

Groundwater Quality State of the Environment monitoring programme

Annual data report, 2013/14

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1. Introduction

This report summarises the results from Greater Wellington Regional Council's (GWRC) Groundwater Quality State of the Environment (GQSoE) monitoring programme for the period 1 July 2013 to 30 June 2014 inclusive. The GQSoE programme incorporates quarterly monitoring of water quality in 71 bores across the Wellington region.

Reports containing detailed analyses of long-term trends are produced approximately every five years (see Jones & Baker 2005, Tidswell et al 2012).

2. Overview of GQSoE monitoring programme

Groundwater quality has been routinely monitored in the western half of the Wellington region (Kapiti Coast and Hutt Valley) since 1994 and in the Wairarapa since 1997. Up until 2003, this monitoring was effectively conducted under two separate programmes, with some differences in the suite of water quality variables and analytical methods. From late 2003, management practices were aligned to provide consistency in sampling methods, sampling frequency (increased from six-monthly to quarterly), analysis and reporting. At this time, a number of changes were also made to the location of monitoring sites, the range of variables monitored and the methods of analysis to improve the representativeness and quality of the information collected (see Jones & Baker 2005 and Tidswell et al 2012) for more details.

2.1 Monitoring objectives

The aims of GWRC's GQSoE monitoring programme are to:

- 1. Provide information on the baseline quality of groundwater;
- 2. Describe the current state of the region's groundwater resources at a regional scale;
- 3. Assist in the detection of spatial and temporal changes in groundwater quality;
- 4. Recommend the suitability of groundwater for designated uses; and
- 5. Provide a mechanism to determine the effectiveness of regional policies and plans.

2.2 Monitoring network

The existing GQSoE monitoring network consists of 71 bores (Figure 2.1, Appendix 1). During the 2013/14 year, only 68 bores were sampled. Three bores could not be used for the reasons shown below:

- Bore S25/5256 was purchased by Transit for the Peka Peka to Otaki Expressway and GWRC have not been able to gain access to the bore to continue sampling.
- Bore R27/1180 has not been able to be sampled due to prolific growth of iron bacteria. However, it is hoped this bore will be online again by early next year.
- Bore R27/1137 has been decommissioned by its owner and pumping equipment removed.

Faecal indicator bacteria¹ are only tested for in 44 of the 71 bores. As sampling could not be conducted at bore R27/1137, only 43 bores were tested for the presence of faecal indicator bacteria during 2013/14.

¹ Escherichia coli and faecal coliforms are only tested for in GQSoE bores that are used for potable water supply.

With the exception of a single bore at Riversdale on the eastern Wairarapa Coast, all bores are located in one of the three principal groundwater management areas in the Wellington region; the Kapiti Coast, Lower Hutt Valley or the Wairarapa Valley (see Jones & Baker 2005 and Hughes & Gyopari 2011 for a description of groundwater management areas in the Wellington region).



Figure 2.1: Location of groundwater quality monitoring sites in the Wellington region. Automated saline intrusion (conductivity) groundwater monitoring sites are also shown (red stars).

2.3 Monitoring variables

The GQSoE network is sampled quarterly for a wide range of physicochemical and microbiological variables. Groundwater samples are collected by trained GWRC staff using nationally accepted protocols (Ministry for the Environment 2006).

Groundwater quality is assessed by measuring 31 different variables including pH, conductivity, turbidity, faecal indicator bacteria, total organic carbon, dissolved nutrients and major ions. A full list of the variables measured and the analytical methods used are provided in Appendix 2.

3. Physico-chemical and microbiological water quality

3.1 Approach to analysis

This section provides a brief overview of groundwater quality in the 2013/14 year. As the sampling regime only provides four sets of results per bore per year, a comprehensive evaluation of all the different variables is not undertaken on an annual basis. Instead, the analysis in this report focuses on two key indicators of groundwater contamination arising from landuse intensification and/or on-site wastewater disposal systems; nitrate-nitrogen (nitrate) and *Escherichia coli* (*E. coli*) bacteria.

Details of the analytical methods used are provided in Appendix 2 (Table A2.2). Summary statistics were calculated using Microsoft Excel (Microsoft Office Professional Plus 2010) and full data summaries are provided in Appendix 3. Data with values less than the laboratory's analytical detection limit were assigned a value of half their respective detection limit.

3.2 Results

3.2.1 Nitrate

Median nitrate concentrations were low (<3 mg/L) in most of the 68 bores monitored during 2013/14. Ten of 68 (14.7%) bores had elevated $(3-7 \text{ mg/L})^2$ concentrations of nitrate (Figure 3.1). A further two bores in Kapiti and the upper Wairarapa Valley had median nitrate concentrations in the relatively high range (7-11.3 mg/L).

