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Porirua Harbour

Intertidal Sediment Monitoring 2010/11

Prepared
for
Greater Wellington Regional Council
June 2011

Porirua Harbour Onepoto Arm - lower estuary.

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By

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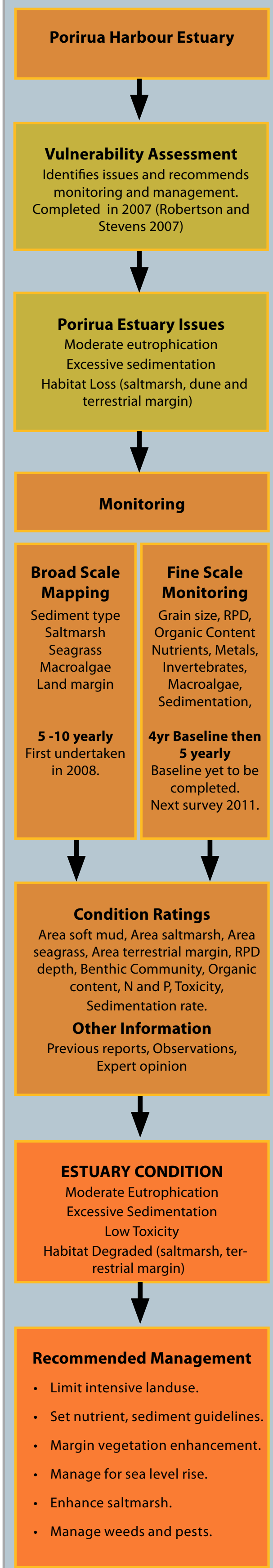
1. INTRODUCTION AND METHODS



Soil erosion is a major issue in New Zealand and the resulting suspended sediment impacts are of particular concern in estuaries because they act as a sink for fine sediments or muds. The main intertidal flats of developed estuaries (e.g. Porirua Harbour) are usually characterised by sandy sediments reflecting their exposure to wind-wave disturbance and are hence relatively low in mud content (2-10% mud).

Recent monitoring (Robertson and Stevens 2008, 2009, 2010) showed Porirua Harbour had low-moderate intertidal sedimentation rates and a benthic invertebrate community dominated by species that prefer sand or a little mud. However, the sand dominated sediments had an elevated mud content, showed a general trend of increasing muddiness, and sediments were not very well oxygenated. Based on these findings, in 2011 Greater Wellington Regional Council (GWRC) continued the existing programme monitoring intertidal sedimentation rates, grain size, and RPD depth in the estuary.

In addition to intertidal areas, Porirua Harbour has also been identified as being particularly at risk from sedimentation because the main subtidal basins are rapidly infilling (Gibb and Cox 2009). Gibb and Cox predict that both estuary arms are highly likely to rapidly infill and change from tidal estuaries to brackish swamps within 145-195 years. The dominant sources contributing to increasing sedimentation rates in the estuary were identified as discharges of both bedload and suspended load from the various input streams (most notably Pauatahanui, Horokiri and Porirua Streams). Elevated inputs of nutrients from the same streams are also causing symptoms of moderate eutrophication (i.e. poor sediment oxygenation and moderate nuisance macroalgal cover) in the estuary (Stevens and Robertson 2009, 2010 2011, Robertson and Stevens 2009, 2010).

To address these issues, GWRC held a technical workshop in April 2011 to initiate work to better quantify predicted sediment and nutrient inputs to the estuary and develop appropriate catchment load guidelines. Expert scientific advice and existing catchment models were used to predict terrestrial inputs, combined with estuary models to highlight the areas of greatest predicted deposition. The initial findings of this work highlight that certain areas in the estuary are subjected to the greatest rates of sediment deposition, many of which are subtidal. Given that the present programme favours intertidal areas for sedimentation rate assessments, there is a key need to establish additional sediment plates in representative subtidal areas.

The current report summarises the monitoring results for intertidal sedimentation rates, grain size, and RPD indicators in Porirua Harbour Estuary. The report presents the results from sampling on 17-18 January 2011, and uses condition ratings developed for Wellington's estuaries to rate the condition of the estuary, and recommend monitoring and management actions.

Pauatahanui Arm - confirming the presence of deep soft muds in the shallow subtidal basin.

