environment SOUTHLAND

Te Taiao Tonga

Surface Water Quality Monitoring Programmes

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1.0 Scope of Report

This report is an updated version of White (2006), documenting Environment Southland's current surface water monitoring programme (excluding recreational bathing). The report describes the design of the programme, and the procedures used for sample collection, sample analysis and data storage. The report does not discuss justifications for monitoring, procedures for data analysis or procedures for reporting.

References are made in this report to other reports where detailed procedures are documented. The field procedures for river water quality monitoring and are already incorporated into the Environmental Data section's Quality System.

Procedures for other monitoring programmes are documented in:

- Kitson (2006): Monitoring Plan for Recreational Bathing and Shellfish Gathering Waters in Southland, July 2006 to June 2009.
- White (2006): Estuarine Monitoring and Assessment in Southland.

2.0 Water Quality Monitoring in Southland

2.1 History of Water Quality Monitoring

Prior to 1989 water quality monitoring in Southland was restricted to one-off samples collected for synoptic surveys, *ad hoc* compliance monitoring, monitoring of water treatment (i.e. Invercargill City Council's weekly sampling of the Oreti River for the water treatment plant), and, short-term monitoring of approximately 33 sites in the early 1980s by the Southland Catchment Board (see Appendix 1).

Baseline water quality monitoring commenced in Southland in 1989 as part of the National River Water Quality Monitoring Network run by NIWA. The network consists of five sites concentrating on the main river systems. To supplement this network, Environment Southland established a comprehensive monitoring programme in 1994 and 1995. Regular monthly monitoring of faecal indicator bacteria commenced in July 1994 at 15 sites. In July 1995, a network of 26 sites (integrated with but not including the NIWA sites) was established to monitor physico-chemical parameters. This network was modified between July 1999 and July 2000 to incorporate tests for *faecal* indicator bacteria at all water quality sites.

A catchment-based water quality programme, Living Streams was initiated in 2005 in the Waihopai catchment and latterly in the Sandstone and Moffat Creek catchments in 2007 and 2009, respectively. Details of the Living Streams programme are not detailed in this document.

Environment Southland began annual monitoring of aquatic macroinvertebrates in December 1994 to assess ecosystem health. The identification and analysis of algae samples was added to the programme in January 1999. Previously macroinvertebrates had been sampled throughout

Southland during a series of synoptic surveys by Robertson Ryder & Associates (e.g. the Waiau catchment water quality review, 1993).

Environment Southland began regular lake water quality monitoring in July 2000 on Lake Te Anau, and on Lake Manapouri in July 2002. Three small lakes on Southland's southern coast (Lake George, Lake Vincent and The Reservoir) were sampled early 2002. Prior to this, data on the water quality of Southland's lakes was limited to one-off investigations and spot samples, most of which are documented in Livingston *et al* (1986).

Regular water quality monitoring on the Waituna Lagoon commenced in October 2001.

2.2 Current Water Quality Monitoring

Environment Southland currently monitors the water quality of Southland rivers and lakes to compare their current state, determine trends over time and identify sources of contaminants. There are four aspects to the surface water quality monitoring network:

1. ***River water quality*** – monthly sampling to assess state and trends;
2. ***River ecosystem health*** – summer sampling of aquatic macroinvertebrates and algae;
3. ***Lake water quality*** – monthly sampling and depth profiles to assess state and trends;
4. ***Lagoon water quality*** – monthly sampling to assess state and trends.

Procedures for each of these programmes are described below and key contacts for each programme are listed in Appendix 2

3.0 River Water Quality Monitoring

3.1 Design and Purpose

The water quality of Southland rivers is monitored to compare their current state, determine trends over time and identify sources of contaminants. These goals dictate the design of the monitoring network. To determine the "state" of river water quality it is cost effective to have a large number of sites and to select new sites every year. In contrast, to determine trends, sampling the same set of sites on an ongoing basis is required. These duel aims have resulted in a core network of long-term sites with additional 'roaming' and focus catchment sites.

Following the completion of the roaming programme in July 2004, a number of the roaming sites were added to the long-term network.

A number of telemetered sites are fitted with instrumentation to record real-time water quality information in the region's major rivers. This information currently includes: 32 flow, 47 water level, 19 water temperature, 6 electrical conductivity, and 2 dissolved oxygen concentration sites.

3.2 Sites Sampled

The current water quality programme began in July 1995 with a core network of 32 long-term sites, including six sites monitored by NIWA. The NIWA sites are part of the National River Water Quality Network (NRWQN), data from these sites are integrated with Environment Southland's monitoring network.

Since 1995, 40 long-term sites have been added to improve network coverage, resulting in a total of 72 sites. Current sites are listed in Table 3.1.

Table 3.1: Long term river monitoring sites

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification	Date Added to WQ Network	REC Classification	Data Ownership
11	Aparima River at Dunrobin	2130425	5485544	Hill	Sep-94	CW/H/HS/IF/HO/LG	ES
95	Aparima River at Otautau	2123733	5441039	Lowland Hard Bed	Aug-99	CD/L/HS/P/HO/LG	ES
14	Aparima River at Thornbury	2131100	5424400	Lowland Hard Bed	Aug-99	CD/L/HS/P/HO/LG	ES
130	Bog Burn d/s Hundred Line Road	2141298	5449941	Lowland Hard Bed	May-01	CD/L/HS/P/MO/LG	ES
16	Cascade Stream at Pourakino Valley Rd	2119500	5427800	Lowland Hard Bed	Jul-95	CW/L/PI/IF/MO/LG	ES
28	Cromel Stream at Selby Road	2149100	5503900	Hill	Jul-00	CW/H/HS/IF/MO/LG	ES
152	Currens Creek at Waituna Lagoon Road	2176300	5398400	Lowland Hard Bed	Aug-01	CD/L/AL/P/MO/LG	ES
153	Currens Creek Trib at Waituna lagoon	2176800	5397800	Lowland Hard Bed	Aug-01	CD/L/M/W/LO/LG	ES
38	Dunsdale Stream at Dunsdale Reserve	2170100	5443600	Natural State	Aug-99	CW/L/SS/IF/MO/LG	ES
29	Irthing Stream at Ellis Road	2153678	5493225	Hill	Jul-95	CW/H/HS/P/HO/LG	ES
230	Longridge Stream at Sandstone	2168600	5471000	Mataura 3	Jul-05	CD/L/Al/P/MO/LG	ES
122	Makarewa River at Lora Gorge Road	2160477	5450551	Lowland Soft Bed	Jul-00	CW/L/SS/P/MO/LG	ES
32	Makarewa River at Wallacetown	2147785	5420535	Lowland Soft Bed	Nov-00	CD/L/SS/P/HO/LG	ES
8	Mararoa River at South Mavora Lake	2132200	5532500	Mountain Lake	Sep-94	CW/M/HS/T/HO/LG	ES
118	Mararoa River at The Key	2110800	5506000	Hill	Jul-00	CW/H/AL/T/HO/LG	ES
7	Mararoa River at Weir Road	2096900	5497900	Hill	Sep-94	CW/H/AL/P/HO/LG	ES
45	Mataura River 200m d/s Mataura Bridge	2190639	5437453	Mataura 3	Jul-95	CD/H/HS/P/HO/MG	ES
91	Mataura River at Garston	2172500	5518400	Mataura 3	Aug-01	CW/H/HS/T/HO/LG	ES
85	Mataura River at Gore	2196731	5448625	Mataura 3	Dec-98	CD/H/HS/P/HO/LG	ES
43	Mataura River at Gorge Road	2182700	5402300	Mataura 3	Sep-94	CD/L/HS/P/HO/LG	ES
44	Mataura River at Mataura Island Bridge	2185132	5416055	Mataura 3	ES (Sept 94) NIWA (Jan-89)	CD/L/HS/P/HO/LG	ES, NIWA
46	Mataura River at Otamita Bridge	2188771	5458506	Mataura 2	Jul-95	CD/H/HS/P/HO/LG	ES
49	Mataura River at Parawa	2163800	5506970	Mataura 3	ES (Sept 94) NIWA (Jan-89)	CW/H/HS/P/HO/LG	ES, NIWA
117	Mimihau Stream at Wyndham	2190966	5423802	Mataura 3	Jul-00	CD/L/SS/P/MO/LG	ES
57	Mimihau Stream Trib at Venlaw Forest	2208092	5426004	Mataura 3	Jul-95	CW/H/SS/EF/LO/HG	ES
154	Moffat Creek at Moffat Road	2170000	5398300	Lowland Hard Bed	Aug-01	CD/L/AL/P/MO/LG	ES
54	Mokoreta River at Wyndham River Road	2189969	5419604	Mataura 3	Jul-03	CW/L/SS/P/HO/LG	ES