Two bores had median nitrate concentrations above the Ministry of Health Drinking Water Standards (DWSNZ) 2008 maximum acceptable value (MAV) of 11.3 mg/L. Bore T26/0489 (54 metres deep) had a median nitrate concentration of 11.35 mg/L and bore S26/0223 (9.92 metres deep) had a median nitrate concentration of 11.55 mg/L. Both bores are located in the Upper Wairarapa.

² While most groundwater in New Zealand rarely has background nitrate-nitrogen concentrations exceeding 1 mg/L (Close et al. 2001), in this report 3 mg/L nitrate nitrogen is used as an indicator of anthropogenic influence in order to increase certainty caused by variability. A threshold concentration of 3 mg/L was also used by Madison & Brunett (1985) and Close et al. (2001). See Tidswell et al. (2012) for further discussion.



Figure 3.1: 2013/14 median nitrate concentrations in GQSoE monitoring bores

Overall, nitrate contamination was found in bores where previous sampling has detected elevated nitrate concentrations, in areas of intensive agriculture (Wairarapa) and horticulture (Kapiti Coast). The wide-ranging depth of bores with elevated nitrate concentrations (<5 m to 54 m) suggests that nitrate contamination is not limited to shallow unconfined aquifers but is able to migrate into deeper aquifer systems³.

Groundwater discharges to a number of surface water bodies throughout the region and there is the potential that groundwater discharge high in nitrate could contribute to the decline of surface water quality. The ANZECC (2000) guidelines are commonly used to assess physico-chemical aspects of surface water quality in rivers and streams. Median nitrate concentrations were above the ANZECC (2000) trigger value for lowland ecosystems (0.444 mg/L) in 34 of the 68 (50%) bores. Of these, 20 (29.4%) recorded median concentrations above the Hickey (2013) threshold for aquatic toxicity $(2.4 \text{ mg/L})^4$.

3.2.2 *E. coli*

The DWSNZ uses *E. coli* as an indicator⁵ of faecal contamination in drinking water. For drinking water supplies, *E. coli* counts should be <1 cfu/100mL.

E. coli was not detected (ie, <1 cfu/100mL) in 32 of the 43 (74.4%) bores monitored.

³ This is particularly evident in recharge areas, with elevated nitrate concentrations not commonly found in deeper confined aquifers. ⁴ This (median) value replaces the former threshold of 1.7 mg/L (Hickey & Martin 2009) and is a recommended replacement value for the

ANZECC (2000) toxicity threshold value of 7.2 mg/L.

⁵ It is impracticable to monitor water supplies for all potential human pathogens, so surrogates are used to indicate possible contamination from such things as human and animal excrement, these being the most frequent causes of health-significant microbial contamination in drinking water supplies.

E. coli was detected (ie, ≥ 1 cfu/100mL) on one or more occasions in 11 of the 43 (25.6%) bores tested (Figure 3.2). The highest *E. coli* count was 160 cfu/100mL in bore R25/5164 at Te Horo Beach. Te Horo Beach is a small settlement reliant on onsite wastewater treatment systems for effluent disposal. Previous studies involving dye tracer tests have confirmed that groundwater at Te Horo Beach is able to move from wastewater treatment systems into nearby bores relatively quickly (Hughes 1998). It is possible that the microbial contamination in bore R25/5164 is due to the bore's proximity to a nearby wastewater treatment system. This bore is not used as a potable drinking water supply.



Figure 3.2: Detection of E. coli bacteria in GQSoE monitoring bores in 2013/14

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S27/0594 Warren 1781350.93 5419721.16 Onoke Category C S27/0602 Weatherstone 1789625.95 5425301.57 Lake Category B	S27/0588	SWDC Piriona	1784844.06	5420713.48	Onoke	Category A
S27/0602 Weatherstone 1789625.95 5425301.57 Lake Category B	S27/0594	Warren	1781350.93	5419721.16	Onoke	Category C
	S27/0602	Weatherstone	1789625.95	5425301.57	Lake	Category B