1. Introduction and Methods (Continued)

Detailed descriptions of sampling sites and methods are provided in (Robertson and Stevens 2008, 2009, 2010), and are briefly summarised below.

Sedimentation Rate

To measure the sedimentation rate from now and into the future, concrete plates were buried at 4 intertidal sites and 1 subtidal site in the estuary in 2007. Each plate, marked by wooden pegs and GPS referenced, was located and the depth of sediment over the plate measured by pushing a probe into the sediment until it hit the plate. A number of measurements on each plate were averaged to account for irregular sediment surfaces.

Grain Size

To monitor changes in the mud content of sediments, three samples (two a composite from four plots, one a composite from two plots) of the top 20mm of sediment were collected from each fine scale site (sites A and B below). A single composite sample was also collected from the subtidal site (site C) and the sediment plate site at Pauatahanui A. All samples were analysed by Hill Laboratories for grain size (% mud, sand, gravel).

Redox Potential Discontinuity (RPD) depth

To assess sediment oxygenation, the depth to the RPD was measured in 10 plots at each fine scale site by digging down from the surface with a hand trowel until the RPD transition level was located (sites A and B below).

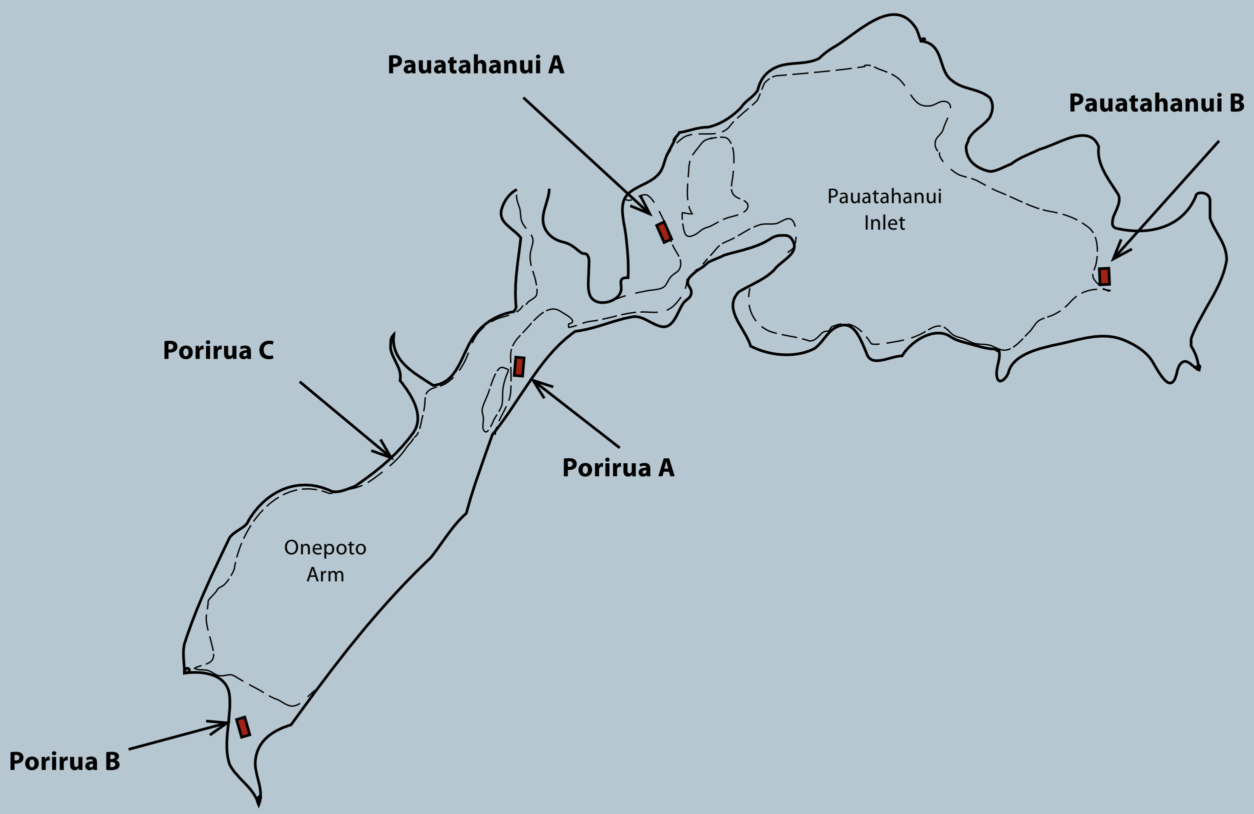


Figure 1. Location of fine scale sites and buried sediment plates in Porirua Harbour Estuary.