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification	Date Added to WQ Network	REC Classification	Data Ownership
148	Mokotua Stream at Awarua	2159641	5397576	Natural State	Jul-01	CD/L/M/W/MO/LG	ES
6	Monowai River d/s gates	2085350	5475005	Lake fed	NIWA (Jan-89)	CW/Lk/HS/IF/HO/LG	NIWA
232	North Peak Stream at Waimea Valley Rd	2170600	5464600	Mataura 3	Jul-05	CD/L/HS/P/LO/LG	ES
139	Opouriki Stream at Tweedie Road	2122835	5424447	Lowland Soft Bed	Jul-01	CD/L/SS/P/MO/LG	ES
169	Orauea River at Orawia Pukemaori Road	2107228	5446229	Lowland Soft Bed	Jul-02	CD/L/SS/P/HO/LG	ES
94	Oreti River at Centre Bush	2147057	5450993	Hill	Aug-99	CW/H/HS/P/HO/HG	ES
26	Oreti River at Lumsden Bridge	2154100	5489200	Hill	ES (Aug 99) (NIWA) Jan-89	CW/H/HS/IF/HO/LG	ES, NIWA
23	Oreti River at Three Kings	2129600	5517700	Hill	Sep-94	CW/H/HS/T/HO/LG	ES
24	Oreti River at Wallacetown	2145400	5420800	Lowland Hard Bed	ES (Oct 94) NIWA (Jan-89)	CD/L/AL/P/HO/LG	ES, NIWA
58	Otamita Stream at Mandeville	2186483	5459549	Mataura 3	Feb-98	CD/L/SS/P/HO/LG	ES
120	Otapiri Stream at Otapiri Gorge	2158135	5457789	Lowland Hard Bed	Jul-00	CW/L/HS/P/HO/LG	ES
22	Otautau Stream at Otautau-Tuatapere	2121900	5441700	Lowland Hard Bed	Jul-95	CD/L/AL/P/HO/LG	ES
143	Otautau Stream at Waikouro	2120511	5444579	Lowland Hard Bed	Jul-00	CD/L/AL/P/MO/LG	ES
42	Otepuni Creek at Nith Street	2152451	5411430	Lowland Soft Bed	Jul-95	CD/L/SS/U/MO/LG	ES
84	Oteramika Stream at Seaward Downs	2183809	5416639	Lowland Soft Bed	Sep-95	CD/L/SS/P/MO/LG	ES
18	Pourakino River at Ermedale Road	2121200	5428900	Lowland Hard Bed	Jul-95	CW/L/HS/IF/MO/LG	ES
138	Pourakino River at Traill Road	2121484	5423196	Lowland Hard Bed	Jul-01	CW/L/PL/IF/HO/LG	ES
234	Sandstone Stream at Kingston Crossing Rd	2178807	5465711	Mataura 3	Jul-05	CD/L/Al/P/LO/LG	ES
217	Tokanui River at Fortrose Otara Road	2194200	5390500	Lowland Soft Bed	Jul-03	CW/L/SS/P/MO/LG	ES
135	Tussock Creek at Cooper Road	2156240	5430355	Lowland Soft Bed	May-01	CD/L/SS/P/MO/LG	ES
99	Upukeroa River at Milford/Te Anau	2098500	5519900	Hill	Feb-01	CW/H/SS/IF/HO/LG	ES
160	Waiau River at Duncraigen Road	2096068	5496558	Lake fed	Jul-02	CX/Lk/PL/IF/HO/LG	ES
96	Waiau River at Sunnyside	2093500	5476400	Lake fed	Sep-98	CX/Lk/PL/IF/HO/LG	ES
1	Waiau River at Tuatapere	2099400	5439700	Lake fed	ES (Sept 94) NIWA (Jan-89)	CX/Lk/PL/IF/HO/LG	ES, NIWA
41	Waihopai Stream u/s Queens Drive	2153543	5414779	Lowland Hard Bed	Jul-95	CD/L/AL/P/HO/LG	ES
98	Waikaia River at Waikaia	2186300	5490200	Mataura 3	Jul-03	CW/H/HS/T/HO/LG	ES
51	Waikaia River at Waipounamu Bridge Rd	2183066	5475811	Mataura 3	Jul-95	CW/H/HS/P/HO/LG	ES
52	Waikaia River u/s Piano Flat	2199869	5510155	Mataura 3	Jul-95	CW/M/HS/T/HO/LG	ES
53	Waikaka Stream at Gore	2197140	5447918	Lowland Soft Bed	Jul-95	CD/L/SS/P/HO/LG	ES

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification	Date Added to WQ Network	REC Classification	Data Ownership
65	Waikawa River at Progress Valley	2214400	5396800	Lowland Soft Bed	Jul-95	CW/L/SS/P/HO/LG	ES
40	Waikiwi Stream at North Road	2151700	5417200	Lowland Hard Bed	Jul-95	CD/L/AL/P/HO/LG	ES
64	Waikopikopiko Stream at Haldane Curio	2205300	5390200	Lowland Soft Bed	Jul-03	CW/L/SS/IF/MO/LG	ES
67	Waimatuku Stream at Lornville Riverton	2138039	5423345	Lowland Hard Bed	Jul-01	CD/L/AL/P/HO/LG	ES
137	Waimatuku Stream d/s Bayswater Bog	2130900	5438400	Spring	Jul-01	CD/L/AL/P/MO/LG	ES
59	Waimea Stream at Mandeville	2184674	5460690	Mataura 3	Feb-03	CD/L/AL/P/HO/LG	ES
243	Waimea Stream at Murphy Road	2163100	5475900	Mataura 3	Jul-05	CD/L/Al/P/HO/LG	ES
215	Waimea Stream at Nine Mile Road	2173480	5464820	Mataura 3	Jul-03	CD/L/AL/P/HO/LG	ES
242	Waimea Stream at Old Balfour Road	2159500	5483800	Mataura 3	Jul-05	CD/L/Al/P/LO/LG	ES
231	Waimea Stream at Pahiwi-Balfour Rd	2164700	5469500	Mataura 3	Jul-05	CD/L/Al/P/HO/LG	ES
241	Waimea Stream Tributary at McCale Rd	2158700	5486300	Mataura 4	Jul-05	CD/L/HS/P/LO/LG	ES
63	Waituna Creek at Marshall Road	2167900	5400500	Lowland Soft Bed	Jul-95	CD/L/SS/P/MO/LG	ES
150	Waituna Creek at Mokotua	2170700	5409700	Lowland Soft Bed	Aug-01	CD/L/SS/P/MO/LG	ES
171	Whitestone River d/s Manapouri-Hillside	2100473	5506748	Hill	Jul-02	CW/H/SS/P/HO/LG	ES
31	Winton Stream at Lochiel	2147450	5435040	Lowland Hard Bed	Jul-95	CD/L/AL/P/MO/LG	ES
155	Winton Stream d/s Winton Dam	2151200	5461263	Lowland Hard Bed	Aug-01	CD/L/HS/P/MO/LG	ES
	Total Water Quality sites	**72**					

Notes

1. *Sites "owned" by NIWA are part of the National River Water Quality Monitoring Network. These sites are also sampled by Environment Southland for E.coli and faecal coliform bacteria with the exception of site No. 6, Monowai River d/s gates.*
2. *Cascade Stream has a history of clarity measurements since July 1995. Chemical parameters were only analysed when this site was included in the roaming network.*

3.3 Field Procedures and Sampling Frequency for Water Quality Sampling

All sites in the river water quality monitoring network are sampled monthly for the parameters listed in Table 3.2. The procedures for water quality monitoring are described in "Environmental Data Field Procedures Manual" chapter 9, Water Quality.

3.4 Parameters and Laboratory Procedures

Samples collected for water quality monitoring are analysed for temperature, electrical conductivity, pH, dissolved oxygen, nitrate, ammoniacal nitrogen, total nitrogen, dissolved reactive phosphorus, total phosphorus, clarity, turbidity, total suspended solids, faecal coliforms and *E. coli* bacteria. Biological oxygen demand is measured at seven sites - Makarewa River at Wallacetown, Winton Stream at Lochiel, Winton Stream u/s Dam, Otautau Stream at Otautau-Tuatapere Road, Mataura River d/s Mataura bridge, Makarewa River at Wallacetown, Waituna Creek at Marshall Road, and Waituna Creek at Mokotua. Samples are analysed by RJ Hill Laboratories, Christchurch (IANZ accredited laboratory).