Appendix 1: GQSoE monitoring sites

Site number	Site name	X coordinates	Y coordinates	Groundwater zone	Category
S27/0607	Finlayson	1786288.91	5425037.20	Lake	Category B
S27/0614	Sorenson South	1786778.28	5421924.10	Unknown	Unknown
S27/0615	Sorenson North	1786805.33	5422158.09	Unknown	Unknown
S27/0681	Te Kairanga Wines	1808952.42	5433542.02	Huangarua	Category A
T26/0003	Lenton	1822559.22	5473236.52	Upper Ruamahanga	Category B
T26/0087	Biss	1820295.66	5464750.15	Waingawa	Category C
T26/0099	Butcher, M	1822518.46	5467619.40	Upper Ruamahanga	Category B
T26/0206	Thornton	1822581.50	5467829.43	Upper Ruamahanga	Category B
T26/0259	Opaki Water Supply Association	1825997.33	5469120.23	Upper Ruamahanga	Category A
	Taratahi Agricultural Training				
T26/0332	Centre	1822230.80	5457401.54	Fernhill-Tiffen	Category C
T26/0413	Seymour	1824485.62	5459978.64	Waingawa	Category B
T26/0430	Trout Hatchery	1822130.71	5463027.57	Waingawa	Category B
T26/0489	Duffy	1827571.49	5461854.50	Te Ore Ore	Category B
T26/0538	Percy	1827738.41	5461169.34	Te Ore Ore	Category B
Riversdale					
T27/0063	Acacia Ave	1858025.04	5446630.37	Riversdale	Unknown
Saline intrusion	monitoring				
R26/6378	Rutherford Drive	1771994.91	5475389.21	Waikanae	Category B
R26/6566	Waikanae Estuary Shallow	1769406.76	5473310.22	Waikanae	Category A
R26/6673	Taiata Shallow	1770438.83	5474422.22	Waikanae	Category B
R26/6955	Taiata Deep	1770438.83	5474422.22	Waikanae	Category B
R26/6956	Waikanae Estuary Deep	1769406.76	5473310.22	Waikanae	Category A
R27/0122	McEwan Park Shallow	1758681.27	5433523.34	Hutt Valley	Category B
R27/7153	McEwan Park Deep	1758681.27	5433523.34	Hutt Valley	Category B
R27/7154	Tamatoa Deep	1757019.47	5434294.51	Hutt Valley	Category B
R27/7215	Tamatoa Shallow	1757021.47	5434298.51	Hutt Valley	Category B

Appendix 2: Monitoring variables and analytical methods

Groundwater samples are collected quarterly by trained GWRC staff using nationally accepted protocols (Ministry for the Environment 2006). This involves purging the bore for a predetermined amount of time to remove any standing water and monitoring the pumped water continuously until field measurements (eg conductivity) stabilise. Field measurements (temperature, conductivity, pH and dissolved oxygen) are taken using field meters which are calibrated on the day of sampling.

Water samples are stored on ice upon collection and transported to an external laboratory within 24 hours of sampling. RJ Hill Laboratories in Hamilton analysed the samples for the variables listed in Table A2.1

The rationale for variables monitored is detailed in Table A2.1 and analytical methods are summarised in Table A2.2.

Test type	Variable	Rationale for inclusion
Bacteria	Faecal coliforms <i>E. coli</i>	Faecal coliforms <i>and E. coli</i> can indicate pollution due to faecal matter and the presence of potentially harmful pathogens in groundwater. Ministry for the Environment uses <i>E. coli</i> as an indicator of ground water quality.
Major ions	Dissolved sodium Dissolved potassium Dissolved calcium Dissolved magnesium Chloride Sulphate Total alkalinity	Concentrations of major ions can give an indication of the chemical composition of the water, the origins of groundwater, water residence time in the aquifer and extent of rock/water interaction. Concentrations of major ions can also be indicative of groundwater contamination from industrial, agricultural and domestic sources.
Nutrients	Total ammoniacal nitrogen Nitrite-nitrate nitrogen (NNN) Nitrate nitrogen Nitrite nitrogen Dissolved reactive phosphorus	Dissolved concentrations of nutrients can indicate impact from anthropogenic activity such as intensive land use. Nitrate nitrogen represents the oxidised form of nitrogen. Elevated concentrations of nitrate nitrogen can have an adverse affect on human health and can be harmful to biota. Total ammoniacal nitrogen usually exists under oxygen-poor conditions and represents the reduced form of nitrogen. Therefore, can be used as an indicator of contamination in the absence of nitrate nitrogen. The ANZECC guidelines (2000) state trigger values for the direct toxicity to biota.

Table A2.1. Rationale for inclusion in GQSoE sampling regime

Chemical tests	Variable	Rationale for inclusion in sampling regime			
Metals	Dissolved iron	Trace metals are usually present in groundwater at low concentrations.			
	Dissolved manganese	groundwater. Elevated concentrations of dissolved of lead and			
	Dissolved lead	manganese can nave an auverse anect on numan nealth.			
	Dissolved zinc				
Trace elements	Bromide	Bromide naturally occurs in water but can suggest contamination from			
	Fluoride	of boron can have an adverse affect on human health and the DWSNZ			
	Dissolved boron	(2005) MAV for fluoride is set to protect against potential dental fluorosis.			
Other	рН	Water with a low pH can have a high plumbosolvency. Measured in the field to identify when the bore is purged and sample can be collected.			
	Electrical conductivity	Electrical conductivity can provide a measure of total dissolved solids. Measured in the field to identify when the bore is purged and sample can be collected.			
	Dissolved oxygen	Dissolved oxygen can indicate whether groundwater is under reduced or oxidised conditions. Measured in the field to identify when the bore is purged and sample can be collected.			
	Dissolved reactive silica	Can help interpret the extent of rock/water interaction			
	Total organic carbon (TOC)	Can indicate the presence of organic matter (either from wastewater or natural sources) in groundwater.			
Calculations	Total dissolved solids (TDS)	Can indicate the extent of rock/water interaction.			
	Free carbon dioxide (CO ₂)	Can indicate the extent of rock/water interaction.			
	Bicarbonate (H ₂ CO ₃)	Can indicate the extent of rock/water interaction.			
	Total hardness	Can indicate the extent of rock/water interaction.			
	Total anions	Sum of all anions			
	Total cations	Sum of all cations			
	% Difference in ion balance	Difference between the sum of all anions and the sum of all cations. Ca be used as a measure of analytical accuracy of water quality data. Valu should be 0% but generally a difference of <5% is considered acceptable			

