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TE RAUHĪTANGA TAIAO

Pollution Gradient Classification

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Pollution Gradient Classification

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Contents

1 What is the purpose of this document?

The site assessment and monitoring components of the Regional Discharges Project have been described in Technical Publication 168 Blueprint for monitoring urban receiving environments (April 2002). This Blueprint sets out:

1. How to assess the impact of urban stormwater or wastewater overflows on coastal marine receiving environments in terms of sediment quality, ecological community health, public health and water quality.
2. Then how to apply this initial assessment of receiving environments to provide a sound scientific basis for a management response at sites that score amber or red.
3. How to provide a monitoring protocol to evaluate management options directed at urban receiving environments across the Auckland region.

The general objective for urban coastal receiving environments in the Auckland region is to maintain natural and healthy saline ecosystems of high quality and improve the condition of those where effects are present. NIWA recommended that the monitoring and evaluation of the ecosystem would focus on community composition. This approach would describe an ecologically meaningful response to stormwater related pollution.

The pollution gradient classification is an essential step in the assessment of a receiving environment site for the purpose of running the *community health model*. The definition of health would be built around a pollution rank index assigned to sites where there is existing data. This classification methodology combines existing sediment quality and benthic ecology data with land use to determine a pollution rank between 1 and 5 for a Primary Deposition Area (PDA) and a Secondary Resuspension Area (SRA). The Regional Discharges Project has divided Auckland's urban marine area into two types of receiving environments for the purposes of monitoring the impact of stormwater and wastewater discharges. These are Settling Zones (equivalent to PDA's) and Outer Zones (equivalent to SRA's).

This report provides guidance on how to rank tidal and harbour sites based on data collected by a number of agencies in the Auckland Region. The site evaluations presented in the report were used to develop the *community health model.*

2 Classification process

The key steps to rank site pollution index (1=uncontaminated, 5=highly contaminated) are outlined in Table 2.1.

Step 1 assesses the catchment land use. This is highly likely to be correlated to the degree of contamination. For rural forested or pastoral sites, with no point sources, we expect no significant contamination of estuarine receiving water sediments. This is based on our experience in the Auckland region. For catchments that were fully urbanized before 1950, we expect maximum inputs of contaminants.

Step 2 assesses the nature of the receiving environment. Is it a PDA or SRA? If a PDA, then does it meet Settling Zone criteria? This is essential background information to check and make sense of contaminant concentrations, and assign the site to "tidal" or the "harbour" database. It is also used to check the final assessment (step 6).

Step 3 assesses the sediment texture. This is essential background information to check and make sense of contaminant concentrations, and assign the site to "tidal" or the "harbour" database. It is also used to check the final assessment (step 6).

Step 4 summarises all the contaminant information for the site.

Step 5 carries out the ranking process using landuse, Cu, Zn, Pb and PAH (as available). The ranking criteria are given in Table 2.2.

Step 6 checks and modifies final rank using the nature of the receiving environment, the sediment texture and historical information.

Table 2.1 The key steps to rank site pollution index (1=uncontaminated, 5=highly contaminated)

Step	Issue	Method
1	Landuse	Define catchment landuse – approximate proportion and age of urban area. Rural = 1, old urban = 5
2	Assess nature of the receiving environment.	Is it a PDA or SRA? If a PDA, does it meet Settling Zone criteria? This information is used to assign site to correct database, and is useful for step 4 and is also used in step 6.
3	Assess sediment texture	This information is useful for step 4 and is also used in step 6.
4	Assess contaminant concentrations	Summarise all relevant existing information (e.g., Appendix 1)
5	Rank pollution status	Rank using landuse, Cu, Zn, Pb and PAH (as available) – see Table 1.2
6	Modify rank using subjective assessment	Base on the nature of the receiving environment, the sediment texture and any historical information.

Table 2.2 Assignation of rank values.

Rank	Landuse	Zn	Pb	Cu	PAH
1	Rural	<125	<30	<19	<0.66
2	25% urban	125-150	30-50	19-34	0.66-1.7
3	50% urban	151-200	51-100	35-50	1.7-3
4	75% urban	201-250	100-150	50-75	3-5
5	Fully urbanized before 1950	>250	>150	>75	>5

3 Estuary (Tidal) Sites

3.1 Te Matuku, Waiheke Island

6 sites located longitudinally down the estuary were surveyed for chemistry and biology in 1995-6, and 2 sites were resurveyed in 1997.

Graded 2, 2, 1, 1, 1, 1 in 2001

1	Landuse	Rural landuse
2	Receiving environment	PDA, Settling Zone (so if the catchment was a source of contamination we should see it here)
3	Texture	Gloopy mud, but the outermost site sandy/shelly (near SZ boundary). Consistent with PDA.
4	Contaminant	See Te Matuku Spreadsheet (Appendix 1)
5	Ranking	See Table 3.1
6	Final Ranking	All information points to a rank of '1'.

Table 3.1 Ranking Te Matuku NIWA sites.

Site	1	2	3	4	5	6
Landuse	1	1	1	1	1	1
Zn	1	1	1	1	1	1
Cu	1	1	1	1	1	1
Pb	1	1	1	1	1	1
PAH	1	1	1	1	1	1
Rank	**1**	**1**	**1**	**1**	**1**	**1**

3.2 Paremoremo

6 sites located longitudinally down the estuary were surveyed for chemistry and biology in 1995-6, and 2 sites were resurveyed in 1997.

Graded 2, 2, 2, 1, 1, 1 in 2001.

1	Landuse	Mostly rural landuse. The middle estuarine sites may be impacted by stormwater from Paremoremo Prison and Village.
2	Receiving environment	PDA, meets SZ criteria for whole catchment if urbanized, but it does not meet SZ criteria for the side stream from Paremoremo Prison and Village. Expect concentration gradients (Williamson & Green 2002).
3	Texture	All gloopy mud
4	Contaminant	See Paremoremo Spreadsheet (Appendix 1)
5	Ranking	See Table 3.2
6	Final Ranking	Most information points to a rank of '1'. Modest contamination with Cu and Pb at middle site, which exceed amber guidelines sometimes, coupled with land use, results in a '2' at this site.