A standard field sheet is used for this monitoring, and can be found in Appendix 3.

Different parameters have been added to the network over the years (e.g. total nitrogen and total phosphorus) and small adjustments have been made to some methods. Details about parameters and methods are recorded in Environment Southland's 'Hilltop Manager' database.

Table 3.2: Parameters analysed in river water quality samples

Parameter	Units	First measured at long term sites	Method Used	Field or laboratory
Temperature	^{0}C	Sept 1994 bathing; July 1995 WQ	Field meter YSI	Field
Electrical Conductivity	µS/cm	Sept 1994 bathing; July 1995 WQ	Field meter YSI	Field
Dissolved Oxygen	gm^{-3} & % saturation	July 1995 – June 2008 (lab); June 2008 – (field)	Field meter YSI	Field
Clarity	m	July 1995	Horizontal black disk	Field
pH		July 1995	APHA 4500 - H^+	RJ Hills
Biological Oxygen Demand	gm^{-3}	July 1995 (7 sites)	APHA 5210 B	RJ Hills
Nitrate-Nitrite Nitrogen	gm^{-3}-N	July 1995	APHA 4500 - NO3 B [FIA]	RJ Hills
Ammoniacal N (NH_3 + NH_4)	gm^{-3}-N	July 1995	APHA 4500 - NH3 [FIA]	RJ Hills
Total Nitrogen	gm^{-3}-N	Dec 1998	APHA - N C [FIA]	RJ Hills
Dissolved Reactive Phosphorus	gm^{-3}	July 1995	APHA 4500 - P [FIA]	RJ Hills
Total phosphorus	gm^{-3}	Dec 1998	APHA 4500 - P B G [FIA]	RJ Hills
Turbidity	NTU	April 1999	APHA 2130 B	RJ Hills
Total Suspended solids	gm^{-3}	July 2008	APHA 2540 D (103 - 105 C)	RJ Hills
Faecal coliform bacteria	CFU/100ml	Sept 1994 bathing; July 1999 WQ	MF 9222 D	RJ Hills
E. coli bacteria	CFU/100ml	April 1998 bathing; July 1999 WQ	APHA 9222 G	RJ Hills

Note:

1. *This table addresses regular monitoring at long term sites in Environment Southland's network (see section 2.1). Sites monitored by NIWA have had a consistent set of parameters since 1989.*

3.5 Control of Records

Lab data is automatically transferred into Environment Southland's 'Hilltop Manager' database from RJ Hills Laboratory, Christchurch. Field data was entered into Hilltop via an access database S:\Cross_Division_Data\Hilltop Access Db\HAD.mdb up until August 2010. Currently all field data is entered directly into 'Hilltop Sampler.' All field data entry is double checked, usually by a different operator. Data entry procedures are described in 'Environmental Data Processing Manual, chapter 7.

Field and laboratory sheets are filed after being entered and checked. Field sheets can be found in files 218/02/40 to 218/02/110 and laboratory result sheets are filed in 218/02/12.

4.0 River Biomonitoring

4.1 Design and Purpose

Benthic macroinvertebrates (e.g. insects, crustaceans, snails, worms) and periphyton (e.g. algae) respond to the water quality in which they live. Different assemblages show varying degrees of sensitivity to pollution. As a result, the macroinvertebrate and periphyton assemblages present can indicate the health of the stream's ecosystem.

The monitoring network consists of "impact" sites and "reference" sites.

4.2 Sites sampled for ecosystem health

River biomonitoring is currently undertaken at 76 sites as listed in Table 4.1.

Table 4.1: River Biomonitoring sites

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification
14	Aparima River at Thornbury	2131100	5424400	Lowland Hard Bed
13	Aparima River at Wreys Bush	2131800	5452700	Lowland Hard Bed
12	Aparima River u/s Dunrobin	2124300	5484100	Hill
60	Brightwater Spring West at Garston Kings	2172331	5521422	Mataura 3
16	Cascade Creek at Pourakino Valley Road	2119500	5427800	Lowland Hard Bed
28	Cromel Stream at Selby Road	2149100	5503900	Hill
30	Dipton Stream at South Hillend Road	2146800	5458900	Lowland Hard Bed
38	Dunsdale Stream at Dunsdale Reserve	2170100	5443600	Lowland Soft Bed
5	Eglington River at McKay Creek Conflence	2115500	5559400	Natural State
19	Hamilton Burn at Goodall Road	2132700	5488800	Hill
36	Hedgehope Stream at Block Road	2166400	5434700	Lowland Soft Bed
21	Hillpoint Stream at Waikana Road	2135100	5462800	Lowland Hard Bed
167	Home Creek at Manapouri	2091183	5502308	Lowland Hard Bed
29	Irthing Stream at Ellis Road	2153678	5493225	Hill
9	Lill Burn at Lill Burn-Monowai Road	2097200	5453900	Lowland Soft Bed
100	Makarewa River at King Rd	2161300	5446400	Lowland Soft Bed

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification
32	Makarewa River at Wallacetown	2147800	5420600	Lowland Soft Bed
83	Makarewa River at Winton - Hedgehope Hwy	2162600	5434200	Lowland Soft Bed
80	Mararoa River at Kiwiburn	2128200	5528600	Lake fed
79	Mararoa River at Mararoa Road Bridge	2117600	5510800	Hill
7	Mararoa River u/s Weir Road	2096900	5497900	Hill
45	Mataura River 200m d/s Mataura Bridge	2190634	5437518	Mataura 3
85	Mataura River at Gore	2196700	5448700	Mataura 3
47	Mataura River at Keowns Road Bridge	2172046	5480614	Mataura 3
44	Mataura River at Mataura Island Bridge	2186200	5416200	Mataura 3
49	Mataura River at Parawa	2163800	5506970	Mataura 3
50	Mataura River d/s Robert Creek Confluence	2164227	5525583	Mataura 3
69	McKay Creek at Milford Road	2115900	5559500	Natural State
228	Meadow Burn at Roundhill Rd	2185385	5464175	Spring-fed
229	Mill Creek u/s Back Rd Bridge (Stewart Is)	2137401	5357039	Lowland Hard Bed
56	Mimihau Stream at Mimihau School Road	2191400	5424400	Mataura 3
57	Mimihau Strem Tributary at Venlaw Forest	2208200	5425800	Mataura 3
154	Moffat Creek at Moffat Rd	2170100	5398400	Lowland Hard Bed
55	Mokoreta River at Egremont Road	2213700	5420300	Mataura 3
54	Mokoreta River at Wyndham River Road	2189600	5419400	Mataura 3
148	Mokotua Stream at Awarua	2159641	5397576	Natural State
70	Murray Creek at Cumming Road	2151300	5488200	Lowland Hard Bed
162	Murray Creek at Double Road	2153819	5483858	Spring fed
78	North Etal Stream u/s Dunrobin Valley R	2123400	5483800	Hill
25	Oreti River at Benmore	2147620	5462600	Hill
26	Oreti River at Lumsden Bridge	2154100	5489200	Hill
27	Oreti River at McKellars Flat	2134500	5531300	Mountain
24	Oreti River at Wallacetown	2145400	5420800	Lowland Hard Bed
58	Otamita Stream at Mandeville	2186483	5459549	Mataura 3
35	Otapiri Stream at Anderson Road	2161300	5441700	Lowland Hard Bed
22	Otautau Stream at Otautau-Tuatapere Road	2121900	5441700	Lowland Hard Bed
84	Oteramika Stream at Seaward Downs	2183700	5416600	Lowland Soft Bed
86	Pig Creek at Borland Lodge	2085000	5478400	Natural State
18	Pourakino River at Ermedale Road	2121200	5428900	Lowland Hard Bed
73	Pourakino River at Jubliee Hill Road	2117900	5433700	Lowland Hard Bed
76	Rowallan Burn East at Rowallan Road	2086644	5438005	Lowland Soft Bed
37	Silver Stream at Lora Gorage Road	2160100	5450700	Lowland Soft Bed
20	Taringatura Creek at Taromaunga	2133300	5473100	Hill
75	Thicket Burn at Lake Hauroko	2080600	5452300	Natural State
72	Trenders Creek at Hall Road	2163500	5450200	Lowland Soft Bed
99	Upukerora River at Milford Road	2098500	5519900	Hill
39	Waianiwa Creek 1 at Lornville Riverton H	2143500	5421800	Lowland Soft Bed
2	Waiau River 100m u/s Clifden Bridge	2101300	5451100	Lake fed
160	Waiau River at Duncraigen Rd	2096068	5496558	Lake fed
159	Waiau River u/s Tuatapere	2099381	5440341	Lake fed
161	Waihopai River at Waihopai Dam	2155800	5415200	Lowland Hard Bed
41	Waihopai Stream u/s Queens Drive	2153300	5414700	Lowland Hard Bed
51	Waikaia River at Waipounamu Bridge Road	2183066	5475811	Mataura 3
52	Waikaia River u/s Piano Flat	2199869	5510155	Mataura 3
53	Waikaka Stream at Gore	2197115	5447913	Lowland Soft Bed
65	Waikawa River at Progress Valley	2214400	5396800	Lowland Soft Bed
40	Waikiwi Stream at North Road	2151700	5417200	Lowland Hard Bed
71	Waikopikopiko Stream at Haldane	2205300	5390300	Lowland Soft Bed

