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TE RAUHITANGA TAIAO

Regional Discharges Project
Marine Receiving Environment Status Report 2003

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Regional Discharges Project
Marine Receiving Environment Status Report 2003

Auckland Regional Council TP 203

R.B. Williamson*
S. Kelly

Prepared for
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*Diffuse Sources Ltd.
PO Box 13002,
Hillcrest, Hamilton
NEW ZEALAND

Contents

1 Executive Summary

The Auckland Regional Council established the Regional Discharges Project (RDP) to coordinate the renewal of stormwater discharge consents throughout the Auckland Region. Sediment quality guidelines and methods of assessing marine ecological health were developed as part of this project and published as a Blueprint for monitoring urban receiving environments (ARC 2002a). A monitoring programme was also developed to determine the present status of the receiving environment and establish a basis for assessing future trends. This report reconsiders the RDP monitoring programme, reviews the process outlined in the Blueprint (ARC 2002a) and updates the community health model using additional data collected throughout the region. It also summarises information on the stormwater contaminants in the marine sediments of Auckland's urban receiving environment and ranks sites according to sediment quality and ecological health. This information is used to provide recommendations on further assessment and ongoing monitoring.

1.1 Ranking of RDP Monitoring Sites

Seventeen RDP monitoring sites originally recommended in TP170 "Regional Maps of Settling Zones and Outer Zones" (ARC 2002d) were discarded and 16 new sites added, to give a total of 72 RDP monitoring sites from which data were assessed. Of the 72 sites, 35 had sufficient sediment chemistry data to rank their contamination status. The remaining 38 sites were sampled for sediment chemistry in November-December 2002. Sixteen of these had a full analysis of the 4 major contaminants (copper, lead, zinc, & PAH) while the other 22 were analysed for copper, lead and zinc only. Nineteen sites were also assessed for benthic ecology, as prescribed in the Blueprint (ARC 2002a) procedures, to determine the community health of selected settling zone sites and refine the community health model for outer zones.`

Maps showing the location and status of the four major contaminants at the 72 RDP monitoring sites are presented in this report, and overall site rankings are summarised in Table 1.1 below. Rankings are based on the environmental response criteria trigger levels given in the Auckland Regional Plan: Coastal, Table 20.1.A.

Table 1.1: Summary of the number of settling and outer zone sites with green, amber or red sediment chemistry and ecological community health (settling zones only).

	Sediment Chemistry			Community Health
Ranking	Total No. of Sites	Settling Zones	Outer Zones	Settling Zones
Green	32	21	11	
Amber	18	6	12	13
Red	22	14	8	
Total	72	41	31	

1.2 Regional Differences

The settling zones of catchments with a long history of urbanisation had the highest levels of contaminants. However, even some of the more recently developed catchments had relatively high concentrations of contaminants (e.g. Pakuranga and Henderson). In contrast, most settling and outer zones surrounded by less intense urbanisation or rural land use, had low contaminant concentrations.

Zinc exceeded the red environmental response criteria (ERC) more frequently than lead or copper. However, copper and lead fell within the amber range more frequently than zinc. Zinc and copper concentrations are generally increasing in estuarine sediments whereas lead concentrations are decreasing. PAH levels were green except at some sites with older catchments (Hobson, Motions and Meola), and sites near historic gas works (Chelsea, Little Shoal Bay).

1.3 Benthic Ecology

The community health models for settling and outer zones were revised by:

1. removing duplicate sites of the same rank within a location,
2. adding in extra data collected in November 2002,
3. revising the pollution ranking of some sites in light of additional sediment chemistry data.

The revised settling zone community health model provided good separation between sites of different pollution rank and was subsequently used to categorise the ecological health of 13 sites with reliable sediment chemistry information. Nine of the new sites were categorised as red, and four as amber, for sediment chemistry, whereas the ecological health of all sites was ranked as amber. This supported the conclusion that the ecological health of benthic communities is degraded in settling zones with an amber pollution rank. The amber ecological health ranking of red sediment chemistry sites indicates that the benthic communities of these settling zones are stressed, but not severely impacted. Remedial action should be implemented to reduce or reverse the rate of decline.

The results of the revised outer zone community health model showed considerable overlap in the community structure of sites with pollution ranks 1&2 and 3&4. Consequently, it was not considered robust enough for ecological ranking purposes, but it does provide a useful index for monitoring trends in community health.

1.4 Review of Blueprint Procedures

The procedures prescribed in the Blueprint (ARC 2002a) were re-evaluated following the site assessments. Recommendations on the procedures are:

1. The Blueprint (ARC 2002a) procedure for the assessment and monitoring of settling and outer zone sites with green contaminant status is appropriate. Green sites should be reassessed in 5 years or if significant landuse changes occur in the catchment.
2. Settling zones ranked as amber for contaminants should have their status confirmed (by the analysis of historical data, findings from a nearby site or by re-sampling the site) and likely trends determined prior to proceeding with ecological assessments. If the amber ranking is solely due to high concentrations of lead the site should be re-assessed in 3 years. Ecological assessments should be carried out according to the Blueprint (ARC 2002a) procedures if zinc, copper or PAH concentrations are above amber thresholds.
3. The Blueprint (ARC 2002a) procedures for the assessment and monitoring of settling zone sites with red contaminant status are appropriate.
4. The Blueprint (ARC 2002a) procedures for the assessment and monitoring of outer zone sites with amber or red contaminant status require modification due to the insensitivity of the community health model for outer zones.
5. Settling and outer zone sites adjacent or otherwise connected to each other are likely to be affected by similar stormwater inputs, and should be treated as an integrated unit during subsequent assessments. Likewise, multiple sites within a settling zone or outer zone should be considered as a unit.
6. The community health model should be used to monitor trends in the ecological health of outer zones using the value of the site on the canonical axis, but should not be used to rank ecological health as green, amber, or red at this stage.

These recommendations were applied to the 72 RDP monitoring sites and used to determine the appropriate actions for each site with respect to future monitoring and further assessment.

2 Introduction

The Regional Discharges Project (RDP) is an Auckland Regional Council initiative to coordinate the renewal of stormwater discharge consents by territorial authorities and stormwater and wastewater network operators in the Auckland region. A fundamental component of the RDP has been the development of protocols for assessing the environmental effects of stormwater and wastewater discharges. Environmental response criteria (ERC) for key marine sediment contaminants have been developed based on recommendations in the ANZECC Water Quality Guidelines (ANZEEC 2000) and other internationally recognised guidelines (see Williamson and Mills (2002) for details). The primary stormwater contaminants of concern for the urbanised Auckland Region are zinc, copper, lead, and polyaromatic hydrocarbons (PAH's). Environmental response criteria for these contaminants are presented in an analogous fashion to traffic lights: with green representing low, amber: elevated, and red: high contaminant concentrations (Table 2.1).

Table 2.1 Contaminant concentrations and traffic light colours assigned to environmental response criteria (from proposed Variation 1 to the Regional Plan: Coastal, Table 20.1.A). Concentrations for zinc, lead and copper are in mg/kg and PAH's in mg/kg.

Traffic Light Colour	Zinc	Lead	Copper	PAH
Green	<125	<30	<19	<0.66
Amber	125-150	30-50	19-34	0.66-1.7
Red	>150	>50	>34	1.7-3

Analytical techniques for examining the response of benthic marine communities to pollution have also been developed to assess the biological effects of stormwater discharges (ARC 2002e). Separate analytical models where established for harbour and tidal creek communities, with the "health" of the benthic communities being expressed in an analogous fashion to the traffic light system used for sediment chemistry environmental response criteria, where: green = "healthy", amber = degraded "health", and red = "unhealthy". The tidal creek and harbour community health models are based on ecologically distinct zones that are roughly analogous to the settling and outer zone categories used for sediment chemistry. Consequently, the community health models for tidal creeks and harbours are subsequently referred to as the settling and outer zone community health models respectively. The outer zone community health model produced by ARC (2002e) was considered preliminary because of the lack of ecological data from this type of habitat in the Auckland Region, and further refinement and testing was required.

Methods for sediment and ecological sample collection and analysis are provided in ARC TP 168: "Blueprint for monitoring urban receiving environments" (ARC 2002a) (hereafter referred to as the Blueprint (ARC 2002a)). The Blueprint (ARC 2002a) also provides details

on appropriate monitoring frequencies and additional assessment requirements, where environmental response criteria are exceeded. These requirements are presented in the form of flowcharts, which direct the assessment procedure depending on the level of contamination present at a site.

The Blueprint (ARC 2002a) divides stormwater receiving environments into settling zones and outer zones for the purposes of assessment and management. Settling zones are areas were most (~75%) contaminants settle out of suspension and become incorporated into benthic sediments. Consequently, settling zones are prone to contaminant accumulation and some level of degradation is expected. Outer zones are wider estuarine areas downstream of the settling zone or located in high energy environments were contaminants are less likely to settle permanently. The rate of contaminant accumulation in outer zones is therefore less than in settling zones. In settling zones total metal concentrations are measured from sediments with grain sizes <500 µm using strong acid digestion. In outer zones a more stringent standard is applied and bio-available metals are measured from the mud fraction (<63 µm grain size) using weak acid digestion. The application of higher sediment quality standards for the outer zones reflects a desire to afford these areas a greater level of protection and limit habitat degradation to settling zones.

In order to identify catchments discharging heavy loads of stormwater contaminants, and assess the current status of stormwater contaminants in settling and outer zones throughout Auckland's urban area, the RDP established a provisional sediment and ecological monitoring programme. Seventy-three potential RDP monitoring sites (42 settling zones and 31 outer zones) were identified in TP170 "Regional maps of settling and outer zones" (ARC 2002d). Available sediment chemistry information was collated for these sites, and sites without data were identified. In November 2002 additional sediment chemistry data was obtained to fill in the information gaps using the methods described in the Blueprint (ARC 2002a). Ecological data was also collected to refine the community health models and check the predictions of the settling zone community health model against sediment chemistry ERC for settling zones. This report presents data for the RDP monitoring sites and assigns a grading to each in accordance with the ERC and ecological health of settling zones. The locations of the RDP monitoring sites proposed in TP170 (ARC 2002d) are also reviewed and revised, and information obtained from the monitoring sites is used to check the efficacy of Blueprint (ARC 2002a) process. Recommendations on revising the Blueprint (ARC 2002a) procedures are provided along with the next steps required for the assessment and/or monitoring of each site in accordance with the proposed changes to these procedures.

The format of the report is therefore:

- Revision of the RDP monitoring sites;
- Presentation and interpretation of sediment chemistry data for the RDP monitoring sites;

- Refinement of the community health models and presentation and interpretation of ecological data;
- Review of the Blueprint (ARC 2002a) process and application of the revised process to develop a plan for the ongoing assessment and monitoring of each RDP site.

3 Verification and Refinement of the Location of RDP Monitoring Sites

Technical Publication 170 "Regional Maps of Settling Zones and Outer Zones" (ARC 2002d) identifies the approximate location of a core set of 42 settling zone sites and 31 outer zone sites for monitoring. Five other sites were also identified as potential future sites, but these are not included in this discussion. During the course of this present project, 17 sites were deleted (either because they were outside the metropolitan urban limits (MUL), were adequately represented by other sites, were shifted, or were special study sites) and 16 new sites were included (as a result of discussions with ARC staff, new information coming to hand and detailed examination of some sites).

The location of the monitoring sites and a summary of the sediment chemistry results are provided in Table 3.1 and Fig. 3.1. Table 3.2 provides comparative data from some useful reference sites. These sites are included to help interpret the results from the RDP monitoring programme.

Figure 3.1 shows: all the recommended monitoring sites for settling zones and outer zones; sites that have been removed or shifted; and the new sites recommended in this report. Recommendations on changing the Proposed Auckland Regional Plan: Coastal, Variation 1 maps containing RDP monitoring sites have also been made in the ARC officer's report to the Auckland Regional Plan: Coastal, Hearing Committee as a consequence of the revision outlined in this section.

The important points to note in Table 3.1 are:

Changes to Sites

- The sites at Mangemangeroa and Okura are outside the MUL and have been removed from the list of RDP monitoring sites.
- The monitoring site at Otara Lake has been deleted pending a major study by Manukau City Council on that estuary.
- Three sites in Pakuranga Creek and 2 from Hellyers Creek have been removed from the RDP list of core sites, and will be sampled in a one-off study of contaminant gradients.
- The Upper Whau and Wairau sites in the Whau estuary were originally omitted erroneously from Map Series 5.
- A reference site near the Te Atatu peninsula recommended in TP170 (ARC 2002d) has been deleted and replaced with the ARC Mid-Waitemata Benthic Ecology monitoring site at Hobsonville.
- There is an additional site for Henderson Creek estuary to better define this large settling zone.

- The number of sites in the Rangitopuni and Papakura settling zones and the Puherehere outer zone has been reduced from 3 to 2 each. These adequately represent these zones.
- An additional site has been recommended at Chelsea Bay on the basis of the recent North Shore City Council (NSCC) sediment survey (NSCC 2002). These sediments are suggesting an amber status for these bays, so are worth including in the monitoring programme.
- Alternatives for monitoring at Soldiers Bay (Birkenhead) are Island Bay and an additional site at Kendalls Bay. These are recommended because NSCC have measured these sites and they represent an improved alternative to the one site at Soldiers Bay.
- The outer zone site off Milford Beach has been deleted pending a special study on contaminant accumulation off the East Coast Bays.
- Sites have been added at Hillsborough and Blockhouse Bay to fill important gaps in the RDP database.
- The Puhinui lower (outer) settling zone site has been deleted as unsuitable.
- The ARC LTB sites in Mangere inlet (Anns Creek and Cemetery) have been added.
- The Harania site has been deleted because the estuary has become completely covered in mangrove forest which is unsuitable for sediment monitoring.
- A further 5 sites have been added to fill important gaps in the database, and because it is important to manage their catchments and estuaries. These sites were excluded in the past because they are within deposition zones which do not fully meet the settling zone criteria. Consequently, their quantitative relationship with the contributing catchment is uncertain, but it is still important to obtain information on contaminant levels within them. The sites are:
    - Two sites in Weymouth estuary.
    - The ARC long term baseline (LTB) monitoring site at Papakura.
    - Otahuhu Creek
    - The ARC LTB site at Waterview.

The ARC LTB Sites

Twenty-one of the 27 ARC long term baseline (LTB) sites are suitable as RDP monitoring sites. The other 6 LTB sites will make useful long-term reference sites for the RDP programme.

Other reference sites

In this report, data from another 40 reference sites are reported (Table 3.2) along with the RDP sites. These sites help bring a bigger perspective to the RDP monitoring

programme. They include some ARC LTB sites, sites recently monitored by the TAs as part of their receiving environment investigations and sites reported in recent one-off studies.

Figure 3.1. Location of RDP sites, including the deleted sites and the new sites recommended in this report.