Table 3.2 Ranking Paremoremo NIWA sites.

Site	1	2	3	4	5	6
Landuse	1	1	2	1	1	1
Zn	1	1	1	1	1	1
Cu	1	1	2	1	1	1
Pb	1	1	2	1	1	1
PAH	1	1	1	1	1	1
Rank	**1**	**1**	**2**	**1**	**1**	**1**

3.3 Hellyers/Kaipatiki

6 sites located longitudinally down the estuary were surveyed for chemistry and biology in 1995-6, and 2 sites were resurveyed in 1997.

Graded 5, 5, 4, 3, 2, 2 in 2001.

1	Landuse	Mostly (70%) residential, balance bush
2	Receiving environment	Sites 1-3 are in a PDA, which meets Settling Zone criteria Sites 4-6 are in a PDA, but is an OZ
3	Texture	All gloopy mud
4	Contaminant	See Hellyers Spreadsheet (Appendix 1)
5	Ranking	See Table 3.3
6	Final Ranking	Upper sites were ranked '3' reflecting landuse, and Pb being 'red', Zn and Cu being 'amber'. Lower sites were ranked '2' because of the lower level of contamination (Pb and Cu were amber, while Zn was 'Green').

Table 3.3 Ranking Kaipatiki NIWA sites.

Site	1	2	3	4	5	6
Landuse	3	3	3	3	3	3
Zn	2	2	2	1	1	1
Cu	2	2	2	2	2	2
Pb	3	3	3	2	2	2
PAH	1	1	1	1	1	1
Rank	3	3	3	2	2	2

3.4 Pakuranga

6 sites located longitudinally down the estuary were surveyed for chemistry and biology in 1995-6, and 2 sites were resurveyed in 1997.

Graded 5, 5, 4, 3, 2, 2 in 2001.

1	Landuse	Mostly (80%) residential, balance pasture
2	Receiving environment	Sites 1-4 are in a PDA, Settling Zone Sites 5-6 are in a PDA, but in an OZ at time of sampling

3	Texture	All gloopy mud
4	Contaminant	See Pakuranga Spreadsheet (Appendix 1). Note that unusually low concentrations measured at the LTB sites in 1998 and 1999, which we attributed to subsoil deposition.
5	Ranking	See Table 3.4
6	Final Ranking	Upper sites were ranked '4' reflecting landuse, and Zn, Cu, Pb being 'red'. Lower sites were ranked '3' because of the lower level of contamination (Pb and Cu were 'amber', while Zn was still 'red').

Table 3.4 Ranking Pakuranga NIWA sites.

Site	1	2	3	4	5	6
Landuse	4	4	4	4	4	4
Zn	4	4	4	3	3	3
Cu	3	3	3	2	2	2
Pb	3	3	3	2	1	1
PAH	1	1	1	1	1	1
Rank	4	4	4	3	3	3

3.5 Metrowater Sites

3.5.1 Meola Creek

Metrowater surveyed 2 sites, metmc1 and metmc2 in 2001. The sites were ranked 4 and 5 in 2001.

1	Landuse	Fully urbanized, old urban area
2	Receiving environment	PDA and SZ
3	Texture	Soft gloopy mud, grading to sandy gloopy mud about the vicinity of the Metrowater sites
4	Contaminant	See Metrowater Spreadsheet (Appendix 1)
5	Ranking	See Table 3.5
6	Final Ranking	Although Metrowater data suggests a rank of '3' we have ranked the site as a '5' on the basis of high contamination found at other times in the 1990's, particularly for Zn and PAH, and because the catchment is fully urbanized and contains older urban landuse.

3.5.2 Newmarket

Metrowater collected samples from three sites from ankle deep mud near the stormwater drain low tide channel. These samples were found in both the "tidal" and "harbour" database. The sites were ranked 5 in 2001.

1	Landuse	Fully urbanized, old urban area
2	Receiving environment	SRA, with anecdotal evidence to suggest that the surface sediments change in texture regularly. In terms of the sampling protocols recommended in the RDP (ARC TP 169, 170), it is not a good site to monitor. Given the paucity of data to test the

		Healthy Benthic Community Model, we suggest it is included as a 'tidal' site.
3	Texture	Ankle-deep, soft gloopy mud on top of firm sand, located on the mud flats adjacent to the stream channel. Note that there is a discrepancy between site description and measured sediment texture.
4	Contaminant	See Metrowater Spreadsheet (Appendix 1)
5	Ranking	See Table 3.5
6	Final Ranking	We ranked it as a '5' because it is likely to be a highly disturbed site (see discussion in Section 3) with relatively high concentrations of contaminants. Given nature of these sites, near the SZ/OZ boundary and the possibility of major sediment textural shifts, the sites should be deleted from the database.

Table 3.5 Ranking of Metrowater sites

Site	MC1	MC2	NM1	NM2	NM3	OM1	OM2	OM3
Landuse	5	5	5	5	5	4	4	4
Zn	3	3	4	4	4	1	1	1
Cu	1	1	3	4	5	1	1	1
Pb	2	2	4	4	5	1	1	1
PAH*	4	4	4	4	4			
Rank	5	5	5@	5@	5@	N/A	N/A	N/A

* Based on ARC LTB results. @ these sites should be removed from the database

3.5.3 Omaru

Three sites (OM1-3) are located at increasing distance from where the Omaru Creek issues from a mangrove forest and discharges over the intertidal flats. These sites appear in the Harbour database (probably assigned thus because of the reported particle size data). With muddy, gloopy sediments, sites OM1 and OM2 may be better considered for the 'Tidal' database. The sites were ranked 4, 3, 2 in 2001 and included in the harbour database.

