figure 15 through to Figure 21. The LWRP water quality standards are shown as red dotted lines in Figure 22 and Figure 23. Statistical data for removal efficiencies and contaminant concentrations has been tabulated, and can be found in Appendix B and Appendix C.

4.2.1 First Flush Basin Removal Efficiency

Removal efficiencies for the FFB have been estimated between the P_FFBF and P_Int sampling locations. Between these sampling locations, there is a conveyance swale approximately 450 m long, and two other FFBs discharge into the first cell of the wetland near the P_Int sampling location. Based on this sample analysis, the removal efficiency of Preston's FFB is displayed in Figure 15 - Figure 17. The red dotted lines in these figures show the WWDG removal efficiencies. All raw statistical data related to removal efficiencies can be found in Appendix B.

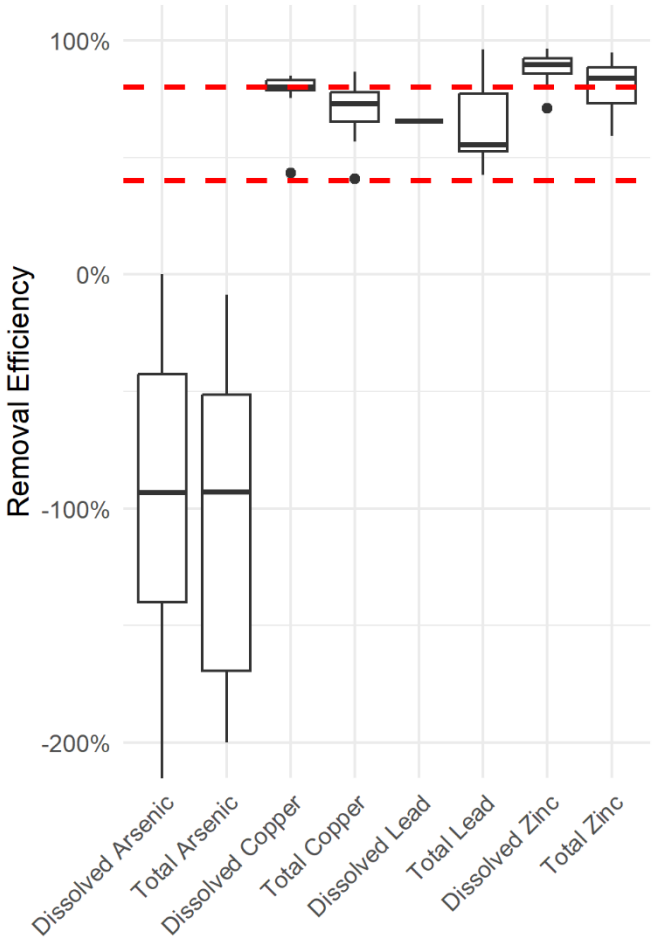

Figure 15. Heavy metals removal efficiencies for the Prestons first flush basin. CCC WWDG Table 6-6 removal efficiency range for an "Extended Detention Wet Pond" shown with red dashed lines.

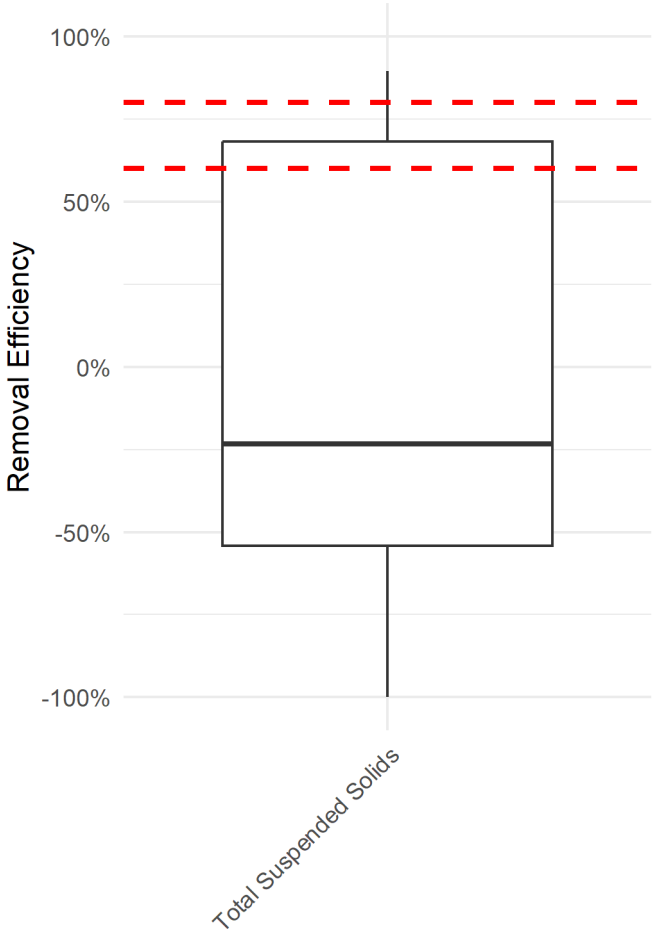

Figure 16. Total suspended solids removal efficiency for the Prestons first flush basin. CCC WWDG Table 6-6 removal efficiency range for an "Extended Detention Wet Pond" shown with red dashed lines.

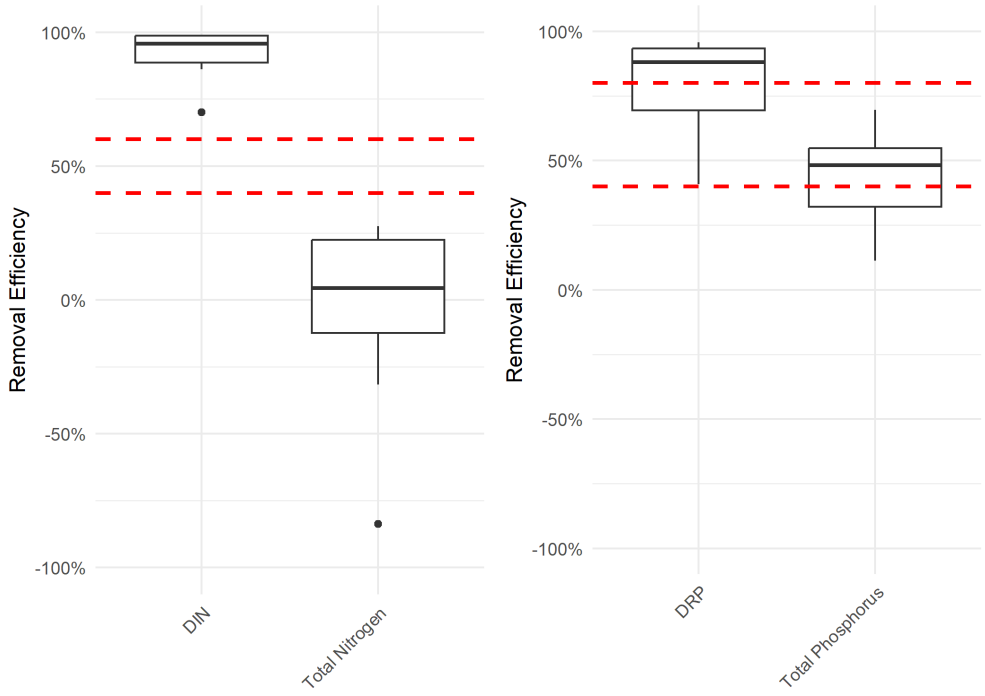

Figure 17. Nitrogen and phosphorus removal efficiencies for the Prestons first flush basin. CCC WWDG Table 6-6 removal efficiency range for an "Extended Detention Wet Pond" shown with red dashed lines.

4.2.2 Wetland Removal Efficiency

Removal efficiencies across the Prestons wetland have been calculated between the P_Int and P_Outlet sampling locations. Based on this analysis, the removal efficiencies of Prestons wetland are displayed in Figure 18 - Figure 20. The red dotted lines in these figures show the WWDG removal efficiencies. Figure 20 does not show the entire IQR for DIN removal through the wetland, as this would reduce the resolution of the data communicated. The DIN IQR ranged from 83% removal to -145% removal. The median DIN removal was 75%. All raw statistical data related to removal efficiencies can be found in Appendix B.

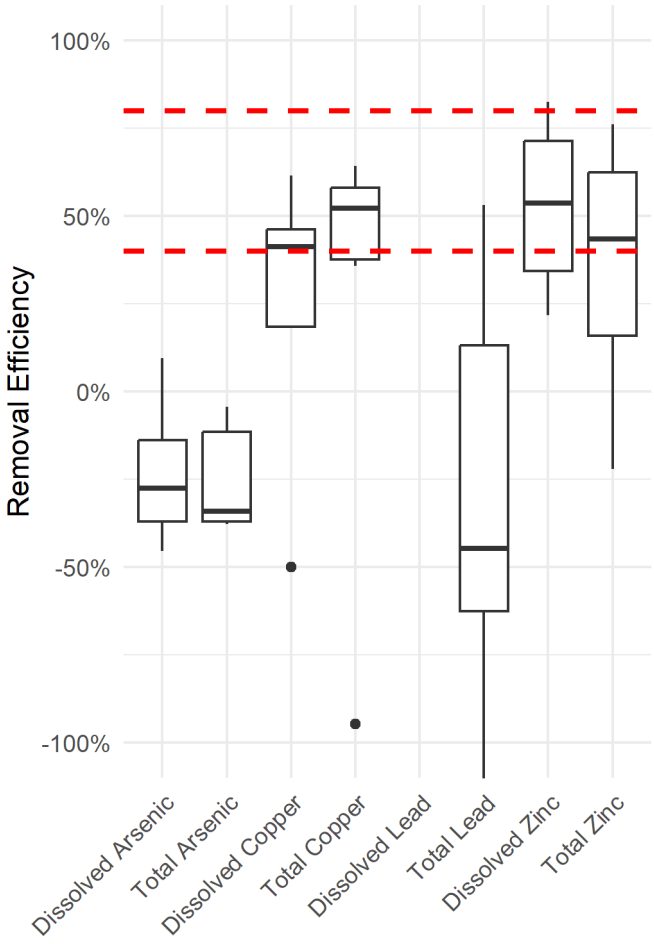

Figure 18. Heavy metals removal efficiencies for the Prestons wetland (dissolved lead values not shown as they were below detection limit). CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

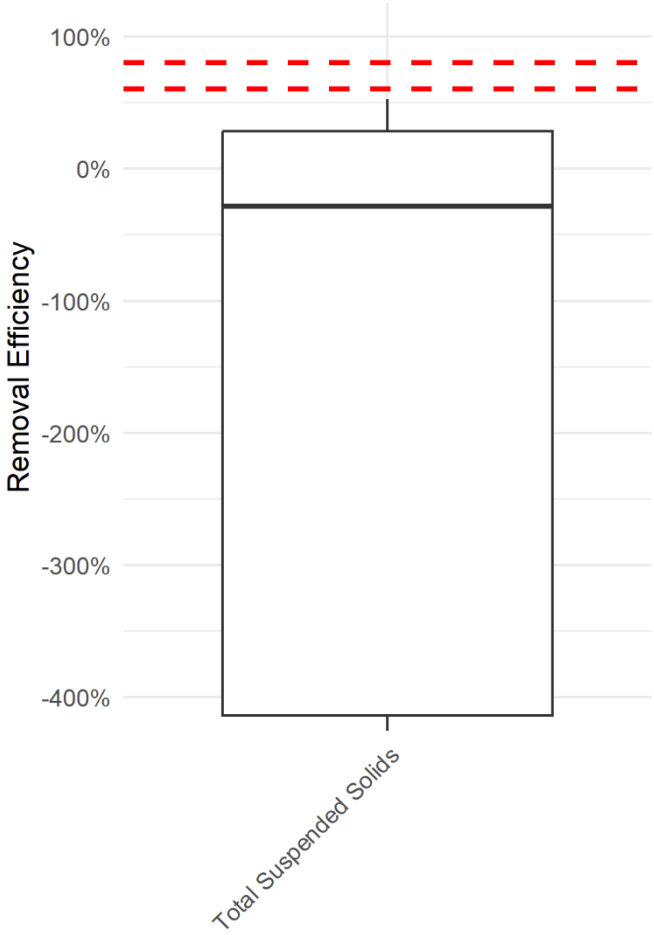

Figure 19. Total suspended solids removal efficiencies for the Prestons wetland. CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

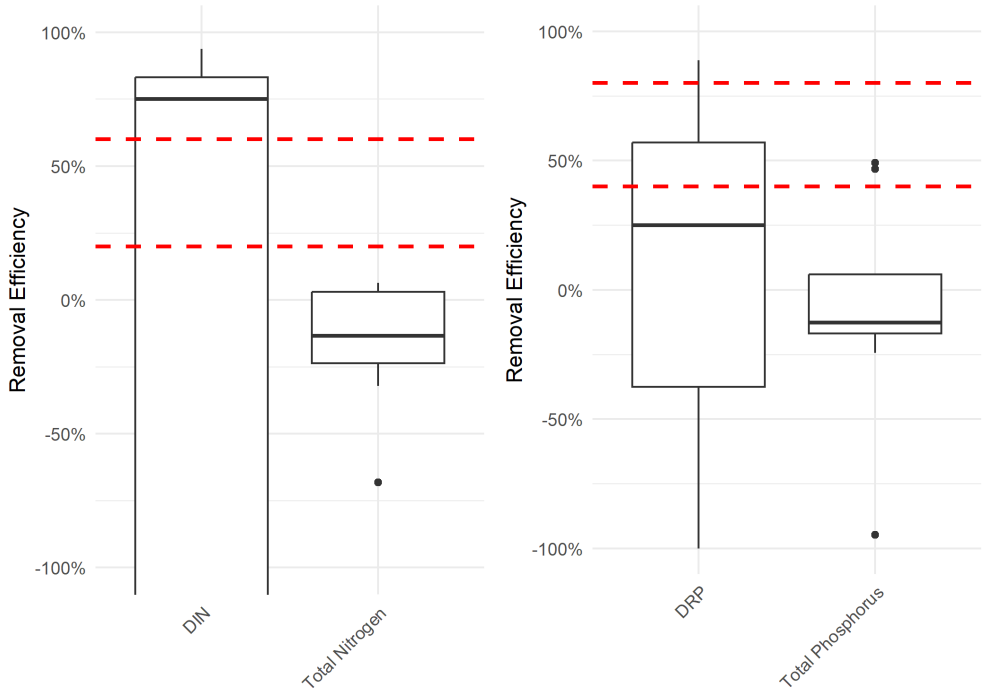

Figure 20. Nitrogen and phosphorus removal efficiencies for the Prestons wetland. CCC WWDG Table 6-6 removal efficiency range for "Wetlands" shown with red dashed lines.

4.2.3 System Removal Efficiency

The removal efficiency of the treatment system has been calculated by comparing the results of P_FFBF to P_Outlet to calculate the total removal efficiency across the facility. Based on this analysis methodology, the removal efficiency of the entire Prestons Treatment Facility is displayed in Figure 21. All raw statistical data related to removal efficiencies can be found in Appendix B.

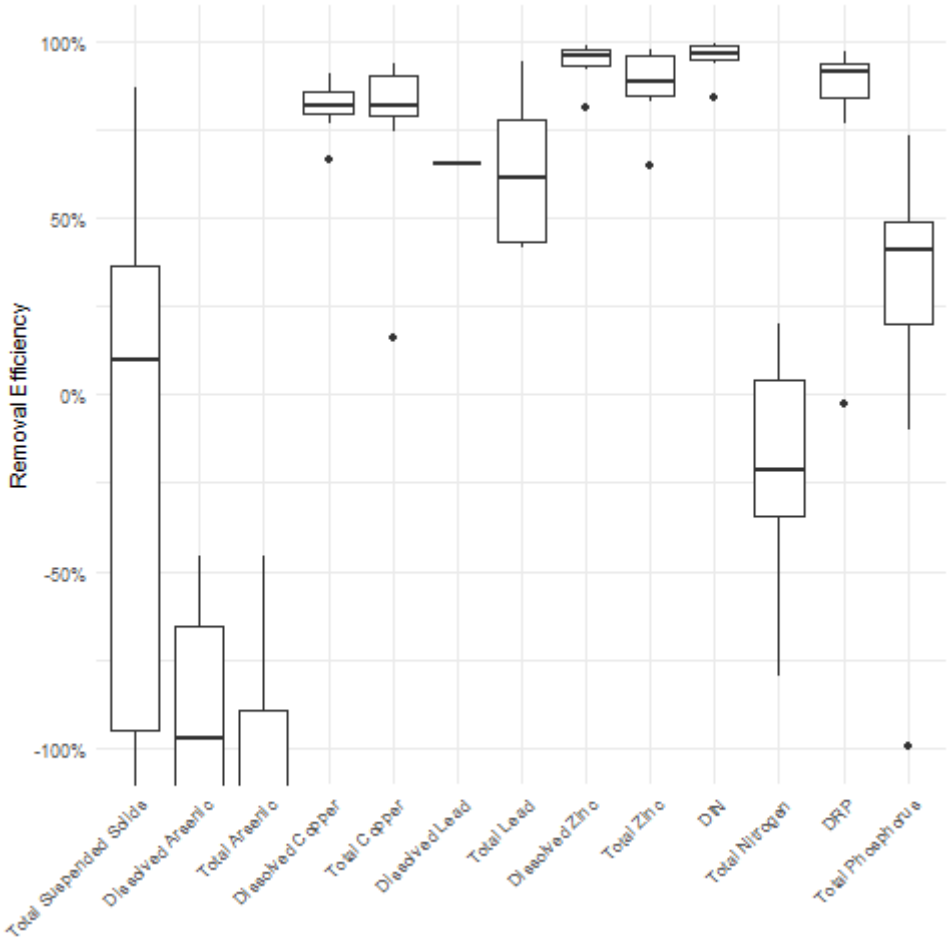

Figure 21. Prestons Treatment System - removal efficiency.

4.2.4 Water quality

Contaminant concentrations at each sampling location within Prestons have been plotted in a box and whisker graph, as shown below in Figure 22, and Figure 23. All raw statistical data related to pollutant influent and effluent concentrations can be found in Appendix C. The water quality standards discussed in Section 2.1.2 are shown as red dashed lines.

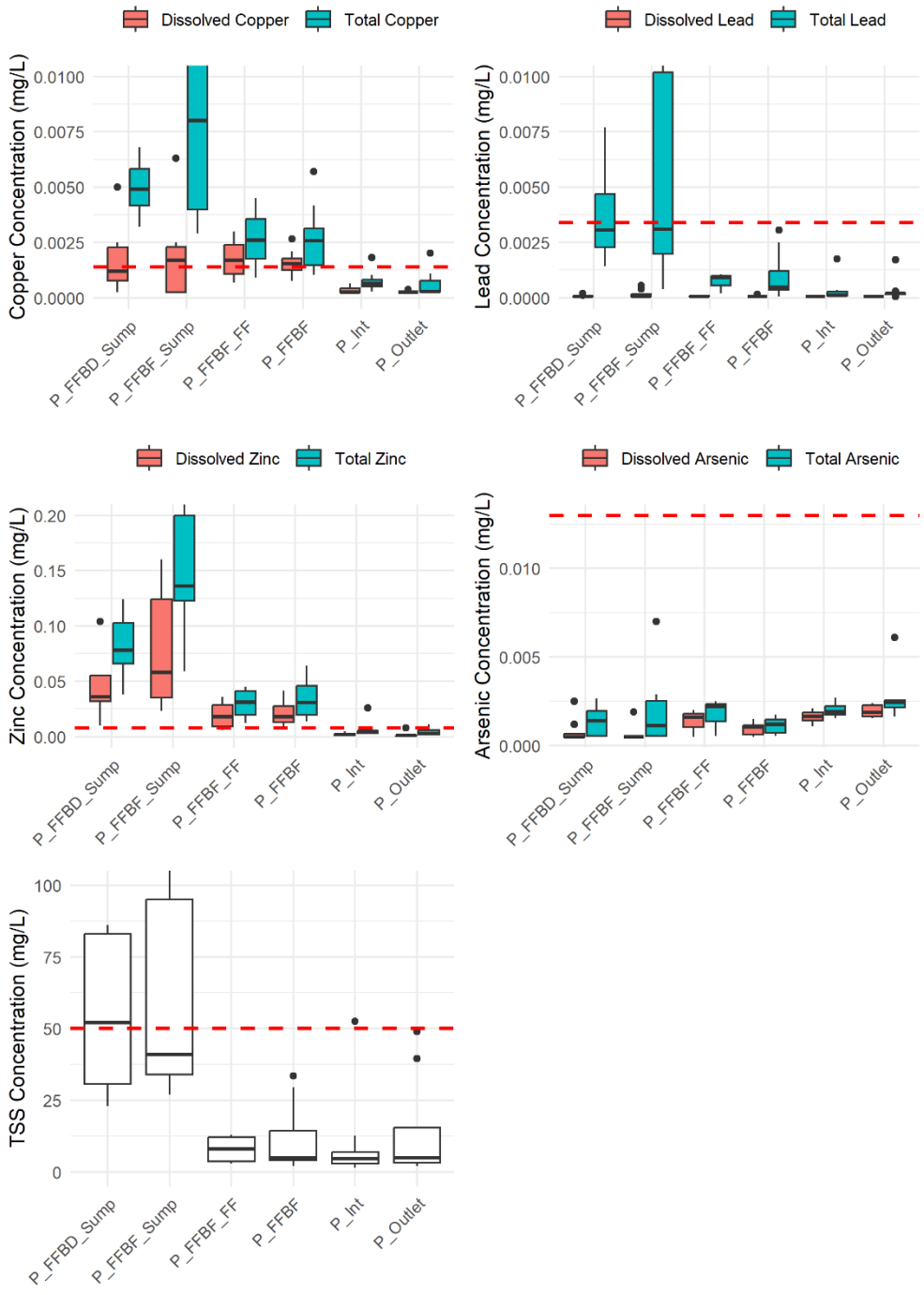

Figure 22. Prestons stormwater detention facility – Heavy metals and TSS concentrations

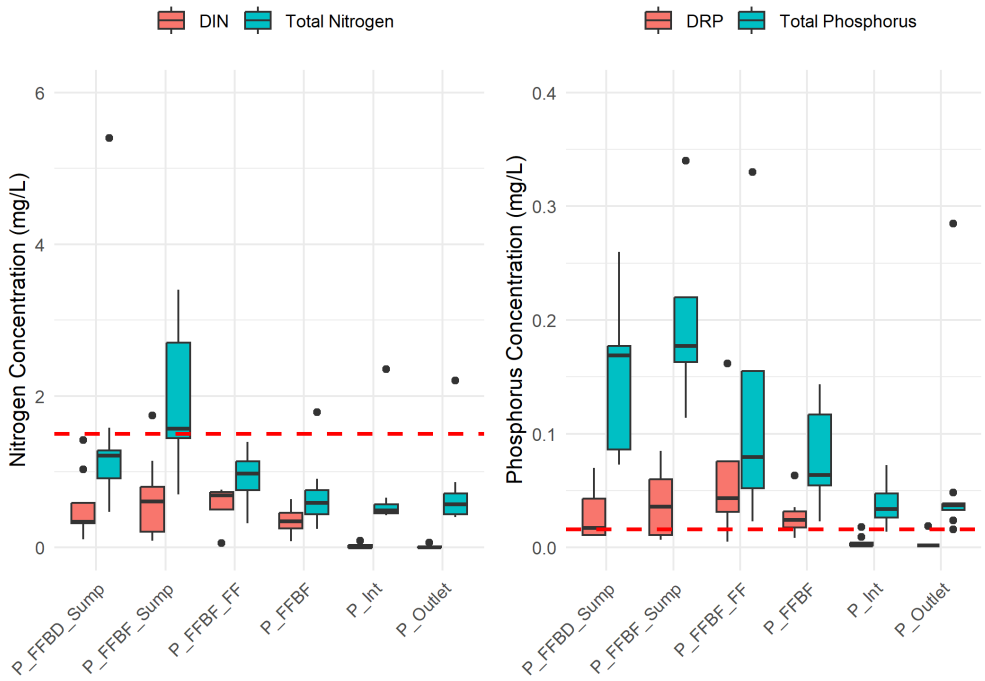

Figure 23. Prestons Stormwater detention facility – phosphorus and nitrogen concentrations

4.3 Discussion

4.3.1 First Flush Nalgene Bottle Results

First flush samples were collected from a sump adjacent to the Prestons First Flush Basin, using a Nalgene bottle. This bottle collected the first litre of runoff generated during each rainfall. The results show that this first flush had significantly higher heavy metal concentrations than the first flush autosampler results.

In general, the Preston stormwater results showed a reduction in contaminant concentrations between the first flush bottles situated at stormwater inlets and the P_FFBF_FF first flush. This reduction was particularly apparent for total heavy metals and TSS. A slight reduction in nutrients (nitrogen and phosphorus) also occurred between these sites, unlike at Knights Stream. This indicates that mechanical settling may be occurring within the sump, prior to treatment through the stormwater system. However, more research would be required to confirm this.

It should be noted that separate first-flush sampling methodologies were utilised at the different sampling locations. The first flush bottle collects the first litre of stormwater that flows into the sump, whereas the autosampler collects a more approximate first flush, due to the triggering mechanism and sampling frequency. This may contribute to or account for the differences between the sample results.

4.3.2 First Flush Autosampler Results

The first flush composite sample taken from the manhole at the inlet of Prestons First Flush Basin (P_FFBF_FF) generally had higher median contaminant concentrations than the P_FFBF sample for all contaminants except dissolved lead. This is as expected, as stormwater is generally more highly contaminated during the start of the storm event.

4.3.3 First Flush Basin Removal Efficiency

The WWDG guideline metal removal efficiencies were met or exceeded by the Preston FFB contaminant IQRs, with the exception of arsenic which increased through the FFB. The increase in arsenic through the FFB is thought to be due to naturally elevated arsenic levels within the peaty soil of the area being released into the FFB or wetland inlet via either overland flow (erosion) and/or groundwater. This was discussed within the Stage 1 report, and the 2020 report (PDP, 2018; PDP, 2022s; Clary et al. 2020).

The median TSS removal efficiency was below 0%. The International Stormwater BMP Database (2020) indicates a significant TSS reduction through the wet pond should be expected – rather than 0% removal. It is unclear what is causing this reduction in TSS removal efficiency. It could be caused by the placement of the autosamplers or low influent concentrations. Regardless, TSS concentrations met the receiving water standards, and therefore are not a key issue.

It should be noted that the low TSS influent concentrations shown at P_Int may be driving the poor TSS removal efficiency seen in the Prestons FFB. The median influent sediment concentrations found in the International Stormwater BMP Database (2020) ranged between 26 and 77 mg/L, whereas the median TSS concentration found at P_Int was just 4.6 mg/L (influent concentrations ranged from 3 – 53 mg/L). Additionally, studies have shown that TSS influent concentrations are highly correlated with treatment performance (Yang, et al. 2023).

Low influent and effluent concentrations can also cause more variable removal efficiencies. The removal efficiency calculation is more sensitive when the concentrations in question are small. This means small changes in contaminant concentrations translate to large changes in removal efficiencies. For example, if the TSS influent concentration was 0.01 mg/L, and the effluent concentration was 0.02 mg/L – the removal efficiency would be -100% despite a minute concentration change.

DRP and DIN removal met or exceeded the CCC WWDG guidelines for nutrient removals. However, the FFB did not meet the guidelines for median total phosphorus and total nitrogen removal.

4.3.4 Wetland Removal Efficiency

Results showed that Preston's wetland had the following characteristics:

- The median wetland removal efficiency for copper and zinc (dissolved and total) met the WWDG guidelines. However, the IQR did not fit within the WWDG ranges.
- The arsenic (dissolved and total) removal efficiency IQR sat below 0%.
- The wetland also performed poorly on total suspended solids and total lead removal; the median removal efficiencies sat below 0%.
- All dissolved lead results were below the detection limit, before and after entering the wetland. Therefore, the wetland did not visibly impact this contaminant.
- DIN and DRP had highly variable removal efficiencies, that do not fit within the WWDG range.
- Total phosphorus and total nitrogen were not effectively removed by this wetland.

This is consistent with the International Stormwater BMP Database (2020), in terms of the effective removal of copper and zinc (total and dissolved). However, the International Stormwater BMP Database (2020) states that wetland basins generally significantly reduce total phosphorus. This is inconsistent with the results displayed in Section 4.2.

As discussed in Section 3.2.2, studies indicate that some bioretention devices have high levels of phosphorus export. The International Stormwater BMP Database (2020) suggests that recent bioretention devices effectively remove phosphorus, as they are designed with low phosphorus content media.

4.3.5 System Removal Efficiency

Results show that Preston's stormwater treatment facility had the following key treatment efficiency characteristics:

- The system removed at least 75% of copper (dissolved and total), zinc (dissolved and total), total lead, and DRP, with the exception of a few outliers.
- Total phosphorus also appeared to be removed through the system, with a median removal efficiency of approximately 40%, and an IQR of between approximately 20% and 50%.
- There was insufficient data to determine the removal efficiency for dissolved lead.
- The stormwater treatment facility appeared to add arsenic (dissolved and total) into the system.

As discussed in earlier sections of this report, the influent pollutant concentrations in this system are relatively small. The removal efficiency calculation is more sensitive when the concentrations in question are small.

