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Stream, Lake & Coastal Water Quality January – December 2004

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STATE OF THE ENVIRONMENT MONITORING: STREAM, LAKE & COASTAL WATER QUALITY JANUARY – DECEMBER 2004

Shane Kelly
Grant Barnes
Mike McMurtry
Joanne Yee
Naveen Kumar

Contents

Acknowledgments

This report was prepared by the Environmental Research team at the Auckland Regional Council. ARC staff, coordinated by Ross Winterburn, collected samples. Watercare Services Ltd. of Auckland conducted chemical analyses. John Maxted, Grant Barnes and Shane Kelly conducted stream, lake and coastal project management, respectively. Mike McMurtry and Joanne Yee managed the data. Mike McMurtry and Joanne Yee assisted with data analysis and report preparation.

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1 Executive Summary

This report summarises 2004 streams, lakes and coastal water quality data from sites spread throughout the Auckland Region. The Auckland Regional Council and its predecessors have been monitoring water quality in the Auckland region since the mid-1980s. This annual report presents data for 27 streams, 7 lakes and 27 coastal sites for the period January – December 2004.

Water quality data is also now available online at
http://maps.arc.govt.nz/website/maps/map_hydrotel.htm .

Streams: The 2004 results are similar to results from previous years for the 27 stream sites. The streams data illustrate the close link between catchment landuse and water quality. High water quality was recorded at sites such as Cascades and Opanuku, set in catchments of bush, or low disturbance bush / rural. In contrast, low water quality in the 6 streams located in the Tamaki catchment reflects the highly urbanised and industrialised nature of the catchment.

Lakes: The 2004 lakes data was analysed to ascertain the nutrient status of each lake. These benchmarks will be helpful in monitoring future changes in the trophic state of each lake. Lake Ototoa has the best water quality of the 7 lakes, yet is still classed as mesotrophic (moderately enriched). Lakes Kereta, Pupuke, Tomarata and Wainamu are classified as eutrophic (nutrient enriched), due to high nitrogen and phosphorus levels. Lake Kuwakatai has lower water quality, classified as supertrophic (nutrient saturated); while the lowest water quality is recorded at Lake Spectacle. This lake is classed as hypertrophic (nutrient overloaded).

Coastal: Patterns in overall water quality were consistent with previous years. Levels of suspended solids were lowest in the open, east coast sites and highest and most variable in the upper Tamaki, Manukau Harbour and Kaipara Harbour. Nutrient levels remain higher in the Manukau Harbour than at other sites in the region, despite the significant reductions that followed the upgrade of the Mangere Sewage Treatment Plant. However, chlorophyll *a* levels are relatively uniform throughout the region, suggesting that elevated nutrient levels within the Manukau Harbour have not led to large scale nuisance algal blooms. Warkworth town basin was noted for high levels of faecal contaminants, but it was not possible to distinguish between animal (ducks plus farm and domestic animals) and human sources. A high intensity storm event in the Mahurangi catchment on 20 - 21 July was responsible for temporarily elevating suspended solid, faecal contaminant, phosphate and nitrate concentrations in Warkworth town basin and at Dawsons Creek.

2 Introduction

2.1 SoE water quality monitoring

The Auckland Regional Council (ARC) and its predecessor agency, the Auckland Regional Authority's Regional Water Board (ARWB), have monitored stream, lake and coastal water quality as part of a State of the Environment (SoE) monitoring programme since 1987.

Coastal resources in the Auckland Region include two oceans, major harbours, and numerous estuaries. The beauty, use, and health of coastal waters are influenced directly by the quality of freshwater that runs from the land through streams and rivers. The microbiological contamination of beaches after heavy rainfall and the sedimentation of harbours and estuaries illustrate the connections between inland and coastal waters, and sensitivity of these systems.

The Auckland region also contains a wide variety of stream types covering four major geology types (hard rock, volcanic, sand, and clay) and four land use categories (bush, forestry, rural, and urban). This variety and 80 million years of isolation has lead to unique species of plants, fish, and invertebrates, many of which are found only in New Zealand. There are approximately 10,000 km of permanently flowing waterways in the Auckland region.

The ARC has pivotal role in sustaining the quality of water resources in the region, and relies on the provision of consistent, robust information on water quality to identify issues and measure the performance of it's policies, plans and regulatory activities. The objectives of the water quality SoE programme data are therefore to:

1. Determine the temporal and spatial variability of selected water quality parameters at sites with different land-use influences throughout the region, and;
2. Provide a baseline of water quality information from which the presence, direction and magnitude of trends can be determined.
3. Identify current and potential impacts of catchment development activities.
4. Collect baseline data for the calibration of short-term surveys of similar areas.
5. Evaluate improvements in water quality due to pollution abatement activities.
6. Assess the effectiveness of land use planning policies intended to protect water quality.
7. Ensure that existing environmental controls are adequate to avoid unacceptable adverse environmental impacts.

The purpose of this report is (1) to document water quality data collected over a 12-month period from January-December 2004, and (2) to provide brief comment on this data. A more detailed review and analysis of the streams water quality data is carried out at five yearly intervals. The most recent reviews of streams water quality were carried out in 2000 (East Coast, Lower Waitemata, Manukau Harbour, and Kaipara (ARC 2000)) and 2003 (Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary (ARC 2003))

2.2 Stream Water Quality

Stream quality is effected by surrounding landuse, the condition of riparian margins, stormwater and wastewater discharges, surface runoff, and groundwater inputs. The streams component of the water quality programme measures 22 parameters related to physico-chemical and microbiological quality of streams at 27 sites in the Auckland Region (Table 3.1). Greater sampling intensity is undertaken in catchments adjoining the Tämaki Estuary, and Mahurangi Harbour, because of the specific local issues. The Tämaki Estuary is one of the most highly impacted urban water bodies in the Auckland region, while the Mahurangi catchment, and it's associated harbour, is recognised for it's high value and sensitivity to landuse activities.

Water quality data from this programme is also used in conjunction with freshwater macroinvertebrate and physical habitat data to provide an integrated overview of the physical, chemical, and biological condition of the region's streams.

2.3 Lakes Water Quality

Lakes can be particularly sensitive habitats due to their limited flushing and small size relative to the surrounding catchment. The lakes component of the water quality programme monitors seven of the largest, natural lakes in the region. The monitored lakes are located in catchments covering a range of landuses including rural, native and urban. It also includes representative lake types (i.e. dune and volcanic) (Table 3.2). Current water quality within the monitored lakes ranges from high to degraded.

A standard set of to physico-chemical and microbiological parameters are used as indicators of sediment, nutrients, and chemical and biological contaminants, and to aid in the interpretation of data. The parameters provide a general indication of the effects of human pressures on the lakes (from both point and non-point sources) and are used to assess the ecological health of the lake environment.

2.4 Coastal Water Quality

The coastal water quality network covers the east coast, Manukau Harbour, Kaipara Harbour, Waitemata Harbour, Tamaki Estuary, and Mahurangi Harbour. Higher sampling intensity is undertaken within the Upper Waitemata Harbour, Tamaki Estuary, and Mahurangi Harbour because of the specific local issues associated with these semi-enclosed water bodies. The Mahurangi catchment is largely rural, with a mix of lifestyle, farm, horticultural, forestry and bush landuse. Warkworth is located at the head of the harbour, and further urban development is proposed around the township and near the mouth of the harbour. The upper Waitemata Harbour has five estuarine arms (Rangitopuni has the largest freshwater input); a mix of rural and urban landuse, ongoing urban development, two military airfields, and a maximum-security prison. The Tamaki Estuary is predominantly urban and is considered to be one of the most highly impacted water bodies in the Auckland region (ARC 1999).