Table A2.1 cont. Rationale for inclusion in GQSoE sampling regime

NB: Groundwater samples are also tested for arsenic, chromium, cadmium, nickel and copper but on a not routine basis. Conductivity and pH are tested both in the field and by Hills Laboratory. Dissolved oxygen is only tested for in the field.

Variable	Method Used	Detection Limit
Temperature	Field meter – Hach HQ40d, YSI 556, WTW P4 Multiline and WTW350i Meters	0.01 °C
Dissolved oxygen	Field meter – Hach HQ40d, YSI 556, WTW P4 Multiline and WTW350i Meters	0.01 mg/L
Electrical conductivity	Field meter – Hach HQ40d, YSI 556, WTW P4 Multiline and WTW350i Meters	0.1 µS/cm
рН	Field meter – Hach HQ40d, YSI 556, WTW P4 Multiline and WTW350i Meters	0.01 units
pH (lab)	pH meter APHA 4500-H+ B 21 st ed. 2005.	0.1 pH units
Total alkalinity	Titration to pH 4.5 (M-alkalinity), Radiometer autotitrator. APHA 2320 B (Modified for alk <20) 21 st ed. 2005.	1 mg/L as CaCO₃
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-CO2 D 21 st ed. 2005.	1 mg/L at 25°C
Free carbon dioxide	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 21 st ed. 2005.	1.0 mg/L at 25°C
Total hardness	Calculation from calcium and magnesium	1.0 mg/L CaCO ₃
Electrical conductivity (lab)	Conductivity meter, 25°C APHA 2510 B 21st ed. 2005.	0.1 mS/m, 1 µS/cm
Total dissolved solids (TDS)	Filtration through GF/C (1.2 μ m), gravimetric. APHA 2540 C (modified; drying temperature of 103 – 105°C used rather than 180 ± 2°C) 21 st ed. 2005.	10 mg/L
Dissolved boron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.005 mg/L
Dissolved calcium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.05 mg/L
Dissolved Iron	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Dissolved Lead	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.0001 mg/L
Dissolved magnesium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Dissolved manganese	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.0005 mg/L
Dissolved potassium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.05 mg/L
Dissolved sodium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Dissolved zinc	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.001 mg/L
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 mg/L
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500-CI- E (modified from continuous-flow analysis) 21st ed. 2005.	0.5 mg/L
Fluoride	Ion selective electrode APHA 4500-F- C 21st ed. 2005.	0.05 mg/L
Total ammoniacal nitrogen	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH ₄ -N = NH ₄ +-N + NH ₃ -N) APHA 4500-NH ₃ F (modified from manual analysis) 21 st ed. 2005.	0.01 mg/L
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₃ - I (modified) 21 st ed. 2005.	0.002 mg/L
Nitrate-N*	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N.	0.001 mg/L
Nitrate-N + Nitrite-N (NNN)	Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ - I (modified) 21 st ed. 2005.	0.002 mg/L
Dissolved reactive phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 mg/L
Reactive silica	Filtered sample. Heteropoly blue colorimetry. Discrete Analyser. APHA 4500-SiO2 F (modified from flow injection analysis) 21st ed. 2005.	0.1 mg/L as SiO ₂
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 mg/L
Total organic carbon (TOC)	Catalytic oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 B (modified) 21st ed. 2005.	0.05 mg/L
Total anions	Calculation: sum of anions as mEquiv/L [Includes Alk, Cl, NOxN & SO4]	0.07 mEquiv/L
Total cations	Calculation: sum of cations as mEquiv/L [Includes Ca, Mg, Na, K, Fe, Mn, Zn & NH ₄ N].	0.05 mEquiv/L
% Difference in Ion Balance	Calculation from Sum of Anions and Cations. Please note: The result reported for the '% Difference in Ion Balance' is an absolute difference between the 'Sum of Anions' and 'Sum of Cations' based on the formula taken from APHA. This does not indicate whether the 'Sum of Anions' or the 'Sum of Cations' produced a higher value. APHA 1030 E 21st ed. 2005.	0.1 %
Faecal coliforms	APHA 21st Ed. Method 9222 D.	1 cfu/100 mL
E. coli	APHA 21st Ed. Method 9222 G.	1 cfu/100 mL

Table A2.2. Analytical methods

*Note the detection limit for Nitrate-N changed from 0.002 mg/L to 0.001 mg/L in November 2013.

