EIMP

Alva Beach Sediment EIMP Report 2022

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1. INTRODUCTION

1.1. Background

The Alva Prawn Farm (the Project) is an aquaculture facility that has been utilised for Black Tiger Prawn (*Panaeus monodon*) production since 1994. It is owned and operated by Pacific Reef Fisheries (Australia) Pty Ltd (PRF) and is situated at 531 Trent Road, Alva, 15 km East of Ayr, North Queensland. on land formally described as Lot 1/Plan RP804106 (Table 1).

Table 1: Project site details

Site Details	
Registered Owner	Pacific Reef Fisheries Pty Ltd
Site Address	531 Trent Road, Alva, Burdekin Shire, 4807
Lot on Plan	Lot 1 Plan RP804106
Lot Size	131.3 hectares
Local Government Area	Burdekin

PRF operates the Project under Environmental Authority (EA) EPPR00864913 issued by the Department of Environment and Science under the *Environmental Protection Act 1994* and an approval from the Department of Agriculture, Water and the Environment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC 2001/402). In accordance with the EA, an Environmental Impact Monitoring Program (EIMP; Gassman 2013) was developed and implemented in June 2013 to monitor, identify, and describe any adverse impacts from the Projects activities on the sediment and macroinvertebrates of the receiving environment (Condition SM12).

1.2. Site Description

The Project consists of 98 hectares (ha) of grow-out ponds, 10.3 ha of settlement treatment ponds and a 23 ha constructed mangrove wetland. The mangrove wetland is used to reduce the concentration of contaminants (nutrients and sediments) withinin the Project’s wastewater prior to release into the receiving environment. Kalamia Creek is the primary source of saltwater used by the Project, with surplus wastewaters discharged via an approved discharge structure into Little Alva Creek (Figure 1).

1.3. Purpose

The design of the PRF EIMP (Gassman 2013) requires sediment and macroinvertebrate monitoring, conducted within the receiving environment and nearby control waterways on an annual basis in Spring (September, October and November). The EIMP is designed to assess if the Project is impacting the sediment characteristics and macroinvertebrate community in the receiving environment. This report has been prepared by NGH Wild Environmental for PRF and presents the results of sampling undertaken in accordance with the approved EIMP in November 2022.

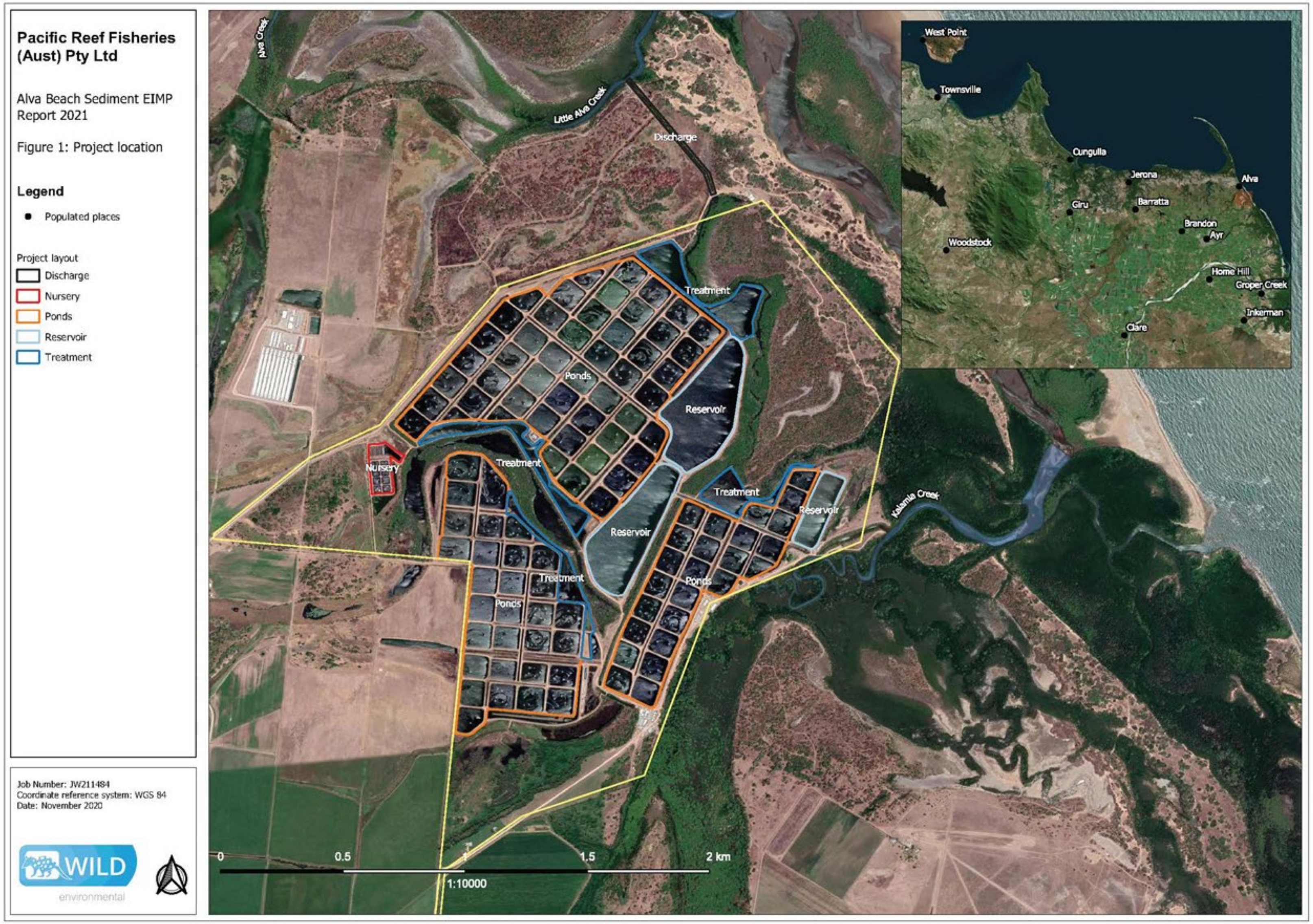

Figure 1: Location of Pacific Reef aquaculture facility at Alva Beach

2. ENVIRONMENTAL CONDITIONS

Rainfall data for the preceding year (November 2021 – November 2022) was obtained from the closest Bureau of Meteorology (BOM) Station, Number 033295 (Alva Beach); approximately 2 km away from the Project. The data were used to understand the environmental conditions prior to the survey and to aid in the interpretation of results.

