Auckland
Regional Council
TE RAUHITANGA TAIAO

Annual Report 2002

Water quality surveys of the Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary

November 2003 Technical Publication 208

Auckland Regional Council
Technical Publication No. 208, November 2003
ISSN 1175 205X ISBN 1877353094

Printed on recycled paper

Annual Report
January – December 2002

Water Quality Surveys of Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary

Robert J. Wilcock
Michael L. Martin

Prepared for

Auckland Regional Council

ARC Technical Publication 208
Auckland Regional Council
Auckland

NIWA Client Report: ARC03277
National Institute of Water & Atmospheric Research Ltd
Hamilton

November 2003

CONTENTS

Executive Summary

This report summarises and reviews the water quality data collected from special investigation sites located in Mahurangi Harbour, Upper Waitemata Harbour, and Tamaki Estuary. The Auckland Regional Council and its antecedent organisations have been monitoring water quality as part of the Long-Term Baseline (LTB) monitoring programme since the mid-1980s. In this report monitoring data are treated in the same way as the other LTB sites that are reported annually. Time series graphs are presented for the period 1992 to 2002 and statistical analyses have been carried out summarising the year January-December 2002.

The 2002 data is similar to that of recent years and reinforces previous conclusions that Mahurangi Harbour and Upper Waitemata Harbour have generally good water quality, with improving trends for water clarity. Tamaki freshwater stream sites have the poorest water quality in terms of dissolved oxygen, associated with high rates of primary production and elevated levels of faecal bacteria. Several sites of Tamaki Estuary and, to a lesser extent, Mahurangi Harbour have high faecal bacteria concentrations that probably derive from human activities.

1. INTRODUCTION

The Auckland Regional Council (ARC) and its predecessor agency, the Auckland Regional Authority's Regional Water Board (ARWB), have regularly monitored freshwater streams since 1986, lakes since 1992 and saline (coastal and harbour) sites since 1987. This monitoring is referred to as the Long-Term Baseline Water Quality (LTB-WQ) network. The data is reviewed annually.

Sampling of sites in Upper Waitemata Harbour (UWH) and Tamaki Estuary commenced during the mid-1980s and was followed by sampling of sites within Mahurangi Harbour. The monitoring of sites within the three water bodies, referred to as the "special survey sites", was undertaken because of specific local issues within each of these semi-enclosed water bodies. Monitoring sites were chosen to represent particular local components of each survey area, in contrast with the other LTB sites, which are chosen to be regionally representative. In the Mahurangi catchment there is a small rural township at the head of the estuary, and rural and lifestyle land use elsewhere in the catchment. There is proposed urban development around the township and alongside the harbour near the mouth. Within the harbour there is commercial oyster farming and high recreation use near the mouth. UWH has five estuarine arms (Rangitopuni is the largest freshwater input); there are some urban developments, two military airfields, a maximum-security prison and light commercial activity. Tamaki Estuary is one of the most highly impacted water bodies in the Auckland region and water quality has been monitored since 1985 (ARC 1999).

The purpose of the special surveys is to answer the key questions:

What is the current water quality of these water bodies, and are they getting better or worse?

How does land use affect water quality?

How does water quality affect regional policy and programmes (and *vice versa*), and public perception of water?

Subsidiary to these aims are:

1. Identification of the present and potential impacts of catchment development activities;

2. Collection of baseline data for calibration of short-term surveys of similar areas;

3. Evaluation of improvement in water quality in response to pollution abatement activities;

4. Assessment of the effectiveness of land use planning policies intended to protect water quality;

5. Ensuring that existing environmental controls are adequate to avoid unacceptable adverse environmental impacts.

This annual report reviews all data collected at monthly intervals from the special survey sites for the period January-December 2002. From time to time reviews will be carried out examining the whole data set from 1992, when improved quality control and assurance measures were introduced in a regular and systematic manner, to the present. The first of these review documents was compiled in 2001 (Wilcock & Kemp, 2002).

2. SAMPLING SITES AND SURVEY DETAILS

All monitoring of the special survey sites is done either from land access bridges or from boats. The location of sites in Mahurangi Harbour, Tamaki Estuary and UWH are shown in Figs. 2.1-2.3.

A list of sites and their locations (map references), as well as periods that each has been monitored, is given in Table 2.1 in the order in which they are sampled in each area.

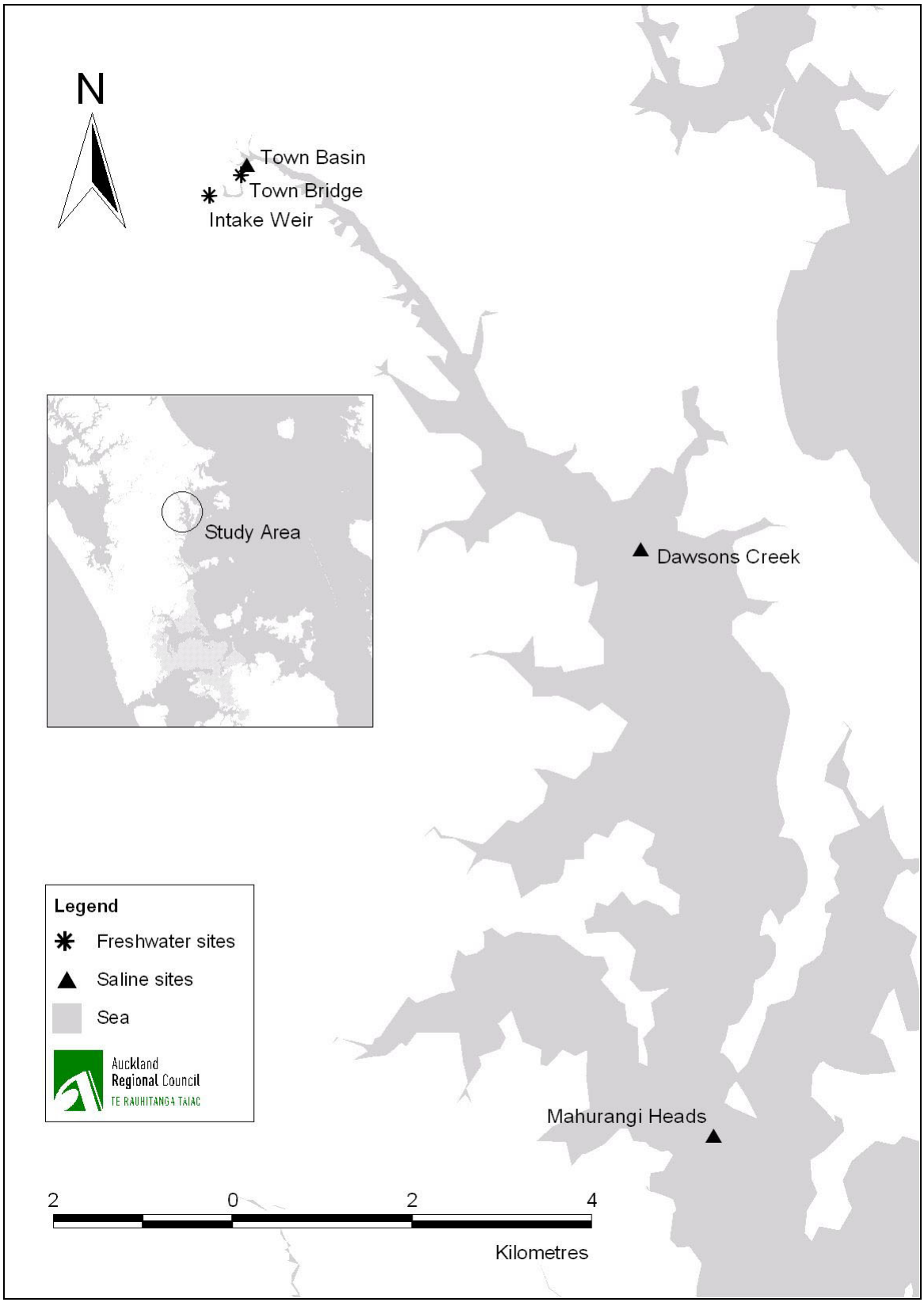


Fig. 2.1 Location of Mahurangi Harbour special survey sites.

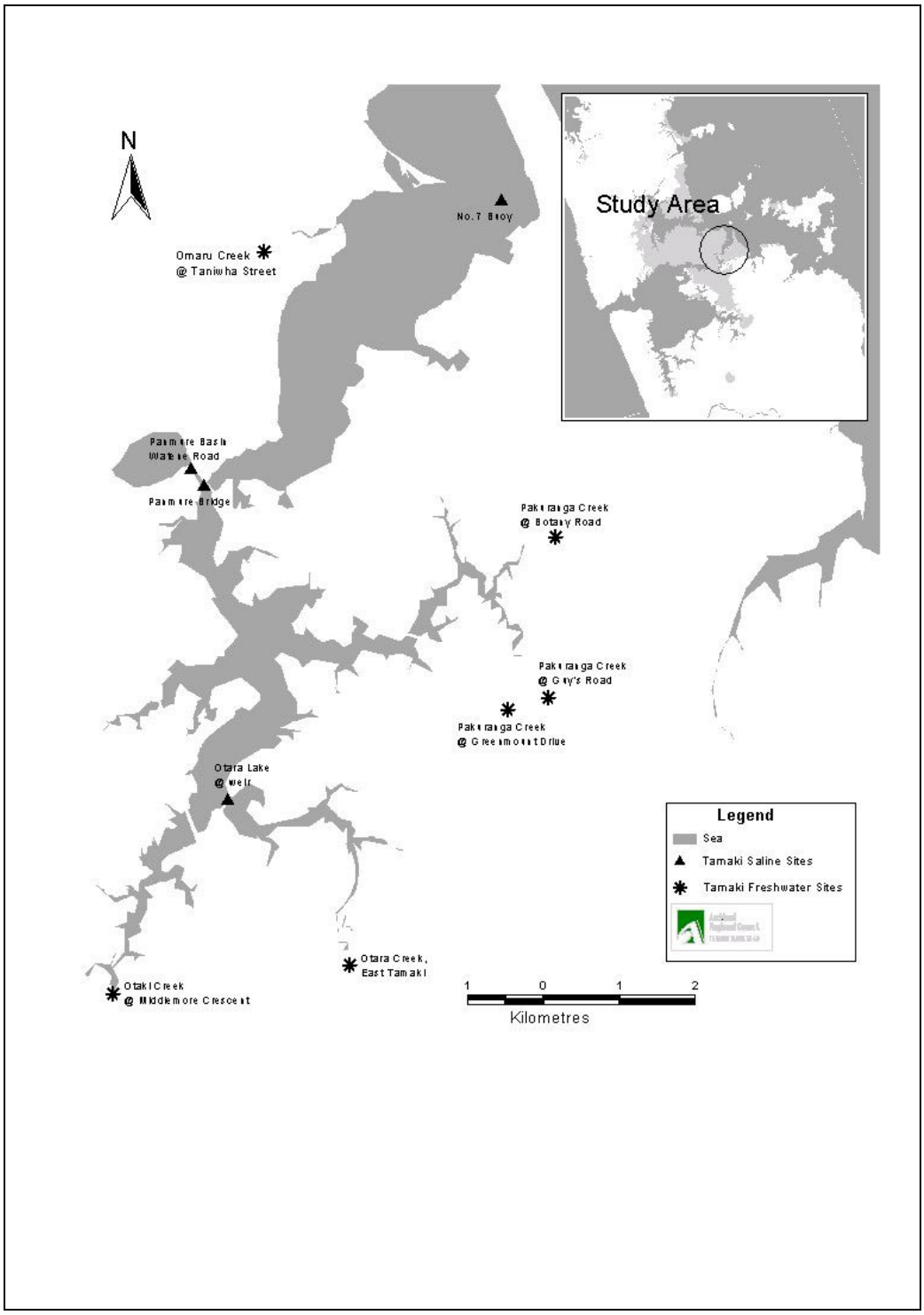


Fig. 2.2 Location of Tamaki Estuary special survey sites.

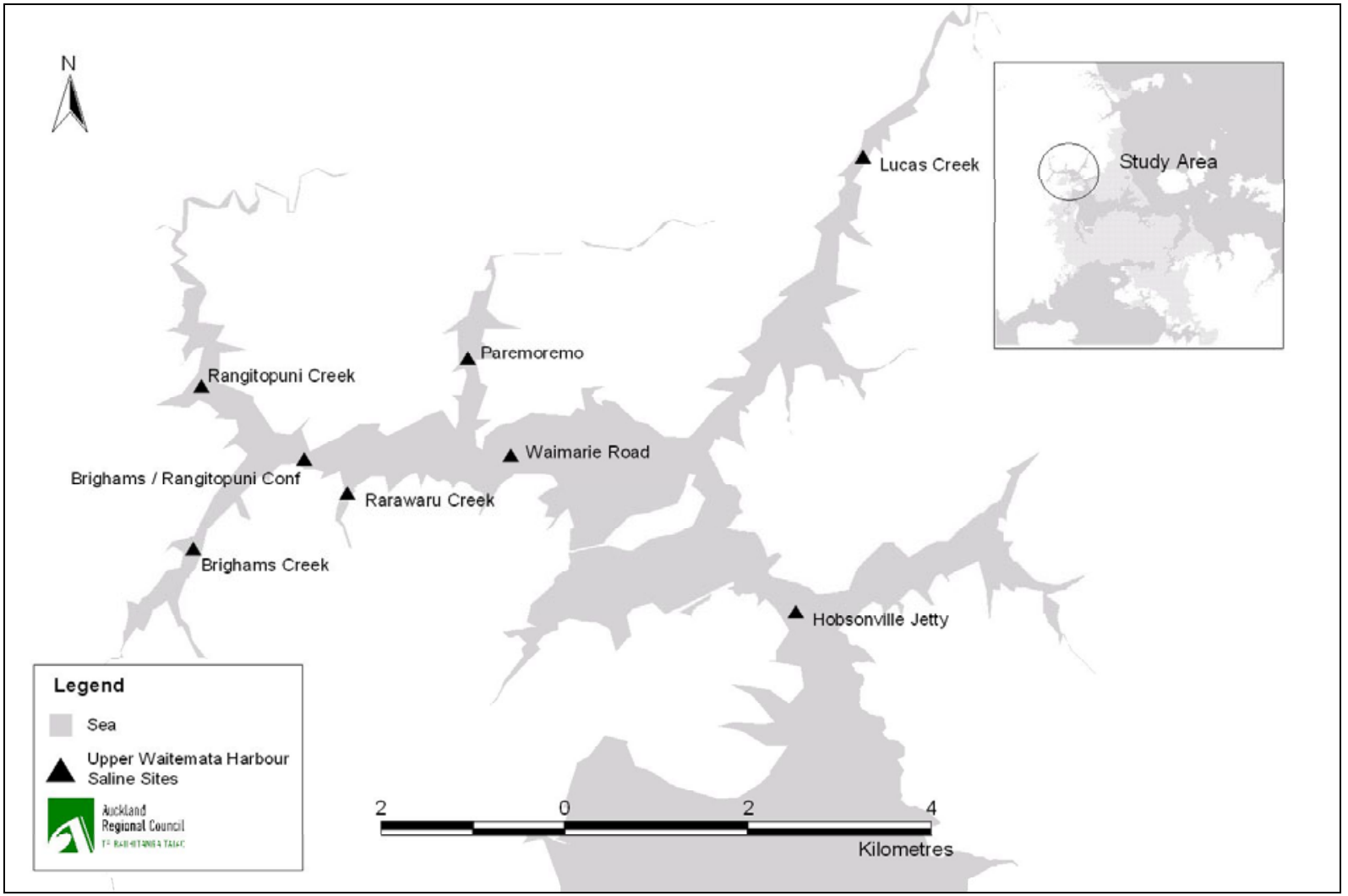


Fig. 2.3 Location of Upper Waitemata Harbour special survey sites.

Table 2.1 Special survey monitoring sites (codes), map references and monitoring periods.

Site (code)	Depths (m)	Map reference NZMS 260	Monitoring period
Mahurangi streams			
Supply Intake Jetty (M01)	0	R09: 593 321	7/7/93 – 5/12/02
Warkworth Town Bridge (M02)	0	R09: 596 323	7/7/93 – 5/12/02
Mahurangi saline			
Warkworth Town Basin – surface (M03) and subsurface (M04)	0, 1	R09: 597 324	7/7/93 – 5/12/02
Dawsons Creek – surface (M05) and subsurface (M06)	0, 1	R09: 640 280	6/5/93 – 5/12/02
Mahurangi Heads – surface (M07) and subsurface (M08)	0, 5	R09: 649 216	2/9/93 – 5/12/02
Tamaki streams			
Otara Creek - East Tamaki Rd (T1)	0	R11: 778 693	9/11/92 – 17/12/02
Pakuranga Creek - Greenmount Drive (T2)	0	R11: 799 725	9/11/92 – 17/12/02
Pakuranga Creek - Guys Rd (T3)	0	R11: 804 727	9/11/92 – 17/12/02
Pakuranga Creek - Botany Rd (T4)	0	R11: 812 747	9/11/92 – 17/12/02
Omaru Creek - Taniwha St (T6)	0	R11: 771 786	9/11/92 – 17/12/02
Otaki Creek – Middlemore Crescent (T7)	0	R11: 747 689	9/11/92 – 17/12/02
Tamaki saline			
No. 7 Buoy (saline site 1)	0, 5, bottom	R11: 799 792 approximate	9/11/92 – 17/12/02
Panmure Basin	0	R11: 758 756	9/11/92 – 15/4/99
Panmure Bridge (saline site 2)	0	R11: 759 754	14/5/99 – 17/12/02
Otara Lake at weir	0	R11: 762 713	16/5/95 – 20/2/01
Upper Waitemata Harbour			
Hobsonville Jetty (UW1)	0, 1	R11: 597 891	22/7/93 – 6/12/02
Lucas Creek (UW2)	0, 1	R10: 588 911	22/7/93 – 6/12/02
Waimarie Road (UW3)	0, 1	R10: 567 907	22/7/93 – 6/12/02
Paremoremo Ski Club (UW4)	0, 1	R10: 562 919	22/7/93 – 6/12/02
Rarawaru Creek (UW5)	0, 1	R10: 549 904	22/7/93 – 6/12/02
Brighams/Rangitopuni Confluence (UW6)	0, 1	R10: 541 909	22/7/93 – 6/12/02
Brighams Creek (1 km from confluence) (UW7)	0, 1	R10: 534 900	22/7/93 – 6/12/02
Rangitopuni Creek (UW8)	0, 1	R10: 534 915	22/7/93 – 6/12/02

3. WATER QUALITY VARIABLES

The water quality variables measured during each sampling run are a combination of physical observations, *in situ* meter readings (Table 3.1), and chemical and biological analysis of collected samples in the laboratory (Table 3.2).

Some observations have not been transcribed to a spreadsheet format and are only documented on ARC field notes, or laboratory notes. These are indicated (*).

Water quality data for the period 1992-2002 that are the primary focus of this report are underlined.

A description of the reasons for choosing to monitor these variables, their major sources and their impacts on water quality and aquatic life is given elsewhere (ARWB 1982; ARC 1995; Wilcock & Stroud 2000). The chosen variables principally describe water clarity and appearance, nutrient status, biological productivity (in response to nutrient inputs) and physical conditions important for supporting aquatic life. They do not include toxicants, such as heavy metals and organochlorine insecticides.

Table 3.1 Field measurements.

Sample collection time (*)	(NZ Standard Time, 24 h clock)
Ambient weather conditions (*)	(Beaufort scale)
Ambient water conditions (*)	(Colour, Clarity, Odour)
Sample depth	m
Water temperature	°C
Dissolved oxygen	mg/L
Dissolved oxygen saturation	%
Salinity	ppt
Conductivity	mS/m
Secchi disc depth (saline only)	m
Black disk (streams only)	m
General comments	

Table 3.2 Laboratory analyses.

Presumptive (total) coliforms	(MPN/100 ml)	M, T, U
Faecal coliforms	(MPN/100 ml)	M, T, U
E. coli (freshwater sites only)	(MPN/100 ml)	T
Enterococci (saline sites only)	(cfu/100 ml)	M, T, U
pH	units	M, T, U
Turbidity	(NTU)	M, T, U
Conductivity	(mS/m at 25°C)	M
Suspended solids (Non-filtrable residue)	(mg/L)	M, T, U
Dissolved oxygen saturation	(%)	M, T, U
Biochemical oxygen demand	(mg/L)	M, T, U
Chloride	(mg/L)	M, T, U
Nitrite nitrogen, NO_2-N	(mg/L)	M, T, U
Nitrate nitrogen, NO_3-N	(mg/L)	M, T
Total ammonia nitrogen, NH_4-N	(mg/L)	M, T, U
Total phosphorous, TP	(mg/L)	M, T, U
Dissolved (soluble) reactive phosphorous, DRP	(mg/L)	M, T, U
Salinity	ppt	M, U
Chlorophyl *a*	mg/L	M, T (saline), U

Notes

M = Mahurangi Harbour; T = Tamaki Estuary; U = Upper Waitemata Harbour

Throughout this report we refer to concentrations for many water quality variables (SS, Cl, DO, NH_4-N, NO_2-N, NO_3-N, DRP, TP, BOD) in units of milligrams per litre, or mg/L. Note that mg/L = g/m^3 (g m^{-3}) = parts per million (ppm).

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

Presumptive coliform may be approximated to "Total coliform".

Chemical oxygen demand (COD) and total copper, iron and zinc were determined on samples from Pakuranga Creek at Greenmount Drive (only), starting from January 2001, as a cross-reference to landfill Consent monitoring activities.

4. METHODS

4.1 Sampling Procedures

Sampling protocols for the special survey sites are detailed in the following ARC reports for Long Term Baseline Program Coastal/Saline Sampling Protocols: Mahurangi Estuary 2nd Edition (May 1999), Upper Waitemata Harbour 2nd Edition (May 2002), and Tamaki Estuary 3rd Edition (May 2002). Timing of each run is critical, to ensure samples are collected on the same relative stage of the tide, and to ensure that temporal variability is minimised. Samples at all sites are collected within the time window: 08:00 - 12:00, New Zealand Standard Time (NZST).

All samples collected in the surveys were analysed by the Watercare Services Ltd Laboratory at Mangere. 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).

4.2 Statistical Analysis

Statistical treatment of the data follows the protocol described in TP190 (Wilcock & Kemp, 2002), which is that used for the LTB water quality surveys.

Water quality results are characteristically highly variable because of the wide variety of external factors influencing them. Because most of the parameters are non-normally distributed the median has been used in this report as the measure of central tendency (typical value). The median is the middle value (or the mean of two middle values) when data are arranged in increasing or decreasing order of magnitude. Because it is based on rank rather than value, the median is not as easily affected by extreme values as the mean. All outliers were included in calculation of summary statistics unless they were obvious typographical errors.

Variability in the data has been expressed as the interquartile range divided by the median (IQR/M). This value is the non-parametric equivalent of the coefficient of variance.

