Memorandum

To: Aileen Craw, Senior Planner, WSP

From: Eloise Ryan, Principal Water Quality Scientist, 4Sight Consulting-Part of SLR

Date: 14 April 2023

Subject: Assessment of effects on Clutha River water quality v1

Clutha District Council (CDC) is applying for statutory approvals to authorise the continued operation of the Mt Cooee Landfill (referred to as 'the Landfill') on Kaitangata Highway, Balclutha. The existing resource consents expire on 1 October 2023. To support the consent renewal and consent acquisition process, CDC requires a series of technical assessments and reports. 4Sight Consulting – Part of SLR was engaged by CDC via WSP to undertake a Water Quality assessment of the Clutha River, undertake a Terrestrial and Wetland Survey and Assessment[1] and prepare a Bird Management Plan[2]. The purpose of this memo is to present the findings from one of these assessments (Task 2 in the Offer of Service): to determine if leachate has been entering the Clutha River from the Landfill based on water quality monitoring results, and to provide a summary of water quality effects on the Clutha River from the Landfill.

CLUTHA RIVER MONITORING DATA

Water quality assessments were undertaken to determine if there is evidence of leachate entering the Clutha River from the landfill. The landfill is located within the Clutha River/Mata-Au catchment, with the River approximately 60m west of the western boundary of the landfill site.

Water quality monitoring was conducted on four occasions in the Clutha River between April 2022 and January 2023. Water samples were collected upstream of the landfill and downstream of the landfill to allow comparison between the two sites. All sampling was conducted by CDC and the analysis in this memo is based on the laboratory results presented in Appendix A. Water samples from all three sampling occasions were tested for electrical conductivity, pH, chloride and total ammoniacal-N. The range of water quality parameters was limited and did not include biochemical oxygen demand, however changes in electrical conductivity and pH are likely to be sufficient to determine if leachate is making its way to the river. In November 2022 and January 2023, a more comprehensive list of analytes was tested including metals, chemical and biological oxygen demand, herbicides, semi volatile and volatile organic compounds (SVOC and VOC)[3].

COMPARISON OF UPSTREAM AND DOWNSTREAM MONITORING LOCATIONS

A comparison of site results for the four parameters measured on the four sampling occasions upstream and downstream of the Landfill to the Clutha River is provided in Table 1. The difference between upstream and downstream concentrations is shown in terms of the absolute differences in median concentration (Absolute), and as a percentage change of the upstream concentration (%).

[1] Rate S. 2022. Mt Cooee Landfill Expansion Area: Terrestrial, Wetland, and Waterway Assessment. 4Sight Consulting Ltd. Prepared for WSP.

[2] Rate S. 2022. Mt Cooee Landfill Bird Management Plan. 4Sight Consulting Ltd. Prepared for WSP.

[3] The full list of analytes is shown on the laboratory report in Appendix A.

Table 1. Summary of water quality in the Clutha River upstream and downstream of the Landfill. A negative change in concentration represents a lower median concentration downstream.

Analyte	Upstream		Downstream		Change in Median	
	Median	Range	Median	Range	Absolute	%
Electrical conductivity (mS/m)	7.4	7.4-8.6	7.6	7.2-8.6	0.2	2
pH	7.7	7.3-7.7	7.7	7.6-7.8	0	0
Chloride (g/m^3)	1.0	0.7-3.7	0.95	0.7-3.7	-0.05	-5
Total Ammoniacal-N (g/m^3)	<0.010	<0.010	<0.010	<0.010-0.012	0	0

There were minimal differences in the median contaminant concentrations between the upstream and downstream sites. While there was a decrease in the downstream median chloride concentration (-5%), examination of the results showed minimal variation between the upstream and downstream sites (0.05 g/m^3) on each sampling occasion, which is within the range of natural variation.

Overall, the results indicate that, at the time of sampling, leachate from the Landfill was not having any meaningful effects on electrical conductivity, pH, chloride, or total ammoniacal nitrogen in the Clutha River; that is, the water quality effects are negligible.

In November 2022 and January 2023, a more comprehensive suite of parameters was measured including metals, chemical and biological oxygen demand, herbicides, SVOCs, VOCs, and others (Appendix 1). There was little to no difference between upstream and downstream concentrations for all measurements and many concentrations were at or below the laboratory level of detection. This supports the conclusion that leachate from the Landfill is not having any meaningful effects on the water quality of the Clutha River; that is, the effects of the leachate from the Landfill on water quality in the Clutha River is negligible.

GUIDELINE VALUES

To put the measured water quality parameters for the Clutha River in context (from the four sampling periods), the concentrations were assessed against relevant guidelines from the NPS-FM (2020)[4] and ANZG (2018)[5]. Guidelines are shown in Table 2 with comparisons in Figure 1; there are no relevant guideline values for chloride. I note that the NPS-FM Attribute Bands for total ammoniacal nitrogen have been developed to be applied to annual median and maximum values for larger datasets than collected here. Assessments of individual or few data points against the NPS-FM bands, however, is still considered appropriate and provides context for results.

Table 2. Guideline values used to assess the water quality of the Clutha River.