2.1. Rainfall

Rainfall at Alva Beach is normally typical of tropical North Queensland with a defined "wet season", typically November to April and "dry season", typically May to October (Figure 2). However, rainfall in 2022 was more variable than historical averages, with lower than average rainfall in February and March, but large rainfall events recorded in April and July. Rainfall in the months preceding the survey (November 2022) was lower than normal. Rainfall on the sampling day was minimal (1.2 mm); although significant rainfall (79 mm) was recorded in the week prior to sampling.

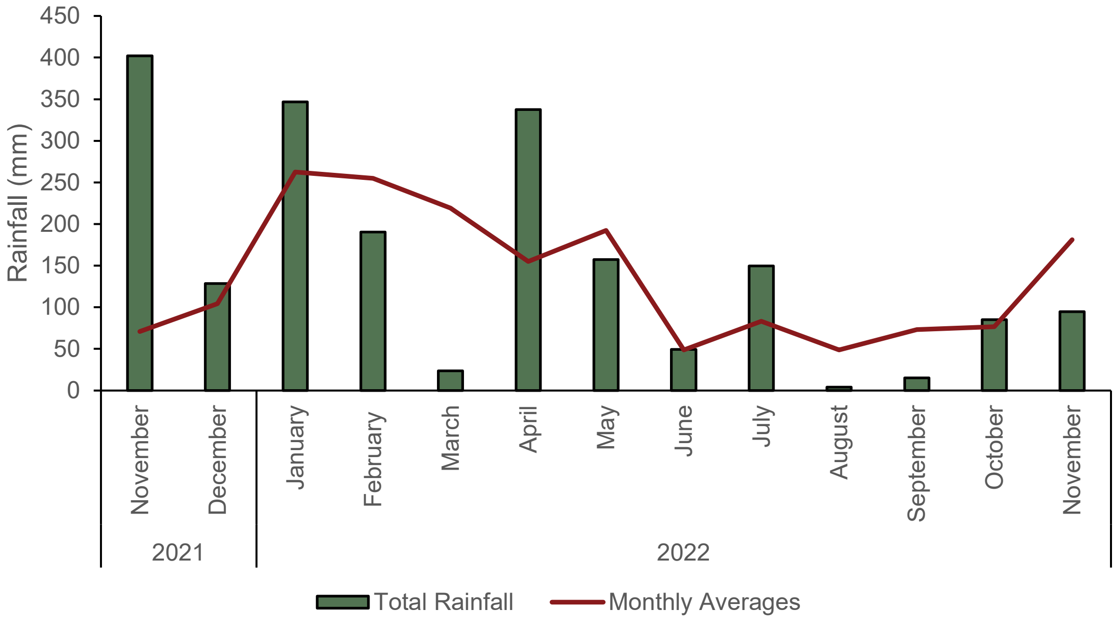

Figure 2: Total monthly rainfall data (BOM station 033295) for Alva Beach between November 2021 and November 2022 compared with the long-term rainfall average (1997-2022)

3. METHODOLOGY

Sampling is conducted annually and in accordance with the approved EIMP prepared by Gassman (2013) at four locations, including (Table 2, Figure 3):

- Two potential impact locations in Little Alva Creek, which may be influenced by Project activities
    - Location E – 500 m downstream into Little Alva Creek
    - Location F – 250 m north of mouth of Little Alva Creek
- Two control locations which are located in Alva Creek, some distance from Project activities and are unlikely to be influenced wastewater discharges
    - Location B – 500 m downstream into Alva Creek
    - Location C – 250 m north of mouth of Alva Creek

At each location, three monitoring sites were sampled, including

- One monitoring site from the left bank
- One monitoring site from the middle of the channel, and
- One monitoring site from the right bank.

Numerical nomenclature of the subsamples progressed from 1 to 3 in an east to west direction at each sampling location as prescribed within the EIMP design documentation.

Sampling for the Spring 2022 survey was conducted on 23 November 2022 at sites outlined above and in Table 2. At each monitoring site, samples were collected for sediment and macroinvertebrate analysis using a 1 litre stainless steel Van Veen grab.

Samples were collected for the analysis of:

- Sediment
    - Total organic carbon (TOC)
    - Particle size distribution
- Benthic infauna
    - Macroinvertebrate abundance
    - Macroinvertebrate taxonomic richness

Detailed methodology and analysis for sediment and benthic infauna collection is provided in Section 3.1 and Section 3.2 below.

3.1. Sediment

At each location, three sites were sampled in a line transect across the width of the creek as detailed in Section 3. Each site sampled in November 2022 had two sediment samples collected using a 1 L stainless steel Van Veen grab, before they were homogenised in sterilised containers. Sediment was placed in appropriate containers provided by the National Association of Testing Authorities (NATA) certified analysing laboratory (Australian Laboratory Services (ALS) Environmental), stored on ice in the field, and delivered within the holding times. Samples were analysed for particle sizing and TOC in accordance with the EIMP (Gassman 2013).

Strict QA/QC protocols were adhered to throughout the sampling, in accordance with the EIMP and the *Queensland Monitoring and Sampling Manual*[1]. Powder-free nitrile gloves were worn during sample container handling for sediment sampling, to reduce the risk of sample contamination during collection. One replicate sample was collected and results for replicate samples were analysed to assess variability by calculating the replicate percentage difference (RPD) between the samples, with a RPD of <50% between field replicates considered acceptable. Equipment was thoroughly cleaned with site water and rinsate and visually inspected between samples.