Until March 1994 UWH sites were taken at both the surface and at a depth of one metre. For a time after this, composite samples were collected for analysis. Currently,

samples are taken from the surface and for that reason only surface water quality data from UWH sites has been subjected to statistical analysis.

Tables are listed in the Appendices giving monthly data for each variable at all sites, and are summarised by median and IQR/M (%) values for the year Jan-Dec 2002. Time-series plots for the entire monitoring records of each site, for which data with adequate quality assurance has been recorded, follow the tables of data.

5. RESULTS

5.1 Water Quality Data

5.1.1 What it tells us

A comprehensive description of each of the water quality variables cited in this report is given in Appendix 64. Black disc and Secchi disc depth data tell us how clear or turbid the water is. This is negatively correlated with turbidity and suspended solids and generally has larger values (i.e., greater clarity) in pristine sites than in sites affected by inputs of sediment (such as urban storm-water from new subdivisions) and the presence of algae caused by high nutrient concentrations.

Chloride and conductivity are not as affected by human activities as the other variables and reflect the relative proportions of freshwater and salt water. Conductivity in freshwater streams is affected by large rainfall events that generate runoff.

Dissolved oxygen (DO) varies diurnally depending upon the amount of plant biomass in the channel producing photosynthetic inputs, the demand on oxygen (BOD) caused by decomposing organic matter, and exchange with the atmosphere produced by turbulence at the air-water interface. Low DO often indicates inputs of degrading organic wastes (such as from sewage and farm effluents), whereas high DO values (> 100%) are attributable to photosynthesis by aquatic plants, including algae. The DO regime dictates the type of aquatic ecosystem that can survive in a given water body.

Presumptive and faecal coliform concentrations indicate the presence of faecal material and the possible presence of pathogenic organisms, such as *Campylobacter, Giardia* cysts and *Cryptospiridium* oocysts.

Ammonia, nitrite and nitrate are indicative of waste inputs from warm-blooded animals, including humans (from sewage effluent), and fertilizer. Nitrite (NO_2-N) is a short-lived intermediate for the transformation of ammonia nitrogen (NH_4-N) to nitrate nitrogen (NO_3-N) and is a useful indicator of how recently pollution events may have occurred. High NH_4-N, in concert with elevated pH and temperatures, can be harmful to many aquatic species because the proportion of the toxic un-ionised NH_3 increases with respect to the more common and much less toxic ammonium ion (NH_4^+) see (Appendix 64).

Dissolved reactive phosphorus (DRP) concentration indicates the potential for eutrophication, whereas total phosphorus (TP) includes DRP and P that is in algal biomass. TP and DRP levels should decline with distance away from land-based sources, such as streams and discharges from wastewater treatment plants.

Temperature and pH are master variables that affect the biological activity of other pollutants as well as determining habitat quality. Seawater pH is strongly buffered so that small changes indicate either large inputs of freshwater, or faulty measuring technique.

5.1.2 "Less than" or "greater than" values

Where values are reported as being less than a detection limit, half that value is cited in the tables (e.g., < 2 mg/L for BOD is cited as 1.0 mg/L). Values exceeding some operational upper limit are nominally given this value in the tables (e.g., >16000 MPN/100 mL for presumptive coliform is cited as 16000 MPN/100mL). In many cases detection limits are set too high for useful information about water quality of natural waters. For example, a DL of 2 mg/L for BOD is not useful, when the bulk of the data is less than this.

5.2 The Data

5.2.1 Water clarity and suspended solids

Water clarity in Mahurangi Harbour is moderate-to-good (apart from times when occasional storms mobilise sediments) and typical of estuarine and harbour waters, with generally low turbidity and suspended solids (SS) values. Secchi values are greatest at Mahurangi Heads and, in general, data are similar to those for 2001 and for the long-term median values (Wilcock & Kemp, 2002).

Tamaki Estuary and UWH sites had similar results to past years (Wilcock & Kemp, 2002). Pakuranga Creek at Guys Road is the most turbid of the Tamaki sites, but there is little difference between the UWH sites.

5.2.2 BOD

BOD values were for the most part below the detection level of 2 mg/L, and have been given a value of 1 mg/L (see 5.1.2). Some occasional values of 2-5 mg/L were noted but medians at all sites were 1 mg/L, indicative of low levels of organic pollution.

5.2.3 Chloride, conductivity and salinity

Chloride, conductivity and salinity data indicate the degree of mixing of saltwater with freshwater and hence, the consistency of timing of sampling. Results for Mahurangi Harbour sites are similar to other years with the exception of the very low values for Town Basin surface water recorded on 15 July 2002. The fact that three independent measurements of ionic strength agreed indicates that on this occasion the sample was dominated by freshwater.

Results for Tamaki Estuary and UWH are similar to other years and show the variable mixtures of saline and freshwater in some Tamaki sites, and the comparative uniformity of the UWH sites, albeit with a gradient from Rangitopuni Creek to Hobsonville Jetty.

5.2.4 Dissolved oxygen

Mahurangi and UWH site DO results were similar to previous years, showing these waters to be well-oxygenated with daytime medians of 72-94% saturation. Tamaki Estuary sites were also similar to data from previous years, with Pakuranga Creek – Botany Road having supersaturated waters on all sampling occasions, indicative of vigorous plant growth and photosynthetic production. The Omaru Creek had consistently lower values than other Tamaki sites, with a minimum value of 24%.

5.2.5 Microbial quality

Concentrations of presumptive and faecal coliform were similar to values measured in recent years, for all sites. Faecal coliform medians showed a pattern of being highest in creeks and headwater sites, and lowest in open harbour waters nearest the heads. Median faecal coliform levels were 1-1000 MPN/100 mL in Mahurangi Harbour, 2-6500 and 3-155 MPN/100 mL in Tamaki Estuary and UWH, respectively. The highest observed value was 240,000 MPN/100 mL recorded for Pakuranga Creek-Botany Road (also having the highest median at 6500 MPN/100 mL) and Otaki Creek-Middlemore Crescent. Median values can be compared with bathing water and shellfishing water guidelines (ANZECC, 2000), which are 150 MPN/100 mL and 14 MPN/100 mL, respectively (note the precise wording of these guidelines with respect to sampling).

Enterococci and *E. coli* levels (measured only for freshwater sites in Tamaki estuary) were similar to the previous year and declined in magnitude as one moves away from land sources and freshwaters towards the harbour entrances.

Enterococci levels at several sites in the Town Basin sites (surface and 1 m depth) in Mahurangi Harbour frequently breached the Alert/Amber mode, for which a single sample has a value greater than 136 enterococci/100 mL (MfE, 2002). *E. coli* concentrations in Tamaki Estuary had a similar pattern to the faecal coliform data.

5.2.6 N nutrients

In nearly all cases data for ammonia, nitrite and nitrate nitrogen were low in magnitude and similar to values measured in recent years. A notable exception was that all three water quality variables were greater than usual for the 15 July Mahurangi Heads 5 m depth sample, indicating the possible presence of wastewater or stormwater. On this occasion the concentrations of NH_4-N, NO_2-N and NO_3-N for this site were (with median values in brackets) 0.19 (0.005), 0.012 (0.001) and 0.072 (0.014) mg/L, respectively. Median concentrations of NH_4-N, NO_2-N and NO_3-N for all sites were ≤ 0.2, 0.1 and 1 mg/L, respectively, for the three water bodies. The ANZECC (2000) NH_4-N trigger value for protection of 95% of freshwater species is 0.90 mg/L, and the corresponding value for 80% species protection is 2.3 mg/L (these values are for total ammonia at pH 8).

5.2.7 P nutrients

In general, concentrations of DRP and TP were consistently low, being typically 0.01-0.05 mg/L and 0.02-0.5 mg/L, respectively, at all sites in the three harbours. Of note was the 29 January sample from Pakuranga Creek – Botany Road, which had concentrations of 0.37 and 1.2 mg/L for DRP and TP, respectively. This site also has consistently high DO values in daytime that are almost certainly associated with aquatic plant productivity (see 5.2.4).

5.2.8 pH and temperature

Temperature and pH values were similar to past measurements. A pH value of 9.4 was recorded for Pakuranga – Guys Road (18 November 2002) and may be anomalous.

5.2.9 Chlorophyll *a*

Long-term median concentrations of chlorophyll *a* for all the sampled sites were about 0.002-0.008 mg/L with UWH sites in river estuaries having the highest values. Chlorophyll *a*/phaeophyton ratios were calculated for three Tamaki Estuary and all UWH sites. Ratios were difficult to quantify because they were reported as being greater than some non-standard value, which varied for each measurement. By

setting the nominal detection limit as the value for each ratio we obtained values that were about 0.6 in Tamaki estuary and 0.7-2.0 in UWH.

5.2.10 COD and total Cu, Fe and Zn

These water quality variables were measured only at the Pakuranga Creek – Greenmount site, starting in January 2001. Total copper and zinc concentrations were nearly all well above the trigger value for the 95% level of protection of marine species (ANZECC, 2000), although it should be noted that the trigger values are for dissolved metals. For the LTB freshwater sites, dissolved Cu is on average nearly 100% of total Cu whereas dissolved Zn comprises 30-70% of total Zn (Wilcock & Kemp, 2002). Assuming similar proportions for the Pakuranga – Greenmount site (also freshwater) then we can say tentatively that the Cu trigger value was exceeded on most occasions but that Zn concentrations were similar to or less than the ANZECC trigger value for the 95% level of protection.

There are no guideline values for total iron or for COD. Given the insensitivity of BOD measurements (DL = 2 mg/L) there is some good reason to include COD in the analytical suite because it gives a more meaningful result.

5.2 Between-site Comparisons

5.3.1 Mahurangi Harbour

Nutrient data show that, in general, Dawson's Creek (surface and 1 m depth) and the Mahurangi Heads sites have the lowest concentrations. Chlorophyll *a* results indicate little difference between sites.

BOD and DO values are generally uniform at all sites other than Warkworth Town Basin, which is clearly more adversely affected than the others.

Bacterial quality varies greatly between sites and there is a clear distinction between the inner four sites (Supply Jetty, Town Bridge and Town Basin surface) and the outer sites (Dawson's Creek and Mahurangi Heads).

5.3.2 Upper Waitemata Harbour

Secchi values indicate that the Hobsonville site has better visual clarity than other sites in UWH. Harbour water (Hobsonville and Waimarie) nutrient concentrations are

generally lower than are those in river estuaries, but differences are small and UWH has the most uniform water quality of the three water bodies.

Bacterial quality is best at Hobsonville Jetty and worst for Rarawaru Creek, Brigham's Creek and Rangitopuni Creek.

5.3.3 Tamaki Estuary

There was a clear pattern for nitrate nitrogen and faecal bacteria concentrations, with the freshwater sites (Otara Creek, the three Pakuranga Creek sites, Omaru Creek and Otaki Creek) markedly higher than the saline sites (the No. 7 Buoy sites and Panmure Bridge).

6. SUMMARY AND CONCLUSIONS

The monitoring data for freshwater and saline sites in Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary provides a valuable resource describing three different but important water bodies in the Auckland region. Each water body is being subjected to different kinds of pressure from urban development and increasing population in the region. Monitoring projects such as this serve as a basis for rational decision making by enabling changes over time to be observed continuously.

The 2002 monitoring data is of good quality and has similar values for water quality variables to those measured in recent years.

7. REFERENCES

ANZECC (2000). National water quality management strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australia.

APHA (1992). Standard methods for the examination of water and wastewater 18th edition. American Public Health Association, American Waterworks Association, Water Environment Federation. 949p.

ARC (1995). Baseline water quality survey of the Auckland region. Annual report April 1993-March 1994. Technical Publication 65, Auckland Regional Council Environment.

ARC (1999). Tamaki Estuary water quality survey 1985-1997. Review report. Technical Publication 105, Auckland Regional Council.

ARWB (1982). Baseline data on water quality in the Auckland region obtained from 1977-82. Technical Report 22, Auckland Regional Water Board.

MfE (2002). Microbial water quality guidelines for marine and freshwater recreational areas, Ministry for the Environment, Wellington.

MoH (2000). Drinking water standards for New Zealand, Ministry of Health, Wellington.

MWD (1987). Lake managers' handbook. Miscellaneous Publication 103, Water and Soil Conservation Authority, Ministry of Works and Development, Wellington.

USEPA (1985). Ambient water quality criteria for ammonia 1984. EPA-440/5-85-001. National Technical Information Service, Springfield, VA.

USEPA (1999). 1999 Update of ambient water quality criteria for ammonia. EPA-822-R-99-014. US Environmental protection Agency, Washington, DC.

Wilcock, R.J.; Stroud, M.J. (2000). Summary Report – Long-term baseline water quality – stream, lake and saline waters. Prepared by the National Institute of

Water and Atmospheric Research under contract with the Auckland Regional Council. Technical Publication 132.

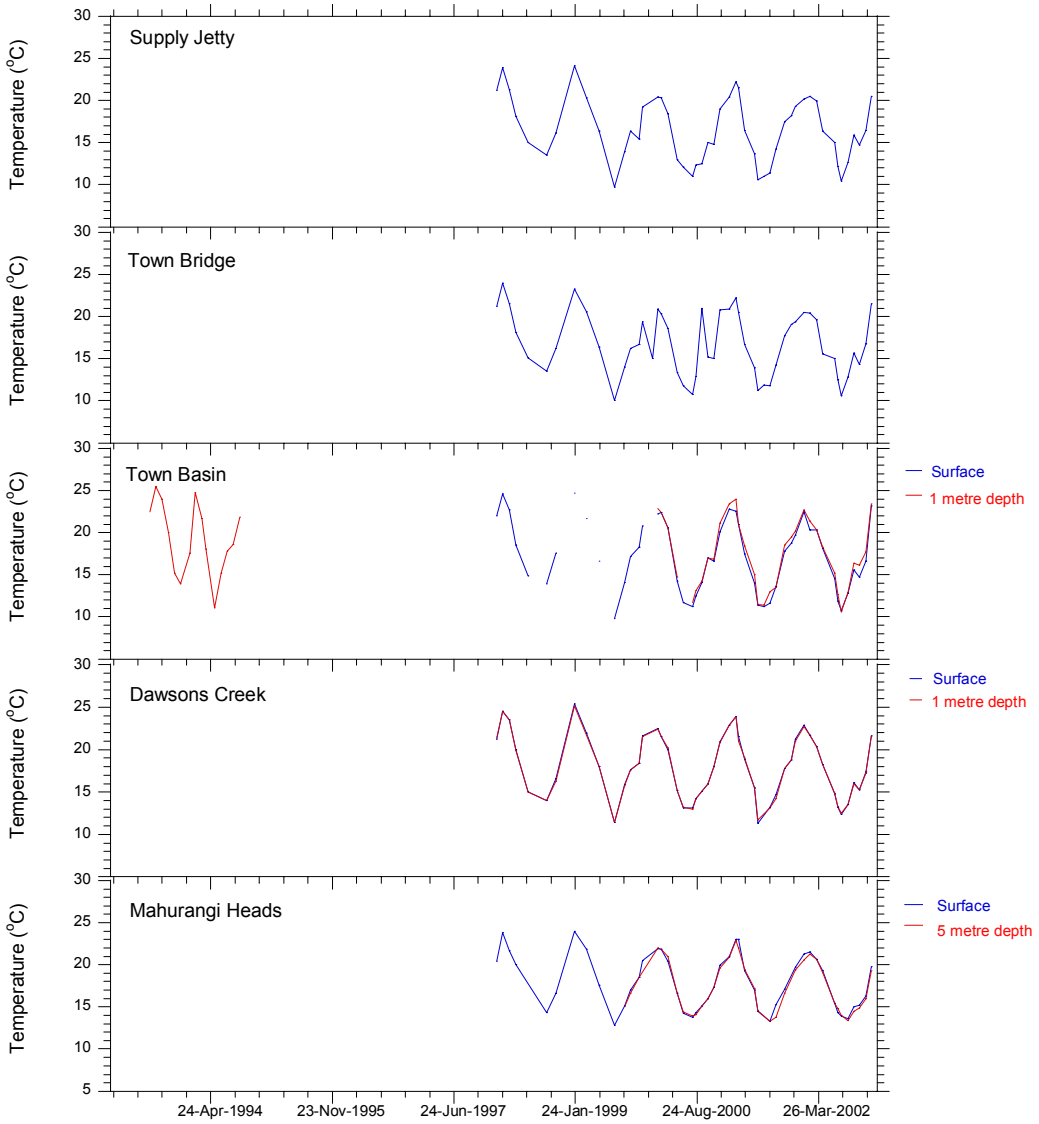
Wilcock, R.J.; Kemp, C.L.S. (2002). Water quality surveys of Mahurangi Harbour, Upper Waitemata Harbour and Tamaki Estuary 1992-2001. Client Report ARC02277/2, prepared for ARC.

APPENDIX 1: MAHURANGI HARBOUR – TEMPERATURE

a) Temperature (°C) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	20.2	20.5	22.5	22.7	22.9	22.7	21.3	20.6
13-Feb-2002	20.5	20.4	20.3	21.4	21.7	21.7	21.5	21.3
18-Mar-2002	19.9	19.6	20.3	20.3	20.4	20.4	20.7	20.7
16-Apr-2002	16.4	15.6	18.1	18.3	18.2	18.2	19.3	19.1
13-Jun-2002	15.0	15.0	14.6	15.2	14.8	14.9	15.4	15.4
26-Jun-2002	12.2	12.5	11.9	12.7	13.2	13.3	14.3	14.8
15-Jul-2002	10.4	10.6	10.8	10.6	12.3	12.5	13.9	14
13-Aug-2002	12.7	12.8	12.8	12.9	13.5	13.5	13.6	13.4
10-Sep-2002	15.9	15.7	15.6	16.4	16.1	16.0	15.0	14.5
8-Oct-2002	14.7	14.3	14.7	16.1	15.3	15.3	15.2	14.9
7-Nov-2002	16.5	16.8	16.6	17.7	17.4	17.2	16.3	16
5-Dec-2002	20.5	21.5	23.2	23.4	21.6	21.6	19.8	19.3
Median	16.2	15.7	16.1	17.1	16.8	16.6	15.9	15.7
IQR/Median %	36	38	38	35	37	37	33	31

b) The graphs on the following pages show temperature measurements from 1993 to December 2002 (where data available).

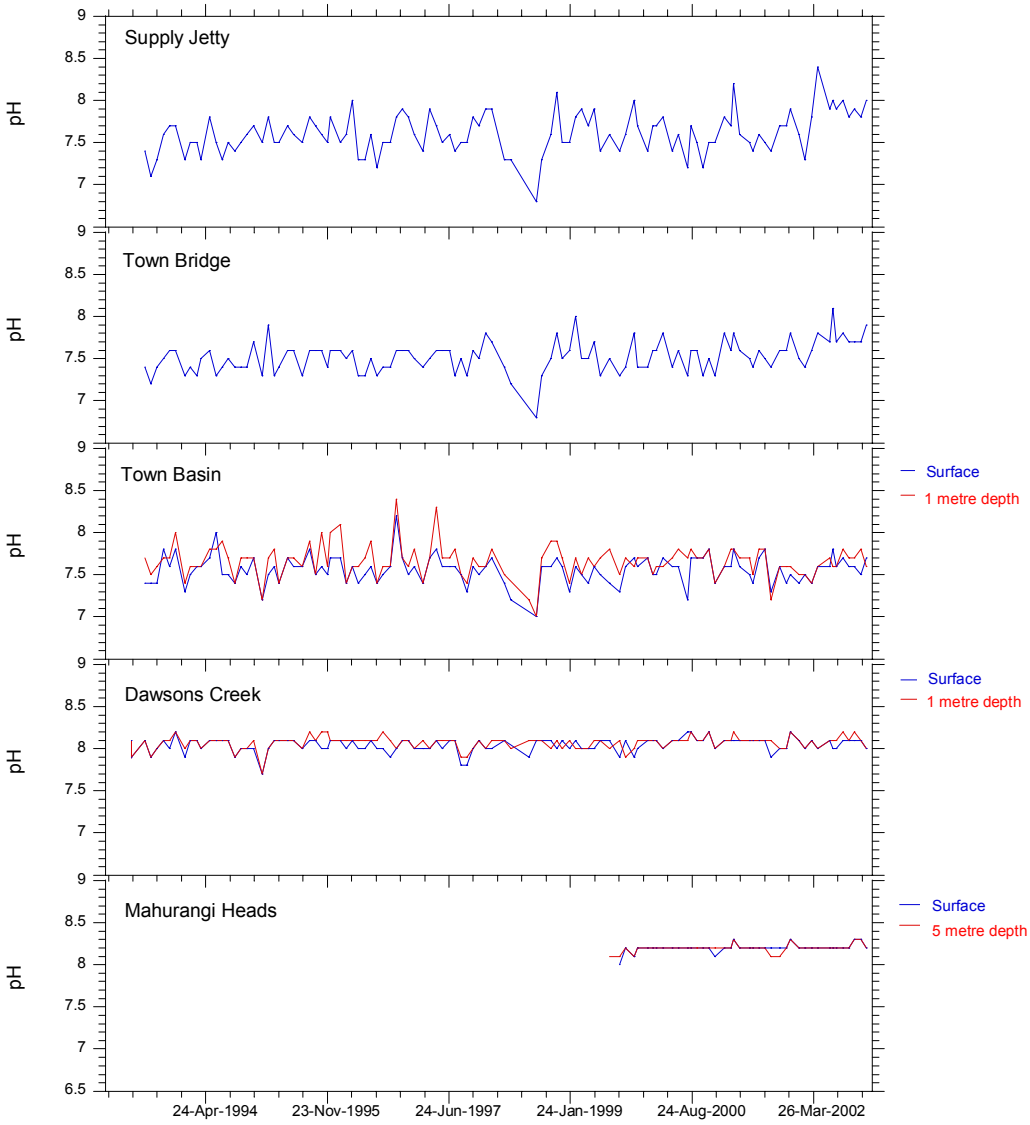

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Temperature (°C)
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 2: MAHURANGI HARBOUR – pH

a) pH (units) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	7.6	7.5	7.4	7.5	8.1	8.1	8.2	8.2
13-Feb-2002	7.3	7.4	7.5	7.5	8.0	8.0	8.2	8.2
18-Mar-2002	7.8	7.6	7.4	7.4	8.1	8.1	8.2	8.2
16-Apr-2002	8.4	7.8	7.6	7.6	8.0	8.0	8.2	8.2
13-Jun-2002	7.9	7.7	7.6	7.7	8.1	8.1	8.2	8.2
26-Jun-2002	8.0	8.1	7.8	7.6	8.0	8.1	8.2	8.2
15-Jul-2002	7.9	7.7	7.6	7.6	8.0	8.1	8.2	8.2
13-Aug-2002	8.0	7.8	7.7	7.8	8.1	8.2	8.2	8.2
10-Sep-2002	7.8	7.7	7.6	7.7	8.1	8.1	8.2	8.2
8-Oct-2002	7.9	7.7	7.6	7.7	8.1	8.2	8.3	8.3
7-Nov-2002	7.8	7.7	7.5	7.8	8.1	8.1	8.3	8.3
5-Dec-2002	8.0	7.9	7.7	7.6	8.0	8.0	8.2	8.2
Median	7.9	7.7	7.6	7.6	8.1	8.1	8.2	8.2
IQR/Median %	3	2	2	2	1	0	0	0

b) The graphs on the following pages show pH measurements from 1993 to December 2002 (where data available).