Variable	Guideline Value	Source
Total ammoniacal-N*	≤0.05 g/m^3 0.40 g/m^3	NPS-FM (2020). Band A, Annual maximum. NPS-FM (2020). NBL, Annual maximum.
Electrical conductivity	11.6 mS/m	ANZG (2018) physical and chemical stressors for cool dry low-elevation River Environment Classification.
pH	7.23 - 7.8	

**pH adjusted, based on pH 8 and temperature of 20°C.*

[4] National Policy Statement for Freshwater Management 2020. National Policy Statement for Freshwater Management 2020 | Ministry for the Environment

[5] ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. www.waterquality.gov.au/anz-guidelines

Figure 1 illustrates the similarity between the upstream and downstream samples and comparisons to relevant guideline values.

Total ammoniacal-N concentrations were within the Band A NPS-FM standard. These results are in agreement with the results of NIWA's National River Water Quality Network site on the Clutha River at Balclutha, which is downstream from the Landfill.[6]

Conductivity and pH concentrations were within the relevant ANZG guideline values.

Overall, at the time of sampling, these results indicate that the water quality in the Clutha River at both upstream and downstream sites is of similar quality and is not being adversely affected by any leachate that may be discharged from the Landfill.

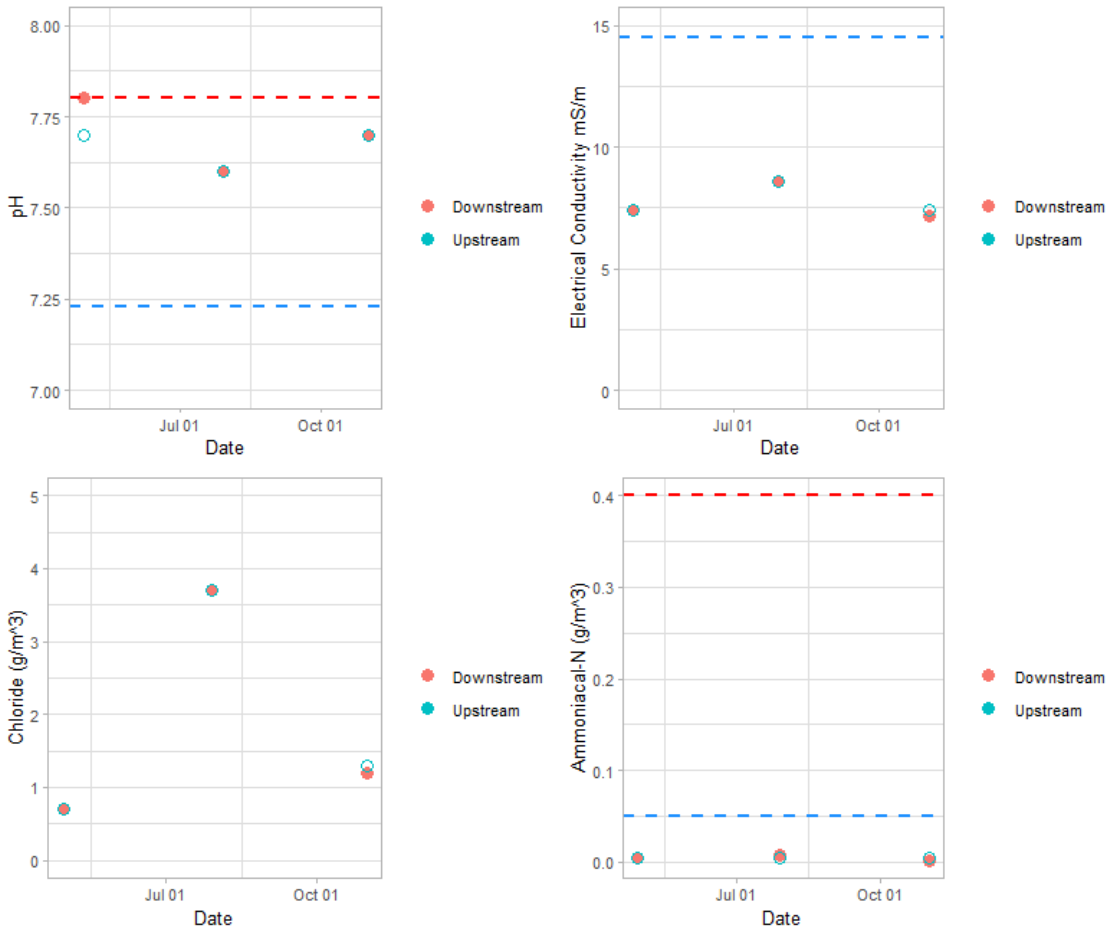

Figure 1. Upstream vs downstream samples in the Clutha River for samples collected between April 2022 – January 2023. Guideline values are sourced from Table 1.

SUMMARY OF EFFECTS ON THE CLUTHA RIVER

The results indicate that any leachate from the Landfill, at the time of sampling, had negligible effects on water quality in the Clutha River.

