Auckland
Regional Council
TE RAUHĪTANGA TAIAO

Weiti Sediment Monitoring 2007

January TR2008/046

Auckland Regional Council
Technical Report No.022 October 2008
ISSN 1179-0504 (Print)
ISSN 1179-0512 (Online)
ISBN 978-1-877483-64-6

Technical report edition one

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Recommended Citation:

REED, J, HUNT, J, BUCKTHOUGHT, D,. (2008). Weiti Sediment Monitoring 2007. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Document Type 2008/046.

Weiti Sediment Monitoring Programme

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NIWA Client Report: AKL-2007-039
April 2008

NIWA Project: ARC07133

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1 Executive Summary

Sediment concentrations of zinc in the Weiti Estuary have increased by 70% during the period 1998-2005 (ARC technical reports). The Auckland Regional Council (ARC) commissioned NIWA to survey sediment metal concentrations at numerous sites in the upper and lower reaches of the Weiti Estuary and to determine the extent to which sediment zinc and other metal concentrations can be linked to land-uses in the catchment.

The land-use adjacent to the upper reaches of the estuary is industrial, whereas the land-use adjacent to the lower reaches is residential. Zinc was observed in the highest concentrations in the surface sediments, followed by copper. Though there was quite some variation in the concentrations of these metals at sites close to industrial areas, the mean and median values in those samples were considerably higher than those in samples collected adjacent to residential sites. A number of the sites adjacent to industrial areas showed zinc and copper concentrations well in excess of background values adopted for the catchment. Other metals analysed (lead, arsenic and chromium) were somewhat elevated over background, and no apparent difference was observed between the industrial and residential sites.

The background values adopted here for the catchment are themselves at the high end of those measured around the Auckland Region for ARC's TP153 document. In comparison with other estuaries sampled as part of ARC's Long Term Sediment Monitoring Programme, the Weiti Estuary would rank amongst the top third in terms of metal contamination (zinc, copper and lead) in surface sediments in 2007.

2 Introduction

The Auckland Regional Council (ARC) has been measuring the concentrations of urban-derived chemicals in surficial sediments of estuaries and the coastal zone of the Auckland region for many years. Current monitoring programmes include the State of Environment (SOE) monitoring with sampling rounds in 1998, 1999, 2001, 2003, 2005 and 2007 (Williamson *et al.*, 1998; Mills *et al.*, 2000; Hawken *et al.*, 2002; Timperley and Mathieson, 2002; Reed and Webster, 2004; ARC, 2006), and the Regional Discharges Programme (RDP) monitoring (Diffuse Sources, 2002). A large amount of data for metal concentrations in marine sediments now exists. The Weiti Estuary is of particular concern to the ARC due to a 70% increase in sediment zinc concentrations between 1998-2005 SOE monitoring.

The Silverdale industrial area is located in the catchment of the Weiti Estuary. The Auckland Regional Council (ARC) has commissioned work to determine if sediment zinc concentrations can be linked to land uses in the catchment, and to investigate metal profiles with depth of sediment. In order to achieve this, a separate monitoring programme has been devised by ARC to determine the spatial distribution of metals in sediments from mouth to upper estuary at present day concentrations.

The Auckland Regional Council contracted NIWA to conduct a monitoring programme in the Weiti Estuary to collect surface sediments at 44 sites and 5 sediment core samples for metal analysis of zinc, copper and lead. Sites were chosen to straddle obvious stream and storm water discharge points from both sides of the estuary and river.

The locations of all of the sampling sites are shown in Figure 1, with closer shots in Figures 2 – 7. Section 3 below contains details of the sample collection and analysis, and the results are interpreted in Section 4. Full site results are listed in Appendix A; photos taken at the surface sediment sites are shown in Appendix B, and photos of the sediment core sites are shown in Appendix C. The latitude and longitude locations of the sites are listed in Appendix D.