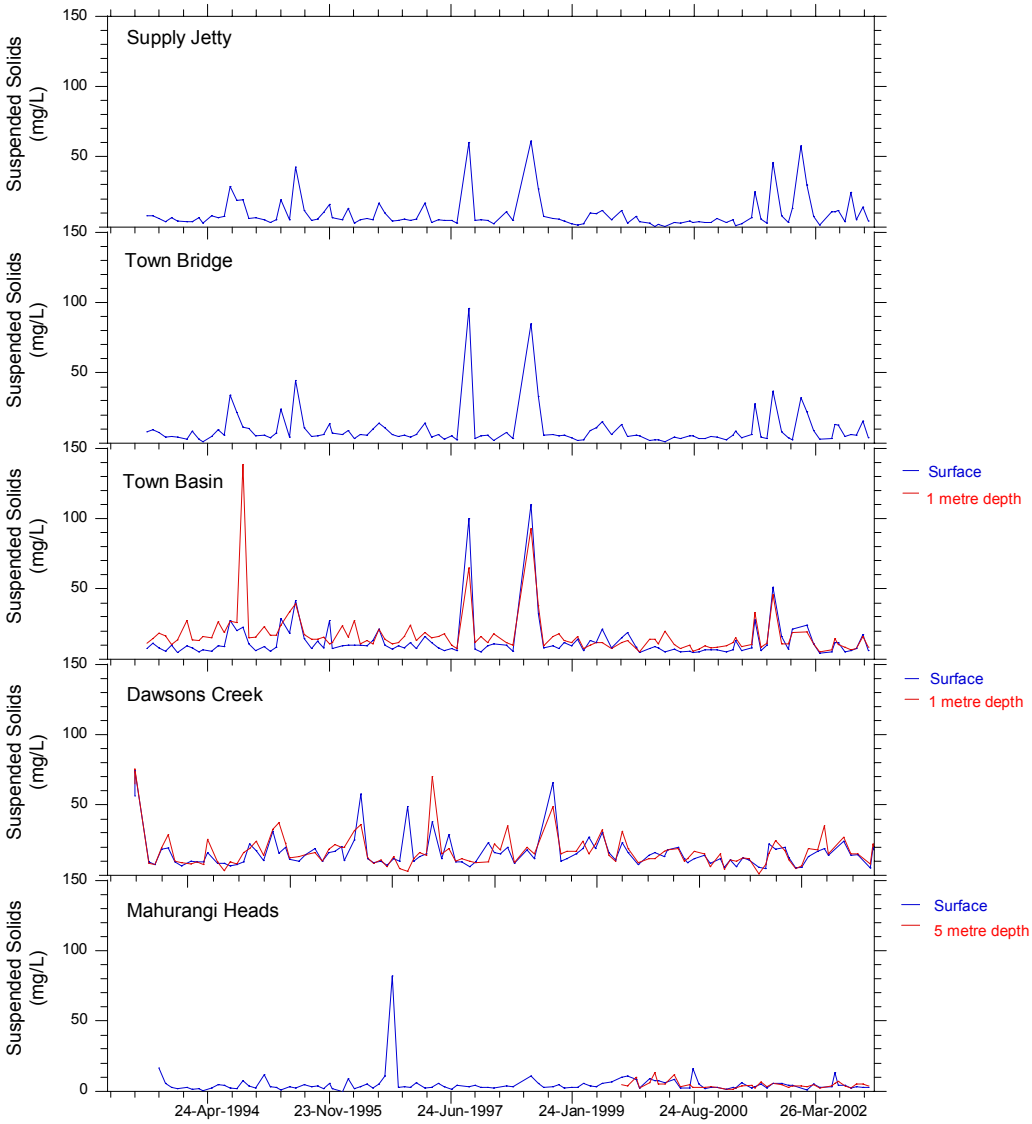

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
pH
9
8.5
8
7.5
7
6.5
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 3: MAHURANGI HARBOUR – SUSPENDED SOLIDS

a) Suspended solids (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	58.0	32.0						3.8
13-Feb-2002	29.8	22.4	24.1	19.4	24.0	26.8	0.9	3.3
18-Mar-2002	7.5	8.9	11.0	11.0	14.0	15.0	4.9	4.7
16-Apr-2002	1.3	2.8	4.0	5.3	14.7	15.3	2.5	2.3
13-Jun-2002	10.8	3.4	5.1	6.5	5.2	8.0	3.3	3.7
26-Jun-2002	11.0	13.2	11.6	14.8	19.2	22.3	13.2	5.5
15-Jul-2002	11.7	12.6	11.8	10.3	9.4	9.9	4.0	7.1
13-Aug-2002	3.6	4.4	5.2	8.6	14.0	12.0	4.0	3.9
10-Sep-2002	24.3	6.3	6.0	6.6	11.4	9.9	2.2	2.0
8-Oct-2002	5.1	5.6	7.5	7.2	11.6	15.8	3.0	5.0
7-Nov-2002	14.3	15.6	17.6	16.0	13.6	29.5	2.8	5.1
5-Dec-2002	4.0	3.8	6.2	8.5	12.9	12.7	2.9	3.5
Median	10.9	7.6	7.5	8.6	13.6	15.0	3.0	3.9
IQR/Median %	110	126	81	70	21	54	45	41

b) The graphs on the following pages show suspended solids measurements from 1993 to December 2002 (where data available).

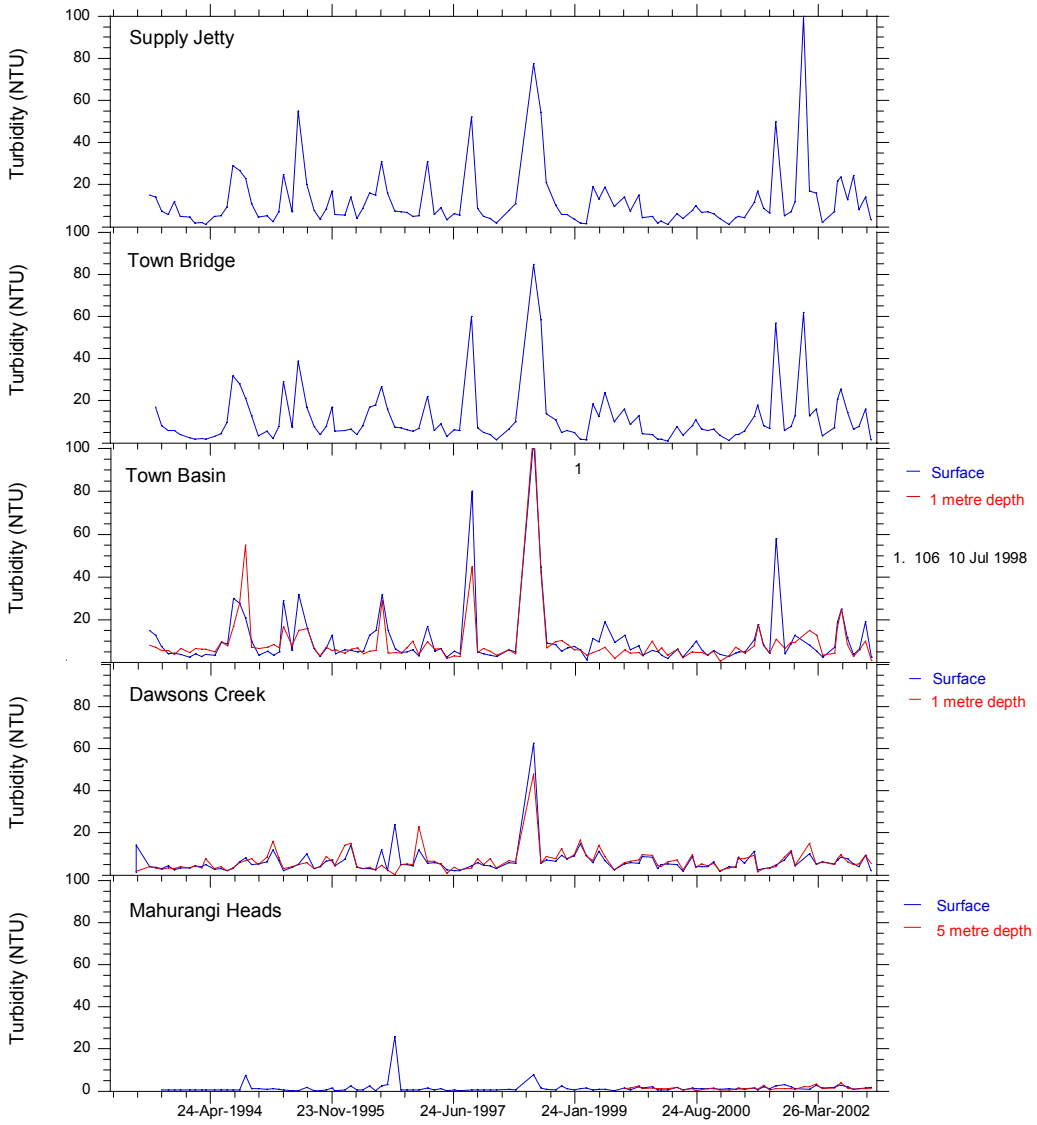

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Suspended Solids (mg/L)
150
100
50
0
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 4: MAHURANGI HARBOUR – TURBIDITY

a) Turbidity (NTU) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	100.0	62.0						2.0
13-Feb-2002	17.0	13.0	8.1	15.0	10.0	15.0	0.8	2.2
18-Mar-2002	16.0	16.0	5.4	13.0	5.2	4.9	2.8	3.3
16-Apr-2002	2.0	3.4	2.7	3.4	6.2	6.4	1.4	1.1
13-Jun-2002	7.1	7.3	7.3	4.5	5.4	4.8	1.8	1.4
26-Jun-2002	21.6	20.7	19.1	16.5	7.3	7.8	2.9	2.6
15-Jul-2002	23.8	25.4	25.0	24.9	8.6	9.7	2.7	4.1
13-Aug-2002	12.9	14.4	11.7	8.4	7.8	6.2	2.1	1.5
10-Sep-2002	24.2	6.6	3.8	2.9	5.3	5.0	0.8	1.0
8-Oct-2002	8.2	8.0	6.5	6.1	4.1	5.3	1.3	1.2
7-Nov-2002	14.0	16.0	19.0	10.0	9.5	9.5	1.5	1.3
5-Dec-2002	3.3	1.4	2.6	1.0	2.2	5.6	1.7	1.3
Median	15.0	13.7	7.3	8.4	6.2	6.2	1.7	1.4
IQR/Median %	95	74	148	119	47	57	59	71

b) The graphs on the following pages show turbidity measurements from 1993 to December 2002 (where data available).

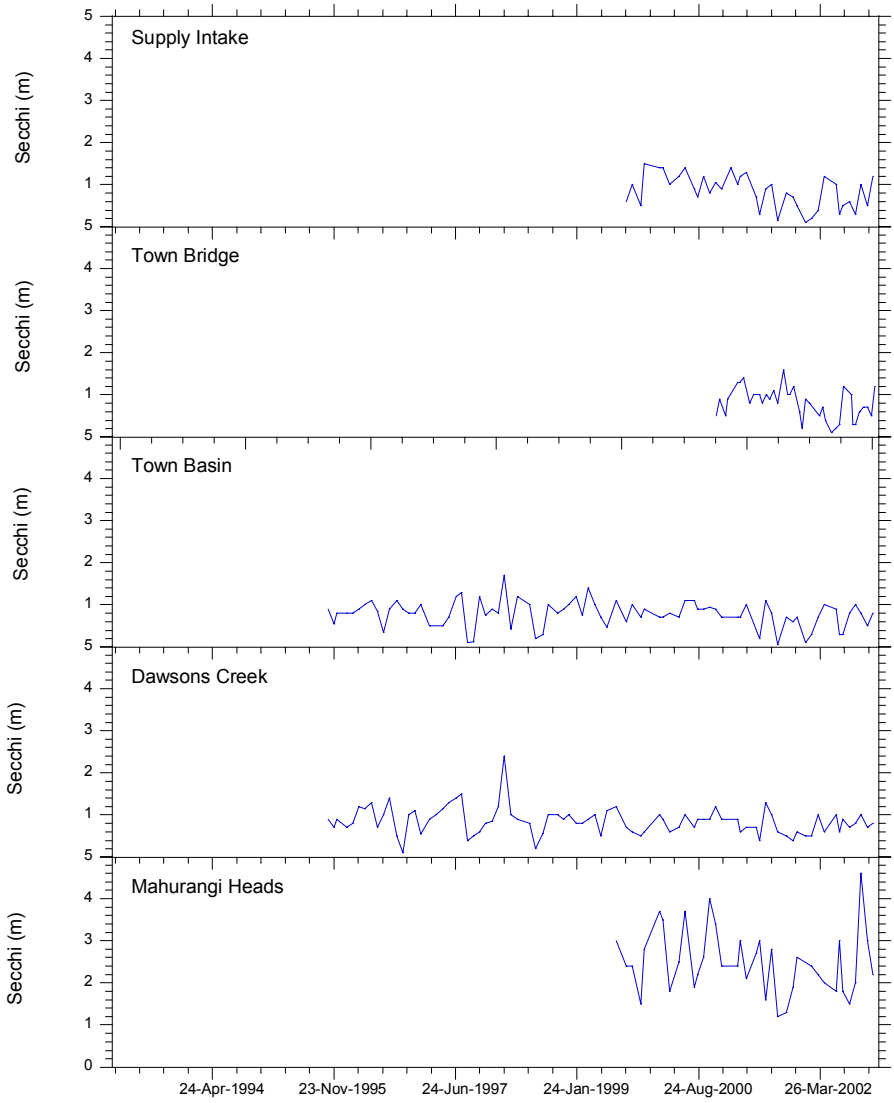

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Turbidity (NTU)
100
80
60
40
20
0
1
1. 106 10 Jul 1998
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 5: MAHURANGI HARBOUR – SECCHI DISK

a) Secchi disk (m) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.1	0.1	0.1		0.5		2.4	
13-Feb-2002	0.2	0.2	0.3		0.5		2.2	
18-Mar-2002	0.4	0.3	0.7	-	1.0		2.0	
16-Apr-2002	1.2	1.2	1.0	-	0.6		1.8	
13-Jun-2002	1.0	1.0	0.9	-	1.0		3.0	
26-Jun-2002	0.3	0.3	0.3	-	0.6		1.8	
15-Jul-2002	0.5	0.3	0.3	0.3	0.9		1.5	
13-Aug-2002	0.6	0.6	0.8	-	0.7		2.0	
10-Sep-2002	0.3	0.7	1.0	-	0.8		4.6	
8-Oct-2002	1.0	0.7	0.8	-	1.0		3.0	
7-Nov-2002	0.5	0.5	0.5		0.7		2.2	
5-Dec-2002	1.2	1.2	0.8		0.8		2.2	
Median	0.5	0.6	0.8	0.3	0.8		2.2	
IQR/Median %	140	86	70	–	43		27	

b) The graphs on the following pages show Secchi disk measurements from 1993 to December 2002 (where data available).

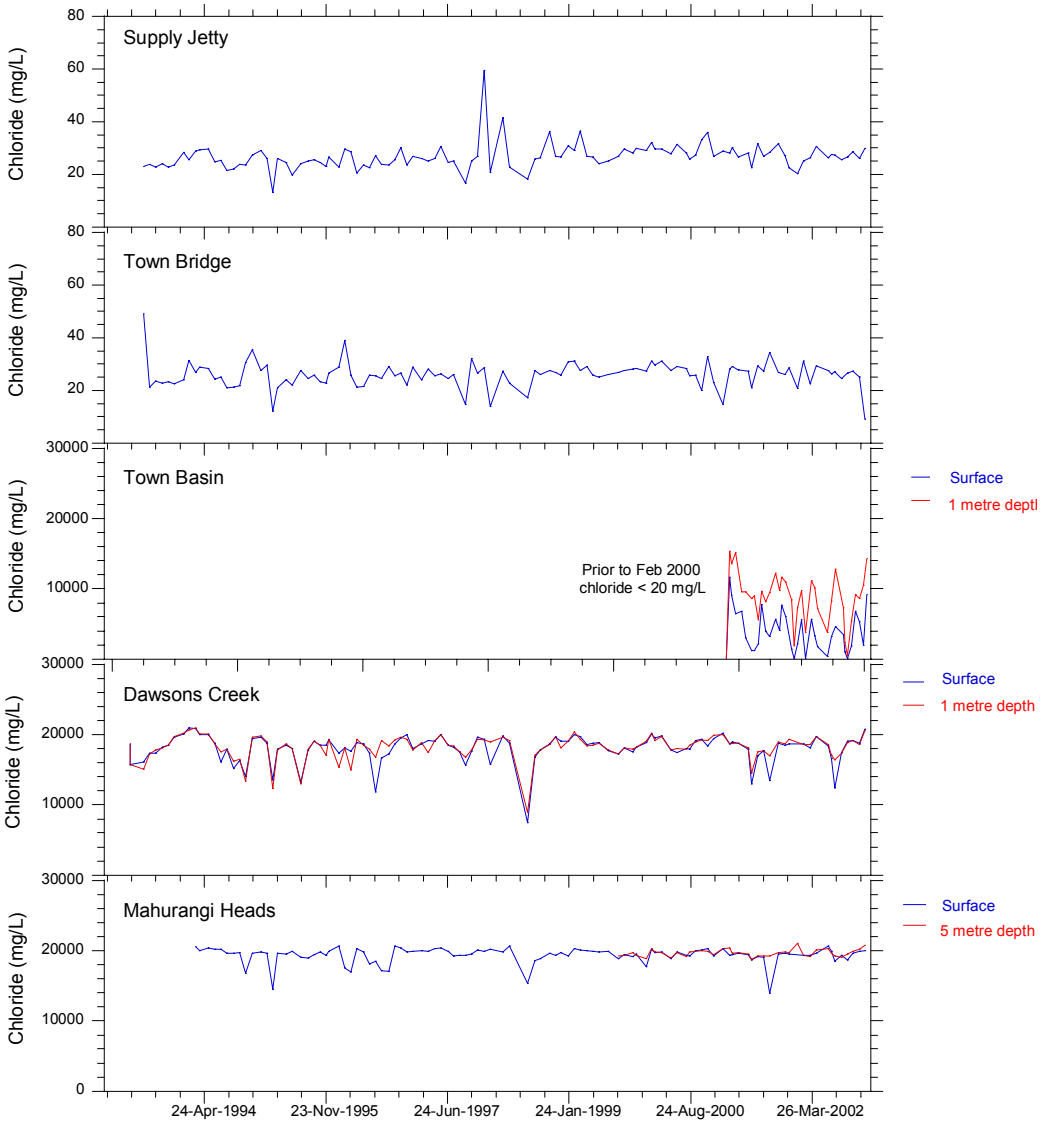

Supply Intake
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Secchi (m)
0
1
2
3
4
5
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 6: MAHURANGI HARBOUR – CHLORIDE

a) Chloride (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	20.1	20.8						19372
13-Feb-2002	24.9	31.2	356	3787	18691	18601	19376	19404
18-Mar-2002	26.2	22.6	3169	8279	18126	18556	19614	19117
16-Apr-2002	30.6	29.4	4608	12814	19745	19756	20656	20059
13-Jun-2002	26.3	27.5	3456	7306	18354	18565	19910	20258
26-Jun-2002	27.5	26.3	1014	2317	16581	17132	18472	19652
15-Jul-2002	27.3	27.0	30	524	12376	16453	19360	19260
13-Aug-2002	25.5	24.4	1856	5343	17455	17378	18721	19052
10-Sep-2002	26.6	26.5	6773	9198	19030	18868	19612	19568
8-Oct-2002	28.5	27.4	5303	8670	19152	19182	19928	19907
7-Nov-2002	26.1	24.9	2005	10550	18756	18632	20025	20163
5-Dec-2002	29.9	9.1	9154	14287	20750	20572	21096	20756
Median	26.5	26.4	3169	8279	18691	18601	19614	19610
IQR/Median %	7	13	111	64	7	6	3	4

b) The graphs on the following pages show chloride measurements from 1993 to December 2002 (where data available).