The Mt Cooee Consenting Strategy[7] states that there are effective measures in place to reduce leaching and run-off with a steel sheet pile that effectively diverts the leachate. Accordingly, very little to no

[6] Land, Air, Water Aotearoa (LAWA) - Clutha River/Mata-Au at Balclutha

[7] WSP 2022. Mt Cooee Landfill: Consenting Strategy. Revision 2.0. Prepared for Clutha District Council.

leachate is anticipated to be discharged to the Clutha River. The sheet piles extend a wall down to the bedrock across the full width of the valley with the wall capped with a low permeability compacted clay bund. The wall and bund have therefore formed a dam for groundwater flow, which minimises the deeper percolation of leachate but also directs groundwater flow out of the site towards the leachate collection system. The leachate/contaminated groundwater is then pumped to the CDC sewer for treatment. Combined with the diversion of the stormwater channel around the landfill (in 2021), these appear to be effective measures to minimise impacts on the Clutha River.

There are large flows in the Clutha River (mean annual low flow at Balclutha 272 m^3/s), enabling a substantial dilution with the likely small discharge from the Landfill. These flows, combined with the Landfill design, means the potential contaminant contribution from the leachate to the overall contaminant load of the river is unlikely to be detectable. However, there were a limited number of sampling occasions in this study (n=4), which does apply some limits to the strength of the conclusions drawn in this memo. Although more data may be beneficial, I consider it unlikely that it would change the conclusion here that the effects of the leachate on the Clutha River water quality is negligible, and, at worst, less than minor.

APPENDIX 1: HILL LABORATORIES RESULTS

Hill Laboratories
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Certificate of Analysis

Client:	WSP New Zealand Limited	**Lab No:**	3107994 SPv1
Contact:	Tara Verhulst	**Date Received:**	02-Nov-2022
	C/- WSP New Zealand Limited	**Date Reported:**	15-Nov-2022
	PO Box 273	**Quote No:**	117964
	Alexandra 9320	**Order No:**	
		Client Reference:	Mt Cooee Quarterly Sampling
		Add. Client Ref:	20399007/1200
		Submitted By:	Tara Verhulst

Sample Type: Aqueous

Sample Name:		SW1 01-Nov-2022 9:30 am	SW2 01-Nov-2022 10:00 am
Lab Number:		3107994.1	3107994.2
Individual Tests			
Sum of Anions	meq/L	0.70	0.70
Sum of Cations	meq/L	0.74	0.74
pH	pH Units	7.7	7.7
Total Alkalinity	g/m³ as $CaCO_3$	29	29
Bicarbonate	g/m³ at 25°C	35	35
Total Hardness	g/m³ as $CaCO_3$	31	31
Electrical Conductivity (EC)	mS/m	7.4	7.2
Dissolved Aluminium	g/m³	0.057	0.057
Dissolved Boron	g/m³	< 0.005	< 0.005
Dissolved Calcium	g/m³	10.7	10.8
Dissolved Iron	g/m³	0.12	0.11
Dissolved Magnesium	g/m³	1.10	1.07
Dissolved Manganese	g/m³	0.0145	0.0129
Dissolved Potassium	g/m³	0.65	0.66
Dissolved Sodium	g/m³	1.98	2.0
Chloride	g/m³	1.3	1.2
Total Ammoniacal-N	g/m³	< 0.010	< 0.010
Nitrite-N	g/m³	< 0.002	< 0.002
Nitrate-N	g/m³	0.067	0.066
Nitrate-N + Nitrite-N	g/m³	0.068	0.067
Total Kjeldahl Nitrogen (TKN)	g/m³	< 0.10	< 0.10
Dissolved Reactive Phosphorus	g/m³	< 0.004	< 0.004
Reactive Silica	g/m³ as SiO_2	3.4	3.3
Sulphate	g/m³	3.8	3.7
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	< 2 #1	< 2 #1
Chemical Oxygen Demand (COD)	g O_2/m³	9	6
Total Organic Carbon (TOC)	g/m³	1.9	1.8
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn			
Dissolved Arsenic	g/m³	< 0.0010	< 0.0010
Dissolved Cadmium	g/m³	< 0.00005	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005
Dissolved Copper	g/m³	0.0005	0.0006
Dissolved Lead	g/m³	0.00018	0.00018
Dissolved Nickel	g/m³	< 0.0005	< 0.0005
Dissolved Zinc	g/m³	< 0.0010	< 0.0010