3.2. Macroinvertebrates

At each location, three sites were sampled in a line transect across the width of the creek as detailed in Section 3. Each site had two samples collected using a 1 L stainless steel Van Veen grab before samples were combined. Sediments collected for benthic macroinvertebrate identification were transferred through a 500 µm sieve in the field and gently rinsed with site water at the Alva Beach foreshore. The retained material was preserved in 70% ethanol for laboratory-based identification of macroinvertebrate species by a taxonomic specialist. Removal of macroinvertebrates from any remaining sediment matrix (i.e., sediment particles >500 µm in diameter) was conducted through a 20-minute timed pick. This methodology is adapted from AusRivAS freshwater macroinvertebrate monitoring (DNRM 2001[2]) and is designed to ensure sufficient individuals are captured for identification when a large ratio of sediment to biota is retained following sieving.

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[1]Monitoring and Sampling Manual 2018: Environment Protection (Water) Policy 2009, Queensland Department of Environment and Science, Queensland Government, Brisbane

[2] Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual 2001, Department of Natural Resources and Mines 2001.

Table 2: Sampling Locations

Location (Site)	Latitude*	Longitude*	Purpose
B (500 m downstream into Little Alva Creek)			
B1	-19.465978°	147.490188°	Potential Impact
B2	-19.465927°	147.490022°	Potential Impact
B3	-19.465863°	147.489925°	Potential Impact
C (250 m north of mouth of Little Alva Creek)			
C1	-19.465155°	147.491744°	Potential Impact
C2	-19.465225°	147.491455°	Potential Impact
C3	-19.465346°	147.492153°	Potential Impact
E (Location in reference creek (Alva Creek), corresponding to B)			
E1	-19.462982°	147.487526°	Control
E2	-19.463039°	147.487371°	Control
E3	-19.462752°	147.487203°	Control
F (Location in reference creek (Alva Creek), corresponding to C)			
F1	-19.462358°	147.488582°	Control
F2	-19.461786°	147.489111°	Control
F3	-19.462085°	147.490483°	Control

*Note: coordinates are provided in GDA94

Figure 3: Sampling Locations

4. RESULTS AND DISCUSSION

4.1. Sediment

4.1.1. Particle Size Distribution

4.1.1.1 Spring 2022

Particles at all four locations were dominated by smaller sizes (>75 µm, >150 µm and >300 µm) (Figure 4). Locations B and C (potential impact) generally had higher contribution of fine sediments (<75 µm,) 43 % and 39 %, respectively, compared to control locations (<11 %). Irrespective of location, contribution to composition decreased as particle size increased. Average particle size was generally more consistent at control locations (as indicated by the smaller error bars) than at impact locations (Figure 4).

Sand particles (>75 µm) dominated particle size classes at all locations, with minimal gravel (<2 mm) or cobble (> 6cm) particle size classes present (Figure 5). Variations in sediment particle size distribution observed amongst the four locations are expected to be an immediate reflection of the physical environmental conditions, rather than impacts from the aquaculture facility. Control locations E and F, located within and in close proximity to the larger Alva creek, are expected to have a higher particle suspension due to greater flows pushing finer particles further downstream. These higher energy sampling locations are characterised by low proportions (<11%) of fine particles within the analysed sediments, resulting in dominant composition of sand sized particles (<90%).

In comparison, within the relatively narrow and protected mouth of Little Alva Creek, locations B and C had the highest fine particle content. Reduced flow velocities associated with the relatively small watercourse of Little Alva Creek result in a lower riverine energy, permitting suitable conditions for fine particles to settle out of the water column into the underlying sediments. These effects were particularly apparent at the northern subsample collected from B1, which was comprised of 45% fine particles. Flow velocities are typically reduced on the inside of a meander, such as observed at B1 (Figure 2), resulting in a zone that is characterised by sediment deposition.

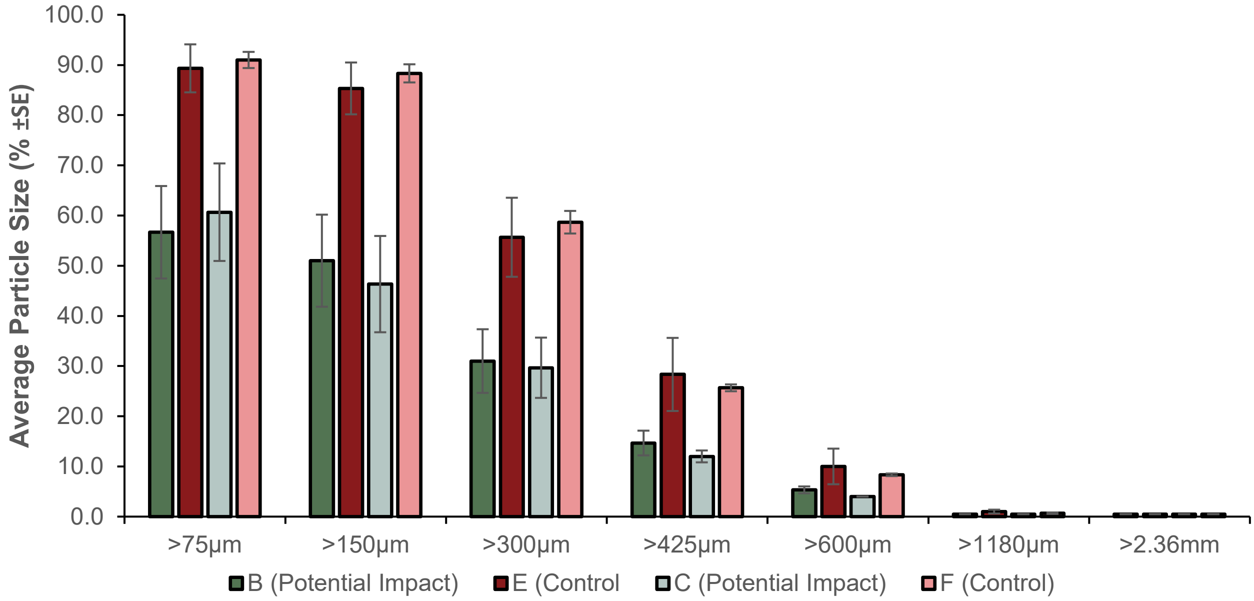

Figure 4: Average particle size (± standard error) at locations sampled under the EIMP in November 2022