1	Landuse	Landuse is predominantly urban.
2	Receiving environment	SRA with a localized PDA around the low tide channel across the intertidal flats.
3	Texture	OM1 and 2 were ankle deep mud, OM3 was silty sand.
4	Contaminant	See Metrowater Spreadsheet (Appendix 1).
5	Ranking	See Table 3.5
6	Final Ranking	The site is relatively uncontaminated with Cu, Zn and Pb. This is surprising considering the large, urban Omaru catchment. One possible reason may be the fact that the receiving area is an SRA. The middle Tamaki is relatively large compared with the total contributing catchment. As it is an SRA, and as such a dynamic receiving environment, contamination maybe being 'spread out' and diluted. This needs to be checked. Consequently, we believe these sites are inappropriate for the development of the 'harbour' or 'estuary' Healthy Benthic Community model, and we have not assigned a rank to these sites.

3.6 Waitakere City Sites

3.6.1 Whau Lower

Waitakere CC surveyed one site in the estuary (wcc3) in 2000. This site was graded 3 in 2001.

1	Landuse	Fully urbanized, mixture of old and new urban areas.
2	Receiving environment	PDA, but OZ, so expect concentration gradients.
3	Texture	All gloopy mud
4	Contaminant	See Waitakere Speadsheet (Appendix 1)
5	Ranking	See Table 3.6
6	Final Ranking	Cu, Pb and Zn are "amber" and suggest ranking of '2', but higher concentrations are found at nearby sites in the lower Whau (Waitakere Spreadsheet), and the catchment is fully urbanized. Thus we ranked the site as a '3'.

Table 3.6 Ranking of Waitakere City sites

	LWhau	UWhau	UWhau	Henderson	Huruhuru	Hend.	Hend.
Site	wcc3	wcc 2	wcc 8	wcc 1	wcc 4	wcc 9	wcc 10
Landuse	5	5	5	3	3	5	5
Zn	2	4	5	3	3	4	4
Cu	2	3	4	2	2	2	2
Pb	2	3	4	2	2	2	2
PAH*	1	2	1	1	1	1	1
Rank	3	5	5	4	4	5	5

* Based on ARC LTB sites

3.6.2 Whau Upper

Waitakere CC surveyed two sites, one in the estuary (wcc2) and one near a major stormwater drain (wcc8). These sites were ranked '5' in 2001.

1	Landuse	Fully urbanized, older urban areas.
2	Receiving environment	PDA, SZ
3	Texture	All gloopy mud
4	Contaminant	See Waitakere Speadsheet (Appendix 1). The wcc2 site was quite sandy, so the concentrations reported are quite high. This is confirmed by concentrations measured in the upper Whau at other times, which definitely suggest the site is highly contaminated.
5	Ranking	See Table 3.6
6	Final Ranking	Because the wcc2 site is in a SZ, we suggest that the historical data showing high contamination (Waitakere Spreadsheet) is given some weight, and the site ranked accordingly as a '5'. The outfall site, wcc8, is highly contaminated and we would expect it to be highly impacted, and is accordingly ranked as '5'.

3.6.3 Henderson/Hurururu

Two estuary sites, wcc1 (Henderson branch) and 4 (Huruhuru branch) and two outfall sites, wcc 9 and wcc 10, were surveyed. The estuary sites were ranked '3' and the outfall sites ranked '5' in 2001.

1	Landuse	Partially urbansied with headwaters in bush and pasture.
2	Receiving environment	PDA, SZ
3	Texture	All gloopy mud
4	Contaminant	See Waitakere Speadsheet (Appendix 1)
5	Ranking	See Table 3.6
6	Final Ranking	The estuary sites have been ranked as '4', because Zn is consistently high historically, and Zn is the contaminant most likely to be toxic. The outfall sites, are similarly contaminated but we would expect them to be highly impacted, so accordingly we ranked them as '5'.

3.6.4 Waituna, Brighams, Waiarohia

One sample was collected from each of these three predominantly rural catchments. Waituna has residential land use, but it is mainly bush with poor connectivity between impervious areas and the estuary. Brighams is ranked '2' on the basis of amber Cu and landuse, the others are ranked as '1' (Table 3.6). (In 2001, Brighams was ranked '3', while the other 2 sites (Waituna and Waiarohia) were ranked '2').

Estuary	Catchment	Sediment texture
Waituna	Low density residential	Sandy
Brighams	Mainly rural, lifestyle, small urban-fringe industries, horticulture	Gloopy mud
Waiaraohia	Mainly rural, airfields, some residential at Hobson and Whenuapai, horticulture	Gloopy mud

Table 3.6 (continued) Ranking of Waitakere City sites

	Waituna	Brighams	Waiarohia
Site	wcc5	wcc7	wcc6
Landuse	2	2	2
Zn	1	1	1
Cu	1	2	1
Pb	1	1	1
PAH			
Rank	1	2	1

3.7 Summary

The new ranks are plotted in Figure 1 against Zn concentrations and compared with the same plot for the original ranks. The goodness of fit is not a validation of the ranking exercise, but there should be a reasonable relationship as shown.