This means small changes in contaminant concentrations translate to large changes in removal efficiencies. For example, if the TSS influent concentration was 0.01 mg/L, and the effluent concentration was 0.02 mg/L – the removal efficiency would be -100% despite a minute concentration change.

4.3.6 Discharge Water quality

The receiving environment water quality standards were met for all contaminants, post-treatment, with the exception of phosphorous. It should be noted that the Prestons stormwater treatment system is hydraulically connected to the groundwater. This groundwater may act to dilute results. Therefore, it is unclear how much "treatment" the facility is undertaking.

DRP, total copper, total zinc, dissolved copper, and dissolved zinc contaminant concentrations all exceeded guideline values before treatment through the FFB. However, all contaminants met the receiving environment standards prior to treatment through the wetland. This indicates that wetlands are not required to treat these parameters, and FFBs may provide sufficient treatment.

The results displayed in Figure 22 and Figure 23 indicate that the majority of treatment occurs prior to stormwater entering the stormwater treatment wetland at Prestons. No contaminants were reduced below guideline values between P_int and P_out; denoting that the wetland is only providing polishing treatment.

5.0 Summary

PDP has provided ongoing stormwater quality monitoring at the Prestons and Knights Stream stormwater facilities, to determine treatment efficiencies and evaluate the discharge quality of these stormwater facilities. Stormwater quality monitoring was undertaken in three separate stages, as described below:

- Stage 1 – Two rainfall events sampled in 2018;
- Stage 2 – Four rainfall events sampled between May 2020 and May 2021; and
- Stage 3 – Three rainfall events sampled between November 2022 and April 2023.

This report includes:

- The results from nine rainfall events between September 2018 and April 2023;
- details of the methodology used to monitor the facilities;
- the rainfall events captured over the reporting period; and
- an analysis of the sampling results to date.

The analysis includes an assessment of the treatment provided by the first flush basins, and wetlands at both facilities, as well as a comparison of the discharge quality to receiving water standards.

This study showed that treatment system performance in Christchurch is highly variable. The system's performance was relatively consistent with treatment system performance across NZ, and internationally. Key differences have been summarised below:

- Both first-flush basins showed poor TSS removal;
- Both wetlands showed poor total phosphorus removal; and
- The variability in contaminant removals through systems was not captured by the CCC WWDG guidelines.

Analysis of the results showed that the treatment systems at both sites are treating key stormwater contaminants below receiving water standards. However, Preston's results indicate that the majority of treatment is occurring through the first flush basins. The Prestons wetland appears to only provide light polishing. The Knights Stream stormwater system appears to provide variable treatment throughout the whole system.

While these results appear to show that the Prestons Stormwater Treatment Facility provided more effective treatment than the Knights Stream Stormwater Treatment Facility, it should be noted they are not comparable. The Prestons Stormwater Treatment Facility is connected to groundwater, and therefore a portion of the "treatment" provided by the system could be due to dilution, rather than treatment.

A key observation derived from this study pertains to the influence of loading rates on the efficiency of treatment. This report indicates that both stormwater treatment facilities exhibit a suboptimal treatment performance in comparison to international research findings. However, low influent concentrations may be driving this comparatively poor treatment performance. For reference, the median influent TSS concentrations found in the International Stormwater BMP Database (2020) ranged between 26 and 77 mg/L; whereas the median TSS concentration at P_Int was just 4.6 mg/L (influent concentrations ranged from 3 – 53 mg/L), and the median influent concentration at K_FFSWale was 5 mg/L (influent concentrations ranged from 1.5 - 23 mg/L). Studies have shown that pollutant influent concentrations are highly correlated with treatment performance (Yang, et al. 2023). Therefore, the treatment facilities in this study may have performed comparitively poorly due to the low concentration of influent pollutants.

Low influent and effluent concentrations can also cause highly variable removal efficiencies as a function of the removal efficiency calculation. The removal efficiency calculation is highly sensitive to the magnitude of concentrations. This means small changes in contaminant concentrations can translate to large changes in removal efficiencies. For example, if the TSS influent concentration

was 0.01 mg/L, and the effluent concentration was 0.02 mg/L – the removal efficiency would be -100% despite a minute concentration increase. Whereas, if the influent concentration was 10 mg/L, and the effluent concentration was 10.01 mg/L, the same increase in contaminant concentration would translate to a removal efficiency of approximately 0%.

This information indicates that wetlands may not be well suited to treating the low pollutant concentrations. While these devices provide great amenity value, flood retention and stormwater attenuation, they may not provide significant and reliable treatment in catchments with low influent contaminant concentrations. International studies appear to indicate that wetlands are more effective with higher pollutant loading rates (Yang, et al. 2023; Clary, et al. 2020). The contributing catchments from both Prestons and Knights Stream have relatively low vehicle movements and new residential housing. These factors may be a reason for the low level of influent contaminants from the catchments.

6.0 Recommendations

The results obtained from the Prestons study appear to indicate that first flush ponds provided the highest treatment efficiency; while the Prestons and Knights Stream wetlands served to provide light polishing treatment. The dry detention first flush basin appeared to provide less reliable treatment than the wet pond at Prestons. PDP recommends that further research should focus on first flush basins, or wetlands with a higher contaminant loading. Wetland sediment sampling may also be beneficial, to ensure wetland maintenance and upkeep are suitable.

A detailed investigation into infiltration basins, dry basins, and wet ponds across different groundwater zones could be an asset for councils looking to provide guidance on urban stormwater treatment.

The Liquiport sampler with the liquid level actuator was less reliable in terms of triggering the collection of water samples. This sampler did not trigger during multiple events. It is unclear what led to the unpredictable triggering. Until the reason for these issues can be isolated, these sampling systems should be treated as less reliable. PDP recommend that Liquiport samplers should be replaced by ISCO samplers where possible.

If CCC carry out future stormwater management investigations, PDP recommends monitoring equipment is kept consistent between sites. This will allow samples to be more comparable and will reduce operator error. Additionally, PDP recommends that flow monitoring is undertaken at all sampling locations – so flow-weighted composite samples can be created, rather than time-weighted samples.

Due to the low lead concentrations (non-detects for the majority of samples), this parameter should be removed. Arsenic was below the receiving environment guidelines at all sampled locations. This parameter may also be removed from future samples.

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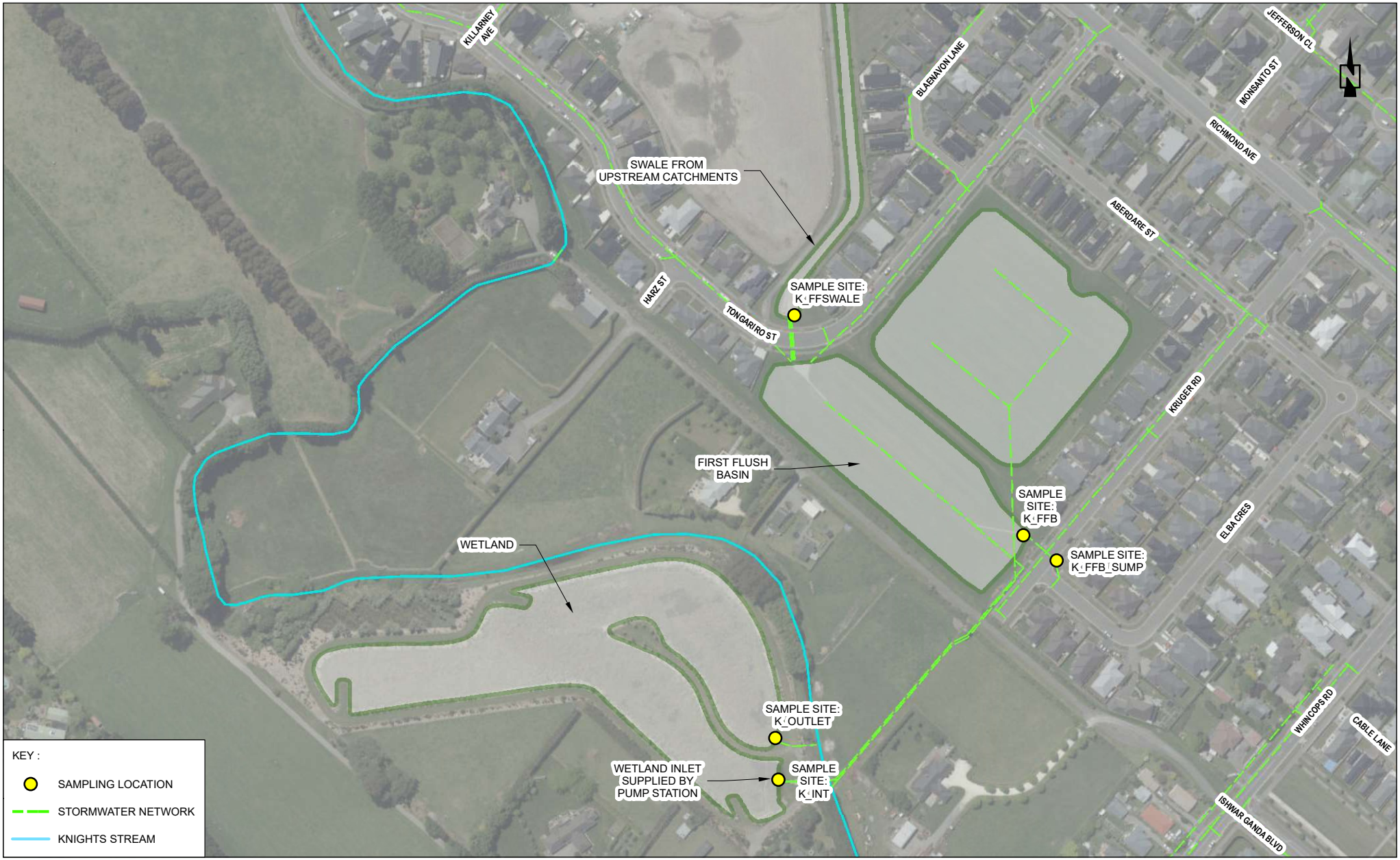
Appendix A: Sampler Layout



SOURCE:
1. AERIAL IMAGERY SOURCED FROM CANTERBURY MAPS PARTNERS LTD AND LICENCED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. STORMWATER ASSET DATA AND WATERWAY ALIGNMENT SOURCED FROM CHRISTCHURCH CITY COUNCIL'S GIS REST SERVICES AT https://gis.ccc.govt.nz/arcgis/rest/services/CorporateData/StormWater/MapServer AND LICENCED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE..

FIGURE 1 : KNIGHTS STREAM STORMWATER FACILITY SAMPLING LOCATIONS

SCALE : 1:3,000 (A4)

0 10 20 40 60

METRES

SOURCE:
1. AERIAL IMAGERY SOURCED FROM CANTERBURY MAPS PARTNERS LTD AND LICENCED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. STORMWATER ASSET DATA AND WATERWAY ALIGNMENT SOURCED FROM CHRISTCHURCH CITY COUNCIL'S GIS REST SERVICES AT https://gis.ccc.govt.nz/arcgis/rest/services/CorporateData/StormWater/MapServer AND LICENCED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE..

FIGURE 2 : PRESTONS STORMWATER FACILITY SAMPLING LOCATIONS

SCALE : 1:6,000 (A4)

0 25 50 100 150

METRES

Appendix B: Removal Efficiency Statistics

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System % Removal	Turbidity	%	89.70%	59.30%	0.70%	38.00%	-25.20%	-181.40%
System % Removal	Total Suspended Solids	%	86.60%	36.60%	-214.40%	9.80%	-95.00%	-1655.60%
System % Removal	DIN	%	99.10%	98.80%	95.20%	96.30%	94.60%	83.80%
System % Removal	Total Nitrogen	%	19.70%	4.40%	-20.20%	-21.30%	-34.60%	-79.60%
System % Removal	Total Ammoniacal-N	%	98.80%	96.60%	90.80%	93.40%	89.40%	70.20%
System % Removal	Nitrate-N + Nitrite-N	%	99.60%	99.40%	95.20%	99.20%	96.10%	76.70%
System % Removal	Total Kjeldahl Nitrogen (TKN)	%	-25.30%	-37.50%	-74.10%	-50.00%	-111.20%	-170.00%
System % Removal	DRP	%	96.80%	93.70%	78.50%	91.30%	84.10%	-2.70%
System % Removal	Total Phosphorus	%	73.10%	49.00%	23.20%	40.80%	20.30%	-99.30%
System % Removal	Dissolved Arsenic	%	-45.50%	-65.50%	-144.30%	-97.10%	-178.30%	-380.00%
System % Removal	Dissolved Copper	%	90.60%	85.80%	81.20%	81.50%	79.10%	66.70%
System % Removal	Dissolved Zinc	%	98.80%	97.60%	94.00%	95.70%	93.20%	81.10%
System % Removal	Total Arsenic	%	-45.70%	-89.20%	-176.80%	-168.60%	-254.50%	-335.70%
System % Removal	Total Copper	%	93.60%	90.40%	76.10%	81.70%	78.90%	16.00%
System % Removal	Total Lead	%	94.00%	77.80%	35.70%	61.10%	43.30%	-172.70%
System Concentration Change	Turbidity	NTU	14.53	2.83	2.72	0.72	-0.85	-1.81
System Concentration Change	Total Suspended Solids	g/m^3	29.00	2.44	-4.00	0.25	-12.38	-37.25

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System Concentration Change	DIN	g/m^3	0.64	0.45	0.34	0.31	0.24	0.08
System Concentration Change	Total Nitrogen	g/m^3	0.14	0.04	-0.10	-0.10	-0.21	-0.42
System Concentration Change	Total Ammoniacal-N	g/m^3	0.41	0.20	0.15	0.11	0.05	0.03
System Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.34	0.23	0.19	0.18	0.14	0.05
System Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	-0.12	-0.17	-0.28	-0.22	-0.35	-0.65
System Concentration Change	DRP	g/m^3	0.06	0.03	0.02	0.02	0.01	0.00
System Concentration Change	Total Phosphorus	g/m^3	0.11	0.04	0.01	0.03	0.00	-0.14
System Concentration Change	Dissolved Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
System Concentration Change	Dissolved Copper	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
System Concentration Change	Dissolved Zinc	g/m^3	0.04	0.03	0.02	0.02	0.01	0.01
System Concentration Change	Total Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	-0.01
System Concentration Change	Total Copper	g/m^3	0.01	0.00	0.00	0.00	0.00	0.00

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System Concentration Change	Total Lead	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
FFB % Removal	Turbidity	%	89.40%	79.50%	39.10%	44.70%	-0.10%	-20.50%
FFB % Removal	Total Suspended Solids	%	89.60%	68.20%	-5.20%	-23.40%	-54.10%	-100.00%
FFB % Removal	DIN	%	98.90%	98.70%	91.70%	95.80%	88.60%	70.20%
FFB % Removal	Total Nitrogen	%	27.60%	22.50%	-4.60%	4.40%	-12.30%	-83.70%
FFB % Removal	Total Ammoniacal-N	%	98.80%	97.60%	90.70%	95.60%	87.60%	65.80%
FFB % Removal	Nitrate-N + Nitrite-N	%	99.70%	99.50%	88.30%	98.50%	88.60%	50.00%
FFB % Removal	Total Kjeldahl Nitrogen (TKN)	%	5.80%	-18.10%	-51.40%	-37.10%	-68.60%	-132.50%
FFB % Removal	DRP	%	95.80%	93.50%	78.20%	88.10%	69.50%	41.00%
FFB % Removal	Total Phosphorus	%	69.60%	54.70%	5.50%	48.20%	32.20%	-291.60%
FFB % Removal	Dissolved Arsenic	%	0.00%	-42.60%	-98.40%	-93.30%	-140.00%	-230.00%
FFB % Removal	Dissolved Copper	%	85.00%	83.20%	76.40%	80.10%	78.70%	43.30%
FFB % Removal	Dissolved Zinc	%	96.40%	92.30%	87.60%	89.70%	85.90%	71.10%
FFB % Removal	Total Arsenic	%	-8.60%	-51.30%	-106.20%	-92.90%	-169.50%	-200.00%
FFB % Removal	Total Copper	%	86.60%	77.80%	69.50%	73.00%	65.30%	40.90%
FFB % Removal	Total Lead	%	96.30%	77.40%	64.90%	55.30%	52.60%	42.60%
FFB Concentration Change	Turbidity	NTU	13.98	0.99	2.57	0.93	0.04	-1.17
FFB Concentration Change	Total Suspended Solids	g/m^3	30.00	3.25	0.80	-1.00	-2.52	-23.00
FFB Concentration Change	DIN	g/m^3	0.55	0.45	0.33	0.34	0.19	0.08

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
FFB Concentration Change	Total Nitrogen	g/m^3	0.25	0.16	-0.02	0.02	-0.07	-0.57
FFB Concentration Change	Total Ammoniacal-N	g/m^3	0.41	0.21	0.15	0.11	0.04	0.03
FFB Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.34	0.22	0.18	0.17	0.13	0.05
FFB Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	0.04	-0.07	-0.20	-0.12	-0.26	-0.75
FFB Concentration Change	DRP	g/m^3	0.06	0.03	0.02	0.02	0.01	0.01
FFB Concentration Change	Total Phosphorus	g/m^3	0.08	0.05	-0.02	0.03	0.01	-0.42
FFB Concentration Change	Dissolved Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
FFB Concentration Change	Dissolved Copper	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
FFB Concentration Change	Dissolved Zinc	g/m^3	0.04	0.02	0.02	0.02	0.01	0.01
FFB Concentration Change	Total Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
FFB Concentration Change	Total Copper	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
FFB Concentration Change	Total Lead	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
Wetland % Removal	Turbidity	%	67.50%	27.60%	-426.40%	6.90%	-79.10%	-2566.70%
Wetland % Removal	Total Suspended Solids	%	52.60%	28.30%	-240.10%	-28.60%	-413.90%	-933.30%
Wetland % Removal	DIN	%	93.80%	83.20%	-196.30%	75.00%	-145.50%	-1087.90%
Wetland % Removal	Total Nitrogen	%	6.40%	3.00%	-16.70%	-13.40%	-23.70%	-68.20%
Wetland % Removal	Total Ammoniacal-N	%	75.60%	-37.20%	-118.10%	-150.00%	-215.00%	-280.00%

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
Wetland % Removal	Nitrate-N + Nitrite-N	%	98.80%	78.60%	-738.70%	52.40%	-104.20%	-4566.70%
Wetland % Removal	Total Kjeldahl Nitrogen (TKN)	%	4.30%	-6.00%	-18.10%	-11.00%	-20.40%	-72.30%
Wetland % Removal	DRP	%	88.90%	56.90%	4.60%	25.00%	-37.50%	-100.00%
Wetland % Removal	Total Phosphorus	%	49.10%	6.10%	-8.80%	-12.70%	-16.80%	-94.70%
Wetland % Removal	Dissolved Arsenic	%	9.50%	-13.80%	-23.60%	-27.60%	-37.00%	-45.50%
Wetland % Removal	Dissolved Copper	%	61.50%	46.30%	23.50%	41.20%	18.40%	-50.00%
Wetland % Removal	Dissolved Zinc	%	82.50%	71.40%	53.00%	53.60%	34.20%	21.70%
Wetland % Removal	Total Arsenic	%	-4.40%	-11.60%	-37.40%	-34.20%	-37.10%	-125.90%
Wetland % Removal	Total Copper	%	64.20%	58.00%	30.40%	52.30%	37.70%	-94.70%
Wetland % Removal	Total Lead	%	53.20%	13.10%	-35.90%	-44.80%	-62.60%	-172.70%
Wetland Concentration Change	Turbidity	NTU	13.98	0.99	2.57	0.93	0.04	-1.17
Wetland Concentration Change	Total Suspended Solids	g/m^3	30.00	3.25	0.80	-1.00	-2.52	-23.00
Wetland Concentration Change	DIN	g/m^3	0.55	0.45	0.33	0.34	0.19	0.08
Wetland Concentration Change	Total Nitrogen	g/m^3	0.25	0.16	-0.02	0.02	-0.07	-0.57
Wetland Concentration Change	Total Ammoniacal-N	g/m^3	0.41	0.21	0.15	0.11	0.04	0.03
Wetland Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.34	0.22	0.18	0.17	0.13	0.05

Table B1. Prestons Removal Efficiency Data								
Location	**Analyte**	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
Wetland Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	0.04	-0.07	-0.20	-0.12	-0.26	-0.75
Wetland Concentration Change	DRP	g/m^3	0.06	0.03	0.02	0.02	0.01	0.01
Wetland Concentration Change	Total Phosphorus	g/m^3	0.08	0.05	-0.02	0.03	0.01	-0.42
Wetland Concentration Change	Dissolved Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
Wetland Concentration Change	Dissolved Copper	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
Wetland Concentration Change	Dissolved Zinc	g/m^3	0.04	0.02	0.02	0.02	0.01	0.01
Wetland Concentration Change	Total Arsenic	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
Wetland Concentration Change	Total Copper	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00
Wetland Concentration Change	Total Lead	g/m^3	0.00	0.00	0.00	0.00	0.00	0.00

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System % Removal	Turbidity	%	51.50%	44.80%	3.00%	26.10%	-3.60%	-138.80%
System % Removal	Total Suspended Solids	%	75.60%	65.30%	-11.20%	49.40%	-18.00%	-263.60%
System % Removal	DIN	%	88.70%	74.00%	11.80%	60.50%	9.60%	-330.80%
System % Removal	Total Nitrogen	%	58.90%	39.50%	-22.50%	-21.30%	-88.60%	-134.30%
System % Removal	Total Ammoniacal-N	%	91.30%	86.10%	37.90%	64.60%	-11.50%	-95.30%
System % Removal	Nitrate-N + Nitrite-N	%	94.10%	79.10%	-25.20%	53.80%	5.40%	-646.20%
System % Removal	Total Kjeldahl Nitrogen (TKN)	%	62.40%	33.70%	-29.00%	-19.50%	-90.50%	-137.20%
System % Removal	DRP	%	62.20%	24.50%	-173.60%	-106.40%	-340.50%	-742.90%
System % Removal	Total Phosphorus	%	53.60%	24.20%	-128.70%	-80.30%	-272.00%	-473.50%
System % Removal	Dissolved Arsenic	%	-26.10%	-104.60%	-183.00%	-183.00%	-261.50%	-340.00%
System % Removal	Dissolved Copper	%	32.40%	25.50%	2.50%	9.10%	-21.70%	-27.30%
System % Removal	Dissolved Lead	%	66.70%	52.30%	11.30%	37.30%	-3.80%	-96.20%
System % Removal	Dissolved Zinc	%	69.30%	57.60%	-97.60%	50.00%	14.00%	-1225.70%
System % Removal	Total Arsenic	%	50.00%	13.90%	-90.70%	-22.20%	-161.10%	-300.00%
System % Removal	Total Copper	%	48.80%	29.90%	7.50%	23.00%	-25.60%	-33.90%
System % Removal	Total Lead	%	83.00%	55.50%	21.70%	37.10%	-5.90%	-94.10%
System % Removal	Total Zinc	%	74.10%	64.40%	-43.50%	40.80%	13.10%	-706.70%
System % Removal	Particulate Arsenic	%	100.00%	97.90%	95.80%	95.80%	93.80%	91.70%
System % Removal	Particulate Copper	%	79.00%	43.30%	-14.80%	28.00%	-6.30%	-240.00%

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System % Removal	Particulate Lead	%	98.20%	78.30%	26.80%	56.40%	-6.90%	-93.50%
System Concentration Change	Turbidity	NTU	4.25	1.688	0.389	1	-0.175	-5.55
System Concentration Change	Total Suspended Solids	g/m^3	15.5	6.5	3.323	2.875	-0.5	-7.5
System Concentration Change	DIN	g/m^3	0.94	0.485	0.203	0.242	0.016	-0.86
System Concentration Change	Total Nitrogen	g/m^3	1.355	0.625	0.107	-0.085	-0.29	-0.96
System Concentration Change	Total Ammoniacal-N	g/m^3	0.961	0.297	0.208	0.106	-0.015	-0.071
System Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.212	0.14	-0.006	0.087	0.004	-0.84
System Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	1.31	0.445	0.108	-0.115	-0.295	-0.555
System Concentration Change	DRP	g/m^3	0.062	0.054	-0.068	-0.072	-0.124	-0.26
System Concentration Change	Total Phosphorus	g/m^3	0.123	0.075	-0.082	-0.111	-0.171	-0.322
System Concentration Change	Dissolved Arsenic	g/m^3	0	-0.001	-0.001	-0.001	-0.001	-0.002
System Concentration Change	Dissolved Copper	g/m^3	0.001	0.001	0	0	0	0
System Concentration Change	Dissolved Lead	g/m^3	0	0	0	0	0	0

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
System Concentration Change	Dissolved Zinc	g/m^3	0.017	0.009	-0.011	0.005	0.002	-0.16
System Concentration Change	Total Arsenic	g/m^3	0.001	0	0	0	-0.001	-0.002
System Concentration Change	Total Copper	g/m^3	0.001	0.001	0	0	0	0
System Concentration Change	Total Lead	g/m^3	0.001	0	0	0	0	-0.001
System Concentration Change	Total Zinc	g/m^3	0.028	0.013	-0.008	0.005	0.001	-0.159
System Concentration Change	Particulate Arsenic	g/m^3	0.001	0	0	0	0	0
System Concentration Change	Particulate Copper	g/m^3	0.001	0.001	0	0	0	0
System Concentration Change	Particulate Lead	g/m^3	0.001	0	0	0	0	0
FFB % Removal	Turbidity	%	33.30%	10.50%	-55.70%	-14.90%	-124.50%	-195.60%
FFB % Removal	Total Suspended Solids	%	62.50%	17.30%	-52.30%	-18.90%	-124.60%	-209.10%
FFB % Removal	DIN	%	79.10%	57.50%	9.70%	8.40%	-30.40%	-62.60%
FFB % Removal	Total Nitrogen	%	68.90%	25.30%	9.10%	10.00%	-12.00%	-44.60%
FFB % Removal	Total Ammoniacal-N	%	94.50%	48.30%	18.10%	21.00%	-17.30%	-54.50%
FFB % Removal	Nitrate-N + Nitrite-N	%	95.00%	31.70%	-15.30%	-33.30%	-52.70%	-114.70%
FFB % Removal	Total Kjeldahl Nitrogen (TKN)	%	75.50%	23.50%	13.00%	19.10%	-4.20%	-35.60%

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
FFB % Removal	DRP	%	66.50%	63.00%	24.70%	39.90%	-0.20%	-59.20%
FFB % Removal	Total Phosphorus	%	50.60%	39.50%	11.00%	21.20%	-5.60%	-70.30%
FFB % Removal	Dissolved Arsenic	%	-17.40%	-73.70%	-105.80%	-130.00%	-150.00%	-170.00%
FFB % Removal	Dissolved Copper	%	50.00%	26.00%	13.50%	21.90%	-5.50%	-18.20%
FFB % Removal	Dissolved Lead	%	54.00%	30.70%	23.30%	21.50%	14.00%	-3.80%
FFB % Removal	Dissolved Zinc	%	63.70%	34.10%	-32.20%	-15.60%	-59.20%	-172.50%
FFB % Removal	Total Arsenic	%	-22.20%	-38.40%	-95.30%	-54.50%	-131.80%	-209.10%
FFB % Removal	Total Copper	%	58.30%	19.20%	5.50%	3.30%	-10.60%	-35.60%
FFB % Removal	Total Lead	%	45.80%	29.60%	-27.40%	-10.90%	-89.00%	-122.90%
FFB % Removal	Total Zinc	%	44.20%	23.00%	-46.40%	-10.00%	-60.30%	-265.30%
FFB % Removal	Particulate Arsenic	%	8.30%	-20.80%	-213.90%	-50.00%	-325.00%	-600.00%
FFB % Removal	Particulate Copper	%	70.00%	-0.70%	-64.50%	-12.40%	-137.20%	-275.00%
FFB % Removal	Particulate Lead	%	57.90%	25.70%	-54.30%	-16.60%	-110.70%	-286.70%
FFB Concentration Change	Turbidity	NTU	2.75	0.46	-2.07	-0.43	-4.74	-8.9
FFB Concentration Change	Total Suspended Solids	g/m^3	3	2.5	-1.49	-0.5	-3.44	-10.5
FFB Concentration Change	DIN	g/m^3	1.01	0.21	0.13	0.05	-0.1	-0.29
FFB Concentration Change	Total Nitrogen	g/m^3	1.59	0.24	0.24	0.09	-0.1	-0.15
FFB Concentration Change	Total Ammoniacal-N	g/m^3	1.07	0.09	0.15	0.04	-0.03	-0.12
FFB Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.13	0.07	-0.01	-0.05	-0.08	-0.16