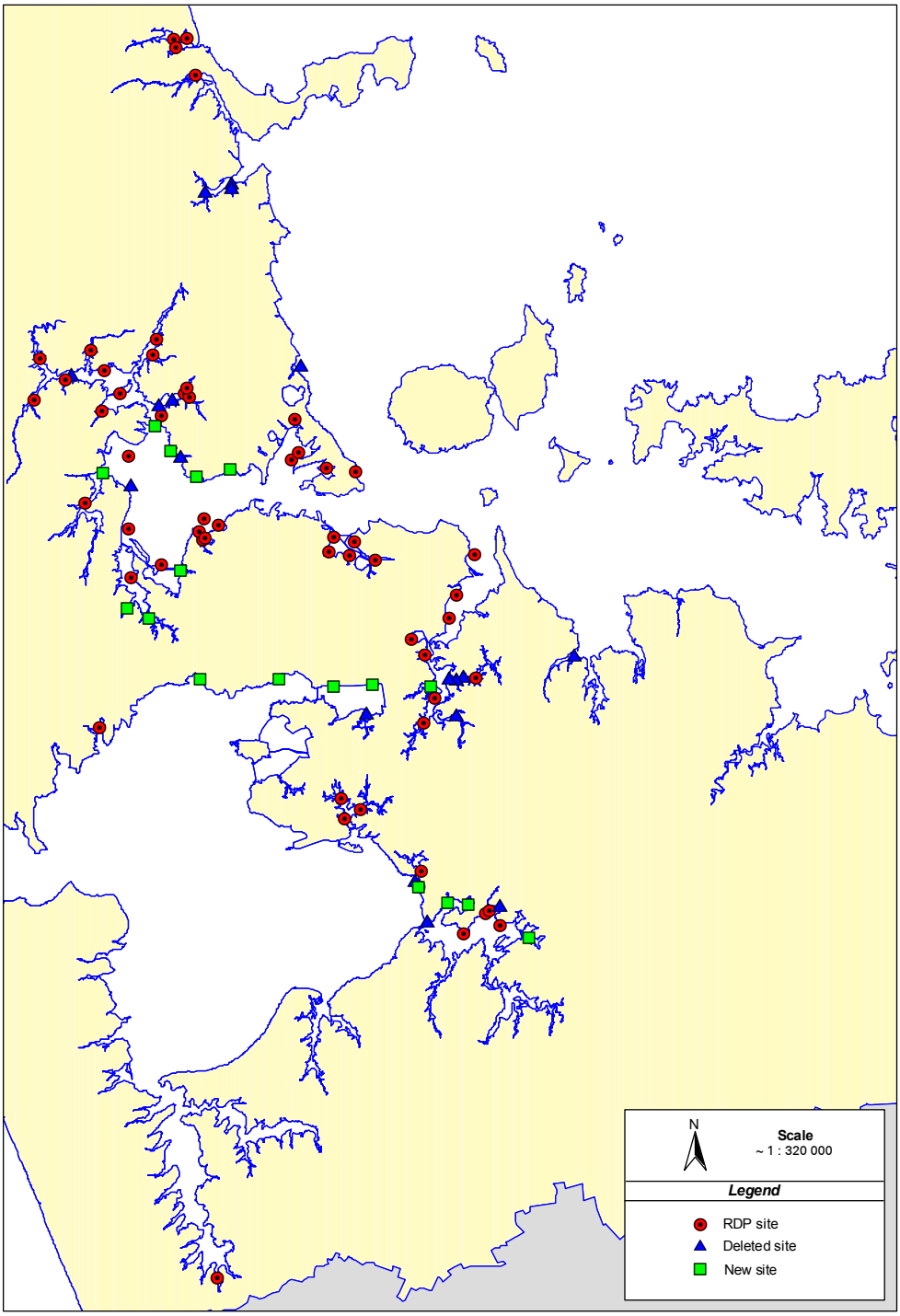


Table 3.1. Recommended RDP monitoring sites and existing data on mean chemical contaminant concentrations in the 63µm and 500 µm sediment fractions. Abbreviations used in the table are: RREA = Regional Receiving Environment Area, SZ = Settling Zone, DZ = Deposition Zone (doesn't fully meet settling zone criteria), OZ = Outer Zone, ARC = Auckland Regional Council, LTB = Long Term Baseline, GAP = data collected by ARC to fill in gaps, ACC = Auckland City Council unpubl. data (2003), NSCC = North Shore City Council (2002), ASP = ARC (1996) unpublished data, WCC = Waitakere City Council (2001). The status of PAH, copper (Cu), zinc (Zn), and lead (Pb) is ranked as 1 = green, 2 = amber, and 3 = red, according to contaminant concentrations (see Table 4.1). PAH concentrations are in ug.kg^{-1}, Cu, Zn, and Pb concentrations are in mg.kg^{-1}.

								500um			63um			500um		Status		
RREA	Location	Type	SZ	OZ	Source	Easting	Northing	Cu	Zn	Pb	Cu	Zn	Pb	PAH	PAH	Cu	Zn	Pb
2	Upper Tamaki (Middlemore)	SZ			ARC LTB	2675627	6470765	24	175	27	32	232	49	282	1	2	3	2
2	Otahuhu, Brady Rd	DZ			ACC, GAP	2676041	6472877				35	202	51		0	2	3	2
2	U Tamaki Upper, Princess	OZ			ACC	2676238	6472175				28	166	41		0	2	3	1
2	U Tamaki Lower, Bowden	OZ			ACC	2675645	6474695				32	179	44		0	2	3	2
2	Panmure	SZ			GAP	2674939	6475596	27	174	38	23	132	37	490	1	2	3	2
2	Pakuranga Upper	SZ			ARC LTB	2678591	6473361	28	177	23	38	235	44	83	1	2	3	1
2	Mid Tamaki Upper, Bengazi	OZ			ACC	2677115	6476792				27	146	39		0	2	1	2
2	Mid Tamaki Lower, Pt England	OZ			ACC	2677510	6478145				24	138	37		0	2	1	2
3	Outer Tamaki (Roberta?)	OZ			ACC	2678535	6480522				10	81	24		0	1	1	1
5	Hobson1	OZ			ARC LTB	2670161	6480662	7	48	11	29	155	62	976	2	2	2	3
5	Hobson2, Victoria	OZ			ACC	2671315	6480490				21	121	48		0	2	1	1
5	Hobson3, Awatea	OZ			ACC	2670397	6481488				23	138	62		0	2	1	3
5	Meadowbank (Purewa)	SZ			GAP	2672799	6480182	16	157	40	15	99	36	429	1	1	3	2
5	Meadowbank (Purewa)	OZ			GAP	2671621	6481222	10	105	27	16	96	37	91	1	1	1	2
5	Meola	SZ			ARC LTB	2662817	6481374	31	281	65	33	194	70	885	2	2	3	3
7	Meola, ACC	OZ			ACC	2662668	6481869				27	168	61		0	2	3	3
7	Motions	SZ			ARC LTB	2663020	6481413	27	276	51	42	250	97	2819	3	2	3	3
7	Meola Reef	OZ			ARC LTB	2662897	6482580	7	100	18	27	146	48	325	1	2	2	2
7	Coxes, ACC	OZ			ACC	2663732	6482215				26	181	71		0	2	3	3
8	Upper Whau	SZ			ARC LTB	2659738	6476817	38	254	78	34	305	82	228	1	3	3	3
8	Wairau	SZ			ARC LTB	2658525	6477463	47	229	70	44	279	91	198	1	3	3	3
8	Lower Whau	OZ			ARC LTB	2658691	6479191	31	167	45	24	165	48	126	1	2	3	2
8	Outer Whau, WHO C	OZ			GAP	2658550	6482000	5	38	12	16	101	33		0	1	1	2

								500um			63um			500um		Status		
RREA	Location	Type	SZ	OZ	Source	Easting	Northing	Cu	Zn	Pb	Cu	Zn	Pb	PAH	PAH	Cu	Zn	Pb
8	Waterview, Oakley	DZ			ARC LTB	2661590	6479618	32	162	44	25	163	49	242	1	2	3	2
8	Waterview	OZ			GAP	2660470	6479877	5	47	14	16	97	34	108	1	1	1	2
8	Henderson Upper	SZ			ARC LTB	2656017	6483479	34	172	31	28	170	36	87	1	2	3	2
9	Henderson Lower	SZ			GAP	2657114	6485207	30	137	38	22	126	34	170	1	2	2	2
9	Henderson	OZ			GAP	2658591	6486244	8	72	24	19	107	31	205	1	2	1	2
9	Hobsonville	OZ			GAP	2660106	6487972	4	26	9	17	78	26	87	1	1	1	1
10	Brighams	SZ			GAP	2653087	6489420	17	74	19	14	73	22		0	1	1	1
10	Paremoremo	SZ			ARC LTB	2656364	6492284	25	99	22	18	90	23	72	1	2	1	1
10	Upper Lucas	SZ			ARC LTB	2660154	6492967	26	113	19	19	104	23	94	1	2	1	1
10	Te Wharau (Lucas)	SZ			NSCC	2660000	6492000	25	103	27	20	89	29		0	2	1	1
10	Upper Hellyers	SZ			GAP	2661953	6490127	13	78	20	14	88	29	230	1	1	1	1
10	Kaipatiki	SZ			GAP	2662042	6489586	22	115	31	19	115	38	183	1	2	1	2
10	Hellyers	OZ			ARC LTB	2661807	6489767	18	100	21	17	110	29	118	1	1	1	1
10	Waiarohia	SZ			GAP	2657008	6488815	15	74	21	17	83	28		0	1	1	1
10	Waiarohia	OZ			GAP	2658089	6489784	7	49	14	14	74	24		0	1	1	1
10	Rarawaru	SZ			GAP	2654930	6490600	12	72	20	16	80	23		0	1	1	1
10	Rangitopuni Upper	SZ			GAP	2653449	6491807	20	86	26	17	82	23		0	1	1	1
10	Rangitopuni Middle	SZ			GAP	2657200	6491100	15	83	25	14	74	23		0	1	1	1
11	Beachhaven	SZ			GAP	2660470	6488550	19	105	32	14	81	29	377	1	1	1	2
11	Island	SZ			NSCC	2661000	6486500	7	54	15	20	104	35		0	1	1	1
11	Kendalls	OZ			NSCC	2662500	6485000	5	40	10	22	104	41		0	1	1	1
11	Chelsea	OZ			NSCC, GAP	2664480	6485475	7	65	18	22	103	35	1747	3	2	1	2
11	Ngataringa	OZ			NSCC, ASP	2670000	6485500	8	63	20	11	70	29		0	1	1	1
12	Hillcrest, Shoal Bay	SZ			NSCC, ASP	2668200	6488300	27	150	45	20	126	46		1	2	3	2
12	Mid Shoal Bay Landsdown	OZ			NSCC	2668400	6486400	6	45	12	17	86	35		0	1	1	2
12	Low Shoal Bay, Sulphur	OZ			NSCC	2668000	6486000	4	29	12	15	73	40		0	1	1	2
14/15	Cheltenham	OZ			ARC LTB	2671700	6485300	2	49	5	12	118	13	339	1	1	1	1
17	Weymouth East	DZ			GAP	2678182	6460344	9	78	15	6	61	13	49	1	1	1	1
17	Weymouth West	DZ			GAP	2677005	6460443	8	68	13	6	59	13	58	1	1	1	1

								500um			63um			500um		Status		
RREA	Location	Type	SZ	OZ	Source	Easting	Northing	Cu	Zn	Pb	Cu	Zn	Pb	PAH	PAH	Cu	Zn	Pb
17	Papakura Stm Upper	SZ			GAP	2679398	6459888	12	86	18	6	54	14		0	1	1	1
17	Papakura Stm Lower	SZ			GAP	2679152	6459749	10	76	16	6	51	13		0	1	1	1
17	Puherehere, Papakura	DZ			ARC LTB	2681696	6458386	7	72	7	7	69	12	83	1	1	1	1
17	Puherehere Upper	OZ			GAP	2680000	6459100	2	18	4	7	57	14		0	1	1	1
17	Puherehere Middle	OZ			GAP	2677950	6458600	2	24	6	5	46	12		0	1	1	1
17	Pukaki, Waitekauri	SZ			GAP	2671938	6465795	9	70	13	6	54	13	57	1	1	1	1
18	Pukaki	SZ			GAP	2670814	6466440	6	47	9	5	50	13	125	1	1	1	1
18	Pukaki Airport	SZ			ARC LTB	2671025	6465235	16	76	5	5	54	7	39	1	1	1	1
18	Puhinui Inner	SZ			ARC LTB	2675460	6462232	11	109	7	6	74	9	27	1	1	1	1
18	Puhinui	OZ			GAP	2675350	6461350	4	51	8	5	48	10	23	1	1	1	1
19	Mangere Cemetery	OZ			ARC LTB	2670400	6472900	37	155	32	22	116	29	65	1	3	3	2
19	Anns Creek	OZ			ARC LTB	2672634	6473059	38	184	32	26	145	32	55	1	3	3	2
20	Hillsborough	OZ			GAP	2667246	6473291	14	89	17	22	105	29		0	2	1	1
21	Blockhouse Bay	OZ			ACC	2662689	6473324				11	68	19		0			
21	Little Muddy	SZ			GAP, WCC	2656894	6470502	11	61	15	10	60	15		0	1	1	1
31	Orewa North	SZ			GAP	2661955	6510345	3	33	5	7	79	11		0	1	1	1
31	Orewa South	SZ			GAP	2661275	6509775	4	28	4	6	35	6		0	1	1	1
31	Orewa	OZ			GAP	2661197	6510298	3	21	3	5	34	6		0	1	1	1
31	Weiti	SZ			ARC LTB	2662420	6508229	10	52	4	18	64	9	51	1	1	1	1
23	Waiuku	SZ			GAP	2663665	6438752	9	93	17	7	81	16		0	1	1	1

Table 3.2 Mean contaminant (copper (Cu), zinc (Zn), and lead (Pb), and PAH) concentrations in the 63µm and 500 µm sediment fractions and contaminant status at reference sites in the Auckland Region. Abbreviations used in the table are: RREA = Regional Receiving Environment Area, SZ = Settling Zone, DZ = Deposition Zone (doesn't fully meet settling zone criteria), OZ = Outer Zone, ARC = Auckland Regional Council, LTB = Long Term Baseline, GAP = data collected by ARC to fill in gaps, ACC = Auckland City Council unpub data (2003), NSCC = North Shore City Council (2002), ASP = ARC unpubl. data (1996), ARC 1997 = ARC unpubl. data (1997), Tricklebank = Tricklebank & Stewart 2001, Works = Ministry of Works (1989). The status of PAH, copper, zinc, and lead is ranked as 1 = green, 2 = amber, and 3 = red, according to contaminant concentrations (see Table 4.1). PAH concentrations are in ug.kg^{-1}, Cu, Zn, and Pb concentrations are in mg.kg^{-1}.

			Type					500um			63um			500um		Status		
RREA	Location	Type	SZ	OZ	Source	Easting	Northing	Cu	Zn	Pb	Cu	Zn	Pb	PAH	PAH	Cu	Zn	Pb
1	Mangamangaroa	SZ			Tricklebank	2684300	6474700								0	1	1	1
2	Otahuhu	DZ			ASP	2675950	6472800				33	181	47		1	2	3	2
2	Panmure	SZ			Tang 2001	2675613	6475738								0	2	3	3
2	Pakuranga Lower	SZ			ARC LTB	2677159	6473386	22	161	22	27	162	34	129	1	2	3	1
2	Middle Tamaki, Spit-S	OZ			ACC	2678896	6479231				10	59	15		0	1	1	1
2	Outer Tamaki, Spit-N	OZ			ACC	2678931	6479497				8	49	16		0	1	1	1
2	Glendowie Vista	OZ			ACC	2678111	6480163				8	57	16		0	1	1	1
5	Hobson	OZ			ARC 1997	2670300	6481200				14	118	65		0	1	1	3
5	Hobson Centre	OZ			ACC	2670889	6480895				14	97	39		0	1	1	2
5	Hobson, Elam	SZ			ACC	2670140	6480907				25	145	70		0	2	1	3
5	Purewa OZ, Ngapipi	OZ			ACC	2671380	6481337				17	114	45		0	1	1	2
7	Coxs	OZ			ARC 1997	2664170	6482030				42	351	132		0	3	3	3
8	Outer Whau, WHO A	OZ			GAP	2659100	6482450	4	30	9	18	106	35		0	1	1	2
8	Outer Whau, WHO B	OZ			GAP	2658700	6482300	5	36	10	15	90	32		0	1	1	2
8	Outer Whau, WHO D	OZ			GAP	2658700	6482600	7	42	13	15	97	30	168	1	1	1	1
8	Waterview, Walkers	OZ			ACC	2661586	6480331				21	121	38		0	2	1	2
8	Henderson, Matipo	SZ			ASP	2656400	6482950	41	199	59					1	3	3	3
8	Huruhuru	SZ			ASP	2655750	6482950	32	161	42					0	2	3	2
10	Upper Lucas	SZ			NSCC	2660300	6493400	26	117	27	19	96	27		0	2	1	1
11	Little Shoal	OZ			NSCC	2665650	6485700	5	36	12	22	86	42	1190	2	2	1	2
12	Esmonde Rd Estuary	SZ			NSCC	2668150	6488200	28	184	54	25	188	60		0	2	3	3
12	Up Shoal Bay, Sydney St	OZ			NSCC	2668000	6487500	5	36	13	15	95	36		0	1	1	2
15	Wairau surf zone	OZ			NSCC	2668700	6491600	4	39	9	6	34	9	163	1	1	1	1
15	Wairau Beach	OZ			NSCC	2668300	6491500	3	50	12	4	32	7	877	2	1	1	1

			Type					500um			63um			500um		Status		
RREA	Location	Type	SZ	OZ	Source	Easting	Northing	Cu	Zn	Pb	Cu	Zn	Pb	PAH	PAH	Cu	Zn	Pb
15	Wairau Mouth	OZ			NSCC	2668100	6491550	11	77	15	32	171	33	601	1	2	3	2
15	Milford Marina	SZ			Works	2668050	6491200								0	3	3	3
15	Deep Creek, Torbay	SZ			NSCC	2666750	6498500	21	190	34	27	251	53		0	2	3	2
15	Deep Creek Mouth, Torbay	OZ			NSCC	2667070	6498400	4	42	7	4	18	4		0	1	1	1
15	Browns Bay	OZ			ARC LTB	2666850	6496845	2	43	0	10	131		49	1	1	2	0
15	Long Bay, Awaruku	OZ			ARC LTB	2667077	6500048	2	26	0	9	87		15	1	1	1	0
15	Long Bay, Vaughan	OZ			ARC LTB	2666838	6500766	1	25	0	9	80		12	1	1	1	0
31	Okura	OZ			NSCC	2664500	6502000	10	39	9	8	37	10		0	1	1	1
31	Okura West	SZ			NSCC	2663000	6501500	7	31	7	7	39	10	16	1	1	1	1
18	Airport LT site	OZ			GAP	2672515	6463388	3	29	5	5	40	9		0	1	1	1
19	Harania	SZ			ASP	2672300	6471350				45	207	61		1	3	3	3
19	Taratata	SZ			ASP	2670650	6471300				41	150	50		0	3	3	3
21	Big Muddy	SZ			ARC LTB	2654500	6468600	9	57	2	6	46	5	41	1	1	1	1
22	Cape Horn LT Site	OZ			GAP	2659917	6470448	3	23	4	11	81	26	21	1	1	1	1
22	Clarks Beach LT Site	OZ			GAP	2661675	6452219	2	27	3	5	37	8		0	1	1	1
31	Te Matuku, Waiheke	SZ			ARC LTB	2700252	6482581	3	39	2	5	53	10	15	1	1	1	1

4 Sediment Chemistry

Table 3.1 ranks the contamination status of each site according to existing data using the green, amber, red traffic light system of expressing environmental response criteria. A summary of the number of sites ranked in terms of sediment quality is shown in Table 4.2 and Figure 4.1. The spatial pattern of copper, lead, zinc concentrations in sediments is also expressed using the traffic light system in Figures 4.2A – 4.2B and 4.3A – 4.3E, and of PAH in Fig. 4.3D.

