WAIMEA COMMUNITY DAM

Construction Phase Environmental Monitoring Annual Report 2019-2020

Prepared for:

Waimea Water Limited
14 Oxford Street
Richmond

SLR Ref: 740.10097.00000-R01
Version No: -v1.0
July 2020

PREPARED BY

SLR Consulting NZ Limited
Company Number 2443058
6/A Cambridge Street
Richmond, Nelson 7020 New Zealand
(PO Box 3032, Richmond 7050 New Zealand)
T: +64 274 898 628
E: nelson@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10097.00000-R01-v1.0	29 July 2020	Craig Allen	Stephen Calder	Dan Govier

EXECUTIVE SUMMARY

Waimea Water Limited (**WWL**) hold resource consents RM140540, RM140542 - RM140559, authorising the construction and operation of the Waimea Community Dam. Condition 41 requires the Consent Holder to undertake monitoring of macroinvertebrate communities (**QMCI**), visual clarity, deposited fine sediments, pH, dissolved oxygen (**DO**), turbidity and total suspended solids during the pre-construction and construction phases of the dam. This monitoring began in September 2017 (preconstruction phase); and will continue fortnightly until construction phase is complete, two months after the filling of the dam. This annual report is required under Condition 121 and provides a summary of water quality related monitoring data for the 2019-2020 construction phase monitoring year, as well as the pre-construction phase.

Monitoring efforts were hampered on several occasions by operational restrictions that were beyond the control of the consent holder. These include site access restrictions due to extreme fire risk, road closures on Lee Valley Road, and the lockdown associated with the Covid-19 pandemic meant that monitoring was not possible for the final three fortnightly monitoring runs of the year (April 2020). Operational restrictions also hampered SLR vehicle movements on-site, citing Health and Safety concerns and ongoing road access issues. This restricted monitoring operations such that travel throughout the site could only take place at certain times of the day. That meant that much of the fortnightly monitoring undertaken during the construction phase was not carried out "*at times chosen at random during working day*", as required under Condition 41. Also, it was difficult to take measurements of DO "*between 0600 and 0900 hours*" with these constraints in place.

Conditions 42 – 46 provide trigger levels for macroinvertebrates, visual clarity, deposited fine sediments, pH, and DO that, if breached, require additional monitoring under Condition 47. The consent holder was largely compliant with Conditions 42 – 46, with one occasion where additional monitoring of suspended fine sediments was required (Condition 44). In the follow up to this additional monitoring, the trigger value was subsequently reviewed by TDC compliance and replaced with a more ecologically relevant trigger. From this point forward any sampling result from the downstream site showing a fine sediment coverage of 20 percentage points (or more) greater than the upstream value will be the trigger for Condition 47. Similarly, discussions between WWL and TDC established that the interpretation of Condition 43 should also be based on a more ecologically relevant trigger. It was decided that, going forward, any sampling result from the downstream site showing a visual clarity result of 2 m or less would be the trigger for Condition 47.

Pairwise comparison showed that there has been a statistically significant decrease in visual clarity, increase in the proportion of deposited fine sediments, and increase in turbidity at the downstream monitoring site as a result of construction activities. There was no statistically significant difference between upstream and downstream scores for of the QMCI, DO, pH, and total suspended solids.

- QMCI – results indicate that construction activities have not affected the QMCI score at the downstream site;
- Visual clarity – results indicate that construction activities are causing a trend of decreased visual clarity at the downstream site. However, this decrease is within acceptable trigger limits set within the revised version of the condition 43;
- Deposited fine sediments – results indicate that construction activities are causing a trend of an increased proportion of deposited fine sediments at the downstream site. However, this increase is within acceptable trigger limits set within the revised version of condition 44;
- DO – results indicate that construction activities have not affected DO at the downstream site;

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- pH - results indicate that construction activities have not affected pH at the downstream site;
- Turbidity – results indicate that construction activities have caused a trend of increased turbidity at the downstream site; and
- Total suspended solids – results are inconclusive because most of the data are below Analytical Detection Limits.

Conditions 42-46 were met in the 2019-2020 monitoring year, implying that the adverse effects of construction activities on water quality and aquatic ecology were within acceptable limits.

However, the trend for some water quality parameters (visual clarity, turbidity and deposited fine sediments) indicate reduced water quality as a result of construction activities.

Of all the water quality parameters monitored, the most useful for assessing the overall health of aquatic ecosystems is QMCI because it provides a biotic (rather than chemical) measure of prevailing stream health. All of the QMCI scores from the pre-construction and construction phase monitoring indicate that the overall health of aquatic ecosystems in the Lee River, including those taken downstream from construction activities, was 'excellent' during the 2019-2020 monitoring year.

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ABBREVIATIONS

ADL	Analytical Detection Limits
DO	Dissolved Oxygen
EPT	Ephemeroptera, Plecoptera, and Trichoptera
NZTM	New Zealand Transverse Mercator 2000
QMCI	Quantitative Macroinvertebrate Community Index
SLR	SLR Consulting NZ Limited
TDC	Tasman District Council
the Dam	Waimea Community Dam
WWL	Waimea Water Limited
WWL Consents	Resource consents RM140540, RM140542 - RM140559

1 Introduction

Waimea Water Limited (**WWL**) hold resource consents RM140540, RM140542 - RM140559 (**the WWL consents**). These resource consents, granted by the Tasman District Council (**TDC**) in 2015[1], authorise the construction and operation of the Waimea Community Dam (**the dam**).

Condition 41 of the WWL consents requires the Consent Holder to undertake water quality monitoring during the pre-construction and construction phases of the dam. The purpose of this monitoring is to assess the effects of construction activities on water quality within the Lee River. Condition 121 requires the Consent Holder to provide an annual monitoring report on the operation of the dam to TDC by 31 July each year.

TDC conducted the pre-construction phase environmental monitoring across four quarters, (11 September 2017, 5 December 2017, 9 March 2018 and 27 June 2018). An additional pre-construction sampling occasion took place on 9 January 2019, with a view to provide additional data immediately prior to commencement of construction operations, which was due to begin the following month (*pers. com* Joseph Thomas (TDC Senior Resource Scientist), 9 June 2020). However, earthworks did not commence until 1 April 2019[2] due to forest closures caused by extreme region-wide fire risk over later summer and early autumn.

Routine fortnightly construction phase monitoring commenced in May 2019. SLR Consulting NZ Limited (**SLR**) was engaged by WWL in June 2019 to undertake routine fortnightly and quarterly water quality surveys to sample discrete[3] water quality parameters during the construction phase of the dam.

This annual monitoring report summarises the results of all fortnightly and quarterly water quality monitoring undertaken during the pre-construction and construction phases, an interpretation of the results, and an assessment of the impact of the discharges from the dam on the water quality and aquatic ecology of the Lee River.

[1] The consents, originally granted to the Tasman District Council and Waimea Community Dam Limited in 2015, were transferred to WWL in 2018.

[2] Work on the access road began earlier on 18 March 2019 (pers. com John Tinsley 17 June 2020).

[3] Consent RM140540 and RM140542 - RM140559 also requires continuous monitoring of water quality related data (flow, rainfall and turbidity) during the construction phase. These have been collected by Tasman District Council, the results of which are not included in this report.

1.1 Regulatory Requirements

1.1.1 Annual Report

Waimea Water Ltd have requested that SLR provide an annual monitoring report to summarise the environmental data collected in the preceding monitoring period.

1.1.2 Monitoring Requirements

Table 1 summarises the frequency and timing of environmental monitoring parameters required for both the pre-construction and construction phases, as set out in Condition 41. The aim of the monitoring is to compare water clarity, fine sediment deposition, pH, dissolved oxygen (**DO**) and macroinvertebrate indices (both Quantitative Macroinvertebrate Community Index (**QMCI**) and Ephemeroptera, Plecoptera, and Trichoptera (**EPT**)) at the upstream and downstream sites and assess compliance according to Conditions 42-46 (**Table** 2).

Conditions 42 – 46 apply specific trigger values to some of the monitored parameters from Condition 41. Condition 47 (**Appendix A**) states that additional monitoring is required if these trigger values are breached; that construction activities must cease; and that further water quality measurements be taken daily for that parameter for ten working days after the breach occurs.

A full description of relevant consent conditions is provided in **Appendix A**.

Table 1 Environmental monitoring to be undertaken at each site during the pre-construction and construction phases, as required by Condition 41

Type	Monitoring Parameter	Pre-construction Phase Frequency	Construction Phase Frequency
Laboratory analysis of water samples	Total Suspended Solids	Quarterly	Fortnightly at times chosen at random during working day
	Turbidity		
Field measurements / sampling (discrete)	Visual clarity (Black Disk)	Quarterly	
	Deposited Fine Sediments	Quarterly	
	pH	Quarterly	
	Dissolved Oxygen	Quarterly	Fortnightly between 0600 and 0900 hours
	Quantitative macroinvertebrate sampling – QMCI and EPT	Quarterly	Quarterly during the first 12 months of construction, then 6-monthly thereafter.
Field Measurements (continuous)	Turbidity	N/A	Continuous – Telemetered to website in real time

Table 2 Monitoring conditions with trigger values that if breached require additional monitoring under Condition 47

Consent Condition	Details
Condition 42	The percentage reduction to the **macroinvertebrate** QMCI score downstream of the construction area relative to the QMCI upstream of the construction area shall not exceed 20% in combination with a 20% reduction in the densities of EPT taxa.

Consent Condition	Details
Condition 43	The percentage reduction in **visual clarity** of water downstream of the construction area relative to water upstream of the construction area shall not exceed 40% at flows less than the median flow. This performance standard shall not apply during works in any active river channel or for a period of 9 hours after their completion.
Condition 44	The coverage of **deposited fine sediment** on the riverbed of the Lee River downstream of the construction area shall be no more than 20% higher than measured at the upstream monitoring site.
Condition 45	The **pH** of the Lee River downstream of the construction area shall not fall outside of the range 6.5 to 9.0.
Condition 46	The level of **dissolved oxygen** in the Lee River downstream of the construction area shall not be less than 80% of the saturation value.

2 Methodology

2.1 Site Locations

Monitoring was undertaken at two locations: one upstream (Control Site) and one downstream (Impacted Site) of the construction area (**Figure 1** and **Figure 2**). As stipulated in Condition 41, the upstream site is located approximately 100 metres upstream of the upstream extent of any construction activity (NZTM coordinates: 1613847 mE, 5407142 mN); and the downstream site is located approximately 1,000 metres downstream of all dam construction activity (NZTM coordinates: 1613547 mE, 5410226 mN).