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

Sample Type: Aqueous			
Sample Name:		SW1 01-Nov-2022 9:30 am	SW2 01-Nov-2022 10:00 am
Lab Number:		3107994.1	3107994.2
Acid Herbicides Screen in Water by LCMSMS			
Acifluorfen	g/m³	< 0.0004	< 0.0004
Bentazone	g/m³	< 0.0004	< 0.0004
Bromoxynil	g/m³	< 0.0004	< 0.0004
Clopyralid	g/m³	< 0.0004	< 0.0004
2,4-Dichlorophenoxyacetic acid (24D)	g/m³	< 0.0004	< 0.0004
2,4-Dichlorophenoxybutyric acid (24DB)	g/m³	< 0.0006	< 0.0006
Dicamba	g/m³	< 0.0006	< 0.0006
Dichlorprop	g/m³	< 0.0004	< 0.0004
Fluazifop	g/m³	< 0.0004	< 0.0004
Fluroxypyr	g/m³	< 0.0004	< 0.0004
Haloxyfop	g/m³	< 0.0004	< 0.0004
2-methyl-4-chlorophenoxyacetic acid (MCPA)	g/m³	< 0.0004	< 0.0004
2-methyl-4-chlorophenoxybutanoic acid (MCPB)	g/m³	< 0.0004	< 0.0004
Mecoprop	g/m³	< 0.0004	< 0.0004
Oryzalin	g/m³	< 0.0006	< 0.0006
2,3,4,6-Tetrachlorophenol (TCP)	g/m³	< 0.0004	< 0.0004
2,4,5-Trichlorophenoxypropionic acid (245TP, Fenoprop, Silvex)	g/m³	< 0.0004	< 0.0004
2,4,5-Trichlorophenoxyacetic acid (245T)	g/m³	< 0.0004	< 0.0004
Pentachlorophenol (PCP)	g/m³	< 0.0004	< 0.0004
Picloram	g/m³	< 0.0004	< 0.0004
Quizalofop	g/m³	< 0.0004	< 0.0004
Triclopyr	g/m³	< 0.0004	< 0.0004
Haloethers Trace in SVOC Water Samples by GC-MS			
Bis(2-chloroethoxy) methane	g/m³	< 0.0005	< 0.0005
Bis(2-chloroethyl)ether	g/m³	< 0.0005	< 0.0005
Bis(2-chloroisopropyl)ether	g/m³	< 0.0005	< 0.0005
4-Bromophenyl phenyl ether	g/m³	< 0.0003	< 0.0003
4-Chlorophenyl phenyl ether	g/m³	< 0.0005	< 0.0005
Nitrogen containing compounds Trace in SVOC Water Samples, GC-MS			
2,4-Dinitrotoluene	g/m³	< 0.0010	< 0.0010
2,6-Dinitrotoluene	g/m³	< 0.0010	< 0.0010
Nitrobenzene	g/m³	< 0.0005	< 0.0005
N-Nitrosodi-n-propylamine	g/m³	< 0.0010	< 0.0010
N-Nitrosodiphenylamine + Diphenylamine	g/m³	< 0.0010	< 0.0010
Organochlorine Pesticides Trace in SVOC Water Samples by GC-MS			
Aldrin	g/m³	< 0.0005	< 0.0005
alpha-BHC	g/m³	< 0.0005	< 0.0005
beta-BHC	g/m³	< 0.0005	< 0.0005
delta-BHC	g/m³	< 0.0005	< 0.0005
gamma-BHC (Lindane)	g/m³	< 0.0005	< 0.0005
4,4'-DDD	g/m³	< 0.0005	< 0.0005
4,4'-DDE	g/m³	< 0.0005	< 0.0005
4,4'-DDT	g/m³	< 0.0010	< 0.0010
Dieldrin	g/m³	< 0.0005	< 0.0005
Endosulfan I	g/m³	< 0.0010	< 0.0010
Endosulfan II	g/m³	< 0.0010	< 0.0010
Endosulfan sulphate	g/m³	< 0.0010	< 0.0010
Endrin	g/m³	< 0.0005	< 0.0005
Endrin ketone	g/m³	< 0.0010	< 0.0010
Heptachlor	g/m³	< 0.0005	< 0.0005
Heptachlor epoxide	g/m³	< 0.0005	< 0.0005
Hexachlorobenzene	g/m³	< 0.0005	< 0.0005