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
FFB Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	1.59	0.17	0.25	0.09	0	-0.21
FFB Concentration Change	DRP	g/m^3	0.15	0.06	0.04	0.03	0	-0.04
FFB Concentration Change	Total Phosphorus	g/m^3	0.16	0.09	0.04	0.02	-0.01	-0.08
FFB Concentration Change	Dissolved Arsenic	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Dissolved Copper	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Dissolved Lead	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Dissolved Zinc	g/m^3	0.02	0.01	0	0	0	-0.02
FFB Concentration Change	Total Arsenic	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Total Copper	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Total Lead	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Total Zinc	g/m^3	0.02	0.01	0	0	-0.01	-0.04
FFB Concentration Change	Particulate Arsenic	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Particulate Copper	g/m^3	0	0	0	0	0	0
FFB Concentration Change	Particulate Lead	g/m^3	0.00%	0.00%	0.00%	0.00%	0.00%	-0.10%
Wetland % Removal	Turbidity	%	82.90%	65.60%	9.70%	37.40%	23.60%	-193.80%
Wetland % Removal	Total Suspended Solids	%	81.30%	68.70%	38.60%	60.00%	22.40%	-50.00%
Wetland % Removal	DIN	%	89.40%	75.60%	-130.90%	54.20%	17.60%	-1403.40%
Wetland % Removal	Total Nitrogen	%	57.90%	17.60%	-25.00%	-31.60%	-51.80%	-109.40%
Wetland % Removal	Total Ammoniacal-N	%	92.60%	77.40%	6.80%	46.00%	-28.70%	-180.60%
Wetland % Removal	Nitrate-N + Nitrite-N	%	87.70%	70.70%	-1779.80	56.20%	46.40%	-14823.10%

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
Wetland % Removal	Total Kjeldahl Nitrogen (TKN)	%	45.50%	13.10%	-39.00%	-26.00%	-91.60%	-150.00%
Wetland % Removal	DRP	%	47.60%	-15.80%	-208.70%	-107.00%	-353.10%	-742.90%
Wetland % Removal	Total Phosphorus	%	34.70%	6.10%	-137.50%	-56.10%	-261.60%	-524.00%
Wetland % Removal	Dissolved Arsenic	%	56.50%	24.60%	-4.60%	-7.40%	-35.20%	-63.00%
Wetland % Removal	Dissolved Copper	%	12.00%	11.00%	-9.90%	-5.30%	-15.10%	-71.40%
Wetland % Removal	Dissolved Lead	%	58.30%	38.50%	-14.30%	-13.40%	-66.20%	-88.90%
Wetland % Removal	Dissolved Zinc	%	73.70%	68.50%	-204.10%	62.80%	18.30%	-1984.30%
Wetland % Removal	Total Arsenic	%	67.60%	43.40%	19.10%	19.10%	-5.10%	-29.40%
Wetland % Removal	Total Copper	%	40.40%	19.10%	-1.00%	5.60%	-15.40%	-76.70%
Wetland % Removal	Total Lead	%	91.50%	69.40%	24.20%	54.00%	-13.00%	-103.20%
Wetland % Removal	Total Zinc	%	75.60%	69.60%	-68.20%	59.90%	36.00%	-955.20%
Wetland % Removal	Particulate Arsenic	%	100.00%	95.50%	74.70%	90.90%	62.10%	33.30%
Wetland % Removal	Particulate Copper	%	81.90%	73.80%	16.90%	19.10%	-21.60%	-88.90%
Wetland % Removal	Particulate Lead	%	99.20%	76.60%	26.20%	61.00%	-10.20%	-122.70%
Wetland Concentration Change	Turbidity	NTU	11.16	5.76	2.63	1.51	0.94	-6.3
Wetland Concentration Change	Total Suspended Solids	g/m^3	13.5	11.88	5.75	4.5	0.75	-1.5
Wetland Concentration Change	DIN	g/m^3	0.66	0.31	0.09	0.14	0.04	-1.05

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
Wetland Concentration Change	Total Nitrogen	g/m^3	0.77	0.18	-0.06	-0.14	-0.27	-0.88
Wetland Concentration Change	Total Ammoniacal-N	g/m^3	0.41	0.17	0.1	0.05	-0.02	-0.11
Wetland Concentration Change	Nitrate-N + Nitrite-N	g/m^3	0.34	0.13	0	0.08	0.07	-0.96
Wetland Concentration Change	Total Kjeldahl Nitrogen (TKN)	g/m^3	0.43	0.13	-0.06	-0.1	-0.25	-0.48
Wetland Concentration Change	DRP	g/m^3	0.05	-0.01	-0.1	-0.09	-0.18	-0.26
Wetland Concentration Change	Total Phosphorus	g/m^3	0.07	0.01	-0.11	-0.09	-0.23	-0.33
Wetland Concentration Change	Dissolved Arsenic	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Dissolved Copper	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Dissolved Lead	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Dissolved Zinc	g/m^3	0.02	0.01	-0.01	0.01	0	-0.16
Wetland Concentration Change	Total Arsenic	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Total Copper	g/m^3	0	0	0	0	0	0

Table B2. Knights Stream Removal Efficiency Data								
	Analyte	**Unit**	**Maximum (%)**	**75th Percentile (%)**	**Mean (%)**	**Median (%)**	**25th Percentile (%)**	**Minimum (%)**
Wetland Concentration Change	Total Lead	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Total Zinc	g/m^3	0.03	0.01	-0.01	0.01	0.01	-0.16
Wetland Concentration Change	Particulate Arsenic	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Particulate Copper	g/m^3	0	0	0	0	0	0
Wetland Concentration Change	Particulate Lead	g/m^3	0	0	0	0	0	0

Appendix C: Contaminant Concentrations Statistics

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFB	Turbidity	3.55	3.14	2.33	2.5	1.69	0.765
K_FFB	Total Suspended Solids	5	4	2.95	2.75	1.5	1.5
K_FFB	DIN	0.32	0.245	0.217	0.196	0.183	0.143
K_FFB	Total Nitrogen	1.07	0.61	0.52	0.4	0.315	0.205
K_FFB	Total Ammoniacal-N	0.185	0.126	0.101	0.108	0.0735	0.011
K_FFB	Nitrate-N + Nitrite-N	0.172	0.14	0.118	0.139	0.072	0.0695
K_FFB	Total Kjeldahl Nitrogen (TKN)	0.885	0.47	0.399	0.26	0.245	0.135
K_FFB	DRP	0.0185	0.0105	0.0073	0.0035	0.002	0.002
K_FFB	Total Phosphorus	0.051	0.036	0.0354	0.033	0.03	0.027
K_FFB	Dissolved Arsenic	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
K_FFB	Dissolved Copper	0.00115	0.0011	0.00082	0.0007	0.0006	0.00055
K_FFB	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFB	Dissolved Zinc	0.057	0.039	0.0306	0.0225	0.0178	0.0169
K_FFB	Total Arsenic	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055
K_FFB	Total Copper	0.0022	0.00171	0.00144	0.00142	0.00099	0.00089
K_FFB	Total Lead	0.00041	0.00036	0.000256	0.00028	0.000175	0.000055
K_FFB	Total Zinc	0.07	0.045	0.036	0.0255	0.0201	0.0193
K_FFB	Particulate Arsenic	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFB	Particulate Copper	0.0011	0.00072	0.000622	0.00056	0.00044	0.00029
K_FFB	Particulate Lead	0.00036	0.00031	0.000206	0.00023	0.000125	0.000005
K_FFB	Particulate Zinc	0.013	0.006	0.00532	0.003	0.00235	0.00223
K_FFB_Sump	Turbidity	25	20.2	16.5	16.3	12.9	8.2

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFB_Sump	Total Suspended Solids	175	154	91.4	79	42	15
K_FFB_Sump	DIN	2.2	1.47	0.908	0.64	0.32	0.096
K_FFB_Sump	Total Nitrogen	5.6	2.4	2.03	1.33	1.18	0.66
K_FFB_Sump	Total Ammoniacal-N	1.76	1	0.672	0.49	0.196	0.078
K_FFB_Sump	Nitrate-N + Nitrite-N	0.46	0.43	0.234	0.185	0.151	0.018
K_FFB_Sump	Total Kjeldahl Nitrogen (TKN)	5.2	1.95	1.8	1.27	1.03	0.64
K_FFB_Sump	DRP	0.137	0.039	0.0416	0.018	0.014	0.012
K_FFB_Sump	Total Phosphorus	0.51	0.47	0.258	0.173	0.136	0.053
K_FFB_Sump	Dissolved Arsenic	0.0017	0.0014	0.001	0.0009	0.0005	0.0005
K_FFB_Sump	Dissolved Copper	0.0061	0.0042	0.00281	0.0018	0.0013	0.0009
K_FFB_Sump	Dissolved Lead	0.0002	0.0000825	0.000085	0.00005	0.00005	0.00005
K_FFB_Sump	Dissolved Zinc	0.152	0.06	0.0516	0.036	0.028	0.0158
K_FFB_Sump	Total Arsenic	0.0029	0.00238	0.00196	0.0022	0.00179	0.00055
K_FFB_Sump	Total Copper	0.0153	0.0109	0.00791	0.0073	0.00468	0.0022
K_FFB_Sump	Total Lead	0.0141	0.00528	0.00472	0.00415	0.00206	0.00027
K_FFB_Sump	Total Zinc	0.23	0.168	0.11	0.086	0.055	0.025
K_FFB_Sump	Particulate Arsenic	0.0017	0.00133	0.000963	0.00105	0.000688	0.00005
K_FFB_Sump	Particulate Copper	0.0135	0.00625	0.0051	0.00505	0.00195	0.0008
K_FFB_Sump	Particulate Lead	0.0141	0.00511	0.00464	0.00404	0.00201	0.00022
K_FFB_Sump	Particulate Zinc	0.179	0.068	0.0582	0.0552	0.026	0.0053
K_FFSwale	Turbidity	8.25	4.28	4.29	3.83	3.3	2.8
K_FFSwale	Total Suspended Solids	23	9.5	8.45	5	4	1.5

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFSwale	DIN	1.27	0.573	0.466	0.405	0.215	0.155
K_FFSwale	Total Nitrogen	2.3	1.19	0.987	0.715	0.525	0.28
K_FFSwale	Total Ammoniacal-N	1.14	0.343	0.298	0.2	0.112	0.0745
K_FFSwale	Nitrate-N + Nitrite-N	0.31	0.23	0.166	0.137	0.0995	0.0645
K_FFSwale	Total Kjeldahl Nitrogen (TKN)	2.1	0.955	0.818	0.583	0.42	0.215
K_FFSwale	DRP	0.22	0.09	0.0845	0.0765	0.06	0.021
K_FFSwale	Total Phosphorus	0.31	0.192	0.153	0.124	0.104	0.047
K_FFSwale	Dissolved Arsenic	0.00115	0.000663	0.000663	0.0005	0.0005	0.0005
K_FFSwale	Dissolved Copper	0.0032	0.0021	0.00166	0.00115	0.0011	0.00105
K_FFSwale	Dissolved Lead	0.000315	0.00015	0.000128	0.00005	0.00005	0.00005
K_FFSwale	Dissolved Zinc	0.0315	0.0148	0.0156	0.0131	0.0114	0.00545
K_FFSwale	Total Arsenic	0.00135	0.00116	0.000888	0.000825	0.00055	0.00055
K_FFSwale	Total Copper	0.00445	0.00305	0.00229	0.00157	0.00118	0.00115
K_FFSwale	Total Lead	0.00164	0.000755	0.000637	0.00034	0.000245	0.0000875
K_FFSwale	Total Zinc	0.046	0.0225	0.0219	0.0179	0.0136	0.00685
K_FFSwale	Particulate Arsenic	0.0006	0.0003	0.000225	0.000125	0.00005	0.00005
K_FFSwale	Particulate Copper	0.0015	0.001	0.000625	0.00047	0.00012	0.00008
K_FFSwale	Particulate Lead	0.00136	0.000465	0.00051	0.00029	0.000195	0.0000375
K_FFSwale	Particulate Zinc	0.016	0.00945	0.00639	0.00443	0.00215	0.0014
K_FFSwale_FF	Turbidity	5.3	4.75	4.23	4.2	3.7	3.2
K_FFSwale_FF	Total Suspended Solids	12	11	10	10	9	8
K_FFSwale_FF	DIN	1.92	1.19	0.89	0.45	0.375	0.3

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFSwale_FF	Total Nitrogen	2.8	1.78	1.42	0.76	0.725	0.69
K_FFSwale_FF	Total Ammoniacal-N	1.02	0.572	0.42	0.123	0.12	0.117
K_FFSwale_FF	Nitrate-N + Nitrite-N	0.89	0.61	0.469	0.33	0.259	0.187
K_FFSwale_FF	Total Kjeldahl Nitrogen (TKN)	1.89	1.23	0.94	0.57	0.465	0.36
K_FFSwale_FF	DRP	0.26	0.147	0.105	0.033	0.028	0.023
K_FFSwale_FF	Total Phosphorus	0.38	0.232	0.175	0.083	0.0725	0.062
K_FFSwale_FF	Dissolved Arsenic	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
K_FFSwale_FF	Dissolved Copper	0.0028	0.0021	0.0018	0.0014	0.0013	0.0012
K_FFSwale_FF	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFSwale_FF	Dissolved Zinc	0.028	0.023	0.0205	0.018	0.0167	0.0154
K_FFSwale_FF	Total Arsenic	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055
K_FFSwale_FF	Total Copper	0.0036	0.00314	0.00268	0.00268	0.00222	0.00176
K_FFSwale_FF	Total Lead	0.00053	0.000493	0.000455	0.000455	0.000418	0.00038
K_FFSwale_FF	Total Zinc	0.043	0.037	0.0312	0.031	0.0253	0.0196
K_FFSwale_FF	Particulate Arsenic	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFSwale_FF	Particulate Copper	0.0008	0.00069	0.00058	0.00058	0.00047	0.00036
K_FFSwale_FF	Particulate Lead	0.00048	0.000443	0.000405	0.000405	0.000368	0.00033
K_FFSwale_FF	Particulate Zinc	0.015	0.014	0.0107	0.013	0.0086	0.0042
K_Int	Turbidity	13.5	8.88	6.46	4.43	3.28	3.2
K_Int	Total Suspended Solids	20	18.5	10.4	8.25	3.88	1.5
K_Int	DIN	0.835	0.403	0.37	0.268	0.244	0.0745
K_Int	Total Nitrogen	1.8	0.933	0.808	0.646	0.454	0.37

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_Int	Total Ammoniacal-N	0.445	0.214	0.179	0.122	0.0916	0.062
K_Int	Nitrate-N + Nitrite-N	0.39	0.249	0.189	0.146	0.128	0.0065
K_Int	Total Kjeldahl Nitrogen (TKN)	1.41	0.834	0.619	0.498	0.306	0.23
K_Int	DRP	0.0955	0.0798	0.0597	0.0535	0.0358	0.035
K_Int	Total Phosphorus	0.189	0.157	0.128	0.136	0.1	0.0625
K_Int	Dissolved Arsenic	0.00135	0.00135	0.00109	0.00125	0.000988	0.0005
K_Int	Dissolved Copper	0.0025	0.00148	0.00141	0.00122	0.00111	0.00105
K_Int	Dissolved Lead	0.000235	0.000138	0.000104	0.000085	0.00005	0.00005
K_Int	Dissolved Zinc	0.03	0.0168	0.0159	0.015	0.0124	0.0083
K_Int	Total Arsenic	0.0017	0.0017	0.0014	0.00168	0.00138	0.00055
K_Int	Total Copper	0.0036	0.00245	0.00199	0.00164	0.00145	0.00128
K_Int	Total Lead	0.00143	0.0011	0.000676	0.000559	0.000296	0.00013
K_Int	Total Zinc	0.0495	0.0269	0.0248	0.0195	0.0171	0.0162
K_Int	Particulate Arsenic	0.00055	0.0004	0.000313	0.000325	0.000238	0.00005
K_Int	Particulate Copper	0.0011	0.000825	0.000577	0.000502	0.000291	0.000147
K_Int	Particulate Lead	0.0012	0.000973	0.000572	0.000462	0.000246	0.00008
K_Int	Particulate Zinc	0.0195	0.0143	0.00883	0.00745	0.00292	0.0019
K_Outlet	Turbidity	9.55	4.18	3.9	2.83	2.45	1.68
K_Outlet	Total Suspended Solids	12	8.5	5.5	5	2.25	1.5
K_Outlet	DIN	1.12	0.205	0.263	0.163	0.085	0.065
K_Outlet	Total Nitrogen	1.68	0.99	0.881	0.87	0.56	0.485
K_Outlet	Total Ammoniacal-N	0.174	0.145	0.0905	0.094	0.0395	0.0305

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_Outlet	Nitrate-N + Nitrite-N	0.97	0.158	0.172	0.061	0.046	0.0055
K_Outlet	Total Kjeldahl Nitrogen (TKN)	1.17	0.8	0.709	0.705	0.51	0.44
K_Outlet	DRP	0.31	0.2	0.152	0.166	0.05	0.034
K_Outlet	Total Phosphorus	0.39	0.295	0.235	0.235	0.158	0.089
K_Outlet	Dissolved Arsenic	0.0022	0.00164	0.00116	0.000975	0.0005	0.0005
K_Outlet	Dissolved Copper	0.0022	0.00175	0.00148	0.0014	0.00125	0.001
K_Outlet	Dissolved Lead	0.000255	0.00016	0.000105	0.00005	0.00005	0.00005
K_Outlet	Dissolved Zinc	0.173	0.0115	0.0265	0.0098	0.0051	0.00397
K_Outlet	Total Arsenic	0.0022	0.00179	0.00124	0.0011	0.00055	0.00055
K_Outlet	Total Copper	0.0031	0.00235	0.00187	0.00154	0.00147	0.0011
K_Outlet	Total Lead	0.00116	0.00073	0.000442	0.000345	0.000135	0.000055
K_Outlet	Total Zinc	0.182	0.0159	0.0303	0.0146	0.00595	0.0045
K_Outlet	Particulate Arsenic	0.0002	0.0000875	0.000075	0.00005	0.0000375	0
K_Outlet	Particulate Copper	0.0009	0.0006	0.000384	0.000235	0.000137	0.000085
K_Outlet	Particulate Lead	0.0009	0.00057	0.000337	0.000295	0.000085	0.000005
K_Outlet	Particulate Zinc	0.0085	0.00605	0.00389	0.00385	0.0009	0.000533

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBD_Sump	Turbidity	87	13.6	19.3	7.8	4.65	3.7
P_FFBD_Sump	Total Suspended Solids	280	83	79.3	52	30.8	23
P_FFBD_Sump	DIN	1.42	0.59	0.56	0.34	0.32	0.11
P_FFBD_Sump	Total Nitrogen	5.4	1.28	1.51	1.21	0.91	0.47
P_FFBD_Sump	Total Ammoniacal-N	1.18	0.38	0.329	0.23	0.094	0.064
P_FFBD_Sump	Nitrate-N + Nitrite-N	0.56	0.24	0.23	0.21	0.089	0.035
P_FFBD_Sump	Total Kjeldahl Nitrogen (TKN)	5.2	1.12	1.28	1.01	0.44	0.38
P_FFBD_Sump	DRP	0.07	0.043	0.0284	0.017	0.011	0.01
P_FFBD_Sump	Total Phosphorus	0.56	0.177	0.192	0.169	0.086	0.073
P_FFBD_Sump	Dissolved Arsenic	0.0025	0.000675	0.000838	0.0005	0.0005	0.0005
P_FFBD_Sump	Dissolved Copper	0.005	0.00228	0.00173	0.0012	0.000775	0.00025
P_FFBD_Sump	Dissolved Lead	0.0002	0.000065	0.0000763	0.00005	0.00005	0.00005
P_FFBD_Sump	Dissolved Zinc	0.104	0.055	0.0433	0.036	0.032	0.01
P_FFBD_Sump	Total Arsenic	0.00265	0.00195	0.00141	0.0014	0.00055	0.00055
P_FFBD_Sump	Total Copper	0.0183	0.00583	0.00645	0.0049	0.00415	0.0032
P_FFBD_Sump	Total Lead	0.0077	0.00468	0.00368	0.00305	0.00228	0.00142
P_FFBD_Sump	Total Zinc	0.28	0.103	0.0988	0.078	0.066	0.038
P_FFBD_Sump	Particulate Arsenic	0.0019	0.000925	0.000575	0.000225	0.00005	0.00005
P_FFBD_Sump	Particulate Copper	0.0133	0.00443	0.00472	0.00353	0.00298	0.0024
P_FFBD_Sump	Particulate Lead	0.0075	0.00461	0.0036	0.003	0.00223	0.00137
P_FFBD_Sump	Particulate Zinc	0.176	0.054	0.0554	0.041	0.038	0.006
P_FFBF	Turbidity	16.2	5.08	5.04	2.83	1.88	0.995
P_FFBF	Total Suspended Solids	33.5	14.4	11.5	5	4.19	2.25

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF	DIN	0.64	0.455	0.353	0.344	0.254	0.085
P_FFBF	Total Nitrogen	1.79	0.759	0.712	0.588	0.441	0.245
P_FFBF	Total Ammoniacal-N	0.415	0.215	0.156	0.116	0.0555	0.0365
P_FFBF	Nitrate-N + Nitrite-N	0.34	0.23	0.195	0.208	0.145	0.049
P_FFBF	Total Kjeldahl Nitrogen (TKN)	1.56	0.536	0.515	0.358	0.264	0.195
P_FFBF	DRP	0.0633	0.0318	0.0275	0.0243	0.0176	0.0085
P_FFBF	Total Phosphorus	0.144	0.117	0.0809	0.0638	0.0545	0.023
P_FFBF	Dissolved Arsenic	0.0015	0.00113	0.000938	0.00105	0.000625	0.0005
P_FFBF	Dissolved Copper	0.00265	0.00178	0.00159	0.00153	0.00126	0.00075
P_FFBF	Dissolved Lead	0.000145	0.00005	0.0000619	0.00005	0.00005	0.00005
P_FFBF	Dissolved Zinc	0.0415	0.0275	0.0216	0.0179	0.013	0.0095
P_FFBF	Total Arsenic	0.00175	0.00148	0.00113	0.0012	0.000713	0.00055
P_FFBF	Total Copper	0.0057	0.00314	0.00271	0.00258	0.00148	0.00104
P_FFBF	Total Lead	0.00305	0.00122	0.000996	0.000475	0.000349	0.000055
P_FFBF	Total Zinc	0.064	0.046	0.0337	0.0307	0.0195	0.0138
P_FFBF	Particulate Arsenic	0.00105	0.000275	0.000187	0.00005	-0.000071	-0.0002
P_FFBF	Particulate Copper	0.00305	0.00153	0.00112	0.000725	0.000286	0.0000833
P_FFBF	Particulate Lead	0.00291	0.00117	0.000934	0.000425	0.000299	0.000005
P_FFBF	Particulate Zinc	0.0309	0.0165	0.0121	0.00723	0.00564	0.00233
P_FFBF_FF	Turbidity	9.1	5.95	4.62	4	2.67	1.39
P_FFBF_FF	Total Suspended Solids	13	12.3	8	8	3.75	3
P_FFBF_FF	DIN	0.76	0.73	0.548	0.685	0.503	0.061
P_FFBF_FF	Total Nitrogen	1.39	1.14	0.915	0.975	0.755	0.32

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF_FF	Total Ammoniacal-N	0.35	0.238	0.151	0.117	0.0298	0.02
P_FFBF_FF	Nitrate-N + Nitrite-N	0.73	0.573	0.398	0.41	0.235	0.041
P_FFBF_FF	Total Kjeldahl Nitrogen (TKN)	0.87	0.668	0.52	0.465	0.318	0.28
P_FFBF_FF	DRP	0.162	0.0758	0.0635	0.0435	0.0313	0.005
P_FFBF_FF	Total Phosphorus	0.33	0.155	0.128	0.0795	0.0523	0.023
P_FFBF_FF	Dissolved Arsenic	0.002	0.0018	0.00137	0.0016	0.00105	0.0005
P_FFBF_FF	Dissolved Copper	0.003	0.0024	0.00178	0.0017	0.00108	0.0007
P_FFBF_FF	Dissolved Lead	0.00013	0.00009	0.0000767	0.00005	0.00005	0.00005
P_FFBF_FF	Dissolved Zinc	0.036	0.0285	0.0195	0.0181	0.00905	0.0059
P_FFBF_FF	Total Arsenic	0.0025	0.00235	0.00175	0.0022	0.00138	0.00055
P_FFBF_FF	Total Copper	0.0045	0.00355	0.00267	0.0026	0.00176	0.00092
P_FFBF_FF	Total Lead	0.00106	0.00099	0.000727	0.00092	0.00056	0.0002
P_FFBF_FF	Total Zinc	0.045	0.0413	0.0299	0.031	0.0196	0.0124
P_FFBF_FF	Particulate Arsenic	0.0006	0.00055	0.000383	0.0005	0.000275	0.00005
P_FFBF_FF	Particulate Copper	0.0015	0.00145	0.00104	0.0014	0.00081	0.00022
P_FFBF_FF	Particulate Lead	0.00093	0.0009	0.00065	0.00087	0.00051	0.00015
P_FFBF_FF	Particulate Zinc	0.019	0.0168	0.0104	0.0101	0.00358	0.0023
P_FFBF_Sump	Turbidity	42	18.7	17.3	11.7	10.4	9.1
P_FFBF_Sump	Total Suspended Solids	126	95	64.4	41	34	27
P_FFBF_Sump	DIN	1.74	0.8	0.652	0.61	0.21	0.092
P_FFBF_Sump	Total Nitrogen	11.5	2.7	2.84	1.57	1.44	0.7
P_FFBF_Sump	Total Ammoniacal-N	1.5	0.31	0.406	0.28	0.137	0.045
P_FFBF_Sump	Nitrate-N + Nitrite-N	0.6	0.33	0.246	0.25	0.048	0.025

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF_Sump	Total Kjeldahl Nitrogen (TKN)	11.2	2.4	2.6	1.46	0.84	0.62
P_FFBF_Sump	DRP	0.085	0.06	0.0382	0.036	0.011	0.007
P_FFBF_Sump	Total Phosphorus	0.54	0.22	0.23	0.177	0.163	0.114
P_FFBF_Sump	Dissolved Arsenic	0.0019	0.0005	0.000675	0.0005	0.0005	0.0005
P_FFBF_Sump	Dissolved Copper	0.0063	0.0023	0.00181	0.0017	0.00025	0.00025
P_FFBF_Sump	Dissolved Lead	0.00055	0.00018	0.000159	0.00005	0.00005	0.00005
P_FFBF_Sump	Dissolved Zinc	0.16	0.124	0.0741	0.058	0.035	0.023
P_FFBF_Sump	Total Arsenic	0.007	0.00253	0.00203	0.00113	0.00055	0.00055
P_FFBF_Sump	Total Copper	0.047	0.0147	0.0139	0.008	0.00398	0.0029
P_FFBF_Sump	Total Lead	0.029	0.0102	0.00719	0.0031	0.00198	0.0004
P_FFBF_Sump	Total Zinc	0.43	0.2	0.183	0.136	0.123	0.059
P_FFBF_Sump	Particulate Arsenic	0.0065	0.0015	0.00135	0.000275	0.00005	0.00005
P_FFBF_Sump	Particulate Copper	0.0453	0.0131	0.0122	0.0048	0.00329	0.0005
P_FFBF_Sump	Particulate Lead	0.029	0.01	0.00703	0.00305	0.00175	0.00035
P_FFBF_Sump	Particulate Zinc	0.395	0.084	0.109	0.065	0.03	-0.003
P_Int	Turbidity	6.87	2.58	2.47	2.23	1.07	0.105
P_Int	Total Suspended Solids	52.5	6.92	10.7	4.63	3	1.5
P_Int	DIN	0.088	0.0366	0.0273	0.0055	0.0055	0.0055
P_Int	Total Nitrogen	2.35	0.571	0.732	0.49	0.454	0.425
P_Int	Total Ammoniacal-N	0.0205	0.005	0.00694	0.005	0.005	0.005
P_Int	Nitrate-N + Nitrite-N	0.0805	0.023	0.0205	0.00125	0.001	0.001
P_Int	Total Kjeldahl Nitrogen (TKN)	2.3	0.569	0.715	0.49	0.441	0.385
P_Int	DRP	0.018	0.00438	0.00502	0.002	0.002	0.002

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_Int	Total Phosphorus	0.56	0.0474	0.1	0.034	0.0265	0.014
P_Int	Dissolved Arsenic	0.0021	0.00186	0.00163	0.00165	0.00143	0.0011
P_Int	Dissolved Copper	0.00065	0.000425	0.000344	0.00025	0.00025	0.00025
P_Int	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
P_Int	Dissolved Zinc	0.0046	0.00278	0.00219	0.00172	0.00135	0.00115
P_Int	Total Arsenic	0.0027	0.00223	0.00201	0.0019	0.00175	0.00155
P_Int	Total Copper	0.00182	0.000814	0.000761	0.000631	0.000519	0.000265
P_Int	Total Lead	0.00175	0.000263	0.000348	0.000121	0.0000831	0.000055
P_Int	Total Zinc	0.026	0.00524	0.00681	0.0047	0.00303	0.00235
P_Int	Particulate Arsenic	0.0016	0.000217	0.000383	0.0002	0.00015	0.00015
P_Int	Particulate Copper	0.00117	0.000494	0.000417	0.00031	0.000183	0.000015
P_Int	Particulate Lead	0.0017	0.000213	0.000298	0.0000713	0.0000331	0.000005
P_Int	Particulate Zinc	0.0247	0.00325	0.00462	0.0018	0.0011	0.0002
P_Outlet	Turbidity	4.5	2.52	2.29	2.15	1.8	0.765
P_Outlet	Total Suspended Solids	49	15.5	14.2	5	3.25	2.25
P_Outlet	DIN	0.0653	0.0135	0.0161	0.0055	0.0055	0.0055
P_Outlet	Total Nitrogen	2.2	0.715	0.757	0.57	0.44	0.4
P_Outlet	Total Ammoniacal-N	0.019	0.005	0.00739	0.005	0.005	0.005
P_Outlet	Nitrate-N + Nitrite-N	0.0467	0.0135	0.0105	0.002	0.001	0.001
P_Outlet	Total Kjeldahl Nitrogen (TKN)	2.2	0.715	0.747	0.565	0.435	0.375
P_Outlet	DRP	0.019	0.002	0.00389	0.002	0.002	0.002
P_Outlet	Total Phosphorus	0.285	0.0387	0.0619	0.037	0.033	0.016
P_Outlet	Dissolved Arsenic	0.0024	0.00226	0.00194	0.00188	0.00164	0.00155