Figure 1 Waimea community dam construction phase environmental monitoring sites

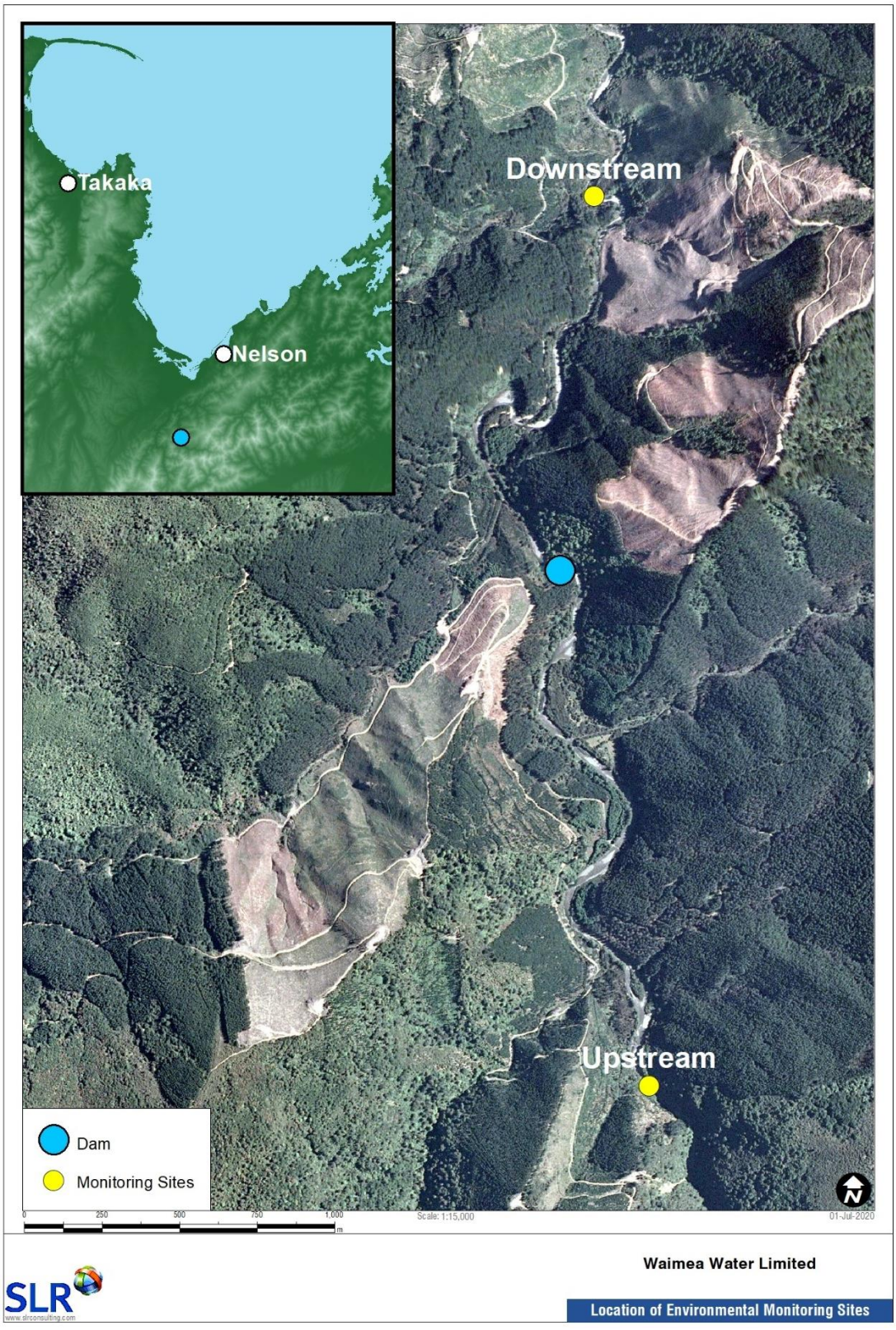
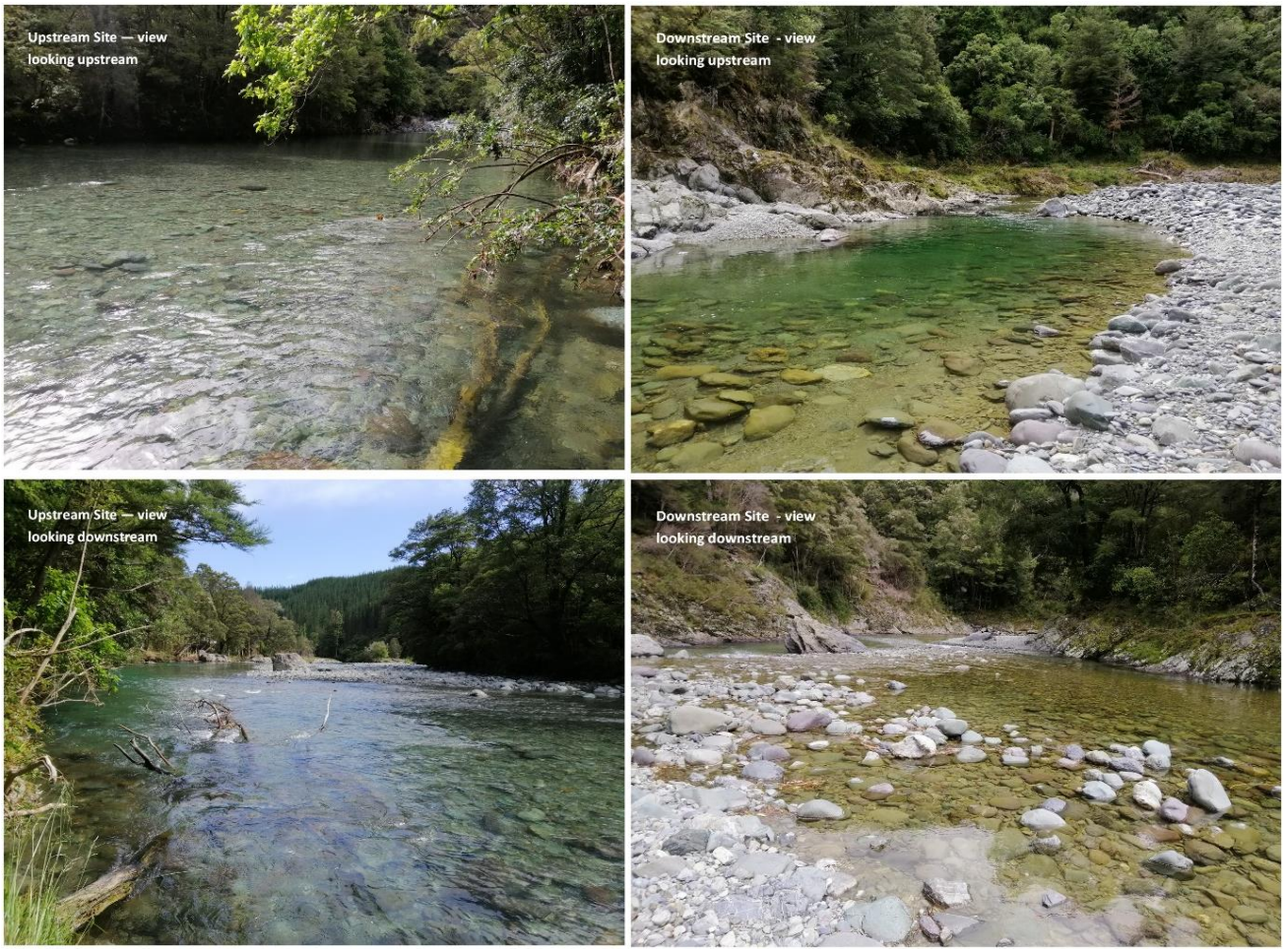


Figure 2 Photos of the upstream and downstream monitoring sites used for pre-construction and construction phase environmental monitoring



2.2 Survey Design

A symmetrical (two site) repeated measures survey design was adopted to test if discharges from dam construction activities impact the water quality and aquatic ecology of the Lee River.

Condition 41 requires monitoring to be undertaken fortnightly and quarterly at the two sites, "*at times chosen at random during working day*", and with "*dissolved oxygen measured between 0600 and 0900 hours*". While the intention was to sample as such, this was not always possible, and the timing of monitoring had to be adapted. Reasons for this include:

- From July 2019, operational restrictions applied to SLR vehicle movements on-site, citing Health and Safety concerns and ongoing road access issues. This effectively restricted monitoring operations such that travel throughout the site should only attempt to take place during the morning and afternoon 'smoko' breaks of dam construction staff and forestry workers (10 am and 2 pm, respectively). While this was not strictly adhered to, SLR did endeavour to aim for these times to minimise risk due to the increased presence of heavy vehicles and plant outside of these times, as well as minimise the likelihood of encountering impassable roads due to ongoing roadworks;

- Following the commencement of construction phase monitoring on 06 May 2019, road access issues hindered TDC / WWL's ability to carry out regular fortnightly monitoring, only able to access the site once more (04 June), before handing monitoring operations to SLR on 02 July [4]; and
- During the nation-wide lockdown enforced during the Covid-19 pandemic. All monitoring was suspended between 25 March and 29 April 2020. As a result, there is not data for the final three monitoring occasions of the year (to the end of April 2020).

Fortnightly construction phase monitoring took place on a total of 21 days over the course of the 2019-2020 monitoring year, with the quarterly construction phase monitoring carried out on three of these days. As outlined in **Section 1**, pre-construction phase quarterly monitoring took place on five occasions from September 2018 to January 2019. This report presents data from the pre-construction phase and the 2019-2020 monitoring year of the construction phase (01 May to 30 April).

2.3 Macroinvertebrate Communities

Sampling was based on the C3 quantitative macroinvertebrate sampling method (Stark *et al*., 2001), where seven composite Surber samples (0.1 m^2 area, 0.5 mm mesh) were collected at each of the upstream and downstream sites. The samples were placed into 600 mL plastic pottles and preserved with 70% ethanol. Macroinvertebrate sampling was not conducted within two weeks of a fresh greater than three times the median flow.

Laboratory processing and identification followed Protocol P3 (Stark *et al.*, 2001). This involved a 'full count' methodology. A binocular microscope was used to aid identification. Examples of macroinvertebrates found in the Lee River are provided in **Figure 3**.

Once identification had been conducted, water quality related metrics required under Condition 41 were calculated (i.e. QMCI, and % EPT taxa). As part of the required Quality Assurance and Quality Control (Stark *et al.* (2001), approximately 10% of the samples taken at the site were checked by an independent taxonomist.

Water quality of stony bottomed streams throughout New Zealand can be interpreted using QMCI scores derived from macroinvertebrate sampling (**Table 3**). Stark and Maxted (2007b) recommend using a biotic index (i.e. QMCI) in combination with EPT richness to analyse macroinvertebrate community data more comprehensively. EPT richness is the percentage of taxa richness comprising mayflies, stoneflies and caddisflies, providing an estimate of the proportion of more sensitive taxa present.

Table 3 Interpretation of water quality and / or pollution levels based on QMCI scores in stony streams

Water quality class Adapted from Stark & Maxted (2007a)	QMCI score
Excellent (clean water)	>5.99
Good (possible mild pollution)	5.00-5.99
Fair (probable moderate pollution)	4.00-4.99
Poor (probable severe pollution)	<4.00

[4] SLR carried out the fortnightly and quarterly monitoring of water quality parameters from this date, while TDC maintained the continuous monitoring of turbidity and flow.