Sample Type: Aqueous			
Sample Name:		SW1 01-Nov-2022 9:30 am	SW2 01-Nov-2022 10:00 am
Lab Number:		3107994.1	3107994.2
Polycyclic Aromatic Hydrocarbons Trace in SVOC Water Samples*			
Acenaphthene	g/m³	< 0.0003	< 0.0003
Acenaphthylene	g/m³	< 0.0003	< 0.0003
Anthracene	g/m³	< 0.0003	< 0.0003
Benzo[a]anthracene	g/m³	< 0.0003	< 0.0003
Benzo[a]pyrene (BAP)	g/m³	< 0.0003	< 0.0003
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m³	< 0.0003	< 0.0003
Benzo[g,h,i]perylene	g/m³	< 0.0003	< 0.0003
Benzo[k]fluoranthene	g/m³	< 0.0003	< 0.0003
1&2-Chloronaphthalene	g/m³	< 0.0003	< 0.0003
Chrysene	g/m³	< 0.0003	< 0.0003
Dibenzo[a,h]anthracene	g/m³	< 0.0003	< 0.0003
Fluoranthene	g/m³	< 0.0003	< 0.0003
Fluorene	g/m³	< 0.0003	< 0.0003
Indeno(1,2,3-c,d)pyrene	g/m³	< 0.0003	< 0.0003
2-Methylnaphthalene	g/m³	0.0003	< 0.0003
Naphthalene	g/m³	< 0.0003	< 0.0003
Phenanthrene	g/m³	< 0.0003	< 0.0003
Pyrene	g/m³	< 0.0003	< 0.0003
Benzo[a]pyrene Toxic Equivalence (TEF)*	g/m³	< 0.0008	< 0.0008
Phenols Trace (drinkingwater) in SVOC Water Samples by GC-MS			
2-Chlorophenol	g/m³	< 0.0005	< 0.0005
2,4-Dichlorophenol	g/m³	< 0.0005	< 0.0005
2,4,6-Trichlorophenol	g/m³	< 0.0010	< 0.0010
Phenols Trace (non-drinkingwater) in SVOC Water Samples by GC-MS			
4-Chloro-3-methylphenol	g/m³	< 0.0010	< 0.0010
2,4-Dimethylphenol	g/m³	< 0.0005	< 0.0005
3 & 4-Methylphenol (m- + p-cresol)	g/m³	< 0.0010	< 0.0010
2-Methylphenol (o-Cresol)	g/m³	< 0.0005	< 0.0005
2-Nitrophenol	g/m³	< 0.0010	< 0.0010
Pentachlorophenol (PCP)	g/m³	< 0.010	< 0.010
Phenol	g/m³	< 0.0010	< 0.0010
2,4,5-Trichlorophenol	g/m³	< 0.0010	< 0.0010
Plasticisers Trace (non-drinkingwater) in SVOC Water by GCMS			
Butylbenzylphthalate	g/m³	< 0.0010	< 0.0010
Diethylphthalate	g/m³	< 0.0010	< 0.0010
Dimethylphthalate	g/m³	< 0.0010	< 0.0010
Di-n-butylphthalate	g/m³	< 0.0010	< 0.0010
Di-n-octylphthalate	g/m³	< 0.0010	< 0.0010
Plasticisers Trace (drinkingwater) in SVOC Water Samples by GCMS			
Bis(2-ethylhexyl)phthalate	g/m³	< 0.003	< 0.003
Di(2-ethylhexyl)adipate	g/m³	< 0.0010	< 0.0010
Other Halogenated compounds Trace (drinkingwater) in SVOC Water			
1,2-Dichlorobenzene	g/m³	< 0.0005	< 0.0005
1,3-Dichlorobenzene	g/m³	< 0.0005	< 0.0005
1,4-Dichlorobenzene	g/m³	< 0.0005	< 0.0005
Other Halogenated compounds Trace (non-drinkingwater) in SVOC			
Hexachlorobutadiene	g/m³	< 0.0005	< 0.0005
Hexachloroethane	g/m³	< 0.0005	< 0.0005
1,2,4-Trichlorobenzene	g/m³	< 0.0005	< 0.0005
Other SVOC Trace in SVOC Water Samples by GC-MS			
Benzyl alcohol	g/m³	< 0.005	< 0.005
Carbazole	g/m³	< 0.0005	< 0.0005
Dibenzofuran	g/m³	< 0.0005	< 0.0005
Isophorone	g/m³	< 0.0005	< 0.0005