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_Outlet	Dissolved Copper	0.000375	0.00025	0.000264	0.00025	0.00025	0.00025
P_Outlet	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
P_Outlet	Dissolved Zinc	0.00775	0.0012	0.00166	0.0009	0.000517	0.0005
P_Outlet	Total Arsenic	0.0061	0.00255	0.00273	0.00245	0.00214	0.00165
P_Outlet	Total Copper	0.00202	0.00078	0.000609	0.000265	0.000265	0.000265
P_Outlet	Total Lead	0.00172	0.000205	0.000338	0.00019	0.00015	0.000055
P_Outlet	Total Zinc	0.011	0.0057	0.00413	0.0028	0.00175	0.0011
P_Outlet	Particulate Arsenic	0.0045	0.000413	0.00079	0.000283	0.00015	0.0001
P_Outlet	Particulate Copper	0.00164	0.00053	0.000346	0.000015	0.000015	0.000015
P_Outlet	Particulate Lead	0.00167	0.000155	0.000288	0.00014	0.0001	0.000005
P_Outlet	Particulate Zinc	0.0101	0.00255	0.00247	0.001	0.00085	0.0006

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBD_Sump	Turbidity	87	13.6	19.3	7.8	4.65	3.7
P_FFBD_Sump	Total Suspended Solids	280	83	79.3	52	30.8	23
P_FFBD_Sump	DIN	1.42	0.59	0.56	0.34	0.32	0.11
P_FFBD_Sump	Total Nitrogen	5.4	1.28	1.51	1.21	0.91	0.47
P_FFBD_Sump	Total Ammoniacal-N	1.18	0.38	0.329	0.23	0.094	0.064
P_FFBD_Sump	Nitrate-N + Nitrite-N	0.56	0.24	0.23	0.21	0.089	0.035
P_FFBD_Sump	Total Kjeldahl Nitrogen (TKN)	5.2	1.12	1.28	1.01	0.44	0.38
P_FFBD_Sump	DRP	0.07	0.043	0.0284	0.017	0.011	0.01
P_FFBD_Sump	Total Phosphorus	0.56	0.177	0.192	0.169	0.086	0.073
P_FFBD_Sump	Dissolved Arsenic	0.0025	0.000675	0.000838	0.0005	0.0005	0.0005
P_FFBD_Sump	Dissolved Copper	0.005	0.00228	0.00173	0.0012	0.000775	0.00025
P_FFBD_Sump	Dissolved Lead	0.0002	0.000065	0.0000763	0.00005	0.00005	0.00005
P_FFBD_Sump	Dissolved Zinc	0.104	0.055	0.0433	0.036	0.032	0.01
P_FFBD_Sump	Total Arsenic	0.00265	0.00195	0.00141	0.0014	0.00055	0.00055
P_FFBD_Sump	Total Copper	0.0183	0.00583	0.00645	0.0049	0.00415	0.0032
P_FFBD_Sump	Total Lead	0.0077	0.00468	0.00368	0.00305	0.00228	0.00142
P_FFBD_Sump	Total Zinc	0.28	0.103	0.0988	0.078	0.066	0.038
P_FFBD_Sump	Particulate Arsenic	0.0019	0.000925	0.000575	0.000225	0.00005	0.00005
P_FFBD_Sump	Particulate Copper	0.0133	0.00443	0.00472	0.00353	0.00298	0.0024
P_FFBD_Sump	Particulate Lead	0.0075	0.00461	0.0036	0.003	0.00223	0.00137
P_FFBD_Sump	Particulate Zinc	0.176	0.054	0.0554	0.041	0.038	0.006
P_FFBF	Turbidity	16.2	5.08	5.04	2.83	1.88	0.995
P_FFBF	Total Suspended Solids	33.5	14.4	11.5	5	4.19	2.25

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF	DIN	0.64	0.455	0.353	0.344	0.254	0.085
P_FFBF	Total Nitrogen	1.79	0.759	0.712	0.588	0.441	0.245
P_FFBF	Total Ammoniacal-N	0.415	0.215	0.156	0.116	0.0555	0.0365
P_FFBF	Nitrate-N + Nitrite-N	0.34	0.23	0.195	0.208	0.145	0.049
P_FFBF	Total Kjeldahl Nitrogen (TKN)	1.56	0.536	0.515	0.358	0.264	0.195
P_FFBF	DRP	0.0633	0.0318	0.0275	0.0243	0.0176	0.0085
P_FFBF	Total Phosphorus	0.144	0.117	0.0809	0.0638	0.0545	0.023
P_FFBF	Dissolved Arsenic	0.0015	0.00113	0.000938	0.00105	0.000625	0.0005
P_FFBF	Dissolved Copper	0.00265	0.00178	0.00159	0.00153	0.00126	0.00075
P_FFBF	Dissolved Lead	0.000145	0.00005	0.0000619	0.00005	0.00005	0.00005
P_FFBF	Dissolved Zinc	0.0415	0.0275	0.0216	0.0179	0.013	0.0095
P_FFBF	Total Arsenic	0.00175	0.00148	0.00113	0.0012	0.000713	0.00055
P_FFBF	Total Copper	0.0057	0.00314	0.00271	0.00258	0.00148	0.00104
P_FFBF	Total Lead	0.00305	0.00122	0.000996	0.000475	0.000349	0.000055
P_FFBF	Total Zinc	0.064	0.046	0.0337	0.0307	0.0195	0.0138
P_FFBF	Particulate Arsenic	0.00105	0.000275	0.000187	0.00005	-0.000071	-0.0002
P_FFBF	Particulate Copper	0.00305	0.00153	0.00112	0.000725	0.000286	0.0000833
P_FFBF	Particulate Lead	0.00291	0.00117	0.000934	0.000425	0.000299	0.000005
P_FFBF	Particulate Zinc	0.0309	0.0165	0.0121	0.00723	0.00564	0.00233
P_FFBF_FF	Turbidity	9.1	5.95	4.62	4	2.67	1.39
P_FFBF_FF	Total Suspended Solids	13	12.3	8	8	3.75	3
P_FFBF_FF	DIN	0.76	0.73	0.548	0.685	0.503	0.061
P_FFBF_FF	Total Nitrogen	1.39	1.14	0.915	0.975	0.755	0.32

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF_FF	Total Ammoniacal-N	0.35	0.238	0.151	0.117	0.0298	0.02
P_FFBF_FF	Nitrate-N + Nitrite-N	0.73	0.573	0.398	0.41	0.235	0.041
P_FFBF_FF	Total Kjeldahl Nitrogen (TKN)	0.87	0.668	0.52	0.465	0.318	0.28
P_FFBF_FF	DRP	0.162	0.0758	0.0635	0.0435	0.0313	0.005
P_FFBF_FF	Total Phosphorus	0.33	0.155	0.128	0.0795	0.0523	0.023
P_FFBF_FF	Dissolved Arsenic	0.002	0.0018	0.00137	0.0016	0.00105	0.0005
P_FFBF_FF	Dissolved Copper	0.003	0.0024	0.00178	0.0017	0.00108	0.0007
P_FFBF_FF	Dissolved Lead	0.00013	0.00009	0.0000767	0.00005	0.00005	0.00005
P_FFBF_FF	Dissolved Zinc	0.036	0.0285	0.0195	0.0181	0.00905	0.0059
P_FFBF_FF	Total Arsenic	0.0025	0.00235	0.00175	0.0022	0.00138	0.00055
P_FFBF_FF	Total Copper	0.0045	0.00355	0.00267	0.0026	0.00176	0.00092
P_FFBF_FF	Total Lead	0.00106	0.00099	0.000727	0.00092	0.00056	0.0002
P_FFBF_FF	Total Zinc	0.045	0.0413	0.0299	0.031	0.0196	0.0124
P_FFBF_FF	Particulate Arsenic	0.0006	0.00055	0.000383	0.0005	0.000275	0.00005
P_FFBF_FF	Particulate Copper	0.0015	0.00145	0.00104	0.0014	0.00081	0.00022
P_FFBF_FF	Particulate Lead	0.00093	0.0009	0.00065	0.00087	0.00051	0.00015
P_FFBF_FF	Particulate Zinc	0.019	0.0168	0.0104	0.0101	0.00358	0.0023
P_FFBF_Sump	Turbidity	42	18.7	17.3	11.7	10.4	9.1
P_FFBF_Sump	Total Suspended Solids	126	95	64.4	41	34	27
P_FFBF_Sump	DIN	1.74	0.8	0.652	0.61	0.21	0.092
P_FFBF_Sump	Total Nitrogen	11.5	2.7	2.84	1.57	1.44	0.7
P_FFBF_Sump	Total Ammoniacal-N	1.5	0.31	0.406	0.28	0.137	0.045
P_FFBF_Sump	Nitrate-N + Nitrite-N	0.6	0.33	0.246	0.25	0.048	0.025

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_FFBF_Sump	Total Kjeldahl Nitrogen (TKN)	11.2	2.4	2.6	1.46	0.84	0.62
P_FFBF_Sump	DRP	0.085	0.06	0.0382	0.036	0.011	0.007
P_FFBF_Sump	Total Phosphorus	0.54	0.22	0.23	0.177	0.163	0.114
P_FFBF_Sump	Dissolved Arsenic	0.0019	0.0005	0.000675	0.0005	0.0005	0.0005
P_FFBF_Sump	Dissolved Copper	0.0063	0.0023	0.00181	0.0017	0.00025	0.00025
P_FFBF_Sump	Dissolved Lead	0.00055	0.00018	0.000159	0.00005	0.00005	0.00005
P_FFBF_Sump	Dissolved Zinc	0.16	0.124	0.0741	0.058	0.035	0.023
P_FFBF_Sump	Total Arsenic	0.007	0.00253	0.00203	0.00113	0.00055	0.00055
P_FFBF_Sump	Total Copper	0.047	0.0147	0.0139	0.008	0.00398	0.0029
P_FFBF_Sump	Total Lead	0.029	0.0102	0.00719	0.0031	0.00198	0.0004
P_FFBF_Sump	Total Zinc	0.43	0.2	0.183	0.136	0.123	0.059
P_FFBF_Sump	Particulate Arsenic	0.0065	0.0015	0.00135	0.000275	0.00005	0.00005
P_FFBF_Sump	Particulate Copper	0.0453	0.0131	0.0122	0.0048	0.00329	0.0005
P_FFBF_Sump	Particulate Lead	0.029	0.01	0.00703	0.00305	0.00175	0.00035
P_FFBF_Sump	Particulate Zinc	0.395	0.084	0.109	0.065	0.03	-0.003
P_Int	Turbidity	6.87	2.58	2.47	2.23	1.07	0.105
P_Int	Total Suspended Solids	52.5	6.92	10.7	4.63	3	1.5
P_Int	DIN	0.088	0.0366	0.0273	0.0055	0.0055	0.0055
P_Int	Total Nitrogen	2.35	0.571	0.732	0.49	0.454	0.425
P_Int	Total Ammoniacal-N	0.0205	0.005	0.00694	0.005	0.005	0.005
P_Int	Nitrate-N + Nitrite-N	0.0805	0.023	0.0205	0.00125	0.001	0.001
P_Int	Total Kjeldahl Nitrogen (TKN)	2.3	0.569	0.715	0.49	0.441	0.385
P_Int	DRP	0.018	0.00438	0.00502	0.002	0.002	0.002

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_Int	Total Phosphorus	0.56	0.0474	0.1	0.034	0.0265	0.014
P_Int	Dissolved Arsenic	0.0021	0.00186	0.00163	0.00165	0.00143	0.0011
P_Int	Dissolved Copper	0.00065	0.000425	0.000344	0.00025	0.00025	0.00025
P_Int	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
P_Int	Dissolved Zinc	0.0046	0.00278	0.00219	0.00172	0.00135	0.00115
P_Int	Total Arsenic	0.0027	0.00223	0.00201	0.0019	0.00175	0.00155
P_Int	Total Copper	0.00182	0.000814	0.000761	0.000631	0.000519	0.000265
P_Int	Total Lead	0.00175	0.000263	0.000348	0.000121	0.0000831	0.000055
P_Int	Total Zinc	0.026	0.00524	0.00681	0.0047	0.00303	0.00235
P_Int	Particulate Arsenic	0.0016	0.000217	0.000383	0.0002	0.00015	0.00015
P_Int	Particulate Copper	0.00117	0.000494	0.000417	0.00031	0.000183	0.000015
P_Int	Particulate Lead	0.0017	0.000213	0.000298	0.0000713	0.0000331	0.000005
P_Int	Particulate Zinc	0.0247	0.00325	0.00462	0.0018	0.0011	0.0002
P_Outlet	Turbidity	4.5	2.52	2.29	2.15	1.8	0.765
P_Outlet	Total Suspended Solids	49	15.5	14.2	5	3.25	2.25
P_Outlet	DIN	0.0653	0.0135	0.0161	0.0055	0.0055	0.0055
P_Outlet	Total Nitrogen	2.2	0.715	0.757	0.57	0.44	0.4
P_Outlet	Total Ammoniacal-N	0.019	0.005	0.00739	0.005	0.005	0.005
P_Outlet	Nitrate-N + Nitrite-N	0.0467	0.0135	0.0105	0.002	0.001	0.001
P_Outlet	Total Kjeldahl Nitrogen (TKN)	2.2	0.715	0.747	0.565	0.435	0.375
P_Outlet	DRP	0.019	0.002	0.00389	0.002	0.002	0.002
P_Outlet	Total Phosphorus	0.285	0.0387	0.0619	0.037	0.033	0.016
P_Outlet	Dissolved Arsenic	0.0024	0.00226	0.00194	0.00188	0.00164	0.00155

Table C2. Prestons Stormwater Sampling Results							
Site	**Analyte**	**Maximum (g/m^3)**	**75th Percentile (g/m^3)**	**Mean (g/m^3)**	**Median (g/m^3)**	**25th Percentile (g/m^3)**	**Minimum (g/m^3)**
P_Outlet	Dissolved Copper	0.000375	0.00025	0.000264	0.00025	0.00025	0.00025
P_Outlet	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
P_Outlet	Dissolved Zinc	0.00775	0.0012	0.00166	0.0009	0.000517	0.0005
P_Outlet	Total Arsenic	0.0061	0.00255	0.00273	0.00245	0.00214	0.00165
P_Outlet	Total Copper	0.00202	0.00078	0.000609	0.000265	0.000265	0.000265
P_Outlet	Total Lead	0.00172	0.000205	0.000338	0.00019	0.00015	0.000055
P_Outlet	Total Zinc	0.011	0.0057	0.00413	0.0028	0.00175	0.0011
P_Outlet	Particulate Arsenic	0.0045	0.000413	0.00079	0.000283	0.00015	0.0001
P_Outlet	Particulate Copper	0.00164	0.00053	0.000346	0.000015	0.000015	0.000015
P_Outlet	Particulate Lead	0.00167	0.000155	0.000288	0.00014	0.0001	0.000005
P_Outlet	Particulate Zinc	0.0101	0.00255	0.00247	0.001	0.00085	0.0006

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFB	Turbidity	3.55	3.14	2.33	2.5	1.69	0.765
K_FFB	Total Suspended Solids	5	4	2.95	2.75	1.5	1.5
K_FFB	DIN	0.32	0.245	0.217	0.196	0.183	0.143
K_FFB	Total Nitrogen	1.07	0.61	0.52	0.4	0.315	0.205
K_FFB	Total Ammoniacal-N	0.185	0.126	0.101	0.108	0.0735	0.011
K_FFB	Nitrate-N + Nitrite-N	0.172	0.14	0.118	0.139	0.072	0.0695
K_FFB	Total Kjeldahl Nitrogen (TKN)	0.885	0.47	0.399	0.26	0.245	0.135
K_FFB	DRP	0.0185	0.0105	0.0073	0.0035	0.002	0.002
K_FFB	Total Phosphorus	0.051	0.036	0.0354	0.033	0.03	0.027
K_FFB	Dissolved Arsenic	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
K_FFB	Dissolved Copper	0.00115	0.0011	0.00082	0.0007	0.0006	0.00055
K_FFB	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFB	Dissolved Zinc	0.057	0.039	0.0306	0.0225	0.0178	0.0169
K_FFB	Total Arsenic	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055
K_FFB	Total Copper	0.0022	0.00171	0.00144	0.00142	0.00099	0.00089
K_FFB	Total Lead	0.00041	0.00036	0.000256	0.00028	0.000175	0.000055
K_FFB	Total Zinc	0.07	0.045	0.036	0.0255	0.0201	0.0193
K_FFB	Particulate Arsenic	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFB	Particulate Copper	0.0011	0.00072	0.000622	0.00056	0.00044	0.00029
K_FFB	Particulate Lead	0.00036	0.00031	0.000206	0.00023	0.000125	0.000005
K_FFB	Particulate Zinc	0.013	0.006	0.00532	0.003	0.00235	0.00223
K_FFB_Sump	Turbidity	25	20.2	16.5	16.3	12.9	8.2

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFB_Sump	Total Suspended Solids	175	154	91.4	79	42	15
K_FFB_Sump	DIN	2.2	1.47	0.908	0.64	0.32	0.096
K_FFB_Sump	Total Nitrogen	5.6	2.4	2.03	1.33	1.18	0.66
K_FFB_Sump	Total Ammoniacal-N	1.76	1	0.672	0.49	0.196	0.078
K_FFB_Sump	Nitrate-N + Nitrite-N	0.46	0.43	0.234	0.185	0.151	0.018
K_FFB_Sump	Total Kjeldahl Nitrogen (TKN)	5.2	1.95	1.8	1.27	1.03	0.64
K_FFB_Sump	DRP	0.137	0.039	0.0416	0.018	0.014	0.012
K_FFB_Sump	Total Phosphorus	0.51	0.47	0.258	0.173	0.136	0.053
K_FFB_Sump	Dissolved Arsenic	0.0017	0.0014	0.001	0.0009	0.0005	0.0005
K_FFB_Sump	Dissolved Copper	0.0061	0.0042	0.00281	0.0018	0.0013	0.0009
K_FFB_Sump	Dissolved Lead	0.0002	0.0000825	0.000085	0.00005	0.00005	0.00005
K_FFB_Sump	Dissolved Zinc	0.152	0.06	0.0516	0.036	0.028	0.0158
K_FFB_Sump	Total Arsenic	0.0029	0.00238	0.00196	0.0022	0.00179	0.00055
K_FFB_Sump	Total Copper	0.0153	0.0109	0.00791	0.0073	0.00468	0.0022
K_FFB_Sump	Total Lead	0.0141	0.00528	0.00472	0.00415	0.00206	0.00027
K_FFB_Sump	Total Zinc	0.23	0.168	0.11	0.086	0.055	0.025
K_FFB_Sump	Particulate Arsenic	0.0017	0.00133	0.000963	0.00105	0.000688	0.00005
K_FFB_Sump	Particulate Copper	0.0135	0.00625	0.0051	0.00505	0.00195	0.0008
K_FFB_Sump	Particulate Lead	0.0141	0.00511	0.00464	0.00404	0.00201	0.00022
K_FFB_Sump	Particulate Zinc	0.179	0.068	0.0582	0.0552	0.026	0.0053
K_FFSwale	Turbidity	8.25	4.28	4.29	3.83	3.3	2.8
K_FFSwale	Total Suspended Solids	23	9.5	8.45	5	4	1.5

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFSwale	DIN	1.27	0.573	0.466	0.405	0.215	0.155
K_FFSwale	Total Nitrogen	2.3	1.19	0.987	0.715	0.525	0.28
K_FFSwale	Total Ammoniacal-N	1.14	0.343	0.298	0.2	0.112	0.0745
K_FFSwale	Nitrate-N + Nitrite-N	0.31	0.23	0.166	0.137	0.0995	0.0645
K_FFSwale	Total Kjeldahl Nitrogen (TKN)	2.1	0.955	0.818	0.583	0.42	0.215
K_FFSwale	DRP	0.22	0.09	0.0845	0.0765	0.06	0.021
K_FFSwale	Total Phosphorus	0.31	0.192	0.153	0.124	0.104	0.047
K_FFSwale	Dissolved Arsenic	0.00115	0.000663	0.000663	0.0005	0.0005	0.0005
K_FFSwale	Dissolved Copper	0.0032	0.0021	0.00166	0.00115	0.0011	0.00105
K_FFSwale	Dissolved Lead	0.000315	0.00015	0.000128	0.00005	0.00005	0.00005
K_FFSwale	Dissolved Zinc	0.0315	0.0148	0.0156	0.0131	0.0114	0.00545
K_FFSwale	Total Arsenic	0.00135	0.00116	0.000888	0.000825	0.00055	0.00055
K_FFSwale	Total Copper	0.00445	0.00305	0.00229	0.00157	0.00118	0.00115
K_FFSwale	Total Lead	0.00164	0.000755	0.000637	0.00034	0.000245	0.0000875
K_FFSwale	Total Zinc	0.046	0.0225	0.0219	0.0179	0.0136	0.00685
K_FFSwale	Particulate Arsenic	0.0006	0.0003	0.000225	0.000125	0.00005	0.00005
K_FFSwale	Particulate Copper	0.0015	0.001	0.000625	0.00047	0.00012	0.00008
K_FFSwale	Particulate Lead	0.00136	0.000465	0.00051	0.00029	0.000195	0.0000375
K_FFSwale	Particulate Zinc	0.016	0.00945	0.00639	0.00443	0.00215	0.0014
K_FFSwale_FF	Turbidity	5.3	4.75	4.23	4.2	3.7	3.2
K_FFSwale_FF	Total Suspended Solids	12	11	10	10	9	8
K_FFSwale_FF	DIN	1.92	1.19	0.89	0.45	0.375	0.3

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_FFSwale_FF	Total Nitrogen	2.8	1.78	1.42	0.76	0.725	0.69
K_FFSwale_FF	Total Ammoniacal-N	1.02	0.572	0.42	0.123	0.12	0.117
K_FFSwale_FF	Nitrate-N + Nitrite-N	0.89	0.61	0.469	0.33	0.259	0.187
K_FFSwale_FF	Total Kjeldahl Nitrogen (TKN)	1.89	1.23	0.94	0.57	0.465	0.36
K_FFSwale_FF	DRP	0.26	0.147	0.105	0.033	0.028	0.023
K_FFSwale_FF	Total Phosphorus	0.38	0.232	0.175	0.083	0.0725	0.062
K_FFSwale_FF	Dissolved Arsenic	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
K_FFSwale_FF	Dissolved Copper	0.0028	0.0021	0.0018	0.0014	0.0013	0.0012
K_FFSwale_FF	Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFSwale_FF	Dissolved Zinc	0.028	0.023	0.0205	0.018	0.0167	0.0154
K_FFSwale_FF	Total Arsenic	0.00055	0.00055	0.00055	0.00055	0.00055	0.00055
K_FFSwale_FF	Total Copper	0.0036	0.00314	0.00268	0.00268	0.00222	0.00176
K_FFSwale_FF	Total Lead	0.00053	0.000493	0.000455	0.000455	0.000418	0.00038
K_FFSwale_FF	Total Zinc	0.043	0.037	0.0312	0.031	0.0253	0.0196
K_FFSwale_FF	Particulate Arsenic	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
K_FFSwale_FF	Particulate Copper	0.0008	0.00069	0.00058	0.00058	0.00047	0.00036
K_FFSwale_FF	Particulate Lead	0.00048	0.000443	0.000405	0.000405	0.000368	0.00033
K_FFSwale_FF	Particulate Zinc	0.015	0.014	0.0107	0.013	0.0086	0.0042
K_Int	Turbidity	13.5	8.88	6.46	4.43	3.28	3.2
K_Int	Total Suspended Solids	20	18.5	10.4	8.25	3.88	1.5
K_Int	DIN	0.835	0.403	0.37	0.268	0.244	0.0745
K_Int	Total Nitrogen	1.8	0.933	0.808	0.646	0.454	0.37

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_Int	Total Ammoniacal-N	0.445	0.214	0.179	0.122	0.0916	0.062
K_Int	Nitrate-N + Nitrite-N	0.39	0.249	0.189	0.146	0.128	0.0065
K_Int	Total Kjeldahl Nitrogen (TKN)	1.41	0.834	0.619	0.498	0.306	0.23
K_Int	DRP	0.0955	0.0798	0.0597	0.0535	0.0358	0.035
K_Int	Total Phosphorus	0.189	0.157	0.128	0.136	0.1	0.0625
K_Int	Dissolved Arsenic	0.00135	0.00135	0.00109	0.00125	0.000988	0.0005
K_Int	Dissolved Copper	0.0025	0.00148	0.00141	0.00122	0.00111	0.00105
K_Int	Dissolved Lead	0.000235	0.000138	0.000104	0.000085	0.00005	0.00005
K_Int	Dissolved Zinc	0.03	0.0168	0.0159	0.015	0.0124	0.0083
K_Int	Total Arsenic	0.0017	0.0017	0.0014	0.00168	0.00138	0.00055
K_Int	Total Copper	0.0036	0.00245	0.00199	0.00164	0.00145	0.00128
K_Int	Total Lead	0.00143	0.0011	0.000676	0.000559	0.000296	0.00013
K_Int	Total Zinc	0.0495	0.0269	0.0248	0.0195	0.0171	0.0162
K_Int	Particulate Arsenic	0.00055	0.0004	0.000313	0.000325	0.000238	0.00005
K_Int	Particulate Copper	0.0011	0.000825	0.000577	0.000502	0.000291	0.000147
K_Int	Particulate Lead	0.0012	0.000973	0.000572	0.000462	0.000246	0.00008
K_Int	Particulate Zinc	0.0195	0.0143	0.00883	0.00745	0.00292	0.0019
K_Outlet	Turbidity	9.55	4.18	3.9	2.83	2.45	1.68
K_Outlet	Total Suspended Solids	12	8.5	5.5	5	2.25	1.5
K_Outlet	DIN	1.12	0.205	0.263	0.163	0.085	0.065
K_Outlet	Total Nitrogen	1.68	0.99	0.881	0.87	0.56	0.485
K_Outlet	Total Ammoniacal-N	0.174	0.145	0.0905	0.094	0.0395	0.0305

Table C1. Knights Stormwater Sampling Results							
Site	Analyte	Maximum (g/m^3)	75th Percentile (g/m^3)	Mean (g/m^3)	Median (g/m^3)	25th Percentile (g/m^3)	Minimum (g/m^3)
K_Outlet	Nitrate-N + Nitrite-N	0.97	0.158	0.172	0.061	0.046	0.0055
K_Outlet	Total Kjeldahl Nitrogen (TKN)	1.17	0.8	0.709	0.705	0.51	0.44
K_Outlet	DRP	0.31	0.2	0.152	0.166	0.05	0.034
K_Outlet	Total Phosphorus	0.39	0.295	0.235	0.235	0.158	0.089
K_Outlet	Dissolved Arsenic	0.0022	0.00164	0.00116	0.000975	0.0005	0.0005
K_Outlet	Dissolved Copper	0.0022	0.00175	0.00148	0.0014	0.00125	0.001
K_Outlet	Dissolved Lead	0.000255	0.00016	0.000105	0.00005	0.00005	0.00005
K_Outlet	Dissolved Zinc	0.173	0.0115	0.0265	0.0098	0.0051	0.00397
K_Outlet	Total Arsenic	0.0022	0.00179	0.00124	0.0011	0.00055	0.00055
K_Outlet	Total Copper	0.0031	0.00235	0.00187	0.00154	0.00147	0.0011
K_Outlet	Total Lead	0.00116	0.00073	0.000442	0.000345	0.000135	0.000055
K_Outlet	Total Zinc	0.182	0.0159	0.0303	0.0146	0.00595	0.0045
K_Outlet	Particulate Arsenic	0.0002	0.0000875	0.000075	0.00005	0.0000375	0
K_Outlet	Particulate Copper	0.0009	0.0006	0.000384	0.000235	0.000137	0.000085
K_Outlet	Particulate Lead	0.0009	0.00057	0.000337	0.000295	0.000085	0.000005
K_Outlet	Particulate Zinc	0.0085	0.00605	0.00389	0.00385	0.0009	0.000533

Appendix D: Stage 3 Raw Laboratory Data

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2054550	SUPv1
Contact:	I Cooper	**Date Received:**	25-Sep-2018	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	02-Oct-2018	
	PO Box 389	**Quote No:**	92232	
	Christchurch 8140	**Order No:**		
		Client Reference:	C03816300	
		Submitted By:	I Cooper	