Figure 3 Examples of macroinvertebrates found in the Lee River

2.4 Visual Clarity

Visual clarity was measured according to the black disk methods set out in NEMS (2019). Care was taken to avoid partial shadows – such that the path of sight was entirely sunlit or entirely in shadow. Plumes of sediment were avoided by placing the disk at the upstream end (stationary) with the viewer box downstream, adjusting the distance by moving the viewer box in an upstream direction. Rain was be avoided when possible as it affects the visibility on the mirror surface within the viewer box.

Condition 43 states that the percentage reduction in visual clarity of water downstream of the construction area relative to water upstream of the construction area shall not exceed 40% at flows less than the median flow. The condition also notes that this performance standard does not apply during works in any active river channel or for a period of nine hours after their completion.

Condition 43 did not apply on 12 of the 21 construction phase monitoring occasions due to either the river being higher than the median flow, or instream works occurring within nine hours of monitoring.

During the 2019-2020 monitoring year WWL raised concerns with TDC about the difficulty of meeting Condition 43 due to very high water clarity at the upstream site and the unknown lag time between a given river works event (with variable distance upstream, duration and streamflow) and the downstream monitoring site. Following discussions between WWL and TDC, it was established that the interpretation of Condition 43 should be based on a more ecologically relevant trigger. It was decided that, going forward, any sampling result from the downstream site showing a visual clarity result of 2 m or less would be the trigger for Condition 47, rather than using 40% reduction from the upstream site (pers com Alasdair Mawdsley).

2.5 Deposited Fine Sediments

The Sediment Assessment Method 2 semi-quantitative method (Clapcott *et al*., 2011) was used to visually estimate the percentage of the streambed covered by fine sediment (<2 mm). The average of 20 quadrats was calculated for each site and reported as the percentage of the streambed covered by fine sediment. Deposited sandy sediments were estimated concurrently, using the same method. Deposited sandy sediment is not a monitoring requirement of the WWL consents but was instead requested by TDC Senior Resource Scientist Trevor James when construction phase monitoring began (*pers com* Steph Bowis, TDC Hydrologist).

Condition 44 states that the coverage of deposited fine sediment on the riverbed of the Lee River downstream of the construction area shall be no more than 20% higher than measured at the upstream monitoring site. For most of the 2019-2020 monitoring period this was interpreted to be multiplicative. For example, a 20% score upstream and a 30% score downstream equates to a 50% increase in fine sediments. However, if the coverage is small, for example, 2% upstream and 3% downstream, the percentage increase is the same, but the ecological effects are *de minimus*.

On 02 December 2019 the 20% trigger value for deposited fine sediments was breached during routine fortnightly monitoring, with estimates of 0.25% and 12.5% coverage at the upstream and downstream monitoring sites, respectively. This constitutes a 4900% increase under Condition 44, thus requiring additional monitoring as described in Condition 47 (**Appendix A**). Results and discussion of this additional monitoring are detailed in **Appendix B**.

Following a similar result on 08 January 2020, discussions between WWL and TDC established that the interpretation of Condition 44 should be based on a more ecologically relevant trigger. From that point forward any sampling result from the downstream site showing a fine sediment coverage of 20 percentage points (or more) greater than the upstream coverage will be the trigger for Condition 47.

2.6 Dissolved Oxygen

A YSI Pro1020 probe was used to take field measurements of DO. Specifications of this instrument comply with precision limits set out in the WWL consents, as well as those recommended within NEMS (2019).

Calibration of the DO probe was undertaken daily before undertaking fieldwork. Calibration records are available on request.

2.7 Water Sampling – pH, Turbidity and Total Suspended Solids

A water sample was collected from each site and sent, under Chain of Custody, to Hill Laboratories for analysis. Sample bottles used were provided by the laboratory. Hill Laboratories is an independent laboratory accredited to IANZ. Detection limits were within those stipulated with the WWL consents.

2.8 Statistical Analysis

The differences between the observed values for each variable measured at the upstream and downstream sites during each monitoring occasion were determined. These differences were then ordered chronologically and split into the two monitoring phases: pre-construction and construction. A paired two tailed unequal variance t-test was used in Microsoft Excel to determine if the differences in variables at the upstream and downstream sites differed significantly ($p = 0.05$) during pre-construction and construction phases. This will test for the presence of a trend indicating that construction activities were affecting a given parameter at the downstream monitoring site.

In the instance that the t-test found the differences in a variable at each site to be statistically significantly different during the pre-construction and construction and monitoring phases, the average difference between sites for that variable over each phase was calculated. Expert judgement was then used to determine if the average difference between sites for that variable during the pre-construction and construction phases was outside of the realm of natural variability (driven by construction discharges) and if so, if that difference was ecologically meaningful[5].

[5] This method was suggested by TDC Senior Resource Scientist Trevor James (pers com 24 June 2020).

3 Results

3.1 Macroinvertebrate Communities

3.1.1 Compliance with Condition 42

The raw data for the macroinvertebrate indices can be found in **Appendix C**.

There were no monitoring occasions where the QMCI score at the downstream site was reduced by 20% or more, in combination with a 20% or more reduction in the densities of EPT taxa (**Table 4**). Therefore, WWL were **compliant with Condition 42** throughout the 2019-2020 monitoring period.

Table 4 Change in Macroinvertebrate Biotic Metrics at the Downstream Site Relative to the Upstream Site

	Date	QMCI upstream	QMCI downstream	Change in QMCI at the downstream site (%)	Change in EPT at the downstream site (%)
Pre-Construction Phase	11-Sep-17	7.88	7.92	+1%	+3%
	05-Dec-17	7.83	7.75	-1%	+27%
	09-Mar-18	7.45	7.71	+3%	-2%
	27-Jun-18	7.7	7.78	+1%	-20%
	09-Jan-19	6.21	7.12	+15%	+16%
Construction Phase	13-Aug-19	7.69	7.56	-2%	+1%
	02-Dec-19	7.71	7.79	+1%	-8%
	04-Feb-20	7.12	7.71	+8%	-12%

3.1.2 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of QMCI scores from the upstream and downstream monitoring sites during the pre-construction and construction monitoring phases showed no significant difference (p=0.05) (**Table 5**). The mean difference during both the pre-construction and construction monitoring phases were greater than zero (0.242 and 0.18, respectively) suggesting slightly increased QMCI at the downstream site. These results indicate that the construction activities are not impacting QMCI, as measured at the downstream monitoring site (**Table 5**).

Table 5 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases QMCI results

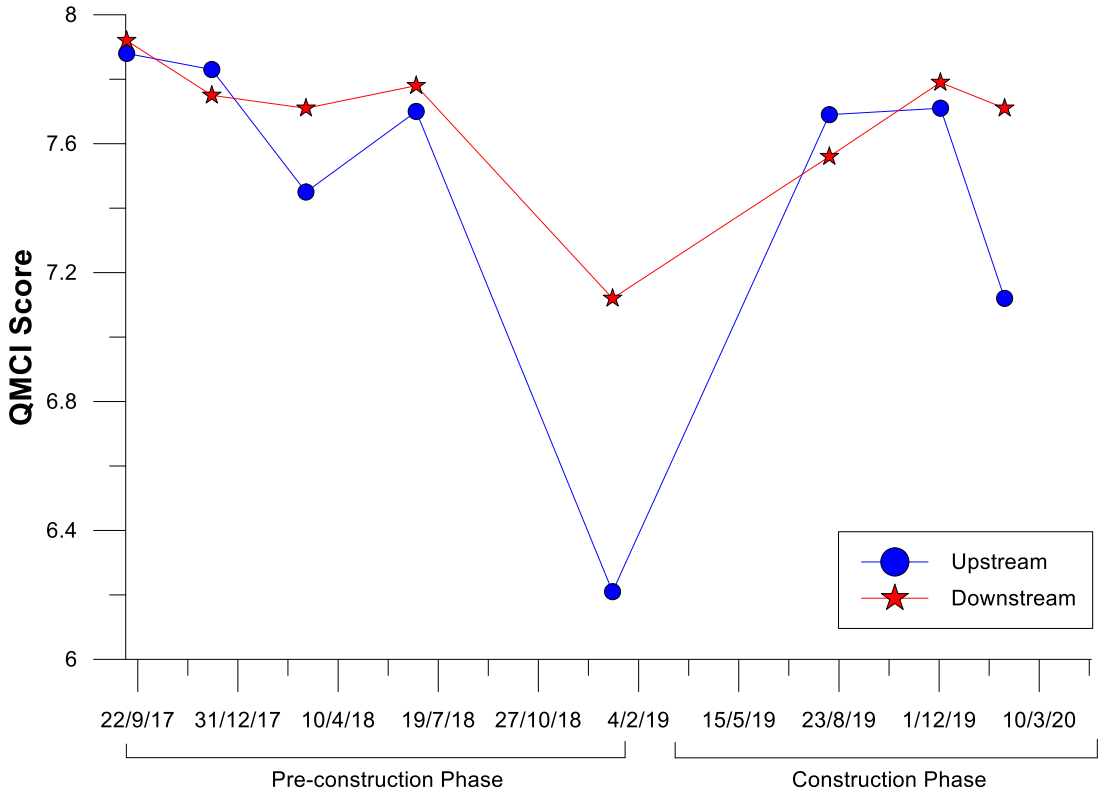
	Mean difference (QMCI)	SD	Range (QMCI)	p-value
Pre-construction Phase	0.242	0.39	0.91 to -0.08	0.832 Not Significant*
Construction Phase	0.18	0.37	0.59 to -0.13	

*p=0.05

3.1.3 Water Quality

According to Stark and Maxted (2007a) (**Table 3**), QMCI scores from the upstream and downstream monitoring sites indicate that water quality and macroinvertebrate community health was 'Excellent' (>6) on all monitoring occasions during both the pre-construction phase (2017-2019) and construction phases (2019-2020) (**Figure 4**).

Figure 4 QMCI scores for macroinvertebrate samples taken at the upstream and downstream monitoring site during the pre-construction and construction phase monitoring



3.2 Visual Clarity

3.2.1 Compliance with Condition 43

The raw data for visual clarity can be found in **Appendix C**.

As previously mentioned, Condition 43 did not apply on 12 of the 21 construction phase monitoring occasions due to either the river being higher than the median flow, or instream works occurring within 9 hours of monitoring (**Table 6** and **Figure 5**). All of the remaining nine monitoring occasions had downstream visual clarity within 40% of that measured upstream. Therefore, WWL were **compliant with Condition 43** throughout the 2019-2020 monitoring period.