Site	х	Y	E. coli detected	No. of <i>E. coli</i> samples	Median nitrate	No. of nitrate samples
R25/5100	1774552	5479451	NO	4	0.001	4
R25/5135	1779152	5481483	NOT TESTED		0.001	4
R25/5164	1775873	5482367	YES	4	0.385	4
R25/5165	1776019	5481886	NO	4	0.390	4
R25/5190	1776678	5478988	NO	4	2.45	4
R25/5233	1779398	5487565	NO	4	1.54	4
R26/6503	1766253	5462295	NOT TESTED		0.016	4
R26/6587	1772634	5473057	NO	4	0.810	4
R26/6624	1773933	5474297	NO	4	2.80	4
R27/0320	1756996	5434508	NOT TESTED		0.002	4
R27/1137	1773406	5444956	NOT TESTED			
R27/1171	1756493	5431227	NOT TESTED		0.007	4
R27/1180	1760435	5435698	NOT TESTED			
R27/1182	1759274	5432161	NOT TESTED		0.695	4
R27/1183	1763084	5438691	NO	4	0.265	4
R27/1265	1756998	5434516	NOT TESTED		0.048	4
R27/6418	1762218	5425695	YES	4	1.68	4
R27/6833	1777716	5445324	NO	4	1.87	4
S25/5125	1782734	5483013	NO	4	2.50	4
S25/5200	1781183	5479785	NO	4	0.006	4
S25/5256	1780491	5483153	NOT TESTED			
S25/5322	1782983	5487486	NO	4	9.50	4
S26/0117	1811483	5456780	YES	4	4.80	4
S26/0223	1816203	5459285	YES	4	11.55	4
S26/0299	1818355	5461870	NO	4	3.95	4
S26/0439	1807492	5455180	NO	4	3.00	4
S26/0457	1807657	5450331	NO	4	0.875	4
S26/0467	1809272	5453850	YES	4	2.60	4
S26/0568	1813487	5451921	NOT TESTED		0.010	4
S26/0576	1813462	5452534	NOT TESTED		0.009	4
S26/0705	1810472	5454279	NO	4	4.40	4
S26/0756	1815919	5448296	NOT TESTED		0.015	4
S26/0762	1815702	5449348	YES	4	0.010	4
S26/0824	1810547	5454381	NO	4	4.70	4
S26/0846	1807902	5449492	NOT TESTED		0.825	4
S27/0009	1793895	5443481	NO	4	3.35	4
S27/0070	1797508	5443111	NO	4	0.595	4
S27/0136	1802217	5446389	YES	4	3.20	4
S27/0156	1803403	5442776	NO	4	0.053	4
S27/0202	1805461	5446520	YES	4	2.55	4
S27/0268	1793453	5434055	NOT TESTED		0.055	4
S27/0283	1797276	5436168	NOT TESTED		0.010	4
S27/0299	1796504	5438936	NO	4	0.335	4

Appendix 3: Tabulated monitoring results

Site	х	Y	E. coli detected	No. of <i>E. coli</i> samples	Median nitrate	No. of nitrate samples
S27/0344	1803348	5437340	NO	4	0.006	4
S27/0389	1807205	5433792	NO	4	0.003	4
S27/0396	1805859	5435962	NO	4	0.345	4
S27/0433	1787692	5427839	NOT TESTED		0.100	4
S27/0435	1787608	5430805	NOT TESTED		0.006	4
S27/0442	1789891	5426884	NOT TESTED		0.008	4
S27/0495	1797227	5431330	NOT TESTED		0.055	4
S27/0522	1803032	5431324	NO	4	3.50	4
S27/0571	1807158	5433014	NO	4	6.45	4
S27/0585	1780321	5422598	NOT TESTED		0.050	3
S27/0588	1784844	5420713	NO	4	0.010	4
S27/0594	1781351	5419721	NOT TESTED		0.026	4
S27/0602	1789626	5425302	NOT TESTED		0.012	4
S27/0607	1786289	5425037	NOT TESTED		0.051	4
S27/0614	1786778	5421924	NOT TESTED		0.055	2
S27/0615	1786805	5422158	NOT TESTED		0.055	4
S27/0681	1808952	5433542	NO	4	0.340	4
T26/0003	1822559	5473237	YES	4	4.14	4
T26/0087	1820296	5464750	NOT TESTED		1.96	4
T26/0099	1822518	5467619	NO	4	2.90	4
T26/0206	1822582	5467829	NO	4	1.77	4
T26/0259	1825997	5469120	YES	4	1.18	4
T26/0332	1822231	5457402	NO	4	0.615	4
T26/0413	1824486	5459979	NOT TESTED		0.002	4
T26/0430	1822131	5463028	YES	4	2.18	4
T26/0489	1827571	5461855	NOT TESTED		11.35	4
T26/0538	1827738	5461169	NO	4	8.75	4
T27/0063	1858025	5446630	NO	4	1.23	4

*Note summary statistics were calculated using Microsoft Excel Professional Plus 2010. Data with values less than the laboratory's analystical detection limit were assigned a value of one half their original value.