The parameters measured in the coastal component of the water quality programme are indicators of sediment, nutrients and biological contaminants. In addition, a number of environmental parameters are measured to provide information on ambient coastal water conditions and/or because they effect the toxicity of contaminants such as ammonia.

3 Methods

3.1 Streams Sampling Sites and Survey Details

A total of 27 sites were sampled every month (Figure 3.1, Tables 3.1):

- 6 sites in the Tämaki Estuary Catchment
- 2 sites in Mahurangi Harbour Catchment
- 19 sites spread throughout the remainder of the region

The general locations of the sites sampled are shown in Figure 3.1.

The sites were selected to provide a broad geographic coverage, and to represent 5 major land use classes (bush, forestry, market garden, rural, urban) (Table 1). Reference sites in native bush catchments cover the two major stream types in the region: hard-bottomed (hard rock) and soft-bottomed (clay). All sites are sampled monthly, and most have been sampled since the mid-1980s.

Sampling of most regionwide sites began in 1986, with the extra sites being added over subsequent years (Tables 3.1). A list of the parameters sampled is provided in Table 3.4.

Sampling protocols are detailed in the following ARC report: Rivers 4th Edition (July 2002). Sampling was timed to ensure that, as far as possible, samples were collected at the same time of day and in the same order to minimise temporal variability. Due to logistic constraints, sampling was carried out over 4 separate days each month.

Black disc data is included in this report. Due to limited access at both the Mahurangi intake jetty and Mahurangi town bridge, water clarity was quantified at these sites using a secchi disc rather than black disc. These results cannot be used for between-site comparisons, but have been reported in this document for the purpose of identifying long term changes in water clarity at these sites.

3.2 Lakes Sampling Sites and Survey Details

Lakes have been selected that best represent or integrate the influences of specific land uses on lake water quality, and to be representative of the Region as a whole. This is achieved by including:

- Seven of the largest natural lakes within the region.
- Lakes located within catchments of different development types: rural, native and urban.
- Lakes with water quality ranging from 'high' to 'degraded'.

- Lakes that are representative of the different types of lakes within the Region (i.e. dune and volcanic).

The general locations of the lakes sampled are shown in Figure 3.2.

Data reviewed in this report cover the four surveys made in Feb, May, August and November of 2004. In addition, three surveys were undertaken in September, October and December at Lake Wainamu as part of a special investigation instigated in the 2004/05 financial year, and an additional survey was undertaken in April at Lake Pupuke.

Each lake was sampled from a single deep-water station where temperature and dissolved oxygen profiles were determined. Sampling was stratified by depth with two vertically distinct samples (surface and bottom) collected at all lakes except Pupuke (an additional middle sample) and Kereta (surface sample only).

The sampling protocols for the LTB surveys have changed little from those reported in various earlier ARC technical publications (TP 234 Annual Report January – December 2003 Baseline water quality: stream, lake and saline waters, TP268 Water quality of selected lakes in the Auckland region). However, some changes did occur in August 2004 with the implementation of depth specific sampling. Previously the same suite of parameters was quantified irrespective of sample depth. This was considered unnecessary because in most cases samples taken at depth are beyond the photic zone and consequently below the point where biological indicators of trophic state and trend either reside or are insufficiently different to warrant additional analysis. These parameters: chlorophyll *a*, phytoplankton, zooplankton, *E.coli*, and faecal coliforms were consequently removed from the array of analytes required for bottom samples.

A list of the parameters sampled is provided in Table 3.4. Appendix 42 of Technical Publication 132 "Year 2000 Summary Report: Baseline Water Quality Stream, Lake, and Saline Waters" contains a summary of the parameters included, what they measure, their likely sources and impacts on the environment.

3.3 Coastal Sampling Sites and Survey Details

A total of 27 coastal water quality sites are sampled every month:

- 6 sites in Manukau Harbour;
- 7 sites in the inner Hauraki Gulf and outer Waitemata Harbour;
- 1 sites in Kaipara Harbour;
- 3 sites in Mahurangi Harbour;
- 2 sites in Tamaki Estuary;
- 8 sites in the Upper Waitemata Harbour.

The general locations of the coastal sites sampled are shown in Figure 3.3. The sites were selected to provide information on:

- Coastal water quality ranging from very high to degraded;
- A range of exposure levels including open coast, sheltered coast, harbours, large estuaries and tidal creeks;
- The main harbours and large estuaries;
- Areas with a variety of adjacent land uses ranging from urban/industrial to rural;
- Regional variation in water quality.

More intense sampling is carried out in three areas identified as being particularly vulnerable to water quality degradation (Mahurangi Harbour and Upper Waitemata Harbour, Tamaki Estuary). The site details and the period sampled are listed in Table 3.3.

Coastal water quality monitoring is predominantly carried out by helicopter, which enables sites spread over a broad area to be collected within a narrow time frame and at approximately the same stage of the tide. The exceptions are: Shelly Beach in the Kaipara Harbour, where samples are collected from a wharf; and the Upper Waitemata Harbour, Mahurangi Harbour, and Tamaki Estuary which are sampled by boat. A list of the parameters sampled is provided in Table 3.4.

Sampling protocols are detailed in the following ARC reports: Mahurangi Estuary 2nd Edition (May 1999), and Tämaki Estuary 3rd Edition (May 2002).

3.4 Water Quality Parameters

Generally, the water quality variables measured during each sampling run were a combination of *in situ* meter readings, physical observations and chemical and biological analysis of collected samples in the laboratory (Table 3.4). The chosen variables principally describe water clarity and appearance, nutrient status, biological productivity (in response to nutrient inputs) and physical conditions. In addition, the heavy metals zinc, copper and lead are monitored at some stream sites: Oakley Creek, Oteha and Lucas Creek.

Samples from all 3 components of the water quality programme were analysed by Watercare Services Ltd. Analytical methods utilised in these surveys are described in "Chemical Methods Manual" and "Microbiological and Biological Methods Manual" compiled by Laboratory Services, Watercare Services Ltd. These methods generally follow the "Standard Methods for the Examination of Water and Wastewater" 18th Edition (APHA 1992).

For extra information on physio-chemical, microbial, and nutrient water quality parameters, see Appendix 4.

3.5 Data Analysis

Stream water quality data are presented as box and whisker plots, bar graphs (standard deviation and interquartile range), and line graphs (time series) for the period from Jan to Dec 2004.

Lakes water quality data for 2004 are presented graphically as box plots and line graphs, while basic statistics are presented in data tables.

Coastal water quality data for the Jan – Dec 2004 period are presented as box and whisker plots, and bar graphs. Selected parameters, which show marked variations across the region, are also presented as bubble plots. Data tables and time series plots showing changes in each parameter throughout the year are also provided in Appendix 1.

For stream water quality and coastal water quality, variability was expressed as interquartile ranges and standard deviations. Interquartile ranges are the non-parametric equivalent of standard deviations, but are less sensitive to extreme values. Data with large standard deviations but small interquartile ranges therefore indicate the presence of extreme outliers. Extreme outliers are often due to short-lived pulse events, such as sediment runoff associated with heavy rainfall, which have a substantial impact on overall water quality.

Table 3.1: Stream water quality site coordinates, date of first sample, sampling frequency, location, geology type and catchment landuse.