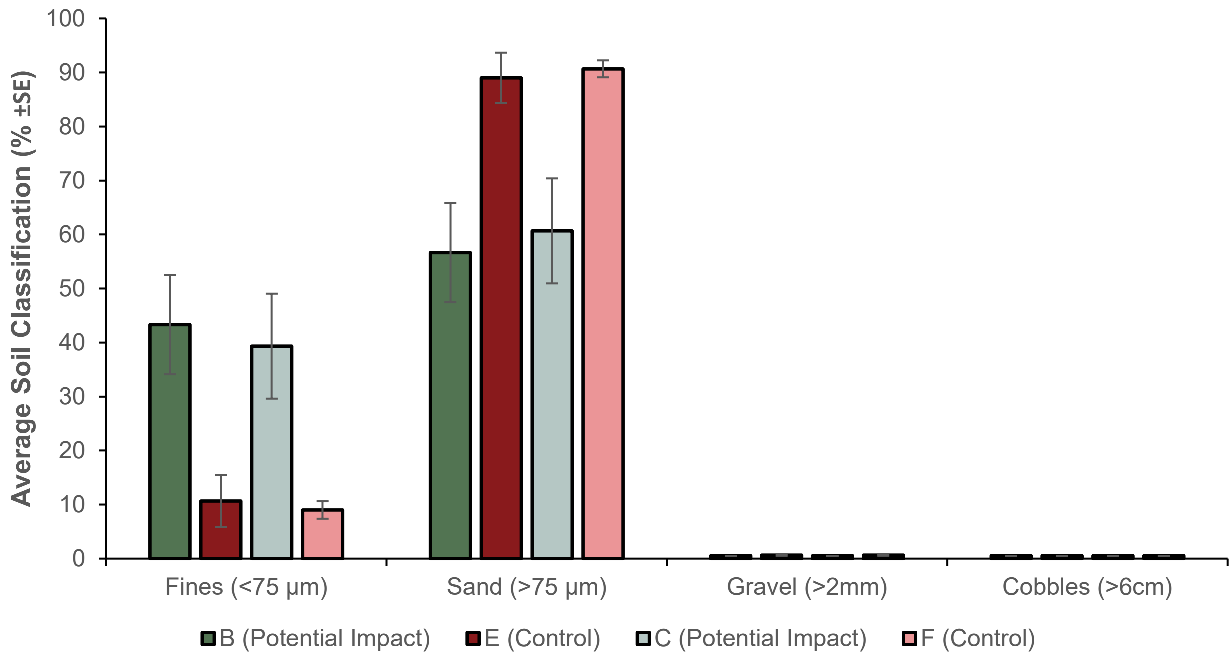

Figure 5: Average particle size distribution at locations sampled under the EIMP in November 2022

4.1.1.2 Temporal Trends

Fine sediment composition at potential impact locations B and C, and control location F, stayed relatively consistent between 2018 and 2021 sampling events (Figure 6). In comparison, control location E displayed a gradual decrease from 16 % to 3 % in the same time period. Limited variations in fine sediments over this time period indicate relatively consistent environmental conditions and pressures.

In 2022, there was an increase in fine particles across all sites, although this was notably higher at location B and C within the watercourse of Little Alva Creek. Previous EIMP reports (Wild Environmental 2021, 2020, 2019) have noted this occurrence likely arising from comparably less riverine energy at Little Alva Creek than at the nearby control waterway of Alva Creek. As riverine energy is lower at Little Alva Creek, fine sediment may be accumulating faster due to higher retention of small particles and reduced flushing throughout the waterway. As discharge quality and quantity from the aquaculture facility has not changed between 2021 and 2022, the increase in fine sediment at location B and C during the 2022 sampling event cannot be solely attributable to the operation of the prawn farm, and dominance of fine sediments may be arising from natural conditions. Further monitoring and an analysis of trends will be required following 2023 monitoring effort.

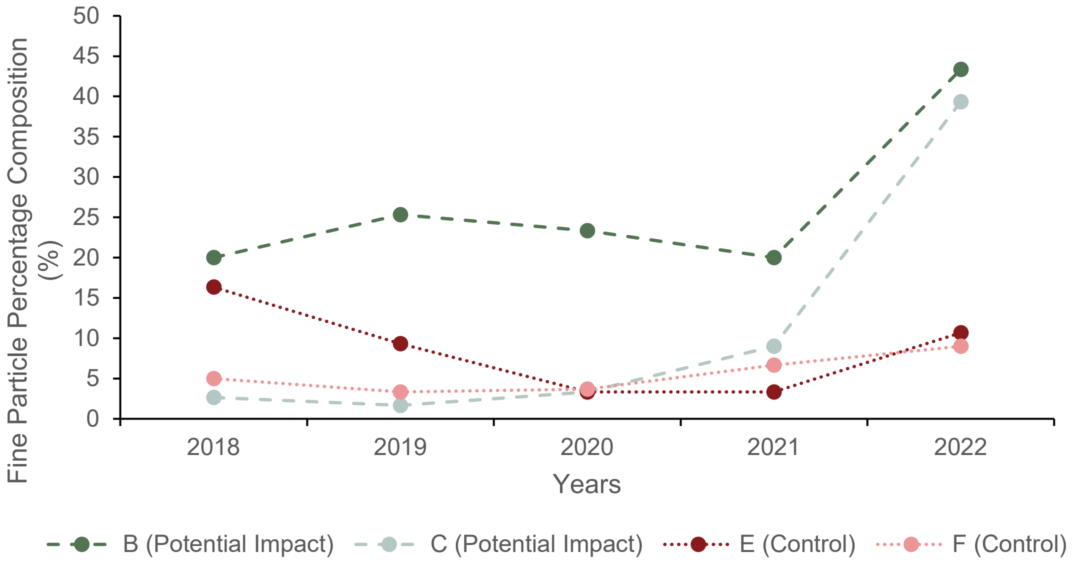

Figure 6: Average fine particle percentage composition at locations during spring EIMP surveys from 2018 to 2022