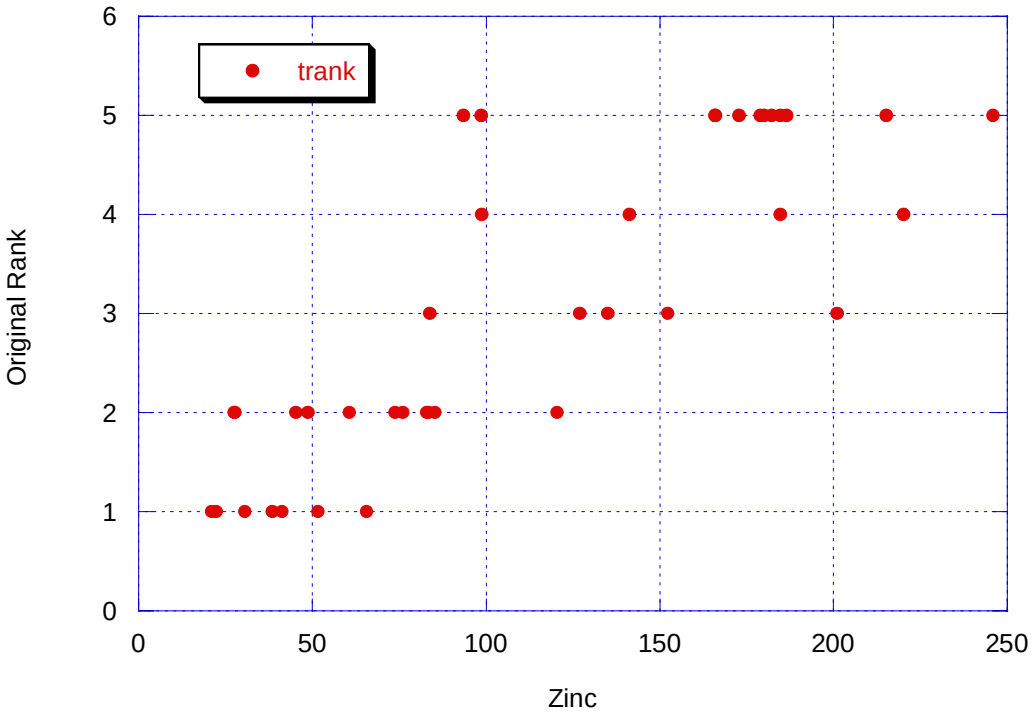
3.8 Recommended further work

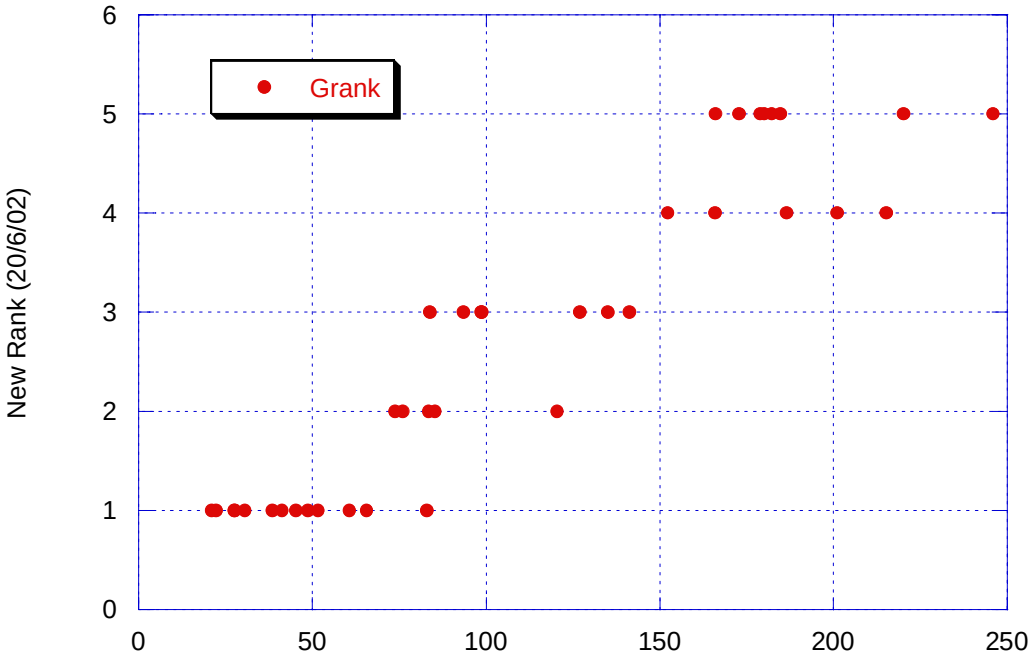
Further sampling is recommended at some of the most contaminated older urban sites (Table 3.7). This would obtain better data for the most highly contaminated sites in Auckland and put less weight on the 3 Waitakere outfall sites.

Table 3.7 Recommended location and number of additional harbour sites.

Site	Benthic ecology	Chemistry
Upper Whau (new site)	1	
Motions	1	
Meola	1	
Upper Shoal Bay (Hillcrest Stm)	1	1
Total	**4**	**1**
Cost per site	3000	2700
Total cost	12000	2700

Figure 1 Ranks versus Zn concentrations for Tidal database.





4 Harbour Sites

There is relatively little contaminant data, so we could not use the same procedure as used with Estuary sites. While some sites have data, it is for the total sediment only, and only two sites have data for the mud fraction. It is impossible to rank the sites on the basis of reported total concentrations because these depend on the texture as well as the magnitude of contaminant inputs. We have therefore carried out a more subjective classification based on the following:

1	Assign to 'harbour', 'tidal' database or remove from the database on the basis of: • Sediment texture • Estuary morphology • Non-urban effects
2	Assign rank based on: • Proximity to SZ or catchment inputs • Age and proportion of urban landuse

The importance of having good chemical data to rank sites can be illustrated for the two sites (Meola Reef and Hobson Bay @ Newmarket drain outlet) that have total and mud fraction concentrations. The concentrations in the mud fraction allow us to compare the relative degree of contamination and rank the sites according to the RDP SQG for OZ sites. This is illustrated in Table 4.1, where the concentrations in the mud fraction (after 2M HCl extraction) are compared with the strong acid digestion of the total sediment from the two sites. The total concentrations are below SQG, except for PAH at Hobson Bay. The concentrations in the mud fraction show Pb exceed the proposed SQG for OZ, while Cu, Zn and PAH are of cause for future concern. However, the total metals The Meola Reef (referred to as 'WAITreef' in spreadsheet) situation is summed up more fully in Case Study 5 in the last pages of the Blueprint report (ARC TP168).