Site #	Name	Catchment land use	Geology Type	Frequency	Easting	Northing	Sampling period
44603	Cascade Stream	Bush reference	HB	monthly	2646046	6478079	1986 to present
7206	WestHoe Stream	Bush reference	SB	monthly	2658699	6512425	2001 to present
6811	Mahurangi River	Forestry	SB	monthly	2658162	6526615	1986 to present
43829	Ngakoroa Stream	Market garden	SB	monthly	2685512	6443288	1986 to present
45703	Hoteo River	Rural	SB	monthly	2645797	6534299	1986 to present
45313	Kumeu River	Rural	SB	monthly	2649698	6490510	1986 to present
6604	Matakana River	Rural	SB	monthly	2663637	6538880	1986 to present
7904	Opanuku Stream	Rural	HB	monthly	2652563	6477294	1986 to present
7805	Rangitopuni River	Rural	SB	monthly	2654892	6494008	1986 to present
7104	Waiwera River	Rural	SB	monthly	2659256	6515392	1986 to present
43856	Papakura Stream	Rural	SB	monthly	2681720	6462011	1986 to present
8516	Wairoa River	Rural	SB	monthly	2693071	6463336	1986 to present
7830	Lucas Creek	Urban	SB	monthly	2661865	6496261	1993 to present
7811	Oteha Stream	Urban	SB	monthly	2661825	6495265	1986 to present
8110	Oakley Creek	Urban	SB	monthly	2662410	6479407	1994 to present
8205	Otara Stream	Urban	SB	monthly	2678752	6470040	1985 to present
43807	Puhinui Stream	Urban	SB	monthly	2676869	6465983	1994 to present
7502	Awanohi	Rural	SB	Monthly	2661879	6500421	2003 to present
7506	Vaughan	Rural	SB	monthly	2666812	6500800	2001 to present
8214	Otara Creek @ East Tamaki	Urban	SB	Monthly	2677814	6469148	1992 to present
8215	Pakuranga Creek - Greenmount Drive	Urban	SB	Monthly	2679890	6472486	1992 to present
8216	Pakuranga Creek – Guys Rd	Urban	SB	Monthly	2680421	6472641	1992 to present
8217	Pakuranga Creek – Botany Rd	Urban	SB	Monthly	2680517	6474729	1992 to present
8218	Omaru Creek – Taniwha Street	Urban	SB	Monthly	2676698	6478449	1992 to present
8219	Otaki Creek - Middlemore	Urban	SB	Monthly	2674700	6468900	1992 to present
	Mahurangi Streams						
6804	Mahurangi at Warkworth water-	Urban	SB	Monthly	2659289	6532066	1993 to present
6840	Mahurangi at Town bridge	Urban	SB	Monthly	2659641	6532299	1993 to present

Figure 3.1: Stream water quality sampling site locations.

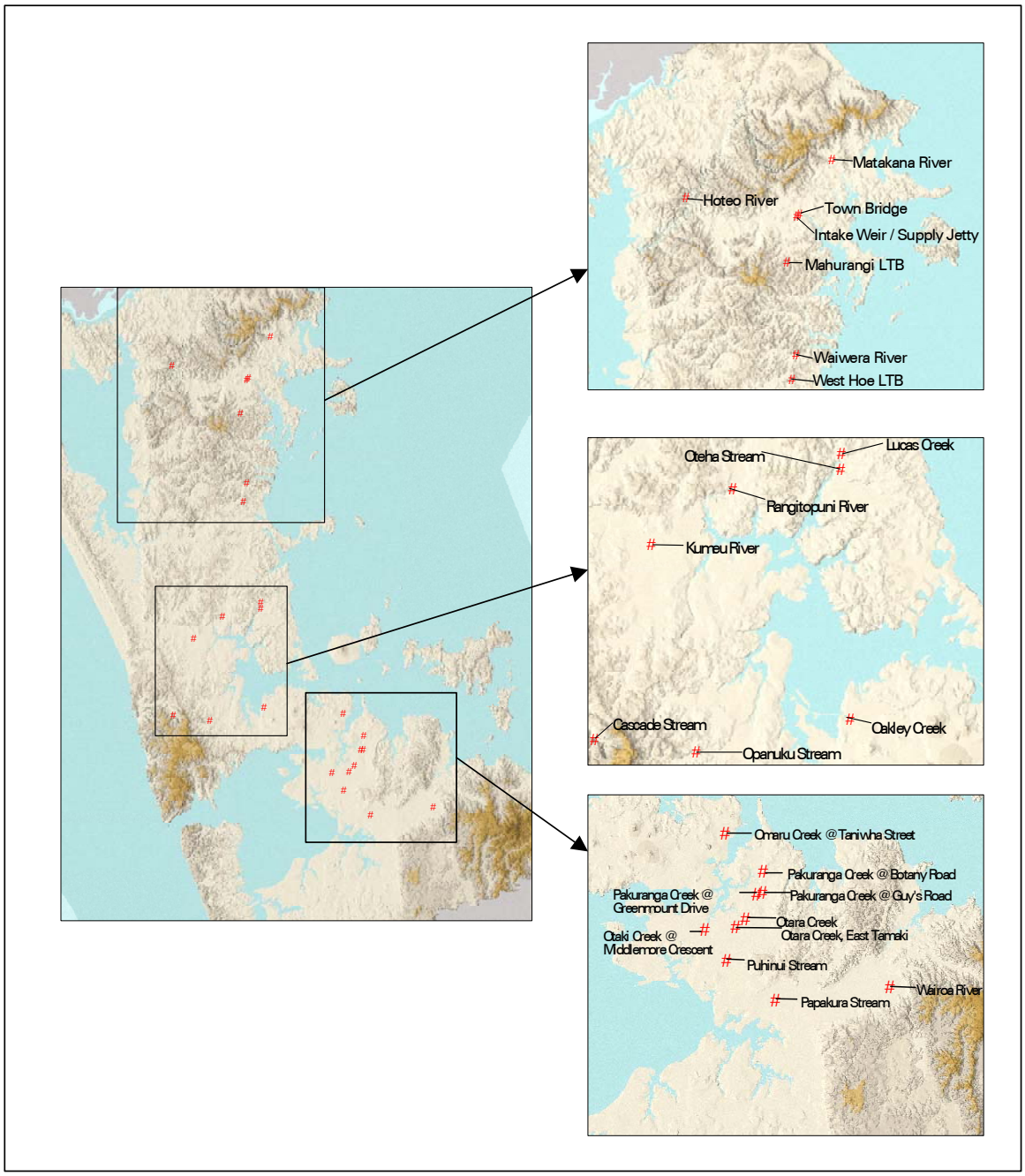

Table 3.2: Lakes water quality sampling site locations

Site #	Lake name	Catchment land use	Geology type	Frequency	Easting	Northing	Sampling Period
45003	Kereta	Rural / forestry	Dune	Bi-monthly	2624825	6511571	1988 to present
45011	Kuwakatai	Rural / forestry	Dune	Bi-monthly	2621896	6518636	1988 to present
45001	Ototoa	Rural / forestry	Dune	Bi-monthly	2621480	6520125	1988 to present
7605	Pupuke	Urban	Volcanic	Bi-monthly	2668158	6489781	1976 to present
6301	Spectacle	Rural / pastoral	Dune	Bi-monthly	2657607	6555922	1988 to present
6303	Tomerata	Rural / pastoral	Dune	Bi-monthly	2658864	6555154	1988 to present
44616	Wainamu	Bush / pastoral	Dune	Bi-monthly	2641049	6478309	1988 to present

Figure 3.2: Lakes water quality sampling site locations

Table 3.3: Coastal water quality sampling site locations and sampling periods.