4.1.2. Total Organic Carbon

4.1.2.1 Spring 2022

Total organic carbon is the amount of organic carbon present in sediment and is used as a proxy for the total amount of organic matter present in the sediment. The average total organic carbon (TOC) concentrations were calculated for each location. TOC concentrations were highest at location B, located at the mouth of Little Alva Creek, with slightly reduced concentrations at location C in the downstream mixing zone (0.89 % and 0.72 %, respectively)(Figure 7). Concentrations of TOC at control locations within and adjacent to Alva Creek were comparable between the creek mouth and downstream mixing zone (location F: 0.22 %, and location E: 0.16 %, respectively). TOC concentrations were generally more consistent at control locations than potential impact locations, as indicated by the smaller error bars.

Total organic carbon is strongly correlated with sites and locations containing smaller particle sizes as provided by the high R-value (0.937) (Figure 8). Given the dominance of fine sediments at potential impact locations B and C (Section 4.1.1.1 above), high TOC at these locations is not unexpected and within the range of historical monitoring (Section 4.1.2.2 below).

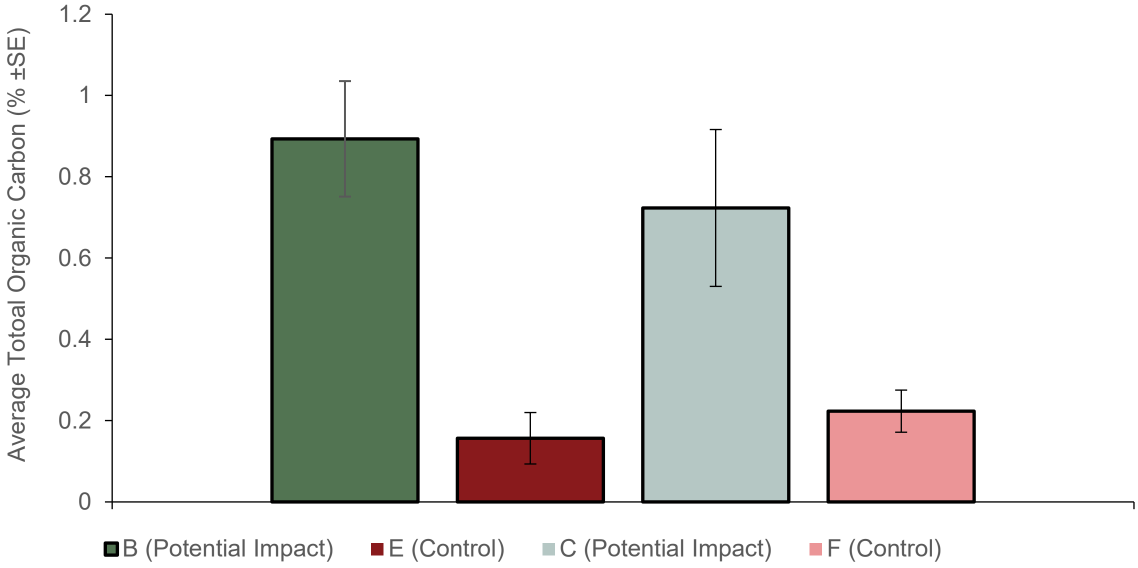

Figure 7: Average total organic carbon in sediment ± standard error at locations sampled under the EIMP in November 2022

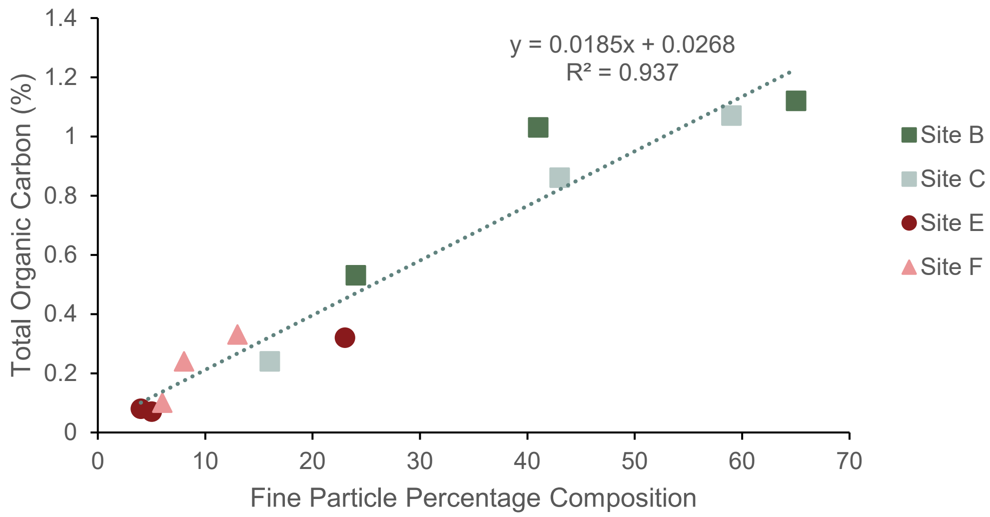

Figure 8: Total organic carbon and sediment fines composition at locations sampled in November 2022

4.1.2.2 Temporal Trends

Total organic carbon concentrations increased in 2022 from 2021, following a similar trend as fine particle composition (Figure 9). As outlined above, given the strong positive linear correlation with TOC concentrations and fine sediment percentage, the increase in TOC concentration is not unexpected. Temporal variations in TOC across all sites between 2018 and 2022 sampling events is observed to correspond with variation in fine sediments.