Sample Type: Aqueous

Sample Name:		P_FFBF_1 25-Sep-2018 12:00 pm	P_FFBF_2 25-Sep-2018 12:00 pm	k_FFSwale_1 25-Sep-2018 3:00 pm	k_FFSwale_2 25-Sep-2018 3:00 pm
Lab Number:		2054550.1	2054550.2	2054550.4	2054550.5
Individual Tests					
Total Suspended Solids	g/m³	30.6 ± 6.5	27.8 ± 5.9	22.2 ± 4.9	23.6 ± 5.1
Dissolved Inorganic Nitrogen*	g/m³	0.668 ± 0.043	0.605 ± 0.039	0.695 ± 0.045	0.694 ± 0.045
Total Nitrogen	g/m³	1.90 ± 0.12	1.67 ± 0.11	2.02 ± 0.12	2.13 ± 0.12
Total Ammoniacal-N	g/m³	0.437 ± 0.037	0.388 ± 0.033	0.384 ± 0.032	0.380 ± 0.032
Nitrate-N + Nitrite-N	g/m³	0.232 ± 0.024	0.218 ± 0.022	0.310 ± 0.032	0.314 ± 0.032
Total Kjeldahl Nitrogen (TKN)	g/m³	1.66 ± 0.11	1.45 ± 0.11	1.71 ± 0.12	1.82 ± 0.12
Dissolved Reactive Phosphorus	g/m³	0.0300 ± 0.0043	0.0312 ± 0.0044	0.105 ± 0.013	0.104 ± 0.012
Total Phosphorus	g/m³	0.140 ± 0.020	0.146 ± 0.021	0.276 ± 0.039	0.282 ± 0.040
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00116 ± 0.00067	0.00101 ± 0.00067	0.00109 ± 0.00067	0.00116 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00272 ± 0.00042	0.00257 ± 0.00041	0.00313 ± 0.00044	0.00330 ± 0.00045
Dissolved Lead	g/m³	0.000149 ± 0.000068	0.000139 ± 0.000067	0.000310 ± 0.000070	0.000300 ± 0.000070
Dissolved Nickel	g/m³	0.00086 ± 0.00034	0.00057 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Zinc	g/m³	0.0358 ± 0.0034	0.0376 ± 0.0036	0.0313 ± 0.0030	0.0318 ± 0.0031
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00136 ± 0.00074	0.00145 ± 0.00074	0.00145 ± 0.00074	0.00126 ± 0.00074
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	0.000066 ± 0.000036	0.000062 ± 0.000036
Total Chromium	g/m³	0.00095 ± 0.00036	0.00126 ± 0.00037	0.00068 ± 0.00036	0.00100 ± 0.00036
Total Copper	g/m³	0.00598 ± 0.00070	0.00542 ± 0.00065	0.00405 ± 0.00054	0.00491 ± 0.00061
Total Lead	g/m³	0.00321 ± 0.00021	0.00295 ± 0.00020	0.00163 ± 0.00013	0.00165 ± 0.00013
Total Nickel	g/m³	0.00132 ± 0.00039	0.00136 ± 0.00039	0.00088 ± 0.00037	0.00112 ± 0.00038
Total Zinc	g/m³	0.0647 ± 0.0053	0.0634 ± 0.0052	0.0447 ± 0.0037	0.0472 ± 0.0039

Sample Name:		P_FFBF_Sump_1 25-Sep-2018 11:00 am	P_FFBD_Sump_1 25-Sep-2018 11:00 am	K_FFSump_1 25-Sep-2018 9:30 am	K_Int_1 25-Sep-2018 4:00 pm
Lab Number:		2054550.7	2054550.8	2054550.9	2054550.10
Individual Tests					
Total Suspended Solids	g/m³	26.9 ± 5.8	279 ± 56	107 ± 22	19.8 ± 4.4
Dissolved Inorganic Nitrogen*	g/m³	1.74 ± 0.13	1.419 ± 0.099	2.19 ± 0.15	0.834 ± 0.054
Total Nitrogen	g/m³	11.49 ± 0.59	5.44 ± 0.28	5.59 ± 0.28	1.72 ± 0.11
Total Ammoniacal-N	g/m³	1.50 ± 0.13	1.181 ± 0.096	1.76 ± 0.15	0.442 ± 0.037
Nitrate-N + Nitrite-N	g/m³	0.247 ± 0.025	0.238 ± 0.024	0.428 ± 0.043	0.392 ± 0.040
Total Kjeldahl Nitrogen (TKN)	g/m³	11.24 ± 0.59	5.21 ± 0.28	5.16 ± 0.28	1.328 ± 0.096
Dissolved Reactive Phosphorus	g/m³	0.0851 ± 0.0099	0.0105 ± 0.0029	0.088 ± 0.011	0.0351 ± 0.0048
Total Phosphorus	g/m³	0.539 ± 0.076	0.562 ± 0.079	0.471 ± 0.066	0.148 ± 0.021

Sample Type: Aqueous					
Sample Name:		P_FFBF_Sump_1 25-Sep-2018 11:00 am	P_FFBD_Sump_1 25-Sep-2018 11:00 am	K_FFSump_1 25-Sep-2018 9:30 am	K_Int_1 25-Sep-2018 4:00 pm
Lab Number:		2054550.7	2054550.8	2054550.9	2054550.10
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00194 ± 0.00068	< 0.0010 ± 0.00067	0.00173 ± 0.00068	0.00125 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	0.00066 ± 0.00034	< 0.0005 ± 0.00034	0.00059 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00631 ± 0.00067	0.00503 ± 0.00057	0.00612 ± 0.00065	0.00240 ± 0.00040
Dissolved Lead	g/m³	0.000553 ± 0.000077	0.000199 ± 0.000068	0.000175 ± 0.000068	0.000238 ± 0.000069
Dissolved Nickel	g/m³	0.00284 ± 0.00035	0.00221 ± 0.00035	0.00201 ± 0.00035	0.00067 ± 0.00034
Dissolved Zinc	g/m³	0.0485 ± 0.0046	0.1036 ± 0.0097	0.152 ± 0.015	0.0208 ± 0.0021
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00241 ± 0.00075	0.00237 ± 0.00075	0.00292 ± 0.00076	0.00170 ± 0.00074
Total Cadmium	g/m³	0.000083 ± 0.000036	0.000099 ± 0.000036	0.000080 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	0.00130 ± 0.00037	0.00378 ± 0.00047	0.00243 ± 0.00041	0.00082 ± 0.00036
Total Copper	g/m³	0.0103 ± 0.0011	0.0183 ± 0.0019	0.0131 ± 0.0014	0.00344 ± 0.00050
Total Lead	g/m³	0.00234 ± 0.00016	0.00770 ± 0.00047	0.00370 ± 0.00024	0.00127 ± 0.00011
Total Nickel	g/m³	0.00333 ± 0.00053	0.00445 ± 0.00064	0.00348 ± 0.00055	0.00101 ± 0.00037
Total Zinc	g/m³	0.133 ± 0.011	0.276 ± 0.023	0.220 ± 0.018	0.0348 ± 0.0029

Sample Name:		K_Int_2 25-Sep-2018 4:00 pm			
Lab Number:		2054550.11			
Individual Tests					
Total Suspended Solids	g/m³	19.9 ± 4.5	-	-	-
Dissolved Inorganic Nitrogen*	g/m³	0.840 ± 0.054	-	-	-
Total Nitrogen	g/m³	1.87 ± 0.11	-	-	-
Total Ammoniacal-N	g/m³	0.451 ± 0.038	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.389 ± 0.039	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	1.48 ± 0.11	-	-	-
Dissolved Reactive Phosphorus	g/m³	0.0347 ± 0.0047	-	-	-
Total Phosphorus	g/m³	0.166 ± 0.024	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00151 ± 0.00067	-	-	-
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	-	-	-
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	-	-	-
Dissolved Copper	g/m³	0.00261 ± 0.00041	-	-	-
Dissolved Lead	g/m³	0.000234 ± 0.000069	-	-	-
Dissolved Nickel	g/m³	0.00062 ± 0.00034	-	-	-
Dissolved Zinc	g/m³	0.0209 ± 0.0021	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00162 ± 0.00074	-	-	-
Total Cadmium	g/m³	< 0.000053 ± 0.000036	-	-	-
Total Chromium	g/m³	0.00076 ± 0.00036	-	-	-
Total Copper	g/m³	0.00376 ± 0.00052	-	-	-
Total Lead	g/m³	0.00159 ± 0.00013	-	-	-
Total Nickel	g/m³	0.00120 ± 0.00038	-	-	-
Total Zinc	g/m³	0.0361 ± 0.0030	-	-	-

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m^3	1-2, 4-5, 7-11
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8	0.000053 - 0.0011 g/m^3	1-2, 4-5, 7-11
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-2, 4-5, 7-11
Total Digestion	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2, 4-5, 7-11
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 22nd ed. 2012.	3 g/m^3	1-2, 4-5, 7-11
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-2, 4-5, 7-11
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-2, 4-5, 7-11
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-House.	0.010 g/m^3	1-2, 4-5, 7-11
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-2, 4-5, 7-11
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-2, 4-5, 7-11
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. 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, 4-5, 7-11
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2, 4-5, 7-11
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-2, 4-5, 7-11
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2, 4-5, 7-11

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.

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

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2055281 SUPv1
Contact:	I Cooper	**Date Received:**	26-Sep-2018
	C/- Pattle Delamore Partners Limited	**Date Reported:**	04-Oct-2018
	PO Box 389	**Quote No:**	92232
	Christchurch 8140	**Order No:**	
		Client Reference:	C03816300
		Submitted By:	I Cooper

Sample Type: Aqueous

Sample Name:		P_Int_1 26-Sep-2018 2:30 pm	P_Int_2 26-Sep-2018 2:30 pm	P_Outlet_1 26-Sep-2018 3:00 pm	P_Outlet_2 26-Sep-2018 3:00 pm
Lab Number:		2055281.1	2055281.2	2055281.4	2055281.5
Individual Tests					
Total Suspended Solids	g/m³	51 ± 11	54 ± 12	50 ± 11	47.9 ± 9.8
Dissolved Inorganic Nitrogen*	g/m³	0.086 ± 0.011	0.090 ± 0.011	< 0.011 ± 0.0068	< 0.011 ± 0.0068
Total Nitrogen	g/m³	2.34 ± 0.14	2.42 ± 0.14	2.19 ± 0.14	2.17 ± 0.14
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0773 ± 0.0079	0.0840 ± 0.0086	< 0.002 ± 0.0014	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	2.26 ± 0.14	2.34 ± 0.14	2.19 ± 0.14	2.17 ± 0.14
Dissolved Reactive Phosphorus	g/m³	0.0172 ± 0.0033	0.0192 ± 0.0034	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.333 ± 0.047	0.79 ± 0.12	0.300 ± 0.043	0.266 ± 0.038
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00107 ± 0.00067	0.00109 ± 0.00067	0.00167 ± 0.00068	0.00154 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00062 ± 0.00034	0.00069 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Dissolved Nickel	g/m³	0.00080 ± 0.00034	0.00075 ± 0.00034	0.00055 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Zinc	g/m³	0.00153 ± 0.00068	0.00115 ± 0.00067	0.00121 ± 0.00067	< 0.0010 ± 0.00067
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00285 ± 0.00076	0.00258 ± 0.00075	0.00650 ± 0.00083	0.00566 ± 0.00081
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	0.00134 ± 0.00037	0.00135 ± 0.00037	0.00091 ± 0.00036	0.00076 ± 0.00036
Total Copper	g/m³	0.00201 ± 0.00041	0.00164 ± 0.00039	0.00117 ± 0.00037	0.00103 ± 0.00037
Total Lead	g/m³	0.00193 ± 0.00014	0.00157 ± 0.00012	0.00182 ± 0.00014	0.00161 ± 0.00013
Total Nickel	g/m³	0.00142 ± 0.00039	0.00154 ± 0.00040	0.00129 ± 0.00039	0.00097 ± 0.00037
Total Zinc	g/m³	0.0295 ± 0.0025	0.0220 ± 0.0020	0.0116 ± 0.0012	0.0103 ± 0.0011

Sample Name:		K_Outlet_1 26-Sep-2018 4:30 pm	K_Outlet_2 26-Sep-2018 4:30 pm		
Lab Number:		2055281.7	2055281.8		
Individual Tests					
Total Suspended Solids	g/m³	8.1 ± 2.6	8.9 ± 2.7	-	-
Dissolved Inorganic Nitrogen*	g/m³	0.206 ± 0.019	0.200 ± 0.019	-	-
Total Nitrogen	g/m³	1.416 ± 0.095	1.263 ± 0.089	-	-
Total Ammoniacal-N	g/m³	0.0359 ± 0.0073	0.0302 ± 0.0071	-	-
Nitrate-N + Nitrite-N	g/m³	0.170 ± 0.018	0.170 ± 0.018	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	1.246 ± 0.093	1.094 ± 0.088	-	-
Dissolved Reactive Phosphorus	g/m³	0.0421 ± 0.0055	0.0437 ± 0.0056	-	-
Total Phosphorus	g/m³	0.161 ± 0.023	0.154 ± 0.022	-	-

Sample Type: Aqueous					
Sample Name:		K_Outlet_1 26-Sep-2018 4:30 pm	K_Outlet_2 26-Sep-2018 4:30 pm		
Lab Number:		2055281.7	2055281.8		
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00149 ± 0.00067	0.00140 ± 0.00067	-	-
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	-	-
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	-	-
Dissolved Copper	g/m³	0.00221 ± 0.00039	0.00219 ± 0.00039	-	-
Dissolved Lead	g/m³	0.000162 ± 0.000068	0.000162 ± 0.000068	-	-
Dissolved Nickel	g/m³	0.00075 ± 0.00034	0.00077 ± 0.00034	-	-
Dissolved Zinc	g/m³	0.0144 ± 0.0015	0.0150 ± 0.0016	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00174 ± 0.00074	0.00155 ± 0.00074	-	-
Total Cadmium	g/m³	0.000072 ± 0.000036	0.000061 ± 0.000036	-	-
Total Chromium	g/m³	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	-	-
Total Copper	g/m³	0.00288 ± 0.00046	0.00329 ± 0.00048	-	-
Total Lead	g/m³	0.000714 ± 0.000085	0.000748 ± 0.000086	-	-
Total Nickel	g/m³	0.00067 ± 0.00036	0.00252 ± 0.00047	-	-
Total Zinc	g/m³	0.0229 ± 0.0020	0.0225 ± 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.

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m³	1-2, 4-5, 7-8
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8	0.000053 - 0.0011 g/m³	1-2, 4-5, 7-8
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-2, 4-5, 7-8
Total Digestion	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-2, 4-5, 7-8
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 22nd ed. 2012.	3 g/m³	1-2, 4-5, 7-8
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-2, 4-5, 7-8
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m³	1-2, 4-5, 7-8
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-House.	0.010 g/m³	1-2, 4-5, 7-8
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m³ is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m³, the Default Detection Limit for Total Nitrogen will be 0.11 g/m³.	0.05 g/m³	1-2, 4-5, 7-8
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m³	1-2, 4-5, 7-8
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m³	1-2, 4-5, 7-8

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-2, 4-5, 7-8
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-2, 4-5, 7-8
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-2, 4-5, 7-8

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.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2065142	SUPv1
Contact:	I Cooper	**Date Received:**	15-Oct-2018	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	23-Oct-2018	
	PO Box 389	**Quote No:**	92232	
	Christchurch 8140	**Order No:**		
		Client Reference:	CO3816300	
		Submitted By:	I Cooper	

Sample Type: Aqueous

Sample Name:		K_FFSump_1 12-Oct-2018 9:30 am	P_FFBD_Sump_1 12-Oct-2018 10:50 am	P_FFBF_Sump_1 12-Oct-2018 10:30 am	K_FFB_1 15-Oct-2018 10:30 am
Lab Number:		2065142.1	2065142.2	2065142.3	2065142.4
Individual Tests					
Total Suspended Solids	g/m³	42.2 ± 8.7	49 ± 11	40.9 ± 8.4	4.7 ± 2.2
Dissolved Inorganic Nitrogen*	g/m³	0.637 ± 0.043	0.316 ± 0.022	0.400 ± 0.027	0.324 ± 0.022
Total Nitrogen	g/m³	1.184 ± 0.087	1.211 ± 0.089	1.57 ± 0.11	0.613 ± 0.073
Total Ammoniacal-N	g/m³	0.486 ± 0.040	0.226 ± 0.020	0.288 ± 0.025	0.185 ± 0.017
Nitrate-N + Nitrite-N	g/m³	0.151 ± 0.016	0.0893 ± 0.0091	0.112 ± 0.012	0.139 ± 0.014
Total Kjeldahl Nitrogen (TKN)	g/m³	1.033 ± 0.086	1.122 ± 0.089	1.46 ± 0.11	0.474 ± 0.071
Dissolved Reactive Phosphorus	g/m³	0.0158 ± 0.0032	0.0131 ± 0.0031	0.0075 ± 0.0028	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.090 ± 0.013	0.086 ± 0.013	0.114 ± 0.017	0.0295 ± 0.0049
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00134 ± 0.00036	0.00131 ± 0.00036	0.00189 ± 0.00038	0.00070 ± 0.00034
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Dissolved Nickel	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	0.00094 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Zinc	g/m³	0.0288 ± 0.0028	0.0403 ± 0.0039	0.0581 ± 0.0055	0.0575 ± 0.0054
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	0.00075 ± 0.00036	0.00108 ± 0.00037	0.00161 ± 0.00038	< 0.00053 ± 0.00036
Total Copper	g/m³	0.00253 ± 0.00044	0.00433 ± 0.00056	0.00751 ± 0.00083	0.00142 ± 0.00038
Total Lead	g/m³	0.00132 ± 0.00011	0.00142 ± 0.00012	0.00306 ± 0.00020	0.000412 ± 0.000078
Total Nickel	g/m³	< 0.00053 ± 0.00036	0.00106 ± 0.00038	0.00161 ± 0.00040	< 0.00053 ± 0.00036
Total Zinc	g/m³	0.0547 ± 0.0045	0.0778 ± 0.0063	0.1229 ± 0.0099	0.0698 ± 0.0057

Sample Name:		K_FFSwale_1 15-Oct-2018 10:00 am	K_FFSwale_2 15-Oct-2018 10:00 am	K_Int_1 15-Oct-2018 10:45 am	K_Int_2 15-Oct-2018 10:45 am
Lab Number:		2065142.5	2065142.6	2065142.8	2065142.9
Individual Tests					
pH	pH Units	-	-	7.4 ± 0.2	-
Total Suspended Solids	g/m³	20.3 ± 4.5	20.5 ± 4.6	17.1 ± 4.0	18.9 ± 4.3
Dissolved Inorganic Nitrogen*	g/m³	0.457 ± 0.031	0.445 ± 0.030	0.736 ± 0.049	0.737 ± 0.049
Total Nitrogen	g/m³	1.189 ± 0.087	1.184 ± 0.086	1.378 ± 0.093	1.281 ± 0.090
Total Ammoniacal-N	g/m³	0.227 ± 0.020	0.212 ± 0.019	0.343 ± 0.029	0.342 ± 0.029
Nitrate-N + Nitrite-N	g/m³	0.231 ± 0.024	0.234 ± 0.024	0.393 ± 0.040	0.395 ± 0.040
Total Kjeldahl Nitrogen (TKN)	g/m³	0.959 ± 0.083	0.951 ± 0.083	0.985 ± 0.084	0.886 ± 0.081
Dissolved Reactive Phosphorus	g/m³	0.089 ± 0.011	0.091 ± 0.011	0.0366 ± 0.0049	0.0350 ± 0.0048
Total Phosphorus	g/m³	0.188 ± 0.027	0.196 ± 0.028	0.118 ± 0.017	0.120 ± 0.017

Sample Type: Aqueous					
Sample Name:		K_FFSwale_1 15-Oct-2018 10:00 am	K_FFSwale_2 15-Oct-2018 10:00 am	K_Int_1 15-Oct-2018 10:45 am	K_Int_2 15-Oct-2018 10:45 am
Lab Number:		2065142.5	2065142.6	2065142.8	2065142.9
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	0.00115 ± 0.00067	0.00121 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00192 ± 0.00038	0.00178 ± 0.00037	0.00136 ± 0.00036	0.00142 ± 0.00036
Dissolved Lead	g/m³	0.000146 ± 0.000068	0.000149 ± 0.000068	0.000121 ± 0.000067	0.000116 ± 0.000067
Dissolved Nickel	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Zinc	g/m³	0.0257 ± 0.0025	0.0282 ± 0.0027	0.0096 ± 0.0012	0.0100 ± 0.0012
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00112 ± 0.00074	0.00112 ± 0.00074	0.00160 ± 0.00074	0.00181 ± 0.00074
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	0.00115 ± 0.00037	0.00094 ± 0.00036	0.00072 ± 0.00036	0.00091 ± 0.00036
Total Copper	g/m³	0.00288 ± 0.00046	0.00280 ± 0.00045	0.00244 ± 0.00043	0.00254 ± 0.00044
Total Lead	g/m³	0.00146 ± 0.00012	0.00156 ± 0.00012	0.001030 ± 0.000096	0.00117 ± 0.00011
Total Nickel	g/m³	0.00112 ± 0.00038	0.00082 ± 0.00037	0.00102 ± 0.00037	0.00101 ± 0.00037
Total Zinc	g/m³	0.0426 ± 0.0035	0.0429 ± 0.0036	0.0226 ± 0.0020	0.0250 ± 0.0022

Sample Name:		K_Outlet_1 15-Oct-2018 11:00 am	K_Outlet_2 15-Oct-2018 11:00 am	P_FFBF_1 15-Oct-2018 12:00 pm	P_FFBF_2 15-Oct-2018 12:00 pm
Lab Number:		2065142.11	2065142.12	2065142.14	2065142.15
Individual Tests					
pH	pH Units	7.0 ± 0.2	-	-	-
Total Suspended Solids	g/m³	5.1 ± 2.2	5.5 ± 2.3	4.5 ± 2.2	5.5 ± 2.3
Dissolved Inorganic Nitrogen*	g/m³	0.0788 ± 0.0087	0.0784 ± 0.0087	0.468 ± 0.031	0.498 ± 0.033
Total Nitrogen	g/m³	0.560 ± 0.072	0.559 ± 0.072	0.882 ± 0.078	0.926 ± 0.079
Total Ammoniacal-N	g/m³	0.0296 ± 0.0071	0.0309 ± 0.0071	0.259 ± 0.022	0.274 ± 0.024
Nitrate-N + Nitrite-N	g/m³	0.0492 ± 0.0051	0.0474 ± 0.0050	0.210 ± 0.022	0.224 ± 0.023
Total Kjeldahl Nitrogen (TKN)	g/m³	0.511 ± 0.072	0.511 ± 0.072	0.672 ± 0.075	0.702 ± 0.076
Dissolved Reactive Phosphorus	g/m³	0.0339 ± 0.0047	0.0339 ± 0.0047	0.0323 ± 0.0045	0.0385 ± 0.0051
Total Phosphorus	g/m³	0.090 ± 0.013	0.088 ± 0.013	0.072 ± 0.011	0.0445 ± 0.0068
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	0.00101 ± 0.00067	< 0.0010 ± 0.00067
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	0.00123 ± 0.00035	0.00126 ± 0.00035	0.00222 ± 0.00039	0.00200 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Dissolved Nickel	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	0.00067 ± 0.00034	0.00054 ± 0.00034
Dissolved Zinc	g/m³	0.0119 ± 0.0013	0.0110 ± 0.0013	0.0405 ± 0.0039	0.0421 ± 0.0040
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	0.00057 ± 0.00036	0.00055 ± 0.00036
Total Copper	g/m³	0.00126 ± 0.00038	0.00166 ± 0.00039	0.00289 ± 0.00046	0.00261 ± 0.00044
Total Lead	g/m³	0.000361 ± 0.000077	0.000330 ± 0.000076	0.000413 ± 0.000078	0.000460 ± 0.000079
Total Nickel	g/m³	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	0.00082 ± 0.00037	0.00100 ± 0.00037
Total Zinc	g/m³	0.0157 ± 0.0015	0.0149 ± 0.0014	0.0473 ± 0.0039	0.0510 ± 0.0042

Sample Name:		P_Int_1 15-Oct-2018 12:30 pm	P_Int_2 15-Oct-2018 12:30 pm	P_Outlet_1 15-Oct-2018 1:30 pm	P_Outlet_2 15-Oct-2018 1:30 pm
Lab Number:		2065142.17	2065142.18	2065142.20	2065142.21
Individual Tests					
pH	pH Units	7.9 ± 0.2	-	7.7 ± 0.2	-
Total Suspended Solids	g/m³	< 3 ± 2.0	< 3 ± 2.0	< 3 ± 2.0	3.0 ± 2.0
Dissolved Inorganic Nitrogen*	g/m³	< 0.011 ± 0.0069	< 0.011 ± 0.0069	< 0.011 ± 0.0068	< 0.011 ± 0.0068
Total Nitrogen	g/m³	0.630 ± 0.074	0.679 ± 0.075	0.856 ± 0.080	0.869 ± 0.081
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0071 ± 0.0015	0.0069 ± 0.0015	< 0.002 ± 0.0014	0.0032 ± 0.0014

Sample Type: Aqueous					
Sample Name:		P_Int_1 15-Oct-2018 12:30 pm	P_Int_2 15-Oct-2018 12:30 pm	P_Outlet_1 15-Oct-2018 1:30 pm	P_Outlet_2 15-Oct-2018 1:30 pm
Lab Number:		2065142.17	2065142.18	2065142.20	2065142.21
Individual Tests					
Total Kjeldahl Nitrogen (TKN)	g/m³	0.622 ± 0.074	0.672 ± 0.075	0.854 ± 0.080	0.866 ± 0.081
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.0295 ± 0.0049	0.0275 ± 0.0047	0.0325 ± 0.0053	0.0335 ± 0.0054
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Dissolved Arsenic	g/m³	0.00147 ± 0.00067	0.00143 ± 0.00067	0.00183 ± 0.00068	0.00186 ± 0.00068
Dissolved Cadmium	g/m³	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034	< 0.00005 ± 0.000034
Dissolved Chromium	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	0.00060 ± 0.00034	0.00164 ± 0.00037	< 0.0005 ± 0.00034
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Dissolved Nickel	g/m³	0.00054 ± 0.00034	0.00051 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Dissolved Zinc	g/m³	0.00307 ± 0.00072	0.00264 ± 0.00071	0.00187 ± 0.00069 #1	< 0.0010 ± 0.00067
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn					
Total Arsenic	g/m³	0.00171 ± 0.00074	0.00161 ± 0.00074	0.00226 ± 0.00075	0.00222 ± 0.00075
Total Cadmium	g/m³	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036	< 0.000053 ± 0.000036
Total Chromium	g/m³	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036
Total Copper	g/m³	0.00074 ± 0.00036	0.00074 ± 0.00036	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036
Total Lead	g/m³	< 0.00011 ± 0.000074	< 0.00011 ± 0.000074	0.000118 ± 0.000074	< 0.00011 ± 0.000074
Total Nickel	g/m³	0.00065 ± 0.00036	0.00082 ± 0.00037	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036
Total Zinc	g/m³	0.00425 ± 0.00081	0.00501 ± 0.00084	0.00112 ± 0.00074 #1	0.00111 ± 0.00074

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.