Site #	Site name	Run *	Frequency	Easting	Northing	Sampling Period
6315	Goat Island	EC	monthly	2672411	6546605	1999 to present
6514	Ti Point	EC	monthly	2670783	6540222	1999 to present
6843	Mahurangi Heads	MAH	monthly	2664900	6521600	1999 to present
6842	Dawsons Creek	MAH	monthly	2664087	6528121	1999 to present
6804	Warkworth	MAH	monthly	2659289	6532066	1999 to present
7207	Orewa	EC	monthly	2663769	6511321	1999 to present
7518	Browns Bay	EC	monthly	2668401	6497478	1999 to present
7705	Chelsea	EC	monthly	2664384	6484577	1999 to present
7702	Hobsonville	UWH	monthly	2659770	6489031	1999 to present
7882	Lucas Creek	UWH	monthly	2660504	6494185	1999 to present
7809	Paremoremo	UWH	monthly	2656200	6491900	1999 to present
7704	Confluence **	UWH	monthly	2654413	6490765	1999 to present
7884	Rangitopuni	UWH	monthly	2653289	6491596	1999 to present
7883	Brighams	UWH	monthly	2653207	6489747	1999 to present
7821	Rarawaru	UWH	monthly	2654885	6490378	1999 to present
7703	Waimarie	UWH	monthly	2656665	6490810	1999 to present
7919	Henderson	EC	monthly	2657153	6485367	1999 to present
8005	Whau	EC	monthly	2658723	6482007	1999 to present
8221	Tamaki	TAM	monthly	2679802	6479121	1999 to present
8220	Panmure	TAM	monthly	2675718	6475615	1999 to present
43905	Mangere	MAN	monthly	2669004	6472408	2000 to present
43906	Puketutu	MAN	monthly	2664289	6470427	2000 to present
43904	Weymouth	MAN	monthly	2675316	6459353	2000 to present
43506	Waiuku River	MAN	monthly	2659019	6459062	2000 to present
43507	Waiuku Channel	MAN	monthly	2660023	6449792	2000 to present
44010	Shag Point	MAN	monthly	2658790	6470166	2000 to present
45214	Shelly Beach	KAI	monthly	2634008	6513666	1999 to present

* EC = East Coast, KAI = Kaipara, MAH = Mahurangi, MAN = Manukau, UWH = Upper Waitemata Harbour.

** Rangitopuni and Brighams confluence.

Figure 3.3: Coastal water quality sampling site locations.

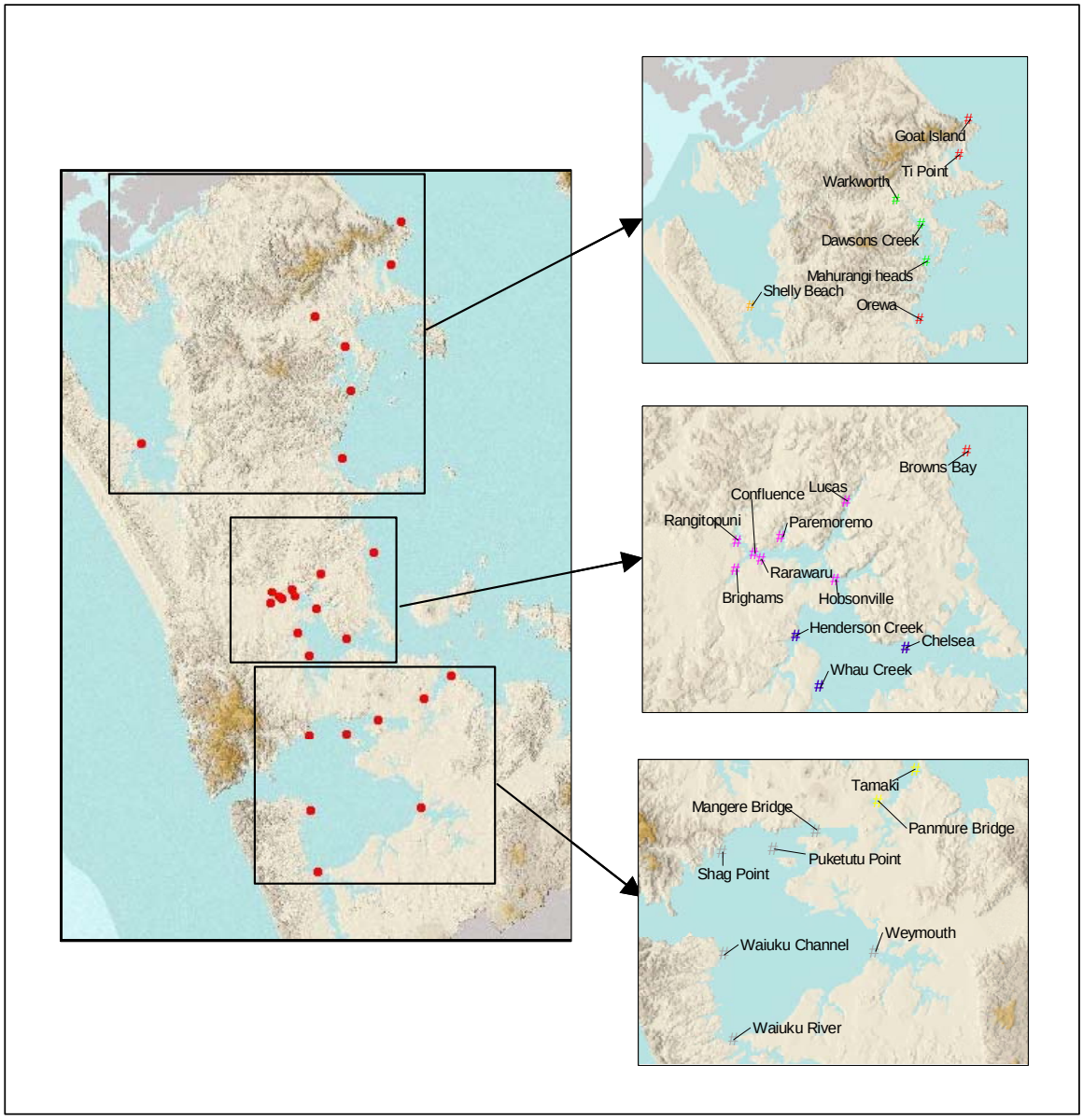

Table 3.4: Water quality parameters and associated units.

Parameter	Units	Programme		
Field Measurements		**Stream**	**Lakes**	**Coastal**
Water temperature	°C	Y	Y	Y
Dissolved oxygen (concentration)	mg/L	Y	Y	Y
Dissolved oxygen (saturation)	%	Y	Y	Y
Salinity	Ppt	Y		Y
Conductivity	MS/m 25°C	Y		
Black disc depth	M	Y		
Secchi disc	M		Y	Y
Laboratory Analyses				
Faecal coliforms	MPN/100 ml	Y	Y	Y
Presumptive Coliforms	MPN/100ml	Y	Y	Y
E.Coli	Cfu/100ml	Y	Y	
Enterococci	Cfu/100ml			Y
BOD	mg/L O	Y	Y	Y
Chloride	mg/L Cl	Y	Y	Y
pH	Units	Y	Y	Y
Turbidity	NTU	Y	Y	Y
Suspended solids (Non-filtrable residue)	mg/l	Y	Y	Y
Nitrite nitrogen, NO_2-N	mg/l	Y	Y	Y
Nitrate nitrogen, NO_3-N	mg/l	Y	Y	Y
Ammonia nitrogen, NH_3 NH_4	mg/l	Y	Y	Y
Total Kjeldahl Nitrogen (TKN)	mg/L N		Y	
Total phosphorus, TP	mg/l	Y	Y	Y
Dissolved (soluble) reactive phosphorus, DRP	mg/l	Y	Y	Y
Salinity	Ppt	Y		Y
Chlorophyll a	mg/l		Y	Y
Copper – soluable	mg/L Cu	Selected streams		
Copper – total	mg/L Cu	Selected streams		
Zinc – soluable	mg/L Zn	Selected streams		
Zinc – total	mg/L Zn	Selected streams		
Lead – soluable	Mg/L Pb	Selected streams		
Lead – total	Mg/L Pb	Selected streams		

Note: MPN = most probable number; cfu = colony-forming units (APHA 1992).