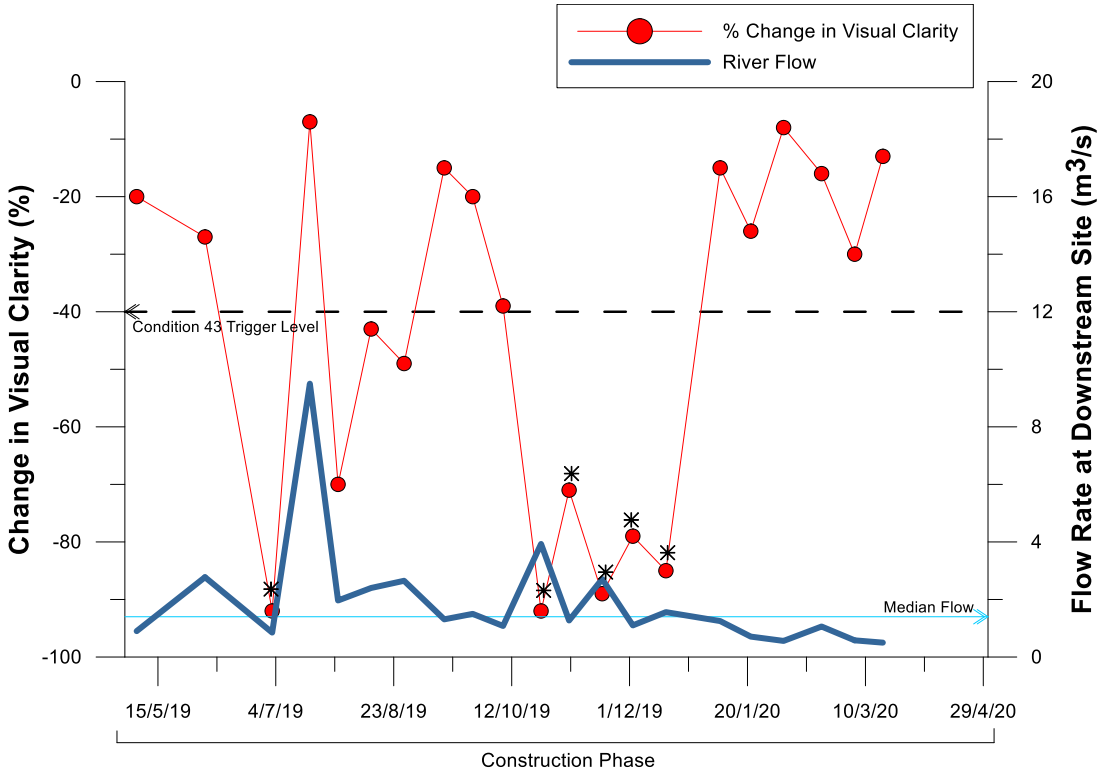
Under the reviewed version of Condition 43, where visual clarity must remain above 2 m at the downstream monitoring site (see **Section 2.4**), WWL were also compliant throughout the 2019-2020 monitoring period (**Table 6**).

Table 6 Change in Visual Clarity at the Downstream Site Relative to the Upstream Site

Date	Change in visual clarity at the downstream site (%)	Visual clarity downstream site (m)	Comments
06-May-19	-20%	11.8	
04-Jun-19	-27%	6.3	River above median flow
02-Jul-19	-92%	0.9	Instream works occurred recently
18-Jul-19	-7%	2.5	River above median flow
30-Jul-19	-70%	2.1	River above median flow
13-Aug-19	-43%	4.0	River above median flow
27-Aug-19	-49%	4.3	River above median flow
13-Sep-19	-15%	10.0	
25-Sep-19	-20%	8.2	River above median flow
08-Oct-19	-39%	8.9	
24-Oct-19	-92%	0.8	River above median flow & instream works occurred
05-Nov-19	-71%	3.7	Instream works occurred recently
19-Nov-19	-89%	1.0	River above median flow & instream works occurred
02-Dec-19	-79%	2.4	Instream works occurred recently
16-Dec-19	-85%	1.6	River above median flow & instream works occurred
08-Jan-20	-15%	8.4	
21-Jan-20	-26%	10.4	
04-Feb-20	-8%	12.3	
20-Feb-20	-16%	7.8	

Date	Change in visual clarity at the downstream site (%)	Visual clarity downstream site (m)	Comments
05-Mar-20	-30%	8.2	
17-Mar-20	-13%	7.7	

Figure 5 Percent change in visual clarity between the upstream and downstream monitoring sites during the construction phase



* Asterix indicates monitoring occasions where instream works were undertaken recently

3.2.2 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of all visual clarity measurements[6] from the upstream and downstream monitoring sites during the pre-construction (n=5) and construction (n=21) monitoring phases showed a significant difference (p=0.05) (**Table 7**). When tested with the monitoring occasions with flows greater than median flow removed (n=16)[7], there is still a significant difference (p-value is 0.007). When tested with the monitoring occasions with flows greater than median flow and instream works removed (n=13), again there is still a significant difference (p-value is 0.046).

Visual clarity was more variable during the construction phase (**Figure 6**). The mean difference in visual clarity between the two sites during the construction phase was much greater in magnitude (-4.42 m) than the pre-construction phase (0.07 m).

[6] Including those when the river was above median flow and following instream works
[7] Three of these occasions had both median flows and instream works on the same day

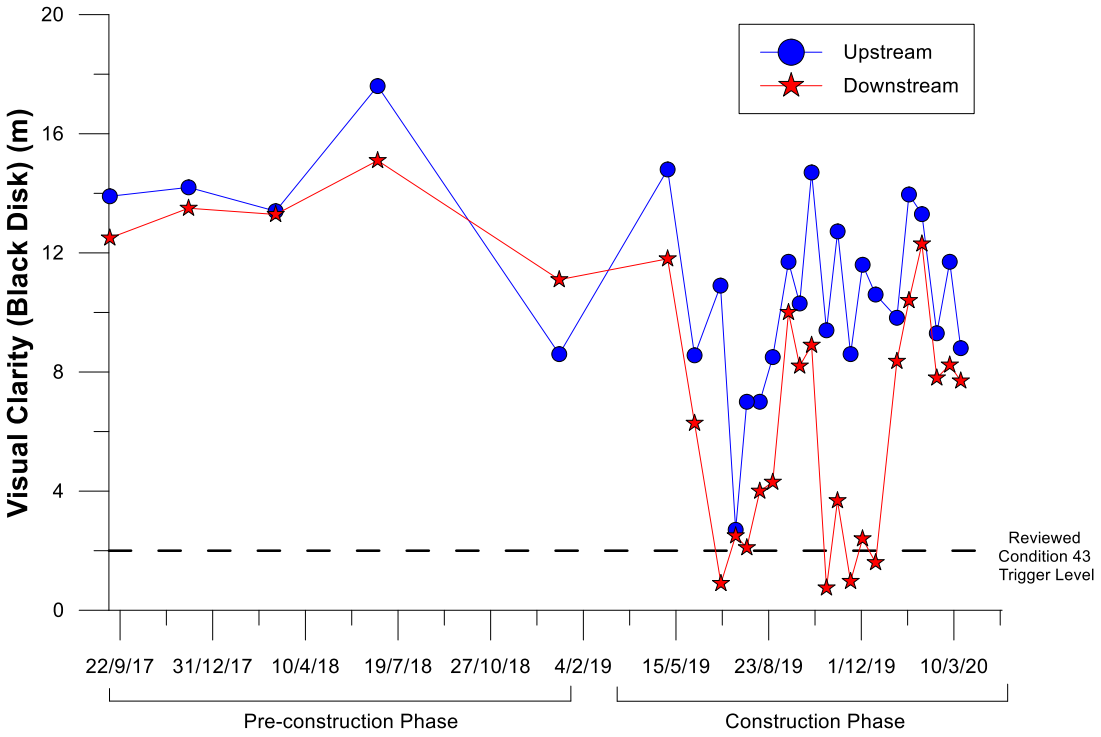
These results indicate that construction activities are decreasing visual clarity at the downstream site. However, as discussed, the effects on stream ecology can be considered minor because visual clarity is not reduced below 40% while the river is below median flow and when river works have not recently taken place, as per Condition 43.

Table 7 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases visual clarity results

	Mean difference (m)	SD	Range (m)	p-value
Pre-construction Phase	0.07	-1.70	2.5 to -1.4	0.003
Construction Phase	-4.42	3.22	-0.2 to -10.0	Significant*

*p=0.05

Figure 6 Visual clarity measurements taken at the upstream and downstream monitoring site during the pre-construction and construction phase monitoring



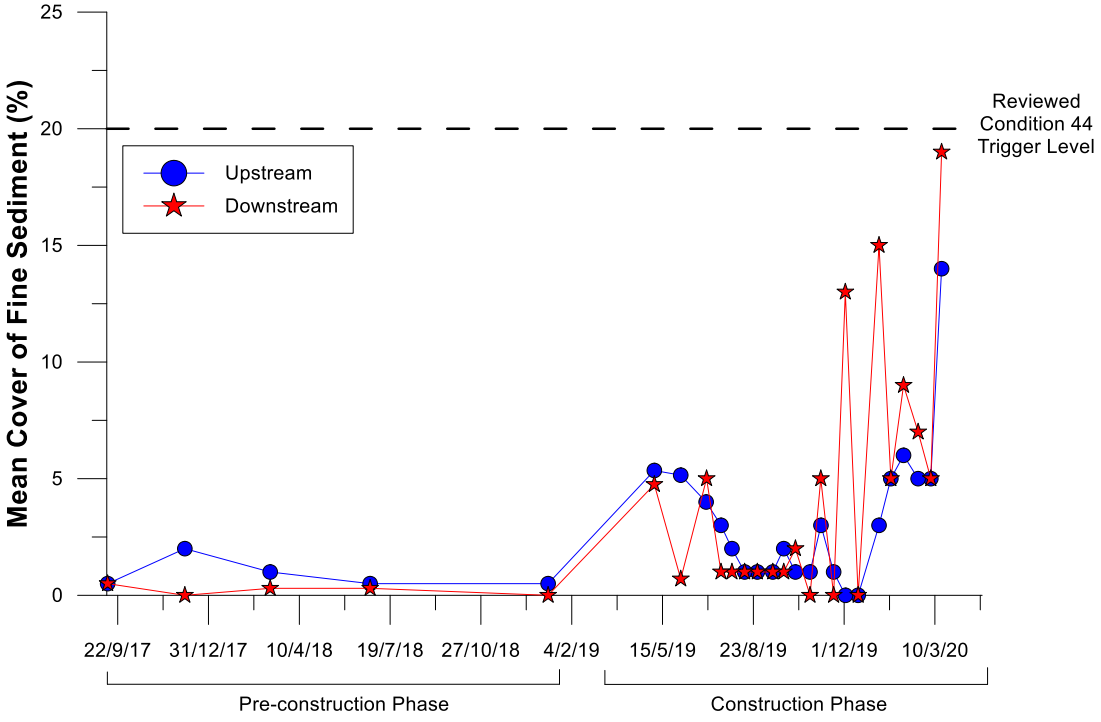
3.3 Deposited Fine Sediments

3.3.1 Compliance with Condition 44

The raw data for deposited fine sediments can be found in **Appendix C**.

Under the reviewed interpretation of Condition 44 (see methodology **Section 2.5**), there were no monitoring occasions where fine sediment deposition exceeded 20% at the downstream monitoring site during the construction phase (**Figure 7**). Therefore, WWL were **compliant with the agreed interpretation of Condition 44** (see **Section 2.5**) throughout the 2019-2020 monitoring period.