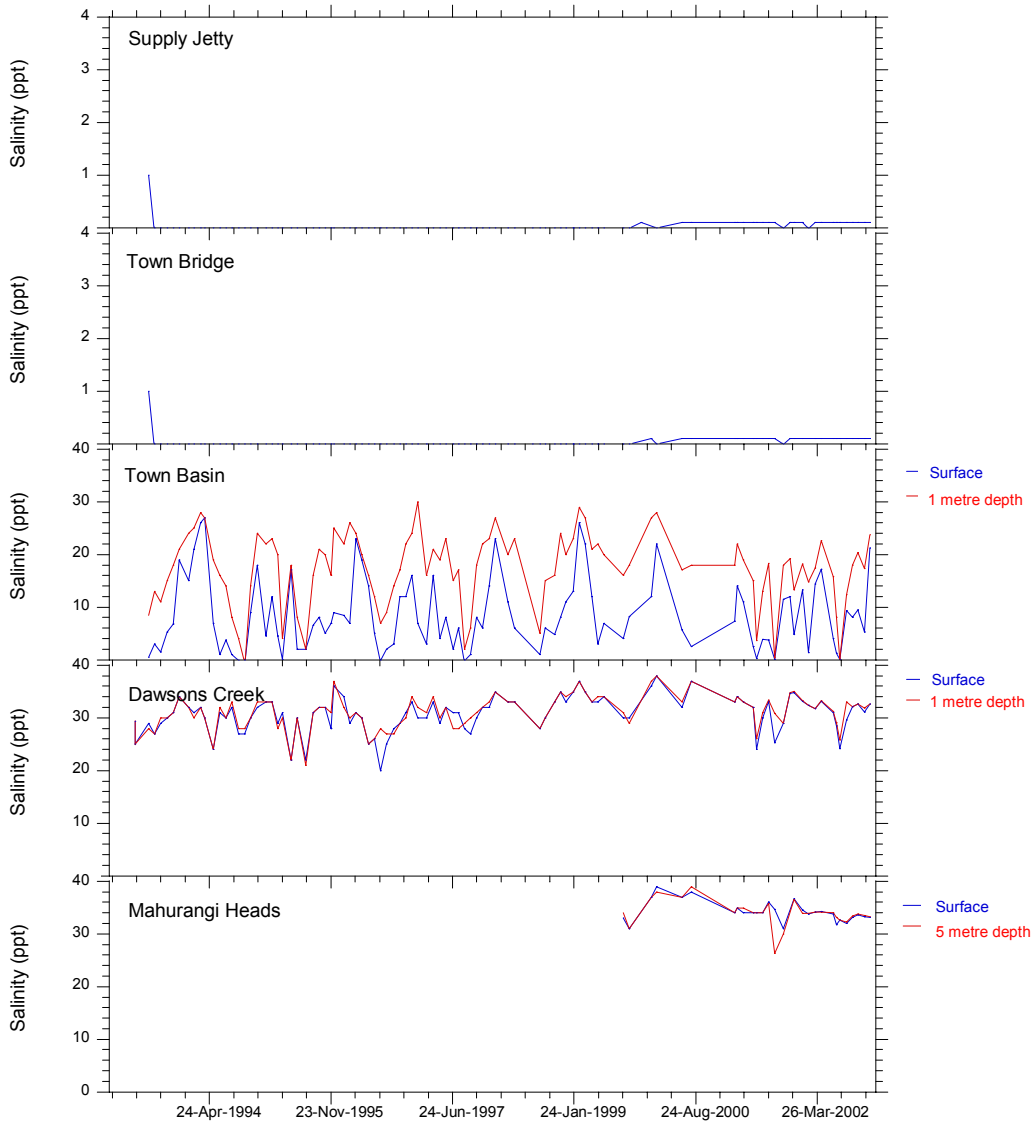

Supply Jetty
Town Bridge
Town Basin
Prior to Feb 2000
chloride < 20 mg/L
Dawsons Creek
Mahurangi Heads
Chloride (mg/L)
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 7: MAHURANGI HARBOUR – SALINITY

a) Salinity (ppt) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.0	0.0						35.2
13-Feb-2002	0.0	0.1	0.6	6.9	33.9	33.8	35.2	35.2
18-Mar-2002	0.0	0.0	5.8	15.0	32.9	33.7	35.6	34.7
16-Apr-2002	0.1	0.1	8.4	23.3	35.8	35.9	37.5	36.4
13-Jun-2002	0.0	0.0	6.3	13.3	33.3	33.7	36.1	36.8
26-Jun-2002	0.0	0.0	1.8	4.2	30.1	31.1	33.5	35.7
15-Jul-2002	0.0	0.0	0.1	1.0	22.5	29.9	35.1	35.0
13-Aug-2002	0.0	0.0	3.4	9.7	31.7	31.5	34.0	34.6
10-Sep-2002	0.0	0.0	12.3	16.7	34.5	34.2	35.6	35.5
8-Oct-2002	0.1	0.0	9.6	15.7	34.8	34.8	36.2	36.1
7-Nov-2002	0.0	0.0	3.6	19.1	34.0	33.8	36.3	36.6
5-Dec-2002	0.1	0.0	16.6	25.9	37.7	37.3	38.3	37.7
Median	0.0	0.0	5.8	15.0	33.9	33.8	35.6	35.6
IQR/Median %	–	–	110	64	7	6	3	4

b) The graphs on the following pages show salinity measurements from 1993 to December 2002 (where data available).

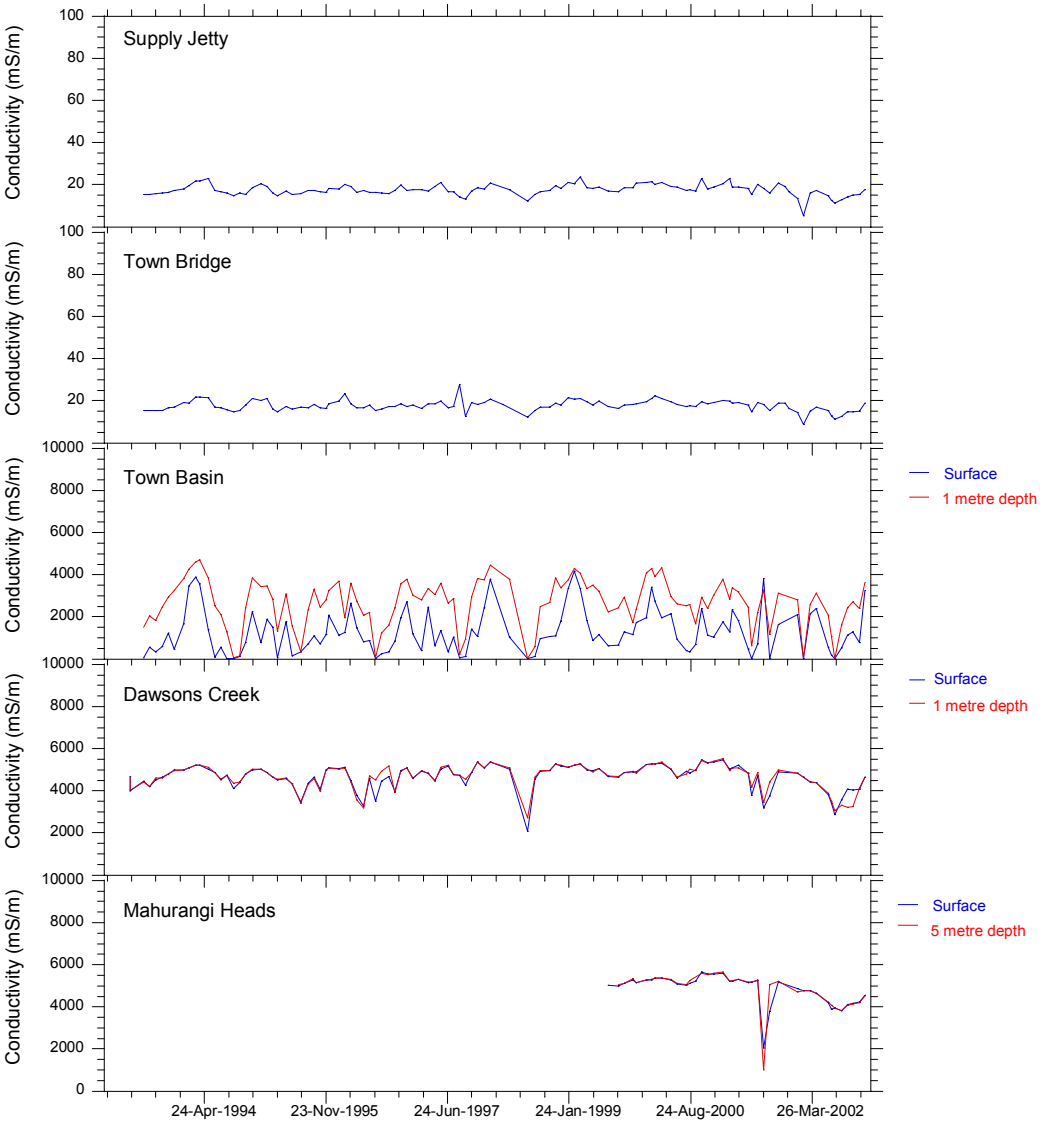

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Salinity (ppt)
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 8: MAHURANGI HARBOUR – CONDUCTIVITY

a) Conductivity (mS/m) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	13.7	14.5	2105	2804	4840	4840	4880	4710
13-Feb-2002	5.4	8.8	23.97	22.71	4640	4636	4790	4790
18-Mar-2002	15.9	15.1	2151	2576	4432	4425	4770	4770
16-Apr-2002	17.2	17.0	2413	3125	4401	4411	4630	4630
13-Jun-2002	14.8	15.3	576	2099	3832	3875	4192	4224
26-Jun-2002	12.6	12.9	178	1063	3417	3492	3880	4075
15-Jul-2002	11.4	11.4	11.6	13.1	2886	3076	3936	3937
13-Aug-2002	12.8	12.6	532	1587	3567	3601	3826	3837
10-Sep-2002	14.2	14.7	1148	2434	4068	3210	4098	4066
8-Oct-2002	15.2	14.9	1285	2705	4057	3260	4159	4148
7-Nov-2002	15.4	15.1	791	2410	4086	4152	4231	4222
5-Dec-2002	17.6	18.9	3270	3635	4660	4660	4550	4513
Median	14.5	14.8	970	2422	4077	4014	4212	4223
IQR/Median %	19	16	173	53	18	26	14	14

b) The graphs on the following pages show conductivity measurements from 1993 to December 2002 (where data available).

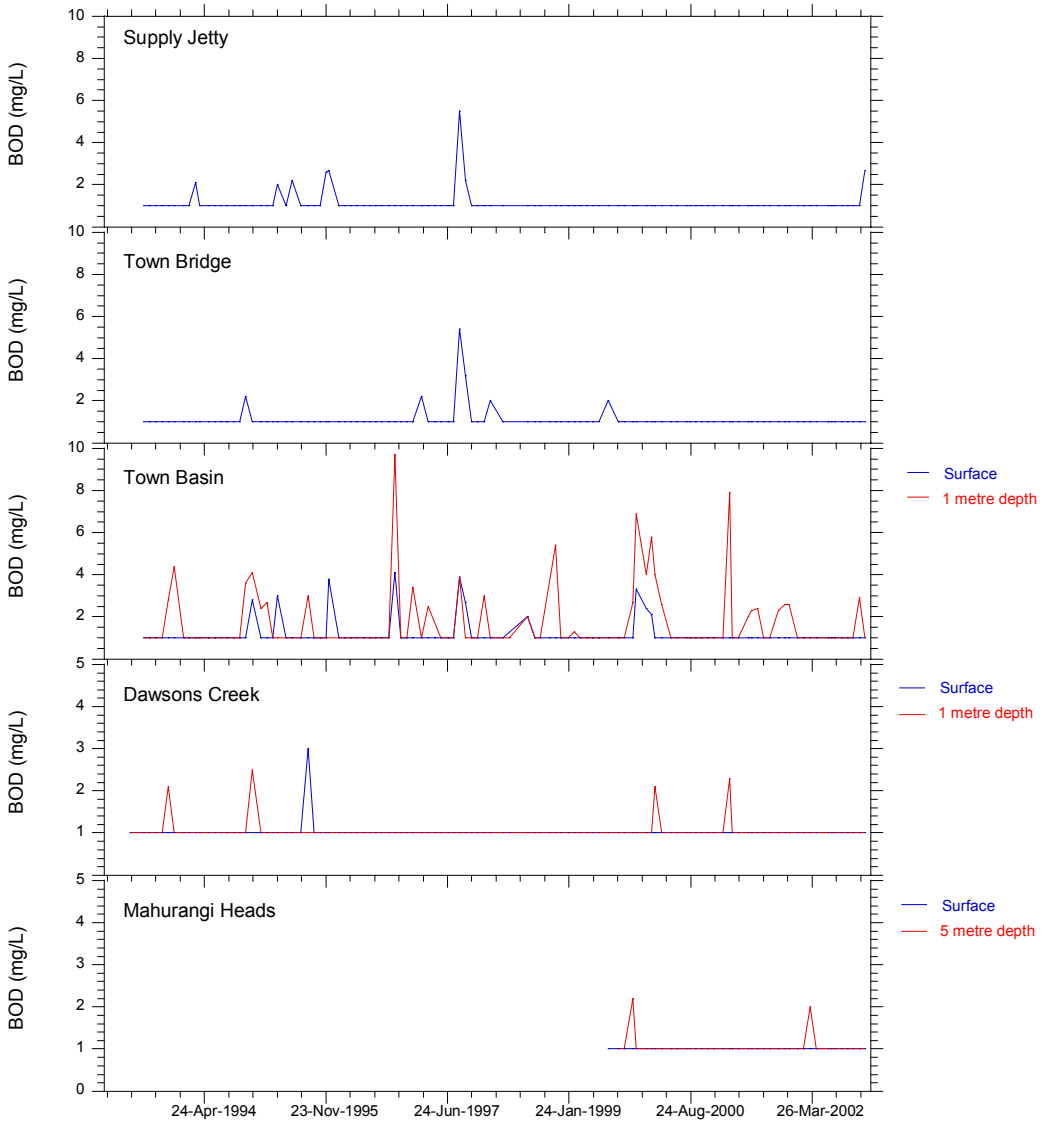

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Conductivity (mS/m)
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 9: MAHURANGI HARBOUR – BIOCHEMICAL OXYGEN DEMAND

a) BOD (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
13-Feb-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
18-Mar-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0
16-Apr-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
13-Jun-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
26-Jun-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
15-Jul-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
13-Aug-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10-Sep-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8-Oct-2002	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7-Nov-2002	1.0	1.0	1.0	2.9	1.0	1.0	1.0	1.0
5-Dec-2002	2.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Median	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IQR/Median %	0	0	0	0	0	0	0	0

b) The graphs on the following pages show BOD measurements from 1993 to December 2002 (where data available).

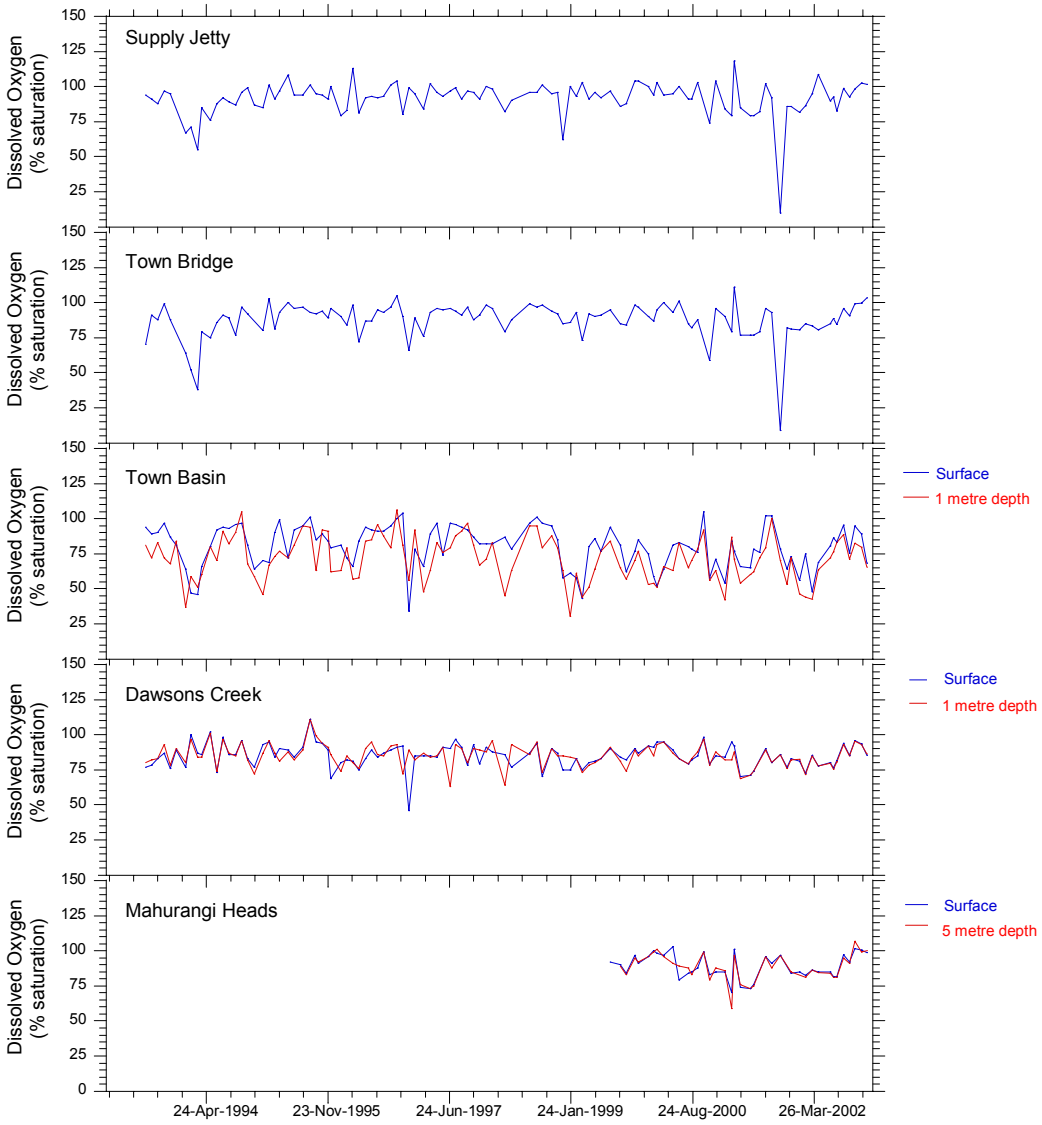

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
BOD (mg/L)
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 10: MAHURANGI HARBOUR – DISSOLVED OXYGEN % SATURATION

a) Dissolved oxygen (% saturation) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	81.6	80.4	55.8	46.3	81.3	82.7	85.0	
13-Feb-2002	86.1	84.8	75.1	44.2	72.7	71.8	82.5	81.0
18-Mar-2002	95.0	83.3	48.0	42.5	85.5	85.0	86.3	86.2
16-Apr-2002	108.6	80.7	68.8	63.4	77.7	77.8	84.7	84.6
13-Jun-2002	89.4	85.1	80.5	72.0	80.1	79.6	84.8	84.1
26-Jun-2002	92.6	88.7	86.5	76.6	76.3	75.2	81.7	81.3
15-Jul-2002	82.6	84.2	83.2	83.0	81.4	80.8	81.4	81.1
13-Aug-2002	98.6	95.8	95.5	88.6	94.2	93.1	97.3	94.9
10-Sep-2002	92.7	90.8	75.5	71.2	85.5	84.9	92.1	91.1
8-Oct-2002	98.4	99.4	94.9	82.6	95.8	95.3	101.3	106.5
7-Nov-2002	102.5	99.7	89.3	79.8	93.4	92.9	100.6	99.0
5-Dec-2002	101.6	103.5	68.1	65.4	85.2	86.1	98.6	100.1
Median	93.9	86.9	78.0	71.6	83.3	83.8	85.7	86.2
IQR/Median %	11	15	24	30	10	10	16	17

b) The graphs on the following pages show dissolved oxygen (% saturation) measurements from 1993 to December 2002 (where data available).

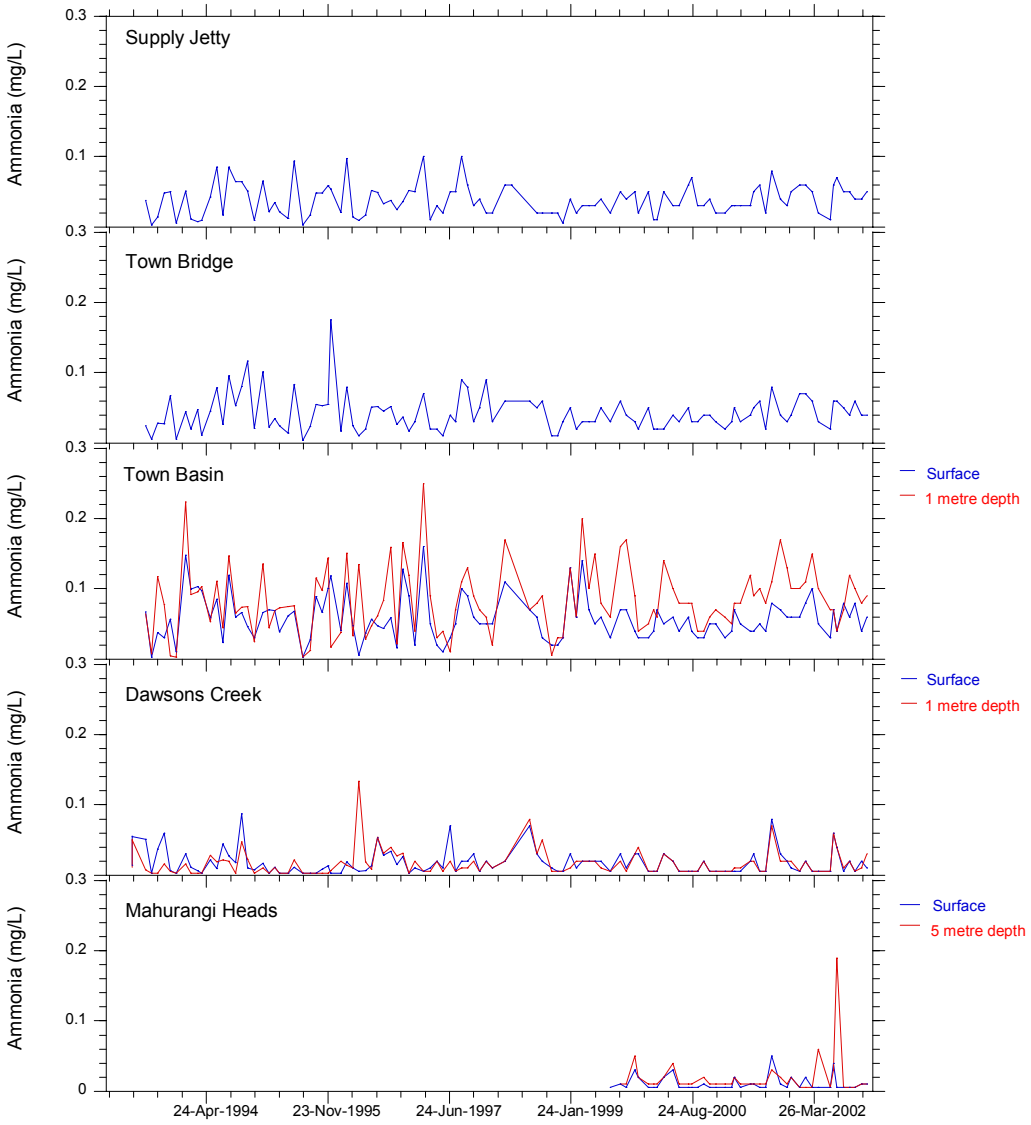

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Dissolved Oxygen (% saturation)
150
125
100
75
50
25
0
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 11: MAHURANGI HARBOUR – AMMONIA NITROGEN

a) Ammonia nitrogen (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.06	0.07	0.06	0.10	0.005	0.005	0.005	0.005
13-Feb-2002	0.06	0.07	0.08	0.11	0.020	0.020	0.020	0.005
18-Mar-2002	0.05	0.06	0.10	0.15	0.005	0.005	0.005	0.005
16-Apr-2002	0.02	0.03	0.05	0.10	0.005	0.005	0.005	0.060
13-Jun-2002	0.01	0.02	0.03	0.07	0.005	0.005	0.005	0.005
26-Jun-2002	0.06	0.06	0.07	0.07	0.060	0.060	0.040	0.030
15-Jul-2002	0.07	0.06	0.04	0.04	0.040	0.040	0.005	0.190
13-Aug-2002	0.05	0.05	0.08	0.07	0.005	0.010	0.005	0.005
10-Sep-2002	0.05	0.04	0.06	0.12	0.020	0.020	0.005	0.005
8-Oct-2002	0.04	0.06	0.08	0.10	0.005	0.005	0.005	0.005
7-Nov-2002	0.04	0.04	0.04	0.08	0.020	0.010	0.010	0.010
5-Dec-2002	0.05	0.04	0.06	0.09	0.010	0.030	0.010	0.010
Median	0.05	0.06	0.06	0.10	0.008	0.010	0.005	0.005
IQR/Median %	40	36	54	34	200	175	100	200

b) The graphs on the following pages show ammonia nitrogen measurements from 1993 to December 2002 (where data available).