Table 4.2 Number of recommended RDP monitoring sites with green, amber or red sediment chemistry status.

	Green	Amber	Red	Total
Settling Zones	22	6	14	42
Outer Zones	10	12	8	20
Total	32	18	22	**72**

Figure 4.1 Sediment quality ranking of recommended RDP monitoring sites.

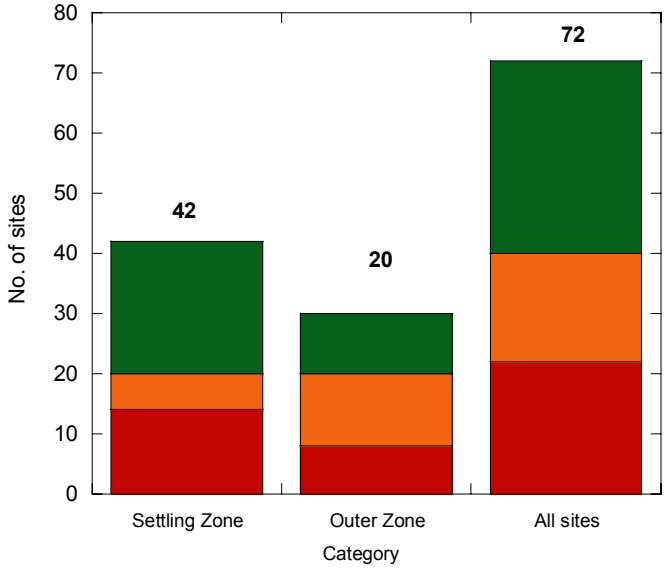


Figure 4.2A. Ranking of sites according to sediment quality. The colour represents the status of the contaminants copper, lead, and zinc according to the traffic light system of grading environmental response criteria .The rank for each contaminant is shown as a composite symbol.

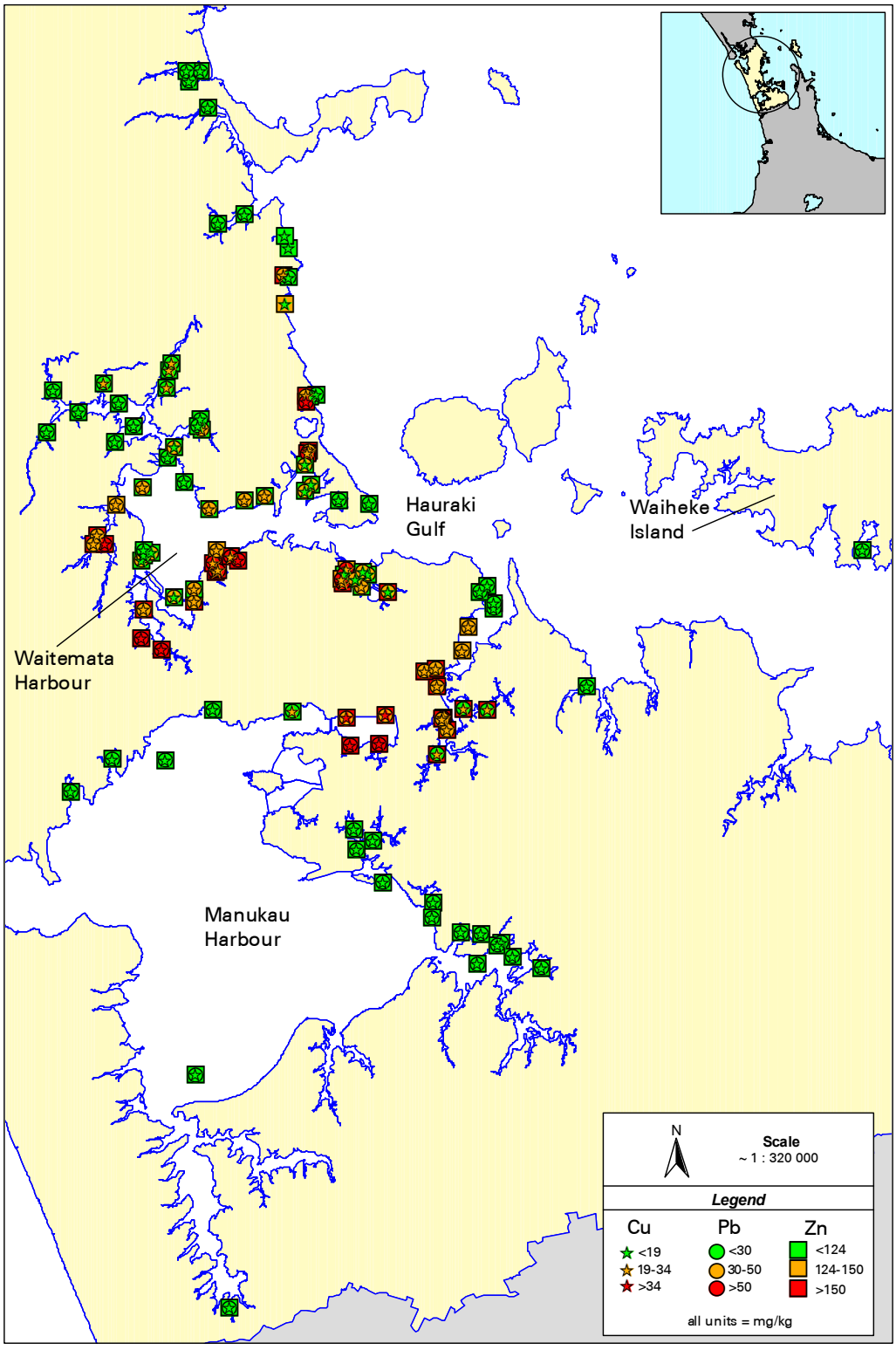


Figure 4.2B. Ranking of sites according to sediment quality for Waitemata Harbour and Tamaki Estuary and northern Manukau Harbour. The colour represents the status of the contaminants copper, lead, and zinc according to the traffic light system of grading environmental response criteria. The rank for each contaminant is shown as a composite symbol.

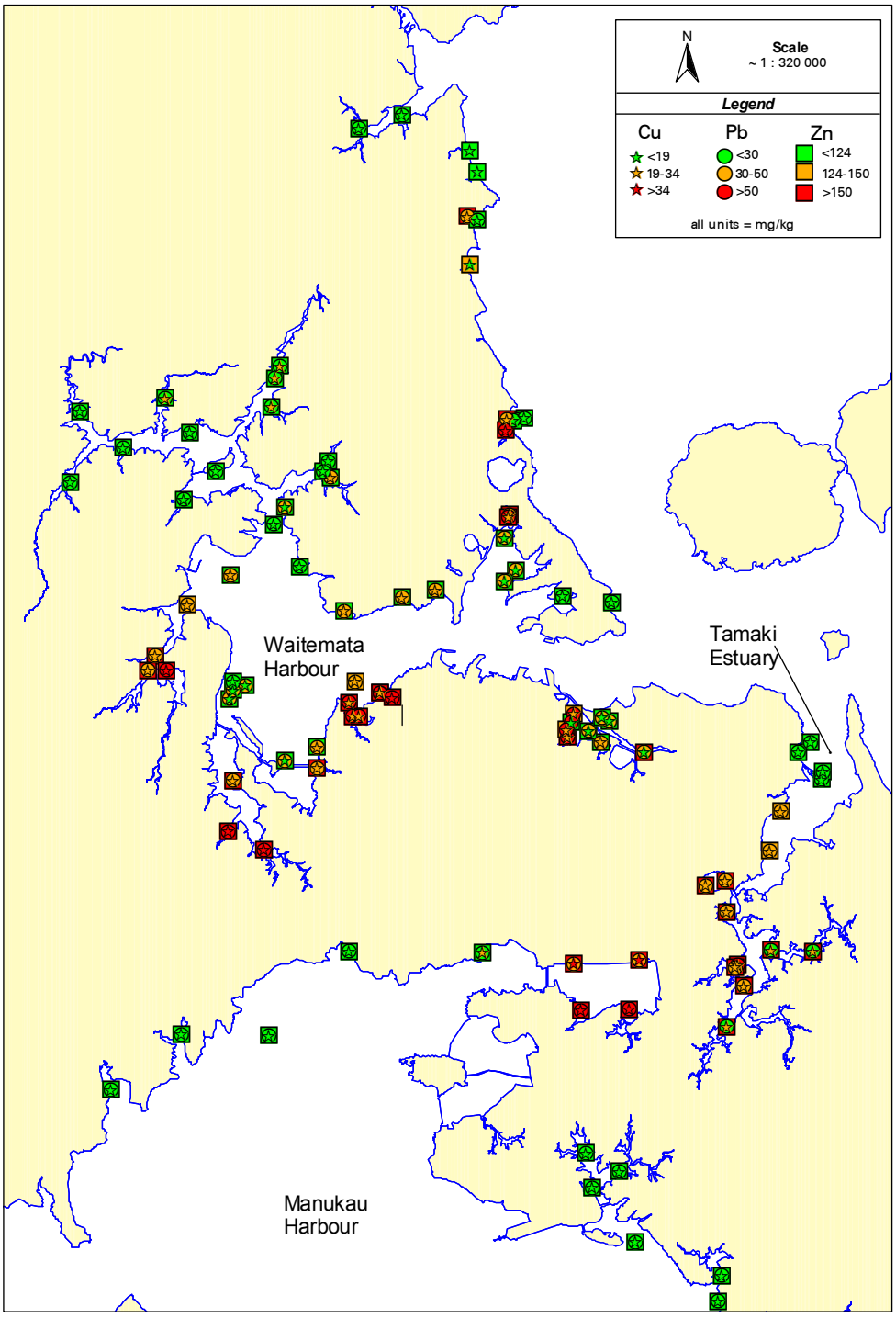


Figure 4.3A The rank of RDP and reference sites according to sediment quality for zinc. The colour represents the status of zinc according to the traffic light system of grading environmental response criteria.

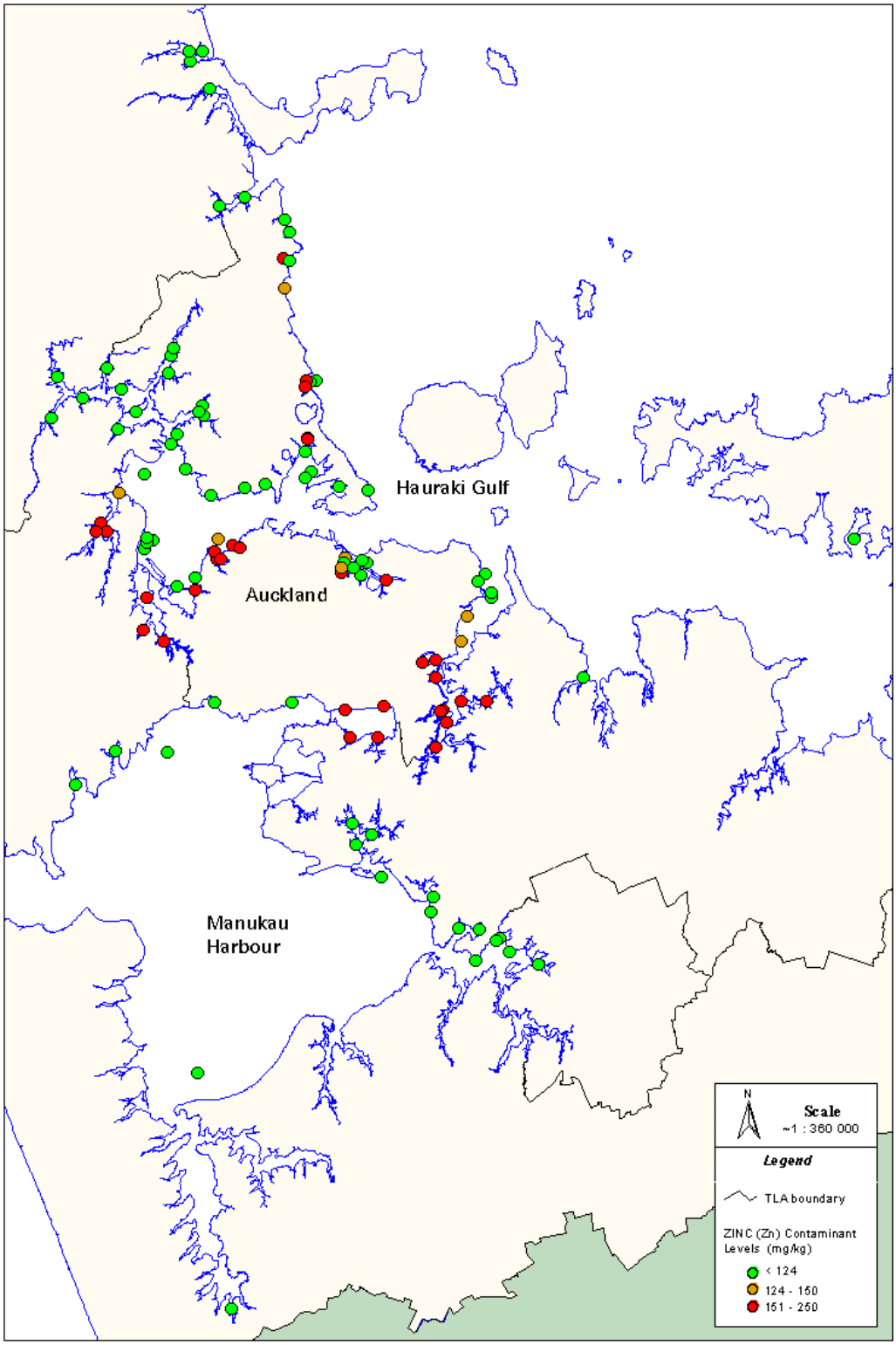


Figure 4.3B The rank of RDP and reference sites according to sediment quality for copper. The colour represents the status of copper according to the traffic light system of grading environmental response criteria.