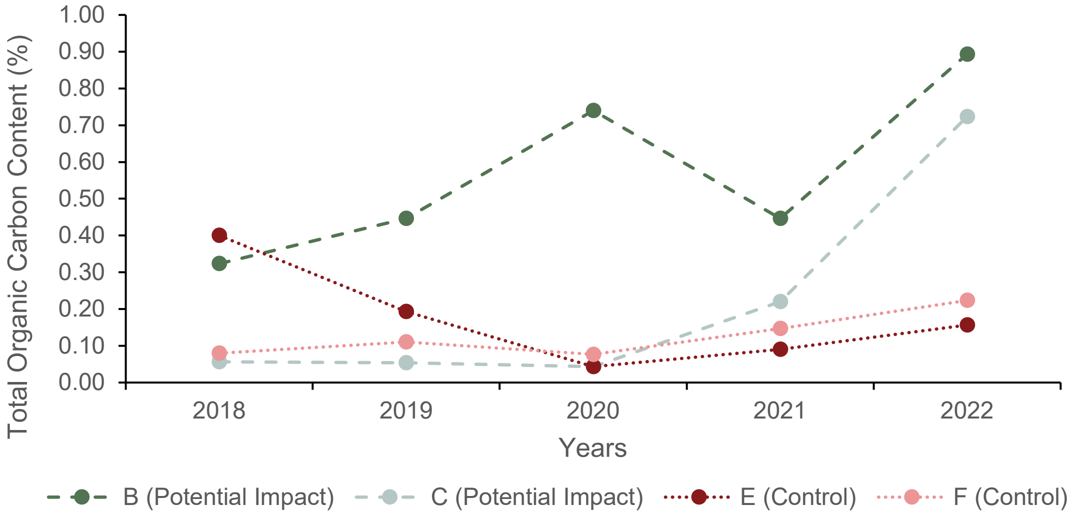

Figure 9: Average total organic carbon content during spring surveys at locations sampled under the EIMP from 2018 to 2022

4.2. Comparison to Water Quality

To understand the increase of organic carbon at potential impact sites (B and C), a review of water quality (client provided) from the 2022-2023 season was undertaken and compared to the previous year, 2021-2022. The review sought to comprehend whether the elevated levels of organic carbon in the receiving environment could be attributed to treated wastewater discharges from the Project.

Generally, water quality was comparable between the years, with total nitrogen and phosphorus concentrations decreasing at sites A and E. Two sites had elevated nutrient concentrations between the 2021-2022 and 2022-2023 sampling years, however these sites included one potential impact site and one control site. As such, differences in water quality, and therefore organic carbon between 2021 and 2022 are considered to be reflective of natural variation.

4.3. Benthic Macroinvertebrates

Macroinvertebrate communities at potential impact locations (location B and location C) were generally comparable to control locations, and it is considered that observed differences in taxonomic abundance and richness are caused by natural variation in environmental conditions, rather than from PRF operations. Additionally, macroinvertebrate communities were variable over EIMP monitoring (2018-2021) with no consistent trend observed.

4.3.1. Community Composition

In November 2022, there were 406 individuals identified from nine taxa and 36 families (Table 3). The most abundant order amongst all sites was Bivalvia; with the largest number of individuals from the family Tellinidae (Order: Bivalvia), equating to almost 80% of all macroinvertebrates collected (128 individuals). Although Bivalvia dominated the taxa present in samples, both Orders Polychaeta and Bivalvia had the same number of families present, although the abundance of Polychaeta was generally smaller than Bivalvia.

Table 3: Macroinvertebrate taxonomic richness in sediment during the November 2022 survey

Phylum	Order	Family
Annelida	Polychaeta	Capitellidae
		Cossuridae
		Goniadidae
		Magelonidae
		Nephtyidae
		Nereididae
		Oweniidae
		Polychaeta
		Phyllodocidae
		Spionidae
		Terebellidae
Brachiopoda	Lingulida	Linguloidea
Crustacean	Amphipoda	Melitidae
	Decapoda	Grapsidae
	Isopoda	Corallanidae
		Cymothooidea
	Tanaidacea	Apseudidae
Insecta	Diptera	Ceratopogonidae
		Chironomidae (Chironominae)
		Dolichopodidae
Mollusca	Bivalvia	Mactridae
		Mytilidae
		Pharidae
		Tellinidae
	Gastropoda	Cassidae
		Cerithiidae
		Haminoeidae
		Littorinidae
		Mitridae
		Naticidae
		Neritidae
		Olividae
		Stenothyridae
		Turritellidae

4.3.2. Abundance

4.2.2.1 Spring 2022

Total abundance varied considerably amongst sites sampled in November 2022 under the PRF EIMP, ranging from 2 to 135 individuals at a site (E2 and F3, respectively)(Figure 10). Total abundance of macroinvertebrates was generally comparable between potential impact locations B and C as indicated by the overlapping error bars. Interestingly, total abundance between the two control locations was highly variable (E:4.6 and F:76). Location F had notably higher abundance of Tellinidae (Bivalvia), Cerithiidae (Gastropoda) and Littorinidae (Gastropoda), all robust marine molluscs which heavily contributed to the overall abundance at location F.