Site ID	Site Name	Easting	Northing	Water Plan Quality Classification
67	Waimatuku Stream at Lornville Riverton H	2138039	5423345	Lowland Hard Bed
59	Waimea Stream at Mandeville	2184674	5460690	Mataura 3
66	Waimeamea River at Young Road	2104500	5425800	Lowland Hard Bed
87	Wairaki River at Blackmount Road	2099400	5461600	Lowland Soft Bed
142	Waituna Creek at Gorge Road	2170920	5407890	Lowland Soft Bed
63	Waituna Creek at Marshall Road	2167900	5400500	Lowland Soft Bed
88	Winton Stream at Benmore - Otapiri Road	2150900	5460300	Lowland Hard Bed
31	Winton Stream at Lochiel	2147450	5435040	Lowland Hard Bed

4.3 Field procedures and sampling frequency for biomonitoring

Sites are sampled once annually during summer, when pressures of temperature, algae growth and contaminant loads are likely to be highest, and river flows are low and stable. Sampling after flood events is avoided because these can significantly reduce the abundance and structure of macroinvertebrate and algae communities. Sampling is avoided within two weeks of the last flood that was greater than three times the median flow. During sampling, all field measurement and observations are recorded on a field sheet as in Appendix 4.

4.3.1 Macroinvertebrate sampling

Since January 2002, aquatic macroinvertebrates samples have been collected using semi-quantitative sampling methods described in Stark *et al* (2001), specifically protocol C1 for hard-bottomed streams and protocol C2 for soft-bottomed streams. Step 5 of protocol C1 and C2 has been slightly modified so that large debris is removed while still in the sample net rather than being transferred to a separated tray or bucket for inspection. In hard bottomed streams samples are collected from riffles.

Details of macroinvertebrate collection protocols (modified from Stark *et al*, 2001 are in Appendix 5.

Prior to January 2002, macroinvertebrate samples were collected according to methods in Hamill (1997).

4.3.2 Periphyton sampling

Periphyton abundance is assessed in stream runs using both a visual assessment of cover and quantitative sample collection (methods detailed in Appendix 6). A visual assessment of the percentage cover of algae is done according to a modification of RAM-2 (line transect-point method) of the "Stream periphyton monitoring manual" (Biggs & Kilroy 2000) and recorded on the field sheet. Quantitative periphyton samples are collected by scraping a 33 cm^2 area from five stones - a modification of method QM-1b in Biggs & Kilroy (2000). Quantitative periphyton samples are stored frozen prior to analysis.

A second periphyton sample is collected for identification of the algae taxa. This is obtained by scraping the algae on the same stones used for quantitative analysis. This sample is preserved with Lugol's iodine and stored in the fridge prior to identification.

4.4 Processing and quality control procedures

4.4.1 Macroinvertebrate processing

Aquatic macroinvertebrates are processed by doing a fixed count of 200 individuals and a scan for rare taxa - protocol P2 of Stark *et al* (2001). Quality control procedures follow protocol QC2. These procedures are reproduced in Appendix 7. Taxa are identified to at least a taxonomic level suitable for calculating MCI values (see Appendix B of Stark *et al* 2001). If the quality control identifies greater than 10 percent error in the identifications or counts, macroinvertebrate samples should be reprocessed or the results labelled as "poor quality".

Macroinvertebrate samples have, to date, been processed by Ryder Consulting Ltd. Initial quality control procedures were implemented in 2001 but did not follow the above method until 2002. Processing of samples for quality control has been done by Cawthron Institute, and more recently by Landcare Research (Stephen Moore, Environmental Consultant, Landcare Research, Auckland).

4.4.2 Periphyton biomass analysis

Quantitative periphyton samples are analysed for chlorophyll *a* and Ash Free Dry Weight (AFDW). Samples should be frozen for storage and transported in a chilly-bin to the laboratory. Methods for analysing periphyton samples for chlorophyll *a* and AFDW are documented in Chapter 7 of Biggs & Kilroy (2000).

Quantitative periphyton samples are analysed by Cawthron Institute.

4.4.3 Periphyton identification

Qualitative periphyton samples for taxonomic identification are collected from the same stones from which quantitative samples were collected for biomass analysis. The relative abundance of each periphyton taxa is ranked on a three point scale of "rare", "common" or "abundant".

Ryder Consulting Ltd has been used to identify relative abundance of periphyton species in the past, but since 2007 this has been carried out by Cawthron Institute.

To date, no quality control procedures have been implemented for periphyton analysis.

4.5 Control of records for macroinvertebrate and periphyton data

Taxonomic data from macroinvertebrate analysis is stored in Excel workbooks, with a separate file for each year. The files are located in S:\Environmental_Info\KirstenM\MONITORING\SOE\Macroinvertebrates.

Periphyton data is stored in Excel workbooks, with a separate work book for each year. The workbooks are located in S:\Environmental_Info\KirstenM\MONITORING\SOE\Algae.

Field sheets are filed in file 218/03/06 and laboratory sheets are filed in file 218/02/12.

5.0 Lake Water Quality

5.1 Design and purpose

The water quality of Southland lakes is monitored to establish baseline water quality, compare their current state and determine trends over time. The monitoring programme is designed to distinguish between different layers in the lake and is consistant with Burns *et al* (2000) "Protocols for monitoring trophic levels of New Zealand lakes and reservoirs".

Environment Southland began regular trophic level monitoring on Lake Te Anau in July 2000. Monthly clarity monitoring was started on Lake Manapouri in July 2001 and trophic level monitoring began in July 2002. Two sites are sampled on Lake Te Anau and three sites on Lake Manapouri. One site is situated in a basin nearest to potential pressures, with another site in a deep basin distant from pressures (reference site). The third site on Lake Manapouri (Frasers Beach) was established in reponse to Meridian Energy and NIWA monitoring of the Waiau Arm, to identify groundwater inputs to the lake.

Bacterial levels are also measured around the lake edge to assess the suitability of the water quality for contact recreation (see Kitson, 2006).

Native forest covers most of Lake Te Anau and Lake Manapouri's catchments, however, major pressures arise from expanding lakeside communities, intensification of land use and hydroelectric generation. Discoloured water from the Mararoa River has been observed to flow up the Waiau River and into Lake Manapouri. The extent to which this affects the lake has not yet been determined.

5.2 Sites sampled for lake water quality

Lake Te Anau and Lake Manapouri are sampled monthly at the sites listed in Table 5.1.

Table 5.1: Lake sampling sites

ID	Site Name	Map Ref	Sample depths when lake is isothermal
126	Lake Te Anau Blue Gum Point	D43 946 203	10m and 50m
127	Lake Te Anau South Arm	D43 925 268	20m and 100m
165	Lake Manapouri off Stoney Point	C43 869 049	10m and 70m
166	Lake Manapouri off Pomona Island	C43 790 060	20m and 100m
	Lake Manapouri near Frasers Beach	C43 894 025	5m and 15m

5.3 Field procedures for lake sampling

Prior to July 2007 lake samples were collected every month, but since this have been monitored quarterly due to the excellent quality of water measured in these two lakes. Monitoring follows the procedure described below in section 5.3.1. Further explanation of the sample techniques is given in Chapter 2 of Burns *et al* (2000) "Protocols for monitoring trophic levels in New Zealand lakes and reservoirs".

Lake sampling is currently carried out by Environment Southland staff using the Toroa vessel. All field measurements are recorded on a field sheet as in Appendix 2. The samples are stored cool and couriered in chilly-bins to RJ Hills Laboratory.

Prior to the purchase of the Eureka Manta D-opto multi-probe sonde in August 2007 for lake profiling, a dissolved oxygen and temperature meter (YSI model 95) was used to measure dissolved oxygen and temperature profiles prior to sample collection. This meter had a 30 metre cable and dissolved oxygen and temperature readings at depths greater than 30 metres were taken from the water samples collected with the Van Dorn sampler.