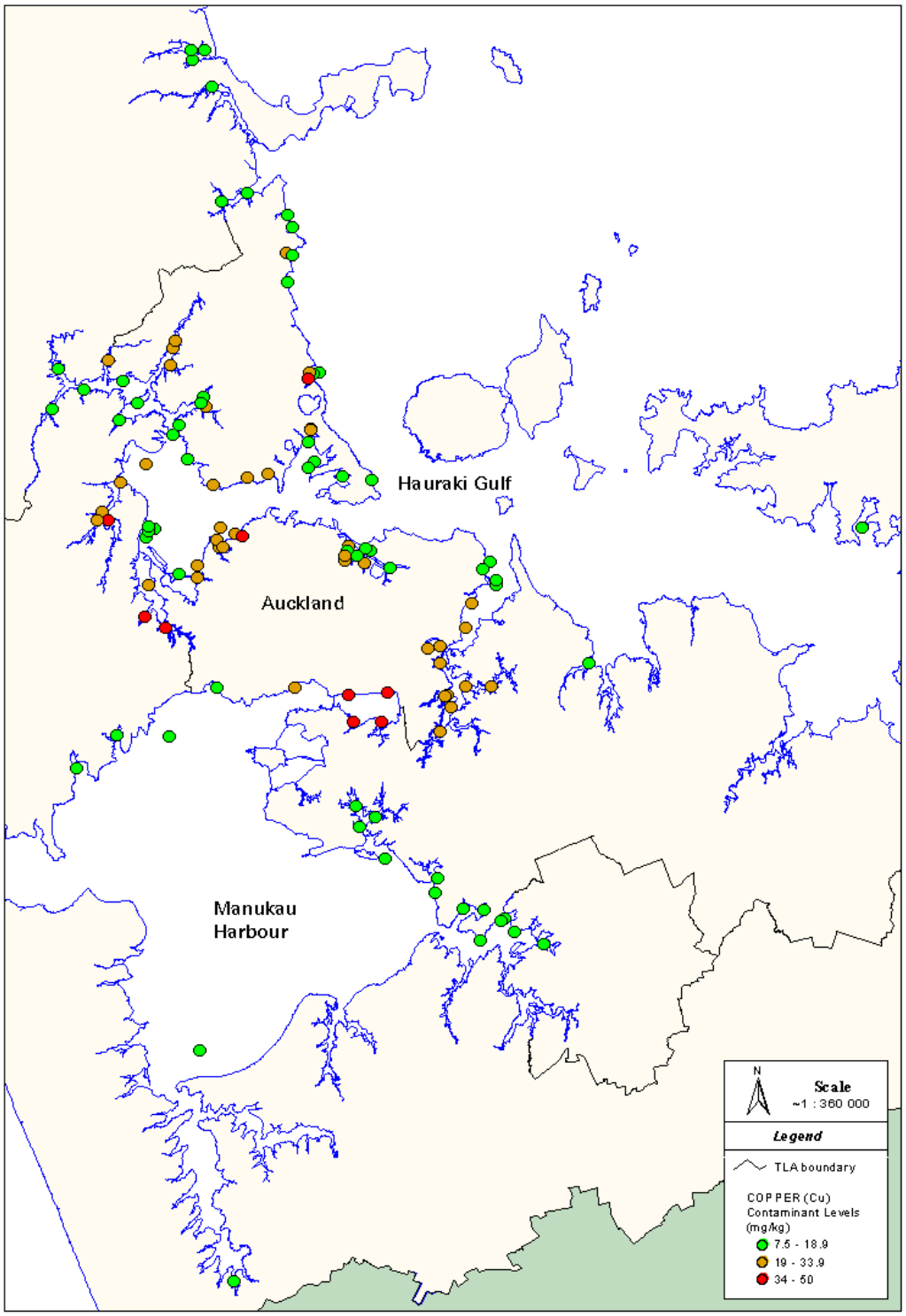


Figure 4.3C The rank of RDP and reference sites according to sediment quality for lead. The colour represents the status of lead according to the traffic light system of grading environmental response criteria.

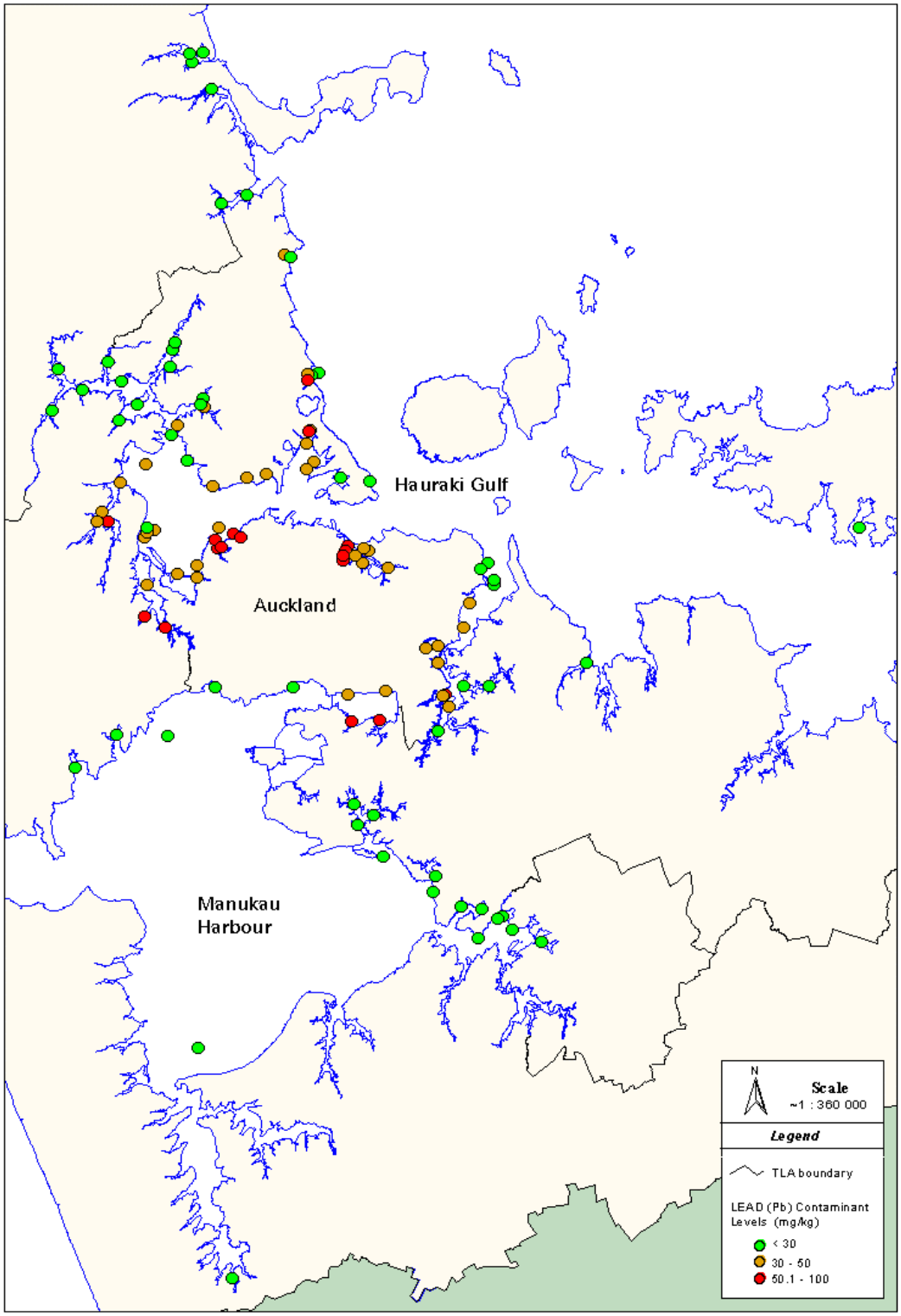
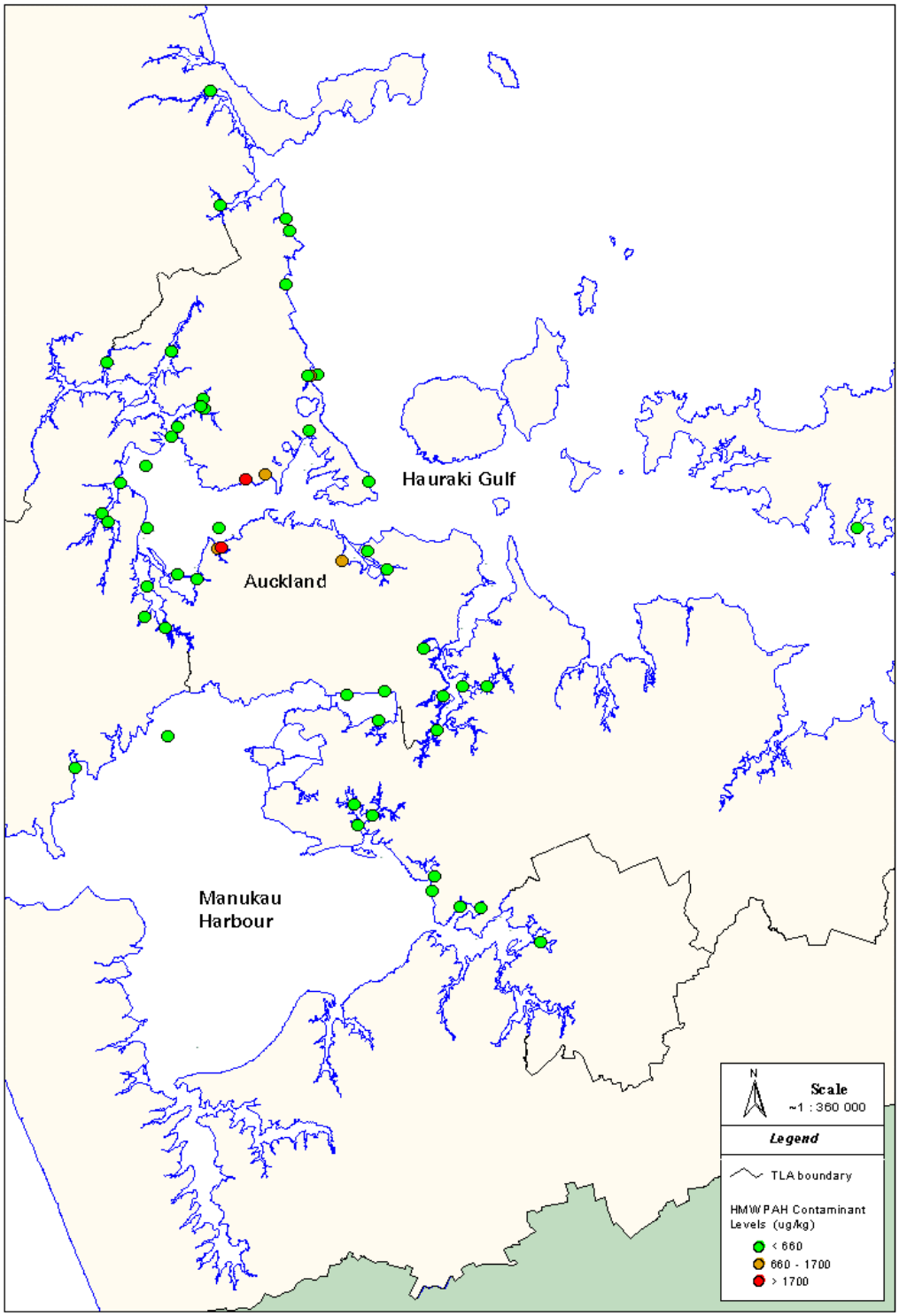


Figure 4.3D The rank of RDP and reference sites according to sediment quality for PAH. The colour represents the status of high molecular weight PAH according to the traffic light system of grading environmental response criteria.



4.1 Overview

Highest concentrations of the three heavy metals are found in settling zones of catchments with the longest history of urbanisation (e.g., Motions, Meola, Coxes, Whau, Upper Tamaki, and Mangere Inlet). Nevertheless, even relatively recently developed catchments, such as those initiated at the start of the boom in Auckland's population expansion in the 1950's to 1970's, also experience quite high concentrations of zinc and lead (e.g., Pakuranga and Henderson).

In contrast, most settling zones and outer zones away from the main centres that have catchments predominantly in rural land use, have low concentrations (e.g., Orewa, Puherehere Inlet, Waiuku). Note that small, sheltered, muddy estuaries are susceptible to rapid contamination where the surrounding catchment is large and urbanised (e.g., Deep Creek at Torbay).

4.2 Differences in contaminants

Zinc clearly stands out as the metal most likely to exceed the red ERC. Copper is least likely to exceed the red status. Both copper and lead fall within the amber status much more frequently than zinc, in about equal numbers. Lead concentrations are decreasing, while zinc and copper are generally increasing.

PAH levels are usually green. Exceptions are found in the sediment receiving discharges from some older catchments (Hobson, Motions and Meola), and sites near historic gas works (Chelsea, Little Shoal Bay).

4.3 Settling and outer zones

Settling zones are inner estuarine areas where catchment-sourced fine sediments and their associated contaminants are most likely to accumulate and reach high concentrations. In some ways, they behave like settling traps for the wider coastal environment. Highest concentrations of contaminants have been found in the settling zones of Whau estuary, and Motions and Meola Creeks. Some of this may be due to historical industrial pollution.

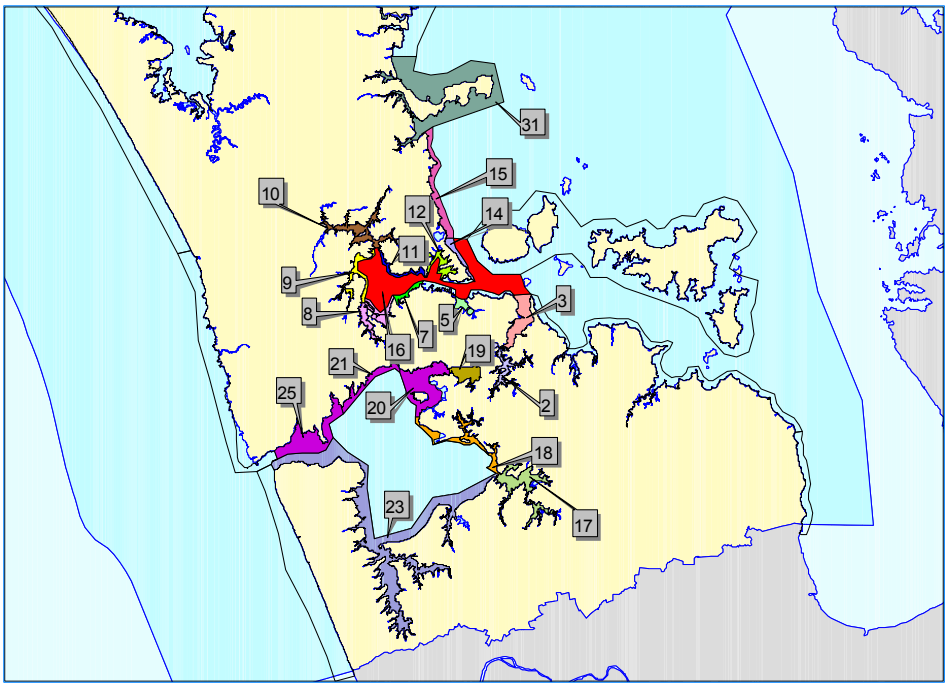
In outer zones, the wider estuarine areas downstream of settling zones, contaminants are widely dispersed, and concentrations are generally lower. [Note: In RDP monitoring programmes, we measure both the total metal concentration in the < 500 μm sediment fraction, and the acid soluble metal in the < 63 μm sediment fraction (the mud fraction). Total concentrations depend on the sediment texture, and sites with a high proportion of sand have very low concentrations. However, the outer zone ERC are devised for the mud fraction, and this is what is shown in Figures 4.1 - 4.3].

Three types of outer zone can be recognised. There are the outer zones in parts of Auckland where the urban catchments are relatively small, so contaminant concentrations are low (e.g. the wider Manukau Harbour and Pahurehure Inlet). There are outer zones whose catchments have a high proportion of urban land use, and that are sheltered and muddy, so contaminants accumulate, but not as rapidly as in the upstream settling zone. Concentrations can be quite high in this type of outer zone, and examples are the lower Whau Estuary, and the Upper and Middle Tamaki Estuary. Outer zones with high hydraulic energies (from waves or currents) are also low in contaminants in the mud fraction, because of the strong resuspension and dispersal processes that spread and dilute the finer contaminated sediment particles. Examples of this type of outer zone are found in the East Coast Bays. Quite high concentrations can be found in the small sheltered estuaries (really intertidal stream mouths) such as Milford Marina and Deep Creek, Torbay. However, immediately outside the estuary, where the stream meets the open coast, and on the adjacent beach or the surf zone, concentrations in the mud fraction are low.