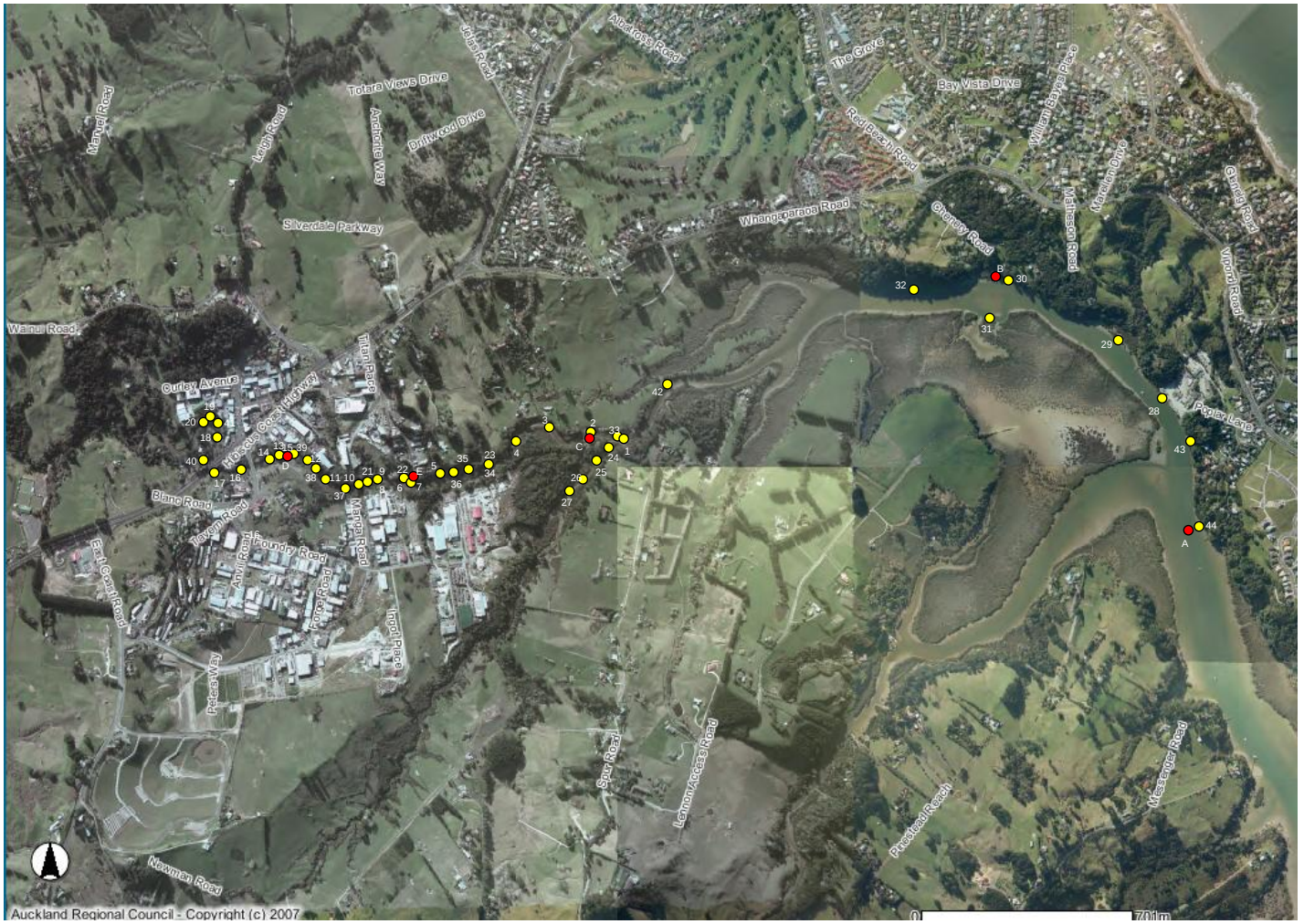

Figure 1: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme (source of photographs: http://maps.arc.govt.nz/website/maps/map_general.htm)

Figure 2: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

Figure 3: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

Figure 4: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

Figure 5: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

Figure 6: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

Figure 7: Location of sediments sampled in 2007 for the Weiti Estuary monitoring programme.

3 Methods

3.1 Sediment Sampling

Surface sediments were collected to a depth of 2cm at each site. Sediments were frozen on return to the NIWA Laboratory, Auckland.

Two deep sediment cores were collected using a sediment corer and frozen immediately on return to the NIWA Laboratory, Auckland. One core was measured for total length (mm) and then the core was sectioned into 50mm lengths. The duplicate core was frozen intact for possible later analysis to confirm results obtained from the first core.

3.2 Sediment Preparation

Each sediment sample was defrosted overnight and homogenized. Sediment samples were wet sieved to <500 µm and dried at 60°C until at constant weight. Dry sediments were ground and weighed to 1g ± 0.001. Sediments were analysed for five metals; Zn, Cu, Pb, As and Cr.

3.2.1 Total Recoverable Metals Digestion and Analysis Method (US EPA 200.2)

A 1 g sample of each dried sediment was placed in a 50 mL polypropylene centrifuge tube and digested for 30 mins at 95 °C in nitric/hydrochloric acid (2 mL HNO_3, 2mL HCl, 10 mL water). Samples were diluted 10x with 1% nitric acid prior to analysis to reduce acid strength and centrifuged at 2500 rpm for 10 minutes to remove suspended solids. The extracts were decanted into clean plastic tubes and analysed by Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) according to APHA method 3125B by Hills Laboratory, Hamilton.

4 Results

Figures 8 – 10 below show the concentrations of metals downstream of the uppermost site (#20), annotated to include changes in land-use adjacent to the sample sites ('Flexman Place area' and 'End of Manga Road' are industrial areas). The metal concentrations are reported as mg kg^{-1} dry weight, and the results for all sites may be found listed in Appendix 1.