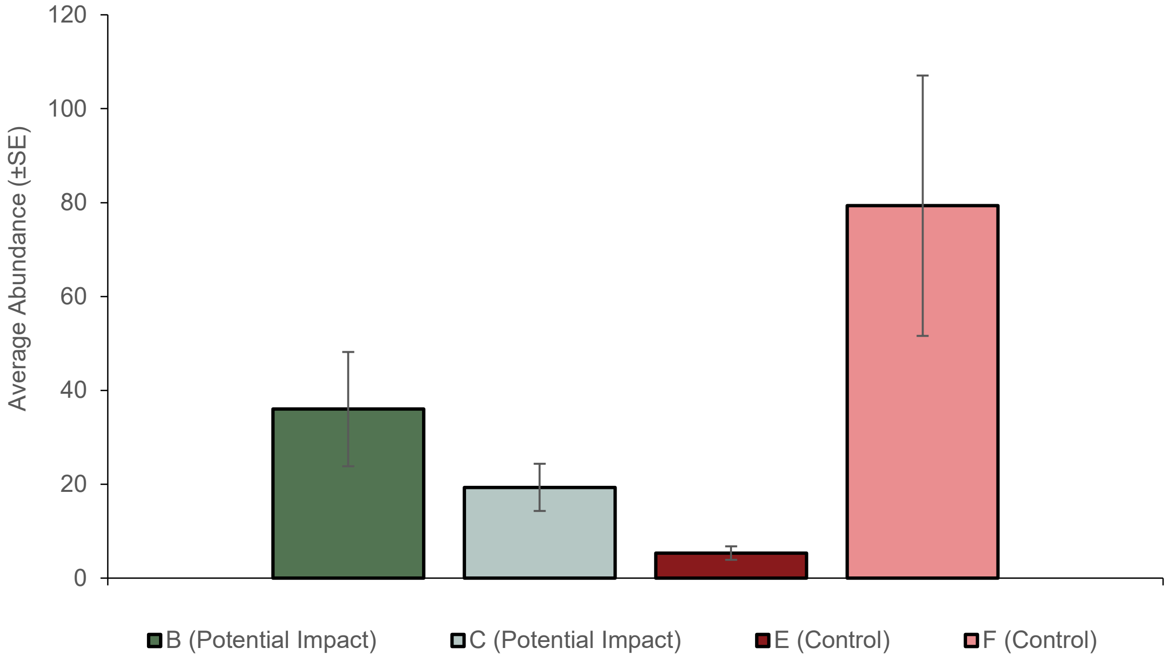

Figure 10: Average abundance ± standard error at each location sampled under the EIMP in November 2022

4.2.2.2 Temporal Trends

Macroinvertebrate abundances in 2022 were compared with previous monitoring results to understand temporal variation. Total abundance increased at all locations in 2020 due to a change in methodology (i.e., reduced mesh size)(Figure 11). Abundance at locations B, E and F has generally been consistent through time since the 2020, although location C peaked in 2021 due to a large abundance of Tellinidae.

Although an increase in TOC and fine particles at potential impact locations (B and C) was notable during the November 2022 EIMP sampling, this has not equated to an obvious change in macroinvertebrate abundances at these locations. As such, discharges from the Project are not considered to be impacting the macroinvertebrate abundance in the receiving environment of Little Alva Creek and surrounding area.

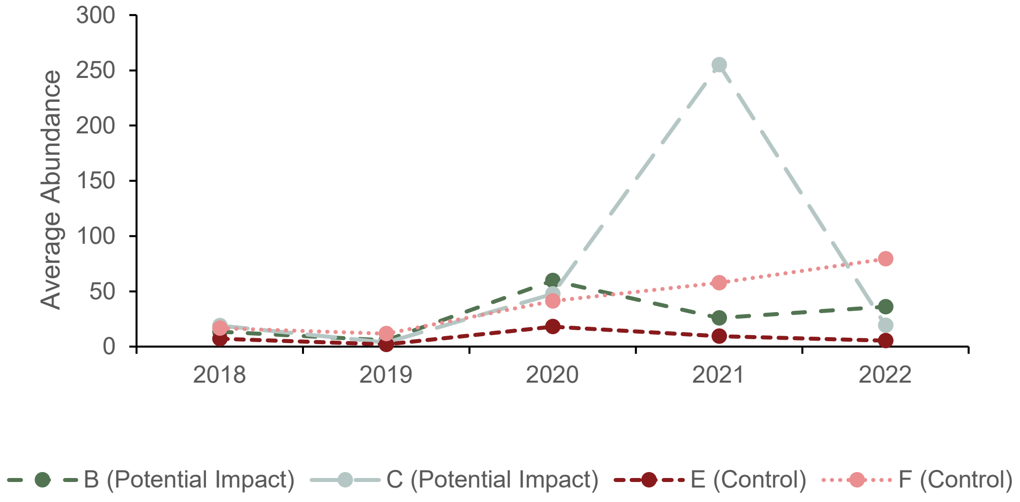

Figure 11: Average abundance at locations surveyed under EIMP monitoring from 2018 to 2022

4.3.3. Taxonomic Richness

4.2.3.1 Spring 2022

Location C (potential impact) and F (control) had higher taxonomic richness, an expected outcome due to the higher marine influence than the riverine locations of B and E (Figure 12). Taxonomic richness was variable amongst locations, however as error bars are overlapping, locations are not considered to be significantly different. As location B (potential impact) had a higher taxonomic richness than comparable location (location E: control), discharge from the aquaculture facility is not expected to be impacting the macroinvertebrate taxonomic richness within Little Alva Creek or the surrounding environment.

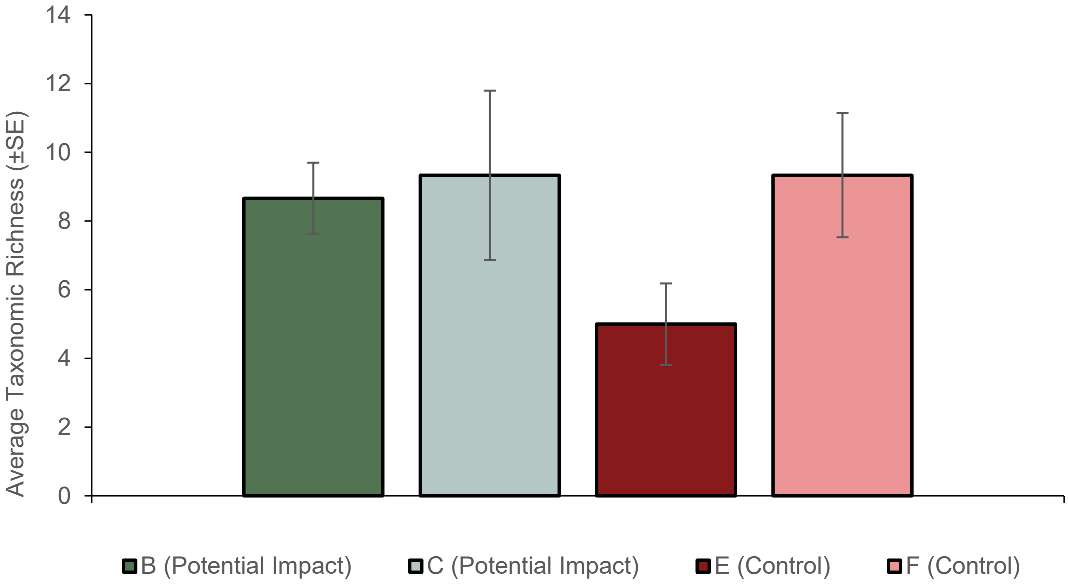

Figure 12: Average macroinvertebrate taxonomic richness ± standard error at each location sampled under the EIMP in November 2022