5.3.1 Lake sampling field procedures

Detailed field procedures for lake sampling are as follows:

Step One: Measure Secchi disc depth

Lower the Secchi disc off the side of the boat until it starts to disappear from view. Use the viewer to view the disc and keep lowering it until it disappears from view altogether. Note the distance on the tape. Raise the Secchi disc slowly until it comes into view. Note this distance on the tape. Take the average of the 2-3 readings.

Step Two: Measure depth profiles

Deploy Eureka Manta sonde logging temperature, dissolved oxygen, turbidity, pH, conductivity at a rate of 3 seconds to approximately ¾ of site depth.

Step Three: Collect samples from top and bottom waters.

If the subsurface temperature is within 3 degrees C of the bottom temperature the lake is **isothermal**. When lakes are isothermal top and bottom samples are collected at set depths detailed in Table 5.1.

If the subsurface temperature differs by more than 3 degrees C from the bottom temperature the lake is **stratified** (Figure 5.1). When stratified the top sample is collected from throughout the Epilimnion and the bottom sample is collected from the hypolimnion at the same depth as usually sampled (see Table 5.1). Calculate the epilimnion sample depths by plotting the temperature-depth profile and noting the bottom of the epilimnion. This is the point where the temperature starts to change rapidly (see diagram).

Take two samples from the epilimnion. One at ¼ depth and the other at ¾ depth of the epilimnion. Mix these samples into a rinsed bottle in equal parts.

Label samples from the top of the lake "ISO T" if the lake is isothermal and "EPI" if the lake is stratified. Label samples from the bottom of the lake "ISO B" if the lake is isothermal and "HYP" if the lake is stratified.

All samples are collected using a Van Dorn sampler.

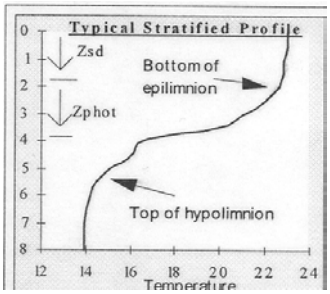

Figure 5.1: Lake stratification profile

5.4 Parameters and laboratory procedures for lake water quality

Lake samples collected for trophic level monitoring are analysed for the parameters listed in Table 5.2. Many of the nutrient results have been less than detection limits and consideration needs to be given to changing to more sensitive analytical methods.

Table 5.2: Parameters analysed in lake trophic level samples

At each lake site water samples are collected from both the top and bottom layers of the lake.

Parameter	Units	Layer collected from	Method used	Field or laboratory
Secchi depth	m		Burns 2000	Field
Temperature	^{0}C	profile	Eureka Manta sonde	Field
Dissolved Oxygen	gm^{-3} & % saturation	profile	Eureka Manta sonde	Field
Electrical Conductivity	µS/cm	profile	Eureka Manta sonde	Field
pH		Top and bottom	APHA 4500 - H^+	RJ Hills
Nitrate-nitrite nitrogen	gm^{-3}-N	Top and bottom	APHA 4500 - NO3 B [FIA]	RJ Hills
Ammonia (NH_3 + NH_4)	gm^{-3}-N	Top and bottom	APHA 4500 - NH3 [FIA]	RJ Hills
Total nitrogen	gm^{-3}-N	Top and bottom	APHA 4500 - N C [FIA]	RJ Hills
Dissolved Reactive Phosphorus	gm^{-3}	Top and bottom	APHA 4500 - P [FIA]	RJ Hills
Total phosphorus	gm^{-3}	Top and bottom	APHA 4500 - P B G [FIA]	RJ Hills
Chlorophyll a	gm^{-3}	Top	APHA (1998) 1020 H 10.18	RJ Hills
Turbidity	NTU	Top	APHA 2130 B	RJ Hills
Suspended solids	gm^{-3}	Top	APHA 2540 D (103 - 105 C)	RJ Hills
Volatile suspended solids	gm^{-3}	Top	APHA 2540 E	RJ Hills

5.5 Control of records for lake monitoring

Lab data is automatically transferred into Environment Southland's 'Hilltop Manager' database from RJ Hills Laboratory, Christchurch. Field data was entered into Hilltop via an access database S:\Cross_Division_Data\Hilltop Access Db\HAD.mdb up until August 2010. Currently all field data is entered directly into 'Hilltop Sampler.' All field data entry is double checked, usually by a different operator. Data entry procedures are described in "Environmental Data Processing Manual", chapter 7".

Field and laboratory sheets are filed after being entered and checked. Field sheets are filed in file 218/02/36 and laboratory sheets are filed in file 218/02/37.

6.0 Lagoon Water Quality

6.1 Design and purpose

The water quality of the Waituna Lagoon is monitored to establish baseline water quality, compare it's current state and determine trends over time. The monitoring programme is designed to identify contaminant loads from freshwater inputs, and saline inputs during lagoon opening.

Environment Southland began regular monitoring on the lagoon at one site (East) in October 2001. Three additional sites were included (West, Centre, South) in August 2003. Sites are located in the deepest areas of the lagoon near freshwater and saline inputs.

Waituna Lagoon is a dynamic system affected by both saline and freshwater inputs. The lagoon is fed by three main waterways (Waituna Creek, Moffat Creek and Currans Creek) which pass through highly developed pastoral lands. Lagoon levels are managed by opening the lagoon to the sea to improve local drainage. Saline inputs occur during opening. The shallow expansive nature of the lagoon makes it susceptible to high turbidity and mixing.

6.2 Sites sampled for lake water quality

The Waituna Lagoon is sampled monthly at the sites listed in Table 6.1.

Table 6.1: Lagoon sampling sites

Site Name	Map Ref	Influencing inputs	Date added to programme
Waituna Lagoon at Lagoon West	F47 704 958	Waituna Creek	Aug-03
Waituna Lagoon at Lagoon Centre	F47 714 958	Farm drains	Aug-03
Waituna Lagoon at Lagoon South	F47 717 941	Sea water	Aug-03
Waituna Lagoon at Lagoon East	F47 735 956	Moffat and Currens creeks	Oct-01

6.3 Field procedures for lake sampling

Lagoon samples are collected monthly by Chris Owen (contact details Appendix 2).

Surface samples only are taken at each site. Due to the nature of the lagoon, it is assumed that it is well mixed at time of sampling. Surface temperature (using a standard thermometer) is taken, and environmental conditions recorded.

Zooplankton samples were collected for two years from April 2003 to May 2006 to cover adequate seasonal and lagoon opening variation. Methods follow those suggested by Dr Ian Duggan (Waikato University):

> Using a 40 μm mesh plankton net, 20 litres of lagoon water is passed through the net (using a jug). The sides of the net are rinsed, and the sample remaining in the collection bucket is transferred into a sample container. Samples are preserved with denatured alcohol (50 % preservative concentration).

All field measurements are recorded on a field sheet as in Appendix 3. The samples are stored cool and delivered to the Invercargill courier depot by Chris Owen.

6.4 Parameters and laboratory procedures for lake water quality

Lagoon samples are analysed for the parameters listed in Table 6.2.

Table 6.2: Parameters analysed in Waituna Lagoon water quality samples

Parameter	Units	Method used	Field or laboratory
Temperature	^{0}C	Thermometer	Field
Secchi depth	m	Burns 2000	Field
Electrical Conductivity	μS/cm	APHA 2510 B	RJ Hills
pH		APHA 4500 - H^+	RJ Hills
Nitrate-nitrite nitrogen	gm^{-3}-N	APHA 4500 - NO3 B [FIA]	RJ Hills
Ammonia (NH_3 + NH_4)	gm^{-3}-N	APHA 4500 - NH3 [FIA]	RJ Hills
Total nitrogen	gm^{-3}-N	APHA 4500 - N C [FIA]	RJ Hills
Dissolved Reactive Phosphorus	gm^{-3}	APHA 4500 - P [FIA]	RJ Hills
Total phosphorus	gm^{-3}	APHA 4500 - P B G [FIA]	RJ Hills
Chlorophyll a	gm^{-3}	APHA (1998) 1020 H 10.18	RJ Hills
Turbidity	NTU	APHA 2130 B	RJ Hills
Suspended solids	gm^{-3}	APHA 2540 D (103 - 105 C)	RJ Hills
Volatile suspended solids	gm^{-3}	APHA 2540 E	RJ Hills
E. coli bacteria	MPN/100ml	APHA 9223 B	RJ Hills

6.5 Control of records for lagoon monitoring

Lab data is automatically transferred into Environment Southland's 'Hilltop Manager' database from RJ Hills Laboratory, Christchurch. Field data was entered into Hilltop via an access database S:\Cross_Division_Data\Hilltop Access Db\HAD.mdb up until August 2010. Currently all field data is entered directly into 'Hilltop Sampler. All data entries are double checked, usually by a different operator. Data entry procedures are described in "Environmental Data Processing Manual", chapter 7".