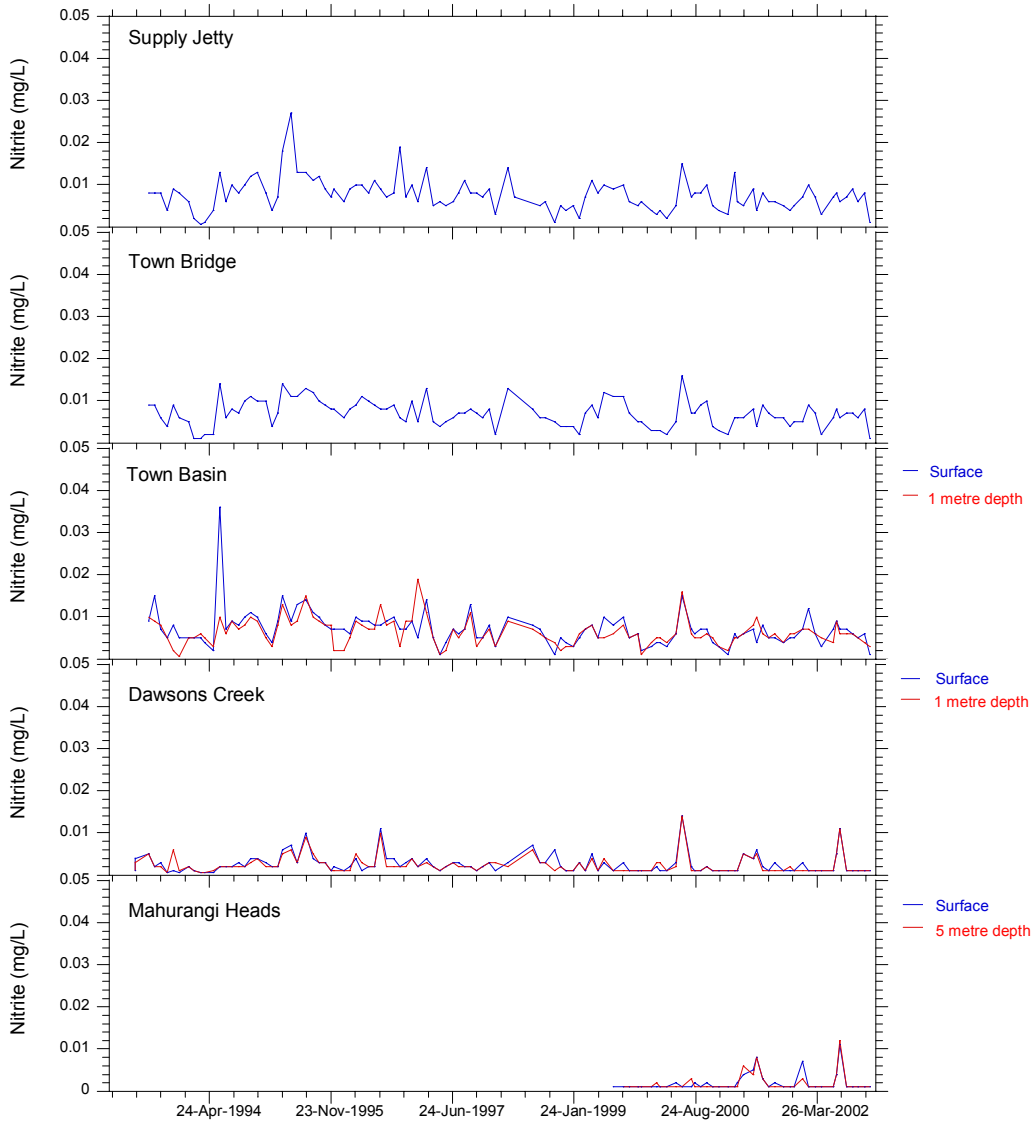

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Ammonia (mg/L)
0.3
0.2
0.1
0
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 12: MAHURANGI HARBOUR – NITRITE NITROGEN

a) Nitrite nitrogen (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.007	0.005	0.007	0.007	0.003	0.001	0.007	0.003
13-Feb-2002	0.010	0.009	0.012	0.007	0.001	0.001	0.001	0.001
18-Mar-2002	0.007	0.007	0.006	0.006	0.001	0.001	0.001	0.001
16-Apr-2002	0.003	0.002	0.003	0.005	0.001	0.001	0.001	0.001
13-Jun-2002	0.007	0.006	0.007	0.004	0.001	0.001	0.001	0.001
26-Jun-2002	0.008	0.008	0.009	0.009	0.005	0.005	0.004	0.004
15-Jul-2002	0.006	0.006	0.007	0.006	0.011	0.011	0.011	0.012
13-Aug-2002	0.007	0.007	0.007	0.006	0.001	0.001	0.001	0.001
10-Sep-2002	0.009	0.007	0.006	0.006	0.001	0.001	0.001	0.001
8-Oct-2002	0.006	0.006	0.005	0.005	0.001	0.001	0.001	0.001
7-Nov-2002	0.008	0.008	0.006	0.004	0.001	0.001	0.001	0.001
5-Dec-2002	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001
Median	0.007	0.007	0.007	0.006	0.001	0.001	0.001	0.001
IQR/Median %	29	23	19	25	50	0	75	50

b) The graphs on the following pages show nitrite nitrogen measurements from 1993 to December 2002 (where data available).

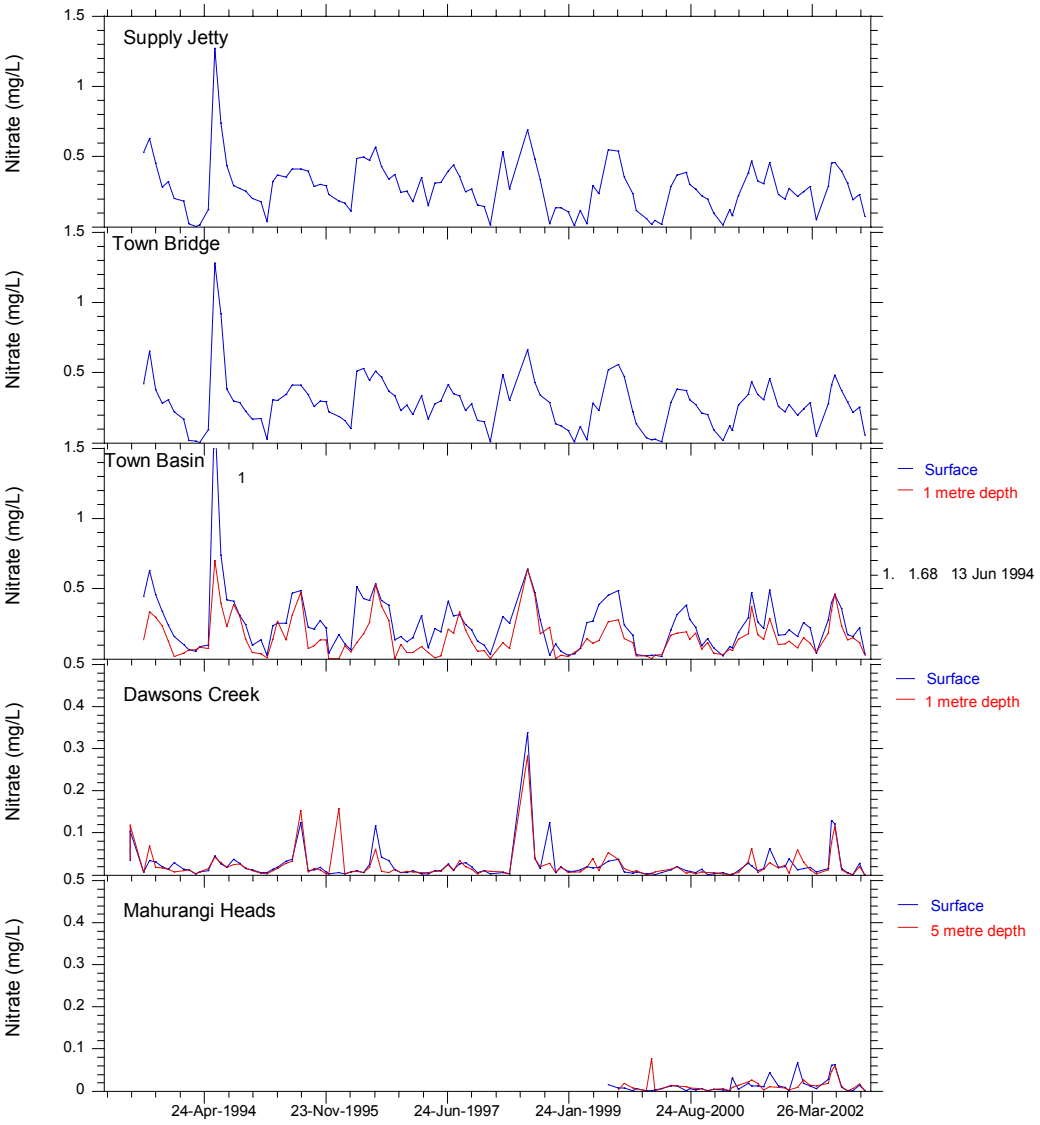

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Nitrite (mg/L)
0.05
0.04
0.03
0.02
0.01
0
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 13: MAHURANGI HARBOUR – NITRATE NITROGEN

a) Nitrate nitrogen (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.224	0.201	0.167	0.084	0.016	0.061	0.074	0.012
13-Feb-2002	0.258	0.248	0.270	0.157	0.016	0.032	0.020	0.028
18-Mar-2002	0.296	0.297	0.226	0.119	0.019	0.013	0.013	0.015
16-Apr-2002	0.053	0.049	0.046	0.050	0.009	0.004	0.007	0.013
13-Jun-2002	0.298	0.284	0.288	0.188	0.016	0.014	0.029	0.019
26-Jun-2002	0.461	0.422	0.413	0.357	0.135	0.083	0.065	0.051
15-Jul-2002	0.467	0.488	0.468	0.470	0.133	0.127	0.073	0.072
13-Aug-2002	0.403	0.381	0.367	0.243	0.016	0.014	0.012	0.010
10-Sep-2002	0.322	0.299	0.181	0.143	0.006	0.005	0.001	0.001
8-Oct-2002	0.201	0.224	0.163	0.158	0.003	0.003	0.001	0.007
7-Nov-2002	0.240	0.265	0.229	0.121	0.029	0.021	0.015	0.018
5-Dec-2002	0.074	0.055	0.039	0.032	0.001	0.001	0.001	0.003
Median	0.277	0.275	0.228	0.150	0.016	0.014	0.014	0.014
IQR/Median %	45	37	62	61	83	246	232	86

b) The graphs on the following pages show nitrate nitrogen measurements from 1993 to December 2002 (where data available).

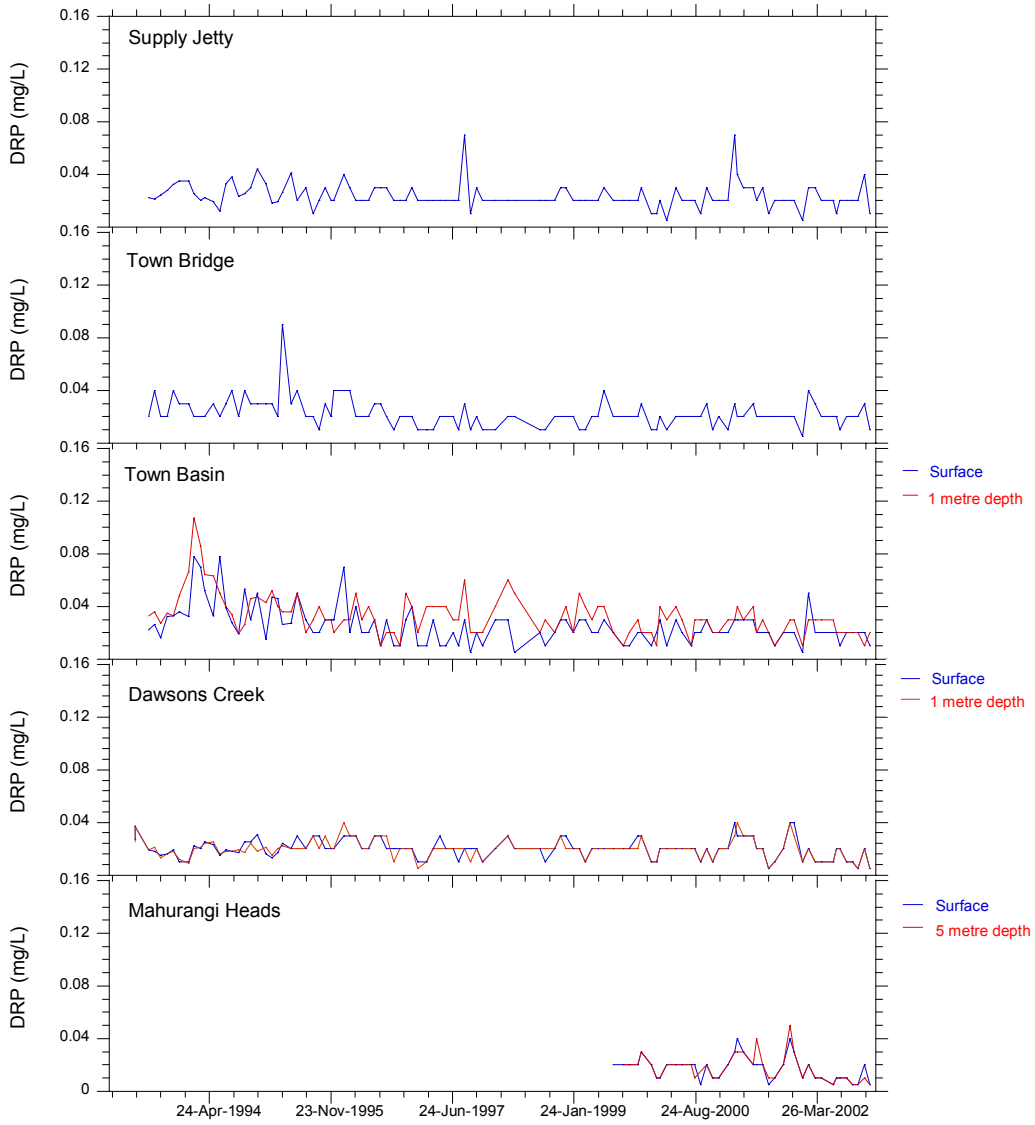

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Nitrate (mg/L)
1.5
1
0.5
0.4
0.3
0.2
0.1
0
1
1. 1.68 13 Jun 1994
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 14: MAHURANGI HARBOUR – DISSOLVED REACTIVE PHOSPHORUS

a) Dissolved reactive phosphorus (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13-Feb-2002	0.03	0.04	0.05	0.03	0.02	0.02	0.02	0.02
18-Mar-2002	0.03	0.03	0.02	0.03	0.01	0.01	0.01	0.01
16-Apr-2002	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01
13-Jun-2002	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01
26-Jun-2002	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01
15-Jul-2002	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01
13-Aug-2002	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
10-Sep-2002	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
8-Oct-2002	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
7-Nov-2002	0.04	0.03	0.02	0.01	0.02	0.02	0.02	0.01
5-Dec-2002	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Median	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
IQR/Median %	25	25	13	50	100	100	50	50

b) The graphs on the following pages show dissolved reactive phosphorus measurements from 1993 to December 2002 (where data available).

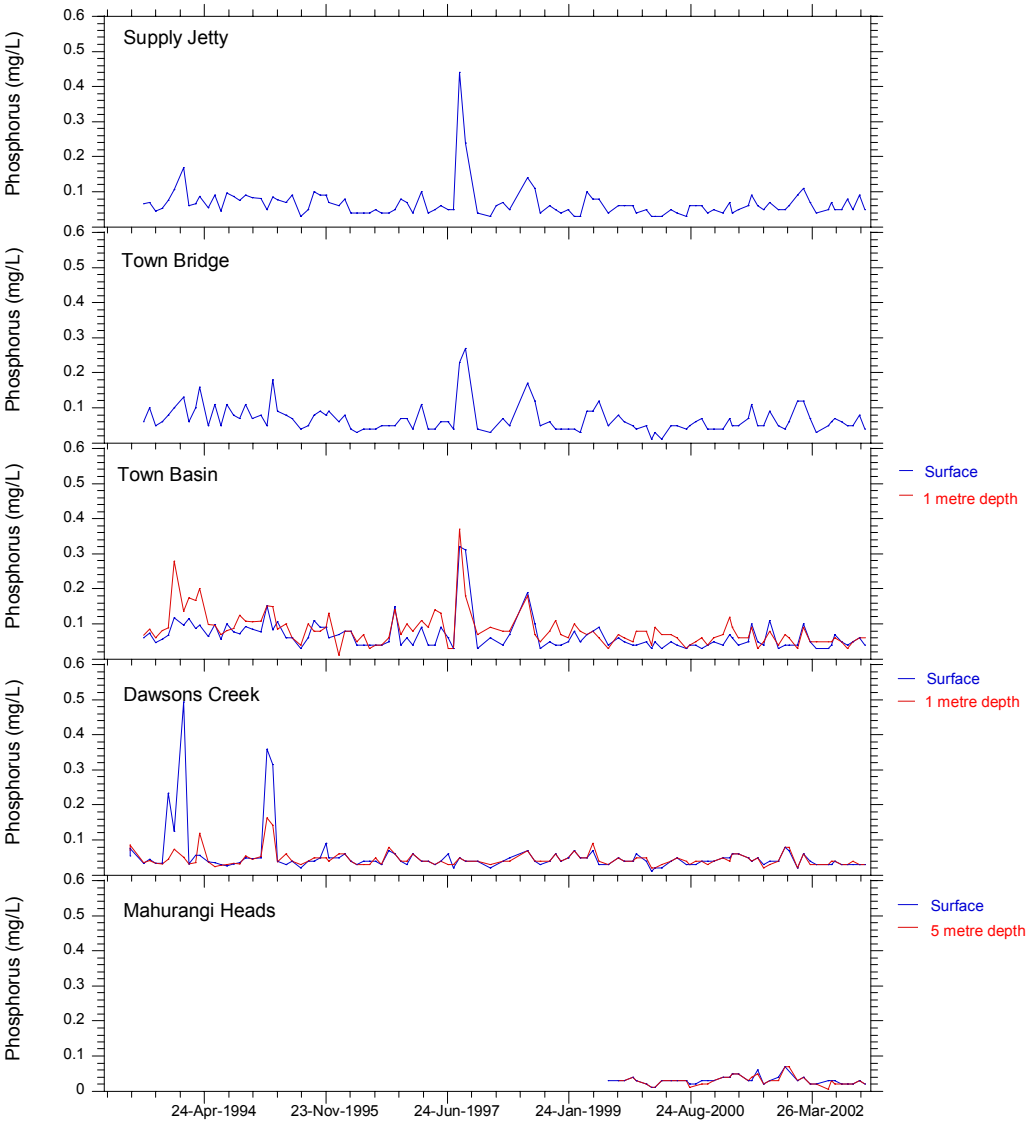

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
DRP (mg/L)
0.16
0.12
0.08
0.04
0
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 15: MAHURANGI HARBOUR – TOTAL PHOSPHORUS

a) Total phosphorus (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	0.09	0.12	0.04	0.03	0.02	0.02	0.03	0.03
13-Feb-2002	0.11	0.12	0.10	0.09	0.06	0.06	0.04	0.04
18-Mar-2002	0.07	0.07	0.05	0.05	0.04	0.03	0.02	0.02
16-Apr-2002	0.04	0.03	0.03	0.05	0.03	0.03	0.02	0.02
13-Jun-2002	0.05	0.05	0.03	0.05	0.03	0.03	0.03	0.01
26-Jun-2002	0.07	0.06	0.04	0.05	0.03	0.04	0.03	0.03
15-Jul-2002	0.05	0.07	0.07	0.06	0.04	0.04	0.03	0.02
13-Aug-2002	0.05	0.06	0.05	0.05	0.03	0.03	0.02	0.02
10-Sep-2002	0.08	0.05	0.04	0.03	0.03	0.03	0.02	0.02
8-Oct-2002	0.05	0.05	0.05	0.05	0.03	0.04	0.02	0.02
7-Nov-2002	0.09	0.08	0.06	0.06	0.03	0.03	0.03	0.03
5-Dec-2002	0.05	0.04	0.04	0.06	0.03	0.03	0.02	0.02
Median	0.06	0.06	0.05	0.05	0.03	0.03	0.03	0.02
IQR/Median %	54	38	28	20	8	33	40	50

b) The graphs on the following pages show total phosphorus measurements from 1993 to December 2002 (where data available).