4.2.3.2 Temporal Trends

Taxonomic richness has been variable at all locations through historical and current monitoring (Figure 13). Lower taxonomic richness prior to 2020 is considered to be a reflection of the methodology (coarser mesh size) with average taxonomic richness from 2020 to 2022 relatively comparable throughout sampling events. Temporal variability in taxonomic richness is considered to be a reflection of estuarine dynamics, with macroinvertebrate communities highly variable spatially and temporally, altering in response to continuously changing environmental conditions.

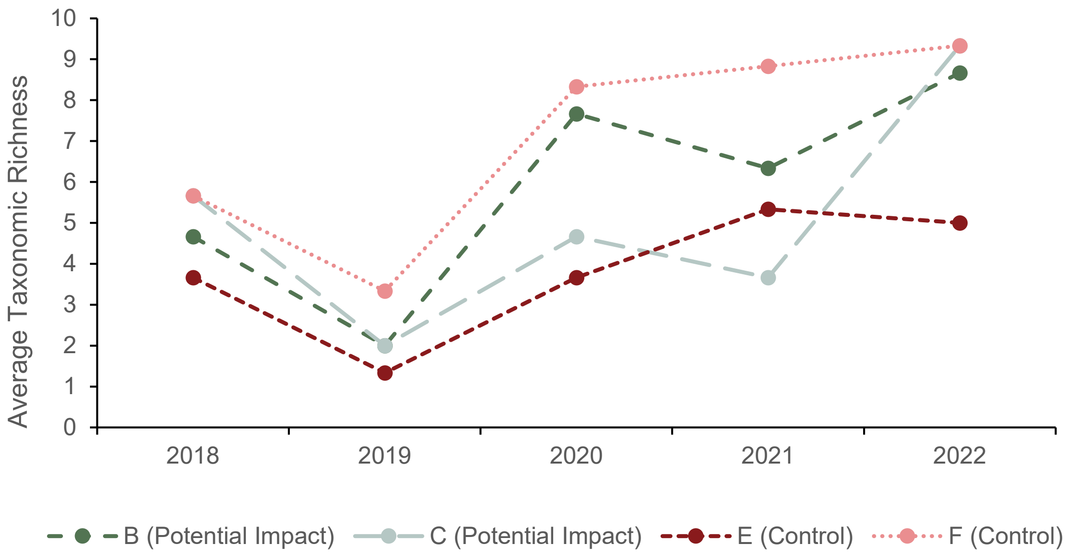

Figure 13: Average taxonomic richness at locations surveyed under EIMP monitoring from 2018 to 2022

5. RECOMENDATIONS AND CONCLUSIONS

5.1. Recommendations

It is recommended that monitoring of the environment continues, however consideration to a review of the EIMP design is recommended to ensure sampling meets the intended purpose and current scientific knowledge. Continual monitoring will look to establish any trends in higher contribution of fine sediments (<75 µm,) and TOC at potential impact sites are arising from operation of the farm, or if results presented herein are from natural variation.

Furthermore, a comprehensive review of water quality, sediment quality and macroinvertebrate community for all available data should be undertaken to provide a detailed assessment on the potential effects of the PRF wastewater discharge on the receiving environment, including where necessary, multivariate statistical analyses (PERMANOVA, ANOSIM, nMDS, SIMPER) to assess potential impacts to the receiving environment and to correlate sediment and water quality parameters to macroinvertebrate community structure where the parameters in the receiving environment indicate a potential influence.

5.2. Conclusions

This report summarises the sediment and macroinvertebrate monitoring completed in November 2022. TOC and fine sediment and has provided results that indicate that the prawn farm may be having a limited impact on organic carbon concentration; however, given there is no change from previous operation, the increase in TOC may be a result of natural conditions of the waterway (i.e., limited flushing, high terrestrial input). However, there is no evidence that the PRF wastewater discharge is having an impact on the macroinvertebrate community (abundance and taxonomic richness), nor on particle sizing at the potentially impacted locations and results were comparable with control locations.

6. APPENDIX A

Table A.1: Particle sizing distribution from sites sampled in November 2022

Particle Size	Unit	B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
>75	µm	35	76	59	57	41	84	77	96	95	87	94	92
>150	µm	31	72	50	32	36	71	72	92	92	84	92	89
>300	µm	20	47	26	20	24	45	45	46	76	54	64	58
>425	µm	11	21	12	10	11	15	21	17	47	24	26	27
>600	µm	5	7	4	4	4	4	7	4	19	8	8	9
>1180	µm	<1	<1	<1	<1	<1	<1	<1	<1	2	<1	<1	1
>2.36	mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Particle Size		B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
Fines	<75 µm	65	24	41	43	59	16	23	4	5	13	6	8
Sand	75 µm – 2mm	35	76	59	57	41	84	77	96	94	87	94	91
Gravel	2mm – 6cm	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	1
Cobbles	>6cm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Particle Sizing	Units	B1	B2	B3	C1	C2	C3	E1	E2	E3	F1	F2	F3
Total Organic Carbon	µg/L	1.12	0.53	1.03	0.86	1.07	0.24	0.32	0.08	0.07	0.33	0.10	0.24