4 Results

Please note that water quality data is now also reported on the ARC website http://maps.arc.govt.nz/website/maps/map_hydrotel.htm . This data is typically available within one month from the sampling run, allowing much more up-to-date reporting. Sites are interrogated separately to gain access to the most recent data, summary data, and time-series plots. The user can also query the database to access data from certain time periods.

4.1 Streams

The 2004 results support the general relationship between water quality and catchment landuse as seen in previous years. Median stream water temperature was lowest in Cascades, Awanohi, Opanuku, Mahurangi, West Hoe and Ngakaroa (Figure 4.1a). These sites, with the exception of Ngakaroa, are located in bush-clad catchments and are therefore well shaded. In contrast, the highest median stream water temperatures were recorded in the Pakuranga stream (3 sites), Omaru, Otaki, Puhunui and Otara, all located in urbanised catchments with no riparian shade. Pakuranga's Botany, Greenmount and Guys sites experienced median temperatures of approx 17 - 18 degrees C.

High DO levels were recorded at many streams, where approximately 19 of the 27 sites featured median DO of 80% or greater. DO had low variability (a SD of less than or approx 15%) at a similar number of sites: Mahurangi, Ngakaroa, Mahurangi @ town bridge and Mahurangi @ intake jetty (Figure 4.1a). Results from two Pakuranga stream sites were the most variable: Pakuranga @ Guys Road and Pakuranga @ Botany Rd (Figure 4.1e). Very high DO was recorded at Botany Rd, with few recordings less than (90%), while Guys Rd stream water quality ranged from high (approx 125%) to anoxic. The lowest DO levels were recorded at West Hoe, Awanohi, Otara, and Pakuranga @ Guys Rd. Of these sites, low DO readings were observed on rare occasions at the first three sites, while Guys Rd commonly exhibited low DO (Figure 4.1a).

Conductivity was very stable and consistent at the majority of sites, excluding five of the six Tämaki sites, Mahurangi @ intake jetty and Mahurangi @ town bridge (Figures 4.1a and 4.1e). Conductivity was highly variable at Omaru. The highest median conductivity was recorded at Pakuranga @ Greenmount Drive (Figure 4.1a). Very low conductivity was recorded at Omaru, Pakuranga @ Guys Rd, Pakuranga @ Botany Rd, and Mahurangi @ intake jetty.

In general, chloride levels at sites Cascades through to Puhinui were generally low and exhibited low variability, compared with the Tämaki stream sites (Figures 4.1a and 4.1e). Both Omaru and Pakuranga @ Greenmount Drive recorded the greatest variability (Figure 4.1e). As expected, the levels of chloride and conductivity are comparable.

For nutrient parameters nitrate (NO3), ammonia (NH3NH4), total phosphorus (TP) and dissolved reactive phosphorus (DRP), the following small number of sites: Cascades, West Hoe, Ngakaroa, and Matakana had consistently low nutrient levels throughout 2004 (Figure 4.1b). Many other sites exhibited low nutrient levels for two or three nutrient parameters, yet recorded elevated levels for the remaining parameter(s) e.g. at Mahurangi and Matakana, high NO3 and high TP were recorded, respectively. Opanuku, Rangitopuni, Awanohi, Vaughan, Mahurangi @ intake jetty and Mahurangi @ town bridge follow this pattern. At all six of the Tamaki sites, many of the urban sites, and a collection of the rural sites, elevated nutrient levels were recorded during 2004 (Figure 4.1b). The graphs show that many sites have low median values coupled with high 90th percentile and outlier values, indicating that typical low nutrient levels were punctuated by periods of elevated nutrients. This result may be due to effluent contamination during rainfall events.

The presence of large bacteriological cell counts for some sites dictates the use of broken scales on the y-axis of faecal coliform, presumptive coliform, and E. coli graphs (Figures 4.1c and 4.1g). Faecal contamination events occurred in the following streams in 2004: Papakura, Wairoa, Otara, Otara @ East Tämaki Rd, Pakuranga @ Botany Rd, Omaru and Otaki. Presumptive coliform counts were high, at times, for all of the above sites excluding Papakura and Wairoa. E.coli counts were quantified at the Tamaki sites only. High E.coli levels were recorded at Puhinui, Omaru and Otaki, while the levels of this bacteria were comparable at the remainder of the Tämaki sites.

Good clarity was recorded at Cascade, West Hoe, Ngakaroa, Oakley, Puhinui and Otaki, with low turbidity and suspended solids readings, and high black disc readings (Figures 4.1d and 4.1h). Periods of elevated turbidity were recorded at: Mahurangi, Hoteo, Wairoa, Lucas, Oteha and Mahurangi @intake jetty. These readings were possibly the result of sediment input from heavy rainfall events. Suspended solids were generally low for all sites. Elevated suspended solids were recorded at Hoteo, Lucas, Oteha, Otara, and all of the Tamaki stream sites (except Otaki). Black disc readings indicate consistently high clarity through 2004 for most sites. Both Pakuranga @ Botany Rd, and Otaki had exceptionally high black disc readings of 2m at times. Consistently low clarity was recorded at Rangitopuni, Papakura and Puhinui. Good black disk readings were recorded for Mahurangi @ intake jetty and Mahurangi @ town bridge

For time series plots of 2004 data see Appendix 1.

Figure 4.1a : Stream water quality results. Box and whisker plots (showing medians, interquartile ranges, 10th percentiles, 90th percentiles and outliers) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