Field and laboratory sheets are filed after being entered and checked. Field sheets are filed in file 218/02/38 and laboratory sheets are filed in file 218/02/39.

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White, M. 2006: *Surface Water Quality Monitoring Programmes at Environment Southland.* Southland Regional Council Publication No. 2006-03

Appendix 1: Baseline water quality monitoring sites sampled by the Southland Catchment Board

Site	Map Reference	Period	Approximate frequency	Reference
Mataura Catchment				
Mataura at Cattle Flat	F44 718 861	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Otamita	F45 885 584	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Gore	F45 968 488	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Mataura	F46:910 380	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Wyndham	F46 910 380	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Mataura Island	F46 849 158	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Gorge Road	F47 827 023	1976 - 1986	2-3 monthly	McKenzie, 1982
Mataura at Garston	F43 725 183	1979 - 1984	3 monthly	McKenzie, 1982
Mataura at Athol	E43 629 127	1979 - 1984	3 monthly	McKenzie, 1982
Mataura at Nokomai	E43 636 071	1979 - 1984	3 monthly	McKenzie, 1982
Nokomai River	F43 701 077	1979 - 1984	3 monthly	McKenzie, 1982
Dome Creek Nokomai	E43 695 072	1979 - 1984	3 monthly	McKenzie, 1982
Tomogalak Stream	E44 698 845	1979 - 1984	3 monthly	McKenzie, 1982
Waikaia at Waipounamu	F44 831 756	1979 - 1984	3 monthly	McKenzie, 1982
Waimea at Mandeville	F45 845 606	1979 - 1984	3 monthly	McKenzie, 1982
Waikaia at McNab	F45 006 508	1979 - 1984	3 monthly	McKenzie, 1982
Mimihau at Wyndham	F46 910 238	1979 - 1984	3 monthly	McKenzie, 1982
Wyndham at Wyndham	F46 904 204	1979 - 1984	3 monthly	McKenzie, 1982
Lower Oreti catchment				
Makarewa @ SH 6		1975 - 1979	monthly	McKenzie 1979
Makarewa at Freezing works bdg		1975 - 1979	monthly	McKenzie 1979
Makarewa at SH 99		1975 - 1979	monthly	McKenzie 1979
Makarewa at Crowe Road		1975 - 1979	monthly	McKenzie 1979
Makarewa at Moffett Road		1975 - 1977	monthly	McKenzie 1979
Makarewa at Waitoru farm		1978 - 1979	monthly	McKenzie 1979
Oreti at Iron Bdg		1975 - 1985	monthly	McKenzie 1979
Oreti at West Plains Rd bdg		1975 - 1979	monthly	McKenzie 1979
Oreti at Ferry Rd bdg		1975 - 1979	monthly	McKenzie 1979
Oreti at Dunns Rd bdg		1975 - 1979	monthly	McKenzie 1979
Upper Oreti catchment				
Oreti at Mavora		1979 - ?	3 monthly	McRae (1979)
Oreti at Mossburn		1979 - ?	3 monthly	McRae (1979)
Irthing Stm at 5 Rivers		1979 - ?	3 monthly	McRae (1979)
Acton Stm at 5 Rivers		1979 - ?	3 monthly	McRae (1979)
Cromel Stm at 5 Rivers		1979 - ?	3 monthly	McRae (1979)
Oreti at Lumsden		1979 - 1985	3 monthly	McRae (1979)
Dipton Stm at Benmore			3 monthly	McRae (1979)
Winton Stm at Lochiel			3 monthly	McRae (1979)
Oreti at Wallacetown			3 monthly	McRae (1979)
Dunsdale Stm at Hedgehope			3 monthly	McRae (1979)
Makarewa at Hokonui			3 monthly	McRae (1979)
Otapiti Stm at Hokonui			3 monthly	McRae (1979)
Hedgehope Stm at Hedgehope			3 monthly	McRae (1979)
Titipua St at Hegehope			3 monthly	McRae (1979)
Makarewa Rv at SH6			3 monthly	McRae (1979)
Aparima catchment				
Hamilton Burn		1981 – 1984	6 monthly	Robertson (1992)
Otautau Stream		1981 – 1984	6 monthly	Robertson (1992)
Pourakino River at Ermadale Rd	D46 212 289	1981 – 1984	6 monthly	Robertson (1992)
Aparima River at Dunrobin	D44 243 841	1981 – 1984	6 monthly	Robertson (1992)
Aparima River at Wreys Bush	E45 318 527	1981 – 1984	6 monthly	Robertson (1992)
Aparima River at Yellow Bluffs	D45 237 410	1981 – 1984	6 monthly	Robertson (1992)
Aparima River at Fairfax	D46 288 326	1981 – 1984	6 monthly	Robertson (1992)
Aparima River at Thornbury	E46 311 244	1981 – 1984	6 monthly	Robertson (1992)

Site	Map Reference	Period	Approximate frequency	Reference
Aparima River at Gummies Bush Waiau catchment		1981 – 1984	6 monthly	Robertson (1992)
Upukerora at Milford Road Bridge	D43 985 199	1979 - 1984	3-6 monthly	Robertson 1993.
North Mavora Lake		1980 - 1984	3-6 monthly	Robertson 1993.
Mararoa River at Key (Te Anau Road bridge)	D43 108 060	1979 - 1984	3-6 monthly	Robertson 1993.
Mararoa River upstream Mararoa Weir	D44 969 979	1979 - 1984	3-6 monthly	Robertson 1993.
Waiau River ds Mararoa Weir		1979 - 1984	3-6 monthly	Robertson 1993.
Whitestone River at Key Manapouri Road Bridge	D43 004 069	1979 - 1984	3-6 monthly	Robertson 1993.
Whare Creek at Redcliff Road	D44 960 942	1979 - 1984	3-6 monthly	Robertson 1993.
Lake Monowai outlet	C44 853 751	1979 - 1984	3-6 monthly	Robertson 1993.
Waiau River at Monowai Road bridge	D44 927 768	1979 - 1984	3-6 monthly	Robertson 1993.
Waiau River at Clifden Road bridge	D45 013 511	1979 - 1984	3-6 monthly	Robertson 1993.
Wairaki River at Clifden (Monowai Road Bridge)	D45 994 616	1979 - 1984	3-6 monthly	Robertson 1993.
Orauea at Pukemaori/ Tuatapere Road Bridge	D45 072 463?	1979 - 1984	3-6 monthly	Robertson 1993.
Waiau River at Tuatapere Road Bridge	D45 993 403	1979 - 1984	3-6 monthly	Robertson 1993.

Note:

1. *The author was not able to confirm the grid references for all of these sites prior to publishing this report.*

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Appendix 2: Contacts

RJ Hills Laboratory

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Lake Water Quality

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Lagoon Water Quality
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Appendix 3: Water Quality sampling field sheet

File Number: 218/02/39

environment SOUTHLAND

Field Sheet
Environmental Information Division

Lab Fields

Project Code SOE Lake Water Quality
Sample Number 20101416
Cost Code EMSWQ2
Date & Time of Collection _____ NZST

ES Fields

Site Name Lake Manapouri at Pomona Island Bottom
Collected By ,
Entered By ,
Checked By ,
GPS - Easting null
GPS - Northing null
Sampled From ○ Coastal ○ Estuary ○ Lake ○ River or Stream ○ Pond ○ Tap ○ Bore Pipe
◉ Other _____
Method of Collection ○ Grab ○ Composite
Sample Appearance ○ Clear ○ Turbid ○ Colourless ○ Humic ○ Sandy
Odour ○ Odour ○ Odourless
Digital Photo ☐
Tide ○ Low ○ Mid ○ High Ebb ○ Flow ○ Flood
Lake Conditions ○ Clam ○ Choppy ○ Waves ○ Rough
Weather ○ Fine ○ Overcast ○ Drizzling ○ Rain
Wind Direction _____
Wind Speed ◉ Calm ○ Light ○ Moderate ○ Strong ○ N/A

Field Measurements

Water Temperature _____
Meter Number _____
Conductivity _____uS/cm
Mean Conductivity 31.6
Dissolved Oxygen Sat _____%
Salinity _____ppt
Dissolved Oxygen _____g/m^3
Water Level ○ Low ○ Normal ○ High ○ Other _____ m
Approx Water Flow _____m^3/s
Black Disc _____ m Disc Size ○ 20mm ○ 60mm ○ 200mm
Secchi Disc _____ m Disc Size ○ 200mm