4.4 Regional differences

The Auckland urban coastal receiving environment has been split into Regional Receiving Environment Areas (RREA) for the purpose of discussion (Fig. 4.4). Where appropriate, adjacent RREA with similar contaminant accumulation characteristics have also been grouped.

Figure 4.4: Location of Regional Receiving Environment Areas (RREA) discussed in the text. Individual RREA numbers are given in the grey boxes.



4.4.1 RREA 2, 3 Tamaki Estuary

The settling zones of older areas (Middlemore, Otahuhu and Panmure Basin), and the Pakuranga estuary are all red. The outer zones show a gradient of the contamination from the upper reaches of the estuary to the mouth (Upper Tamaki = red, Middle Tamaki = amber, Outer Tamaki = green). However, a few localised hot spots exist (Gabador Place, Panmure Slip/Yacht Club - Nipper et al. 1988).

A detailed survey of the Panmure basin demonstrates that it has the characteristics of a settling zone (Williamson and Green 2002), with relatively consistent high concentrations around the basin except near the one major inflow, where concentrations are much higher.

Detailed surveys of Otara lake by Manukau City Council have found very high levels of contamination.

4.4.2 RREA 5 Hobson Bay

This large system consists of Hobson Bay and Purewa Estuaries. The muddy depositional areas are red, while the mud fraction at sites in the wider outer zone are red and amber.

4.4.3 RREA 7-8 Coxes Bay to Whau Estuary

Muddy areas on the southern shore of the Waitemata are amongst the most contaminated in Auckland. There is good reason to suppose that part of this is due to past industrial pollution (Glasby et al 1986). However, as with Mangere Inlet (see later), much of this past pollution would have been buried or dispersed.

The outer zones are also contaminated in these areas. The outer zone samples at Lower Whau, Meola and Coxes were red. The outer zone samples at Motions (Meola Reef) were amber for zinc, copper and lead and PAH. A more comprehensive survey (ARC 2002b, ARC 2002c) found zinc levels sometimes exceeding the amber status in this area. An earlier sample collected in Coxes Bay found very high zinc levels in the mud fraction (ARC 1997, unpublished data).

The Wairau Branch of Whau Creek contains very high copper c.f. zinc concentrations, and the ratio of copper to zinc is much higher that expected for urban stormwater-derived contamination. This is possibly due to past pollution because the ARC long term baseline data for Wairau indicate that copper concentrations are not increasing at the present time.

4.4.4 RREA 9 Henderson Creek

The Henderson settling zone site is red. The settling zone is very large because of the large contributing catchments (Oratia, Opanuku, Swanson) and rather poorly defined due to the presence of mangroves and a marina. A sample collected in the lower (outer) area of the settling zone had a high proportion of sand and was ranked as amber for copper,

zinc and lead. The outer zone sample was amber for copper and lead. A nearby outer zone sample near Hobsonville was green.

4.4.5 REAA 10 Upper Harbour

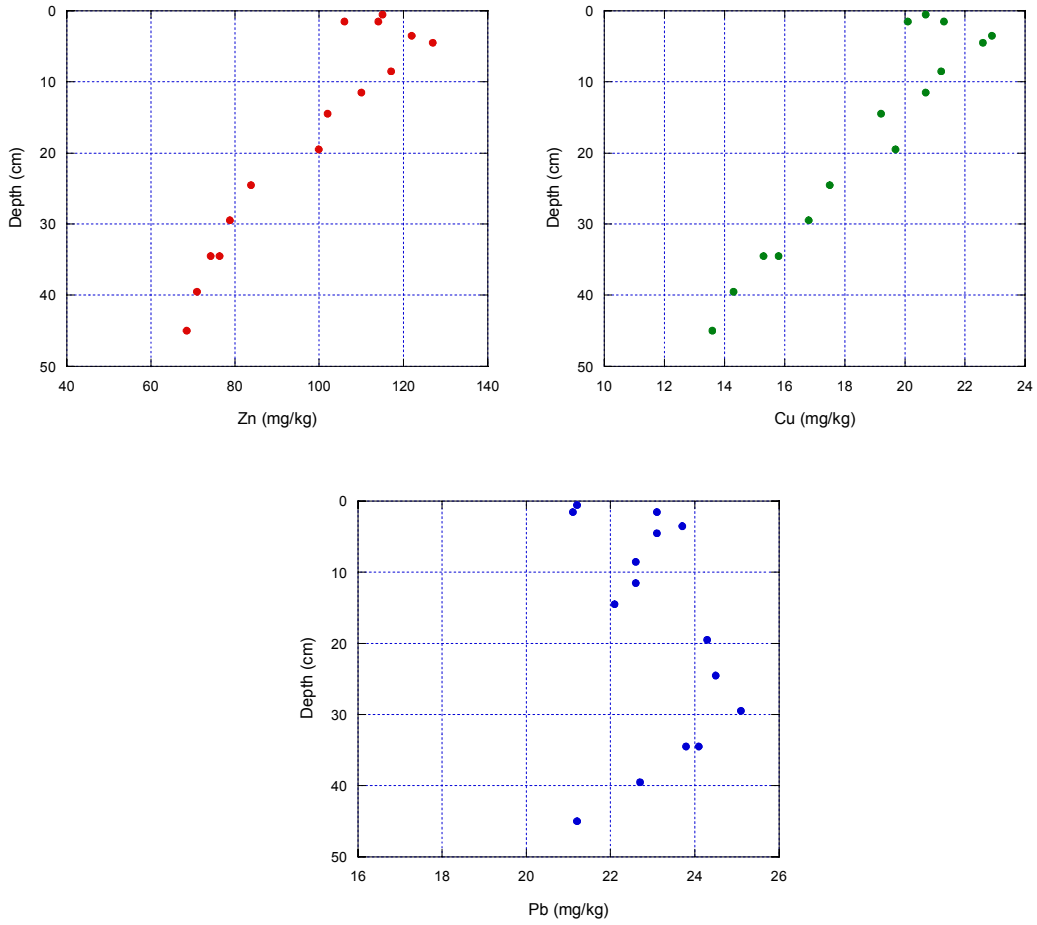
The upper harbour is mostly green except for the RDP monitoring sites at Hellyers, Paremeromo and Lucas.

The Kaipatiki arm has the most urbanised subcatchment of the Upper Harbour (Birkenhead, Beachhaven). Here zinc and copper are amber while lead has decreased rapidly in recent times from red to amber. The decline is unusually rapid and coincides with little or no increase in zinc or copper, so dilution by uncontaminated sediments from infilling and development in this catchment is the most likely cause. The outer zone sample (Hellyers) is green, although it decreased from lead amber status between 1998 and 2001.

Zinc levels are clearly increasing in Lucas Creek, although they are still green, while copper has reached amber levels, which is in line with its recent urbanisation. This is demonstrated in recent depth profiles. Stratigraphic records of contaminant concentrations in estuarine sediment cores show the build up contaminants in Auckland's estuaries. Figure 4.5 shows concentrations in Lucas Creek, which receives runoff from Albany, a relatively new urban area. Data were averaged from 9 cores, and the deepest samples did not reach background (pre-urban) concentrations.

Figure 4.5 shows a steady build-up in zinc and copper over time, with a recent decline in the uppermost layers. The reason for the decline in concentrations at the surface is likely to be due to dilution by subsoils low in zinc and copper. At the time of sampling, there was a large earth working operation nearby, and fine, clay-like sediments were observed on a nearby bank. Figure 4.5 also shows a steady build-up in lead from 45 to 30 cm depth, followed by a decline to present day levels. This is consistent with reduced lead loads following its removal from petrol between 1995-1996.

Figure 4.5. Concentration profiles of zinc, copper and lead in the top 45 cm of sediment from a mudflat in Lucas Creek, Auckland.



4.4.6 REAA 7-12, 16 Waitemata Harbour - Upper Harbour to Stanley Point

On reviewing the existing information, the following picture emerges of the contamination status of the Waitemata harbour:

1. Auckland Harbour, Westhaven Marina, Coxes-Meola are red because of older urban areas and port activities.
2. Meola – Henderson outer zone samples are usually amber because of moderate urban activity, and leakage from contaminated settling zones or outer zones (Waterview, Whau, Henderson)
3. Upper reaches of the harbour (Hobsonville, Island Bay) are green because urban catchments are small and there is probably a large input of uncontaminated sediment from the Upper Harbour (Rangitopuni).

4. Beachhaven – Kendalls – Chelsea – Shoal Bay are amber because of moderate urban activity, and often because of amber lead levels. Samples from Ngataringa are green, despite its old urban catchment, but this catchment is very small.
5. The middle harbour appears to be contaminated with zinc (Swales et al 2002) but nothing else is known.

Overall, there is some serious contamination of intertidal areas in the central Waitemata Harbour, with clear warning signals from amber status tending to red status in some areas. It will be important to understand how much of this is due to past industrial activity and port activities, how rapidly the harbour is deteriorating, and the spread of the contamination.

4.4.7 REAA 14, 15, 31 East Coast Bays: Cheltenham to Orewa

This area is subject to a separate investigation (Diffuse Sources 2003) . The mud fraction of the Bays in the coastal zone near shore are green and occasionally amber near settling zones. The ARC long term baseline site at Cheltenham Beach, while green is showing a clear increase in zinc and copper (and a decline in lead). This may be a localized input or be due to the export of contaminants from the Middle Harbour.

The small muddy urbanised estuaries that discharge to the coast are contaminated (Deep Creek, Wairau estuary).

Orewa and Weiti are uncontaminated because of relatively low level of urbanisation and/or large receiving body size c.f. catchment, although Weiti is showing evidence of rapidly increasing zinc and copper concentrations.

4.4.8 REAA 19 Mangere Inlet

Mangere inlet has red status. However, there is evidence that concentrations have decreased from very high levels experienced in the past (Glasby et al 1988). Deep cores taken at this site show very high concentrations buried at depth by very high sedimentation rates (Williamson and Wilcock 1994), while an earlier survey conducted in 1986 found very high copper, zinc and lead concentrations in the <20 μm sediment fraction.

4.4.9 REAA 20-21, 25 NE Manukau Coast - Hillsborough to Big Muddy Creek

Galsby et al. (1988) data suggested a pollution gradient along this coast (Williamson et al. 1992) because of industrial discharges to Mangere Inlet. Recent samples are mostly green, with some contamination at Hillsborough – which could be due to localised inputs or be a residual signal from the historical pollution gradient.

Overall, the Manukau Harbour is relatively uncontaminated.

4.4.10 REAA 17-18, 23 Eastern Manukau –Pukaki to Puherehere and Waiuku

The samples from these areas are all green, presumably because of the relatively small amount, and recent nature of urbanisation compared to the receiving water body size. However, some sites were expected to be amber (e.g., Pukaki, Puhinui, Pakuranga Inlet, Papakura Stream), because there were significant urban areas upstream. This warrants further investigation.

5 Benthic Ecology

Methods for ranking sites according to the health of the benthic community are provided in ARC, TP 184 (ARC 2002e). Categorisation of benthic community data is based on the multivariate modelling technique, canonical analysis of principal coordinates (CAP). Two models were required due to ecological differences between settling zones (~tidal creeks) and outer zones (~harbour sites).

Further refinement of the community health models has occurred since TP 184 (ARC 2002e) was published and an executable software package has been developed for analysing settling zone data. Changes to the original models were necessary because the outputs were potentially biased by the inclusion of multiple sites of the same rank from a single location, which may cause spatial confounding. A single site was therefore randomly selected from each rank within each location to eliminate this possibility in the refined models.

5.1 Settling zones

In the revised settling zone model clear separation was apparent between groups in the CAP group ordination analysis (Fig. 5.1 (a)) (see ARC 2002e for details of this analysis). The pollution rank remained highly correlated with the value of the ordination axis in the CAP gradient analysis (Fig. 5.1(b)). However, changes to the ordination axis values (ordination codes) used to rank community health were necessary due to a slightly different relationship between pollution rank and the ordination axis in the refined model (Figure 5.1 (b), Table 5.1). Benthic health categories are derived from the average of the ordination code (Table 5.1) and the closest pollution ranked group in ordination space (ARC 2002e). Average values <2.5 correspond to green, 2.5 – 3.5 to amber, and >3.5 to red health status.

Table 5.1: Ordination axis value limits used to derive ordination codes for ranking benthic health.

	Canonical ordination axis value	
Ordination Code	Lower Limit	Upper Limit
1		-0.17525
2	-0.17525	-0.05095
3	-0.05095	0.07335
4	0.07335	0.19765
5	0.19765	

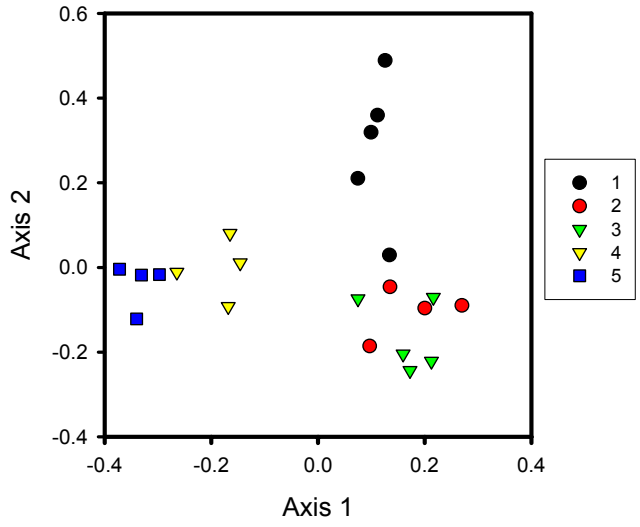
Benthic community data from 10 settling zone sites were collected in November 2002 (Figure 5.2). Data from 3 additional settling zone sites were obtained from North Shore City Council, who collected ecological samples in January/Feburary 2003. The settling zone sites sampled for benthic community health tended to be relatively polluted, with 9

sites ranked as red, and 3 sites ranked as amber according to sediment chemistry ERC (Table 5.2).

The benthic communities of all sites were ranked as amber according to the settling zone community health model, indicating signs of degraded biological health (Table 5.2). The amber ranking of benthic communities from red or amber sediment chemistry sites suggests that contaminants are affecting benthic biology, but the effect was not sufficient to result in a red community structure.

Figure 5.1: (a) CAP group ordination plot for the refined settling zone community health model with pollution ranks 1(= unpolluted) to 5 (= polluted) shown; (b) CAP gradient analysis of settling zone data using the refined model. Ranges for ordination codes 1-5 (horizontal dotted lines) and new site data (red dots) are given.

(a)



(b)

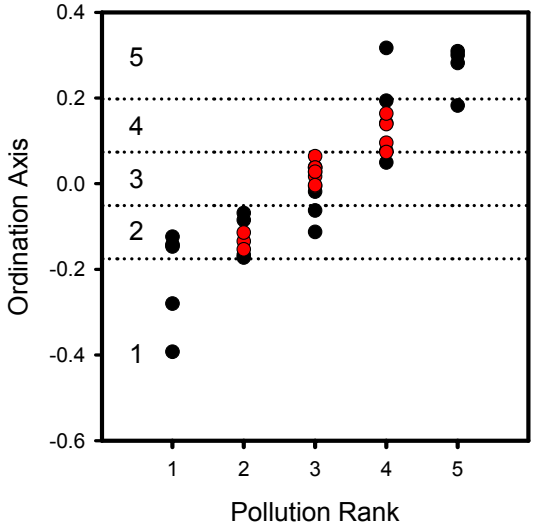


Figure 5.2: Location of benthic health sites sampled by ARC in November 2002, and by North Shore City Council in January/February 2003. Tidal creek (settling zone) sites are coloured blue and harbour sites (outer zones) coloured purple.