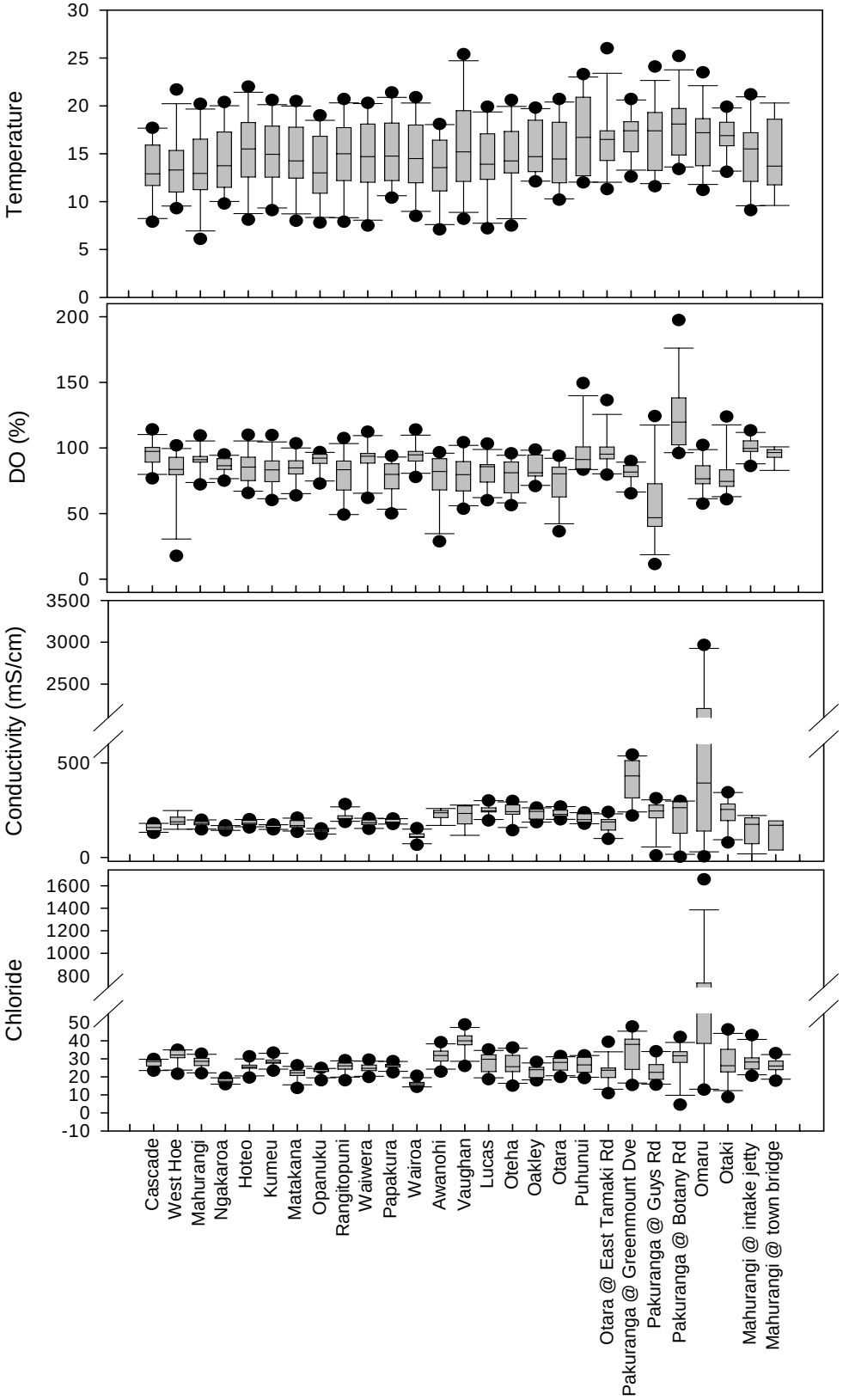

Figure 4.1b : Stream water quality results. Box and whisker plots (showing medians, interquartile ranges, 10th percentiles, 90th percentiles and outliers) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

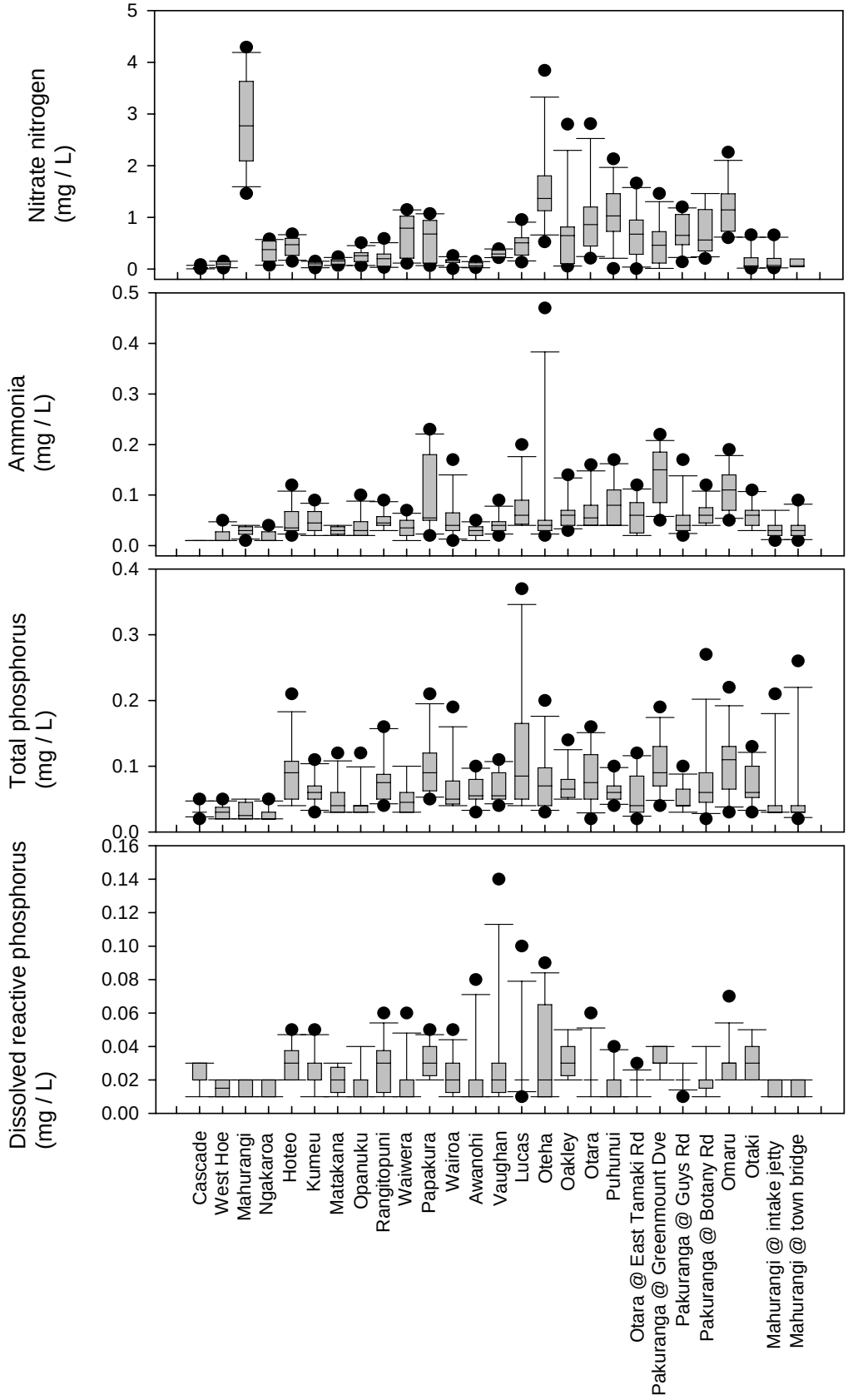

Figure 4.1c : Stream water quality results. Box and whisker plots (showing medians, interquartile ranges, 10th percentiles, 90th percentiles and outliers) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