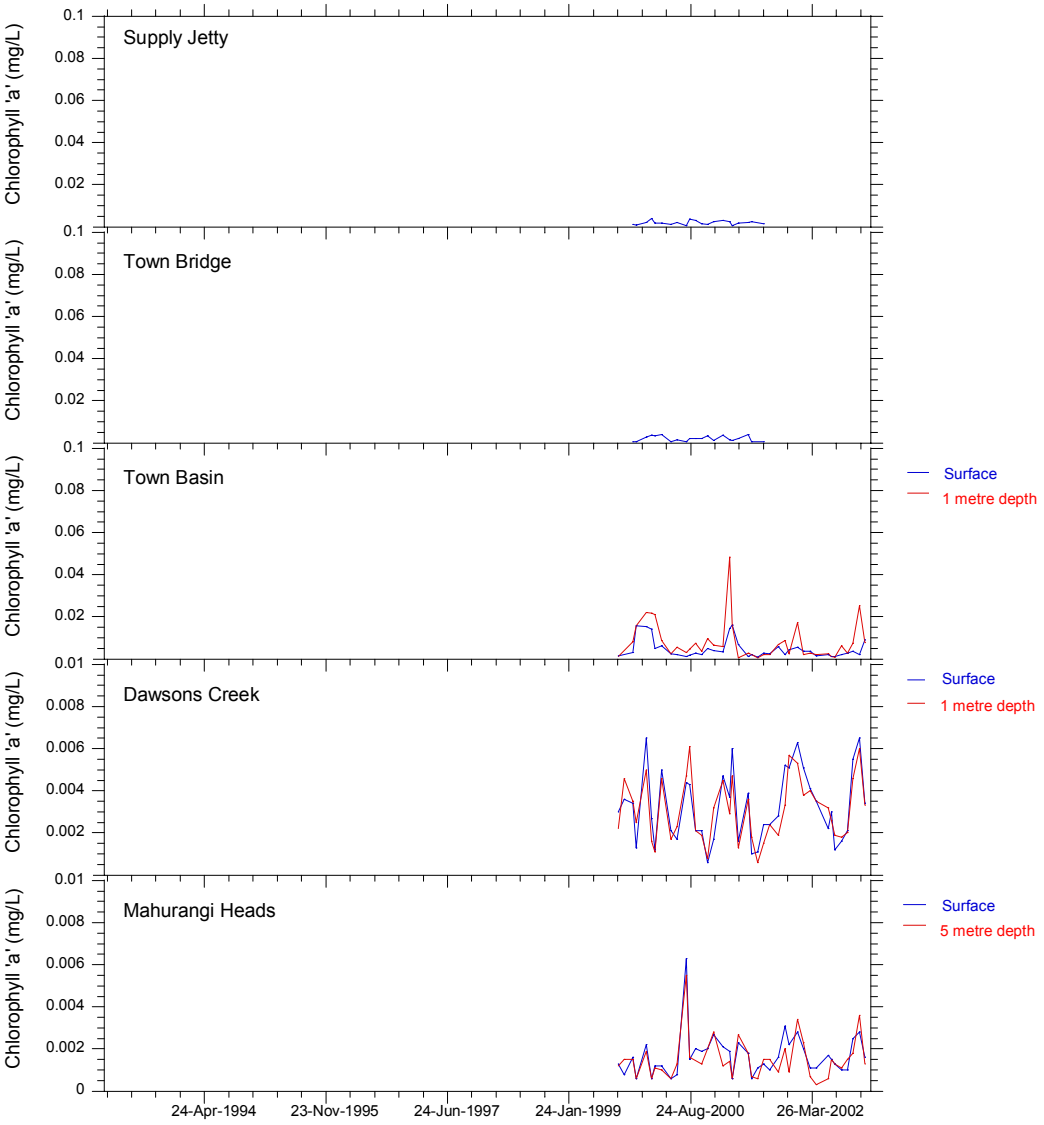

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Phosphorus (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 16: MAHURANGI HARBOUR – CHLOROPHYLL *a*

a) Chlorophyll *a* (mg/L) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002			0.0055	0.0173	0.0063	0.0053	0.0028	0.0034
13-Feb-2002			0.0036	0.0023	0.0051	0.0038	0.0020	0.0023
18-Mar-2002			0.0037	0.0027	0.0041	0.0040	0.0011	0.0007
16-Apr-2002			0.0016	0.0023	0.0035	0.0035	0.0011	0.0003
13-Jun-2002			0.0022	0.0024	0.0022	0.0032	0.0017	0.0006
26-Jun-2002			0.0013	0.0013	0.0030	0.0026	0.0015	0.0015
15-Jul-2002			0.0012	0.0008	0.0012	0.0019	0.0013	0.0013
13-Aug-2002			0.0022	0.0062	0.0016	0.0018	0.0010	0.0011
10-Sep-2002			0.0027	0.0028	0.0021	0.0020	0.0010	0.0015
8-Oct-2002			0.0037	0.0075	0.0055	0.0046	0.0025	0.0018
7-Nov-2002			0.0022	0.0253	0.0065	0.0060	0.0028	0.0036
5-Dec-2002			0.0092	0.0078	0.0034	0.0033	0.0016	0.0013
Median			0.0025	0.0028	0.0035	0.0034	0.0016	0.0014
IQR/Median %			67	192	88	50	66	66

b) The graphs on the following pages show chlorophyll *a* measurements from 1993 to December 2002 (where data available).

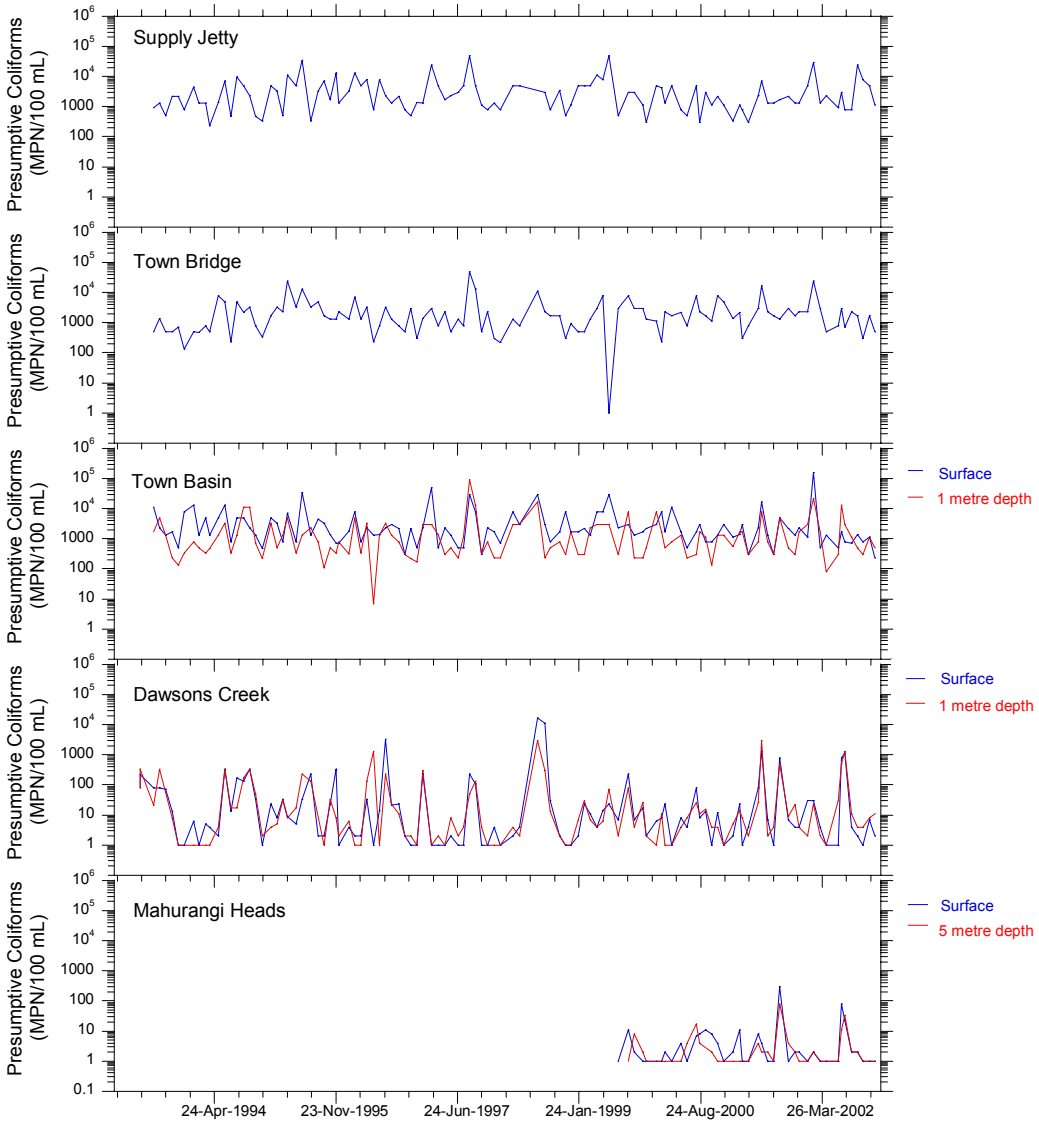

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Chlorophyll 'a' (mg/L)
0.1
0.08
0.06
0.04
0.02
0.01
0.008
0.006
0.004
0.002
0
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth

APPENDIX 17: MAHURANGI HARBOUR – PRESUMPTIVE COLIFORM

a) Presumptive coliform (MPN/100 mL) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	5000	2300	1100	3000	30	2	1	1
13-Feb-2002	30000	24000	160000	22000	30	23	2	2
18-Mar-2002	1300	3000	500	1700	4	2	1	1
16-Apr-2002	2300	500	1300	80	1	1	1	1
13-Jun-2002	900	800	500	300	1	30	1	1
26-Jun-2002	3000	3000	1700	13000	800	500	80	11
15-Jul-2002	800	700	800	3000	1100	1300	22	34
13-Aug-2002	800	2300	700	1100	4	11	2	2
10-Sep-2002	24000	1700	1400	500	2	4	2	2
8-Oct-2002	8000	300	800	300	1	4	1	1
7-Nov-2002	5000	1700	1100	1100	7	8	1	1
5-Dec-2002	1100	500	230	500	2	11	1	1
Median	2650	1700	950	1100	4	10	1	1
IQR/Median %	177	107	71	232	706	224	100	100

b) The graphs on the following pages show presumptive coliform measurements from 1993 to December 2002 (where data available).

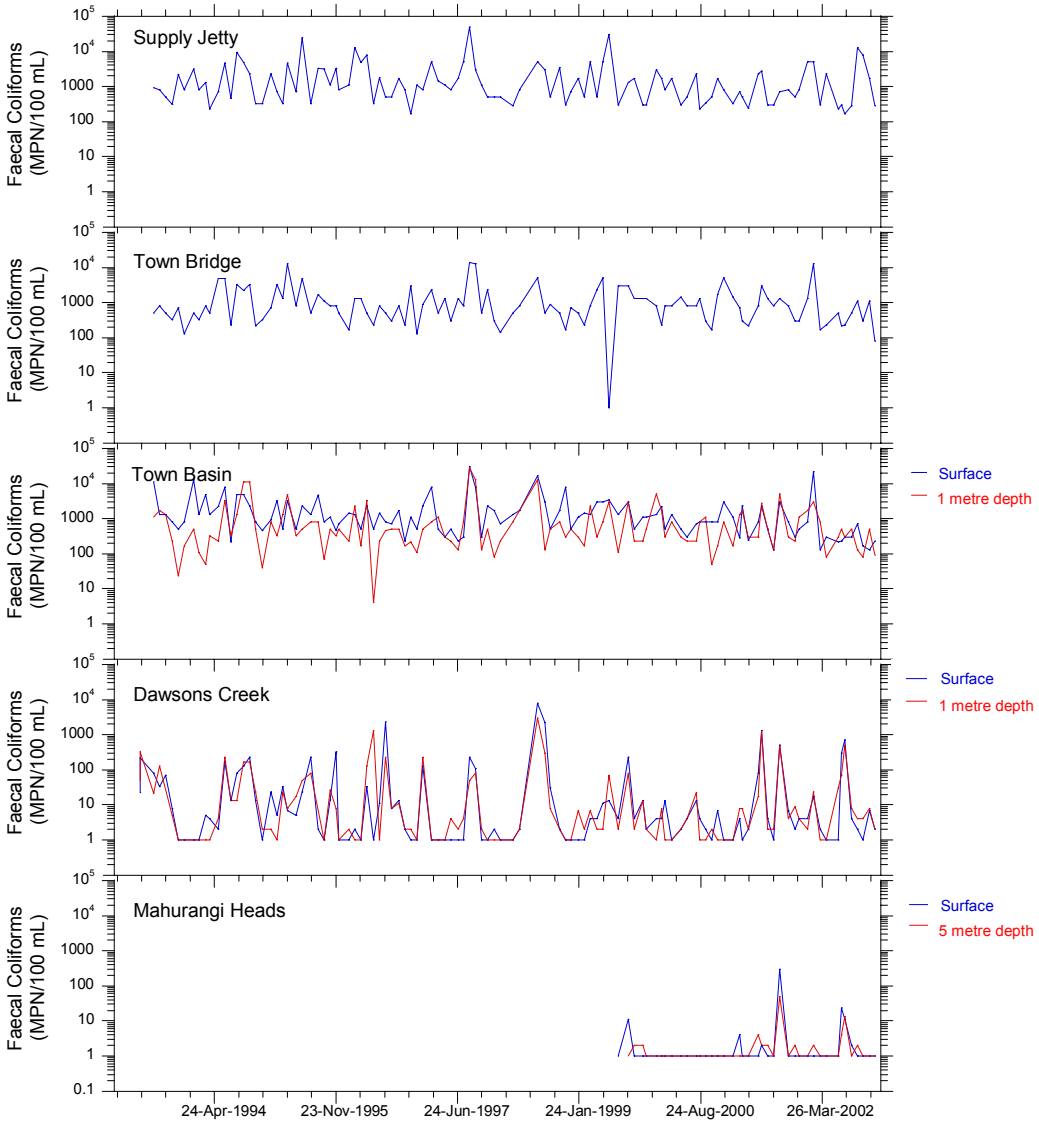

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Presumptive Coliforms (MPN/100 mL)
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 18: MAHURANGI HARBOUR – FAECAL COLIFORM

a) Faecal coliform (MPN/100 mL) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002	5000	1300	800	1700	4	2	1	1
13-Feb-2002	5000	13000	22000	3000	17	23	1	2
18-Mar-2002	300	170	130	800	2	1	1	1
16-Apr-2002	2300	230	300	80	1	1	1	1
13-Jun-2002	230	500	220	300	1	30	1	1
26-Jun-2002	300	220	230	500	300	70	23	4
15-Jul-2002	170	230	300	300	700	500	11	13
13-Aug-2002	280	500	300	500	4	8	2	1
10-Sep-2002	13000	1100	700	130	2	4	1	2
8-Oct-2002	8000	300	170	80	1	4	1	1
7-Nov-2002	1700	1100	130	500	7	8	1	1
5-Dec-2002	280	80	230	90	2	2	1	1
Median	1000	400	265	400	3	6	1	1
IQR/Median %	472	218	73	114	258	379	25	100

b) The graphs on the following pages show faecal coliform measurements from 1993 to December 2002 (where data available).

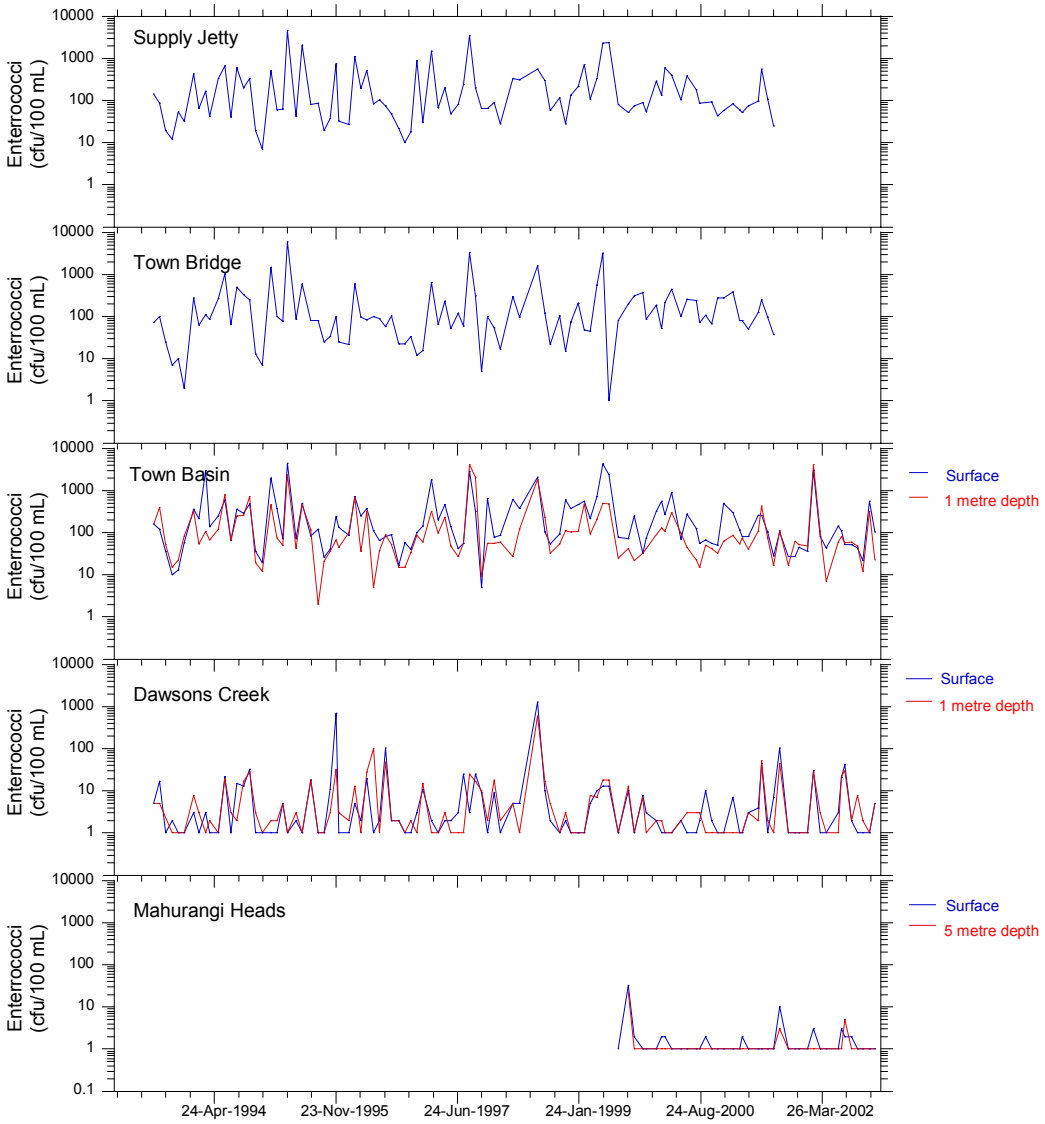

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Faecal Coliforms (MPN/100 mL)
Surface
1 metre depth
Surface
1 metre depth
Surface
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

APPENDIX 19: MAHURANGI HARBOUR – ENTEROCOCCI

a) Enterococci (cfu/100 mL) during January 2002 - December 2002

Date	Supply Intake Jetty	Town Bridge	Town Basin surface	Town Basin 1 m	Dawsons Creek surface	Dawsons Creek 1 m	Mahurangi Heads surface	Mahurangi Heads 5 m
17-Jan-2002			36	48	1	1	1	0
13-Feb-2002			3000	4100	30	28	3	1
18-Mar-2002			82	110	1	3	1	1
16-Apr-2002			44	7	1	1	1	1
13-Jun-2002			145	60	3	1	1	1
26-Jun-2002			114	80	21	23	3	1
15-Jul-2002			52	58	42	30	2	5
13-Aug-2002			52	60	2	2	2	1
10-Sep-2002			44	48	1	8	1	1
8-Oct-2002			22	12	1	2	1	1
7-Nov-2002			560	330	1	1	1	1
5-Dec-2002			106	23	5	5	1	1
Median			67	59	2	3	1	1
IQR/Median %			116	78	533	430	100	0

b) The graphs on the following pages show enterococci measurements from 1993 to December 2002 (where data available).

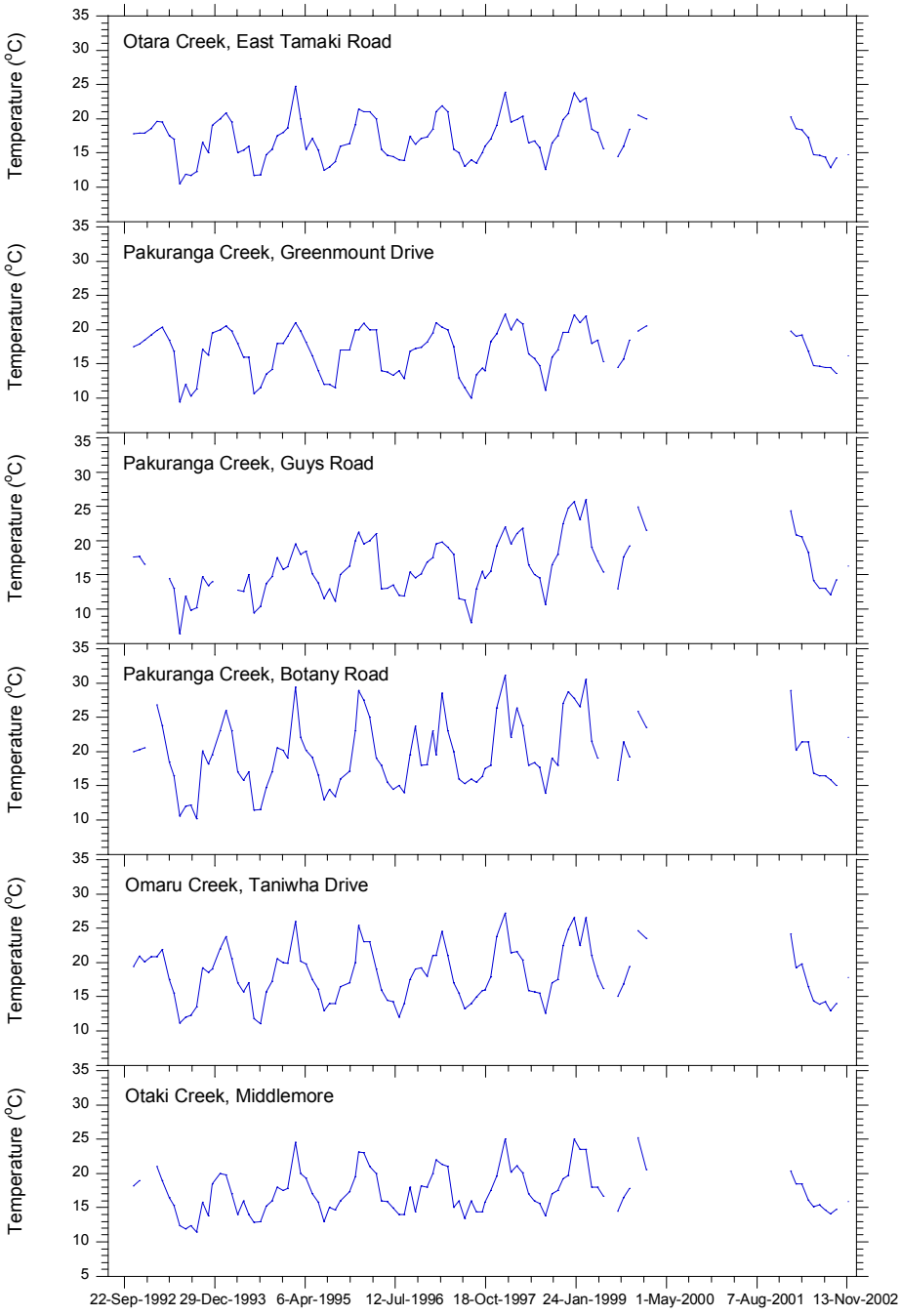

Supply Jetty
Town Bridge
Town Basin
Dawsons Creek
Mahurangi Heads
Enterrococci (cfu/100 mL)
10000
1000
100
10
1
0.1
Surface
1 metre depth
5 metre depth
24-Apr-1994
23-Nov-1995
24-Jun-1997
24-Jan-1999
24-Aug-2000
26-Mar-2002