Appendix 4: Raw data

				E.coli	Nitrate nitrogen
Site	Х	Y	Date	(cfu/100mlL	(mg/L)
R25/5100	1774552	5479451	Sep-13	<1.00	<0.02
			Dec-13	<1.00	<0.002
			Mar-14	<1.00	<0.002
			Jun-14	<1.00	<0.002
R25/5135	1779152	5481483	Sep-13	Not tested	<0.02
			Dec-13	Not tested	<0.002
			Mar-14	Not tested	<0.002
			Jun-14	Not tested	< 0.002
R25/5164	1775873	5482368	Sep-13	<1.00	0.29
			Dec-13	<1.00	0.58
			Mar-14	160	0.42
D05/5405	4770040	F101000	Jun-14	50	0.35
R25/5165	1776019	5481886	Sep-13	<1.00	0.43
			Dec-13	<1.00	0.35
				<1.00	0.054
D25/5100	1776670	E170000	Jun-14	<1.00	<u> </u>
R25/5190	1//00/0	3470900	Sep-13	<1.00	0.2
			Dec-15	<1.00	2.0
			Ivial-14	<1.00	2.4
D05/5022	1770308	5/97565	Son 13	<1.00	2.4
NZJ/JZJJ	1119390	5407505	 Dec_13	<1.00	1.32
			Dec-13	<1.00	1.59
			lun-1/	<1.00	1.05
R26/6503	1766253	5462295	Sen-13	Not tested	0.025
1120/0000	1100200	0402200	Dec-13	Not tested	0.020
			Mar-14	Not tested	0.0145
			Jun-14	Not tested	0.018
R26/6587	1772634	5473057	Sep-13	<1.00	0.82
			Dec-13	<1.00	0.8
			Mar-14	<1.00	0.48
			Jun-14	<1.00	0.82
R26/6624	1773933	5474297	Sep-13	<1.00	2.8
			Dec-13	<1.00	2.7
			Mar-14	<1.00	2.9
			Jun-14	<1.00	2.8
R27/0320	1756996	5434508	Sep-13	Not tested	<0.002
			Dec-13	Not tested	0.002
			Mar-14	Not tested	<0.002
			Jun-14	Not tested	0.089
R27/1171	1756493	5431227	Sep-13	Not tested	0.104
			Dec-13	Not tested	0.004
			Mar-14	Not tested	<0.002
007/4400	4750074	E100404	Jun-14	Not tested	0.009
R27/1182	1/592/4	5432161	Sep-13	Not tested	0./1
			Dec-13	Not tested	0.65
			Mar-14	Not tested	0.68
D07/1102	1762004	E129601	Jun-14		0.76
NZ//1103	1703004	0400091	Dec 12	<1.00	0.00
			Mor 14	<1.00	0.20
			lun_1/	<1 00	0.20
R27/1265	1756008	5434516	Sen-13	Not tested	0.27
1121/1205	1100390	0-10-010	Dec-13	Not tested	0.035
			Mar-14	Not tested	0.000
			Jun-14	Not tested	<0.02
R27/6418	1762218	5425695	Sep-13	<1.00	2.1
		0.20000	Dec-13	<1.00	1.48
			Mar-14	1	1.07
	_		Jun-14	3	1.88