Comments (e.g. stock on banks/in water, river discoloured, wildlife, algae, local bank erosion etc)

Laboratory Tests

Turbidity	pH	Suspended Solids (Total)	Nitrogen (Total)
Nitrogen (Total Ammoniacal)	Electrical Conductivity	Phosphorus (Total)	Phosphorus (Dissolved Reactive)
Nitrogen (Nitrate + Nitrite)			

Appendix 4: Biomonitoring Field Sheet

environment SOUTHLAND

Entered: _____

Checked: _____

SITE NAME & ID:

Date & time: _____ (NZST) **Collector:** _____ **Cloud cover**_____ %

SITE DETAILS

Site: Open / Partial / Shaded **River width:** _____ m **Riffle depth:** _____ m **Max depth:** _____ m

WATER MEASUREMENTS

Flow: Low / Normal / High _____ m^3/s **Meter:**_____

Temperature: _____ ^0C **Conductivity**: _____ µS/cm **DO:**_____mg/l _____%

Black Disc Distance: _____ m **Disc used:** 20mm ☐ 60mm ☐ 200mm ☐

MACROINVERTEBRATES

Substrate sampled**: Riffles / Runs Woody debris / Bank margins / Macrophytes**

Kicks: _____ **Sweeps:** _____

Other by-catch:_____

PERIPHYTON

Filament	**Green**	**Brown**	**Brown-Red**
Short < 2cm			
Long > 2cm			
Mat thickness	**Green**	**Light brown**	**Dark brown-Black**
Thin < 0.5mm			
Medium 0.5-3mm			
Thick > 3mm			

1 Stones clean and surface rough

2 Stones slippery but no growths visible

3 Thin algal growths visible

4 Algae abundant

5 Thick covering of algae on over 80% of upper stone surface

CYANOBACTERIA

Cyanobacteria cover: _____ % **Area:** _____x_____ m **Avg. mat thickness**: _____ mm

Colour: Green / Brown / Black **Habitat type:** Riffles / Runs / Pools

Toxin sample: Yes / No **Further monitoring**: Yes / No

MACROPHYTES (% cover over 10 metre stretch)

< 1% ☐ 1-5% ☐ 5-10% ☐ 10-25% ☐ 25-50% ☐ 50-75% ☐ 75-100% ☐

GENERAL COMMENTS **Photo #:** _____ **Sediment sample:** Yes / No **Suit WQ:** Yes / No

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Appendix 5: Macroinvertebrate collection protocols

Protocol C1: Hard-bottomed Semi-quantitative (Stark *et al* 2001)

Requirements:

1. Waders or sturdy boots
2. D-net (0. 5 mm mesh)
3. White tray or bucket
4. Sieve or sieve bucket (0.5 mm mesh)
5. Plastic screw-top sample containers (600-1000 ml volume)
6. Fine tweezers
7. Preservative
8. Labels and waterproof marker pen

Protocol:

1. Ensure that the sampling net and bucket/sieve are clean.
2. Select the appropriate habitat (e.g. riffle).
3. Sample beginning at the downstream end of the reach and proceed across and upstream.
4. Select an area of substrate (0.1-0.2 m^2) to sample with a natural flow that will direct organisms into the net. Place the net on the streambed and step into the sampling area immediately upstream of the net, disturb the substrate under your feet by kicking to dislodge the upper layer of cobbles or gravel and to scrape the underlying bed. The area disturbed should extend no further than 0.5 m upstream from the net. Remove the material from the net into the tray, bucket or sieve bucket if the net begins to get clogged.
5. Repeat Step 4 at several different locations within a 50 m stream reach and covering a variety of velocity regimes until a total area of 0.6–1.0 m^2 of riffle habitat has been sampled. Transfer this material to a white tray or bucket approximately half full of water, or to a sieve bucket. Wash or pick all animals off the net.
6. Rinse and remove any unwanted large debris items (e.g., stones, sticks, leaves) that may not fit into the sample container or will absorb and diminish the effectiveness of the preservative.
7. Transfer the sample to the sample container via a 0.5 mm sieve if a sieve bucket is not used. Inspect the sieve or sieve bucket and return any macroinvertebrates to the sample container. (Tweezers may be useful).
8. Add preservative (denatured alcohol obtained from Mobil Service Station). Aim for a preservative concentration in the sample container of 70–80% (i.e., allowing for the water already present). Be generous with preservative for samples containing plant material (leaves, sticks, macrophytes, or moss).
9. Place a sticky label on the side of the sample container and record the site code/name, date, and replicate number (if applicable) using a permanent marker. Screw the lid on tightly. Make notes on the field data sheet describing the substrates sampled (cobble size, periphyton, embeddedness, etc.), the collector's name, sample type (e.g. D-net, 0.5 mm), and preservative used.

Protocol C2: Soft-bottomed, Semi-quantitative (Stark *et al* 2001)

Requirements:

1. Waders (chest)
2. D-net (0.5 mm mesh)
3. White tray or bucket
4. Sieve or sieve bucket (0.5 mm mesh)
5. Plastic screw-top sample containers (600-1000 ml volume)

6. Fine tweezers
7. Preservative
8. Labels and waterproof marker pen (or pencil)

Protocol:

1. Ensure that the sampling net and bucket are clean.

2. Sample a unit effort (0.3 m^2) of woody debris, bank margins, or aquatic macrophytes using the following procedures. Avoid dredging the net along the bottom in mud or sand, and avoid leaves and algae if possible. Avoid hard (stony) substrates (or sample them separately using Protocol C1).

   Woody Debris – Select submerged and partially decayed woody debris (50-250 mm diameter preferred). Place over the mouth of the bucket or sieve bucket. Pour water over the substrate while brushing the substrate gently by hand to remove organisms. Larger pieces may be sampled in situ by brushing the log while holding the net directly behind it. Each 1-metre section of woody debris has a sample area of about 0.3 m^2.

   Bank Margins – Locate an area of bank with good structure and aggressively jab the net into the bank for a distance of 1-metre to dislodge organisms, followed by 2-3 cleaning sweeps to collect organisms in the water column. Each sample unit is about 0.3 m^2.

   Macrophytes – Sweep the net through macrophyte beds for a distance of 1-metre to dislodge organisms, followed by 2-3 cleaning sweeps to collect organisms in the water column. Each sample unit is about 0.3 m^2.

3. Repeat Step 2 at 10 locations while moving progressively upstream. Remove sample material to a bucket or sieve bucket after each collection to avoid clogging the net. Select substrates to be sampled in proportion to their prevalence along a 50-100 m reach of stream. Record the reach length and the proportion of the sample taken from each substrate type (e.g. 50% wood, 25% banks, 25% macrophytes). After the 10th unit effort, wash or pick all animals off the net. The bucket or sieve bucket should now contain one entire sample comprising material dislodged from 3 m^2 of substrate.

4. Fill the bucket with water and rinse and remove any unwanted large debris items (e.g. sticks, leaves) that may not fit into the sample container or will absorb and diminish the effectiveness of the preservative. 5. Transfer the sample to the sample container via a 0.5 mm sieve if a sieve bucket is not used. Two containers may be needed; each container should be no more than two-thirds full with sample material. Inspect the sieve or sieve bucket and return any macroinvertebrates to the sample container. (Tweezers may be useful here).

6. Add preservative. Aim for a preservative concentration in the sample container of 70-80% (i.e. allowing for the water already present). Be generous with preservative for samples containing plant material (leaves, fine detritus, algae, moss, and macrophytes).

7. Place a sticky label on the side of the sample container and record the site code/name, date, and replicate number (if applicable) using a permanent marker. Place a waterproof label inside the container. Screw the lid on tightly.

8. Note the sample type (e.g. D-net), collector's name and preservative used on the field data sheet.

9. Record notes on the field data sheet describing the proportion of habitat units sampled (e.g. 4/5/1, woody debris/bank margins/macrophytes). Also describe on the field sheet the condition of the substrates sampled (woody debris diameter range, type of wood, %cover, periphyton, macrophytes species, bank structure, etc.).

Appendix 6: Periphyton sampling methods

Visual assessment line-point method. Modification of RAM-2 of Biggs & Kilroy 2000

Select one transect across the section of stream to be assessed. This will usually be a run with relatively uniform velocity and depth. In small streams transects run from waters edge to waters edge but in larger streams only the wadeable section of the stream is assessed i.e. the sections with water depth below knee deep.