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

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.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00005 - 0.0010 g/m³	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8	0.000053 - 0.0011 g/m³	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Total Digestion	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	1-6, 8-9, 11-12, 14-15, 17-18, 20-21

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
pH	pH meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. 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. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	8, 11, 17, 20
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 22nd ed. 2012.	3 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-House.	0.010 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 22nd ed. 2012.	0.010 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified). 22nd ed. 2012.	0.004 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NAWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-6, 8-9, 11-12, 14-15, 17-18, 20-21

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.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

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

Hill Laboratories
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R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2373849	SUPv1
Contact:	I Cooper	**Date Received:**	27-May-2020	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	04-Jun-2020	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:		
		Submitted By:	Liam Allan	

Sample Type: Aqueous

Sample Name:		P_FFBF_Sump_1 25-May-2020 11:15 am	P_FFBD_Sump_1 25-May-2020 11:30 am	P_Outlet_1 27-May-2020 10:45 am	P_Outlet_2 27-May-2020 10:45 am
Lab Number:		2373849.1	2373849.2	2373849.3	2373849.4
Turbidity	NTU	21.8 ± 2.0	16.1 ± 1.5	2.12 ± 0.19	2.24 ± 0.20
Total Suspended Solids	g/m³	38.0 ± 7.9	82 ± 17	4.6 ± 2.2	< 3 ± 2.0
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	0.00120 ± 0.00067	0.00163 ± 0.00068	0.00174 ± 0.00068
Total Arsenic	g/m³	< 0.0011 ± 0.00074	0.00148 ± 0.00074	0.00181 ± 0.00074	0.00182 ± 0.00074
Dissolved Copper	g/m³	0.00254 ± 0.00041	0.00221 ± 0.00039	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Total Copper	g/m³	0.00302 ± 0.00047	0.00506 ± 0.00062	0.00101 ± 0.00037	0.00055 ± 0.00036
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000395 ± 0.000077	0.00221 ± 0.00016	0.000187 ± 0.000074	0.000194 ± 0.000074
Dissolved Zinc	g/m³	0.160 ± 0.015 #1	0.0563 ± 0.0053	0.00754 ± 0.00097	0.00801 ± 0.0010
Total Zinc	g/m³	0.157 ± 0.013	0.1030 ± 0.0083	0.00847 ± 0.0010	0.0089 ± 0.0011
Dissolved Inorganic Nitrogen*	g/m³	0.799 ± 0.066	0.588 ± 0.043	0.0259 ± 0.0075	0.0250 ± 0.0075
Total Nitrogen	g/m³	1.45 ± 0.11	1.277 ± 0.090	0.493 ± 0.071	0.306 ± 0.069
Total Ammoniacal-N	g/m³	0.309 ± 0.029	0.378 ± 0.034	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.489 ± 0.059	0.209 ± 0.026	0.0259 ± 0.0034	0.0250 ± 0.0033
Total Kjeldahl Nitrogen (TKN)	g/m³	0.964 ± 0.084	1.068 ± 0.087	0.467 ± 0.071	0.281 ± 0.069
Dissolved Reactive Phosphorus	g/m³	0.0597 ± 0.0041	0.0699 ± 0.0045	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.215 ± 0.031	0.176 ± 0.025	0.0220 ± 0.0041	0.0262 ± 0.0046

Sample Name:		K_FFSW_Sump_1 25-May-2020 12:30 pm	K_FFB_Sump_1 25-May-2020 12:40 pm	K_FFSwale_1 26-May-2020 1:50 pm	K_FFSwale_2 26-May-2020 1:55 pm
Lab Number:		2373849.6	2373849.7	2373849.8	2373849.9
Turbidity	NTU	19.6 ± 1.8	13.4 ± 1.2	2.97 ± 0.27	2.76 ± 0.25
Total Suspended Solids	g/m³	96 ± 14	79 ± 16	4.4 ± 2.2	3.6 ± 2.1
Dissolved Copper	g/m³	0.00395 ± 0.00049	0.00141 ± 0.00036	0.00106 ± 0.00035	0.00096 ± 0.00035
Total Copper	g/m³	0.00699 ± 0.00079	0.00219 ± 0.00042	0.00120 ± 0.00037	0.00110 ± 0.00037
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.00202 ± 0.00015	0.000271 ± 0.000075	< 0.00011 ± 0.000074	0.000118 ± 0.000074
Dissolved Zinc	g/m³	0.0438 ± 0.0042	0.0197 ± 0.0020	0.00555 ± 0.00084	0.00545 ± 0.00084
Total Zinc	g/m³	0.0708 ± 0.0058	0.0254 ± 0.0022	0.00681 ± 0.00091	0.00692 ± 0.00092
Dissolved Inorganic Nitrogen*	g/m³	1.182 ± 0.085	0.256 ± 0.020	0.407 ± 0.031	0.399 ± 0.031
Total Nitrogen	g/m³	2.56 ± 0.14	1.334 ± 0.094	0.557 ± 0.074	0.681 ± 0.075
Total Ammoniacal-N	g/m³	0.779 ± 0.069	0.196 ± 0.019	0.205 ± 0.020	0.205 ± 0.020
Nitrate-N + Nitrite-N	g/m³	0.403 ± 0.049	0.0604 ± 0.0074	0.203 ± 0.025	0.195 ± 0.024
Total Kjeldahl Nitrogen (TKN)	g/m³	2.15 ± 0.13	1.274 ± 0.094	0.354 ± 0.069	0.486 ± 0.072
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	0.0176 ± 0.0029	0.0748 ± 0.0047	0.0782 ± 0.0048
Total Phosphorus	g/m³	0.253 ± 0.036	0.157 ± 0.023	0.126 ± 0.018	0.122 ± 0.018

Sample Type: Aqueous					
Sample Name:		K_FFB_1 26-May-2020 2:50 pm	K_FFB_2 26-May-2020 2:50 pm	K_Int_1 26-May-2020 3:45 pm	K_Int_2 26-May-2020 3:45 pm
Lab Number:		2373849.10	2373849.11	2373849.12	2373849.13
Turbidity	NTU	1.37 ± 0.13	0.164 ± 0.037	3.35 ± 0.30	3.31 ± 0.30
Total Suspended Solids	g/m³	< 3 ± 2.0	< 15 ± 2.9 #2	< 3 ± 2.0	< 3 ± 2.0
Dissolved Copper	g/m³	0.00059 ± 0.00034	0.00052 ± 0.00034	0.00099 ± 0.00035	0.00106 ± 0.00035
Total Copper	g/m³	0.00100 ± 0.00037	0.00098 ± 0.00037	0.00126 ± 0.00038	0.00137 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000131 ± 0.000074	0.000218 ± 0.000075	0.000154 ± 0.000074	0.000239 ± 0.000075
Dissolved Zinc	g/m³	0.0175 ± 0.0018	0.0163 ± 0.0017	0.0149 ± 0.0016	0.0148 ± 0.0016
Total Zinc	g/m³	0.0193 ± 0.0018	0.0192 ± 0.0018	0.0162 ± 0.0015	0.0173 ± 0.0016
Dissolved Inorganic Nitrogen*	g/m³	0.204 ± 0.016	0.191 ± 0.016	0.290 ± 0.023	0.289 ± 0.023
Total Nitrogen	g/m³	0.314 ± 0.069	0.323 ± 0.069	0.459 ± 0.071	0.480 ± 0.071
Total Ammoniacal-N	g/m³	0.130 ± 0.014	0.121 ± 0.013	0.138 ± 0.014	0.137 ± 0.014
Nitrate-N + Nitrite-N	g/m³	0.0739 ± 0.0090	0.0699 ± 0.0085	0.152 ± 0.019	0.152 ± 0.019
Total Kjeldahl Nitrogen (TKN)	g/m³	0.240 ± 0.068	0.253 ± 0.068	0.307 ± 0.069	0.328 ± 0.069
Dissolved Reactive Phosphorus	g/m³	0.0111 ± 0.0028	0.0095 ± 0.0028	0.0456 ± 0.0036	0.0464 ± 0.0036
Total Phosphorus	g/m³	0.0282 ± 0.0048	0.0260 ± 0.0045	0.082 ± 0.012	0.081 ± 0.012

Sample Name:		K_Out_1 26-May-2020 2:30 pm	K_Out_2 26-May-2020 2:30 pm		
Lab Number:		2373849.14	2373849.15		
Turbidity	NTU	2.65 ± 0.24	2.60 ± 0.24	-	-
Total Suspended Solids	g/m³	3.0 ± 2.0	< 3 ± 2.0	-	-
Dissolved Copper	g/m³	0.00123 ± 0.00035	0.00121 ± 0.00035	-	-
Total Copper	g/m³	0.00153 ± 0.00039	0.00155 ± 0.00039	-	-
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	-	-
Total Lead	g/m³	< 0.00011 ± 0.000074	< 0.00011 ± 0.000074	-	-
Dissolved Zinc	g/m³	0.00497 ± 0.00081	0.00522 ± 0.00082	-	-
Total Zinc	g/m³	0.00596 ± 0.00088	0.00594 ± 0.00087	-	-
Dissolved Inorganic Nitrogen*	g/m³	0.161 ± 0.014	0.165 ± 0.014	-	-
Total Nitrogen	g/m³	0.869 ± 0.079	0.869 ± 0.079	-	-
Total Ammoniacal-N	g/m³	0.092 ± 0.011	0.096 ± 0.011	-	-
Nitrate-N + Nitrite-N	g/m³	0.0691 ± 0.0084	0.0687 ± 0.0084	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.800 ± 0.079	0.800 ± 0.079	-	-
Dissolved Reactive Phosphorus	g/m³	0.204 ± 0.011	0.202 ± 0.011	-	-
Total Phosphorus	g/m³	0.293 ± 0.042	0.296 ± 0.042	-	-

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.

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

#2 There was insufficient sample left to filter the usual amount for the Total Suspended Solids test, so the detection limit is higher than normal.

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-4, 6-15

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-4, 6-15
Turbidity	Analysis using a Hach 2100 Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-4, 6-15
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1-4, 7-10, 12-15
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 (modified) 23rd ed. 2017.	3 g/m^3	6, 11
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-4, 6-15
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-4
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-4
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-4, 6-15
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m^3	1-4, 6-15
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-4, 6-15
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-4, 6-15
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-4, 6-15
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-4, 6-15
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-4, 6-15
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-House.	0.010 g/m^3	1-4, 6-15
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-4, 6-15
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-4, 6-15
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-4, 6-15
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-4, 6-15
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-4, 6-15
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis and also modified to include a reductant to reduce interference from any arsenic present in the sample) 23rd ed. 2017. NWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-4, 6-15

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

Dates of testing are available on request. Please contact the laboratory for more information.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

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Kim Harrison MSc
Client Services Manager - Environmental

Hill Laboratories
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R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2472438	SUPv1
Contact:	Liam Allan	**Date Received:**	12-Nov-2020	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	19-Nov-2020	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:		
		Submitted By:	Liam Allan	

Sample Type: Aqueous

Sample Name:		P_FFBF_Sump 09-Nov-2020 4:45 pm	P_FFBD_Sump 09-Nov-2020 5:00 pm	P_FFBF_1 10-Nov-2020 10:00 am	P_FFBF_2 10-Nov-2020 10:00 am
Lab Number:		2472438.1	2472438.2	2472438.3	2472438.4
Turbidity	NTU	42.1 ± 3.7	4.60 ± 0.41	8.35 ± 0.74	23.7 ± 2.1
Total Suspended Solids	g/m³	90 ± 19	23.3 ± 5.1	33.3 ± 7.0	34.3 ± 7.2
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Arsenic	g/m³	0.00700 ± 0.00085	< 0.0011 ± 0.00074	0.00153 ± 0.00074	0.00162 ± 0.00074
Dissolved Copper	g/m³	0.00165 ± 0.00037	< 0.0005 ± 0.00034	0.00142 ± 0.00036	0.00152 ± 0.00036
Total Copper	g/m³	0.0469 ± 0.0048	0.00372 ± 0.00052	0.00409 ± 0.00054	0.00420 ± 0.00055
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.0286 ± 0.0018	0.00283 ± 0.00019	0.00246 ± 0.00017	0.00246 ± 0.00017
Dissolved Zinc	g/m³	0.0347 ± 0.0033	0.0246 ± 0.0024	0.0151 ± 0.0016	0.0132 ± 0.0014
Total Zinc	g/m³	0.430 ± 0.035	0.0656 ± 0.0053	0.0446 ± 0.0037	0.0449 ± 0.0037
Dissolved Inorganic Nitrogen*	g/m³	0.0925 ± 0.0097	0.110 ± 0.011	0.216 ± 0.021	0.195 ± 0.019
Total Nitrogen	g/m³	3.43 ± 0.19	0.473 ± 0.071	0.496 ± 0.072	0.478 ± 0.071
Total Ammoniacal-N	g/m³	0.0451 ± 0.0078	0.0751 ± 0.0094	0.0659 ± 0.0088	0.0543 ± 0.0082
Nitrate-N + Nitrite-N	g/m³	0.0474 ± 0.0059	0.0354 ± 0.0045	0.150 ± 0.019	0.141 ± 0.017
Total Kjeldahl Nitrogen (TKN)	g/m³	3.38 ± 0.19	0.438 ± 0.071	0.346 ± 0.069	0.337 ± 0.069
Dissolved Reactive Phosphorus	g/m³	0.0134 ± 0.0028	0.0111 ± 0.0028	0.0184 ± 0.0029	0.0200 ± 0.0029
Total Phosphorus	g/m³	0.199 ± 0.028	0.073 ± 0.011	0.093 ± 0.014	0.123 ± 0.018

Sample Name:		P_Int_1 10-Nov-2020 11:30 am	P_Int_2 10-Nov-2020 11:30 am	P_Outlet_1 11-Nov-2020 4:30 pm	P_Outlet_2 11-Nov-2020 4:30 pm
Lab Number:		2472438.5	2472438.6	2472438.7	2472438.8
Turbidity	NTU	1.75 ± 0.16	2.73 ± 0.25	1.65 ± 0.15	1.70 ± 0.16
Total Suspended Solids	g/m³	3.3 ± 2.1	3.9 ± 2.1	4.7 ± 2.2	4.1 ± 2.1
Dissolved Arsenic	g/m³	0.00163 ± 0.00068	0.00171 ± 0.00068	0.00236 ± 0.00068	0.00238 ± 0.00068
Total Arsenic	g/m³	0.00193 ± 0.00074	0.00183 ± 0.00074	0.00256 ± 0.00075	0.00248 ± 0.00075
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Total Copper	g/m³	0.00057 ± 0.00036	0.00054 ± 0.00036	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000128 ± 0.000074	< 0.00011 ± 0.000074	0.000162 ± 0.000074	0.000144 ± 0.000074
Dissolved Zinc	g/m³	0.00128 ± 0.00068	0.00102 ± 0.00067	0.00131 ± 0.00068	< 0.0010 ± 0.00067
Total Zinc	g/m³	0.00269 ± 0.00076	0.00202 ± 0.00075	0.00207 ± 0.00075	0.00174 ± 0.00075
Dissolved Inorganic Nitrogen*	g/m³	0.0236 ± 0.0070	0.0203 ± 0.0070	< 0.011 ± 0.0068	< 0.011 ± 0.0068
Total Nitrogen	g/m³	0.436 ± 0.071	0.405 ± 0.070	0.708 ± 0.076	0.718 ± 0.077
Total Ammoniacal-N	g/m³	0.0214 ± 0.0069	0.0199 ± 0.0069	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0021 ± 0.0014	< 0.002 ± 0.0014	< 0.002 ± 0.0014	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	0.434 ± 0.071	0.405 ± 0.070	0.708 ± 0.076	0.718 ± 0.077
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.0255 ± 0.0045	0.0410 ± 0.0064	0.0340 ± 0.0055	0.0380 ± 0.0060

Sample Type: Aqueous					
Sample Name:		K_FFB_Sump 09-Nov-2020 2:15 pm	K_FFSwale_1 10-Nov-2020 2:30 pm	K_FFSwale_2 10-Nov-2020 2:30 pm	K_FFB_1 10-Nov-2020 3:30 pm
Lab Number:		2472438.9	2472438.10	2472438.11	2472438.12
Turbidity	NTU	12.3 ± 1.1	2.80 ± 0.25	2.85 ± 0.26	1.89 ± 0.17
Total Suspended Solids	g/m³	21.7 ± 4.8	< 3 ± 2.0	< 3 ± 2.0	4.1 ± 2.1
Dissolved Copper	g/m³	0.00579 ± 0.00063	0.00107 ± 0.00035	0.00109 ± 0.00035	0.00110 ± 0.00035
Total Copper	g/m³	0.00801 ± 0.00088	0.00116 ± 0.00037	0.00120 ± 0.00037	0.00193 ± 0.00040
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.00228 ± 0.00016	0.000201 ± 0.000075	0.000288 ± 0.000076	0.000312 ± 0.000076
Dissolved Zinc	g/m³	0.0604 ± 0.0057	0.0110 ± 0.0013	0.0102 ± 0.0012	0.0232 ± 0.0023
Total Zinc	g/m³	0.0864 ± 0.0070	0.0119 ± 0.0013	0.0126 ± 0.0013	0.0263 ± 0.0023
Dissolved Inorganic Nitrogen*	g/m³	1.47 ± 0.11	0.157 ± 0.014	0.152 ± 0.013	0.178 ± 0.022
Total Nitrogen	g/m³	2.41 ± 0.14	0.315 ± 0.069	0.244 ± 0.068	1.71 ± 0.11
Total Ammoniacal-N	g/m³	1.005 ± 0.089	0.092 ± 0.011	0.088 ± 0.011	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.463 ± 0.056	0.0654 ± 0.0080	0.0644 ± 0.0079	0.172 ± 0.021
Total Kjeldahl Nitrogen (TKN)	g/m³	1.95 ± 0.13	0.250 ± 0.068	0.180 ± 0.068	1.54 ± 0.11
Dissolved Reactive Phosphorus	g/m³	0.0389 ± 0.0034	0.0641 ± 0.0043	0.0668 ± 0.0044	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.136 ± 0.020	0.103 ± 0.015	0.104 ± 0.015	0.0520 ± 0.0078

Sample Name:		K_FFB_2 10-Nov-2020 3:30 pm	K_Int_1 09-Nov-2020 3:00 pm	K_Int_2 09-Nov-2020 3:00 pm	K_Out_1 10-Nov-2020 4:30 pm
Lab Number:		2472438.13	2472438.14	2472438.15	2472438.16
Turbidity	NTU	2.10 ± 0.19	3.78 ± 0.34	2.55 ± 0.23	1.83 ± 0.17
Total Suspended Solids	g/m³	3.9 ± 2.1	4.3 ± 2.1	4.1 ± 2.1	< 3 ± 2.0
Dissolved Copper	g/m³	0.00116 ± 0.00035	0.00122 ± 0.00035	0.00138 ± 0.00036	0.00139 ± 0.00036
Total Copper	g/m³	0.00149 ± 0.00038	0.00156 ± 0.00039	0.00164 ± 0.00039	0.00148 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000253 ± 0.000075	0.000299 ± 0.000076	0.000358 ± 0.000077	0.000148 ± 0.000074
Dissolved Zinc	g/m³	0.0223 ± 0.0022	0.0134 ± 0.0015	0.0130 ± 0.0014	0.00545 ± 0.00084
Total Zinc	g/m³	0.0251 ± 0.0022	0.0164 ± 0.0016	0.0160 ± 0.0015	0.00753 ± 0.00095
Dissolved Inorganic Nitrogen*	g/m³	0.188 ± 0.022	0.247 ± 0.021	0.243 ± 0.021	0.164 ± 0.014
Total Nitrogen	g/m³	0.444 ± 0.071	0.412 ± 0.070	0.395 ± 0.070	0.618 ± 0.073
Total Ammoniacal-N	g/m³	0.0170 ± 0.0068	0.107 ± 0.012	0.105 ± 0.012	0.104 ± 0.012
Nitrate-N + Nitrite-N	g/m³	0.171 ± 0.021	0.140 ± 0.017	0.137 ± 0.017	0.0595 ± 0.0073
Total Kjeldahl Nitrogen (TKN)	g/m³	0.273 ± 0.068	0.272 ± 0.068	0.258 ± 0.068	0.558 ± 0.073
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	0.0623 ± 0.0042	0.0603 ± 0.0041	0.300 ± 0.016
Total Phosphorus	g/m³	0.0500 ± 0.0075	0.104 ± 0.015	0.109 ± 0.016	0.389 ± 0.055

Sample Name:		K_Out_2 10-Nov-2020 4:30 pm			
Lab Number:		2472438.17			
Turbidity	NTU	1.53 ± 0.14	-	-	-
Total Suspended Solids	g/m³	< 3 ± 2.0	-	-	-
Dissolved Copper	g/m³	0.00138 ± 0.00036	-	-	-
Total Copper	g/m³	0.00149 ± 0.00038	-	-	-
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	-	-	-
Total Lead	g/m³	0.000122 ± 0.000074	-	-	-
Dissolved Zinc	g/m³	0.00519 ± 0.00082	-	-	-
Total Zinc	g/m³	0.00700 ± 0.00092	-	-	-
Dissolved Inorganic Nitrogen*	g/m³	0.171 ± 0.014	-	-	-
Total Nitrogen	g/m³	0.519 ± 0.071	-	-	-
Total Ammoniacal-N	g/m³	0.109 ± 0.012	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.0621 ± 0.0076	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.457 ± 0.071	-	-	-
Dissolved Reactive Phosphorus	g/m³	0.321 ± 0.017	-	-	-
Total Phosphorus	g/m³	0.381 ± 0.054	-	-	-

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-17
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-17
Turbidity	Analysis using a Hach 2100 Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-17
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1-17
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-17
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-8
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-8
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-17
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m^3	1-17
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-17
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-17
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-17
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-17
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-17
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-House.	0.010 g/m^3	1-17
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1-17
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-17
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-17
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-17
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-17
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis and also modified to include a reductant to reduce interference from any arsenic present in the sample) 23rd ed. 2017. NWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1-17

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

Testing was completed between 16-Nov-2020 and 19-Nov-2020. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2612393	SUPv2
Contact:	Liam Allan	**Date Received:**	14-May-2021	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	24-May-2021	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:	C03816300	
		Submitted By:	Liam Allan	

Sample Type: Aqueous

Sample Name:		P_FFBF_Sump 14-May-2021 2:00 pm	P_FFBF_Sump 14-May-2021 1:45 pm	P_FFBF_1 14-May-2021 9:00 am	P_FFBF_2 14-May-2021 9:00 am
Lab Number:		2612393.1	2612393.2	2612393.3	2612393.4
Turbidity	NTU	11.7 ± 1.1	87.4 ± 7.7	5.07 ± 0.45	6.14 ± 0.54
Total Suspended Solids	g/m³	34.0 ± 7.1	-	8.0 ± 2.5	9.6 ± 2.8
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.005 ± 0.00072	0.00115 ± 0.00067	0.00114 ± 0.00067
Total Arsenic	g/m³	0.00170 ± 0.00074	< 0.0053 ± 0.00080	0.00119 ± 0.00074	0.00114 ± 0.00074
Dissolved Copper	g/m³	0.00084 ± 0.00034	0.00112 ± 0.00035	0.00171 ± 0.00037	0.00159 ± 0.00037
Total Copper	g/m³	0.00432 ± 0.00056	0.00466 ± 0.00059	0.00265 ± 0.00044	0.00290 ± 0.00046
Dissolved Lead	g/m³	0.000180 ± 0.000068	0.000112 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.01017 ± 0.00062	0.00523 ± 0.00033	0.000730 ± 0.000086	0.000871 ± 0.000090
Dissolved Zinc	g/m³	0.0594 ± 0.0056	0.0099 ± 0.0012	0.0219 ± 0.0022	0.0225 ± 0.0022
Total Zinc	g/m³	0.1090 ± 0.0088	0.0397 ± 0.0033	0.0337 ± 0.0028	0.0356 ± 0.0030
Dissolved Inorganic Nitrogen*	g/m³	1.139 ± 0.083	0.588 ± 0.064	0.395 ± 0.031	0.408 ± 0.032
Total Nitrogen	g/m³	2.69 ± 0.15	0.905 ± 0.094	0.663 ± 0.075	0.710 ± 0.076
Total Ammoniacal-N	g/m³	0.824 ± 0.073	0.0637 ± 0.0087	0.193 ± 0.019	0.204 ± 0.020
Nitrate-N + Nitrite-N	g/m³	0.315 ± 0.038	0.524 ± 0.063	0.202 ± 0.025	0.204 ± 0.025
Total Kjeldahl Nitrogen (TKN)	g/m³	2.38 ± 0.14	0.381 ± 0.070	0.460 ± 0.071	0.506 ± 0.072
Dissolved Reactive Phosphorus	g/m³	0.0604 ± 0.0041	0.0432 ± 0.0035	0.0636 ± 0.0042	0.0625 ± 0.0042
Total Phosphorus	g/m³	0.177 ± 0.022	0.169 ± 0.021	0.132 ± 0.016	0.148 ± 0.018

Sample Name:		P_Int_1 14-May-2021 11:30 am	P_Int_2 14-May-2021 11:30 am	P_Outlet_1 14-May-2021 1:00 pm	P_Outlet_2 14-May-2021 1:00 pm
Lab Number:		2612393.5	2612393.6	2612393.7	2612393.8
Turbidity	NTU	6.76 ± 0.60	6.86 ± 0.61	2.26 ± 0.21	2.30 ± 0.21
Total Suspended Solids	g/m³	12.2 ± 3.1	12.8 ± 3.2	4.6 ± 2.2	5.4 ± 2.2
Dissolved Arsenic	g/m³	0.00191 ± 0.00068	0.00199 ± 0.00068	0.00230 ± 0.00068	0.00220 ± 0.00068
Total Arsenic	g/m³	0.00233 ± 0.00075	0.00216 ± 0.00075	0.00263 ± 0.00075	0.00275 ± 0.00075
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Total Copper	g/m³	0.00060 ± 0.00036	0.00069 ± 0.00036	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000362 ± 0.000077	0.000344 ± 0.000076	0.000182 ± 0.000074	0.000203 ± 0.000075
Dissolved Zinc	g/m³	0.00150 ± 0.00068	0.00167 ± 0.00068	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Zinc	g/m³	0.00492 ± 0.00083	0.00481 ± 0.00083	< 0.0011 ± 0.00074	0.00116 ± 0.00074
Dissolved Inorganic Nitrogen*	g/m³	< 0.011 ± 0.0068	< 0.011 ± 0.0068	0.0615 ± 0.0089	0.0642 ± 0.0091
Total Nitrogen	g/m³	0.563 ± 0.073	0.518 ± 0.072	0.586 ± 0.073	0.603 ± 0.073
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	0.0152 ± 0.0068	0.0150 ± 0.0068
Nitrate-N + Nitrite-N	g/m³	< 0.002 ± 0.0014	< 0.002 ± 0.0014	0.0463 ± 0.0058	0.0492 ± 0.0061
Total Kjeldahl Nitrogen (TKN)	g/m³	0.562 ± 0.073	0.518 ± 0.072	0.539 ± 0.073	0.554 ± 0.073
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.0720 ± 0.0088	0.0738 ± 0.0090	0.0331 ± 0.0042	0.0359 ± 0.0045

Sample Type: Aqueous					
Sample Name:		P_FFBF_FF 14-May-2021 9:00 am	K_FFB_Sump 13-May-2021 11:20 am	K_FFSwale_1 13-May-2021 11:00 am	K_FFSwale_2 13-May-2021 11:00 am
Lab Number:		2612393.9	2612393.10	2612393.11	2612393.12
Turbidity	NTU	4.94 ± 0.44	22.9 ± 2.1	3.79 ± 0.34	3.79 ± 0.34
Total Suspended Solids	g/m³	12.4 ± 3.2	64 ± 13	5.4 ± 2.2	4.8 ± 2.2
Dissolved Arsenic	g/m³	0.00161 ± 0.00068	0.00127 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Arsenic	g/m³	0.00220 ± 0.00075	0.00216 ± 0.00075	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074
Dissolved Copper	g/m³	0.00300 ± 0.00043	0.00421 ± 0.00051	0.00114 ± 0.00035	0.00111 ± 0.00035
Total Copper	g/m³	0.00453 ± 0.00058	0.0102 ± 0.0011	0.00151 ± 0.00039	0.00153 ± 0.00039
Dissolved Lead	g/m³	0.000130 ± 0.000067	0.000204 ± 0.000068	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.001058 ± 0.000097	0.00480 ± 0.00030	0.000313 ± 0.000076	0.000327 ± 0.000076
Dissolved Zinc	g/m³	0.0259 ± 0.0025	0.0729 ± 0.0069	0.0138 ± 0.0015	0.0131 ± 0.0014
Total Zinc	g/m³	0.0449 ± 0.0037	0.168 ± 0.014	0.0184 ± 0.0017	0.0181 ± 0.0017
Dissolved Inorganic Nitrogen*	g/m³	0.720 ± 0.066	1.069 ± 0.077	0.583 ± 0.043	0.573 ± 0.042
Total Nitrogen	g/m³	1.39 ± 0.11	1.87 ± 0.12	0.764 ± 0.078	0.807 ± 0.078
Total Ammoniacal-N	g/m³	0.201 ± 0.019	0.620 ± 0.055	0.354 ± 0.032	0.345 ± 0.032
Nitrate-N + Nitrite-N	g/m³	0.519 ± 0.063	0.449 ± 0.054	0.228 ± 0.028	0.228 ± 0.028
Total Kjeldahl Nitrogen (TKN)	g/m³	0.871 ± 0.081	1.42 ± 0.10	0.536 ± 0.072	0.578 ± 0.073
Dissolved Reactive Phosphorus	g/m³	0.1618 ± 0.0087	0.0357 ± 0.0033	0.0879 ± 0.0053	0.0893 ± 0.0053
Total Phosphorus	g/m³	0.335 ± 0.041	0.173 ± 0.021	0.146 ± 0.018	0.136 ± 0.017

Sample Name:		K-Int_1 13-May-2021 12:00 pm	K-Int_2 13-May-2021 12:00 pm	K_Out_1 13-May-2021 1:00 pm	K_Out_2 13-May-2021 1:00 pm
Lab Number:		2612393.13	2612393.14	2612393.15	2612393.16
Turbidity	NTU	9.66 ± 0.85	10.20 ± 0.90	3.32 ± 0.30	2.85 ± 0.26
Total Suspended Solids	g/m³	7.6 ± 2.5	7.8 ± 2.5	< 3 ± 2.0	< 3 ± 2.0
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Arsenic	g/m³	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074
Dissolved Copper	g/m³	0.00120 ± 0.00035	0.00115 ± 0.00035	0.00098 ± 0.00035	0.00096 ± 0.00035
Total Copper	g/m³	0.00166 ± 0.00039	0.00170 ± 0.00039	0.00108 ± 0.00037	0.00109 ± 0.00037
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000654 ± 0.000083	0.000645 ± 0.000083	< 0.00011 ± 0.000074	< 0.00011 ± 0.000074
Dissolved Zinc	g/m³	0.0157 ± 0.0017	0.0152 ± 0.0016	0.00442 ± 0.00078	0.00414 ± 0.00077
Total Zinc	g/m³	0.0215 ± 0.0019	0.0215 ± 0.0019	0.00532 ± 0.00085	0.00527 ± 0.00085
Dissolved Inorganic Nitrogen*	g/m³	0.265 ± 0.021	0.273 ± 0.021	0.0656 ± 0.0083	0.0626 ± 0.0081
Total Nitrogen	g/m³	0.593 ± 0.073	0.519 ± 0.071	0.462 ± 0.071	0.525 ± 0.072
Total Ammoniacal-N	g/m³	0.168 ± 0.017	0.176 ± 0.017	0.0473 ± 0.0079	0.0450 ± 0.0077
Nitrate-N + Nitrite-N	g/m³	0.097 ± 0.012	0.097 ± 0.012	0.0183 ± 0.0026	0.0176 ± 0.0025
Total Kjeldahl Nitrogen (TKN)	g/m³	0.496 ± 0.072	0.422 ± 0.070	0.443 ± 0.071	0.507 ± 0.072
Dissolved Reactive Phosphorus	g/m³	0.0927 ± 0.0055	0.0973 ± 0.0057	0.1832 ± 0.0098	0.1791 ± 0.0096
Total Phosphorus	g/m³	0.161 ± 0.020	0.156 ± 0.019	0.253 ± 0.031	0.254 ± 0.031