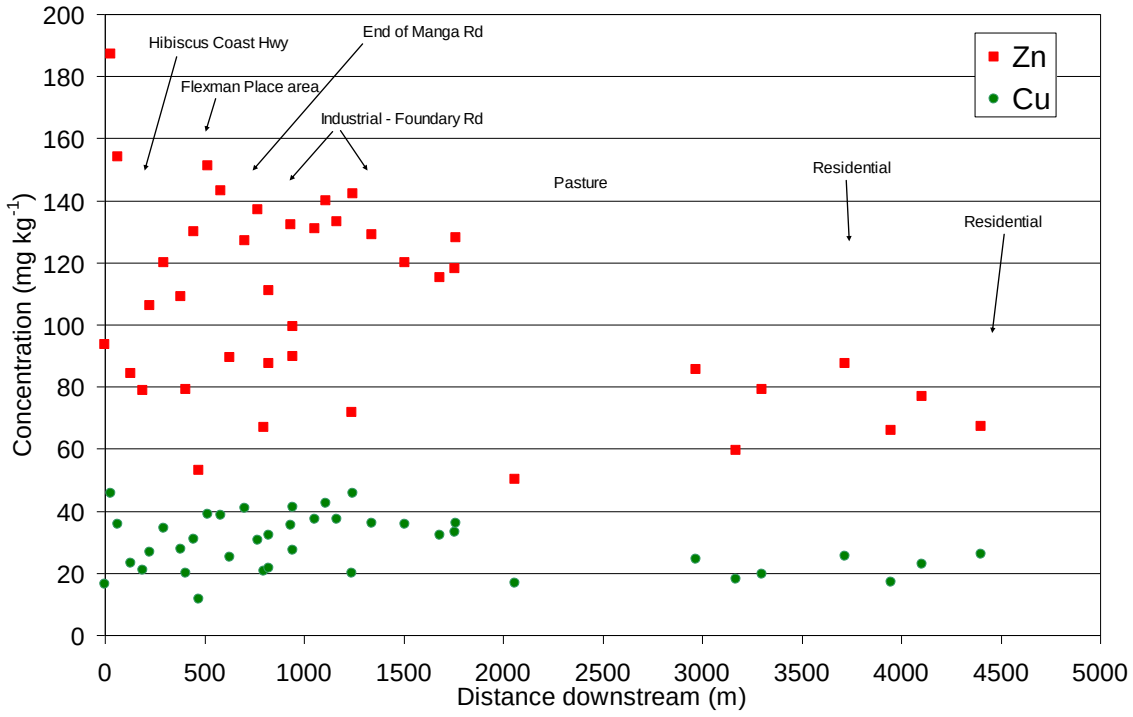

Figure 8: Zinc and copper concentrations (mg kg^{-1} dw) in surficial sediments < 500 µm.

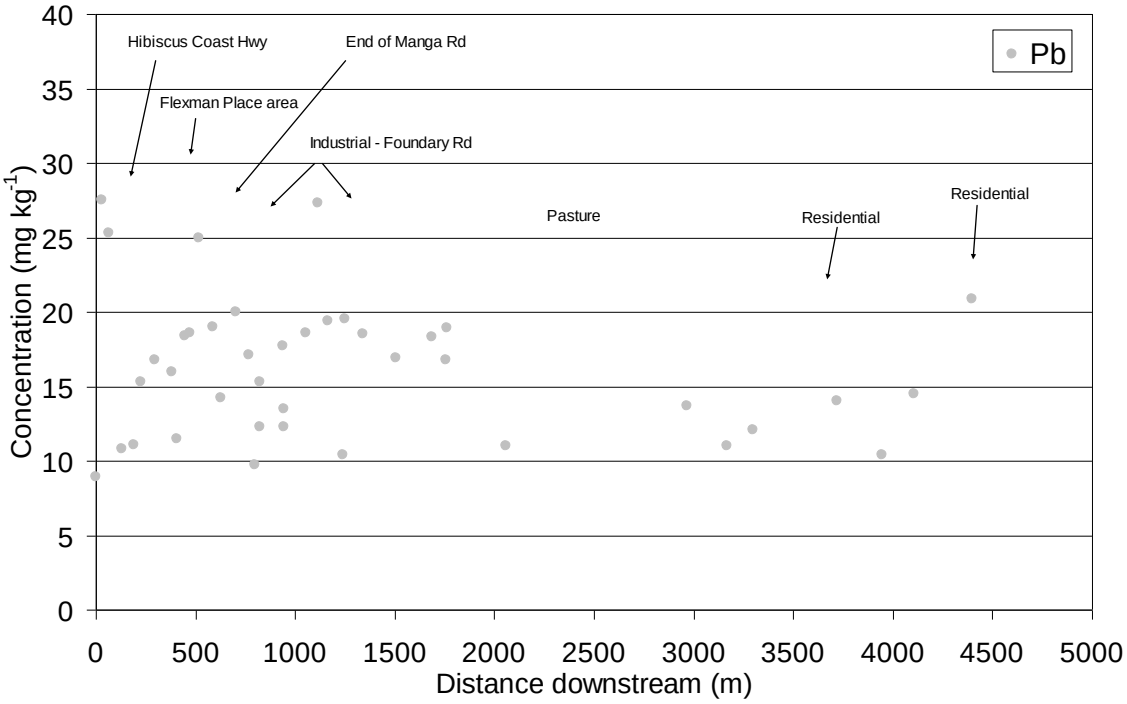

Figure 9: Lead concentrations (mg kg^{-1} dw) in surficial sediments < 500 µm.