Sample Type: Aqueous			
Sample Name:		SW1 01-Nov-2022 9:30 am	SW2 01-Nov-2022 10:00 am
Lab Number:		3107994.1	3107994.2
BTEX in VOC Water by Headspace GC-MS			
Benzene	g/m³	< 0.0003	< 0.0003
Ethylbenzene	g/m³	< 0.0005	< 0.0005
Toluene	g/m³	< 0.0003	< 0.0003
m&p-Xylene	g/m³	< 0.0005	< 0.0005
o-Xylene	g/m³	< 0.0003	< 0.0003
Halogenated Aliphatics in VOC Water by Headspace GC-MS			
Bromomethane (Methyl Bromide)	g/m³	< 0.0003	< 0.0003
Carbon tetrachloride	g/m³	< 0.0003	< 0.0003
Chloroethane	g/m³	< 0.0003	< 0.0003
Chloromethane	g/m³	< 0.0003	< 0.0003
1,2-Dibromo-3-chloropropane	g/m³	< 0.0003	< 0.0003
1,2-Dibromoethane (ethylene dibromide, EDB)	g/m³	< 0.0003	< 0.0003
Dibromomethane	g/m³	< 0.0003	< 0.0003
Dichlorodifluoromethane	g/m³	< 0.0003	< 0.0003
1,1-Dichloroethane	g/m³	< 0.0003	< 0.0003
1,2-Dichloroethane	g/m³	< 0.0003	< 0.0003
1,1-Dichloroethene	g/m³	< 0.0003	< 0.0003
cis-1,2-Dichloroethene	g/m³	< 0.0003	< 0.0003
trans-1,2-Dichloroethene	g/m³	< 0.0003	< 0.0003
Dichloromethane (methylene chloride)	g/m³	< 0.010	< 0.010
1,2-Dichloropropane	g/m³	< 0.0003	< 0.0003
1,3-Dichloropropane	g/m³	< 0.0003	< 0.0003
1,1-Dichloropropene	g/m³	< 0.0003	< 0.0003
cis-1,3-Dichloropropene	g/m³	< 0.0005	< 0.0005
trans-1,3-Dichloropropene	g/m³	< 0.0005	< 0.0005
Hexachlorobutadiene	g/m³	< 0.0003	< 0.0003
1,1,1,2-Tetrachloroethane	g/m³	< 0.0003	< 0.0003
1,1,2,2-Tetrachloroethane	g/m³	< 0.0003	< 0.0003
Tetrachloroethene (tetrachloroethylene)	g/m³	< 0.0003	< 0.0003
1,1,1-Trichloroethane	g/m³	< 0.0003	< 0.0003
1,1,2-Trichloroethane	g/m³	< 0.0003	< 0.0003
Trichloroethene (trichloroethylene)	g/m³	< 0.0003	< 0.0003
Trichlorofluoromethane	g/m³	< 0.0003	< 0.0003
1,2,3-Trichloropropane	g/m³	< 0.0003	< 0.0003
1,1,2-Trichlorotrifluoroethane (Freon 113)	g/m³	< 0.0003	< 0.0003
Vinyl chloride	g/m³	< 0.0003	< 0.0003
Halogenated Aromatics in VOC Water by Headspace GC-MS			
Chlorobenzene (monochlorobenzene)	g/m³	< 0.0003	< 0.0003
1,2-Dichlorobenzene	g/m³	< 0.0003	< 0.0003
1,3-Dichlorobenzene	g/m³	< 0.0003	< 0.0003
1,4-Dichlorobenzene	g/m³	< 0.0003	< 0.0003
1,2,3-Trichlorobenzene	g/m³	< 0.0003	< 0.0003
1,2,4-Trichlorobenzene	g/m³	< 0.0003	< 0.0003
1,3,5-Trichlorobenzene	g/m³	< 0.0003	< 0.0003
Bromobenzene	g/m³	< 0.0003	< 0.0003
2-Chlorotoluene	g/m³	< 0.0003	< 0.0003
4-Chlorotoluene	g/m³	< 0.0003	< 0.0003
Monoaromatic Hydrocarbons in VOC Water by Headspace GC-MS			
n-Butylbenzene	g/m³	< 0.0005	< 0.0005
tert-Butylbenzene	g/m³	< 0.0003	< 0.0003
4-Isopropyltoluene (p-Cymene)	g/m³	< 0.0005	< 0.0005
Isopropylbenzene (Cumene)	g/m³	< 0.0003	< 0.0003
n-Propylbenzene	g/m³	< 0.0005	< 0.0005
sec-Butylbenzene	g/m³	< 0.0003	< 0.0003

Sample Type: Aqueous			
Sample Name:		SW1 01-Nov-2022 9:30 am	SW2 01-Nov-2022 10:00 am
Lab Number:		3107994.1	3107994.2
Monoaromatic Hydrocarbons in VOC Water by Headspace GC-MS			
Styrene	g/m³	0.0009	0.0014
1,2,4-Trimethylbenzene	g/m³	< 0.0003	< 0.0003
1,3,5-Trimethylbenzene	g/m³	< 0.0003	< 0.0003
Ketones in VOC Water by Headspace GC-MS			
Acetone	g/m³	< 0.05	< 0.05
2-Butanone (MEK)	g/m³	< 0.05	< 0.05
Methyl tert-butylether (MTBE)	g/m³	< 0.0003	< 0.0003
4-Methylpentan-2-one (MIBK)	g/m³	< 0.010	< 0.010
Trihalomethanes in VOC Water by Headspace GC-MS			
Bromodichloromethane	g/m³	< 0.0003	< 0.0003
Bromoform (tribromomethane)	g/m³	< 0.0003	< 0.0003
Chloroform (Trichloromethane)	g/m³	< 0.0003	< 0.0003
Dibromochloromethane	g/m³	< 0.0003	< 0.0003
Other VOC in Water by Headspace GC-MS			
Carbon disulphide	g/m³	< 0.0005	< 0.0005
Naphthalene	g/m³	< 0.0005	< 0.0005

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Certificate of Analysis

Client:	WSP New Zealand Limited	**Lab No:**	3161688 SPv2
Contact:	Tara Verhulst	**Date Received:**	27-Jan-2023
	C/- WSP New Zealand Limited	**Date Reported:**	08-Feb-2023
	PO Box 273	**Quote No:**	121901
	Alexandra 9320	**Order No:**	
		Client Reference:	Mt. Cooee groundwater
		Submitted By:	Tara Verhulst