WELLINGTON ESTUARIES: CONDITION RATINGS

A series of interim fine scale estuary "condition ratings" (presented below) have been proposed for Porirua Harbour (based on the ratings developed for Southland's estuaries - e.g. Robertson & Stevens 2006). The ratings are based on a review of estuary monitoring data, guideline criteria, and expert opinion. They are designed to be used in combination with each other, and with other fine and broad scale indicators (usually involving expert input) when evaluating overall estuary condition and deciding on appropriate management. The condition ratings include an "early warning trigger" to highlight rapid or unexpected change, and each rating has a recommended monitoring and management response. In most cases initial management is to further assess an issue and consider what response actions may be appropriate (e.g. develop an Evaluation and Response Plan - ERP).

Sedimentation Rate

Elevated sedimentation rates are likely to lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse, and indicate where changes in land use management may be needed.

SEDIMENTATION RATE CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Low	0-1mm/yr (typical pre-European rate)	Monitor at 5 year intervals after baseline established
Low	1-2mm/yr	Monitor at 5 year intervals after baseline established
Moderate	2-5mm/yr	Monitor at 5 year intervals after baseline established
High	5-10mm/yr	Monitor yearly. Initiate ERP
Very High	>10mm/yr	Monitor yearly. Manage source
Early Warning Trigger	Rate increasing	Initiate Evaluation and Response Plan

Redox Potential Discontinuity

The RPD is the grey layer between the oxygenated yellow-brown sediments near the surface and the deeper anoxic black sediments. It is an effective ecological barrier for most but not all sediment-dwelling species. A rising RPD will force most macrofauna towards the sediment surface to where oxygen is available. The depth of the RPD layer is a critical estuary condition indicator in that it provides a measure of whether nutrient enrichment in the estuary exceeds levels causing nuisance anoxic conditions in the surface sediments. The majority of the other indicators (e.g. macroalgal blooms, soft muds, sediment organic carbon, TP, and TN) are less critical, in that they can be elevated, but not necessarily causing sediment anoxia and adverse impacts on aquatic life. Knowing if the surface sediments are moving towards anoxia (i.e. RPD close to the surface) is important for two main reasons:

1. As the RPD layer gets close to the surface, a "tipping point" is reached where the pool of sediment nutrients (which can be large), suddenly becomes available to fuel algal blooms and to worsen sediment conditions.
2. Anoxic sediments contain toxic sulphides and very little aquatic life.

The tendency for sediments to become anoxic is much greater if the sediments are muddy. In sandy porous sediments, the RPD layer is usually relatively deep (>3cm) and is maintained primarily by current or wave action that pumps oxygenated water into the sediments. In finer silt/clay sediments, physical diffusion limits oxygen penetration to <1cm (Jørgensen and Revsbech 1985) unless bioturbation by infauna oxygenates the sediments.

RPD CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	>10cm depth below surface	Monitor at 5 year intervals after baseline established
Good	3-10cm depth below sediment surface	Monitor at 5 year intervals after baseline established
Fair	1-3cm depth below sediment surface	Monitor at 5 year intervals. Initiate ERP
Poor	<1cm depth below sediment surface	Monitor at 2 year intervals. Initiate ERP
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate Evaluation and Response Plan

2. RESULTS, RATING AND MANAGEMENT

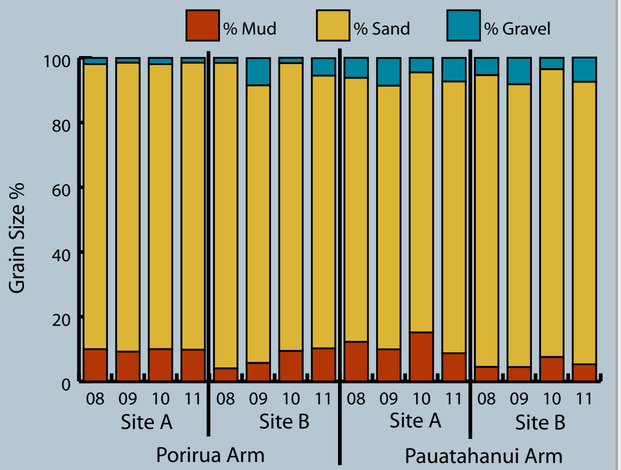


Figure 2. Grain size, Porirua Harbour Estuary (2008-2011).