				E.coli	Nitrate nitrogen
Site	Х	Y	Date	(cfu/100mlL	(mg/L)
R27/6833	1777716	5445324	Sep-13	<1.00	2.8
			Dec-13	<1.00	3.6
			Mar-14	<1.00	0.48
005/5405	4700704	E400040	Jun-14	<1.00	0.93
525/5125	1782734	5483013	Sep-13	<1.00	<u> </u>
			Dec-13 Mor 14	<1.00	2.3 0.75
			IVIdI-14	<1.00	0.75
\$25/5200	1781182	5/70785	Son-13	<1.00	<0.0100
020/0200	1701102	5475705	Dec-13	<1.00	<0.0100
			Mar-14	<1.00	<0.002
			Jun-14	<1.00	<0.02
S25/5322	1783001	5487382	Sep-13	<1.00	9.8
010/0011		0.0002	Dec-13	<1.00	9.6
			Mar-14	<1.00	9.4
			Jun-14	<1.00	9.4
S26/0117	1811483	5456780	Sep-13	<1.00	5.7
			Dec-13	1	5.1
			Mar-14	<1.00	3.3
			Jun-14	1	4.5
S26/0223	1816203	5459285	Sep-13	<1.00	10.6
			Dec-13	<1.00	12.5
			Mar-14	<1.00	12.2
			Jun-14	7	10.9
S26/0299	1818355	5461870	Sep-13	<1.00	4
			Dec-13	<1.00	4.3
			Mar-14	<1.00	3.9
000/0400	4007400	E4EE400	Jun-14	<1.00	3./
526/0439	1807492	5455180	Sep-13	<1.00	<u> </u>
			Dec-13 Mor 14	<1.00	<u> </u>
			lun_14	<1.00	35
\$26/0457	1807657	5450331	Sen-13	<1.00	1.08
020/0407	1007037	0400001	Dec-13	<1.00	0.67
			Mar-14	<1.00	0.5
			Jun-14	<1.00	1.53
S26/0467	1809272	5453850	Sep-13	<1.00	2.5
			Dec-13	1	2.9
			Mar-14	<1.00	2.7
			Jun-14	4	2.1
S26/0568	1813487	5451921	Sep-13	Not tested	<0.02
			Dec-13	Not tested	0.002
			Mar-14	Not tested	<0.02
			Jun-14	Not tested	<0.200
\$26/0576	1813462	5452534	Sep-13	Not tested	< 0.002
			Dec-13	Not tested	0.017
			IVIAr-14	Not tested	<0.002
\$26/0705	1810/72	5454270	Juli-14		0.040
320/07/03	1010472	5454279	Dec-13	<1.00	4.7
			Mar-14	<1.00	43
			Jun-14	<1.00	4.4
S26/0756	1815919	5448296	Sep-13	Not tested	0.02
			Dec-13	Not tested	< 0.002
			Mar-14	Not tested	<0.02
			Jun-14	Not tested	<0.200
S26/0762	1815702	5449348	Sep-13	<1.00	<0.02
			Dec-13	<1.00	0.002
			Mar-14	<1.00	<0.02
			Jun-14	7	<0.200
S26/0824	1810547	5454381	Sep-13	<1.00	4.7
			Dec-13	<1.00	4.5

Sito	Y	v	Dato	<i>E.coli</i> (cfu/100mll	Nitrate nitrogen
JIC	Λ	I	Mar-14	<1.00	<u> </u>
			.lun-14	<1.00	51
S26/0846	1807902	5449492	Sep-13	Not tested	0.79
020/00/10	1001002	0110102	 Dec-13	Not tested	0.91
			Mar-14	Not tested	0.86
			Jun-14	Not tested	0.71
S27/0009	1793895	5443482	Sep-13	<1.00	3.3
			Dec-13	<1.00	3.4
			Mar-14	<1.00	3.4
			Jun-14	<1.00	2.5
S27/0070	1797508	5443111	Sep-13	<1.00	0.61
			Dec-13	<1.00	0.58
			Mar-14	<1.00	0.147
007/0400	4000047	F 1 10000	Jun-14	<1.00	0.99
S27/0136	1802217	5446389	Sep-13	<1.00	3.7
			Dec-13	<1.00	0.57
			War-14	<1.00	2.1
S07/0156	1002402	E440776	Jun-14		4.9
321/0100	1003403	5442770	Dec 13	<1.00	0.005
			Dec-13	<1.00	0.00/
			lun-14	<1.00	<0.004
S27/0202	1805461	5446520	Sen-13	<1.00	3.6
OLINOLOL	1000101	0110020	 Dec-13	<1.00	2.2
			Mar-14	1	2.3
			Jun-14	<1.00	2.8
S27/0268	1793453	5434055	Sep-13	Not tested	0.002
			Dec-13	Not tested	<0.200
			Mar-14	Not tested	<0.200
			Jun-14	Not tested	<0.02
S27/0283	1797276	5436168	Sep-13	Not tested	<0.02
			Dec-13	Not tested	<0.02
			Mar-14	Not tested	0.05
			Jun-14	Not tested	<0.02
S27/0299	1796504	5438936	Sep-13	<1.00	0.34
			Dec-13	<1.00	0.3
			Mar-14	<1.00	0.33
007/0044	4000040	E 407040	Jun-14	<1.00	0.84
527/0344	1803348	5437340	Sep-13	<1.00	0.20
			Dec-15	<1.00	<0.002
			lun_1/	<1.00	<0.002
S27/0389	1807205	5433792	Sen-13	<1.00	<0.02
021/0003	1007200	0400102	0ep-18	<1.00	<0.002
			Mar-14	<1.00	0.107
			Jun-14	<1.00	0.004
S27/0396	1805859	5435962	Sep-13	<1.00	0.36
			Dec-13	<1.00	0.186
			Mar-14	<1.00	0.74
			Jun-14	<1.00	0.33
S27/0433	1787692	5427839	Sep-13	Not tested	<0.02
			Dec-13	Not tested	<0.200
			Mar-14	Not tested	<0.200
007/0405	4707000	E400005	Jun-14	Not tested	0.3
527/0435	1787608	5430805	Sep-13	Not tested	0.002
			Dec-13	Not tested	<0.02
				Not tested	<0.002
\$27/0//2	1780801	5126881	Juil-14 Son-12	Not tested	0.200
02110442	1602031	J420004	Dec-13	Not tested	<0.000
			Mar-14	Not tested	<0.02
			Jun-14	Not tested	<0.02