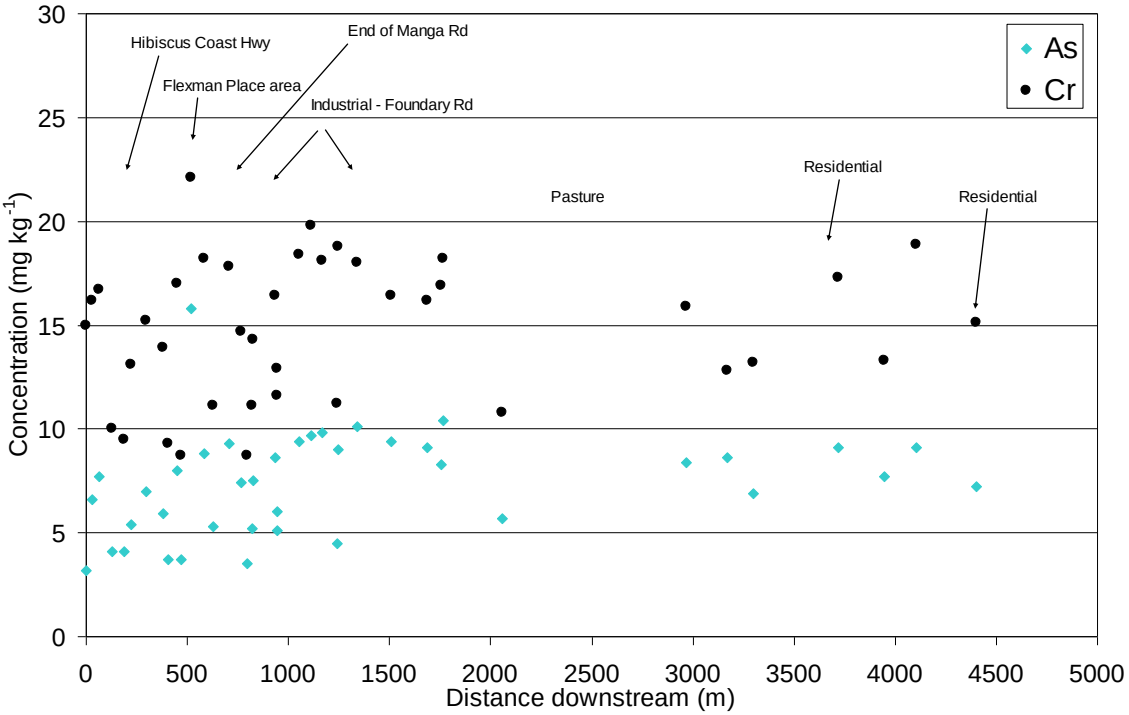

Figure 10: Arsenic and chromium concentrations (mg kg^{-1} dw) in surficial sediments < 500 µm.

The metal concentrations shown in Figures 8 – 10 may be divided into two separate groups according to land-use: (i) those from sediments collected at sites adjacent to

industrial areas (0 – 2000 m downstream), and (ii) those from sediments collected at sites adjacent to residential areas (3000 – 4400 m downstream). Mean and median values for each group, along with the range of metal concentrations observed, are shown in Table 1.

Table 1. Mean, median and range of metal concentrations in surficial sediments of sites grouped according to their adjacent land-use

Land-Use	Metal	Mean (mg kg^{-1})	Median (mg kg^{-1})	Range (mg kg^{-1})
Industrial	Zn	112.3	118.0	50.3 – 187.0
	Cu	30.8	32.2	11.5 – 45.5
	Pb	16.7	16.9	8.9 – 27.5
	As	7.2	7.4	3.2 – 15.8
	Cr	14.7	15.2	8.7 – 22.1
Residential	Zn	74.5	76.7	59.6 – 87.4
	Cu	21.9	22.8	17.0 – 26.0
	Pb	13.8	13.7	10.4 – 20.9
	As	8.1	8.4	6.9 – 9.1
	Cr	15.2	15.1	12.8 – 18.9

Zinc is observed in by far the highest concentrations, followed by copper. The remaining metals share similar concentrations, with arsenic being the lowest. Comparing the results for the sediment samples collected near industry against those collected near residential, zinc, and to a lesser extent copper, are the only two metals which show any great difference. Both the mean and median zinc and copper levels in the sediment samples near industry are significantly higher than in those near residential areas; the lower end of the range of measurements is similar however, reflecting the variability across the industrial sites evidenced in Figure 1. Likely reasons for the higher zinc and copper levels in sediments adjacent to industrial areas include the widespread presence of galvanized roofs, which are a major source of zinc, and proximity to roads which are a major source of both copper and zinc. If the industrial area contains automotive or metal processing activities these could also contribute to higher copper and zinc levels, and in the upper reaches of the estuary runoff from the Hibiscus Coast Highway is an obvious further source of both metals.