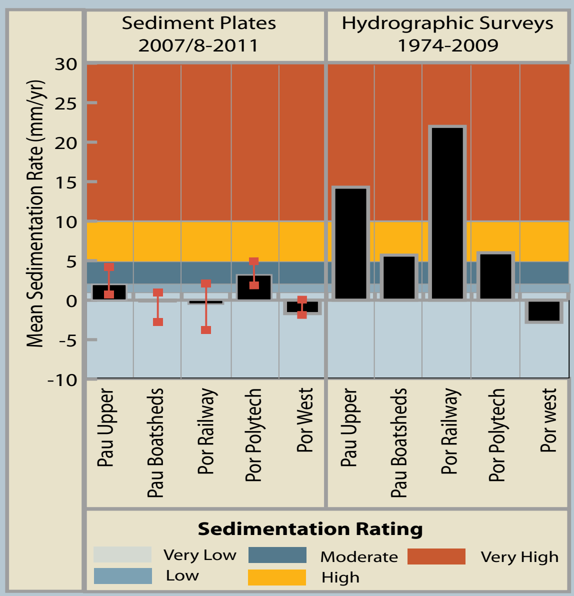


Figure 3. Sedimentation rate (mean and range) from plate data, Porirua Harbour Estuary (2008-2011).

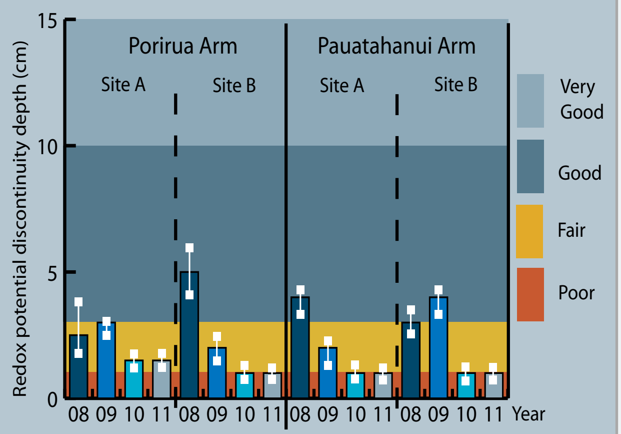


Figure 4. RPD depth (mean and range), Porirua Harbour Estuary fine scale sites, (2008-2011).

Three indicators were used to assess sedimentation in 2011: grain size, sedimentation rate, and RPD depth.

Grain Size

Grain size (% mud, sand, gravel) is a key indicator of both eutrophication and sediment changes. Increasing mud content signals a deterioration in estuary condition and can exacerbate eutrophication symptoms.

Grain size monitoring at fine scale sites (Figure 2, Table 1) shows that although sandy sediments dominate the fine scale monitoring sites, the mud content was also significant (7-15% mud). At the lower estuary fine scale sites (PorA, PauaA) the mud content has remained similar since 2007/8, while at the upper estuary sites (PauaA and especially PorB) a trend of increasing mud content is evident.

Baseline measures were made at sediment plate sites PorC and the boatsheds west of Pau A for the first time in 2011. Results were comparable to nearby fine scale sites (see Table 1).

Rate of Sedimentation

The depths to 15 sedimentation plates buried at 5 sites in Porirua Harbour (see Robertson and Stevens 2008) were measured in January 2011 as part of annual long term monitoring of sedimentation rates in the estuary (Figure 3, Table 2).