Figure 7 Deposited fine sediment measurements taken at the upstream and downstream monitoring site during the pre-construction and construction phase monitoring



3.3.2 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of deposited fine sediment measurements from the upstream and downstream monitoring sites during the pre-construction and construction monitoring phases showed a significant difference (p=0.05) (**Table 8**). These results indicate that the construction activities are increasing the deposition of fine sediments at the downstream site. However, as the coverage remains below 20% it is not considered that the construction activities are having a deleterious impact on river health (**Figure 7**).

It is noteworthy, however, that deposited fine sediments at the downstream site during the pre-construction phase was lower than the upstream site on four out of the five monitoring occasions, possibly suggesting that the downstream site has a naturally lower proportion of deposited fine sediments than the upstream site. However, this seems unlikely due to the very small proportions observed (0-2% during the pre-construction phase) and is more likely due to natural variation or observer error.

Table 8 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases deposited fine sediment results

	Mean difference (%)	SD	Range (%)	p-value
Pre-construction Phase	-0.68	0.79	0 to -2	0.050 Significant*
Construction Phase	1.33	4.17	13 to -2	

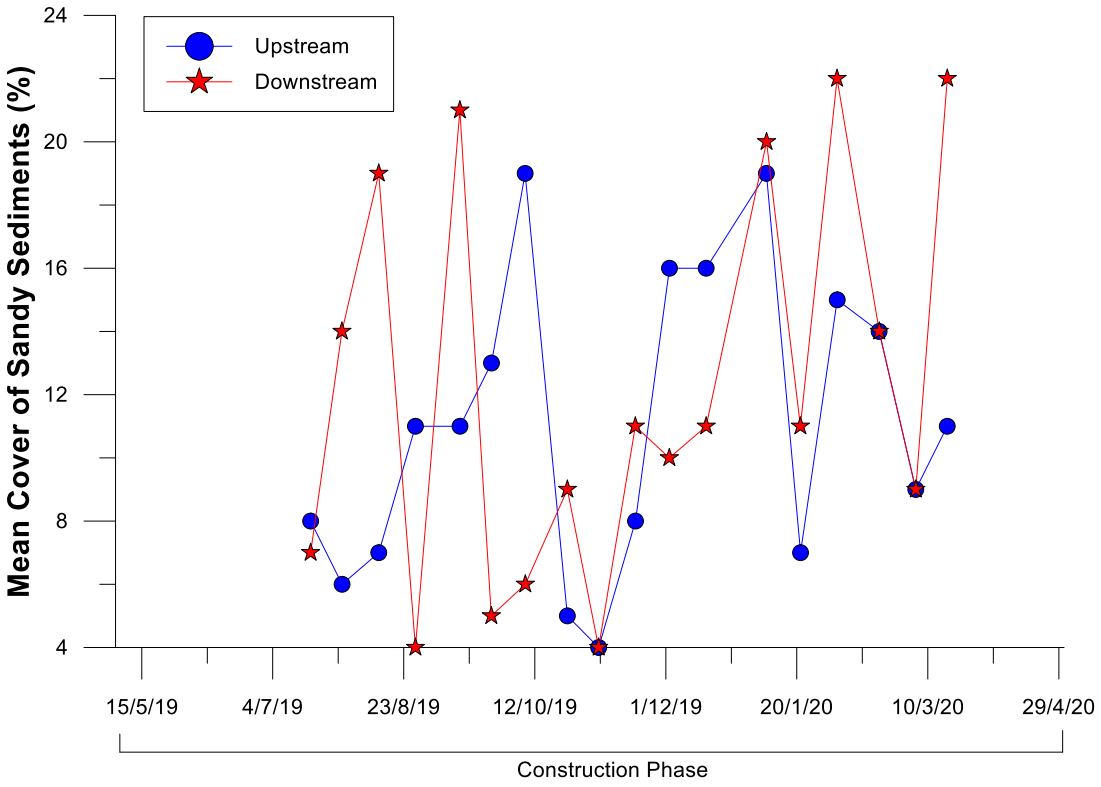
*p=0.05

3.3.3 Deposited Sandy Sediments

This parameter is not a monitoring requirement of the WWL consents but was instead requested by TDC Senior Resource Scientist Trevor James when construction phase monitoring began (*pers com* Steph Bowis, TDC Hydrologist). Therefore, no comparison can be made with the pre-construction phase.

The mean was very similar for the upstream and downstream sites (11% and 12%, respectively), as was the range (4-19% and 4-22%, respectively) (**Figure 8**).

Figure 8 Deposited sandy sediment



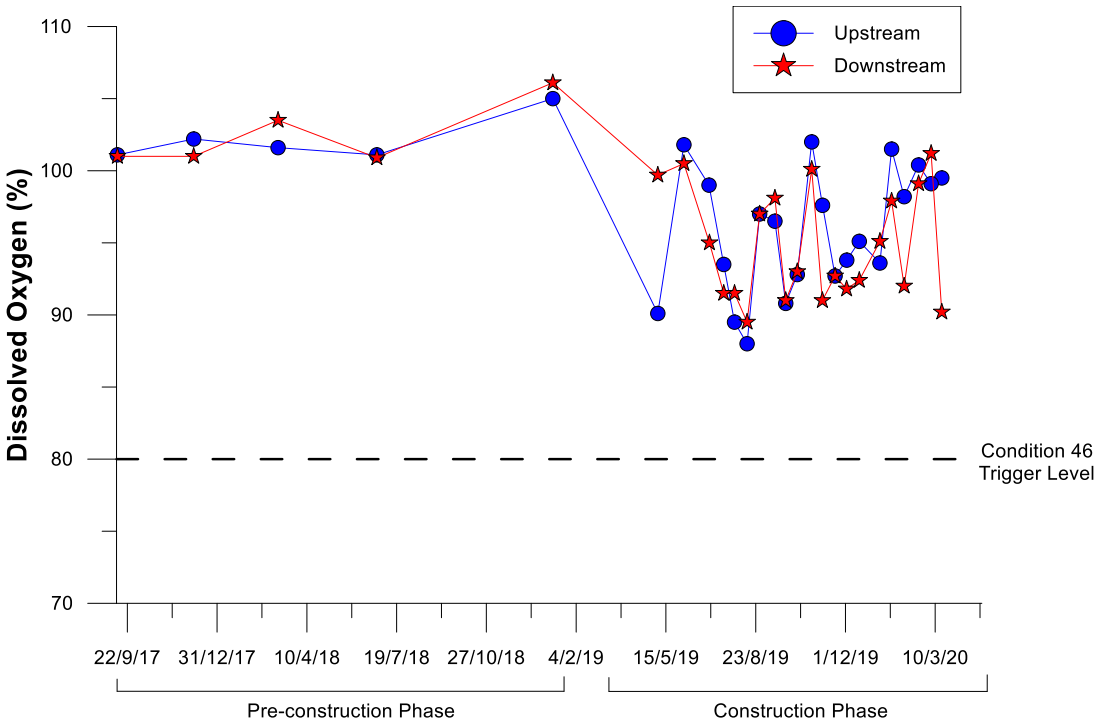
3.4 Dissolved Oxygen (%)

3.4.1 Compliance with Condition 46

The raw data for DO can be found in **Appendix C**.

There were no monitoring occasions where spot measurements of DO at the downstream site were below 80% (**Figure 9**). Therefore, WWL were **compliant with Condition 46** throughout the 2019-2020 monitoring period.

Figure 9 DO measurements taken at the upstream and downstream monitoring site during the pre-construction and construction phase monitoring



3.4.2 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of DO measurements from the upstream and downstream, monitoring sites during both the pre-construction and construction monitoring phases showed no significant difference (p=0.05) (**Table 9**). With a mean difference close to zero (0.3% and -1.0%, respectively), these results indicate that the construction activities are not impacting DO, as measured at the downstream monitoring site (**Table 9**).

Also, the mean differences are less than the accuracy specification of the probe (+/- 2%), which means that any observed trend in the DO results are not necessarily due to the effects of construction activities or natural variability but could in fact be a product of variable DO probe accuracy.

Table 9 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases DO results

	Mean difference (%)	SD	Range (%)	p-value
Pre-construction Phase	0.3	1.21	1.9 to -1.2	0.192 Not Significant*
Construction Phase	-1.06	3.90	9.6 to -9.3	

*p=0.05

Note: The accuracy specification of the YSI Pro1020 handheld DO probe is +/- 2%

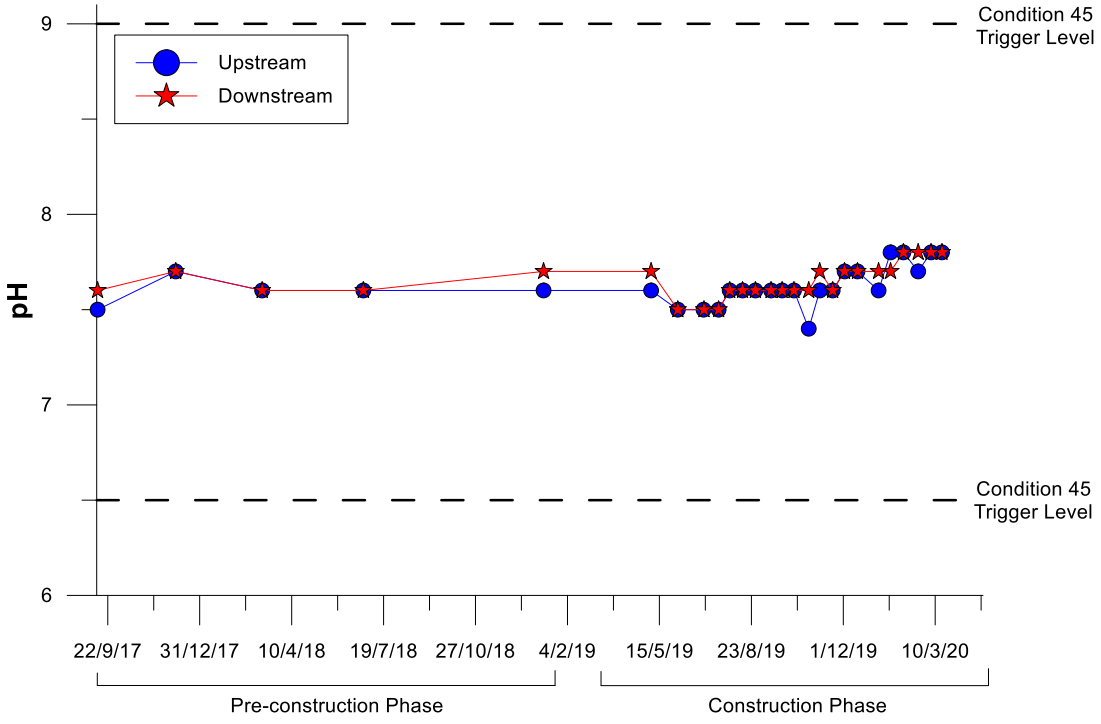
3.5 pH

3.5.1 Compliance with Condition 45

The raw data for pH can be found in **Appendix C**.