				E.coli	Nitrate nitrogen	
Site	Х	Y	Date	(cfu/100mlL	(mg/L)	
S27/0495	1797227	5431330	Sep-13	Not tested	0.006	
			Dec-13	Not tested	<0.02	
			Mar-14	Not tested	0.2	
			Jun-14	Not tested	<0.200	
S27/0522	1803032	5431324	Sep-13	<1.00	3.3	
			Dec-13	<1.00	3.5	
			Mar-14	<1.00	3.5	
			Jun-14	<1.00	3.8	
S27/0571	1807158	5433014	Sep-13	<1.00	6.6	
			Dec-13	<1.00	6.3	
			Mar-14	<1.00	6	
			Jun-14	<1.00	6.7	
S27/0585	1780320	5422598	Sep-13	Not tested	<0.0100	
			Dec-13	Not tested	0.05	
			Mar-14	Could not	be sampled	
			Jun-14	Not tested	<0.200	
S27/0588	1784844	5420714	Sep-13	<1.00	<0.02	
			Dec-13	<1.00	<0.02	
			Mar-14	<1.00	<0.02	
			Jun-14	<1.00	<0.200	
S27/0594	1781351	5419721	Sep-13	Not tested	<0.0100	
			Dec-13	Not tested	<0.002	
			Mar-14	Not tested	<0.002	
			Jun-14	Not tested	0.107	
S27/0602	1789626	5425302	Sep-13	Not tested	<0.002	
			Dec-13	Not tested	0.02	
			Mar-14	Not tested	<0.200	
			Jun-14	Not tested	0.003	
S27/0607	1786289	5425037	Sep-13	Not tested	0.9	
			Dec-13	Not tested	0.002	
			Mar-14	Not tested	< 0.002	
		- 10 100 1	Jun-14	Not tested	<0.200	
S27/0614	1/86//8	5421924	Sep-13	Not tested	<0.200	
			Dec-13	Not tested	<0.02	
			Mar-14	Could not be sampled		
007/0045	1700000	E4004E0	Jun-14		Could not be sampled	
521/0015	C00001	3422130	Sep-13	Not tested	<0.02	
			Dec-13 Mor 14	Not tested	<0.200	
			IVIdI-14	Not tested	<0.02	
\$27/0681	1808052	5/335/2	Son 13		0.200	
321/0001	1000932	J4JJJ4Z	Dog 13	<1.00	0.30	
			Mor 14	<1.00	0.39	
			lun_14	~1.00	0.0	
T26/0003	1822550	5473036	Sen-13	<1.00	6.24	
120/0000	1022000	0710200	Dec-13	1	7.4	
			Mar-14	<1.00	0.51	
			Jun-14	<1.00	1.48	
T26/0087	1820296	5464750	Sep-13	Not tested	2.9	
			Dec-13	Not tested	2.3	
			Mar-14	Not tested	0.92	
			Jun-14	Not tested	1.62	
T26/0099	1822518	5467619	Sep-13	<1.00	3	
			Dec-13	<1.00	3.2	
			Mar-14	<1.00	2.7	
			Jun-14	<1.00	2.8	
T26/0206	1822582	5467829	Sep-13	<1.00	1.76	
			Dec-13	<1.00	1.78	
			Mar-14	<1.00	1.65	
			Jun-14	<1.00	1.94	
T26/0259	1825997	5469120	Sep-13	<1.00	3.6	
			Dec-13	2	1.61	

Site	Х	Y	Date	<i>E.coli</i> (cfu/100mlL	Nitrate nitrogen (mg/L)
			Mar-14	<1.00	0.66
			Jun-14	<1.00	0.74
T26/0332	1822231	5457402	Sep-13	<1.00	1.08
			Dec-13	<1.00	0.69
			Mar-14	<1.00	0.54
			Jun-14	<1.00	0.52
T26/0413	1824486	5459979	Sep-13	Not tested	<0.002
			Dec-13	Not tested	0.002
			Mar-14	Not tested	<0.002
			Jun-14	Not tested	0.058
T26/0430	1822131	5463028	Sep-13	1	3.8
			Dec-13	<1.00	2.6
			Mar-14	<1.00	1.29
			Jun-14	4	1.75
T26/0489	1827572	5461854	Sep-13	Not tested	12.6
			Dec-13	Not tested	11.3
			Mar-14	Not tested	10.5
			Jun-14	Not tested	11.4
T26/0538	1827738	5461169	Sep-13	<1.00	9.8
			Dec-13	<1.00	8.7
			Mar-14	<1.00	8.8
			Jun-14	<1.00	7.8
T27/0063	1858025	5446630	Oct-13	<1.00	1.37
			Dec-13	<1.00	0.005
			Mar-14	<1.00	1.1
			Jun-14	<1.00	1.36