Mean annual sedimentation rates for the site since 2007/8 range from -1.7 to +3.2mm/yr. Such rates fit within the "very low to moderate" categories (Table 2). The highest rate (3.2mm/yr) was recorded in the upper estuary of the Porirua Arm (opposite the Polytech). Because of high variability at this site, 2 additional sedimentation plates were deployed in 2011 (Appendix 1).

The results indicate that the highest intertidal deposition is occurring at a moderate rate on the upper part of each arm, with a trend of increased sediment depths since 2008 (Figure 5). The lowest sedimentation rate (-1.7mm/yr) was recorded in the subtidal area of the western Porirua Arm. The measured rates are still well below those predicted by Gibb and Cox, (2009) at these locations (Figure 3). However, the presence of deep soft muds in the main subtidal basins which Gibb and Cox (2009) identified as being at risk of rapid infilling were confirmed by wading into these areas at low tide.

Redox Potential Discontinuity (RPD)

The depth to the RPD boundary is a critical estuary condition indicator in that it provides a direct measure of sediment oxygenation. This commonly shows whether nutrient enrichment in the estuary exceeds levels causing nuisance anoxic conditions in the surface sediments, and also reflects the capacity of tidal flows to maintain and replenish sediment oxygen levels.

In well flushed sandy intertidal sediments, tidal flows typically oxygenate the top 10cm of sediment. However, when fine muds fill the interstitial pore spaces, less re-oxygenation occurs and the RPD moves closer to the surface.

In response to the presence of both fine muds and nutrient enrichment, the RPD depth has decreased at all sites in Porirua Harbour since 2008 (Figure 4, Table 1). In 2011 it remained relatively shallow (1cm) indicating sediments are relatively poorly oxygenated. Such moderately shallow RPD values fit the "fair-poor" condition rating.

2. Results, Rating and Management (Continued)

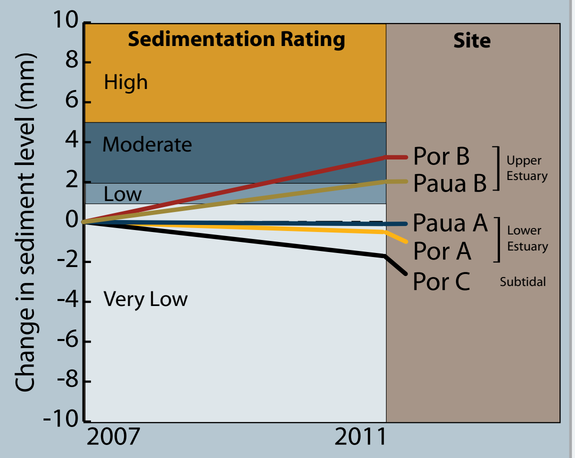


Figure 5. Mean change in sediment showing trends over buried plates from 2007/8-2011.

Table 1. RPD depth and grain size results, Porirua Harbour Estuary (17-18 Jan 2011).

Site		Replicate	RPD	Mud	Sand	Gravel
			cm	%		
Onepoto Arm	Por A. Lower (Railway)	1-4	2	10.0	89.5	0.5
	Por A. Lower (Railway)	5-8	1	11.0.	86.4	2.6
	Por A. Lower (Railway)	9-10	1	8.4	90.3	1.4
	Por B. Upper (Polytech)	1-4	1	9.6	82.1	8.2
	Por B. Upper (Polytech)	5-8	1	12.1	84.1	3.8
	Por B. Upper (Polytech)	9-10	1	9.0	86.7	4.3
	Por C. Western Subtidal	sed. plate site	1	10.3	88.0	1.6
Pauatahanui Arm	Pau A. Lower (Boatsheds)	1-4	1	8.3	85.4	6.3
	Pau A. Lower (Boatsheds)	5-8	1	9.3	83.8	6.9
	Pau A. Lower (Boatsheds)	9-10	1	8.6	82.7	8.8
	Pau A. Lower (Plates)	sed. plate site	1	10.6	74.5	14.8
	Pau B. Upper (East Arm)	1-4	1	5.3	91.4	3.3
	Pau B. Upper (East Arm)	5-8	1	5.5	84.3	10.3
	Pau B. Upper (East Arm)	9-10	1	5.0	86.1	9.0

Table 2. Intertidal sediment plate data, Porirua Harbour Estuary (2007-2011).