Table 4.1

Site	Mud fraction (2M HCl)			Total (digested)			Total
	Zn	Cu	Pb	Zn	Cu	Pb	PAH
Te Tokorau, Meola Reef	146.0	25.8	63.5	100	7.3	24.9	931
Hobson Bay, Upper	118.0	22.6	69.2	46	5.6	17.8	2900

The following Table 4.2 conducts a rapid and somewhat subjective appraisal of the pollution ranking in the harbour database. We have assigned muddy sheltered sites to the 'tidal 'database. The Metrowater data has suspect particle size data that have made assignation difficult. Particle size was determined from dried samples after gentle grinding, and is highly unlikely to reflect the true particle size (which must be done on wet samples; drying 'cakes' fine sediments, and grinding produces a particle size spectrum reflecting the grinding process).

We are not sure which database should contain Newmarket or the Tohunga inner sites, or if they should be used at all. Newmarket appears in both databases, while Tohunga appears in the harbour database. Newmarket, and Tohunga sites (both in Hobson Bay) are located near the SZ/OZ boundary. The sites have ~ ankle deep mud on sand. We suspect this mud layer is ephemeral, and moves around Hobson Bay depending on wind direction, strength and perseverance. These sites are probably very dynamic, in that they undergo frequent changes

in sediment texture with wind direction. Williamson has observed these large changes from mud-on-sand (sometimes ankle deep) to firm sand after repeated visits to:

- Hobson (including near the Newmarket site),
- Coxes Bay,
- Meola Creek (at the end of the landfill where it opens to an embayment), and
- St Mary's Bay.

The blanket of mud presumably would have a major effect on in sand fauna – depending on the length of time the blanket was there. Thus the type of benthic animals that live in these sites probably reflect these dynamic sediment shifts, and the differences from other sites may be a result of this process, rather than being caused by contamination – although that still may be a factor. In the wider harbour, this effect would not occur to nearly the same extent. (However, would this effect be also found in the uncontaminated Whitford data where ephemeral mud lenses have been reported? Also, at other more remote sand flat sites in the Manukau, fine sediment can build up under boccardia mats, although this is probably a seasonal rather than wind-related ephemeral effect.)

Such a situation seems to be inherently different from either stable muddy sites or stable sandy sites. It is arguable that we will be unable to maintain a healthy benthic community typical of the OZ near the OZ/SZ boundary because of this effect.

The textural shifts will not be evident from analyzing the existing database, because the data is only one instant in time. While there is a lack of relationship between pollution rank and particle size (J. Hewitt, pers. comm.) it is not valid to apply this relationship to the Hobson Bay sites given:

- The likelihood of incorrect particle size data.
- It does not address dynamic shifts in sediment texture.

These Hobson Bay sites are all pollution ranked as 4's and 5's, so are the main 'drivers' of the Community Health relationship for the Harbour. It is questionable whether this data should be used in the development of the Healthy Community model, and we recommend their deletion. Their removal will substantially change the model. While these sites are probably highly impacted – and thus deserve a high pollution rank, their inclusion in the model may lead to an overestimate of contaminant effects when considering the wider harbour. This is consistent with our recommendations for the Regional Discharges Project: that samples are not collected near the SZ/OZ boundary; so their inclusion will bias the analysis. Whatever is the correct assignation (to the Tidal, Harbour or to neither database), there is clearly a need for more information on contaminated Harbour sites. We recommend that data the Newmarket and Tohunga data is omitted from the database, and further data are collected at the following sites (Table 4.3) (see Regional Maps for Settling and Outer Zones, ARC TP170):

Table 4.2. Assignation and ranking of Harbour sites.

Data Group	No.		Comments	New Rank	Old rank
Mahurangi	5	Jamiesons Bay	Sandy, rural, near shore	1	1
			Sand changing to mud	Unsuitable site	1
		Te Kapa	Gloopy mud, rural, near shore	Tidal database	2
		Cowans Bay	Muddy sand, rural, remote	1	2
		Mid Harbour	Gloopy mud, rural, near shore	Tidal database	3
		Hamiltons			
Manukau	6	Clarks Beach	Sandy rural remote	1	1
		Ellets Beach	Sandy rural remote	1	1
		Airport	Sandy rural remote	1	2
		Karaka Point	Sandy rural remote	1	2
		Puhinui	Sandy, outflow from Puhinui but not	2	2
		Cape Horn	direct	3	3
			Sandy, remote, but impacts from sewage plant		
Walkers Reserve, Waterview	6	WR1	Sandy	To be checked	1
		WR2	Sandy	c.f Waterview	1
		WR3	Sandy	estuary outflow	1
		WR4	Sandy		2
		WR5	Sandy		2
		WR6	Sandy		2
Okura	2	OK1	Rural, sand	1	1
		OK2		1	1
Whitford	34	34 sites	NIWA assigned ranks of '1' to '2'. The slightly contaminated sites were those close to the marina or Cockle Bay	1-2	1-2
Omaru	3	OM1	Mud, near shore, fully urban,	Unsuitable site	4
		OM2	Mud, near shore, fully urban	Unsuitable site	3
		OM3	Sand, near shore, fully urban	2	2
Waitemata	5	WAIThbv	Hobsonville, mixed rural/urban, remote	1	2
		WAThc	Henderson Ck, overflow from moderately contaminated SZ	3	3
		WAITshb	Shoal Bay (Sulphur Bay),remote, minor inputs from general harbour and	2	3
		WAITwhau	Northcote	3	4
			Overflow from moderately contaminated		
		WAITreef	Whau OZ	4	5
			Meola Reef, overflows from highly contaminated Motions SZ		
Newmarket	3		See Metrowater Spreadsheet and Table 5		5
Tohunga, Hobson Bay	6	T1	Silt on sand	Not suitable	4
		T2		Not suitable	4
		T3		Not suitable	4
		T4	Sand, near shore, direct discharge from	4	3
		T5	SW draining an older urban area	4	3
		T6		4	3

5 References

Auckland Regional Council 2002a. Blueprint for monitoring the Urban Receiving Environment. TP169.