There were no monitoring occasions where pH, as measured from water samples taken at the downstream site, were outside the range of 6.5 to 9.0 (**Figure 10**). Therefore, **WWL were compliant with Condition 45** throughout the 2019-2020 monitoring period.

Figure 10 pH measurements taken at the upstream and downstream monitoring site during the pre-construction and construction phase monitoring



3.5.2 Trend Analysis - Pairwise Comparison

Pairwise comparison of the mean difference of pH measurements from the upstream and downstream monitoring sites during the pre-construction and construction monitoring phases showed no significant difference (p=0.05) (**Table 10**). With a mean difference close to zero (0.04 and 0.02, respectively), these results indicate that the construction activities are not impacting on pH, as measured at the downstream monitoring site.

Also, the mean differences are less than the Hill Laboratories Analytical Detection Limits (**ADL**) (+/- 0.1), which means that any observed trend in pH results are not necessarily due to the effects of construction activities or natural variability but could in fact be a product of variable laboratory precision.

Table 10 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases pH results

	Mean difference (pH)	SD	Range (pH)	p-value
Pre-construction Phase	0.04	0.05	0.1 to 0	0.582 Not Significant*
Construction Phase	0.02	0.06	0.2 to -0.1	

*p=0.05

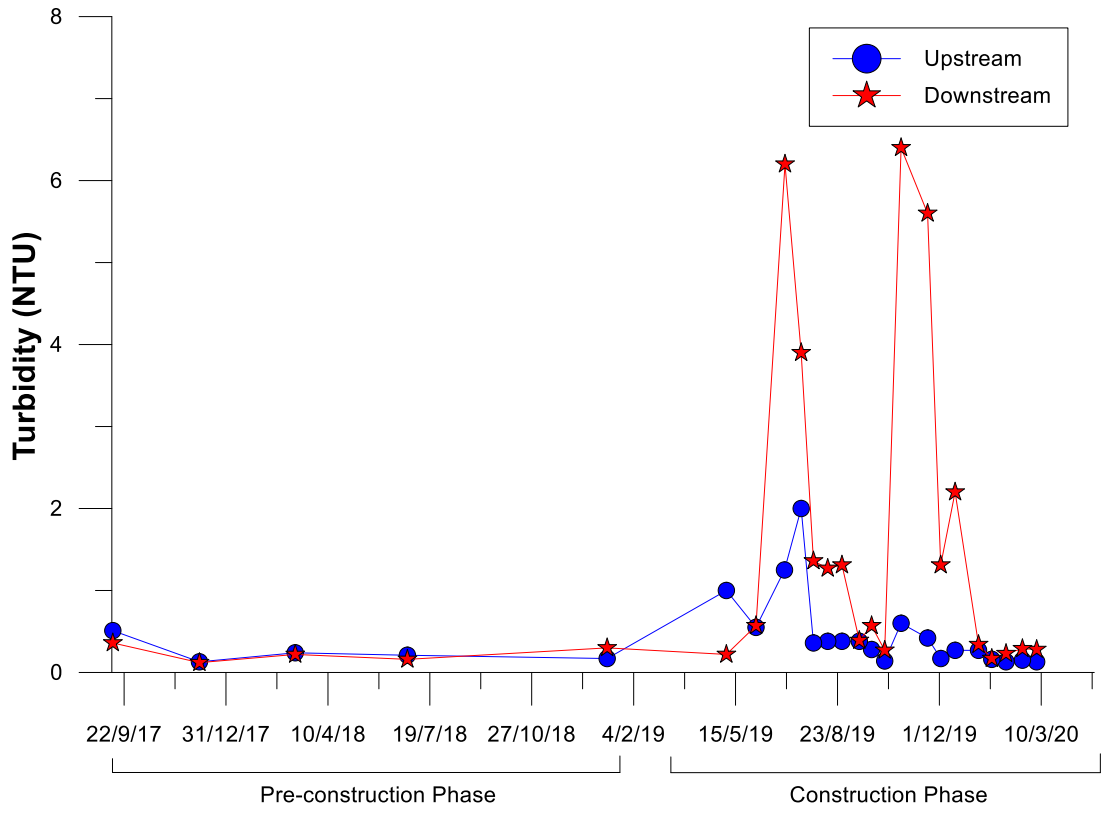
Note: The Hill Laboratories ADL for pH is +/- 0.1 (pH)

3.6 Turbidity

The raw data for turbidity can be found in **Appendix C**.

Spot measurement of turbidity is required as part of fortnightly monitoring under Condition 41, but there is no additional condition specific to this parameter with an associated trigger value. Data appear more variable during the construction phase, with little difference upstream and downstream during the pre-construction phase (**Figure 11**).

Figure 11 Turbidity (NTU)



3.6.1 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of turbidity measurements from the upstream and downstream monitoring sites during the pre-construction and construction phases showed a significant difference (p=0.05) (**Table 11**). With a mean difference close to zero (and below the ADL) during the pre-construction phase, these results indicate that the construction activities are causing an increase in turbidity at the downstream site.

During the construction phase turbidity was more variable both upstream and downstream, but the significantly higher mean difference indicates that turbidity was greater at the downstream site compared to upstream, on average. The mean difference (1.26 NTU) is well outside the Hill Laboratories ADL (0.05 NTU), and low variability observed in the pre-construction phase results indicates that it is not due to natural variability.

Table 11 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases turbidity (NTU) results

	Mean difference (NTU)	SD	Range (NTU)	p-value
Pre-construction Phase	-0.02	0.1	0.13 to -0.15	0.010 Significant*
Construction Phase	1.26	1.93	5.8 to -0.78	

*p=0.05

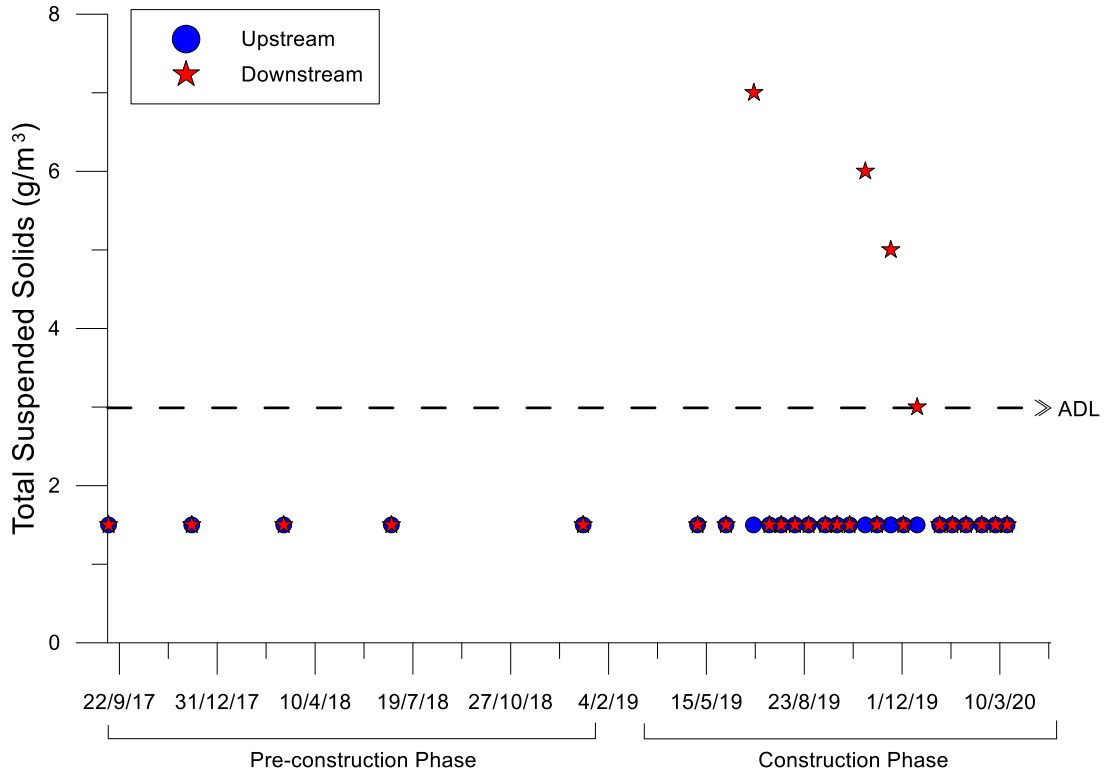
Note: The Hill Laboratories ADL for turbidity is +/- 0.05 NTU

3.7 Total Suspended Solids

The raw data for total suspended solids can be found in **Appendix C**.

Spot measurement of total suspended solids is required as part of fortnightly monitoring under Condition 41, but there is no additional condition specific to this parameter with an associated trigger value. Spot measurements of total suspended solids remained below the Hill Laboratories ADL (3 g/m^3) for all of the pre-construction phase (upstream and downstream) and much of the construction phase (**Figure 12**).

Figure 12 Total suspended solids



3.7.1 Trend Analysis – Pairwise Comparison

Pairwise comparison of the mean difference of total suspended solids measurements from the upstream and downstream monitoring sites during the pre-construction monitoring phase shows that the mean difference of the upstream / downstream is zero, indicating little difference between the sites before construction began (**Table 12**). This is to be expected because all results were below ADL. The mean difference during the construction phase was 0.71 g/m^3 is not significantly different to the pre-construction phase (p=0.05) (**Table 12**)[8].

The mean difference calculated using the construction phase results is well outside the ADL (0.05 g/m^3), and low variability observed in the pre-construction phase results indicates that the difference is not due to natural variability. However, any apparent trend should be interpreted with caution, due of the use of half ADL for so many data points and the low number of results measuring anything greater than the ADL. These results are therefore inconclusive.

Table 12 Mean difference of paired sites (upstream and downstream) for pre-construction and construction phases total suspended solids results

	Mean difference (g/m^3)	SD	Range (g/m^3)	p-value
Pre-construction Phase	0.00	0.00	0 to 0	0.061 Not Significant
Construction Phase	0.71	1.65	5.5 to 0	

*p=0.05

Note: The Hill Laboratories ADL for total suspended solids is <3 (g/m^3)

3.8 Other Observations

While the assessment of periphyton and filamentous algae coverage is not required under the consent, general observations were made during site visits. During the extended period of low flow over January and February 2020, proliferations of long filamentous algae were observed in abundance at the upstream monitoring site (**Figure 13**). Accelerated algae growth was also evident at the downstream site but to a far lesser extent, suggesting that flow velocity and depth at the upstream site is more suitable for algae growth during periods of low flow.

None-the-less, spot measurements of dissolved oxygen remained within acceptable levels during fieldwork, and the QMCI score for macroinvertebrate sampling carried out on 04 February 2020 was indicative of 'excellent' water quality for both sites.

[8] This analysis used half x ADL (1.5 g/m^3) in place of measurements where samples measured below ADL (3 g/m^3).