Sample Type: Aqueous

Sample Name:		GW2 24-Jan-2023	GW3 24-Jan-2023	GW4 24-Jan-2023	GW5 24-Jan-2023	GW6 24-Jan-2023
Lab Number:		3161688.1	3161688.2	3161688.3	3161688.4	3161688.5
Individual Tests						
Sum of Anions	meq/L	10.0	7.3	162	20	6.9
Sum of Cations	meq/L	10.9	7.6	162	19.5	7.7
pH	pH Units	6.7	7.2	7.5	6.6	6.1
Total Alkalinity	g/m³ as $CaCO_3$	380	280	6,600	750	161
Bicarbonate	g/m³ at 25°C	460	340	8,000	910	197
Total Hardness	g/m³ as $CaCO_3$	320	280	1,930	500	230
Electrical Conductivity (EC)	mS/m	92.5	68.2	1,305	178.1	71.3
Dissolved Aluminium	g/m³	0.008	0.010	< 0.3	< 0.06	0.022
Dissolved Boron	g/m³	2.6	0.29	63	8.2	0.107
Dissolved Calcium	g/m³	63	77	107	102	43
Dissolved Iron	g/m³	0.08	0.30	2	1.6	4.1
Dissolved Magnesium	g/m³	39	22	400	59	28
Dissolved Manganese	g/m³	2.4	9.1	0.34	3.3	5.8
Dissolved Potassium	g/m³	17.2	2.5	720	22	2.4
Dissolved Sodium	g/m³	90	35	1,010	128	62
Chloride	g/m³	52	32	1,050	189	84
Total Ammoniacal-N	g/m³	0.95	0.048	860 #1	45	0.52
Nitrite-N	g/m³	0.002	0.004	0.03	0.004	< 0.02 #3
Nitrate-N	g/m³	< 0.002	0.005	0.33	0.035	< 0.02
Nitrate-N + Nitrite-N	g/m³	0.004	0.009	0.36	0.038	< 0.02 #3
Total Kjeldahl Nitrogen (TKN)	g/m³	1.60	0.75	810 #1	43 #1	1.04
Dissolved Reactive Phosphorus	g/m³	0.014	0.011	2.0	< 0.004	< 0.004
Reactive Silica	g/m³ as SiO_2	12.4	12.7	29	24	17.8
Sulphate	g/m³	46	44	< 5 #2	0.7	63
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	< 2	< 2	62	< 2	< 2
Total Organic Carbon (TOC)	g/m³	7.3	10.6	420	15	5.0
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	< 0.0010	< 0.0010	< 0.10	< 0.02	0.0014
Dissolved Cadmium	g/m³	< 0.00005	0.00008	< 0.005	< 0.0010	< 0.00005
Dissolved Chromium	g/m³	< 0.0005	< 0.0005	< 0.05	< 0.010	< 0.0005
Dissolved Copper	g/m³	0.0034	0.0040	< 0.05	< 0.010	0.0012
Dissolved Lead	g/m³	< 0.00010	0.00018	< 0.010	< 0.002	< 0.00010
Dissolved Nickel	g/m³	0.0034	0.0085	0.07	< 0.010	0.0061
Dissolved Zinc	g/m³	0.0031	0.028	< 0.10	< 0.02	0.0025

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

Sample Type: Aqueous						
Sample Name:		GW7 24-Jan-2023	BH1 25-Jan-2023	BH2 25-Jan-2023	BH4 25-Jan-2023	SW1 25-Jan-2023
Lab Number:		3161688.6	3161688.7	3161688.8	3161688.9	3161688.10
Individual Tests						
Sum of Anions	meq/L	4.8	16.2	2.7	2.2	0.73
Sum of Cations	meq/L	5.0	16.8	3.0	2.3	0.75
pH	pH Units	6.6	7.2	6.1	6.2	7.3
Total Alkalinity	g/m^3 as $CaCO_3$	77	610	65	69	32
Bicarbonate	g/m^3 at 25°C	94	740	79	84	39
Total Hardness	g/m^3 as $CaCO_3$	153	630	79	58	33
Electrical Conductivity (EC)	mS/m	52.4	142.1	29.5	23.0	7.4
Dissolved Aluminium	g/m^3	< 0.003	< 0.003	0.048	0.29	0.010
Dissolved Boron	g/m^3	0.038	0.54	0.046	0.051	< 0.005
Dissolved Calcium	g/m^3	33	136	16.0	12.6	11.7
Dissolved Iron	g/m^3	0.05	< 0.02	0.51	0.78	0.05
Dissolved Magnesium	g/m^3	17.0	71	9.4	6.5	0.91
Dissolved Manganese	g/m^3	0.35	0.43	0.72	0.55	0.0062
Dissolved Potassium	g/m^3	3.5	6.2	2.2	2.5	0.60
Dissolved Sodium	g/m^3	41	92	30	23	1.64
Chloride	g/m^3	97	133	25	19.0	0.7
Total Ammoniacal-N	g/m^3	0.73	< 0.010	0.036	0.061	< 0.010
Nitrite-N	g/m^3	0.026	< 0.002	< 0.002	0.003	< 0.002
Nitrate-N	g/m^3	0.054	< 0.002	0.003	0.030	0.010
Nitrate-N + Nitrite-N	g/m^3	0.079	< 0.002	0.003	0.032	0.010
Total Kjeldahl Nitrogen (TKN)	g/m^3	1.68	0.14	0.18	0.17	< 0.10
Dissolved Reactive Phosphorus	g/m^3	0.58	< 0.004	0.008	< 0.004	< 0.004
Reactive Silica	g/m^3 as SiO_2	32	18.1	22	27	2.5
Sulphate	g/m^3	21	15.0	33	11.1	3.3
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	$g\ O_2/m^3$	4	< 2	< 2	< 2	< 2
Total Organic Carbon (TOC)	g/m^3	13.8	6.2	1.4	< 0.5	1.3
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0011
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Copper	g/m^3	< 0.0005	0.0005	0.0018	0.0016	< 0.0005
Dissolved Lead	g/m^3	< 0.00010	< 0.00010	0.00011	0.00046	< 0.00010
Dissolved Nickel	g/m^3	< 0.0005	0.0007	0.0026	0.0009	< 0.0005
Dissolved Zinc	g/m^3	0.0089	0.0020	0.0011	0.0028	< 0.0010