Auckland Regional Council 2002b. Environmental Targets for Urban Coastal Marine Area. TP169.

Auckland Regional Council 2002c. Regional Maps of Settling Zones and Outer Zones. TP170.

Appendix 1

NIWA Benthic Studies

Date	Estuary	Site	Mud	Sand	Gravel	VOM	Cu	Zn	Pb	Fe	PAH	Diedrin	Chlordane	DDT	PCB
1995/6	Waiheke	1	58.4	41.6	0.0	5.3	6.0	27.5	7.3	9239	121	0.00	0.05	0.50	0.06
1995/6	Waiheke	2	46.8	44.2	7.8	3.8	5.2	27.6	2.6	8434	70	0.00	0.01	0.15	0.04
1995/6	Waiheke	3	33.5	49.2	17.3	2.9	4.4	22.2	0.0	6644	83	0.00	0.01	0.08	0.03
1995/6	Waiheke	4	45.6	52.8	1.7	3.1	5.7	30.7	0.0	9445	95	0.00	0.00	0.12	0.06
1995/6	Waiheke	5	78.3	18.2	3.5	5.7	7.8	41.4	1.5	14494	126	0.00	0.18	0.40	0.06
1995/6	Waiheke	6	26.6	51.5	21.9	2.5	5.8	21.0	0.0	6361	58	0.00	0.02	0.13	0.00
1997	Waiheke	4	39.7	58.6	1.7	3.2	1.0	26.9	25.8	7088.8					
1997	Waiheke	6	47.3	27.5	25.2	3.4	0.4	30.3	31.1	9037.9					
Corrected Data															
1995/6	Waiheke	1					16.0	62.5	17.3		54.6	0	0.02	0.22	0.0247
1995/6	Waiheke	2					15.2	62.6	12.6		43.7	0	0.01	0.1	0.0218
1995/6	Waiheke	3					14.4	57.2	10.0		68.4	0	0.01	0.06	0.0226
1995/6	Waiheke	4					15.7	65.7	10.0		72.6	0	0	0.09	0.0483
1995/6	Waiheke	5					17.8	76.4	11.5		52.3	0	0.07	0.16	0.0229
1995/6	Waiheke	6					15.8	56.0	10.0		55.3	0	0.02	0.12	0
1997	Waiheke	4					11.0	61.9							
1997	Waiheke	6					10.4	65.3							

	suspect data
	green
	amber
	red

NIWA Benthic Studies

Date	Estuary	Site	Mud	Sand	Gravel	VOM	Cu	Zn	Pb	Fe	PAH	Diedrin	Chlordane	DDT	PCB
1995/6	Paremoremo	1	83.9	16.1	0.0	5.5	13.3	60.7	11.0	12548	509	0.13	0.25	2.84	1.47
1995/6	Paremoremo	2	73.5	25.4	1.0	4.8	11.9	48.7	7.9	10428	438	0.17	0.24	2.27	1.48
1995/6	Paremoremo	3	95.6	4.4	0.0	5.5	20.0	73.7	18.2	13961	618	0.23	0.39	3.32	2.44
1995/6	Paremoremo	4	36.8	63.0	0.2	2.3	9.0	38.4	9.1	8068	192	0.09	0.10	1.39	0.76
1995/6	Paremoremo	5	38.1	61.9	0.1	2.7	10.1	65.7	14.8	13972	222	0.09	0.09	1.59	0.89
1995/6	Paremoremo	6	52.2	46.5	1.2	4.1	10.9	51.6	8.1	12424	470	0.22	0.28	2.57	1.53
1997	Paremoremo	3	97.9	2.1	0.0	9.7	14.1	71.8	58.9	11895.4					
1997	Paremoremo	6	38.7	58.8	2.5	5.1	5.9	49.3	40.8	10962.3					
Corrected Data							10	35	10						
1995/6	Paremoremo	1					23.3	95.7	21.0		220	0.06	0.11	1.2294	0.6358
1995/6	Paremoremo	2					21.9	83.7	17.9		215	0.08	0.12	1.1143	0.7249
1995/6	Paremoremo	3					30.0	108.7	28.2		267	0.1	0.17	1.434	1.0539
1995/6	Paremoremo	4					19.0	73.4	19.1		198	0.09	0.1	1.4384	0.7825
1995/6	Paremoremo	5					20.1	100.7	24.8		199	0.08	0.08	1.421	0.7922
1995/6	Paremoremo	6					20.9	86.6	18.1		274	0.13	0.16	1.4965	0.8918
1997	Paremoremo	3					24.1	106.8							
1997	Paremoremo	6					15.9	84.3							