Figure 13 Algae proliferation at the upstream monitoring site in late January 2020

4 Key Findings

4.1 Compliance with Consent Conditions

Monitoring efforts were hampered on several occasions by operational restrictions that were beyond the control of the consent holder. These include site access restrictions due to extreme fire risk in early 2019 over February and March. Also, slips and road works on Lee Valley Road led to TDC monitoring staff missing three fortnightly monitoring runs in mid-April, mid-May, and mid-June 2019. In addition, the lockdown associated with the Covid-19 pandemic meant that monitoring was not possible for the final three fortnightly monitoring runs of the year (April 2020).

Operational restrictions also hampered SLR vehicle movements on-site, citing Health and Safety concerns and ongoing road access issues. This effectively restricted monitoring operations such that travel throughout the site should only attempt to take place during the morning and afternoon 'smoko' breaks of dam construction staff and forestry workers (10 am and 2 pm, respectively). While this was not strictly adhered to, SLR did endeavour to aim for these times to minimise risk due to the increased presence of heavy vehicles and plant outside of these times, as well as minimise the likelihood of encountering impassable roads due to ongoing roadworks. That meant that much of the fortnightly monitoring undertaken during the construction phase was not carried out "*at times chosen at random during working day*", as required under Condition 41. Also, it was difficult to take measurements of DO "*between 0600 and 0900 hours*" with these constraints in place.

Conditions 42 – 46 provide trigger levels for macroinvertebrates, visual clarity, deposited fine sediments, pH, and DO that, if breached, require additional monitoring under Condition 47. The consent holder was largely compliant with Conditions 42 – 46, with one occasion where additional monitoring of suspended fine sediments was required (Condition 44). In the follow up to this additional monitoring, the trigger value was subsequently reviewed by TDC compliance and replaced with a more ecologically relevant trigger. From this point forward any sampling result from the downstream site showing a fine sediment coverage of 20 percentage points (or more) greater than the upstream result will be the trigger for Condition 47. Similarly, discussions between WWL and TDC established that the interpretation of Condition 43 should also be based on a more ecologically relevant trigger. It was decided that, going forward, any sampling result from the downstream site showing a visual clarity result of 2 m or less would be the trigger for Condition 47.

4.2 Trends in the Data

Pairwise comparison showed that there has been a significant decrease in visual clarity, increase in the proportion of deposited fine sediments, and increase in turbidity at the downstream monitoring site as a result of construction activities. There was no significant difference between upstream and downstream scores for of the QMCI, DO, pH, and total suspended solids.

In summary:

- QMCI – results indicate that construction activities have not affected the QMCI score at the downstream site;
- Visual clarity – results indicate that construction activities are causing a trend of decreased visual clarity at the downstream site. However, this decrease is within acceptable trigger limits set within the agreed interpretation of condition 43;

- Deposited fine sediments – results indicate that construction activities are causing a trend of an increased proportion of deposited fine sediments at the downstream site. However, this increase is within acceptable trigger limits set within the agreed interpretation of condition 44;
- DO – results indicate that construction activities have not affected DO at the downstream site;
- pH - results indicate that construction activities have not affected pH at the downstream site;
- Turbidity – results indicate that construction activities have caused a trend of increased turbidity at the downstream site; and
- Total suspended solids – results are inconclusive because most of the data are below ADL

4.3 Interpretation of the Results and Assessment of the Impact on Water Quality and Aquatic Ecology

Conditions 42-46 were met in the 2019-2020 monitoring year, implying that the adverse effects of construction activities on water quality and aquatic ecology were within acceptable limits.

However, the trend for some water quality parameters (visual clarity, turbidity and deposited fine sediments) indicate reduced water quality as a result of construction activities. These changes were anticipated, with trigger values incorporated into the relevant consent conditions.

Each of the monitoring parameters set out Condition 41 provide background information to help paint a picture of water quality in an environment where an impact is anticipated. Most of these provide physical or chemical information which is only relevant at the time of sampling (visual clarity, total dissolved solids, turbidity, pH, DO). Others (fine sediment deposition and QMCI) provide an indication of the prevailing conditions, making them more ecologically relevant as an indicator of the health of aquatic ecosystems. The most useful of these is QMCI, because the macroinvertebrate community of a given stream lives with the stresses and changes that occur in the aquatic environment, whatever their cause (Stark and Maxted, 2007b). This includes stressors due to human activities (such as increased fine sediment), as well as natural events such as floods and droughts. Therefore, macroinvertebrate samples are ideal for use as “biotic” (rather than chemical) measures of prevailing stream health.

All of the QMCI scores from the upstream and downstream monitoring sites indicate ‘excellent’ water quality during both the pre-construction phase (2017-2019) and construction phase (2019-2020) environmental monitoring. Therefore, these results indicate that the overall health of aquatic ecology in the Lee River, downstream from construction activities associated with the Waimea Community dam, was ‘excellent’ during the 2019-2020 monitoring year.

5 References

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Stark, J.D.; Boothroyd, I.K.G.; Harding, J.S.; Maxted, J.R.; Scarsbrook, M.R. 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate working group report No. 1. Ministry for the Environment. 57p.

Stark JD, Maxted JR 2007a. A biotic index for New Zealand's soft-bottomed streams. New Zealand Journal of Marine and Freshwater Research 41: 43-61.

Stark JD, Maxted JR 2007b. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No.1166. 58 p.

APPENDIX A

Relevant Resource Consent Conditions (RM140540 and RM140542 - RM140559)

The following conditions are from resource consents relating to the building of the Waimea Community Dam.

Condition 41. *The Consent Holder shall establish two monitoring sites within the Lee River, one located as close as practicable to 100 metres upstream of the upstream extent of any construction activity areas and one as close as practicable to a point located 1,000 metres downstream of all dam construction activity areas. For the purposes of this condition the 'upstream extent of any construction activity areas' shall be limited to those works specifically associated with the construction of the dam, including the gravel extraction (borrow) and material processing areas, but does not include the area further upstream where vegetation removal from the reservoir impoundment area is proposed. The Consent Holder shall undertake monitoring for the parameters and at the frequencies specified in the following table. Monitoring at both sites shall commence at least twelve months before the beginning of the construction activities (excluding investigation activities, enabling works and vegetation clearance) and cease not less than two calendar months after completion of the construction of the dam and the commencement of first filling of the reservoir.*

Type	Monitoring Parameter	Pre-construction Phase Frequency	Construction Phase Frequency
Laboratory Analysis	Total Suspended Solids	Quarterly	Fortnightly at times chosen at random during working day
	Turbidity		
Field Measurements (discrete)	Visual clarity (Black Disk)	Quarterly	
	Deposited Fine Sediments	Quarterly	
	pH	Quarterly	
	Dissolved Oxygen	Quarterly	Fortnightly between 0600 and 0900 hours
	Quantitative macroinvertebrate sampling – QMCI[1] and EPT[2]	Quarterly	Quarterly during the first 12 months of construction, then 6 monthly thereafter.
	Turbidity	Once	Continuous – Telemetered to website in real time

All sampling shall be carried out by a person(s) suitably qualified and experienced in environmental monitoring. All samples that are to be analysed by a laboratory shall be collected in containers supplied by the laboratory and analyses shall be undertaken by an independent laboratory accredited to IANZ. Equipment used to undertake field measurements shall be calibrated in accordance with the manufacturer's specifications to minimise measurement errors. Calibration records shall be kept and made available to the Council upon request.

Condition 42. *The percentage reduction to the Quantitative Macroinvertebrate Community Index (QMCI) score downstream of the construction area relative to the QMCI upstream of the construction area (these two locations being in appropriately matched habitats as close as is practical to the two sites specified in Condition 41) shall not exceed 20% in combination with a 20% reduction in the densities of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa.*

Condition 43. *The percentage reduction in visual clarity of water downstream of the construction area relative to water upstream of the construction area (these two locations being those specified in Condition 41) shall not exceed 40% at flows less than the median flow. This performance standard shall not apply during works in any active river channel or for a period of 9 hours after their completion.*

Condition 44. *The coverage of deposited fine sediment on the riverbed of the Lee River downstream of the construction area, as measured at the downstream monitoring site specified in Condition 41, shall be no more than 20% higher than measured at the upstream monitoring site.*

Condition 45. *The pH of the Lee River downstream of the construction area, as measured at the downstream monitoring site specified in Condition 41, shall not fall outside of the range 6.5 to 9.0.*

Condition 46. *The level of dissolved oxygen in the Lee River downstream of the construction area, as measured at the downstream monitoring site specified in Condition 41 shall not be less than 80% of the saturation value.*

Condition 47. *In the event that either monitoring undertaken pursuant to Condition 41 or spot sampling by the Council indicates a breach of any of the receiving environment standards specified in Condition 42 - 46 of these consents (which apply at all times for out of river work, and at least 9 hours after the end of any in-river construction work), the Consent Holder shall:*

(a) Cease construction activities in any area identified as causing the breach until corrective action is taken to meet the breached standard;

(b) Within five working days undertake a full review of the relevant erosion and sediment control devices or other construction management protocols within the area identified as causing the breach;

(c) Within five working days identify any potential causes beyond the control of the Consent Holder such as slips or stream bank erosion;

(d) undertake further water quality measurements for that parameter which was breached, daily for ten working days after the breach occurs and, where breaches of the receiving environment standards specified in Condition 42 – 46 are detected in two consecutive samples, commission an ecological assessment of the receiving environment to determine any responses by the aquatic communities to the breach and any necessary or appropriate corrective action to the cause of the breach;

(e) Implement any corrective action to the area causing the breach (and equivalent corrective action on other erosion and sediment controls or other construction management protocols using the same methodologies in the wider catchment) as recommended in the ecological assessment required by clause (d) above;

(f) identify action(s), including amendments to erosion and sediment control plan design, methodologies and policies within the relevant catchment and, as appropriate, as applicable elsewhere within the site, necessary to ensure future compliance with the water quality standard(s) that was breached;

(g) Implement the actions identified in (e) and (f) above;

(h) Advise the Council in writing of the steps taken in accordance with paragraphs (b) to (g) above. This advice shall be provide in writing within one week of the steps being taken; and

(i) Review the CEMP and/or the relevant SCEMP prepared under Condition 32, and revise it if necessary to ensure compliance with conditions 42 – 46 occurs. All revised CEMPs or SCEMPs shall be submitted to the Council for certification that they meet the objectives and performance standards as required by Condition 32 within one month of monitoring identifying a breach of any of the receiving environment standards.

Condition 121. *The Consent Holder shall prepare an Annual Monitoring Report for the operation of the dam and provide it to the Council by 31 July of each year. The report shall cover the period from 1 May to 30 April and include the results of all monitoring undertaken, an interpretation of the results, and an assessment of the impact of the discharges from the dam on the water quality and aquatic ecology of the Lee River, and terrestrial ecology bordering the Lee River, downstream of the dam. This assessment shall include an analysis of pre- and post-dam construction monitoring data and identification of any trends in the results.*

APPENDIX B

Additional Monitoring of Fine Sediments – December 2019

On 02 December 2019 the consented trigger value for deposited fine sediments (Condition 44, **Table** 2) was breached during routine fortnightly monitoring, requiring that additional monitoring be conducted under Condition 47. Condition 47 requires, among other things, that WWL undertake further measurements of that parameter, daily for ten working days after the breach occurs (**Appendix A**). **Table 13** summarises the results and notes for this additional monitoring, which began on 04 December.