Sample Name:		K_FFSwale_FF 13-May-2021 11:00 am	K_FFSwale_3 13-May-2021 11:00 am	K_Int_3 13-May-2021 12:00 pm	K_Out_3 13-May-2021 1:00 pm
Lab Number:		2612393.17	2612393.18	2612393.19	2612393.20
Turbidity	NTU	5.31 ± 0.47	3.90 ± 0.35	10.10 ± 0.89	2.43 ± 0.22
Total Suspended Solids	g/m³	9.8 ± 2.8	5.6 ± 2.3	8.0 ± 2.5	< 3 ± 2.0
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Arsenic	g/m³	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074
Dissolved Copper	g/m³	0.00280 ± 0.00042	0.00115 ± 0.00035	0.00113 ± 0.00035	0.00102 ± 0.00035
Total Copper	g/m³	0.00359 ± 0.00051	0.00167 ± 0.00039	0.00170 ± 0.00039	0.00113 ± 0.00037
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000526 ± 0.000080	0.000331 ± 0.000076	0.000626 ± 0.000083	< 0.00011 ± 0.000074
Dissolved Zinc	g/m³	0.0280 ± 0.0027	0.0132 ± 0.0014	0.0151 ± 0.0016	0.00439 ± 0.00078
Total Zinc	g/m³	0.0431 ± 0.0036	0.0178 ± 0.0016	0.0200 ± 0.0018	0.00496 ± 0.00083
Dissolved Inorganic Nitrogen*	g/m³	1.92 ± 0.15	0.571 ± 0.042	0.268 ± 0.021	0.0664 ± 0.0083
Total Nitrogen	g/m³	2.78 ± 0.16	0.855 ± 0.079	0.619 ± 0.073	0.486 ± 0.071
Total Ammoniacal-N	g/m³	1.021 ± 0.091	0.344 ± 0.031	0.171 ± 0.017	0.0483 ± 0.0079
Nitrate-N + Nitrite-N	g/m³	0.89 ± 0.11	0.228 ± 0.028	0.097 ± 0.012	0.0181 ± 0.0026

Sample Type: Aqueous					
Sample Name:		K_FFSwale_FF 13-May-2021 11:00 am	K_FFSwale_3 13-May-2021 11:00 am	K_Int_3 13-May-2021 12:00 pm	K_Out_3 13-May-2021 1:00 pm
Lab Number:		2612393.17	2612393.18	2612393.19	2612393.20
Total Kjeldahl Nitrogen (TKN)	g/m³	1.89 ± 0.12	0.627 ± 0.074	0.522 ± 0.072	0.468 ± 0.071
Dissolved Reactive Phosphorus	g/m³	0.258 ± 0.014	0.0866 ± 0.0052	0.0927 ± 0.0055	0.1832 ± 0.0098
Total Phosphorus	g/m³	0.378 ± 0.046	0.134 ± 0.017	0.156 ± 0.019	0.250 ± 0.030

Sample Name:		P_FFBF_3 14-May-2021 9:00 am	P_Int_3 14-May-2021 11:30 am	P_Outlet_3 14-May-2021 1:00 pm	
Lab Number:		2612393.21	2612393.22	2612393.23	
Turbidity	NTU	5.91 ± 0.52	6.88 ± 0.61	2.07 ± 0.19	-
Total Suspended Solids	g/m³	9.8 ± 2.8	12.9 ± 3.3	9.3 ± 2.7	-
Dissolved Arsenic	g/m³	0.00121 ± 0.00067	0.00200 ± 0.00068	0.00239 ± 0.00068	-
Total Arsenic	g/m³	0.00128 ± 0.00074	0.00213 ± 0.00075	0.00241 ± 0.00075	-
Dissolved Copper	g/m³	0.00166 ± 0.00037	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	-
Total Copper	g/m³	0.00277 ± 0.00045	0.00065 ± 0.00036	< 0.00053 ± 0.00036	-
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	-
Total Lead	g/m³	0.000760 ± 0.000087	0.000383 ± 0.000077	0.000198 ± 0.000074	-
Dissolved Zinc	g/m³	0.0213 ± 0.0021	0.00197 ± 0.00069	< 0.0010 ± 0.00067	-
Total Zinc	g/m³	0.0343 ± 0.0029	0.00517 ± 0.00084	0.00180 ± 0.00075	-
Dissolved Inorganic Nitrogen*	g/m³	0.404 ± 0.031	< 0.011 ± 0.0068	0.0711 ± 0.0090	-
Total Nitrogen	g/m³	0.694 ± 0.076	0.551 ± 0.073	0.780 ± 0.077	-
Total Ammoniacal-N	g/m³	0.201 ± 0.019	< 0.010 ± 0.0067	0.0266 ± 0.0071	-
Nitrate-N + Nitrite-N	g/m³	0.202 ± 0.025	< 0.002 ± 0.0014	0.0445 ± 0.0055	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.492 ± 0.072	0.551 ± 0.073	0.735 ± 0.077	-
Dissolved Reactive Phosphorus	g/m³	0.0637 ± 0.0042	0.0041 ± 0.0027	< 0.004 ± 0.0027	-
Total Phosphorus	g/m³	0.151 ± 0.019	0.0722 ± 0.0088	0.0473 ± 0.0058	-

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-23
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-23
Turbidity	Analysis using a Hach 2100 Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-23
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m³	1, 3-23
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-23
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1-23
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m³	1-23
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1-23
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m³	1-23

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-23
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-23
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-23
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-23
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-23
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.010 g/m^3	1-23
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-23
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-23
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-23
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-23
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-23
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H 23rd ed. 2017.	0.002 g/m^3	1-23

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

Testing was completed between 15-May-2021 and 24-May-2021. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	2629798	SUPv2
Contact:	Liam Allan C/- Pattle Delamore Partners Limited PO Box 389 Christchurch 8140	**Date Received:**	04-Jun-2021	
		Date Reported:	02-Jul-2021	**(Amended)**
		Quote No:	103440	
		Order No:		
		Client Reference:		
		Submitted By:	Liam Allan	

Sample Type: Aqueous

Sample Name:		P_FFBF_Sump 02-Jun-2021 3:00 pm	P_FFBD_Sump 02-Jun-2021 2:50 pm	P_FFBF_1 02-Jun-2021 3:00 pm	P_FFBF_2 02-Jun-2021 3:00 pm
Lab Number:		2629798.1	2629798.2	2629798.3	2629798.4
Turbidity	NTU	15.3 ± 1.4	11.00 ± 0.97	2.84 ± 0.26	2.13 ± 0.19
Total Suspended Solids	g/m³	27.0 ± 5.8	32.1 ± 6.7	< 3 ± 2.0	3.1 ± 2.1
Dissolved Arsenic	g/m³	< 0.002 ± 0.00068	< 0.002 ± 0.00068	< 0.002 ± 0.00068	< 0.002 ± 0.00068
Total Arsenic	g/m³	< 0.011 ± 0.00097	< 0.011 ± 0.00097	< 0.011 ± 0.00097	< 0.011 ± 0.00097
Dissolved Copper	g/m³	0.00228 ± 0.00040	< 0.0010 ± 0.00035	0.00138 ± 0.00036	0.00125 ± 0.00035
Total Copper	g/m³	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064
Dissolved Lead	g/m³	0.000432 ± 0.000073	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068
Total Lead	g/m³	0.00158 ± 0.00012	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097
Dissolved Zinc	g/m³	0.124 ± 0.012	0.0317 ± 0.0031	0.0241 ± 0.0024	0.0233 ± 0.0023
Total Zinc	g/m³	0.136 ± 0.011	0.0375 ± 0.0031	0.0301 ± 0.0026	0.0240 ± 0.0021
Dissolved Inorganic Nitrogen*	g/m³	0.740 ± 0.074	0.341 ± 0.028	0.270 ± 0.022	0.269 ± 0.022
Total Nitrogen	g/m³	1.44 ± 0.11	1.275 ± 0.093	0.445 ± 0.071	0.414 ± 0.071
Total Ammoniacal-N	g/m³	0.137 ± 0.014	0.300 ± 0.028	0.127 ± 0.014	0.128 ± 0.014
Nitrate-N + Nitrite-N	g/m³	0.603 ± 0.073	0.0407 ± 0.0051	0.143 ± 0.018	0.141 ± 0.017
Total Kjeldahl Nitrogen (TKN)	g/m³	0.841 ± 0.080	1.234 ± 0.093	0.302 ± 0.069	0.273 ± 0.068
Dissolved Reactive Phosphorus	g/m³	0.0365 ± 0.0033	0.0241 ± 0.0030	0.0178 ± 0.0029	0.0185 ± 0.0029
Total Phosphorus	g/m³	0.166 ± 0.020	0.147 ± 0.018	0.0442 ± 0.0055	0.0439 ± 0.0054

Sample Name:		P_Int_1 02-Jun-2021 3:30 pm	P_Int_2 02-Jun-2021 3:30 pm	P_Outlet_1 02-Jun-2021 4:00 pm	P_Outlet_2 02-Jun-2021 4:00 pm
Lab Number:		2629798.5	2629798.6	2629798.7	2629798.8
Turbidity	NTU	2.79 ± 0.25	2.65 ± 0.24	2.03 ± 0.19	1.86 ± 0.17
Total Suspended Solids	g/m³	3.3 ± 2.1	5.5 ± 2.3	76 ± 16	3.5 ± 2.1
Dissolved Arsenic	g/m³	< 0.002 ± 0.00068	< 0.002 ± 0.00068	< 0.002 ± 0.00068	< 0.002 ± 0.00068
Total Arsenic	g/m³	< 0.011 ± 0.00097	< 0.011 ± 0.00097	< 0.011 ± 0.00097	< 0.011 ± 0.00097
Dissolved Copper	g/m³	< 0.0010 ± 0.00035	< 0.0010 ± 0.00035	< 0.0010 ± 0.00035	< 0.0010 ± 0.00035
Total Copper	g/m³	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064
Dissolved Lead	g/m³	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068
Total Lead	g/m³	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097
Dissolved Zinc	g/m³	0.00457 ± 0.00079	0.00390 ± 0.00076	< 0.002 ± 0.00069	< 0.002 ± 0.00069
Total Zinc	g/m³	< 0.011 ± 0.0012	< 0.011 ± 0.0012	< 0.011 ± 0.0012	< 0.011 ± 0.0012
Dissolved Inorganic Nitrogen*	g/m³	0.080 ± 0.011	0.081 ± 0.011	0.0141 ± 0.0070	0.0133 ± 0.0070
Total Nitrogen	g/m³	0.443 ± 0.070	0.472 ± 0.071	0.472 ± 0.071	0.392 ± 0.070
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0707 ± 0.0086	0.0707 ± 0.0086	0.0141 ± 0.0022	0.0133 ± 0.0021
Total Kjeldahl Nitrogen (TKN)	g/m³	0.372 ± 0.070	0.401 ± 0.070	0.458 ± 0.071	0.378 ± 0.070
Dissolved Reactive Phosphorus	g/m³	0.0102 ± 0.0028	0.0088 ± 0.0027	0.0185 ± 0.0029	0.0186 ± 0.0029
Total Phosphorus	g/m³	0.0391 ± 0.0049	0.0387 ± 0.0048	0.0413 ± 0.0051	0.0555 ± 0.0068

Sample Type: Aqueous					
Sample Name:		P_FFBF_FF 02-Jun-2021 3:00 pm	K_FFBF_Sump 02-Jun-2021 11:00 am	K_FFSwale_1 02-Jun-2021 10:00 am	K_FFSwale_2 02-Jun-2021 10:00 am
Lab Number:		2629798.9	2629798.10	2629798.11	2629798.12
Turbidity	NTU	3.12 ± 0.28	8.21 ± 0.72	7.88 ± 0.70	8.60 ± 0.76
Total Suspended Solids	g/m³	3.3 ± 2.1	15.3 ± 3.7	5.1 ± 2.2	5.3 ± 2.2
Dissolved Arsenic	g/m³	< 0.002 ± 0.00068	-	-	-
Total Arsenic	g/m³	< 0.011 ± 0.00097	-	-	-
Dissolved Copper	g/m³	0.00218 ± 0.00039	0.00284 ± 0.00042	< 0.0010 ± 0.00035	0.00132 ± 0.00036
Total Copper	g/m³	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064
Dissolved Lead	g/m³	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068
Total Lead	g/m³	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097
Dissolved Zinc	g/m³	0.0363 ± 0.0035	0.0282 ± 0.0028	0.0126 ± 0.0014	0.0119 ± 0.0013
Total Zinc	g/m³	0.0404 ± 0.0034	0.0359 ± 0.0030	0.0195 ± 0.0018	0.0173 ± 0.0016
Dissolved Inorganic Nitrogen*	g/m³	0.645 ± 0.048	0.449 ± 0.033	0.206 ± 0.017	0.216 ± 0.018
Total Nitrogen	g/m³	0.896 ± 0.082	1.302 ± 0.091	0.424 ± 0.070	0.380 ± 0.070
Total Ammoniacal-N	g/m³	0.347 ± 0.032	0.264 ± 0.025	0.107 ± 0.012	0.116 ± 0.013
Nitrate-N + Nitrite-N	g/m³	0.298 ± 0.036	0.185 ± 0.023	0.099 ± 0.012	0.100 ± 0.013
Total Kjeldahl Nitrogen (TKN)	g/m³	0.597 ± 0.074	1.116 ± 0.088	0.324 ± 0.069	0.280 ± 0.069
Dissolved Reactive Phosphorus	g/m³	0.0471 ± 0.0036	0.0140 ± 0.0028	0.0336 ± 0.0032	0.0357 ± 0.0033
Total Phosphorus	g/m³	0.097 ± 0.012	0.0532 ± 0.0065	0.0664 ± 0.0081	0.0705 ± 0.0086

Sample Name:		K_FFB_1 02-Jun-2021 11:00 am	K_FFB_2 02-Jun-2021 11:00 am	K_Int_1 02-Jun-2021 12:00 pm	K_Int_2 02-Jun-2021 12:00 pm
Lab Number:		2629798.13	2629798.14	2629798.15	2629798.16
Turbidity	NTU	3.21 ± 0.29	2.78 ± 0.25	5.43 ± 0.48	5.56 ± 0.49
Total Suspended Solids	g/m³	3.7 ± 2.1	< 3 ± 2.0	3.2 ± 2.1	4.4 ± 2.2
Dissolved Copper	g/m³	< 0.0010 ± 0.00035	< 0.0010 ± 0.00035	0.00116 ± 0.00035	0.00122 ± 0.00035
Total Copper	g/m³	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064
Dissolved Lead	g/m³	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068
Total Lead	g/m³	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097
Dissolved Zinc	g/m³	0.0173 ± 0.0018	0.0178 ± 0.0018	0.0140 ± 0.0015	0.0153 ± 0.0016
Total Zinc	g/m³	0.0228 ± 0.0020	0.0188 ± 0.0017	0.0181 ± 0.0017	0.0178 ± 0.0017
Dissolved Inorganic Nitrogen*	g/m³	0.142 ± 0.013	0.144 ± 0.013	0.239 ± 0.021	0.240 ± 0.021
Total Nitrogen	g/m³	0.188 ± 0.068	0.224 ± 0.068	0.378 ± 0.070	0.361 ± 0.070
Total Ammoniacal-N	g/m³	0.0727 ± 0.0092	0.0745 ± 0.0094	0.099 ± 0.011	0.100 ± 0.012
Nitrate-N + Nitrite-N	g/m³	0.0689 ± 0.0084	0.0696 ± 0.0085	0.140 ± 0.017	0.140 ± 0.017
Total Kjeldahl Nitrogen (TKN)	g/m³	0.119 ± 0.067	0.154 ± 0.067	0.237 ± 0.068	0.221 ± 0.068
Dissolved Reactive Phosphorus	g/m³	0.0174 ± 0.0029	0.0196 ± 0.0029	0.0352 ± 0.0033	0.0355 ± 0.0033
Total Phosphorus	g/m³	0.0332 ± 0.0042	0.0331 ± 0.0042	0.0617 ± 0.0075	0.0629 ± 0.0077

Sample Name:		K_Out_1 02-Jun-2021 12:45 pm	K_Out_2 02-Jun-2021 12:45 pm	K_FFSwale_FF 02-Jun-2021 10:00 am	K_FFB_FF 02-Jun-2021 11:00 am
Lab Number:		2629798.17	2629798.18	2629798.19	2629798.20
Turbidity	NTU	4.04 ± 0.36	3.96 ± 0.35	3.24 ± 0.29	3.60 ± 0.32
Total Suspended Solids	g/m³	3.0 ± 2.0	< 3 ± 2.0	8.3 ± 2.6	4.8 ± 2.2
Dissolved Copper	g/m³	0.00135 ± 0.00036	0.00147 ± 0.00036	0.00121 ± 0.00035	0.00133 ± 0.00036
Total Copper	g/m³	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.0053 ± 0.00064	< 0.011 ± 0.0012
Dissolved Lead	g/m³	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068	< 0.0002 ± 0.000068
Total Lead	g/m³	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0011 ± 0.000097	< 0.0021 ± 0.00015
Dissolved Zinc	g/m³	0.00371 ± 0.00075	0.00358 ± 0.00074	0.0185 ± 0.0019	0.0259 ± 0.0025
Total Zinc	g/m³	< 0.011 ± 0.0012	< 0.011 ± 0.0012	0.0308 ± 0.0026	0.0354 ± 0.0030
Dissolved Inorganic Nitrogen*	g/m³	0.0773 ± 0.0092	0.0932 ± 0.0097	0.450 ± 0.042	0.391 ± 0.030
Total Nitrogen	g/m³	0.523 ± 0.072	0.447 ± 0.070	0.688 ± 0.080	0.522 ± 0.073
Total Ammoniacal-N	g/m³	0.0314 ± 0.0072	0.0476 ± 0.0079	0.123 ± 0.013	0.204 ± 0.020
Nitrate-N + Nitrite-N	g/m³	0.0460 ± 0.0057	0.0455 ± 0.0057	0.327 ± 0.040	0.187 ± 0.023
Total Kjeldahl Nitrogen (TKN)	g/m³	0.477 ± 0.071	0.401 ± 0.070	0.360 ± 0.070	0.334 ± 0.069
Dissolved Reactive Phosphorus	g/m³	0.293 ± 0.016	0.296 ± 0.016	0.0230 ± 0.0030	0.0151 ± 0.0028
Total Phosphorus	g/m³	0.386 ± 0.047	0.385 ± 0.047	0.0617 ± 0.0076	0.0392 ± 0.0049

Sample Type: Aqueous					
Sample Name:		K_FFSwale_3 02-Jun-2021 10:00 am	K_FFB_3 02-Jun-2021 11:00 am	K_Int_3 02-Jun-2021 12:00 pm	K_Out_3 02-Jun-2021 12:45 pm
Lab Number:		2629798.21	2629798.22	2629798.23	2629798.24
Dissolved Copper	g/m³	0.00080 ± 0.00034	0.00061 ± 0.00034	0.00099 ± 0.00035	0.00117 ± 0.00035
Total Copper	g/m³	0.00117 ± 0.00037	0.00089 ± 0.00037	0.00128 ± 0.00038	0.00147 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000238 ± 0.000075	< 0.00011 ± 0.000074	0.000130 ± 0.000074	0.000177 ± 0.000074
Dissolved Zinc	g/m³	0.0138 ± 0.0015	0.0185 ± 0.0019 #1	0.0162 ± 0.0017	0.00391 ± 0.00076
Total Zinc	g/m³	0.0161 ± 0.0015	0.0182 ± 0.0017 #1	0.0172 ± 0.0016	0.00449 ± 0.00082

Sample Name:		P_FFBF_3 02-Jun-2021 3:00 pm	P_Int_3 02-Jun-2021 3:30 pm	P_Outlet_3 02-Jun-2021 4:00 pm	
Lab Number:		2629798.25	2629798.26	2629798.27	
Dissolved Copper	g/m³	0.00116 ± 0.00035	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	-
Total Copper	g/m³	0.00135 ± 0.00038	< 0.00053 ± 0.00036	< 0.00053 ± 0.00036	-
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	-
Total Lead	g/m³	< 0.00011 ± 0.000074	< 0.00011 ± 0.000074	0.000146 ± 0.000074	-
Dissolved Zinc	g/m³	0.0256 ± 0.0025	0.00480 ± 0.00080	0.00122 ± 0.00067	-
Total Zinc	g/m³	0.0256 ± 0.0022	0.00484 ± 0.00083	0.00281 ± 0.00077	-

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.

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Amended Report: This certificate of analysis replaces report '2629798-SUPv1' issued on 17-Jun-2021 at 11:22 am. Reason for amendment: Additional metals testing added.

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-20
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-27
Turbidity	Analysis using a Hach 2100 Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-20
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m³	1-20
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-27
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m³	1-9
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m³	1-9
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1-27
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m³	1-27
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m³	1-27
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m³	1-27

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-27
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-27
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-20
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.010 g/m^3	1-20
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-20
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-20
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-20
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-20
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-20
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H 23rd ed. 2017.	0.002 g/m^3	1-20

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

Testing was completed between 04-Jun-2021 and 02-Jul-2021. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

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

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	3120930	SUPv1
Contact:	I Cooper	**Date Received:**	22-Nov-2022	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	30-Nov-2022	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:	C03816300	
		Submitted By:	I Cooper	

Sample Type: Aqueous

Sample Name:		P_FFBF_Sump 21-Nov-2022 12:40 pm	P_FFBD_Sump 21-Nov-2022 12:33 pm	Prest_In_1 21-Nov-2022 11:54 am	Prest_In_2 21-Nov-2022 11:54 am
Lab Number:		3120930.1	3120930.2	3120930.3	3120930.4
Turbidity	NTU	10.5 ± 1.1	4.71 ± 0.48	1.56 ± 0.16	2.88 ± 0.29
Total Suspended Solids	g/m³	126 ± 26	26.9 ± 5.8	4.5 ± 2.2	4.5 ± 2.2
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	0.00172 ± 0.00068	0.00176 ± 0.00068
Total Arsenic	g/m³	0.00288 ± 0.00076	0.00181 ± 0.00074	0.00189 ± 0.00074	0.00190 ± 0.00074
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	0.00247 ± 0.00040	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034
Total Copper	g/m³	0.0280 ± 0.0029	0.00683 ± 0.00077	0.00072 ± 0.00036	0.00135 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.01303 ± 0.00079	0.00334 ± 0.00022	0.000221 ± 0.000075	0.000241 ± 0.000075
Dissolved Zinc	g/m³	0.0227 ± 0.0023	0.0355 ± 0.0034	0.00277 ± 0.00071	0.00269 ± 0.00071
Total Zinc	g/m³	0.296 ± 0.024	0.0905 ± 0.0073	0.00588 ± 0.00087	0.00618 ± 0.00089
Dissolved Inorganic Nitrogen*	g/m³	0.137 ± 0.012	1.026 ± 0.080	< 0.011 ± 0.007	< 0.011 ± 0.007
Total Nitrogen	g/m³	1.88 ± 0.20	1.58 ± 0.14	0.521 ± 0.085	0.514 ± 0.084
Total Ammoniacal-N	g/m³	0.089 ± 0.011	0.462 ± 0.042	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0478 ± 0.0059	0.564 ± 0.068	< 0.002 ± 0.0014	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	1.83 ± 0.20	1.01 ± 0.13	0.521 ± 0.085	0.513 ± 0.084
Dissolved Reactive Phosphorus	g/m³	0.0111 ± 0.0028	0.0572 ± 0.0040	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.337 ± 0.041	0.177 ± 0.022	0.0346 ± 0.0044	0.0339 ± 0.0043

Sample Name:		P_Out_1 22-Nov-2022 10:00 am	P_Out_2 22-Nov-2022 10:00 am	K_FFB_Sump 21-Nov-2022 3:43 pm	K_FFSwale_1 22-Nov-2022 12:30 pm
Lab Number:		3120930.5	3120930.6	3120930.7	3120930.8
Turbidity	NTU	3.44 ± 0.35	5.60 ± 0.56	17.4 ± 1.8	4.24 ± 0.43
Total Suspended Solids	g/m³	3.9 ± 2.1	5.9 ± 2.3	165 ± 34	< 3 ± 2.0
Dissolved Arsenic	g/m³	0.00221 ± 0.00068	0.00226 ± 0.00068	-	-
Total Arsenic	g/m³	0.00254 ± 0.00075	0.00263 ± 0.00075	-	-
Dissolved Copper	g/m³	0.00051 ± 0.00034	< 0.0005 ± 0.00034	0.00176 ± 0.00037	0.00207 ± 0.00038
Total Copper	g/m³	0.00063 ± 0.00036	0.00345 ± 0.00050	0.0153 ± 0.0016	0.00255 ± 0.00044
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	0.000438 ± 0.000073
Total Lead	g/m³	0.000192 ± 0.000074	0.000408 ± 0.000078	0.01406 ± 0.00085	0.000902 ± 0.000091
Dissolved Zinc	g/m³	0.00188 ± 0.00069	0.00166 ± 0.00068	0.0508 ± 0.0048	0.0123 ± 0.0014
Total Zinc	g/m³	0.00407 ± 0.00080	0.00731 ± 0.00094	0.229 ± 0.019	0.0136 ± 0.0014
Dissolved Inorganic Nitrogen*	g/m³	< 0.011 ± 0.007	< 0.011 ± 0.007	1.67 ± 0.14	0.259 ± 0.021
Total Nitrogen	g/m³	0.535 ± 0.085	0.607 ± 0.090	3.07 ± 0.30	0.694 ± 0.089
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	1.48 ± 0.14	0.130 ± 0.014
Nitrate-N + Nitrite-N	g/m³	0.0023 ± 0.0014	0.0026 ± 0.0014	0.191 ± 0.023	0.128 ± 0.016
Total Kjeldahl Nitrogen (TKN)	g/m³	0.532 ± 0.085	0.604 ± 0.090	2.88 ± 0.30	0.565 ± 0.087
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	< 0.004 ± 0.0027	0.1372 ± 0.0075	0.0604 ± 0.0041
Total Phosphorus	g/m³	0.0346 ± 0.0044	0.0418 ± 0.0052	0.508 ± 0.061	0.106 ± 0.013

Sample Type: Aqueous					
Sample Name:		K_FFB_1 21-Nov-2022 3:02 pm	K_FFB_2 21-Nov-2022 3:02 pm	K_Inlet_1 21-Nov-2022 2:00 pm	K_Inlet_2 21-Nov-2022 2:00 pm
Lab Number:		3120930.9	3120930.10	3120930.11	3120930.12
Turbidity	NTU	4.07 ± 0.41	3.01 ± 0.31	2.88 ± 0.29	3.58 ± 0.36
Total Suspended Solids	g/m³	< 5 ± 2.2	< 6 ± 2.2	7.8 ± 2.5	9.0 ± 2.7
Dissolved Copper	g/m³	0.00111 ± 0.00035	0.00110 ± 0.00035	0.00113 ± 0.00035	0.00104 ± 0.00035
Total Copper	g/m³	0.00237 ± 0.00043	0.00203 ± 0.00041	0.00134 ± 0.00038	0.00166 ± 0.00039
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	0.000136 ± 0.000067	0.000146 ± 0.000068
Total Lead	g/m³	0.000362 ± 0.000077	0.000363 ± 0.000077	0.000389 ± 0.000077	0.000557 ± 0.000081
Dissolved Zinc	g/m³	0.0413 ± 0.0039	0.0375 ± 0.0036	0.0300 ± 0.0029	0.0297 ± 0.0029
Total Zinc	g/m³	0.0457 ± 0.0038	0.0443 ± 0.0037	0.0461 ± 0.0038	0.0526 ± 0.0043
Dissolved Inorganic Nitrogen*	g/m³	0.252 ± 0.021	0.243 ± 0.021	0.077 ± 0.010	0.072 ± 0.009
Total Nitrogen	g/m³	0.432 ± 0.075	0.372 ± 0.072	0.76 ± 0.11	0.84 ± 0.11
Total Ammoniacal-N	g/m³	0.111 ± 0.012	0.105 ± 0.012	0.0704 ± 0.0091	0.0659 ± 0.0088
Nitrate-N + Nitrite-N	g/m³	0.141 ± 0.017	0.138 ± 0.017	0.0066 ± 0.0016	0.0060 ± 0.0015
Total Kjeldahl Nitrogen (TKN)	g/m³	0.291 ± 0.073	0.234 ± 0.070	0.76 ± 0.11	0.84 ± 0.11
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	0.0052 ± 0.0027	0.0940 ± 0.0055	0.0972 ± 0.0057
Total Phosphorus	g/m³	0.0368 ± 0.0046	0.0353 ± 0.0044	0.186 ± 0.023	0.192 ± 0.024