NIWA Benthic Studies

Date	Estuary	Site	Mud	Sand	Gravel	VOM	Cu	Zn	Pb	Fe	PAH	Diedrin	Chlordane	DDT	PCB
1995/6	Kaipatiki	1	82.2	17.8	0.0	4.8	25.6	98.6	76.3	12586	788	0.33	0.67	2.84	4.68
1995/6	Kaipatiki	2	81.9	18.1	0.0	4.7	23.2	93.4	57.4	12184	850	0.30	0.71	3.43	4.54
1995/6	Kaipatiki	3	80.8	19.2	0.0	4.8	23.6	98.7	54.8	10514	893	0.23	0.66	3.12	5.59
1995/6	Hellyers	4	60.7	39.1	0.2	3.9	17.9	83.8	31.3	11013	701	0.21	0.47	2.40	3.77
1995/6	Hellyers	5	70.3	29.7	0.0	4.1	16.7	83.5	32.0	10770	704	0.23	0.57	3.68	4.17
1995/6	Hellyers	6	65.7	34.3	0.0	4.5	17.1	85.4	31.1	10745	742	0.30	0.56	2.96	4.80
1997	Kaipatiki	3	79.8	20.2	0.0	8.0	14.3	111.0	72.9	11095.8					
1997	Hellyers	5	47.8	52.2	0.1	4.5	8.4	78.5	51.1	9444.0					
Corrected Data															
1995/6	Kaipatiki	1					35.6	133.6	86.3		393	0.17	0.34	1.42	2.34
1995/6	Kaipatiki	2					33.2	128.4	67.4		428	0.15	0.36	1.73	2.29
1995/6	Kaipatiki	3					33.6	133.7	64.8		442	0.12	0.33	1.55	2.77
1995/6	Hellyers	4					27.9	118.8	41.3		424	0.13	0.28	1.45	2.28
1995/6	Hellyers	5					26.7	118.5	42.0		413	0.13	0.33	2.16	2.45
1995/6	Hellyers	6					27.1	120.4	41.1		394	0.16	0.30	1.58	2.55
1997	Kaipatiki	3					24.3	146.0							
1997	Hellyers	6					18.4	113.5							

1998	Hellyers	ARC LTB					16	97	29		580
1999	Hellyers	ARC LTB					14	83	26		630

NIWA Benthic Studies

Date	Estuary	Site	Mud	Sand	Gravel	VOM	Cu	Zn	Pb	Fe	PAH	Diedrin	Chlordane	DDT	PCB
1995/6	Pakuranga	1	78.6	21.3	0.1	4.9	32.4	215.2	63.0	14732	892	0.71	1.49	2.36	6.69
1995/6	Pakuranga	2	69.0	28.9	2.2	4.7	25.0	165.8	43.4	11715	654	0.42	0.95	1.83	5.55
1995/6	Pakuranga	3	88.7	11.3	0.0	5.4	32.7	220.1	56.3	14675	861	0.91	1.40	3.34	7.70
1995/6	Pakuranga	4	64.2	35.7	0.1	4.0	19.2	141.2	27.9	9900	581	0.31	0.71	1.88	4.17
1995/6	Pakuranga	5	32.5	62.5	5.0	2.8	14.9	127.0	21.7	13911	406	0.34	0.63	1.27	2.86
1995/6	Pakuranga	6	25.2	72.8	2.0	2.3	12.4	120.5	19.9	11978	351	0.18	0.33	1.02	1.94
1997	Pakuraga	2	51.3	43.1	5.5	4.6	10.8	134.9		7827.2					
1997	Pakuraga	5	29.7	69.0	1.2	3.6	9.8	138.0		9783.7					
Corrected Data															
1995/6	Pakuranga	1					42.4	250.2	73.0		435	0.35	0.73	1.15	3.26
1995/6	Pakuranga	2					35.0	200.8	53.4		329	0.21	0.48	0.92	2.79
1995/6	Pakuranga	3					42.7	255.1	66.3		376	0.40	0.61	1.46	3.36
1995/6	Pakuranga	4					29.2	176.2	37.9		345	0.18	0.42	1.12	2.48
1995/6	Pakuranga	5					24.9	162.0	31.7		350	0.29	0.54	1.09	2.46
1995/6	Pakuranga	6					22.4	155.5	29.9		364	0.18	0.34	1.05	2.01
1997	Pakuraga	3					20.8	169.9							
1997	Pakuraga	6					19.8	173.0							

1998	Pakuranga Creek, Lower	ARC LTB					21	145	31
1999	Pakuranga Creek, Lower	ARC LTB					27	134	20

1991	Pakuranga	ARC Tamaki					42.0	239.0	80.0
1993	Pakuranga	Roper & De Wit					34.0	209.0	55.0
1995	Pakuranga	ARC ASP Survey					37	230	119
1998	Pakuranga Creek, Upper	ARC LTB					29	183	41
1999	Pakuranga Creek, Upper	ARC LTB					28	138	30

				Note	Cu	Zn	Pb	PAH	Mud%	TOC	PAH1	PAH2	PAH3	1% PAH
Whau Middle Hepburn Park	1995		ARC ASP Survey		31	165	62							
Whau Creek Lower	1998		ARC LTB		28.8	163	62							
Whau Creek Lower	1999		ARC LTB		35	170	58	386		7	1124	1189	1093	386.1678
Lower Whau Te Atatu	2000	TAS	wcc3		26.0	135.0	39.0	582	93.10	5.1	1266	1247	1227	582.0106
Whau Upper	1995		ARC ASP Survey		50	273	130							
Whau Creek Upper	1998		ARC LTB		37.8	252	99	915		4.8	2005	1852	1677	915.0132
Whau Creek Upper	1999		ARC LTB		37.8	252	99	758		6	1795	1875	2063	758.3333
Whau New Lynn	2000	NLE	wcc2		23.0	180.0	48.0		22.43					
Whau New Lynn	2000	SNUC	wcc8	OUTFALL	49.0	246.0	88.0		78.27					
Huruhuru Creek Selwood Rd	1995		ARC ASP Survey		32	161	42							
Henderson Rutledge Rd,	1995		ARC ASP Survey		41	199	59							
Henderson Creek	1998		ARC LTB		44.3	178	33	404		4.8	737	850	857	404.1005
Henderson Creek	1999		ARC LTB		39	194	49	227		8.5	771	839	826	227.451
Henderson Creek	2000	HCC	wcc1		32.0	152.3	36.3		92.22					
Henderson Creek	2000	SCPD	wcc9	OUTFALL	26.0	166.0	40.0		57.23					
Henderson Creek	2000	SEPP	wcc10	OUTFALL	35.0	179.0	33.0		61.90					
Huruhuru	2000	HHL	wcc4		42.0	201.0	38.0		93.56					
Waituna	2000	WA1	wcc5		5.2	45.3	4.5		10.00					
Waiarohia	2000	DAL	wcc6		17.0	76.0	16.0		72.05					
Brighams	2000	WHE	wcc7		20.0	83.0	23.0		85.67					