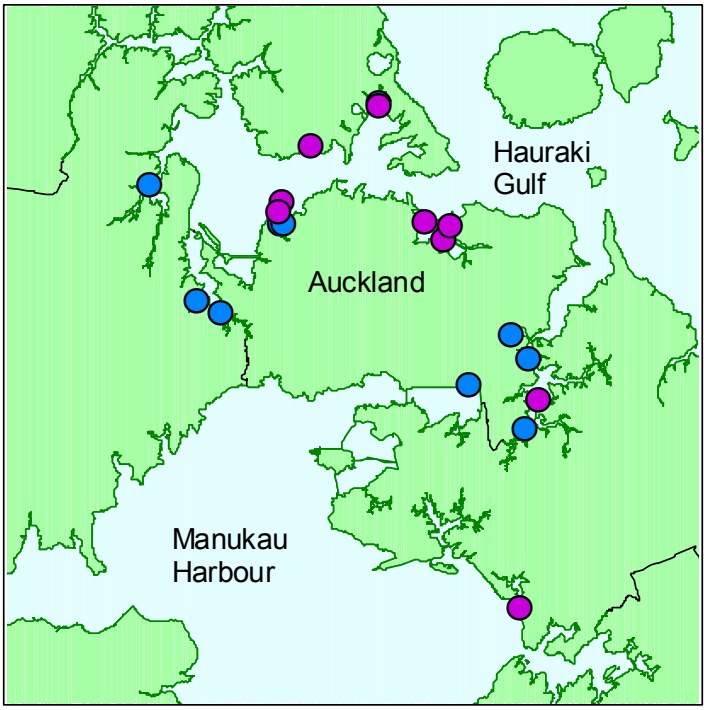


Table 5.2: Sediment chemistry and benthic community ranks for settling zone sites sampled by ARC and North Shore City Council.

Site	Sediment Chemistry Rank	Benthic Community Rank
Upper Tamaki (Middlemore)		
Panmure		
Meola		
Motions		
Wairau		
Upper Whau		
Middle Tamaki		
Henderson Upper		
Hillcrest Shoal Bay		
Ann's Creek		
Hellyers		
Te Wharau		
Lucas		

5.2 Outer zones

In order to improve the outer zone community health model, which was based on relatively few samples, benthic community data from 9 extra outer zone sites were collected in November 2002 (Figure 5.2). However, as outlined for the settling zone community health model, changes to the outer zone community health model where necessary to eliminate the potential for bias from the inclusion of multiple sites with the same rank from a single location. Replicated sites were therefore removed from the model. The ranking of some outer zone sites was also revised in light of new information on contaminant concentrations. Only 1 site was given a pollution rank of 5 (Metrowater Newmarket site 3). However, this site was included with the rank 4 sites because CAP analysis requires at least 2 sites within each rank. This meant the revised outer zone community health model was based on only 4 pollution ranks. A list of sites used in the outer zone community health model and their pollution rank is given in Table 5.3.

The addition of extra data and removal of replicated sites produced a negative relationship between the ordination axis value and pollution rank in the CAP correlation analysis (Fig. 5.3(a)). The change from a positive to negative trend in the refined model was not unexpected and does not alter the validity of the model, as the ordination axis represents a constrained multivariate axis that does not have a fixed orientation in multivariate space. In the CAP gradient analysis there was little overlap between ranks 2, 3, & 4, but ranks 1 & 2 had a high degree of overlap (Fig. 5.3(a)). In the CAP group ordination analysis considerable overlap was also apparent among sites with different pollution ranks (Fig. 5.3(b)), particularly among sites ranked 1 & 2, and 3 & 4. Consequently, the existing outer zone community health model was not considered robust enough for ecological ranking purposes, but may be useful for detecting persistent changes in community structure through time. The ordination axis value of the site provides a useful index of ecological health, with healthy communities having a value greater than zero in the revised model. Ecological health declines as the value of the ordination axis declines.

5.3 Discussion

All of the new settling zone sites ranked as amber or red for sediment quality were ranked as amber according to ecological health. The lack of concordance between red sediment chemistry and benthic ecology may mean that the amber-red sediment chemistry ERC are not optimal. However, at present it is not sensible to change the amber-red ERC, given criteria are based on widely accepted sediment quality guidelines, and there are insufficient data to set new values.

The ecological results support the conclusion that ecological impacts occur in the amber sediment quality range. Benthic communites of sites with red sediment quality showed signs of ecological stress, but they were not degraded to the point where the ecology was severely impacted. Remedial actions that reduced or reversed the accumulation of

contaminants would be expected to delay further degradation, or improve, the ecological health of these sites.

The revised outer zone community health model supports the conclusion that ecological health is affected by contaminant levels present in Auckland's harbours and estuaries. However, a lack of data from highly degraded sites[1], and a relatively high degree of overlap between sites ranked 1 & 2, and 3 & 4, means that it is not sufficiently robust to be used as a ranking tool. Nevertheless, in its present form, the outer zone community health model remains a useful tool for monitoring trends in ecological health. The addition of extra data, particularly from highly contaminated sites, should increase its utility.

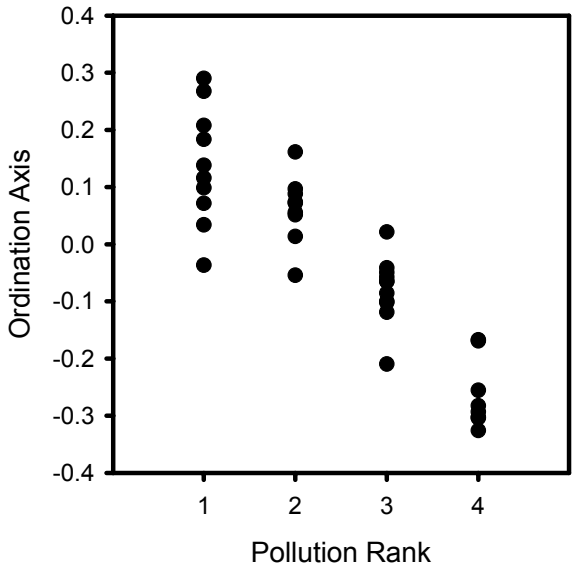
Table 5.3: Sites included in the revised outer zone community health model and their associated pollution rank.

Location	Site	Site Code	Pollution Rank
Mahurangi	Jamisons Bay	MAHjb	1
Manukau	Auckland Airport	MANaa	1
Manukau	Clarkes Beach	MANcb	1
Manukau	Ellets Beach	MANeb	1
Manukau	Karaka Point	MANkp	1
Waitemata	Walkers Reserve Site 2	METwr2	1
Okura	Okura Site 2	OK2	1
Manukau	RDP Puhinui Site	Puhinui	1
Waitemata	Hobsonville	WAIThbv	1
Whitford	Whitford Site 55	WHH55	1
Mahurangi	Cowans Bay	MAHcb	2
Mahurangi	Hamiltons Landing	MAHhl	2
Mahurangi	Mid Harbour	MAHmh	2
Mahurangi	Te Kapa	MAHtk	2
Manukau	Cape Horn	MANch	2
Manukau	Puhinui	MANps	2
Tamaki	Omaru Creek Site 3	METo3	2
Hobson Bay	RDP Purewa Site	Purewa	2
Waitemata	RDP Shoal Bay Site	Shoal Bay Upper	2
Waitemata	RDP Chelsea Site	Chelsea	3
Hobson Bay	RDP Hobson Site	Hobson	3
Hobson Bay	Hobson Site 3	Hobson3	3
Waitemata	RDP Meola 2 Site	Meola 2	3
Waitemata	RDP Meola Reef Site	Meola Reef	3
Tamaki	Omaru Creek Site 1	METo1	3
Tamaki	RDP Middle Tamaki Site	Middle Tamaki	3
Waitemata	Henderson Creek	WAIThc	3
Waitemata	Meola Reef	WAITreef	3
Waitemata	Shoal Bay	WAITshb	3
Waitemata	Whau	WAITwhau	3
Manukau	RDP Ann's Creek Site	Ann's Creek	4
Hobson Bay	Tohunga Site 5	METt5	4
Tamaki	RDP Upper Tamaki Site	U Tamaki	4
Hobson	New Market Site 3	METnm3	5 (4)

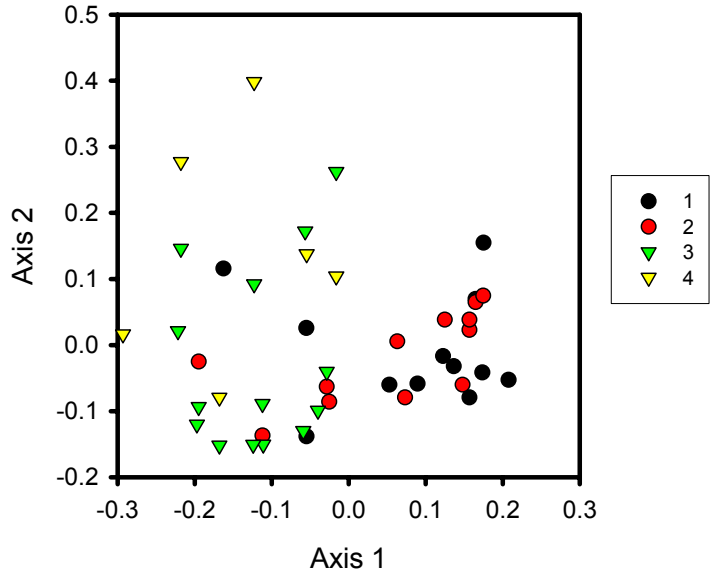
[1] The fact that these sites are rare is a positive reflection on the present state of Auckland's marine environment.

Figure 5.3: (a) CAP gradient analysis of outer zone data using the reduced site model and including the extra data collected by ARC in November 2002, and (b) CAP group ordination plot for the refined outer zone community health model with pollution ranks 1 - 4 shown. Pollution rankings are from 1 (= unpolluted) to 4 (= most polluted).

(a)



(b)



6 Amber Sediment Quality Sites

6.1 Overview

A total of 6 settling zone sites and 12 outer zone sites were identified as amber according to sediment chemistry ERC (Table 6.1). In this section, we consider applying the recommendations made in the Blueprint (ARC 2002a) to these sites. We then reassess the recommendations in the light of this reality check.

Many of the amber sites fall into 3 categories:

- Settling zones with catchments undergoing relatively new urban development (Lucas, Te Wharau, Paremoremo, Kaipatiki, Beachaven).
- Outer zones where contaminant inputs are predominantly received from upstream settling zones (Purewa, Waterview, Henderson, Upper Shoal Bay).
- Outer zones downstream of contaminated outer zones (Mid Tamaki, Hobson, Outer Whau, Kendalls, Shoal Bay, Hillsborough).

Of the latter, Mid Tamaki and Shoal Bay also have significant direct inputs from their watersheds.

Table 6.1 Settling zone sites with amber status.

Site	Type	Amber status	Local catchments/suburbs
Henderson Lower	SZ	Cu, Zn, Pb	Henderson, Swanson
Lucas	SZ	Cu	Albany
Te Wharau	SZ	Cu	Greenhithe
Paremoremo	SZ	Cu	Paremoremo
Kaipatiki	SZ	Cu, Pb	Beachaven, Birkdale, Birkenhead
Beachaven	SZ	Pb	Beachhaven
Mid Tamaki Bengazi	OZ	Cu, Pb, Zn	Pakuranga, Glen Innes, Omaru
Mid Tamaki Pt England	OZ	Cu, Pb, Zn	Pakuranga, Glen Innes, Omaru
Hobson 2	OZ	Cu, Pb	Newmarket, Remuera
Purewa	OZ	Pb	Meadowbank
Meola Reef	OZ	Cu, Pb, Zn	Motions, Meola
Waterview	OZ	Pb	Oakley
Outer Whau	OZ	Pb	Whau
Henderson	OZ	Cu, Pb	Henderson, Swanson, Te Atatu
Kendalls	OZ	Cu, Pb	Birkenhead
Shoal Bay Upper	OZ	Pb	Northcote, Takapuna
Shoal Bay Lower	OZ	Pb	Northcote, Takapuna
Hillsborough	OZ	Cu	Hillsborough

6.2 Blueprint procedure

The Blueprint (ARC 2002a) describes the assessment process for sites that have been graded amber. The Blueprint (2002a) decision trees for amber settling zones (see

Flowchart 3, Chapter 6) and outer zones (see Flowchart 6, Chapter 6) have been reproduced in Figures 6.1 and 6.2 respectively. It is recommended that the existing Blueprint (2002a) flowchart for outer zones (Fig. 6.2) be superseded by a revised version (Fig. 6.3), given that community health cannot be reliably ranked using the existing outer zone community health model. All decision trees require benthic ecology to be assessed for amber sites, but community health rankings are not used to direct further assessment in the revised outer zone flow chart (Fig. 6.3).

Figure 6.1: Blueprint (ARC 2002a) flowchart 3 showing the assessment tree for settling zones with amber sediment quality, and community health (ecological) rankings of green, amber or red.

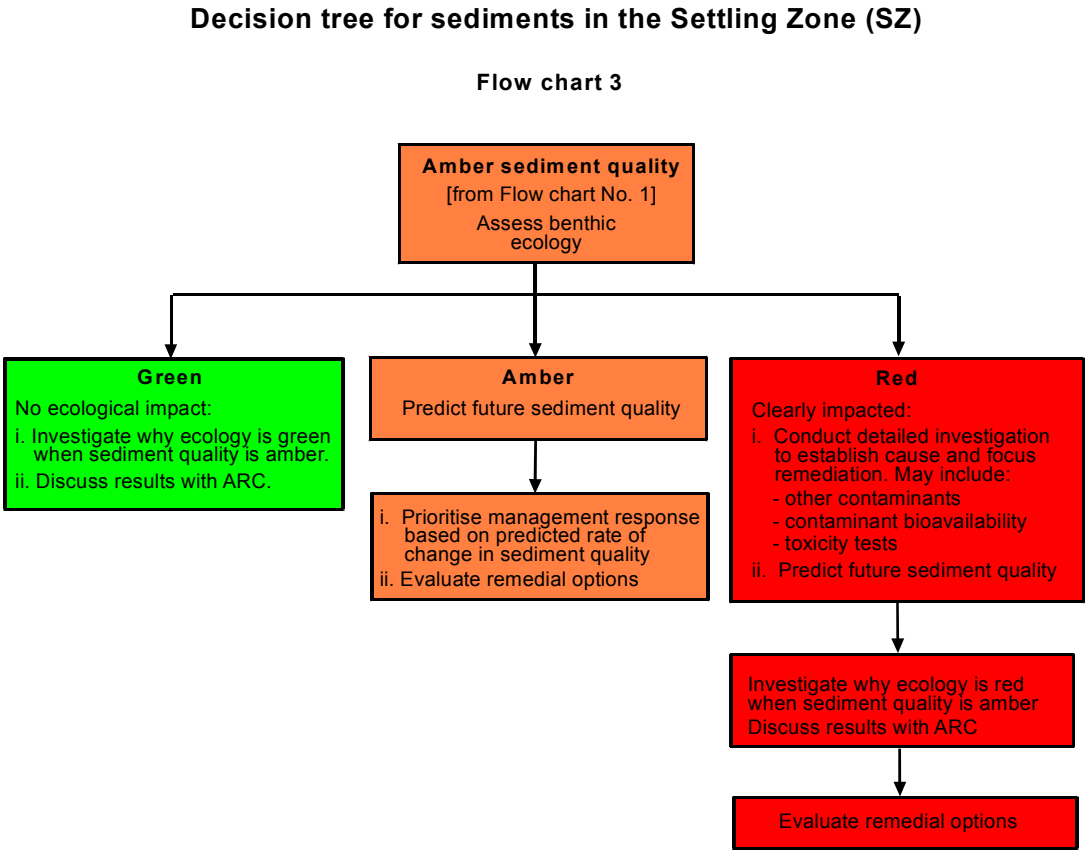


Figure 6.2: Existing Blueprint (ARC 2002a) flowchart 6 showing the assessment tree for outer zones with amber sediment quality. As the outer zone community health model is not robust enough to reliably rank benthic ecology it is recommended that this flowchart be superseded by the one provided in Fig. 6.3.