The catchment of the Weiti Estuary is predominantly occupied by Mahurangi Limestone/Otamatea calcareous claystone soils, with areas of Waitemata Group, Onerahi Chaos-Breccia and Quarternary alluvial soils bordering the estuary. ARC TP153 (ARC, 2001) provides background concentrations of metals in these soils from around the Auckland Region (see Table 2). The closest TP153 site is at the North Shore Aerodrome, just to the south of the Weiti Estuary catchment; this site has Limestone soil, and in fact corresponds to the maximum Limestone range values in Table 2, which suggests that the background metal concentrations for the Weiti Estuary are likely to be near the upper end of the TP153 Limestone range. On this basis, the metal concentrations in the sediment samples from the Weiti estuary (Table

1) are somewhat elevated, more so for those samples collected adjacent to industrial areas, and zinc and copper show the greatest elevation. The mean and median metal concentrations from the Weiti Estuary are however reasonably consistent with the upper range of the other soil types in Table 2, but we have placed less emphasis on this comparison. In any case, a number of the sediment samples collected at sites adjacent to industrial areas showed zinc and copper concentrations well in excess of those for any soil type in Table 2, indicating that these are the metals of concern.

Table 2. Background metal concentrations in soils from the Auckland Region. Source: ARC (2001)

Soil	Metal	Mean (mg kg^{-1})	Median (mg kg^{-1})	Range (mg kg^{-1})
Limestone	Zn	25.3	14.1	9.2 – 63.9
	Cu	6.3	3.3	1.3 – 17.1
	Pb	6.6	5.7	2.4 – 12.6
	As	1.7	1.7	1.2 – 2.3
	Cr	7.6	8.3	3.5 – 10.2
Waitematas	Zn	54.3	45.8	9.6 – 123.0
	Cu	11.7	8.4	2.2 – 35.3
	Pb	11.5	8.6	2.8 – 40.9
	As	3.9	2.8	1.3 – 11.5
	Cr	16.5	16.9	2.2 – 40.4
Onerahi Chaos	Zn	-	-	27.2 – 36.5
	Cu	-	-	4.0 – 8.6
	Pb	-	-	9.1 – 13.0
	As	-	-	3.0 – 4.9
	Cr	-	-	10.9 – 11.2
Quaternary	Zn	66.1	63.9	21.0 – 111.0
	Cu	15.5	15.2	4.8 – 27.4
	Pb	28.4	22.6	11.2 – 56.2
	As	6.4	7.0	1.9 – 10.6
	Cr	11.1	8.0	3.9 – 28.1

ARC's long-term sediment monitoring programme provides concentrations of zinc, copper and lead in surficial sediments from 27 estuaries in the Auckland Region (Reed & Gadd, 2009). The three most heavily contaminated of these estuaries in 2007 (Whau Upper, Meola and Whau Wairau) had zinc concentrations of 230 – 270 mg kg^{-1}, copper concentrations of 33 – 41 mg kg^{-1}, and lead concentrations of 61 – 65 mg kg^{-1}. Looking at the full range of measurements from those sites adjacent to industrial areas in Table 1, the Weiti Estuary would be amongst the top third of the 27 sites in terms of metal contamination.

5 Conclusions

Sediment surface and core samples were collected from the Weiti Estuary and analysed for metal concentrations. The sampling sites were categorized as those adjacent to industrial areas, and those adjacent to residential areas. Zinc primarily, and also copper were found to be the metals of concern. Though there was quite some variation in the concentrations of these metals across the sites adjacent to industrial areas, the mean and median concentrations of copper and zinc in these samples were considerably higher than those in samples collected adjacent to the residential areas. For the remaining metals analysed there was no apparent difference between the industrial and residential sites. Comparing against background values adopted for the catchment, the metals concentrations from the Weiti Estuary sediments were somewhat elevated, more so for the samples collected adjacent to industrial areas. A number of the sites close to industry showed zinc and copper concentrations well in excess of background.

The background values adopted here for the catchment are themselves at the high end of those measured around the Auckland Region (ARC, 2001). In comparison with other estuaries sampled as part of ARC's Long Term Sediment Monitoring Programme, the Weiti Estuary would rank amongst the top third in terms of metal contamination (zinc, copper and lead) in surface sediments in 2007.

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7 Appendix A – Full Site Results

Table A1: Metal concentrations in surficial sediments < 500 µm (mg kg^{-1} dry weight)

Site #	As	Cr	Cu	Pb	Zn
1	10.4	18.2	35.9	18.9	128
2	9.1	16.2	32.2	18.3	115
3	9.4	16.4	35.6	16.9	120
4	10.1	18	35.9	18.5	129
5	9.4	18.4	37.3	18.6	131
6	8.6	16.4	35.3	17.7	132
7	6	11.6	41.1	13.5	99.4
8	7.5	14.3	32.1	15.3	111
9	5.2	11.1	21.4	12.3	87.3
10	7.4	14.7	30.7	17.1	137
11	5.3	11.1	25.2	14.2	89.5
12	15.8	22.1	38.8	25	151
13	3.7	9.3	19.9	11.5	79.1
14	5.9	13.9	27.8	16	109
15	8	17	31	18.4	130
16	7	15.2	34.5	16.8	120
17	5.4	13.1	26.7	15.3	106
18	4.1	10	23.3	10.8	84.2
19	6.6	16.2	45.5	27.5	187
20	3.2	15	16.4	8.94	93.6
21	3.5	8.7	20.6	9.76	67
22	5.1	12.9	27.2	12.3	89.8
23	4.5	11.2	19.9	10.4	71.6
24	8.7	17.3	28.2	15.5	92.3
25	9.4	16.5	26.3	15.3	86.9
26	8.5	15.7	26.9	14.9	89.8
27	7.3	15.8	26.8	15	88.5
28	7.7	13.3	17	10.4	66
29	9.1	17.3	25.3	14	87.4
30	6.9	13.2	19.7	12.1	79
31	8.6	12.8	17.9	11	59.6
32	8.4	15.9	24.3	13.7	85.5
33	8.3	16.9	33.1	16.8	118
34	9	18.8	45.5	19.5	142
35	9.8	18.1	37.2	19.4	133
36	9.7	19.8	42.4	27.3	140
37	9.3	17.8	40.7	20	127
38	8.8	18.2	38.7	19	143
39	3.7	8.7	11.5	18.6	53.1
40	4.1	9.5	21	11.1	78.9
41	7.7	16.7	35.6	25.3	154
42	5.7	10.8	16.8	11	50.3