Select five stones evenly spaced along the transect. Each stone must be selected in an unbiased way. Do this by touching the stream sediment without looking at what is there. Ideally, pick up the first stone that is touched. Disregarded small gravel and sand and choose the next nearest stone greater than 4 cm across.

If the majority of the streambed is small gravels of sand then a handful of the gravel is assessed instead of a single stone.

Examine each stone and identify the categories of periphyton present according to their colour and thickness using the field sheet in Appendix 1. For the top surface of the stone estimate the percentage cover of periphyton in each category and enter on the field sheet. The categories are:

1. filamentous algae > 2cm long
2. filamentous algae < 2 cm long
3. algal mats > 3 mm thick
4. algal mats 0.5-3 mm thick
5. algal mats < 0.5mm thick.

The colour for both mats and filamentous algae is also recorded.

When complete calculate the mean percentage cover of sampling points for each category of periphyton.

Periphyton quantitative sampling – scraping or brushing a sample from a defined area. Modification of QM-1b in Biggs & Kilroy 2000

Select a transect across the section of stream to be assessed. This will usually be a run with relatively uniform velocity and depth. In small streams transects run from waters edge to waters edge but in larger streams only the wadeable section of the stream is assessed i.e. the sections with water depth below knee deep.

Select five stones evenly spaced along the transect. Each stone must be selected in an unbiased way. Do this by touching the stream sediment without looking at what is there. Ideally, pick up the first stone that is touched. Disregarded small gravel and sand and choose the next nearest stone greater than 4 cm across. **These are usually the same stones as used for the transect-point visual assessment**.

On the stream bank, select a known area on the rock surface to sample. A 6.5cm diameter lid from an alkythene pottle used to send periphyton samples to the laboratory is currently used by Environment Southland.

Hold pottles lid over rock surface and remove all periphyton, leaving only the amount under the lid to scrape and rinse into a container. The periphyton is best removed by first scraping and than brushing the stone with a small wire brush. Ensure that the container in which the periphyton is placed is sufficiently large as to catch drips off the stone, alternatively a funnel is often used. Use a minimal amount of water to ensure that all the rinse water and material will fit into the final storage container.

Store labelled containers of periphyton on-ice in a chilli-bin.

***Note**: For both methods above, more stones should be collected for a more accurate assessment of algae cover or when there is a large diversity of algae on the streambed.*

Appendix 7: Macroinvertebrate processing and QC procedures

Protocol P2: 200 Fixed Count + Scan for Rare Taxa (Stark *et al* 2001)

Requirements:

1. Running water – tap with hose recommended
2. 0.5 mm sieve
3. Clean, flat-bottomed, white tray marked in 6 cm x 6 cm grids
4. 6 cm x 6 cm cookie cutters
5. Fine forceps
6. 70% ethanol preservative
7. Specimen vials with stoppers
8. Bench lamp
9. Labels and sharp pencil
10. Counter
11. 500 ml wash bottle
12. Identification keys & taxonomic references
13. Binocular dissecting microscope and light source for species identification

Protocol:

1. All samples received should be recorded in a "laboratory log". A unique job number, the date received, number and type/s of samples, analyses required, results-required-by date, job manager, and sample processor's name should be recorded. The date completed should be entered once sample processing has finished. The fate of samples can be verified in conjunction with a Chain–of-Custody form.

2. Thoroughly rinse sample in a clean 0.5 mm sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected for organisms, and discarded. Gently mix the sample by hand while rinsing, and continue until wash water runs clear and the sample is thoroughly homogenised (i.e., break down lumps of algae etc). A coarse sieve (e.g., 4 mm) can be helpful for removing larger pieces of unwanted organic material so long as all macroinvertebrates are picked out and placed into the 0.5 mm sieve.

3. After washing, transfer contents of sieve to a white sorting tray marked with grids approximately 6 cm x 6 cm (use black indelible marker). Visually check sieve before washing in preparation for next sample. Using the wash bottle spread the sample evenly across the tray. There should be enough water to just cover all material. If the samples have been preserved in alcohol some organisms (particularly ostracods and early instar insects) may float on the surface. If this is occurs add a drop of washing detergent and stir gently.

4. Use a random numbers table to select a starting grid square within the tray. A cookie cutter (6 x 6 cm) is recommended to delineate the chosen grid square. Moving systematically across the square remove all organisms visible to the naked eye. Place captured organisms in a separate labelled vial (add preservative), counting each individual with a counter. When complete, do a final check of the square's contents to ensure no animals have been missed.

5. Any organism that is lying over a line separating two grids is considered to be in the square containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organism is considered to be in the square containing most of its body.

6. After all visible organisms have been removed use forceps and/or a suction device to transfer remaining detritus to a container labelled as "sorted residue". Include location and date information (as per original sample label). Add preservative. This provides material for sorting QA/QC procedures.

7. If a total of at least 200 organisms have been obtained sample sorting ceases. However, if less than 200 organisms have been enumerated, place another cookie cutter on a second randomly chosen square. Continue this process until at least 200 animals have been captured.

8. Once a square has been started it should be finished, even if the 200 individual total is exceeded. The total number of grid squares covered should be noted, along with the total individual count.

9. Save the remaining unsorted sample debris residue in a separate container labelled "sample residue"; this container should include the original sample label. Add preservative.

10. The "sample residue" and vial containing the 200 individuals must be sorted by an experience taxonomist. *(Note: In situations where the sorter is an experienced taxonomist, invertebrate identification and counting can be carried out during the sorting process to save time).* Pour the 200 individual sample into a Petri-dish or Bogorov tray and observe under a binocular microscope. Compile a taxa list and count the numbers of each taxon. Return the 200 individuals to a labeled vial and add preservative. This sample will be used for taxonomic QA/QC (see below).

11. The minimum level of identification required is that specified in Appendix B. Do not include aerial adult insects, pupae, terrestrial invertebrates, empty snail shells, caddisfly cases or exuviae. Examination of late pupae can, however, assist greatly with larval identifications.

12. Complete the taxa list by scanning the "sample residue" for rare taxa. This is carried out with the sample spread in white sorting trays. Any rare taxa obtained should be placed in a labelled vial with preservative. This is also an opportunity to remove larger (e.g., late instar) or better-conditioned individuals of taxa already encountered to assist in identification.

13. The vial containing the 200 individuals, and the vial containing rare taxa should be taped together. Record the taxa found in the scan for rare taxa separately from the 200 fixed count data.

14. Return the "sample residue" to its container with the original labels.

15. On completion of sample processing there should be:

    (a) A labelled container holding the sample residue (already scanned for rare taxa);
    (b) A labelled container holding the sorted residue (required for QC procedures to assess sorting efficiency);
    (c) A labelled vial containing the 200+ individuals; and
    (d) A labelled vial containing the rare taxa (not included in the 200+ sample) removed from the sample residue.

Protocol QC2: Quality Control for Fixed Count (P2) (Stark *et al* 2001)

Protocol:

1. All samples received, processed and identified should be recorded in a "laboratory log". The fate of samples can then be verified in conjunction with a Chain–of- Custody form.

2. Ten percent of the sorted samples to be re-examined by another sorter. The second sorter must be familiar with sorting procedures and the full range of macroinvertebrate taxa from running waters in New Zealand and will be provided with the results from the first sorter.

3. The fixed count protocol requires examination of the sample residue (were all rare taxa removed by the first sorter?) and the sorted residue (were any animals missed during the collection of the 200+ individual sub-sample?). A check on the taxonomic efficiency of both the 200+ sub-sample and the vial of rare taxa are also required.

4. Taxonomic accuracy. On average, the number of taxa that are identified as different taxa, in either the full 200+ individual vial, or the rare taxa vial, between the two taxonomists must be < 10% of the total taxa recorded from the sample. For example, a sample with 31 taxa passes QC when no more than 3 taxa are identified differently between the two taxonomists. If the correct taxonomic identification of an organism is disputed, then a specimen should be checked by an agreed expert.

5. Sorting accuracy 1 (missed taxa). If average > 10% new species are found in the sample residue then the scan for rare taxa is deemed to have failed and a further 10% of samples are to be re-checked. If the criterion is still not met then all samples must be re-processed.

6. Sorting accuracy 2 (missed individuals). If average > 10% more organisms are found in the sorted residue then a further 10% of samples are to be re-checked. If the criterion is still not met then all samples must be re-processed.

7. Trainee sorters should have at least 50% of samples re-checked for QC, and can be considered competent sorters when < 10% of checked samples are returning < 10% new taxa, or < 10% re-codes than first sort.

8. After a sample has been completely sorted all sieves, trays and equipment should be thoroughly cleaned and picked free of organisms and debris before the next sample is begun.