			Cu	Zn	Pb	PAH
Hobson Lower	1995	ARC ASP Survey	15	131	45	
Hobson Lower	1996	ARC Sandy Sediments	15.0	131.0	45.0	
Hobson Bay, Upper	1998	ARC LTB	5.6	46	17.8	2900
Hobson Bay, Upper	1999	ARC LTB	8.4	52.4	22.1	1000
Newmarket	2001	metnm1	39.7	182.2	81.6	
Newmarket	2001	metnm2	53.7	186.4	94.3	
Newmarket	2001	metnm3	91.0	172.8	147.9	
Omaru	2001	metom1	9.5	89.7	18.8	
Omaru	2001	metom2	6.7	75.8	15.1	
Omaru	2001	metom3	4.8	58.1	12.3	
Meola	1995	ARC ASP Survey	14	222	31	
Meola	1997	Particle size study	24	275	74	5700
Meola Creek	1998	ARC LTB	38.9	280	94	5000
Meola Creek	1999	ARC LTB	38.3	261	74.4	
Meola	2001	metmc2	17.1	184.6	42.7	
Meola	2001	metmc1	17.1	184.6	42.7	
Motions	1995	ARC ASP Survey	14	208	45	
Motions Creek	1997	Particle size study	26	209	89	10800
Motions Creek	1998	ARC LTB	24.4	294	65.5	8500
Motions Creek	1999	ARC LTB	44.5	197	22	

Mud Fraction (2M HCl)

Cu	Zn	Pb
14	118	65
22.6	118.0	69.2
28.5	160	76

The following is the re-vamped tidal database

Sample			Copper	Zinc	Lead	Iron	PAH	dieldrin	chlordane	DDT	PCB	%mud	old rank	Grank
wai6			5.8	21.0	0.00	6360.87	57.9	0	0.016667	0.13	0	26.60	1	**1**
wai3			4.4	22.2	0.00	6644.30	83.3	0	0.0125	0.08	0.03	33.50	1	1
Wai1			6.0	27.5	7.35	9238.76	121.4	0	0.05	0.5	0.06	58.40	2	1
Wai2			5.2	27.6	2.64	8434.01	70.2	0	0.0125	0.15	0.04	46.80	2	1
wai4			5.7	30.7	0.00	9445.18	95.2	0	0	0.12	0.06	45.60	1	1
par4			9.0	38.4	9.08	9900	581	0.31	0.71	1.88	4.17	36.80	1	1
wai5			7.8	41.4	1.51	14493.72	125.7	0	0.175	0.4	0.06	78.30	1	1
wcc5	WA1	Waituna	5.2	45.3	4.5							9.93	2	1
par2			11.9	48.7	7.91	10428.16	438.2	0.165	0.2425	2.27	1.48	73.50	2	1
par6			10.9	51.6	8.11	11978	351	0.18	0.33	1.02	1.94	52.20	1	1
par1			13.3	60.7	10.98	12548.30	509.0	0.1275	0.25	2.84	1.47	83.90	2	1
par5			10.1	65.7	14.84	13911	406	0.34	0.63	1.27	2.86	38.10	1	1
wcc6	DAL	Waiarohia	17.0	76.0	16.0							72.05	2	1
par3			20.0	73.7	18.23	13960.67	617.5	0.2325	0.385	3.32	2.44	95.60	2	2
wcc7	WHE	Brighams	20.0	83.0	23.0							85.67	2	2
hel5			16.7	83.5	31.95	10770	704	0.23	0.57	3.68	4.17	70.30	2	2
hel4			17.9	83.8	31.33	11013	701	0.21	0.47	2.40	3.77	60.70	3	2
hel6			17.1	85.4	31.13	10745	742	0.30	0.56	2.96	4.80	65.70	2	2
hel2			23.2	93.4	57.4	12184	850	0.30	0.71	3.43	4.54	81.90	5	3
hel1			25.6	98.6	76.3	12586	788	0.33	0.67	2.84	4.68	82.20	5	3
hel3			23.6	98.7	54.8	10514	893	0.23	0.66	3.12	5.59	80.80	4	3
pak6			12.4	120.5	19.93	11978.25	351.3	0.175	0.3325	1.02	1.94	25.20	2	3
pak5			14.9	127.0	21.73	13910.50	406.4	0.3425	0.625	1.27	2.86	32.50	3	3
wcc3	TAS	Whau	26.0	135.0	39.0							93.10	3	3
pak4			19.2	141.2	27.9	9900.25	581.3	0.3075	0.705	1.88	4.17	64.20	4	3
wcc1	HCC	Henderson	32.0	152.3	36.3							92.22	3	4
pak2			25.0	165.8	43.4	11715	654	0.42	0.95	1.83	5.55	69.00	5	4
wcc4	HHL	Huruhuru	42.0	201.0	38.0							93.56	3	4

pak1			32.4	215.2	63.0	14732	892	0.71	1.49	2.36	6.69	78.60	5	4
pak3			32.7	220.1	56.3	14675	861	0.91	1.40	3.34	7.70	88.70	4	4
wcc9	SCPD	Henderson	26.0	166.0	40.0							57.23	5	5
metnm3		Newmarket	91.0	172.8	147.9							3.00	5?	5
wcc10	SEPP	Henderson	35.0	179.0	33.0							61.90	5	5
wcc2	NLE	Whau NL	23.0	180.0	48.0							22.43	5	5
metnm1		Newmarket	39.7	182.2	81.6							7.00	5?	5
metmc2		Meola	17.1	184.6	42.7							14.00	4	5
metmc1		Meola	17.1	184.6	42.7							14.00	5	5
metnm2		Newmarket	53.7	186.4	94.3							3.00	5?	5
wcc8	SNUC	Whau NL	49.0	246.0	88.0							78.27	5	5