43	9.1	18.9	22.8	14.5	76.7
44	7.2	15.1	26	20.9	67.1

Table A2: Metal concentrations in core sediments (mg kg^{-1} dry weight)

Cores						
Site	Depth (mm)	As	Cr	Cu	Pb	Zn
A	0 - 50	7.7	9.8	7.7	15.5	38.6
	50 - 100	6.8	11.9	6.5	26.4	33.9
	100 - 150	4.4	18.1	6	41.6	24.5
	150 - 200	4	19.9	5.5	52.5	23.6
	200 - 250	4.6	18.8	6.8	39.9	27.3
	250 - 300	5	13.1	5.2	24.9	22.1
B	0 - 50	6.5	11.2	17	13.9	60.4
	50 - 100	5.9	11.8	15.6	17.3	60.1
	100 - 150	7.1	9.5	13.1	14.6	52.4
	150 - 200	7.5	13.8	17.2	27.9	59.2
	200 - 250	9	17.1	14.9	41.9	54.5
	250 - 280	2.5	12	13.7	22.3	25.8
C	0 - 50	10.1	19	31.8	19.5	107
	50 - 100	8.7	19.3	31.4	20.2	100
	100 - 150	9.6	17.3	28	23.6	88.1
	150 - 190	7.8	15.1	21.7	20.2	60.9
D	0 - 50	4.6	13.1	25.4	20.5	91.2
	50 - 100	6.5	15.5	30.2	46.4	83.6
	100 - 150	7.2	19.1	29.8	78	80.2
	150 - 200	6.8	15.3	27.3	52.5	70.6
	200 - 230	4.1	9.7	20.4	36.3	71
E	0 - 50	8.9	17.4	31.9	18.3	101
	50 - 100	7.4	18.1	32.1	18.8	92.3
	100 - 150	7.6	13.9	27.6	20.2	82.5
	150 - 210	6.6	13.6	26.3	27.4	78.5

8 Appendix B – Site Photographs

Figure B1: Surface sample 1 (Sample taken next to fallen tree)

Figure B2: Surface sample 1 (Sample taken opposite fork in the river next to fallen tree)

Figure B3: Surface sample 2 (Sample taken between telegraph poles on right bank)

Figure B4: Surface sample 2 (Sample taken where cables run under river bed)

Figure B5: Surface sample 3 (Sample taken just downstream from 2 tree stumps on right bank)

Figure B6: Surface sample 4 (Sample taken between 2 broken jetties)

Figure B7: Surface sample 4 (Sample taken at base of old road)

Figure B8: Surface sample 5 (Sample taken just before old jetty on corner before boat ramp)

Figure B9: Surface sample 6 (Sample taken opposite boat ramp)

Figure B10: Surface sample 6 (Sample taken here on right bank straight opposite building)

Figure B11: Surface sample 7 (Sample taken just downstream of boat ramp on left bank)

Figure B12: Surface sample 8 & 9 (Samples taken both sides of discharge point by wooden posts)

Figure B13: Surface sample 10 (Sample taken near small pipe just upstream from #'s 8 & 9)

Figure B14: Surface sample 11 (Sample taken at stern of old orange ship on left bank)

Figure B15: Surface sample 12 (Sample taken just upstream of old orange ship on right bank just down from buildings)

Figure B16: Surface sample 13 (Sample taken just downstream from bridge)

Figure B17: Surface sample 13 (Sample taken beside discharge point on right bank)

Figure B18: Surface sample 14 (Sample taken beside discharge point, 10m upstream from sample #13)

Figure B19: Surface sample 15 (Sample taken beside discharge point on right bank, just downstream from bridge 10m upstream from sample #14)

Figure B20: Surface sample 16 (Sample taken just upstream of first bridge)

Figure B21: Surface sample 16 (Sample taken on left bank upstream of rocky bank)

Figure B22: Surface sample 17 (Sample taken directly underneath 2 bridges on right bank)

Figure B23: Surface sample 18 (Sample taken just past corrugated iron shed on left bank)

Figure B24: Surface sample 19 (Sample taken by discharge pipe on bend under half fallen tree)

Figure B25: Surface sample 20 (Sample taken by small discharge pipe 20m upstream from sample 19)

Figure B26: Surface sample 21 (Sample taken opposite samples 8 & 9 below large building)