Sample Name:		K_Out_1 22-Nov-2022 11:30 am	K_Out_2 22-Nov-2022 11:30 am	K_FFSwale_2 22-Nov-2022 12:30 pm	Prest MH1 21-Nov-2022 10:20 am
Lab Number:		3120930.13	3120930.14	3120930.15	3120930.22
Turbidity	NTU	8.52 ± 0.85	10.6 ± 1.1	3.84 ± 0.39	3.53 ± 0.36
Total Suspended Solids	g/m³	9.0 ± 2.7	10.8 ± 2.9	4.4 ± 2.2	4.8 ± 2.2
Dissolved Arsenic	g/m³	-	-	-	0.00153 ± 0.00067
Total Arsenic	g/m³	-	-	-	0.00181 ± 0.00074
Dissolved Copper	g/m³	0.00175 ± 0.00037	0.00183 ± 0.00037	0.00211 ± 0.00039	0.00161 ± 0.00037
Total Copper	g/m³	0.00227 ± 0.00042	0.00296 ± 0.00046	0.00465 ± 0.00059	0.00220 ± 0.00042
Dissolved Lead	g/m³	0.000222 ± 0.000069	0.000244 ± 0.000069	0.000192 ± 0.000068	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000817 ± 0.000088	0.001105 ± 0.000099	0.000613 ± 0.000082	0.000488 ± 0.000079
Dissolved Zinc	g/m³	0.0098 ± 0.0012	0.0098 ± 0.0012	0.0105 ± 0.0012	0.0104 ± 0.0012
Total Zinc	g/m³	0.0142 ± 0.0014	0.0175 ± 0.0016	0.0135 ± 0.0014	0.0158 ± 0.0015
Dissolved Inorganic Nitrogen*	g/m³	1.16 ± 0.13	1.08 ± 0.12	0.262 ± 0.021	0.438 ± 0.042
Total Nitrogen	g/m³	1.67 ± 0.16	1.68 ± 0.15	0.742 ± 0.092	0.743 ± 0.088
Total Ammoniacal-N	g/m³	0.145 ± 0.015	0.145 ± 0.015	0.130 ± 0.014	0.101 ± 0.012
Nitrate-N + Nitrite-N	g/m³	1.01 ± 0.13	0.93 ± 0.12	0.132 ± 0.016	0.337 ± 0.041
Total Kjeldahl Nitrogen (TKN)	g/m³	0.658 ± 0.094	0.75 ± 0.10	0.610 ± 0.090	0.406 ± 0.078
Dissolved Reactive Phosphorus	g/m³	0.0528 ± 0.0038	0.0468 ± 0.0036	0.0604 ± 0.0041	0.0297 ± 0.0031
Total Phosphorus	g/m³	0.120 ± 0.015	0.127 ± 0.016	0.116 ± 0.014	0.0704 ± 0.0086

Sample Name:		Prest MH2 21-Nov-2022 10:20 am
Lab Number:		3120930.23
Turbidity	NTU	2.95 ± 0.30
Total Suspended Solids	g/m³	4.2 ± 2.1
Dissolved Arsenic	g/m³	0.00146 ± 0.00067
Total Arsenic	g/m³	0.00172 ± 0.00074
Dissolved Copper	g/m³	0.00162 ± 0.00037
Total Copper	g/m³	0.00262 ± 0.00044
Dissolved Lead	g/m³	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000540 ± 0.000080
Dissolved Zinc	g/m³	0.0086 ± 0.0011
Total Zinc	g/m³	0.0163 ± 0.0015
Dissolved Inorganic Nitrogen*	g/m³	0.449 ± 0.043
Total Nitrogen	g/m³	0.678 ± 0.085
Total Ammoniacal-N	g/m³	0.106 ± 0.012
Nitrate-N + Nitrite-N	g/m³	0.343 ± 0.042
Total Kjeldahl Nitrogen (TKN)	g/m³	0.334 ± 0.074
Dissolved Reactive Phosphorus	g/m³	0.0292 ± 0.0031
Total Phosphorus	g/m³	0.0596 ± 0.0073

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-15, 22-23
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-15, 22-23
Turbidity	Analysis by Turbidity meter. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-15, 22-23
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1-15, 22-23
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-15, 22-23
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-6, 22-23
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-6, 22-23
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-15, 22-23
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m^3	1-15, 22-23
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-15, 22-23
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-15, 22-23
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-15, 22-23
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-15, 22-23
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-15, 22-23
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.005 g/m^3	1-15, 22-23
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-15, 22-23
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-15, 22-23
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-15, 22-23
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-15, 22-23
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-15, 22-23
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) 23rd ed. 2017.	0.002 g/m^3	1-15, 22-23

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

Testing was completed between 25-Nov-2022 and 30-Nov-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
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R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	3185002	SUPv2
Contact:	Liam Allan	**Date Received:**	28-Feb-2023	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	14-Mar-2023	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:	C03816300	
		Submitted By:	Liam Allan	

Sample Type: Aqueous

Sample Name:		K- Outlet_1 28-Feb-2023 10:00 am	K_FF Swale_2 28-Feb-2023 9:35 am	K_FF Swale 28-Feb-2023 9:30 am	P_Out_1 27-Feb-2023 12:15 pm
Lab Number:		3185002.1	3185002.2	3185002.3	3185002.4
Turbidity	NTU	1.99 ± 0.21	4.31 ± 0.44	4.83 ± 0.49	1.40 ± 0.15
Total Suspended Solids	g/m³	5.9 ± 2.3	11.3 ± 3.0	7.7 ± 2.5	5.3 ± 2.2
Dissolved Arsenic	g/m³	0.00220 ± 0.00068	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	0.00180 ± 0.00068
Total Arsenic	g/m³	0.00230 ± 0.00075	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	0.00239 ± 0.00075
Dissolved Copper	g/m³	0.00169 ± 0.00037	0.00229 ± 0.00040	0.00242 ± 0.00040	< 0.0005 ± 0.00034
Total Copper	g/m³	0.00235 ± 0.00043	0.00302 ± 0.00047	0.00312 ± 0.00047	< 0.00053 ± 0.00036
Dissolved Lead	g/m³	0.000257 ± 0.000069	0.000130 ± 0.000067	0.000127 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000675 ± 0.000084	0.000492 ± 0.000079	0.000696 ± 0.000085	0.000213 ± 0.000075
Dissolved Zinc	g/m³	0.171 ± 0.016	0.0129 ± 0.0014	0.0132 ± 0.0014	< 0.0010 ± 0.00067
Total Zinc	g/m³	0.182 ± 0.015	0.0228 ± 0.0020	0.0217 ± 0.0019	0.00354 ± 0.00079
Dissolved Inorganic Nitrogen*	g/m³	0.334 ± 0.026	1.30 ± 0.11	1.243 ± 0.099	0.012 ± 0.007
Total Nitrogen	g/m³	0.91 ± 0.11	2.27 ± 0.23	2.25 ± 0.23	0.540 ± 0.086
Total Ammoniacal-N	g/m³	0.176 ± 0.017	1.17 ± 0.11	1.102 ± 0.098	0.0108 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.158 ± 0.020	0.132 ± 0.016	0.142 ± 0.018	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	0.76 ± 0.11	2.14 ± 0.23	2.11 ± 0.23	0.538 ± 0.086
Dissolved Reactive Phosphorus	g/m³	0.1670 ± 0.0090	0.226 ± 0.012	0.208 ± 0.011	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.232 ± 0.028	0.332 ± 0.040	0.291 ± 0.035	0.0389 ± 0.0049

Sample Name:		Prest_MLT_1 27-Feb-2023 9:30 am	K_Int_1 27-Feb-2023 4:02 pm	P_IFFBD_Sump 27-Feb-2023 12:00 pm	K_FFB_Sump 27-Feb-2023 2:10 pm
Lab Number:		3185002.5	3185002.6	3185002.7	3185002.8
Turbidity	NTU	0.780 ± 0.085	13.8 ± 1.4	7.80 ± 0.78	16.3 ± 1.7
Total Suspended Solids	g/m³	5.7 ± 2.3	14.5 ± 3.5	86 ± 18	154 ± 31
Dissolved Arsenic	g/m³	0.00103 ± 0.00067	0.00131 ± 0.00067	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067
Total Arsenic	g/m³	0.00124 ± 0.00074	0.00172 ± 0.00074	0.00130 ± 0.00074	0.00217 ± 0.00075
Dissolved Copper	g/m³	0.00091 ± 0.00035	0.00160 ± 0.00037	0.00072 ± 0.00034	0.00101 ± 0.00035
Total Copper	g/m³	0.00154 ± 0.00039	0.00244 ± 0.00043	0.00549 ± 0.00066	0.00656 ± 0.00075
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000408 ± 0.000078	0.001107 ± 0.000099	0.00447 ± 0.00028	0.00668 ± 0.00041
Dissolved Zinc	g/m³	0.0136 ± 0.0015	0.0082 ± 0.0011	0.0552 ± 0.0052	0.0158 ± 0.0017
Total Zinc	g/m³	0.0192 ± 0.0017	0.0191 ± 0.0017	0.124 ± 0.010	0.0710 ± 0.0058
Dissolved Inorganic Nitrogen*	g/m³	0.282 ± 0.030	0.257 ± 0.025	0.332 ± 0.026	0.096 ± 0.010
Total Nitrogen	g/m³	0.443 ± 0.075	0.630 ± 0.083	0.539 ± 0.079	0.657 ± 0.092
Total Ammoniacal-N	g/m³	0.0428 ± 0.0076	0.0641 ± 0.0087	0.175 ± 0.017	0.0782 ± 0.0096
Nitrate-N + Nitrite-N	g/m³	0.240 ± 0.029	0.193 ± 0.024	0.156 ± 0.019	0.0182 ± 0.0026
Total Kjeldahl Nitrogen (TKN)	g/m³	0.203 ± 0.069	0.436 ± 0.080	0.382 ± 0.077	0.638 ± 0.092
Dissolved Reactive Phosphorus	g/m³	0.0156 ± 0.0028	0.0749 ± 0.0047	0.0114 ± 0.0028	0.0123 ± 0.0028
Total Phosphorus	g/m³	0.0429 ± 0.0053	0.148 ± 0.018	0.262 ± 0.032	0.504 ± 0.061

Sample Type: Aqueous					
Sample Name:		P_FFBF_Sump 27-Feb-2023 10:50 am	P_FFBF 27-Feb-2023 9:30 am	P_Int_1 27-Feb-2023 11:00 am	K- Outlet_2 27-Feb-2023 10:00 am
Lab Number:		3185002.9	3185002.10	3185002.11	3185002.12
Turbidity	NTU	10.3 ± 1.1	9.13 ± 0.91	0.059 ± 0.034	2.61 ± 0.27
Total Suspended Solids	g/m³	102 ± 21	12.7 ± 3.2	< 3 ± 2.0	7.1 ± 2.4
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	0.00198 ± 0.00068	0.00209 ± 0.00068	0.00218 ± 0.00068 #1
Total Arsenic	g/m³	< 0.0011 ± 0.00074	0.00249 ± 0.00075	0.00226 ± 0.00075	0.00205 ± 0.00075 #1
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	0.00119 ± 0.00035	< 0.0005 ± 0.00034	0.00184 ± 0.00038
Total Copper	g/m³	0.00851 ± 0.00093	0.00257 ± 0.00044	0.00056 ± 0.00036	0.00232 ± 0.00042
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	0.000247 ± 0.000069
Total Lead	g/m³	0.00309 ± 0.00020	0.000915 ± 0.000092	0.000122 ± 0.000074	0.00164 ± 0.00013
Dissolved Zinc	g/m³	0.130 ± 0.013	0.00591 ± 0.00086	0.00186 ± 0.00069	0.175 ± 0.017
Total Zinc	g/m³	0.204 ± 0.017	0.0223 ± 0.0020	0.00271 ± 0.00076	0.181 ± 0.015
Dissolved Inorganic Nitrogen*	g/m³	0.609 ± 0.048	0.758 ± 0.088	< 0.011 ± 0.007	0.329 ± 0.026
Total Nitrogen	g/m³	0.95 ± 0.10	1.05 ± 0.12	0.478 ± 0.082	0.98 ± 0.11
Total Ammoniacal-N	g/m³	0.276 ± 0.026	0.0333 ± 0.0073	< 0.010 ± 0.0067	0.172 ± 0.017
Nitrate-N + Nitrite-N	g/m³	0.333 ± 0.040	0.725 ± 0.088	< 0.002 ± 0.0014	0.158 ± 0.019
Total Kjeldahl Nitrogen (TKN)	g/m³	0.621 ± 0.091	0.329 ± 0.074	0.478 ± 0.082	0.82 ± 0.11
Dissolved Reactive Phosphorus	g/m³	0.0636 ± 0.0042	0.0405 ± 0.0034	< 0.004 ± 0.0027	0.1651 ± 0.0089
Total Phosphorus	g/m³	0.163 ± 0.020	0.0624 ± 0.0076	0.0182 ± 0.0025	0.238 ± 0.029

Sample Name:		P_Out_2 27-Feb-2023 12:15 pm	Prest_MLT_2 27-Feb-2023 9:30 am	K_Int_2 27-Feb-2023 4:02 pm	P_Int_2 27-Feb-2023 11:00 am
Lab Number:		3185002.14	3185002.16	3185002.18	3185002.20
Turbidity	NTU	4.18 ± 0.42	1.21 ± 0.13	13.1 ± 1.4	0.148 ± 0.037
Total Suspended Solids	g/m³	25.7 ± 5.5	5.0 ± 2.2	25.7 ± 5.5	< 3 ± 2.0
Dissolved Arsenic	g/m³	0.00198 ± 0.00068	0.00106 ± 0.00067	0.00138 ± 0.00067	0.00209 ± 0.00068
Total Arsenic	g/m³	0.00229 ± 0.00075	< 0.0011 ± 0.00074	0.00175 ± 0.00074	0.00225 ± 0.00075
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	0.00156 ± 0.00036 #1	0.00180 ± 0.00037	< 0.0005 ± 0.00034
Total Copper	g/m³	< 0.00053 ± 0.00036	0.00151 ± 0.00039 #1	0.00249 ± 0.00043	< 0.00053 ± 0.00036
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	0.000221 ± 0.000069	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000197 ± 0.000074	0.000360 ± 0.000077	0.001102 ± 0.000099	0.000129 ± 0.000074
Dissolved Zinc	g/m³	< 0.0010 ± 0.00067	0.0137 ± 0.0015	0.0084 ± 0.0011	0.00151 ± 0.00068
Total Zinc	g/m³	0.00255 ± 0.00076	0.0217 ± 0.0019	0.0153 ± 0.0015	0.00231 ± 0.00076
Dissolved Inorganic Nitrogen*	g/m³	0.015 ± 0.007	0.291 ± 0.031	0.269 ± 0.027	< 0.011 ± 0.007
Total Nitrogen	g/m³	0.543 ± 0.086	0.447 ± 0.076	0.801 ± 0.093	0.450 ± 0.080
Total Ammoniacal-N	g/m³	0.0142 ± 0.0068	0.0413 ± 0.0076	0.0600 ± 0.0085	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	< 0.002 ± 0.0014	0.250 ± 0.031	0.209 ± 0.026	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	0.542 ± 0.086	0.196 ± 0.069	0.591 ± 0.089	0.449 ± 0.080
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	0.0140 ± 0.0028	0.0754 ± 0.0047	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.0352 ± 0.0044	0.0819 ± 0.0099	0.158 ± 0.020	0.0195 ± 0.0027

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.

Analyst's Comments

#1 It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-12, 14, 16, 18, 20

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-12, 14, 16, 18, 20
Turbidity	Analysis by Turbidity meter. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-12, 14, 16, 18, 20
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1-12, 14, 16, 18, 20
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-12, 14, 16, 18, 20
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-12, 14, 16, 18, 20
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-12, 14, 16, 18, 20
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-12, 14, 16, 18, 20
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m^3	1-12, 14, 16, 18, 20
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-12, 14, 16, 18, 20
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-12, 14, 16, 18, 20
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-12, 14, 16, 18, 20
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-12, 14, 16, 18, 20
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-12, 14, 16, 18, 20
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.005 g/m^3	1-12, 14, 16, 18, 20
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-12, 14, 16, 18, 20
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-12, 14, 16, 18, 20
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-12, 14, 16, 18, 20
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-12, 14, 16, 18, 20
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-12, 14, 16, 18, 20
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) 23rd ed. 2017.	0.002 g/m^3	1-12, 14, 16, 18, 20

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

Testing was completed between 07-Mar-2023 and 14-Mar-2023. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Pattle Delamore Partners Limited	**Lab No:**	3255686	SUPv1
Contact:	Liam Allan	**Date Received:**	26-Apr-2023	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	08-May-2023	
	PO Box 389	**Quote No:**	103440	
	Christchurch 8140	**Order No:**		
		Client Reference:	C03816300	
		Submitted By:	Ella Harris	

Sample Type: Aqueous

Sample Name:		P_FFBD_Sump 24-Apr-2023	K_FFB_Sump 24-Apr-2023	P_FFBF_Sump 24-Apr-2023	K_FFSWALE_FF 24-Apr-2023
Lab Number:		3255686.1	3255686.2	3255686.3	3255686.4
Turbidity	NTU	3.66 ± 0.33	24.9 ± 2.2	9.14 ± 0.81	4.16 ± 0.37
Total Suspended Solids	g/m³	55 ± 12	175 ± 36	95 ± 20	12.4 ± 3.2
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	-	< 0.0010 ± 0.00067	-
Total Arsenic	g/m³	< 0.0011 ± 0.00074	-	< 0.0011 ± 0.00074	-
Dissolved Copper	g/m³	0.00084 ± 0.00034	0.00089 ± 0.00035	< 0.0005 ± 0.00034	0.00135 ± 0.00036
Total Copper	g/m³	0.00317 ± 0.00048	0.00536 ± 0.00064	0.00289 ± 0.00046	0.00176 ± 0.00040
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.00228 ± 0.00016	0.00460 ± 0.00029	0.00198 ± 0.00014	0.000380 ± 0.000077
Dissolved Zinc	g/m³	0.0317 ± 0.0031	0.0361 ± 0.0035	0.0291 ± 0.0028	0.0154 ± 0.0016
Total Zinc	g/m³	0.0696 ± 0.0057	0.0970 ± 0.0078	0.0595 ± 0.0049	0.0196 ± 0.0018
Dissolved Inorganic Nitrogen*	g/m³	0.311 ± 0.029	0.319 ± 0.025	0.209 ± 0.018	0.304 ± 0.026
Total Nitrogen	g/m³	0.932 ± 0.097	0.861 ± 0.095	0.696 ± 0.091	0.759 ± 0.086
Total Ammoniacal-N	g/m³	0.094 ± 0.011	0.160 ± 0.016	0.184 ± 0.018	0.117 ± 0.013
Nitrate-N + Nitrite-N	g/m³	0.216 ± 0.027	0.159 ± 0.020	0.0249 ± 0.0033	0.187 ± 0.023
Total Kjeldahl Nitrogen (TKN)	g/m³	0.716 ± 0.094	0.702 ± 0.093	0.671 ± 0.090	0.572 ± 0.083
Dissolved Reactive Phosphorus	g/m³	0.0167 ± 0.0028	0.0144 ± 0.0028	0.0085 ± 0.0027	0.0330 ± 0.0032
Total Phosphorus	g/m³	0.083 ± 0.011	0.229 ± 0.028	0.155 ± 0.019	0.083 ± 0.010

Sample Name:		K_Outlet_1 24-Apr-2023	K_FFSWALE_1 24-Apr-2023	P_INT_1 24-Apr-2023	P_OUTLET_1 24-Apr-2023
Lab Number:		3255686.5	3255686.6	3255686.7	3255686.8
Turbidity	NTU	2.80 ± 0.25	3.66 ± 0.33	0.757 ± 0.075	0.726 ± 0.072
Total Suspended Solids	g/m³	14.1 ± 3.5	3.3 ± 2.1	7.6 ± 2.5	3.5 ± 2.1
Dissolved Arsenic	g/m³	-	-	0.00141 ± 0.00067	0.00148 ± 0.00067
Total Arsenic	g/m³	-	-	0.00159 ± 0.00074	0.00168 ± 0.00074
Dissolved Copper	g/m³	0.00140 ± 0.00036	0.00117 ± 0.00035	0.00058 ± 0.00034	< 0.0005 ± 0.00034
Total Copper	g/m³	0.00168 ± 0.00039	0.00172 ± 0.00039	0.00065 ± 0.00036	< 0.00053 ± 0.00036
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000422 ± 0.000078	0.000329 ± 0.000076	0.000183 ± 0.000074	< 0.00011 ± 0.000074
Dissolved Zinc	g/m³	0.0105 ± 0.0012	0.0148 ± 0.0016	0.00125 ± 0.00068	0.00129 ± 0.00068
Total Zinc	g/m³	0.0154 ± 0.0015	0.0177 ± 0.0016	0.00312 ± 0.00077	0.00164 ± 0.00074
Dissolved Inorganic Nitrogen*	g/m³	0.146 ± 0.015	0.174 ± 0.016	< 0.011 ± 0.007	< 0.011 ± 0.007
Total Nitrogen	g/m³	1.01 ± 0.12	0.535 ± 0.076	0.513 ± 0.079	0.437 ± 0.075
Total Ammoniacal-N	g/m³	0.140 ± 0.014	0.0769 ± 0.0095	< 0.010 ± 0.0067	< 0.010 ± 0.0067
Nitrate-N + Nitrite-N	g/m³	0.0062 ± 0.0015	0.097 ± 0.012	< 0.002 ± 0.0014	< 0.002 ± 0.0014
Total Kjeldahl Nitrogen (TKN)	g/m³	1.00 ± 0.12	0.438 ± 0.075	0.513 ± 0.079	0.435 ± 0.075
Dissolved Reactive Phosphorus	g/m³	0.0930 ± 0.0055	0.0201 ± 0.0029	< 0.004 ± 0.0027	< 0.004 ± 0.0027
Total Phosphorus	g/m³	0.191 ± 0.023	0.0466 ± 0.0058	0.0135 ± 0.0021	0.0195 ± 0.0027

Sample Type: Aqueous					
Sample Name:		P_FFBF_1 24-Apr-2023	P_FF 24-Apr-2023	K_Outlet_2 24-Apr-2023	K_FFSWALE_2 24-Apr-2023
Lab Number:		3255686.9	3255686.10	3255686.11	3255686.13
Turbidity	NTU	1.73 ± 0.16	1.39 ± 0.13	5.92 ± 0.52	3.75 ± 0.33
Total Suspended Solids	g/m³	< 3 ± 2.0	4.3 ± 2.1	10.3 ± 2.9	6.4 ± 2.3
Dissolved Arsenic	g/m³	< 0.0010 ± 0.00067	< 0.0010 ± 0.00067	-	-
Total Arsenic	g/m³	< 0.0011 ± 0.00074	< 0.0011 ± 0.00074	-	-
Dissolved Copper	g/m³	0.00082 ± 0.00034	0.00073 ± 0.00034	0.00137 ± 0.00036	0.00112 ± 0.00035
Total Copper	g/m³	0.00105 ± 0.00037	0.00092 ± 0.00037	0.00159 ± 0.00039	0.00139 ± 0.00038
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	0.000218 ± 0.000075	0.000198 ± 0.000074	0.000303 ± 0.000076	0.000346 ± 0.000076
Dissolved Zinc	g/m³	0.0108 ± 0.0013	0.0101 ± 0.0012	0.0105 ± 0.0012	0.0147 ± 0.0016
Total Zinc	g/m³	0.0136 ± 0.0014	0.0124 ± 0.0013	0.0137 ± 0.0014	0.0181 ± 0.0017
Dissolved Inorganic Nitrogen*	g/m³	0.083 ± 0.010	0.061 ± 0.009	0.156 ± 0.015	0.160 ± 0.015
Total Nitrogen	g/m³	0.249 ± 0.064	0.322 ± 0.067	0.97 ± 0.12	0.509 ± 0.075
Total Ammoniacal-N	g/m³	0.0343 ± 0.0073	0.0200 ± 0.0069	0.151 ± 0.015	0.0722 ± 0.0092
Nitrate-N + Nitrite-N	g/m³	0.0491 ± 0.0061	0.0412 ± 0.0052	0.0052 ± 0.0015	0.088 ± 0.011
Total Kjeldahl Nitrogen (TKN)	g/m³	0.200 ± 0.064	0.281 ± 0.067	0.97 ± 0.12	0.422 ± 0.074
Dissolved Reactive Phosphorus	g/m³	0.0083 ± 0.0027	0.0053 ± 0.0027	0.0924 ± 0.0055	0.0218 ± 0.0029
Total Phosphorus	g/m³	0.0208 ± 0.0028	0.0229 ± 0.0030	0.190 ± 0.023	0.0474 ± 0.0059

Sample Name:		P_INT_2 24-Apr-2023	P_OUTLET_2 24-Apr-2023	P_FFBF_2 24-Apr-2023
Lab Number:		3255686.14	3255686.16	3255686.18
Turbidity	NTU	0.617 ± 0.064	0.804 ± 0.078	1.65 ± 0.15
Total Suspended Solids	g/m³	< 3 ± 2.0	< 3 ± 2.0	5.5 ± 2.3
Dissolved Arsenic	g/m³	0.00144 ± 0.00067	0.00163 ± 0.00068 [#1]	< 0.0010 ± 0.00067
Total Arsenic	g/m³	0.00155 ± 0.00074	0.00156 ± 0.00074	< 0.0011 ± 0.00074
Dissolved Copper	g/m³	< 0.0005 ± 0.00034	< 0.0005 ± 0.00034	0.00068 ± 0.00034
Total Copper	g/m³	0.00058 ± 0.00036	< 0.00053 ± 0.00036	0.00103 ± 0.00037
Dissolved Lead	g/m³	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067	< 0.00010 ± 0.000067
Total Lead	g/m³	< 0.00011 ± 0.000074	< 0.00011 ± 0.000074	0.000260 ± 0.000075
Dissolved Zinc	g/m³	0.00154 ± 0.00068	< 0.0010 ± 0.00067	0.0110 ± 0.0013
Total Zinc	g/m³	0.00333 ± 0.00078	0.00188 ± 0.00075	0.0140 ± 0.0014
Dissolved Inorganic Nitrogen*	g/m³	< 0.011 ± 0.007	< 0.011 ± 0.007	0.087 ± 0.010
Total Nitrogen	g/m³	0.388 ± 0.072	0.437 ± 0.075	0.239 ± 0.064
Total Ammoniacal-N	g/m³	< 0.010 ± 0.0067	< 0.010 ± 0.0067	0.0388 ± 0.0075
Nitrate-N + Nitrite-N	g/m³	< 0.002 ± 0.0014	< 0.002 ± 0.0014	0.0486 ± 0.0060
Total Kjeldahl Nitrogen (TKN)	g/m³	0.387 ± 0.072	0.435 ± 0.075	0.190 ± 0.063
Dissolved Reactive Phosphorus	g/m³	< 0.004 ± 0.0027	< 0.004 ± 0.0027	0.0090 ± 0.0027
Total Phosphorus	g/m³	0.0137 ± 0.0021	0.0132 ± 0.0020	0.0253 ± 0.0033

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.

Analyst's Comments

[#1] It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

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 simple 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. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Performed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch.	-	1-11, 13-14, 16, 18

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1-11, 13-14, 16, 18
Turbidity	Analysis by Turbidity meter. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2130 B 23rd ed. 2017 (modified).	0.05 NTU	1-11, 13-14, 16, 18
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. Analysed at Hill Laboratories - Chemistry; 101c Waterloo Road, Christchurch. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1-11, 13-14, 16, 18
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-11, 13-14, 16, 18
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1, 3, 7-10, 14, 16, 18
Total Arsenic	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1, 3, 7-10, 14, 16, 18
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m^3	1-11, 13-14, 16, 18
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00053 g/m^3	1-11, 13-14, 16, 18
Dissolved Lead	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00010 g/m^3	1-11, 13-14, 16, 18
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.00011 g/m^3	1-11, 13-14, 16, 18
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0010 g/m^3	1-11, 13-14, 16, 18
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8.	0.0011 g/m^3	1-11, 13-14, 16, 18
Dissolved Inorganic Nitrogen*		0.002 - 0.010 g/m^3	1-11, 13-14, 16, 18
Dissolved Inorganic Nitrogen*	Calculation: NH_4-N + NO_3-N + NO_2-N. In-house calculation.	0.005 g/m^3	1-11, 13-14, 16, 18
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3. In-house calculation.	0.05 g/m^3	1-11, 13-14, 16, 18
Total Ammoniacal-N	Filtered Sample from Christchurch. Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1-11, 13-14, 16, 18
Nitrate-N + Nitrite-N	Filtered sample from Christchurch. Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1-11, 13-14, 16, 18
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-Norg D (modified) 4500 NH3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1-11, 13-14, 16, 18
Dissolved Reactive Phosphorus	Filtered sample from Christchurch. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1-11, 13-14, 16, 18
Total Phosphorus	Total phosphorus digestion, automated ascorbic acid colorimetry. Flow Injection Analyser. APHA 4500-P H (modified) 23rd ed. 2017.	0.002 g/m^3	1-11, 13-14, 16, 18

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

Testing was completed between 28-Apr-2023 and 08-May-2023. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

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