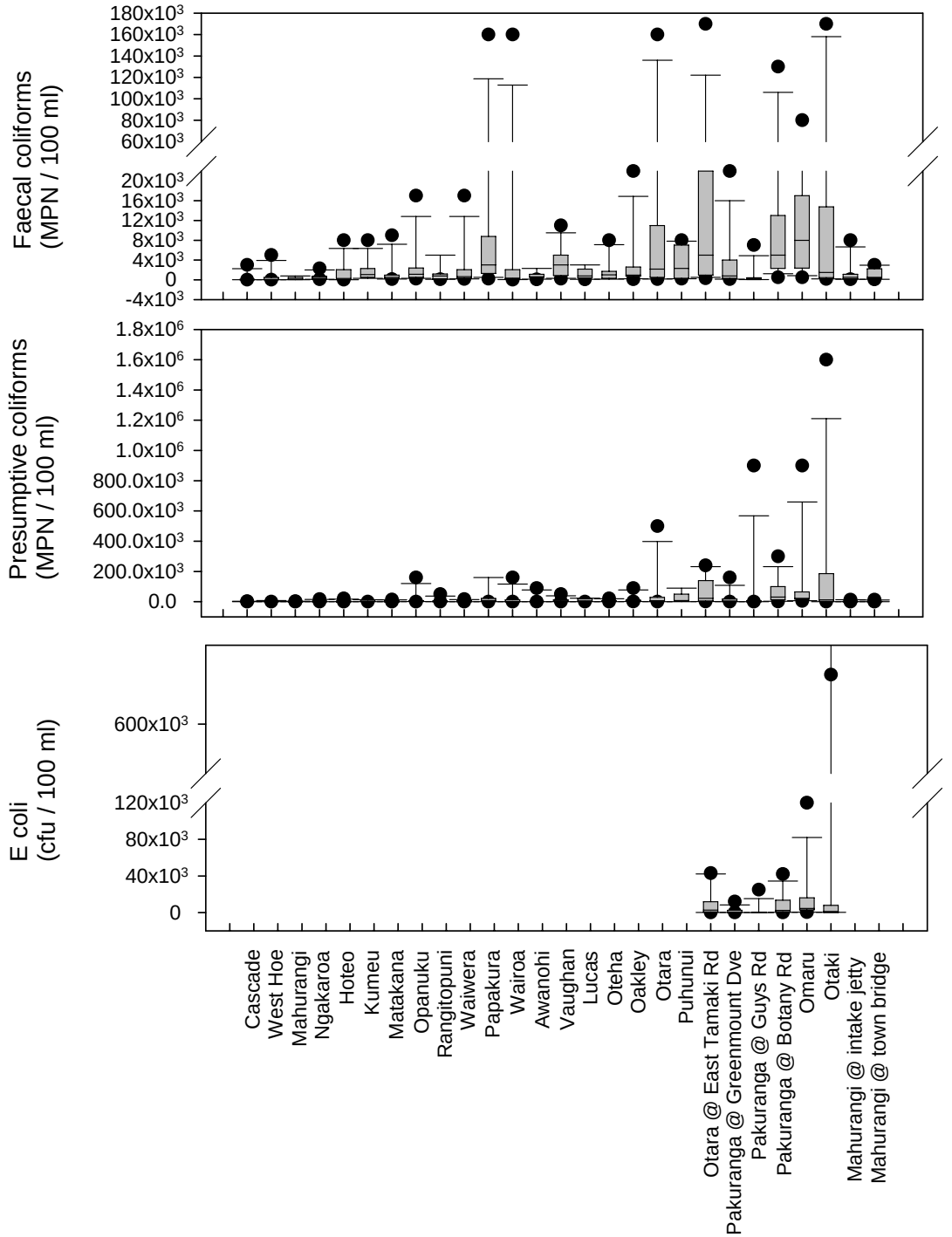

Figure 4.1d : Stream water quality results. Box and whisker plots (showing medians, interquartile ranges, 10th percentiles, 90th percentiles and outliers) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

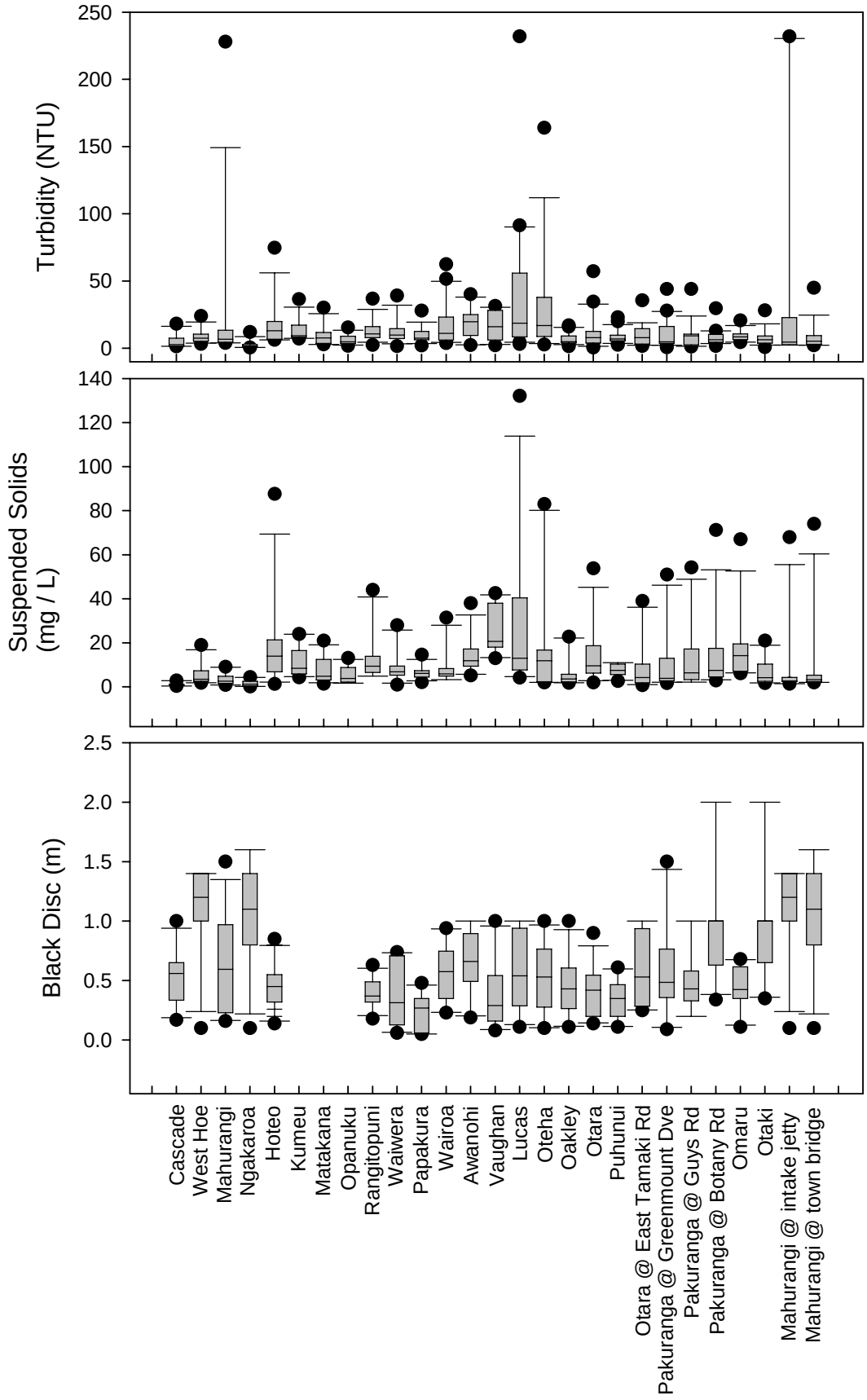

Figure 4.1e : Stream water quality results. Bar graphs (showing standard deviation and interquartile ranges) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