		Sediment Depth (mm)				Change (mm)			Site Mean (mm/yr)			Overall Rate (mm/yr)	2007-2011 SEDIMENTATION RATE CONDITION RATING
Site		13/12/07	15/1/09	20/1/10	18/1/11	2007-2009	2009-2010	2010-2011	2007-2009	2009-2010	2010-2011	2007-2011	
Onepoto Arm	A. Lower (Railway)	168	164	159	155	-4	-5	-4	0.8	2.3	-4.5	-0.5	VERY LOW
	A. Lower (Railway)	150	152	158	156	2	6	-2					
	A. Lower (Railway)	152	155	163	150	3	8	-13					
	A. Lower (Railway)	93	95	95	96	2	0	1					
	B. Upper (Polytech)	237	237	240	242	0	3	2	7	0.5	2	3.2	MODERATE
	B. Upper (Polytech)	230	244	242	244	14	-2	2					
	C. Western Subtidal	120	-	115	115	-5		0	-	-5	0	-1.7	VERY LOW
Pauatahanui Arm	A. Lower (Boatsheds)	Baseline	171	172	165	-	1	-7	-	0.5	-0.8	-0.1	VERY LOW
	A. Lower (Boatsheds)	Baseline	213	213	215	-	0	2					
	A. Lower (Boatsheds)	Baseline	232	232	233	-	0	1					
	A. Lower (Boatsheds)	Baseline	234	235	236	-	1	1					
	B. Upper (East Arm)	181	182	186	186	1	4	0	2.3	3.8	0.3	2.0	MODERATE
	B. Upper (East Arm)	215	218	228	233	3	10	5					
	B. Upper (East Arm)	182	186	183	183	4	-3	0					
	B. Upper (East Arm)	176	177	181	177	1	4	-4					

CONCLUSION

The moderate but increasing rate of sedimentation in the upper estuary intertidal flats, combined with increased sediment mud content and a "poor" RPD rating, indicate estuary sediments are becoming muddier in these areas. Sedimentation rates in the most affected subtidal parts of the estuary require targeted monitoring.

RECOMMENDED MONITORING

It is recommended that monitoring continue as outlined below:

Annual Sediment Monitoring. To address problems associated with increasing muddiness and a "poor RPD" rating, monitor sedimentation rate, RPD depth and grain size at the existing intertidal sites annually until the situation improves (next monitoring due in January 2012). Additional sedimentation rate monitoring sites should also be established, particularly in subtidal areas. Site selection should be a stratified monitoring design guided by the estimated sedimentation rates in the recent addendum to the 2009 bathymetric survey (Gibb and Cox 2009) and catchment and sediment transport modelling currently underway for Greater Wellington.

Fine Scale Monitoring. It is recommended that a "complete" fine scale monitoring assessment (including sedimentation rate and macroalgal mapping) be undertaken at 5 yearly intervals (next scheduled for Jan-Feb 2015).

Broad Scale Habitat Mapping. It is recommended that broad scale habitat mapping be repeated in summer 2012/2013.

2. Results, Rating and Management (Continued)

RECOMMENDED MANAGEMENT

The sediment indicators monitored in 2011 reinforce the 2008 to 2010 fine scale monitoring results about the need to manage fine sediment inputs to the estuary.

In particular the following specific management actions are recommended:

- Limit catchment suspended sediment inputs to levels that will not cause excessive estuary infilling i.e. limit sedimentation rates to an estuary average of 1mm/yr. It is expected that there will be areas of very high and very low sedimentation throughout the estuary, which together will average 1mm/yr. Such an approach will allow the development of input load guidelines for suspended sediment and targeted management of problem areas.

Greater Wellington's recent commencement of catchment and sediment transport modelling will help determine the catchment suspended sediment load inputs and the target reductions required to reduce in-estuary sedimentation rates.

ACKNOWLEDGEMENT

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APPENDIX 1

Location of additional sediment plates deployed in 2011.

Porirua Harbour Onepoto Arm	Location	NZTM East	NZTM North	Depth to plate
Por B. Upper (Polytech) Plate 3	2m from NE corner of PorB fine scale site	1754558	5445529	110mm
Por B. Upper (Polytech) Plate 4	4m from NE corner of PorB fine scale site	1754560	5445531	75mm