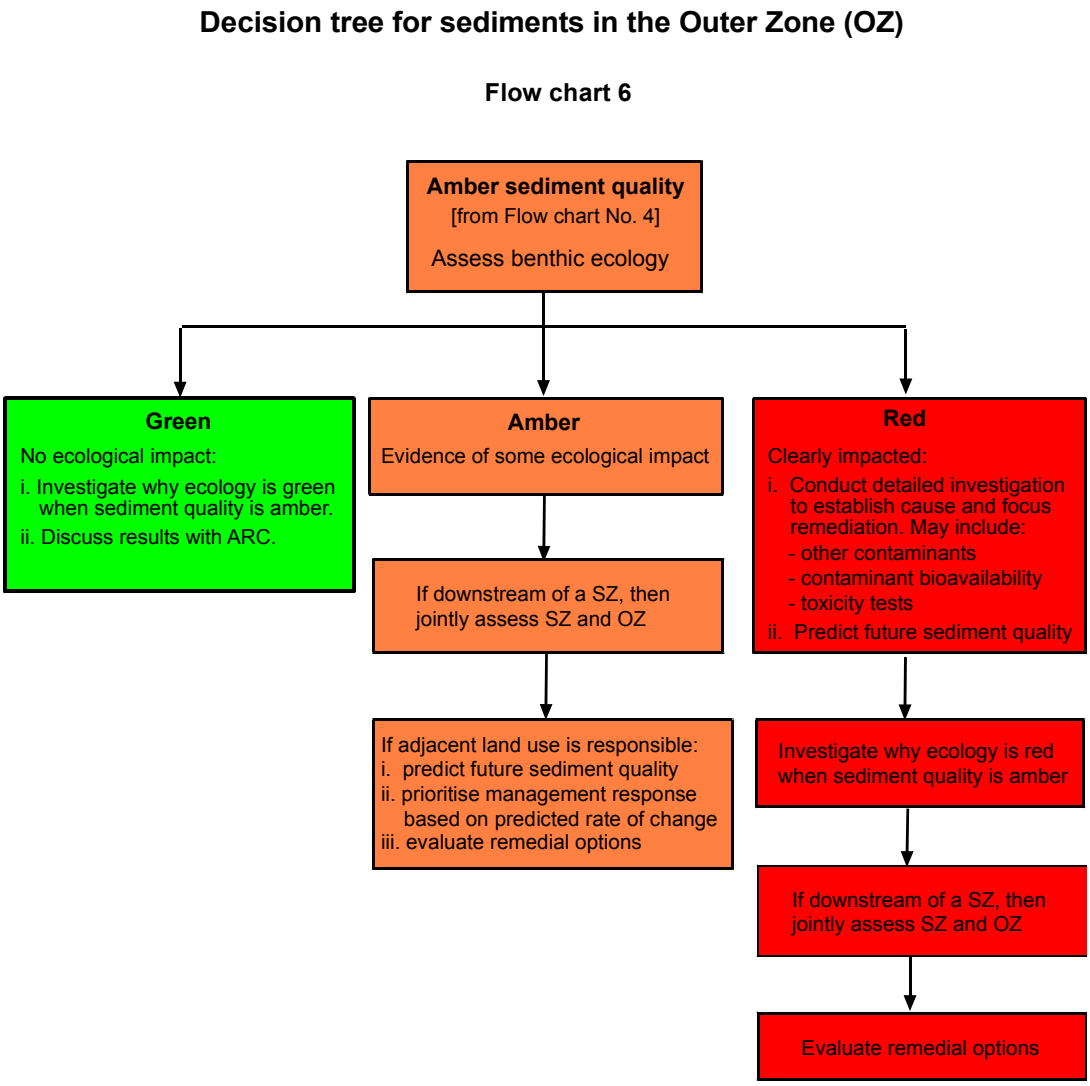
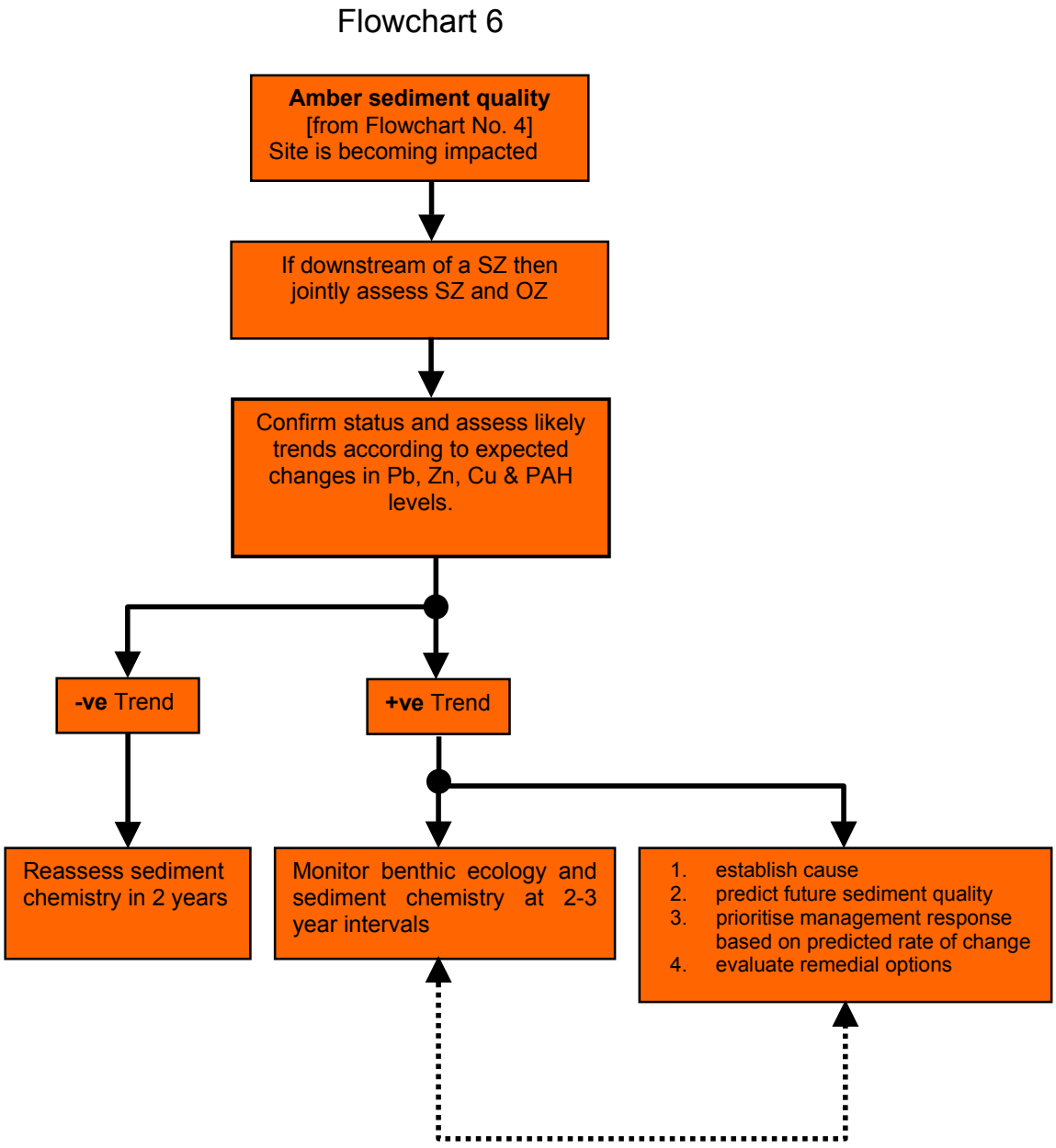


Figure 6.3. Revised Blueprint (ARC 2002a) flowchart 6 showing the steps to be taken for outer zones where sediment chemistry is amber.



6.3 Recommendations on amber sites

6.3.1 Refinement of the Blueprint procedures and decision tree

A review of the assessment procedures for amber sediment chemistry sites has highlighted an important step that needs to be included in the Blueprint (ARC 2002a). To describe this, firstly let us consider the grading exercise. To assign amber status to a site one or more contaminants must be amber, while none can be red. If this result were obtained at a new site from one sampling, then confirmation of the status is warranted before proceeding with subsequent steps. Confirmation could come from historical data, findings from a nearby site, or by re-sampling. Although the need to confirm the status of a site is implicit in the Blueprint (ARC 2002a), this step also needs to be stated explicitly in its flow charts (Fig. 6.3).

In addition for the need for confirmation, there is a second important step that needs to be carried out before proceeding to the benthic ecology survey. This step determines the likely trend in the concentration of sediment contaminants. Lead concentrations are likely to decrease with time, whereas zinc, copper and PAH concentrations are likely to increase with time. If lead is the only contaminant to have amber status, the others being green, then it may be more sensible to repeat the sediment quality sampling at a later date, than assess ecological community health. If zinc, copper and/or PAH levels are the cause of the amber status then an ecological community health assessment should be carried out.

6.3.2 Actions to be taken once amber sediment quality is confirmed

6.3.2.1 Settling zones

If the benthic ecology is amber for settling zones then the rate of deterioration needs to be determined. The rate of predicted increase in concentration to a red sediment quality condition determines the priority for evaluating remedial options (see ARC (2002a) Section 5.2.4). Note that these are priorities for the assessment process, and not priorities for management action (e.g., putting best management practises (BMPs) in place) which also need to be assessed.

- < 5 years - very high priority
- 5-10 years - high priority
- 10-20 years - moderate priority
- >20 years – low priority

If the benthic ecology is red for settling zones, more detailed assessments are necessary, as outlined in the settling zone flowchart (Fig. 6.1).

6.3.2.2 Outer zones

Outer zones will not be ranked for ecological health due to the insensitivity of the outer zone community health model. Consequently, the Blueprint (ARC 2002a) flow chart needs modification for amber outer zones as outlined in Figure 6.3.

Outer zone sites that are associated with a settling zone, (i.e. settling zone and outer zone sites are adjacent or otherwise connected to each other) should be treated as an integrated unit in terms of assessment and management during subsequent steps. Similarly, multiple sites within a settling zone or outer zone should be considered together. Actions for all of the amber sites identified in this report were determined using this approach and are set out in Table 6.2.

Table 6.2 Sites with amber status. SQ=sediment quality, BE=Benthic ecology, SZ=Settling Zone, DZ=Deposition Zone, OZ=Outer Zone, BEM = historical data used to develop community health models from this site. When "Next step" refers to an associated red site in Table 7.2, then the more contaminated site determines monitoring and management. For SZ, benthic ecology indicates the health category (red, amber, green). For outer zone, benthic ecology indicates the value of the site on the canonical axis in the outer zone community health model. Values >0 indicate healthy benthic communities while values decreasing from 0 to –0.4 indicate increasing ecological stress (see Section 5.2).

Site	Type	Amber status	Status confirm (a)	Likely trend (b)	Benthic ecology	Next step
Henderson Lower	SZ	Cu Zn Pb	✔	+	Unknown	Assess with Henderson Upper SZ (Table 7.2). Check benthic ecological health
Upper Lucas	SZ	Cu	✔	+	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Te Wharau	SZ	Cu	✔	+	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Paremoremo	SZ	Cu	✔	(+)	Unknown, BEM	Check benthic ecological health
Kaipatiki	SZ	Cu Pb	✔	+	amber, BEM	Check benthic ecological health
Beachhaven	SZ	Pb	No	-	Unknown	Remonitor SQ in 5 years
Mid Tamaki Benghazi	OZ	Cu Zn Pb	✔	+	Unknown	Check benthic ecological health
Mid Tamaki Pt England	OZ	Cu Pb Zn	✔	+	Unknown	Check benthic ecological health
Hobson 2	OZ	Cu Pb	✔	+	Unknown	Check benthic ecological health. Assess with Hobson 1 (Table 7.2)
Purewa OZ	OZ	Pb	✔	-	0.16	Remonitor SQ in 5 years
Meola Reef	OZ	Cu Zn Pb	✔	+	-0.09	Assess with Motions SZ. Assess accumulation rate, prioritise and evaluate options for remediation
Waterview	OZ	Pb	✔	-	Unknown	Remonitor SQ in 5 years
Outer Whau	OZ	Pb	✔	-	-0.10	Assess with Lower and Upper Whau, Wairau. Remonitor 2 yrs.
Henderson OZ	OZ	Cu Pb	✔	+	-0.12	Assess with Henderson Upper SZ (Table 7.2). Remonitor 2 yrs
Kendalls	OZ	Cu Pb	No	?	Unknown	Confirm data
Shoal Bay Upper	OZ	Pb	✔	-	0.05	Assess with Hillcrest. Remonitor in 2 years
Shoal Bay Lower	OZ	Pb	✔	-	Unknown	Remonitor SQ in 5 years
Hillsborough	OZ	Cu	No	?	Unknown	Confirm data

'✔' = confirmed; = not-confirmed. (b) '+' concentrations increase, '-' concentrations decrease.

Table 6.3 Rate which amber sites reach red status. Zn = Zinc, Cu = Copper.

Site	Type	Amber status	Rate Zn (a)	Rate Cu (a)	Years to reach red
Henderson Lower	SZ	Cu Zn Pb	4.8	0.6	3
Upper Lucas	SZ	Cu	8	1.1	6
Te Wharau	SZ	Cu	(8)	(1.1)	(4)
Paremoremo	SZ	Cu	6.7	1.6	6
Kaipatiki	SZ	Cu Pb	(5.3)	(0.3)	(4)
Hobson 2	OZ	Cu Pb	(10.2)	(1.8)	(3)
Meola Reef	OZ	Cu Zn Pb	0	0	?

(a) Rate = measured change in concentration at ARC LTB site;

7 Red Sediment Quality Sites

7.1 Overview

In this section we consider applying the recommendations made in the Blueprint (ARC 2002a) report to the sites that have been assessed as red for sediment quality (Table 3.1). We then reassess the recommendations in the light of this reality check.

A total of 22 sites were classified as red according to sediment chemistry ERC (Table 7.1). The sites fell into 4 categories:

1. settling zones downstream of old, intensely urbanised catchments (Middlemore, Otahuhu, Purewa, Meola, Motions, Waterview, Whau)
2. settling zones downstream of catchments largely urbansied since the 1950's (Panmure, Pakuranga, Wairau, Henderson)
3. outer zones downstream of red settling zones (Upper Tamaki, Meola, Lower Whau)
4. outer zones with largely direct inputs of contaminants from their catchments (Mangere, Hobson, Coxes, Chelsea)

In addition, contamination at some sites may be due to past industrial pollution (Upper Whau, Mangere, Panmure).

Table 7.1 Settling zone sites with red status.

Site	Type	Red status	Other Amber levels
Upper Tamaki	SZ	Zn	Cu, Pb
Panmure	SZ	Zn	Cu, Pb
Otahuhu	DZ	Zn	Cu, Pb
Pakuranga	SZ	Zn	Cu
Purewa	SZ	Zn	Cu
Meola	SZ	Zn, Pb	Cu, PAH
Motions	SZ	Zn, Pb, PAH	Cu
Waterview	DZ	Zn	Cu, Pb
Upper Whau	SZ	Cu, Zn, Pb	
Whau, Wairua	SZ	Cu, Zn, Pb	
Oratia/Henderson Upper	SZ	Zn	Cu, Pb
Hillcrest, Shoal Bay	SZ	Zn	Cu, Pb
Mangere, Cemetery	OZ	Cu. Zn	Pb
Mangere, Anns Creek	OZ	Cu, Zn	Pb
Upper Tamaki, Princess	OZ	Zn	Cu, Pb
Upper Tamaki, Bowden	OZ	Zn	Cu, Pb
Hobson 1	OZ	Zn, Pb	Cu, PAH
Hobson 3	OZ	Pb	Cu, Zn
Coxes	OZ	Cu, Zn, Pb	
Lower Whau	OZ	Zn	Cu, Pb
Chelsea	OZ	PAH	Cu, Pb

7.2 Blueprint procedure

The process to be followed for red settling zones is detailed in the Blueprint (ARC 2002a) report Flowchart 2 (Chapter 6) (Fig. 7.1), while Flowchart 5 (Chapter 6) describes the process to be followed for red outer zones (Fig. 7.2). It is recommended that the existing flowchart for outer zones (Flowchart 5, Fig. 7.2) be superseded by a revised version (Fig. 7.3), given that community health cannot be reliably ranked using the existing outer zone community health model. The Blueprint (ARC 2002a) settling zone and revised outer zone procedures were considered for sites with known red status. For each site the appropriate monitoring frequency was established and the next steps involved in investigating the cause and impact of contaminants were considered.

Figure 7.1: Blueprint (ARC 2002a) flowchart 2 showing the assessment tree for settling zones with red sediment quality and community health (ecological) rankings of green, amber, or red.