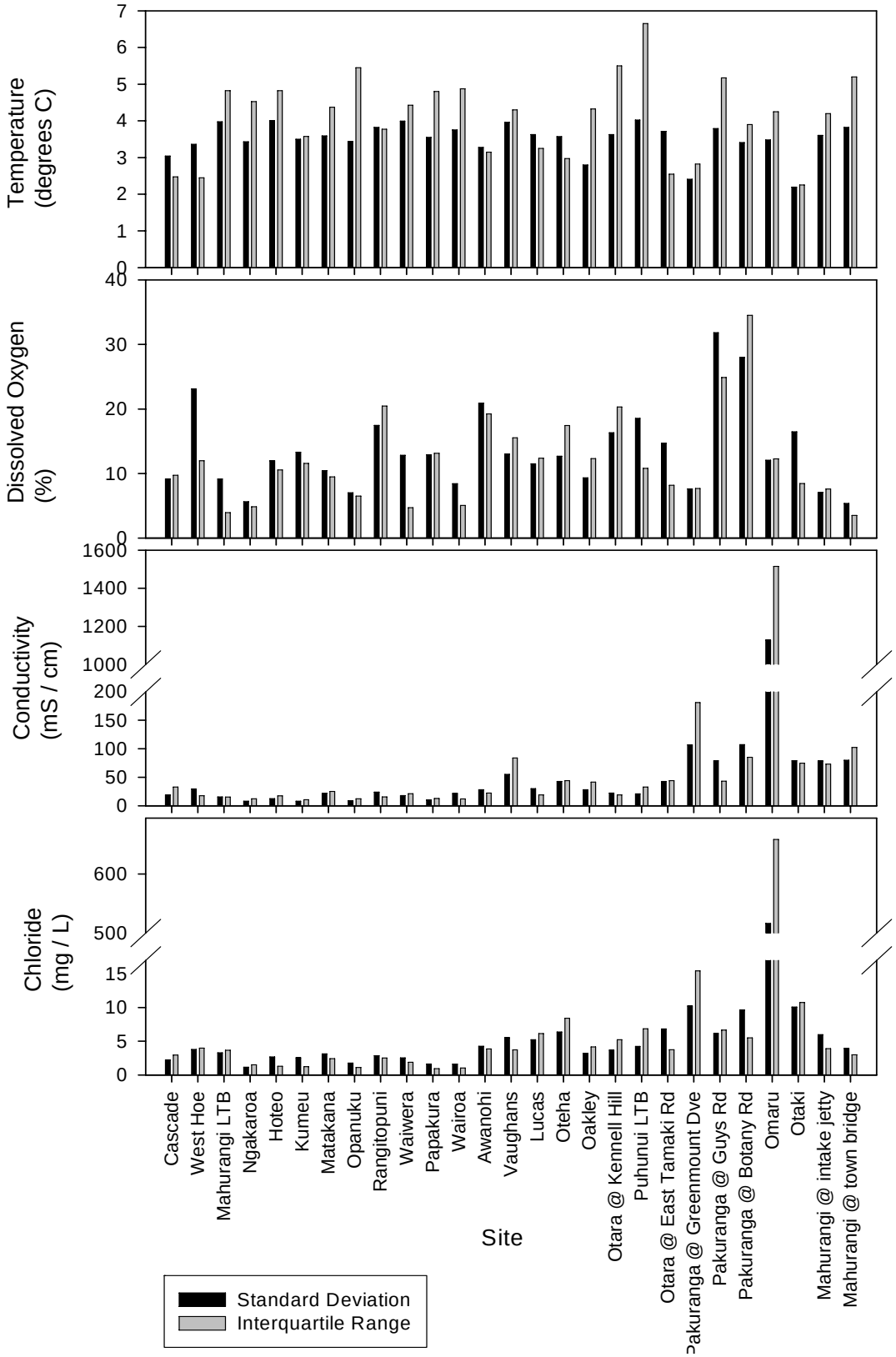

Figure 4.1f : Stream water quality results. Bar graphs (showing standard deviation and interquartile ranges) of water quality parameters obtained from monthly samples at each monitoring site in 2004.

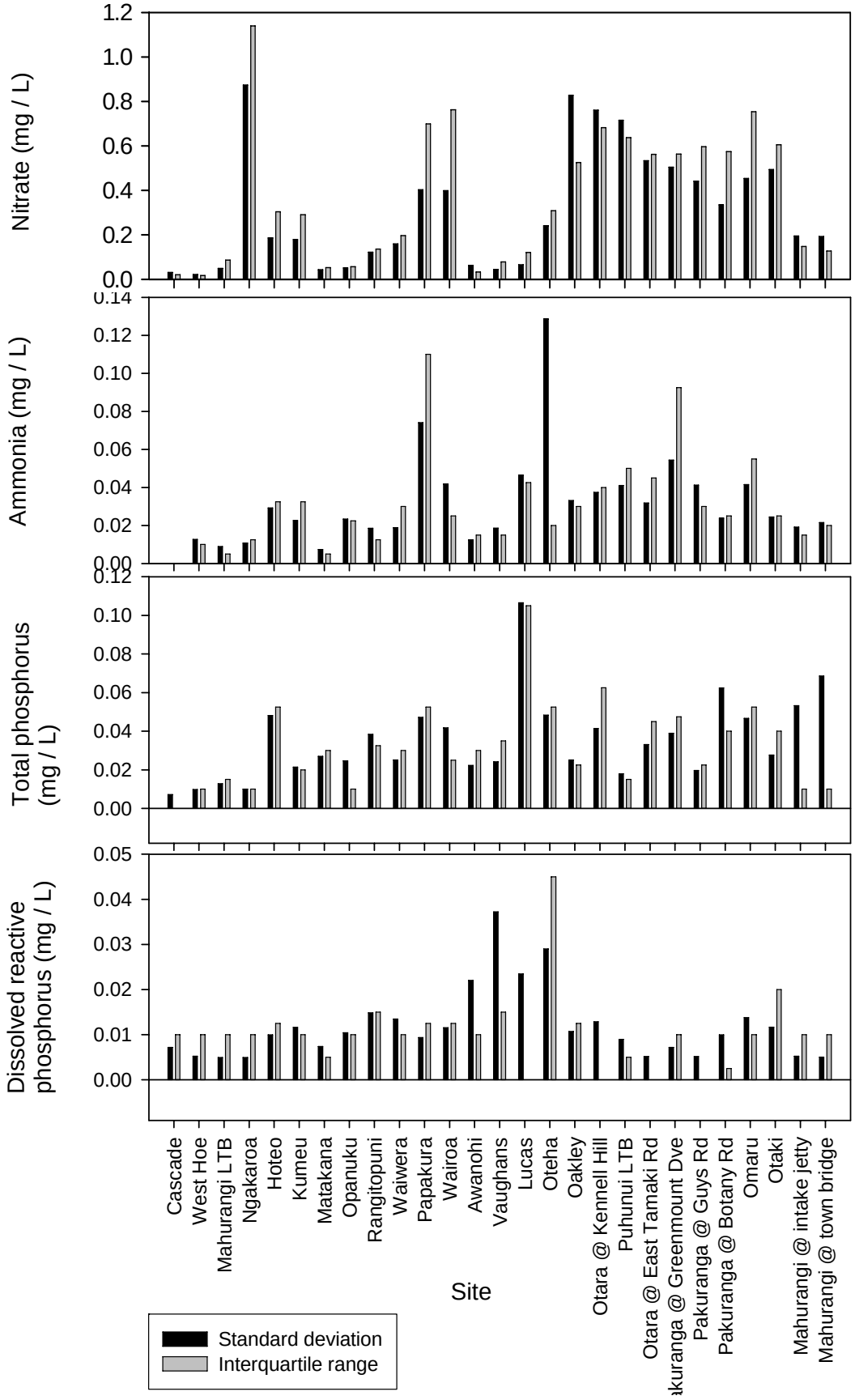

Figure 4.1g : Stream water quality results. Bar graphs (showing standard deviation and interquartile ranges) of water quality parameters obtained from monthly samples at each monitoring site in 2004.