Figure B27: Surface sample 21 (Sample taken next to photographed tyre)

Figure B28: Surface sample 22 (Sample taken opposite boat ramp on right bank)

Figure B29: Surface sample 23 (Sample taken just upstream from sample # 4 on right bank by large fallen tree)

Figure B30: Surface sample 24 (Sample taken across from large tree on left bank)

Figure B31: Surface sample 24 (Sample taken upstream of narrow fork near sample # 1, 20 m from entrance on left bank)

Figure B32: Surface sample 25 (Sample taken upstream of narrow fork near sample # 1)

Figure B33: Surface sample 25 (Sample taken opposite large fallen tree)

Figure B34: Surface sample 26 (Sample taken upstream of narrow fork near # 1 on right bank)

Figure B35: Surface sample 27 (Sample taken upstream of narrow fork near # 1 on left bank between old and new telegraph pole)

Figure B36: Surface sample 28 (Sample taken near concrete works)

Figure B37: Surface sample 28 (Sample taken at discharge point from concrete works)

Figure B38: Surface sample 29(Sample taken 100m upstream from broken jetty)

Figure B39: Surface sample 29(Sample taken at small inlet)

Figure B40: Surface sample 30 (Sample taken beside inlet by first jetty on right side of "island")

Figure B41: Surface sample 30 (Sample taken beside inlet by first jetty on right side of "island")

Figure B42: Surface sample 31 (Sample taken up narrow left channel around "island")

Figure B43: Surface sample 31 (Sample taken up narrow left channel around "island" at gap in mangroves)

Figure B44: Surface sample 32 (Sample taken just upstream from "island" on right bank)

Figure B45: Surface sample 32 (Sample taken just upstream from "island" on right bank)

Figure B46: Surface sample 33 (Sample taken on fork in river opposite sample # 1)

Figure B47: Surface sample 33 (Sample taken on fork in river opposite sample # 1)

Figure B48: Surface sample 34 (Sample taken opposite large fallen tree on bend just after # 4)

Figure B49: Surface sample 34 (Sample taken opposite large fallen tree on bend just after # 4)

Figure B50: Surface sample 35 (Sample taken at Inlet 80m upstream from # 34 on right bank)

Figure B51: Surface sample 35 (Sample taken downstream of boat ramp at inlet on right bank)

Figure B52: Surface sample 36 (Sample taken on left bank downstream of sample # 35)

Figure B53: Surface sample 36 (Sample taken at small inlet on left bank)

Figure B54: Surface sample 37 (Sample taken on bend just before old orange ship)

Figure B55: Surface sample 37 (Sample taken on bend just before old orange ship)

Figure B56: Surface sample 38 (Sample taken off the bow of the old orange ship on left bank)

Figure B57: Surface sample 39 (Sample taken on right bank just downstream from bridge)

Figure B58: Surface sample 39 (Sample taken on right bank, between samples # 12 & 13)

Figure B59: Surface sample 40 (Sample taken 20m upstream from 2 bridges on left bank)

Figure B60: Surface sample 41 (Sample on bend between # 18 & 19 on left bank)

Figure B61: Surface sample 42 (Sample taken on bend on right bank in front of farmland)

Figure B62: Surface sample 42 (Sample taken on bend on right bank in front of farmland)

Figure B63: Surface sample 43 (Sample taken just downstream from cement works on right bank)

Figure B64: Surface sample 44 (Sample taken just upstream from jetty near port marker on right bank)

Figure B65: Surface sample 44 (Sample taken just upstream from jetty near port marker on right bank)

9 Appendix C – Core Site Photographs

Figure C1: Core A (on left bank down from house)

Figure C2: Core B (at start of right channel around "island" on right bank

Figure C3: Core C (Sample taken next to fallen tree)

Figure C4: Core C (Sample taken opposite fork in the river next to fallen tree)

Figure C5: Core D (beside discharge point just downstream from bridge on right bank)

Figure C6: Core E (opposite boat ramp on right bank)

10 Appendix D – Site Descriptions

Table D1. Lat/longs and descriptions of sediment core sampling sites

Site	Date	Latitude	Longitude	Description
A	8/09/2007	36˚ 37,277S	174˚ 42,707E	5 mins from boat ramp on left bank down from large brown house
B	8/09/2007	36˚ 36,838S	174˚ 42,268E	At start of right channel around "island" on right bank
C	8/09/2007	36˚ 37,122S	174˚ 41,385E	Surface sample # 1
D	8/09/2007	36˚ 37,176S	174˚ 40,698E	Surface sample # 15
E	8/09/2007	36˚ 37,208S	174˚ 40,978E	Surface sample # 22