Sample Name:		SW2 25-Jan-2023	BH2.QA
Lab Number:		3161688.11	3161688.12
Individual Tests			
Sum of Anions	meq/L	0.74	-
Sum of Cations	meq/L	0.76	-
pH	pH Units	7.6	6.5
Total Alkalinity	g/m^3 as $CaCO_3$	32	-
Bicarbonate	g/m^3 at 25°C	39	-
Total Hardness	g/m^3 as $CaCO_3$	33	-
Electrical Conductivity (EC)	mS/m	7.8	29.7
Dissolved Aluminium	g/m^3	0.004	-
Dissolved Boron	g/m^3	0.005	0.047
Dissolved Calcium	g/m^3	11.7	-
Dissolved Iron	g/m^3	< 0.02	-
Dissolved Magnesium	g/m^3	1.01	-
Dissolved Manganese	g/m^3	< 0.0005	-
Dissolved Potassium	g/m^3	0.60	2.3
Dissolved Sodium	g/m^3	1.72	-
Chloride	g/m^3	0.7	26
Total Ammoniacal-N	g/m^3	< 0.010	0.044

Sample Type: Aqueous			
Sample Name:		SW2 25-Jan-2023	BH2.QA
Lab Number:		3161688.11	3161688.12
Individual Tests			
Nitrite-N	g/m^3	< 0.002	< 0.002
Nitrate-N	g/m^3	0.009	< 0.002
Nitrate-N + Nitrite-N	g/m^3	0.010	< 0.002
Total Kjeldahl Nitrogen (TKN)	g/m^3	< 0.10	-
Dissolved Reactive Phosphorus	g/m^3	< 0.004	-
Reactive Silica	g/m^3 as SiO_2	2.5	-
Sulphate	g/m^3	3.4	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m^3	< 2	-
Total Organic Carbon (TOC)	g/m^3	1.3	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn			
Dissolved Arsenic	g/m^3	< 0.0010	-
Dissolved Cadmium	g/m^3	< 0.00005	-
Dissolved Chromium	g/m^3	< 0.0005	-
Dissolved Copper	g/m^3	< 0.0005	-
Dissolved Lead	g/m^3	< 0.00010	-
Dissolved Nickel	g/m^3	< 0.0005	-
Dissolved Zinc	g/m^3	< 0.0010	-

Analyst's Comments

#1 It has been noted that the result for Total Ammoniacal-N was greater than that for Total Kjeldahl Nitrogen, but within the analytical variation of these methods.

#2 Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the SO4 analysis.

#3 Severe matrix interferences required that a dilution be performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NOxN /NO2N analysis.

Samples 1, 4 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (up to 200-300% at the 95% confidence level).

Samples 2, 10-11 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (up to 100-200% at the 95% confidence level).

Samples 5, 7-8 Comment:
Please note that the level of Uncertainty of Measurement (UOM) for the TOC result is significantly greater than that usually reported for this analyte (>300% at the 95% confidence level).

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**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm Filtration, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.00005 - 0.0010 g/m^3	1-11
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-12
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.07 meq/L	1-11
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 23rd ed. 2017.	0.05 meq/L	1-11

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. 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	1-12
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (modified for Alkalinity <20) 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1-11
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO_2 D 23rd ed. 2017.	1.0 g/m³ at 25°C	1-11
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 23rd ed. 2017.	1.0 g/m³ as $CaCO_3$	1-11
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 23rd ed. 2017.	0.1 mS/m	1-12
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 23rd ed. 2017.	-	1-8, 11-12
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.003 g/m³	1-11
Dissolved Boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.005 g/m³	1-12
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1-11
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-11
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-11
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.0005 g/m³	1-11
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.05 g/m³	1-12
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017.	0.02 g/m³	1-11
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1-12
Total Ammoniacal-N	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/m³	1-12
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1-12
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m³	1-12
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m³	1-12
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/m³	1-11
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m³	1-11
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Flow Injection Analyser. APHA 4500-SiO2 F (modified) 23rd ed. 2017.	0.10 g/m³ as SiO_2	1-11
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 23rd ed. 2017.	0.5 g/m³	1-11
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, seeded. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m³	1-11
Total Organic Carbon (TOC)	Supercritical persulphate oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC.The uncertainty of the calculated result is a combination of the uncertainties of the two analytical determinands in the subtraction calculation. Where both determinands are similar in magnitude, the calculated result has a significantly higher uncertainty than would normally be achieved if one of the results was significantly less than the other. In such cases, the elevated uncertainty should be kept in mind when interpreting the data. APHA 5310 C (modified) 23rd ed. 2017.	0.5 g/m³	1-11

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

Testing was completed between 31-Jan-2023 and 08-Feb-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.

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