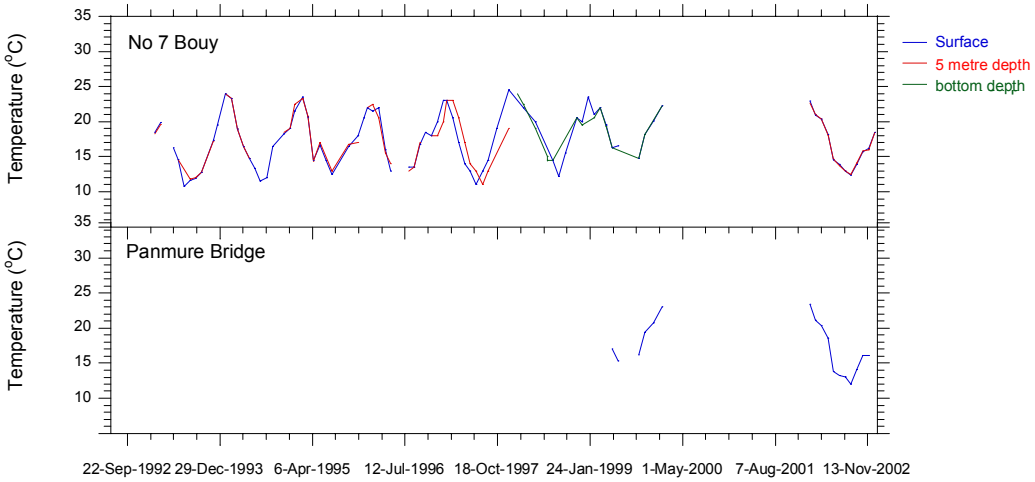
APPENDIX 20: TAMAKI ESTUARY – TEMPERATURE

a) Temperature (°C) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	20.4	19.8	24.4	28.9	24.2	20.3	22.9	22.7	23.4
25-Feb-2002	18.5	19.0	20.8	20.2	19.2	18.6	20.9	21.0	21.1
27-Mar-2002	18.5	19.2	20.5	21.4	19.8	18.4	20.4	20.4	20.4
30-Apr-2002	16.1	16.9	18.3	21.4	16.5	17.2	18.2	18.1	18.6
27-May-2002	15.1	14.8	14.2	16.9	14.4	14.8	14.6	14.7	13.8
25-Jun-2002	15.4	14.7	13.1	16.5	13.9	14.7	13.9	13.7	13.2
24-Jul-2002	14.7	14.5	13.1	16.5	14.3	14.4	13.0	13.0	13.1
21-Aug-2002	14.1	14.5	12.1	15.9	13.0	12.9	12.4	12.5	12.0
20-Sep-2002	14.8	13.6	14.3	15.0	14.0	14.3	13.9	14.1	14.1
18-Oct-2002							15.7	15.8	16.1
18-Nov-2002	15.9	16.2	16.3	22.1	17.8	14.8	16.2	16.0	16.1
17-Dec-2002									
Median	15.7	15.5	15.3	18.6	15.5	14.8	15.7	15.8	16.1
IQR/Median %	19	25	43	26	31	24	34	34	37

b) The graphs on the following pages show temperature measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
Pakuranga Creek, Greenmount Drive
Pakuranga Creek, Guys Road
Pakuranga Creek, Botany Road
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
Temperature (°C)
35
30
25
20
15
10
5
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

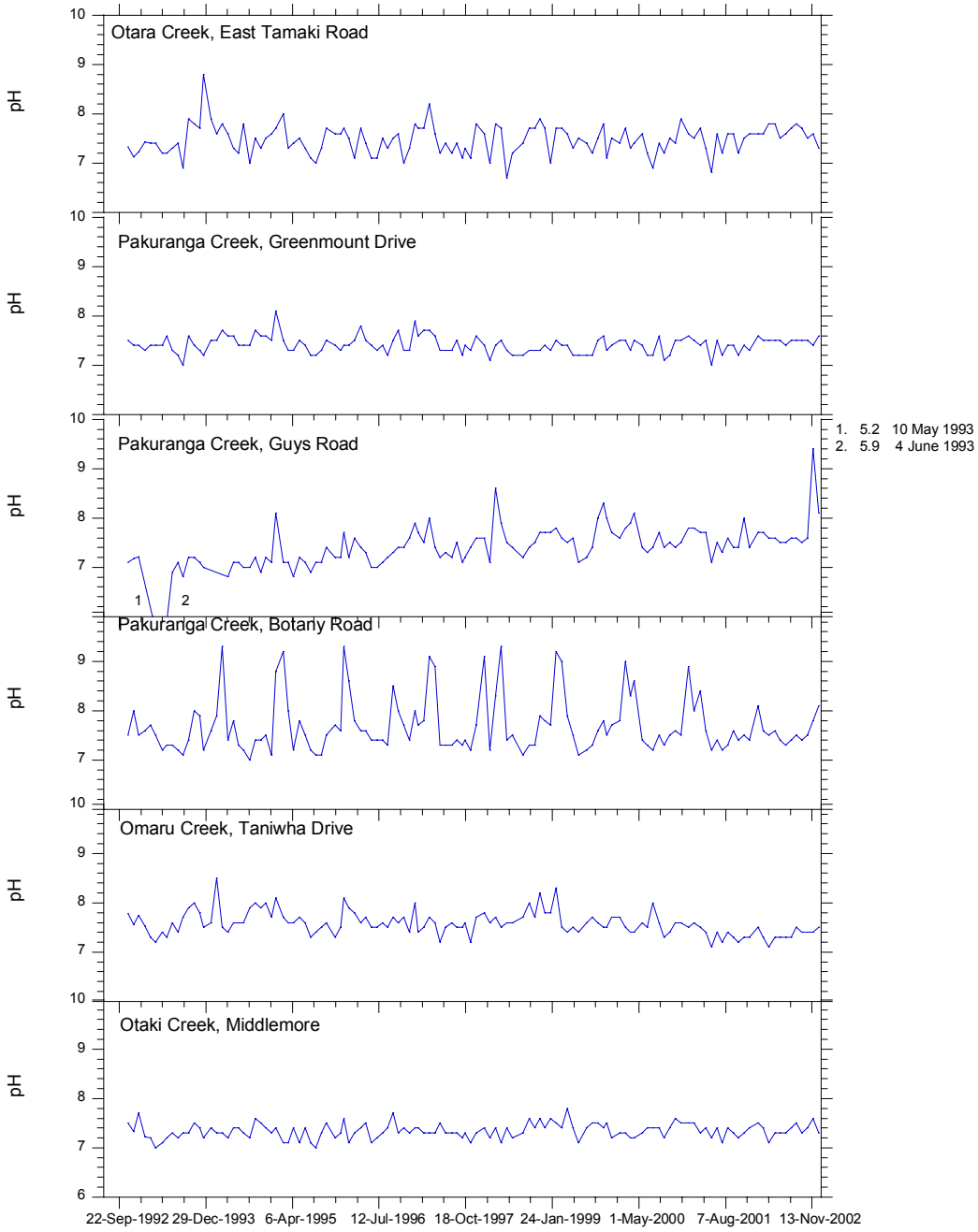

No 7 Bouy
Panmure Bridge
Temperature (°C)
Temperature (°C)
35
30
25
20
15
10
35
30
25
20
15
10
Surface
5 metre depth
bottom depth
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

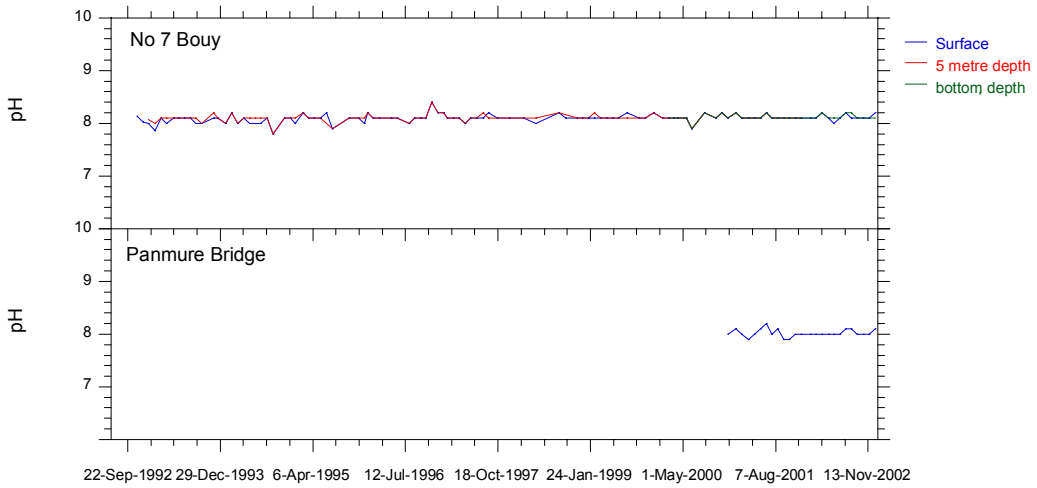
APPENDIX 21: TAMAKI ESTUARY – pH

a) Temperature (°C) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	7.6	7.6	7.7	8.1	7.5	7.5	8.1	8.1	8.0
25-Feb-2002	7.6	7.5	7.7	7.6	7.3	7.4	8.1	8.1	8.0
27-Mar-2002	7.8	7.5	7.6	7.5	7.1	7.1	8.2	8.2	8.0
30-Apr-2002	7.8	7.5	7.6	7.6	7.3	7.3	8.1	8.1	8.0
27-May-2002	7.5	7.5	7.5	7.4	7.3	7.3	8.0	8.1	8.0
25-Jun-2002	7.6	7.4	7.5	7.3	7.3	7.3	8.1	8.1	8.0
24-Jul-2002	7.7	7.5	7.6	7.4	7.3	7.4	8.2	8.2	8.1
21-Aug-2002	7.8	7.5	7.6	7.5	7.5	7.5	8.1	8.2	8.1
20-Sep-2002	7.7	7.5	7.5	7.4	7.4	7.3	8.1	8.1	8.0
18-Oct-2002	7.5	7.5	7.6	7.5	7.4	7.4	8.1	8.1	8.0
18-Nov-2002	7.6	7.4	9.4	7.8	7.4	7.6	8.1	8.1	8.0
17-Dec-2002	7.3	7.6	8.1	8.1	7.5	7.3	8.2	8.1	8.1
Median	7.6	7.5	7.6	7.5	7.4	7.4	8.1	8.1	8.0
IQR/Median %	2	0	2	3	2	2	0	0	0

b) The graphs on the following pages show pH measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
Pakuranga Creek, Greenmount Drive
Pakuranga Creek, Guys Road
Pakuranga Creek, Botany Road
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
pH
1
2
1. 5.2 10 May 1993
2. 5.9 4 June 1993
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

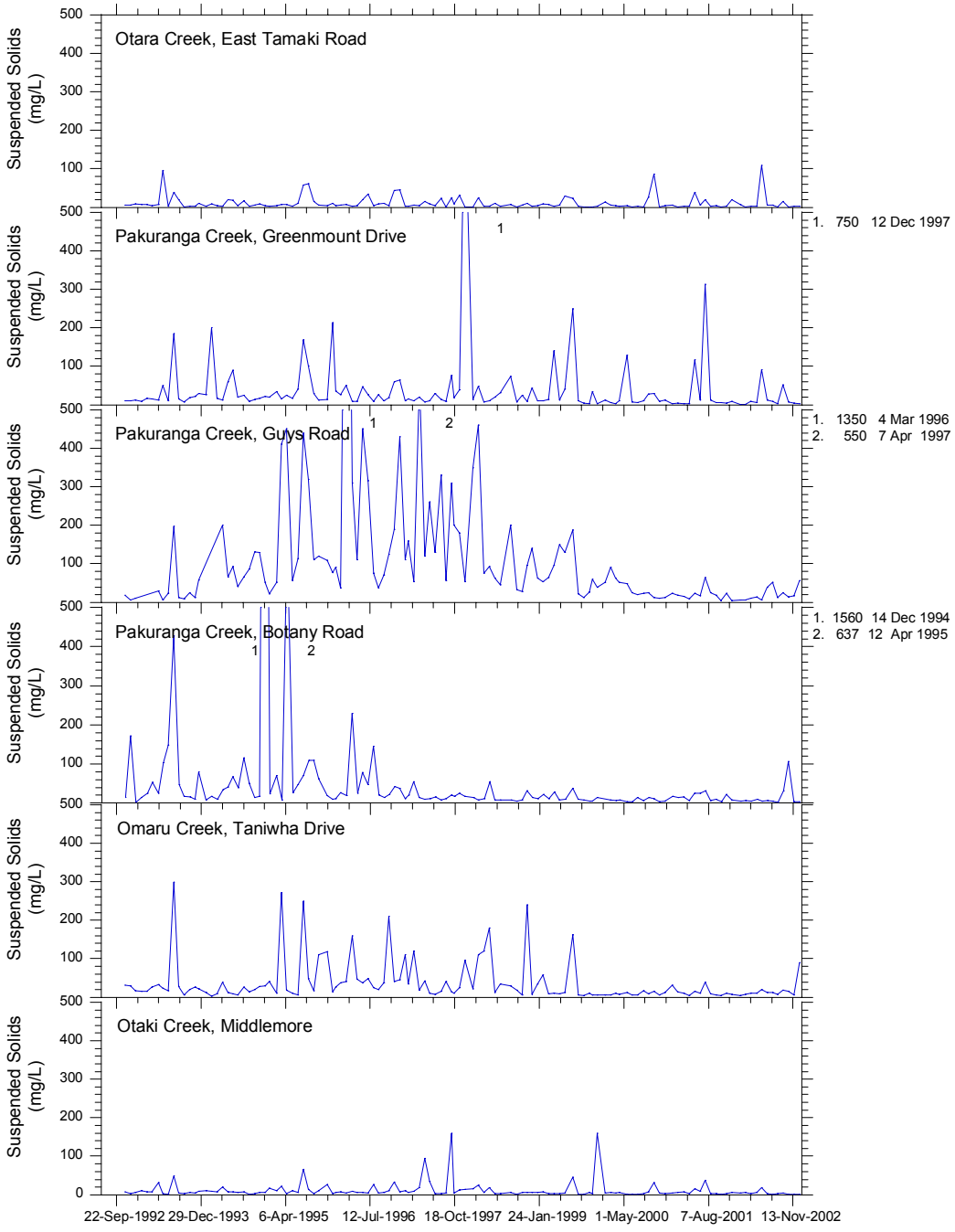

No 7 Bouy
Panmure Bridge
pH
10
9
8
7
Surface
5 metre depth
bottom depth
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

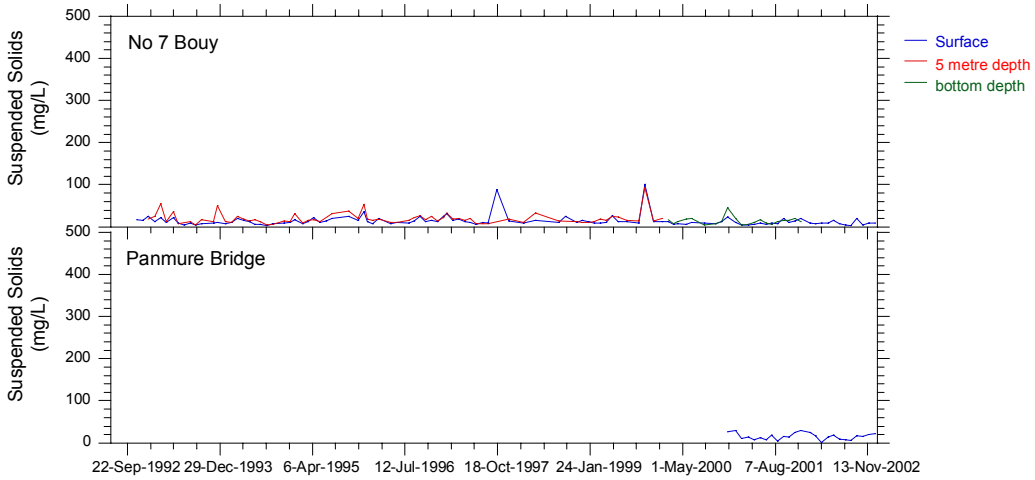
APPENDIX 22: TAMAKI ESTUARY – SUSPENDED SOLIDS

a) Suspended solids (mg/L) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	6.9	1.4	5.1	5.4	4.8	4.9	9.6	29.0	24.0
25-Feb-2002	1.3	2.0	5.9	5.8	7.4	5.6	7.1	10.1	17.0
27-Mar-2002	2.3	9.7	11.0	4.9	11.0	3.3	9.7	20.0	1.9
30-Apr-2002	3.2	5.3	13.6	9.8	11.0	5.3	8.3	14.9	14.0
27-May-2002	108.0	91.0	5.6	5.2	20.7	18.7	14.9	14.6	18.2
25-Jun-2002	5.4	12.8	39.3	6.3	12.6	2.2	8.0	7.9	8.7
24-Jul-2002	5.2	8.6	52.3	5.4	12.9	1.3	3.9	6.7	8.2
21-Aug-2002	1.4	3.2	13.0	1.5	7.0	2.7	3.4	4.8	5.1
20-Sep-2002	14.8	52.0	24.0	31.0	19.0	3.8	21.0	19.9	16.8
18-Oct-2002	1.6	7.5	13.9	106.0	14.6	2.0	4.7	6.0	15.5
18-Nov-2002	2.7	4.4	16.9	4.5	6.4	0.6	8.5	11.4	20.4
17-Dec-2002	3.1	2.9	56.0	4.1	90.0	1.4	8.9	7.8	22.0
Median	3.2	6.4	13.8	5.4	11.8	3.0	8.4	10.8	16.2
IQR/Median %	116	115	132	44	71	105	37	80	63

b) The graphs on the following pages show suspended solids measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
Pakuranga Creek, Greenmount Drive
1. 750 12 Dec 1997
Pakuranga Creek, Guys Road
1. 1350 4 Mar 1996
2. 550 7 Apr 1997
Pakuranga Creek, Botany Road
1. 1560 14 Dec 1994
2. 637 12 Apr 1995
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
Suspended Solids (mg/L)
0
100
200
300
400
500
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

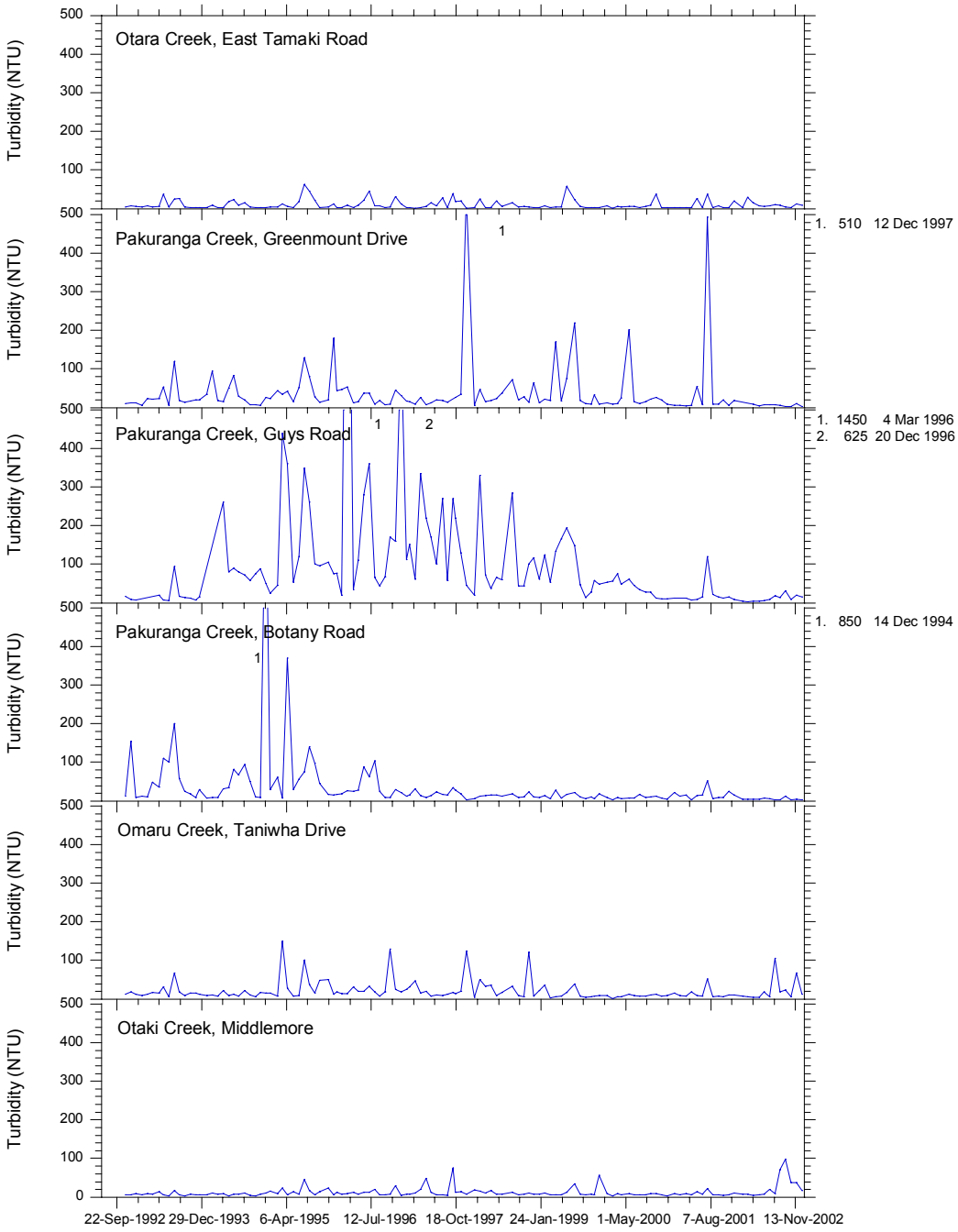

No 7 Bouy
Panmure Bridge
Suspended Solids (mg/L)
Surface
5 metre depth
bottom depth
500
400
300
200
100
0
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