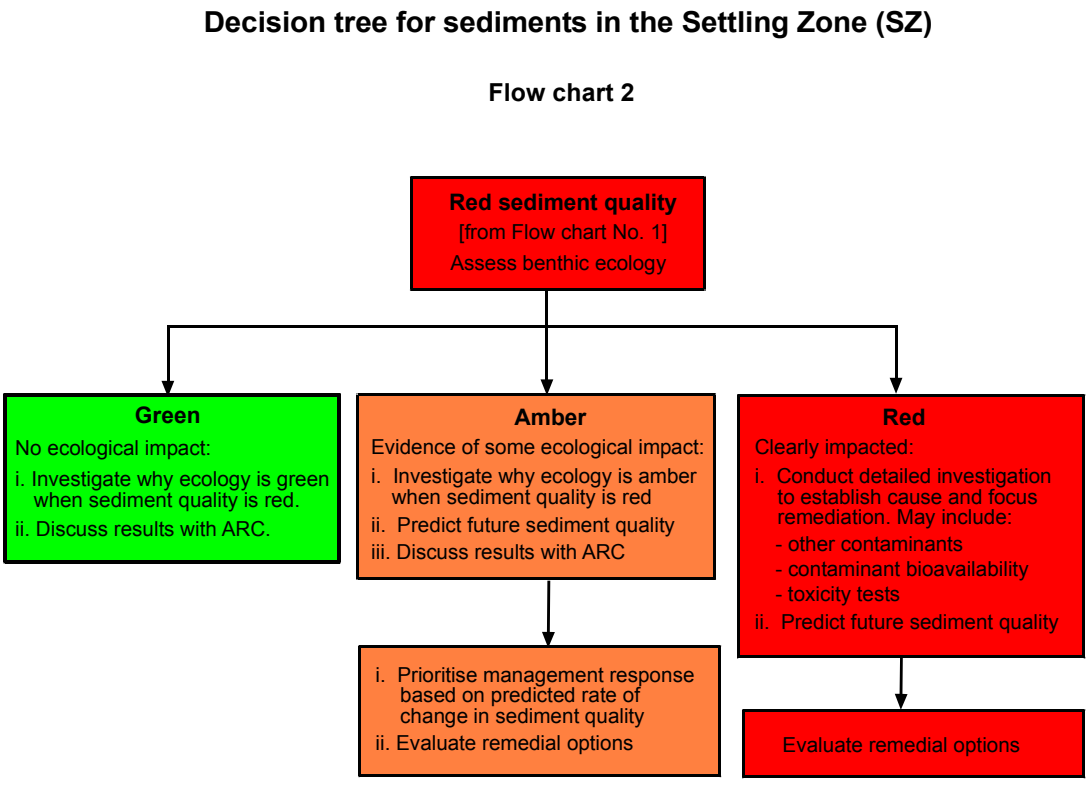


Figure 7.2: Existing Blueprint (ARC 2002a) flowchart 5 showing the assessment tree for outer zones with red sediment quality. As the outer zone community health model is not robust enough to reliably rank benthic ecology it is recommended that this flowchart be superseded by the one provided in Fig. 7.3.

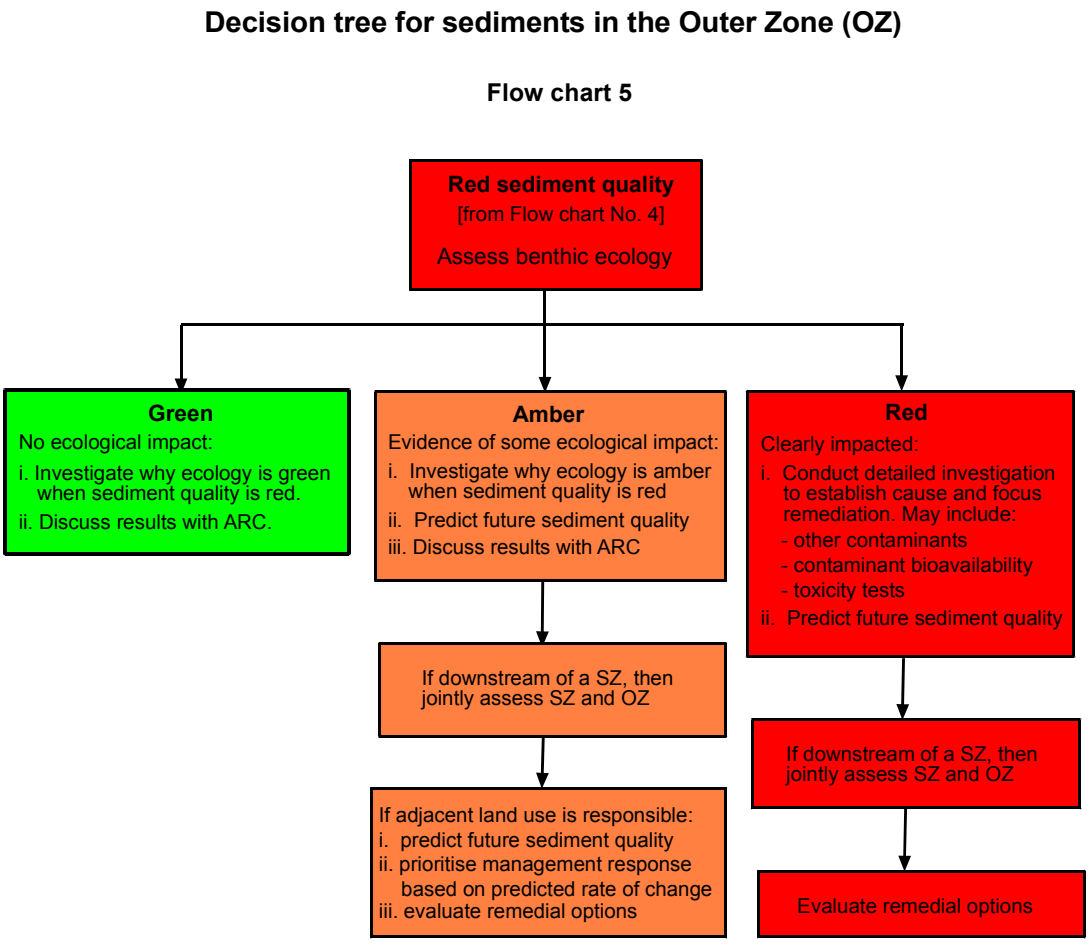
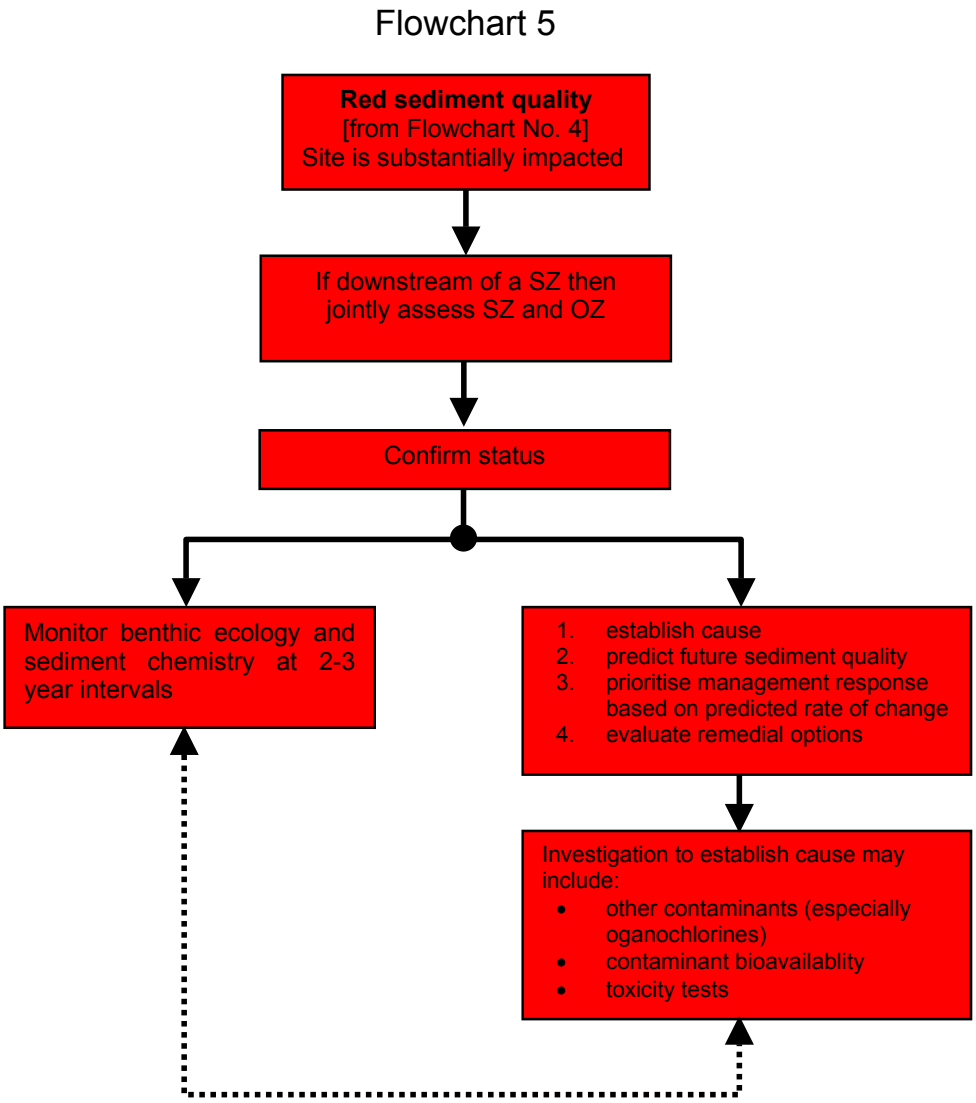


Figure 7.3. Revised Blueprint (ARC 2002a) flowchart No. 5 showing the steps to be taken for outer zones where sediment chemistry is red.



7.3 Recommendations on red sites

7.3.1 Refinement of the Blueprint procedures and decision tree

As with amber sites with only one set of analyses, the red status needs to be confirmed by checking consistency with any nearby reference site, and/or by re-sampling and re-analysis. This step needs to be explicitly stated in the Blueprint (ARC 2002a) decision tree (Fig. 7.3).

7.3.2 Monitoring frequency and next step

Generally the monitoring type and frequency at a site will depend on the place in the decision tree (see Figs. 7.1 & 7.3) and the staging and implementation of remediation. There is no fixed, standard frequency for monitoring once a site is deemed to reach a red status. Instead, the approach is focussed on confirming and establishing the cause. Once remediation options are put in place, however, monitoring would occur every two years to test efficacy of the management options adopted. The following outlines the recommended monitoring action for the sites identified as red above.

After sediment chemistry has been determined and checked, the next step is to check benthic ecology. Many red sites now have this information (Section 6). All of the sites that are classified as red for sediment quality have amber benthic ecology. As concluded in Section 6, this means that they are only partially degraded and remedial action would be beneficial in reducing or reversing the rate of degradation. For these sites the subsequent action should estimate the rate of accumulation of contaminants in order to set priorities for remediation. For outer zone sites downstream from a settling zone site, such an appraisal should proceed in concert with the appraisal of the settling zone site.

For sites without benthic ecology data, the ecological sampling should take place as soon as possible.

- If benthic ecology monitoring confirms the red status of a settling zone, this suggests that the site is in the process of becoming seriously degraded. The next step in the decision tree (see Figs. 7.1) is to conduct a detailed investigation to establish the cause and develop an appropriate plan for remediation. Given the likelihood of serious ecological impacts, this should take place in the current or next financial year. [Note: This may require the measurement of organochlorines (Variation 1 to the Coastal Plan, Table 20.1B) at one or more sites within a receiving area. However, the ARC are reviewing the need for organochlorine information as it obtains a more comprehensive picture of the magnitude and range of concentrations in the Auckland region. Therefore, before measuring organochlorines, check with the ARC whether this is necessary.]
- If benthic ecology monitoring does not confirm the red status of a settling zone, the next step in the decision tree (see Figs. 7.1) is to consider reasons for the apparent contradiction. If the site is amber for Benthic Ecology, then this is consistent with a lower degradation and places a high priority on remedial action to prevent any further decline in habitat quality.
- If a settling zone is green for benthic ecology, then discussion should be held with the ARC regarding further assessment and/or management action.
- For outer zones the value of the site on the canonical axis should be used as an indication of ecological health status and as a method of monitoring changes that occur over time. This information should be interpreted in conjunction with data on

contaminant levels and appropriate action taken as outlined in the revised decision tree for sediments in the outer zone (Fig. 7.3).

- The appropriate monitoring frequency and next steps that should be taken to identify the source and/or impact of contaminants are set out in Table 7.2 for all the red sites identified in this report.

It is recommended that the other investigations recommended in the Blueprint (2002a): flow charts, toxicity testing and AVS analysis; only be undertaken if there is the need to increase the weight of evidence for adverse effects or to sort out any ambiguity in the assessment of sites. Such may be the case with some sites which show a red benthic ecology.

Table 7.2 Sites with red status. SQ=sediment quality, BE=Benthic ecology, SZ=Settling Zone, DZ=Deposition Zone, OZ=Outer Zone. For settling zones benthic ecology indicates the health category (red, amber green). For outer zones benthic ecology indicates the value of the site on the canonical axis in the outer zone community health model. Values >0 indicate healthy benthic communities while values decreasing from 0 to –0.4 indicate increasing ecological stress (see Section 5.2).

Site	Type	Red status	Status confirm	Amber levels	Benthic ecology	Next step
Upper Tamaki	SZ	Zn	✔	Cu Pb	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Panmure	SZ	Zn	✔	Cu Pb	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Otahuhu	DZ	Zn	✔	Cu Pb	Unknown	Check benthic ecological health
Pakuranga	SZ	Zn	✔	Cu	Unknown	Check benthic ecological health
Purewa SZ	SZ	Zn	No	Cu	Unknown	Confirm data
Meola SZ	SZ	Zn Pb	✔	Cu PAH	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Motions SZ	SZ	Zn Pb PAH	✔	Cu	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Waterview DZ	DZ	Zn	✔	Cu Pb	Unknown	Assess accumulation rate, prioritise and evaluate options for remediation
Upper Whau	SZ	Cu, Zn, Pb	✔		Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Wairua, Whau	SZ	Cu, Zn, Pb	✔		Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Henderson Upper	SZ	Zn	✔	Cu Pb	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Hillcrest, Shoal Bay	SZ	Zn	✔	Cu Pb	Amber	Assess accumulation rate, prioritise and evaluate options for remediation
Mangere Cemetery	DZ	Cu Zn	✔	Pb	Unknown	Identify contaminant sources
Mangere Anns Creek	DZ	Cu Zn	✔	Pb	Amber	Identify contaminant sources
Upper Tamaki, Princess	OZ	Zn	✔	Cu Pb	Unknown	Check benthic ecological health
Upper Tamaki, Bowden	OZ	Zn	✔	Cu Pb	Unknown	Check benthic ecological health
Hobson 1	OZ	Zn Pb	✔	Cu PAH	Amber	Assess accumulation rate, prioritise and evaluate options for remediation

Site	Type	Red status	Status confirm	Amber levels	Benthic ecology	Next step
Hobson 3	OZ	Pb	✔	Cu Zn	Unknown	Assess rate at Hobson 1, prioritise and evaluate remediation
Meola OZ	OZ	Zn Pb	✔	Cu	Unknown	Assess accumulation rate, prioritise and evaluate options for remediation
Coxes	OZ	Zn Pb	✔	Cu	Unknown	Check benthic ecological health
Lower Whau	OZ	Zn	✔	Cu Pb	Unknown	Assess accumulation rate, prioritise and evaluate options for remediation. Assess with Upper Whau and Wairau.
Chelsea	OZ	PAH	No	Cu Pb	-0.06	Identify contaminant sources, confirm PAH data

(a) '✔' = confirmed; = not-confirmed.

8 Territorial Responsibilities

The following tables (8.1 & 8.2) set out the number of monitoring sites in each Territorial Authority area. Some sites are common to 2 or more councils.

- ACC = Auckland City Council
- FDC = Franklin District Council
- MCC = Manukau City Council
- NSC = North Shore City Council
- PDC = Papakura District Council
- RDC = Rodney District Council
- WCC = Waitakere City Council

Table 8.1 Local jurisdiction of all monitoring sites

Territorial Authority	Number of sites
ACC	16
ACC/WCC	3
FDC	1
MCC	8
MCC/ACC	8
MCC/PDC	2
MCC/PDC/FDC	2
PDC	1
NSC	13
RDC	5
RDC/NSC	1
WCC	9
WCC/RDC	3

Table 8.2 Pro-rated responsibility for all monitoring sites.

Territorial Authority	Number of sites
ACC	21.5
FDC	1.67
MCC	13.67
NSC	14.5
PDC	2.67
RDC	6
WCC	12

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