Table D2. Lat/longs and descriptions of surface sediment sampling sites

Site	Date	Latitude	Longitude	Description
1	8/09/2007	36˚ 37,122S	174˚ 41,437E	On right bank opposite fork in river by fallen tree
2	8/09/2007	36˚ 37,117S	174˚ 41,385E	Where cables run under river between telegraph poles on right bank
3	8/09/2007	36˚ 37,100S	174˚ 41,294E	Just downstream from 2 tree stumps on right bank
4	8/09/2007	36˚ 37,135S	174˚ 41,211E	At base of old road between 2 broken jetties
5	8/09/2007	36˚ 37,200S	174˚ 41,050E	Just before old jetty on corner before boat ramp
6	8/09/2007	36˚ 37,209S	174˚ 40,974E	Opposite boat ramp on right bank straight opposite building
7	8/09/2007	36˚ 37,210S	174˚ 40,978E	Just left of boat ramp
8	8/09/2007	36˚ 37,201S	174˚ 40,899E	Just downstream of discharge point by wooden posts
9	8/09/2007	36˚ 37,201S	174˚ 40,899E	Just upstream of discharge point by wooden posts
10	8/09/2007	36˚ 37,211S	174˚ 40,866E	Small pipe just upstream from # 8 & 9
11	8/09/2007	36˚ 37,210S	174˚ 40,778E	Stern of old orange ship on left bank
12	8/09/2007	36˚ 37,160S	174˚ 40,738E	Discharge point just upstream from orange ship on right down from buildings
13	8/09/2007	36˚ 37,167S	174˚ 40,668E	Beside discharge point just before bridge on right next to large mangrove tree
14	8/09/2007	36˚ 37,174S	174˚ 40,655E	Beside discharge point just before bridge on right 10m past # 13

Table D2 (contin.) Lat/longs and descriptions of surface sediment sampling sites

15	8/09/2007	36˚ 37,176S	174˚ 40,698E	Beside discharge point just before bridge on right 10m past # 14
16	8/09/2007	36˚ 37,194S	174˚ 40,603E	Just past first bridge on left after rocky bank
17	8/09/2007	36˚ 37,184S	174˚ 40,554E	Directly underneath 2 bridges on right bank
18	8/09/2007	36˚ 37,135S	174˚ 40,560E	Just past corrugated iron shed on left bank by tall narrow trees
19	8/09/2007	36˚ 37,095S	174˚ 40,542E	By discharge pipe on bend under half fallen tree
20	8/09/2007	36˚ 37,101S	174˚ 40,523E	By small discharge pipe 20m upstream from # 19
21	8/09/2007	36˚ 37,209S	174˚ 40,885E	Opposite # 8 & 9 beside tyre
22	8/09/2007	36˚ 37,208S	174˚ 40,978E	Opposite # 7 by boat ramp
23	8/09/2007	36˚37,172S	174˚ 41,169E	Just upstream from # 4 on right bank by large fallen tree
24	8/09/2007	36˚ 37,140S	174˚ 41,419E	Up narrow fork near # 1 20m from entrance on left bank
25	8/09/2007	36˚ 37,155S	174˚ 41,407E	Up narrow fork near # 1 opposite large fallen tree
26	8/09/2007	36˚ 37,200S	174˚ 41,370E	Up narrow fork near # 1 on right bank where sheds and poles first become visible
27	8/09/2007	36˚ 37,236S	174˚ 41,330E	Up narrow fork near # 1 on left bank between old telegraph pole and new telegraph pole
28	9/09/2007	36˚ 37,032S	174˚ 42,640E	Beside discharge point at concrete works
29	9/09/2007	36˚ 36,932S	174˚ 42,549E	Small inlet 100m upstream from broken jetty
30	9/09/2007	36˚ 36,833S	174˚ 42,295E	Beside inlet by first jetty on right side of "island"
31	9/09/2007	36˚ 36,890S	174˚ 42,247E	Up narrow left channel around "island" at gap in mangroves
32	9/09/2007	36˚ 36,845S	174˚ 42,128E	Just upstream from "island" on right bank
33	9/09/2007	36˚ 37,123S	174˚ 41,434E	On fork in river opposite # 1
34	9/09/2007	36˚ 37,175S	174˚ 41,172E	Opposite large fallen tree on bend just after # 4
35	9/09/2007	36˚ 37,181S	174˚ 41,121E	Inlet 80m upstream from # 34 on right bank
36	9/09/2007	36˚ 37,191S	174˚ 41,087E	Small inlet just before # 5 on left bank
37	9/09/2007	36˚ 37,223S	174˚ 40,827E	On bend just before old orange ship
38	9/09/2007	36˚ 37,188S	174˚ 40,768E	Bow of old orange ship on left bank
39	9/09/2007	36˚ 37,154S	174˚ 40,707E	On right bank in front of large pine tree, between # 12 & 13
Table D2 (contin.) Lat/longs and descriptions of surface sediment sampling sites				
40	9/09/2007	36˚ 37,166S	174˚ 40,548E	20m upstream from 2 bridges on left bank by small toetoe bush
41	9/09/2007	36˚ 37,101S	174˚ 40,564E	On bend between # 18 & 19 on left bank in front of white house

42	9/09/2007	36˚ 37,021S	174˚ 41,562E	On bend with farmland on right bank in front of large pine tree
43	9/09/2007	36˚ 37,095S	174˚ 42,704E	Just downstream from cement works on right bank at start of walking track
44	9/09/2007	36˚ 37,251S	174˚ 42,739E	Just upstream from jetty near port marker on right bank

*Note: "right bank" and "left bank" are determined when the sampler is facing upstream