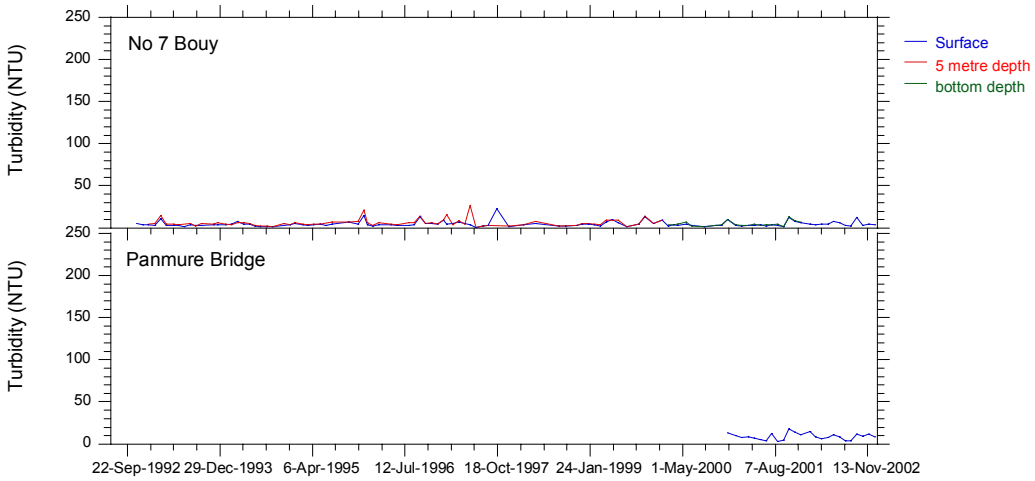
APPENDIX 23: TAMAKI ESTUARY – TURBIDITY

a) Turbidity (NTU) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	3.5	4.9	4.4	10.0	4.1	7.7	4.4	8.8	15.0
25-Feb-2002	1.8	4.9	5.8	6.3	4.3	6.0	3.8	4.0	8.1
27-Mar-2002	2.0	18.0	6.7	14.0	6.4	7.4	4.5	6.9	6.2
30-Apr-2002	5.1	6.1	20.3	14.8	9.2	6.8	4.9	7.5	7.6
27-May-2002	36.4	105.0	9.6	9.4	19.0	18.4	7.6	7.4	10.7
25-Jun-2002	11.4	17.8	70.1	12.2	13.9	5.4	6.3	6.6	8.5
24-Jul-2002	14.3	23.1	97.6	13.2	31.4	5.2	2.9	3.6	4.0
21-Aug-2002	3.8	6.5	37.3	8.3	8.9	5.8	2.2	2.5	3.7
20-Sep-2002	19.6	68.0	36.8	30.5	19.9	8.5	12.2	10.6	11.6
18-Oct-2002	3.4	13.1	16.4	89.0	15.0	5.9	2.9	2.9	9.3
18-Nov-2002	3.4	7.6	2.8	6.9	5.2	3.7	4.3	3.8	11.5
17-Dec-2002	3.5	6.7	29.6	5.1	57.3	5.7	3.6	3.4	8.9
Median	3.7	10.4	18.4	11.1	11.6	6.0	4.4	5.3	8.7
IQR/Median %	239	124	166	56	113	31	42	73	42

b) The graphs on the following pages show turbidity measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
Pakuranga Creek, Greenmount Drive
1. 510 12 Dec 1997
Pakuranga Creek, Guys Road
1. 1450 4 Mar 1996
2. 625 20 Dec 1996
Pakuranga Creek, Botany Road
1. 850 14 Dec 1994
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
Turbidity (NTU)
0
100
200
300
400
500
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

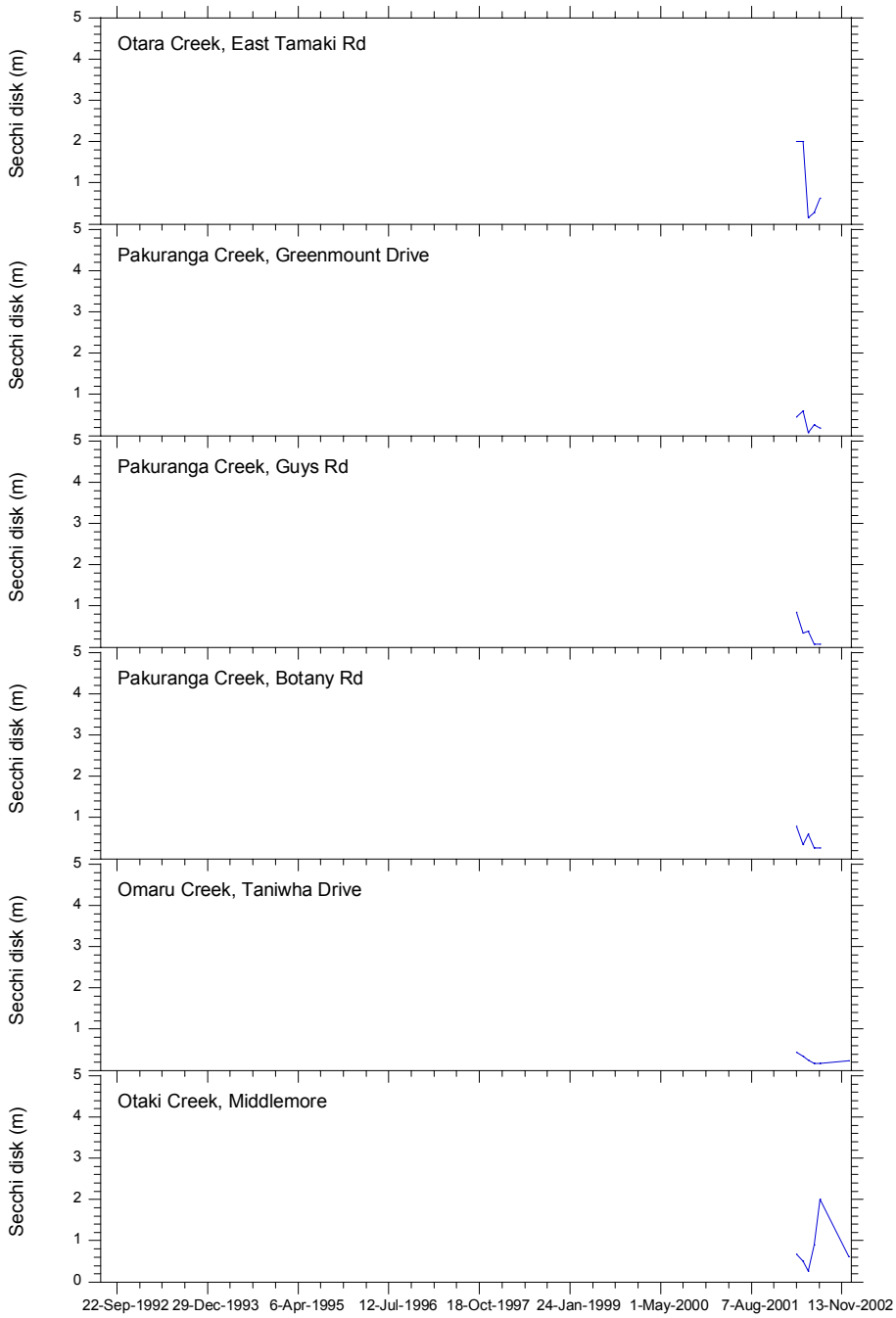

No 7 Bouy
Panmure Bridge
Turbidity (NTU)
Turbidity (NTU)
250
200
150
100
50
0
Surface
5 metre depth
bottom depth
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

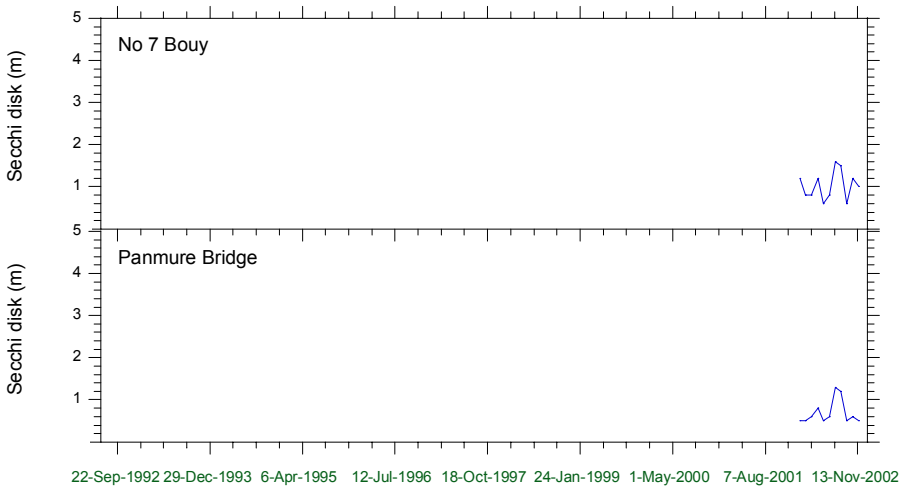
APPENDIX 24: TAMAKI ESTUARY – SECCHI DEPTH

a) Secchi depth (m) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002						1.4	1.2		0.5
25-Feb-2002						0.3	0.8		0.5
27-Mar-2002	1.0	0.5	0.9	0.8	0.4	0.5	0.8		0.6
30-Apr-2002	1.0	0.6	0.3	0.3	0.3	0.6	1.2		0.8
27-May-2002	0.2	0.1	0.4	0.6	0.3	0.7	0.6		0.5
25-Jun-2002	0.3	0.3	0.1	0.3	0.2	0.9	0.8		0.6
24-Jul-2002	0.6	0.2	0.1	0.3	0.2	0.4	1.6		1.3
21-Aug-2002							1.5		1.2
20-Sep-2002							0.6		0.5
18-Oct-2002							1.2		0.6
18-Nov-2002					0.2		1.0		0.5
17-Dec-2002									
Median	0.6	0.3	0.3	0.3	0.2	0.6	1.0		0.6
IQR/Median %						1.4	1.2		0.5

b) The graphs on the following pages show Secchi depth measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Rd
Pakuranga Creek, Greenmount Drive
Pakuranga Creek, Guys Rd
Pakuranga Creek, Botany Rd
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
Secchi disk (m)
0
1
2
3
4
5
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

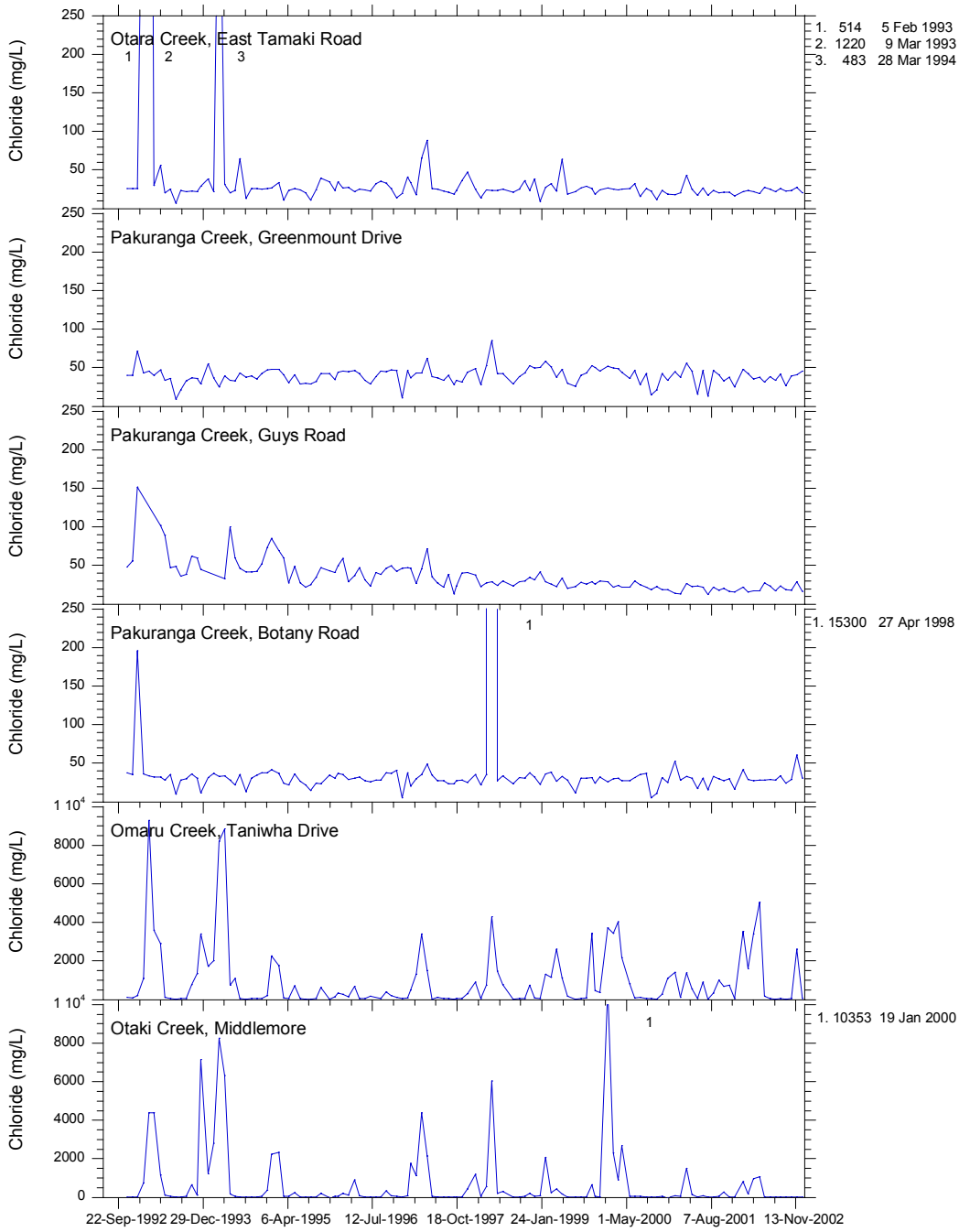

No 7 Bouy
Panmure Bridge
Secchi disk (m)
Secchi disk (m)
5
4
3
2
1
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

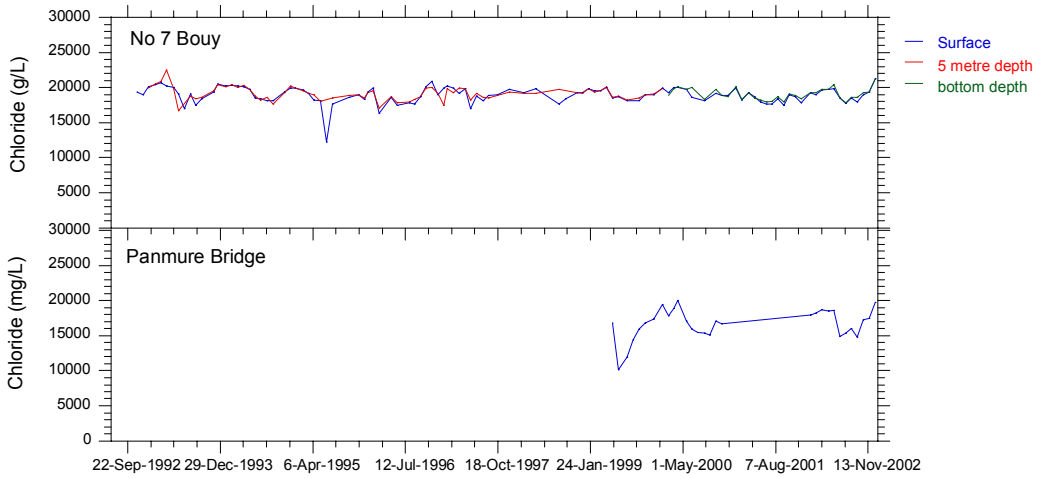
APPENDIX 25: TAMAKI ESTUARY – CHLORIDE

a) Chloride (mg/L) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	22.2	48.5	22.3	42.0	3525	829	19270	19232	17941
25-Feb-2002	23.3	42.8	15.9	28.8	1599	191	18958	19216	18182
27-Mar-2002	21.5	35.7	16.9	27.2	3424	983	19616	19749	18653
30-Apr-2002	19.5	37.7	17.1	28.6	5056	1062	19751	19700	18452
27-May-2002	27.4	31.0	27.8	28.2	185	39.2	19804	20441	18592
25-Jun-2002	25.2	38.9	23.2	29.1	48.8	27.9	18496	18528	14871
24-Jul-2002	22.2	33.5	17.1	28.1	35.2	25.0	17763	17822	15371
21-Aug-2002	25.7	41.7	23.4	33.9	51.0	23.1	18453	18606	16058
20-Sep-2002	22.4	26.4	18.5	24.3	33.0	25.4	17945	18553	14780
18-Oct-2002	23.6	39.5	18.2	29.2	45.9	35.9	18990	19217	17221
18-Nov-2002	27.8	40.9	29.1	60.7	2608	31.0	19318	19321	17488
17-Dec-2002	20.6	45.8	16.7	30.7	52.0	31.7	21249	21270	19700
Median	22.9	39.2	18.4	29.0	119	33.8	19100	19200	17700
IQR/Median %	14	17	34	11	2332	956	6	6	15

b) The graphs on the following pages show chloride measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
1. 514 5 Feb 1993
2. 1220 9 Mar 1993
3. 483 28 Mar 1994
Pakuranga Creek, Greenmount Drive
Pakuranga Creek, Guys Road
Pakuranga Creek, Botany Road
1. 15300 27 Apr 1998
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
1. 10353 19 Jan 2000
Chloride (mg/L)
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

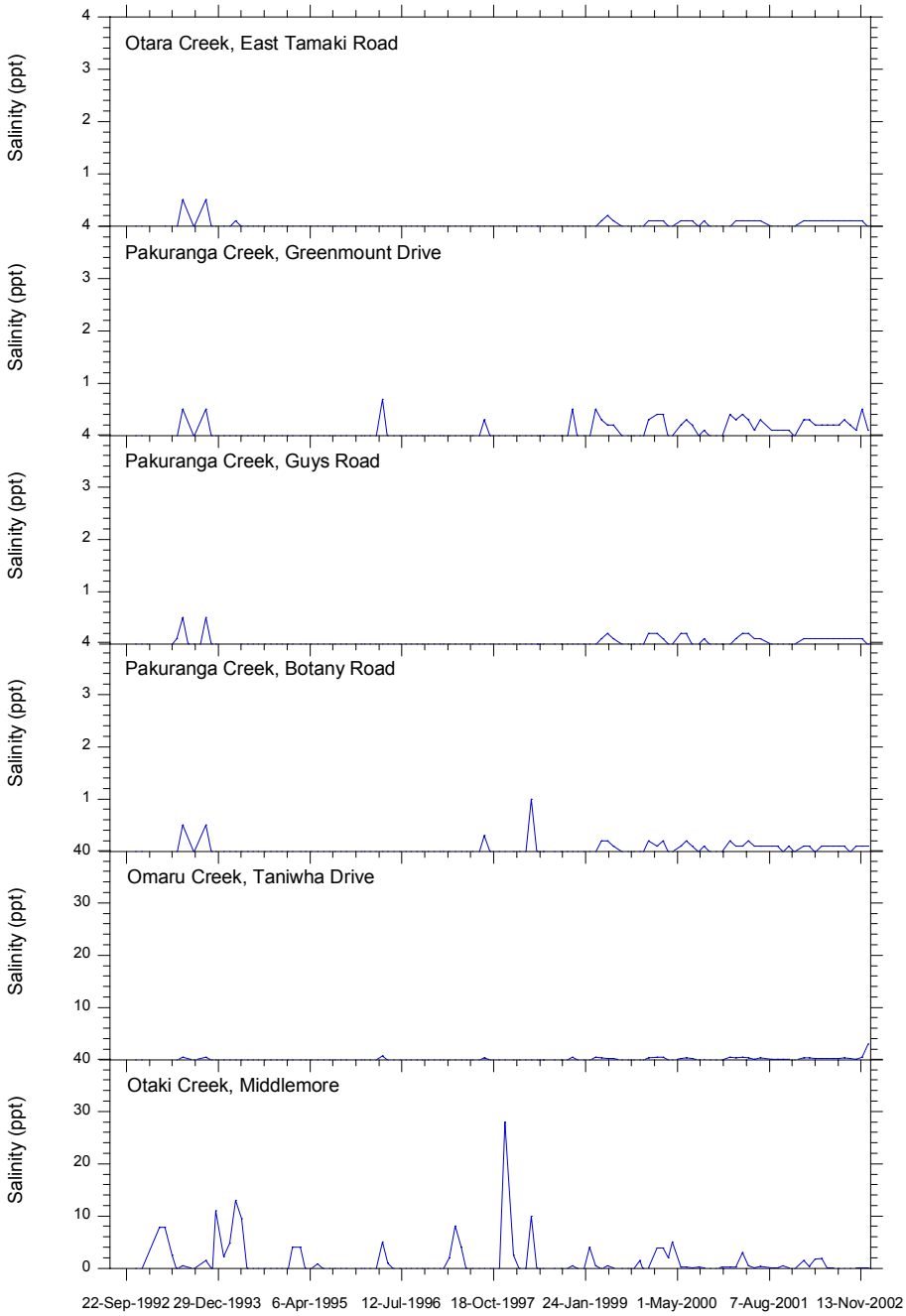

No 7 Bouy
Panmure Bridge
Chloride (g/L)
Chloride (mg/L)
30000
25000
20000
15000
10000
5000
0
Surface
5 metre depth
bottom depth
22-Sep-1992
29-Dec-1993
6-Apr-1995
12-Jul-1996
18-Oct-1997
24-Jan-1999
1-May-2000
7-Aug-2001
13-Nov-2002

APPENDIX 26: TAMAKI ESTUARY – SALINITY

a) Salinity (ppt) during January 2002 - December 2002

	Otara Creek East Tamaki	Pakuranga Ck Greenmount	Pakuranga Ck Guys	Pakuranga Ck Botany	Omaru Creek Taniwha	Otaki Creek Middlemore	No. 7 Buoy surface	No. 7 Buoy bottom	Panmure Bridge
29-Jan-2002	0.0	0.1	0.0	0.1	6.3	1.5	35.0	34.9	32.6
25-Feb-2002	0.0	0.1	0.0	0.1	2.9	0.3	34.4	34.9	33.0
27-Mar-2002	0.0	0.1	0.0	0.0	6.2	1.8	35.6	35.8	33.8
30-Apr-2002	0.0	0.1	0.0	0.1	9.2	1.9	35.8	35.7	33.5
27-May-2002	0.0	0.1	0.1	0.1	0.3	0.1	35.9	37.1	33.7
25-Jun-2002	0.0	0.1	0.0	0.1	0.1	0.1	33.6	33.6	27.0
24-Jul-2002	0.0	0.1	0.0	0.1	0.1	0.0	32.2	32.3	27.9
21-Aug-2002	0.0	0.1	0.0	0.1	0.1	0.0	33.5	33.8	29.1
20-Sep-2002	0.0	0.0	0.0	0.0	0.1	0.0	32.6	33.7	26.8
18-Oct-2002	0.0	0.1	0.0	0.1	0.1	0.1	34.5	34.9	31.3
18-Nov-2002	0.1	0.1	0.1	0.1	4.7	0.1	35.1	35.1	31.7
17-Dec-2002	0.0	0.1	0.0	0.1	0.1	0.1	38.6	38.6	35.7
Median	0.0	0.1	0.0	0.1	0.2	0.1	34.8	34.9	32.2
IQR/Median %	–	0	–	0	2488	525	6	6	15

b) The graphs on the following pages show salinity measurements from 1992 to December 2002 (where data available).


Otara Creek, East Tamaki Road
Pakuranga Creek, Greenmount Drive
Pakuranga Creek, Guys Road
Pakuranga Creek, Botany Road
Omaru Creek, Taniwha Drive
Otaki Creek, Middlemore
Salinity (ppt)
22-Sep-1992 29-Dec-1993 6-Apr-1995 12-Jul-1996 18-Oct-1997 24-Jan-1999 1-May-2000 7-Aug-2001 13-Nov-2002