High flows overnight on 02 December and instream works on 05 December resulted in delays in conducting the additional monitoring. Also, the river was in flood from 17-20 December, immediately prior to the Christmas shutdown period, resulting in the TDC compliance officer agreeing that eight additional sampling events would suffice, rather than the ten required under Condition 47 (pers. Com Alasdair Mawdsley).

Fine sediment coverage at the downstream site was observed to be within the range stipulated under consent condition 44 in six of the eight additional monitoring occasions. Observations on 12 and 13 December indicated coverage at the downstream site was more than 20% higher than that observed at the upstream site. Observations during all additional monitoring indicated downstream fine sediment coverage of less than 2%.

Subsequent discussions between Mike Scott (WWL CEO) and Dave Shaw (TDC Compliance) established that the effects of fine sediment coverage less than 20% is de minimus (pers com January 2020). Therefore, going forward, Condition 44 will be interpreted with this as the bottom line for triggering Condition 47 - any sampling result that shows a coverage of 20% (or more) at the downstream site will be the trigger for Condition 47.

Table 13 Additional fine sediments monitoring, December 2019

Date	Upstream (%coverage)	Downstream (%coverage)	Difference	Notes
02-Dec-19	0.25	12.5	+ 4900%	Routine monitoring - fine sediments trigger reached
03-Dec-19	-	-	-	Overnight flood - flows too high to enter river
04-Dec-19	1.5	1.25	- 17%	Day 1 of additional fine sediments monitoring
05-Dec-19	-	-	-	Turbidity too high to carry out monitoring - couldn't see the bottom of the river. Black disk 0.15m [9]
06-Dec-19	1.05	0.44	- 58%	Day 2 of additional fine sediments monitoring
07-Dec-19	-	-	-	Weekend - no sampling
08-Dec-19	-	-	-	Weekend - no sampling
09-Dec-19	0.1	0.06	- 38%	Day 3 of additional fine sediments monitoring
10-Dec-19	0	0	0%	Day 4 of additional fine sediments monitoring
11-Dec-19	0.25	0.39	+ 56%	Day 5 of additional fine sediments monitoring
12-Dec-19	0.3	0.75	+ 150%	Day 6 of additional fine sediments monitoring
13-Dec-19	0.35	0.2	- 43%	Day 7 of additional fine sediments monitoring
14-Dec-19	-	-	-	Weekend - no sampling
15-Dec-19	-	-	-	Weekend - no sampling
16-Dec-19	0.4	0.1	- 75%	Day 8 of additional fine sediments monitoring
17-Dec-19	-	-	-	Flows too high to enter river
18-Dec-19	-	-	-	Flows too high to enter river
19-Dec-19	-	-	-	Flows too high to enter river

[9] Instream works were scheduled on this day to assist with calibration of TDC's continuous turbidity monitoring.

Date	Upstream (%coverage)	Downstream (%coverage)	Difference	Notes
20-Dec-19	-	-	-	Flows too high to enter river
21 Dec – 06 Jan	-	-	-	Christmas shutdown period. Remaining additional monitoring events called off.

APPENDIX C

Raw Data

Site	Date and Time	Total Suspended Solids (g/m3)	Turbidity (NTU)	Turbidity (FNU)	pH	Black Disk (m)	Deposited Fine Sediment (%)	Deposited Sandy Sediment (%)	QMCI	% EPT	DO (%)	Temp (°C)	Flow (l/s)
Pre-construction Phase													
Upstream	11-11-17	<3	0.51	-	7.5	13.9	0.5	-	7.88	-	101.1	-	-
Downstream	11-11-17	<3	0.36	-	7.6	12.5	0.5	-	7.92	-	101	-	-
Upstream	05-12-17	<4	0.13	-	7.7	14.2	2	-	7.83	-	102.2	-	524
Downstream	05-12-17	<3	0.12	-	7.7	13.5	0	-	7.75	-	101	-	524
Upstream	09-03-18	<3	0.24	-	7.6	13.4	1	-	7.45	-	101.6	-	1267
Downstream	09-03-18	<3	0.22	-	7.6	13.29	0.3	-	7.71	-	103.5	-	1267
Upstream	27-06-18	<3	0.21	-	7.6	17.6	0.5	-	7.7	-	101.1	-	697
Downstream	27-06-18	<3	0.16	-	7.6	>15	0.3	-	7.78	-	100.9	-	697
Upstream	09-01-19	<3	0.17	-	7.6	8.6	0.5	-	6.21	-	105	-	691
Downstream	09-01-19	<3	0.3	-	7.7	11.1	0	-	7.12	-	106.1	-	691
Construction Phase													
Upstream*	06-05-19	<3	1	0.52	7.6	14.8	5.35	-	-	-	90.1	-	901
Downstream*	06-05-19	<3	0.22	0.22	7.7	11.8	4.75	-	-	-	99.7	-	901
Upstream*	04-06-19 10:05	<3	0.55	0.45	7.5	8.56	5.15	-	-	-	101.8	-	2773
Downstream*	04-06-19 8:56	<3	0.57	0.46	7.5	6.28	0.7	-	-	-	100.5	-	2773
Upstream*	02-07-19 11:53	<3	1.25	0.25	7.5	10.9	4	-	-	-	99	4.8	850
Downstream*	02-07-19 10:30	7	6.2	3.6	7.5	0.9	5	-	-	-	95	4.2	850
Upstream	18-07-19 11:15	<3	2	2.4	7.5	2.7	3	8	-	-	93.5	6.7	9500

Site	Date and Time	Total Suspended Solids (g/m3)	Turbidity (NTU)	Turbidity (FNU)	pH	Black Disk (m)	Deposited Fine Sediment (%)	Deposited Sandy Sediment (%)	QMCI	% EPT	DO (%)	Temp (°C)	Flow (l/s)
Downstream	18-07-19 10:15	<3	3.9	4.2	7.5	2.5	1	7	-	-	91.5	6.7	9500
Upstream	30-07-19 11:00	<3	0.36	0.44	7.6	7	2	6	-	-	89.5	8.6	1963
Downstream	30-07-19 10:15	<3	1.36	1.84	7.6	2.1	1	14	-	-	91.5	8.8	1963
Upstream	13-08-19 11:30	<3	0.38	0.37	7.6	7	1	7	7.69	70	88	6	2400
Downstream	13-08-19 10:30	<3	1.27	1.3	7.6	4	1	19	7.56	71	89.5	6.1	2400
Upstream	27-08-19 11:30	<3	0.38	0.35	7.6	8.5	1	11	-	-	97	6.6	2650
Downstream	27-08-19 10:15	<3	1.31	1.34	7.6	4.3	1	4	-	-	97	7.1	2650
Upstream	13-09-19 11:30	<3	0.38	0.15	7.6	11.7	1	11	-	-	96.5	6.7	1311
Downstream	13-09-19 9:30	<3	0.39	0.29	7.6	10	1	21	-	-	98.1	6.8	1311
Upstream	25-09-19 11:20	<3	0.28	0.25	7.6	10.3	2	13	-	-	90.8	7.6	1500
Downstream	25-09-19 10:30	<3	0.57	0.57	7.6	8.2	1	5	-	-	91	8.5	1500
Upstream	08-10-19 8:20	<3	0.14	0.17	7.6	14.7	1	19	-	-	92.8	7.2	1080

Site	Date and Time	Total Suspended Solids (g/m3)	Turbidity (NTU)	Turbidity (FNU)	pH	Black Disk (m)	Deposited Fine Sediment (%)	Deposited Sandy Sediment (%)	QMCI	% EPT	DO (%)	Temp (°C)	Flow (l/s)
Downstream	08-10-19 9:10	<3	0.27	0.31	7.6	8.9	2	6	-	-	93	7.7	1080
Upstream	24-10-19 10:01	<3	0.6	0.69	7.4	9.4	1	5	-	-	102	8	3930
Downstream	24-10-19 10:56	6	6.4	7.9	7.6	0.75	0	9	-	-	100.1	10	3930
Upstream	05-11-19 9:27	<3	-	0.19	7.6	12.72	3	4	-	-	97.6	11.4	1271
Downstream	05-11-19 8:3	<3	-	0.72	7.7	3.68	5	4	-	-	91	12.1	1271
Upstream	19-11-19 10:13	<3	0.42	0.65	7.6	8.6	1	8	-	-	92.7	8.9	2710
Downstream	19-11-19 9:16	5	5.6	5.6	7.6	0.97	0	11	-	-	92.7	9.4	2710
Upstream	02-12-19 10:03	<3	0.17	0.14	7.7	11.6	0	16	7.71	60	93.8	13.5	1100
Downstream	02-12-19 8:53	<3	1.31	1.34	7.7	2.4	13	10	7.79	55	91.8	14.3	1100
Upstream	16-12-19 10:24	<3	0.27	0.24	7.7	10.6	0	16	-	-	95.1	12.1	1560
Downstream	16-12-19 9:55	3	2.2	2.8	7.7	1.6	0	11	-	-	92.4	12.9	1560
Upstream	08-01-20 9:57	<3	0.27	0.24	7.6	9.82	3	19	-	-	93.6	13.8	1250

Site	Date and Time	Total Suspended Solids (g/m3)	Turbidity (NTU)	Turbidity (FNU)	pH	Black Disk (m)	Deposited Fine Sediment (%)	Deposited Sandy Sediment (%)	QMCI	% EPT	DO (%)	Temp (°C)	Flow (l/s)
Downstream	08-01-20 11:26	<3	0.34	0.43	7.7	8.36	15	20	-	-	95.1	11.5	1250
Upstream	21-01-20 10:22	<3	0.16	0.1	7.8	13.96	5	7	-	-	101.5	15.3	710
Downstream	21-01-20 9:26	<3	0.17	0.17	7.7	10.4	5	11	-	-	97.9	16.7	710
Upstream	04-02-20 9:36	<3	0.13	0.1	7.8	13.3	6	15	7.12	65	98.2	18.2	560
Downstream	04-02-20 8:06	<3	0.23	0.16	7.8	12.3	9	22	7.71	57	92	19.6	560
Upstream	20-02-20 9:41	<3	0.15	0.14	7.7	9.3	5	14	-	-	100.4	15.6	1060
Downstream	20-0220 10:45	<3	0.29	0.46	7.8	7.8	7	14	-	-	99.1	17.4	1060
Upstream	05-03-220 9:20	<3	0.13	0.36	7.8	11.7	5	9	-	-	99.1	12.9	580
Downstream	05-03-20 10:20	<3	0.28	0.24	7.8	8.233	5	9	-	-	101.2	14.4	580
Upstream	17-03-20 9:15	<3	-	0.17	7.8	8.8	14	11	-	-	99.5	12.8	500
Downstream	17-03-20 9:50	<3	-	0.26	7.8	7.7	19	22	-	-	90.2	13.8	500

* Completed by TDC

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 404 939 922

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628