Stormwater Compliance Monitoring 2014

Stormwater Discharges from Dunedin City

(ORC Discharge Permits RM11.313.01 – RM11.313.10)

Prepared for

Dunedin City Council

by

Ryder Consulting Ltd.

July 2014

ryderconsulting
environment + planning + project management

Stormwater Compliance Monitoring 2012

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prepared by

Brian Stewart

Ryder Consulting

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Cover photo: Orari Street stormwater outfall.

Ryder Consulting Ltd.
PO Box 1023
Dunedin
New Zealand
Ph: 03 477 2119
Fax: 03 477 3119

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Executive Summary

This report presents the findings for the first round of annual monitoring of Dunedin's stormwater outfalls since new discharge consents were granted.

Monitoring comprised assessment of time/flow proportional samples at the South Dunedin catchment, and grab samples and dry weather samples from other catchments.

Also included were assessments of harbour water quality and harbour sediment quality at representative sites.

Stormwater from all outfalls monitored showed variable levels of contamination, with numerous parameters being present at concentrations above recommended ANZECC guidelines or trigger values at a variety of outfalls.

Sediments too showed varying levels of contamination from outfall to outfall with levels of contaminants breaching ANZECC trigger values for arsenic, lead, nickel, and zinc at all sites, and copper, cadmium and chromium breaching ANZECC trigger values at some sites.

Contaminant levels in both stormwater and sediment were generally within the ranges observed in previous surveys carried out in 2007, 2008, 2009, 2010, 2011, 2012 and 2013 with no clear trends in contaminant levels discernible at this juncture.

1. Introduction

1.1 Background

As with all urban centres throughout New Zealand and indeed most of the world, Dunedin's stormwater is reticulated to receiving environments via networks of gutters, open channels and pipes. The principal receiving water environments for Dunedin's reticulated stormwater are the upper basin of Otago Harbour, Second Beach/St. Clair Beach on the open coast, Kaikorai Stream and the Water of Leith. Dunedin City Council (DCC) was, on 8th August 2013, granted resource consents for its major urban stormwater discharges into the coastal marine environment, namely into Otago Harbour (including Sawyers Bay and Port Chalmers), St Clair and Second Beach.

Conditions under which consents have been granted include compliance monitoring. Specifically: Condition 2 and Appendix 1, Environmental Monitoring (Condition 7) and Appendix 2 (A. Stormwater quality, B. Harbour water quality, C. Harbour sediment quality, and D. Biological monitoring) (see Appendix 1 for text of consent conditions).

The following report presents the results of the first round of sampling/monitoring carried out since the consents were granted and June 2014.

1.2 Stormwater Outfalls

Stormwater is discharged from Dunedin City to the Upper Otago Harbour, Second Beach and Port Chalmers from fourteen reasonably large and permanent stormwater outfalls, and from a number of smaller outfalls and non-point sources (Table 1.1). Many of the outfalls have very long histories dating back to the days of the early settlement of Dunedin and a numbers were dual-purpose outfalls, discharging both wastewater and stormwater. All current outfalls, however, are designated to discharge stormwater.

A total of 10 consents have been granted for the 33 individual stormwater outfalls listed in Table 1.1.

Table 1.1 *Current stormwater outfalls being monitored and their locations. Pink shading denotes outfalls that are not easily accessed at end of pipe and require manhole access. Orange shading denotes manhole access required at high tide only.*

Outfall	DCC ref	Location	Catchment
1	SWX03979	Second Beach	St Clair
2	SWX00011 & SWX00012	St Clair Beach	St Clair
3	SWX04625	Shore Street	Shore Street
4	SWX03649	Portobello Rd	Portobello Rd
5	SWX03644	Teviot St	Foreshore
6	SWX03640	Midland St	Foreshore
7	SWX03631	Orari St	Orari St
8	SWX03635 & SWX70740	Orari St	Orari St
9	SWX03579	Kitchener St	Kitchener St
10	SWX03568	Kitchener St	Kitchener St
11	SWX70102	French St	Foreshore
12	SWX03547	Kitchener St	Foreshore
13	SWX03562	Birch St	Foreshore
14	SWX03556	Birch St	Foreshore
15	SWX03559	Wharf St	Foreshore
16	SWZ70569	Fryatt St	Foreshore
17	SWX03540	Fryatt St	Foreshore
18	SWX03536	Fryatt St	Foreshore
19	SWX03532	Fryatt St	Foreshore
20	SWX70370	Fryatt St	Foreshore
21	SWX03489	Mason St	Mason St
22	SWX03506	Mason St	Bauchop St
23	SWX03466	Mason St	Bauchop St
24	SWX03455	Halsey St	Halsey St
25	SWX03450	Halsey St	Wickliffe St
26	SWX03472	Halsey St	Wickliffe St
27	SWX03718	Wickliffe St	Wickliffe St
28	SWX02628	Magnet St	Magnet St
29	SWX02623	Magnet St	Magnet St
30	SPN02502	Ravensbourne Rd	Gas Works
31	SWX12941	George St/SH88	Port Chalmers
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers
33	SWX12879	George St (Port Otago)	Port Chalmers

2. Methods

2.1 Stormwater

A number of the outfalls listed in Table 1.1 do not have outfall structures or are located in places that are inaccessible. Consequently it is neither practical nor possible to sample the entire 33 outfalls listed at the end of pipe. However, access to those that cannot be sampled at end of pipe is available via manholes a short distance up pipe (Table 1.1).

An ISCO automated sampler was set up at the Portobello Road stormwater pumping station (consent RM11.313.09, South Dunedin catchment) to fulfil the requirements of Appendix 2A (a) of the consent conditions. The sampler was programmed to collect samples over the first two hour period of a rain event that produced at least 2.5 mm of rain following an antecedent dry period of at least 72 hours.

Dry weather flow sampling, as per Condition 2(a), was carried out at each of the thirty three outfalls on a monthly basis for the first three months, provided there had been an antecedent dry period of at least 72 hours. In the event, the 2013/2014 summer was exceedingly wet and samples were able to be collected for just November, December and February. At the end of this time, sampling was reviewed and, depending on results, was continued on a monthly basis, or scaled back to once every 6 months.

Wet weather grab samples of stormwater were collected from each of the ten outfalls with the highest flows (as per consent condition Appendix A (b)(1)) stormwater outfall within 1 hour of the commencement of a rain event (>2.5 mm) in an endeavour to ensure that first flush water was gathered. Collections took place only if there was an antecedent period of at least 72 hours with no rain before the targeted rain event. Samples were collected from the end of pipe where possible, or from the closest manhole to the end of pipe where an outfall was not readily accessible.

Harbour water quality sampling was carried out at the locations shown in Figure 2.1 on four occasions. These occasions targeted two rainfall events and two dry periods, with samples being collected at mid flood tide and mid ebb tide for each occasion.

Grab stormwater samples and stormwater samples from the automated sampler were sent to Hill Laboratories in Hamilton and to Citilab in Dunedin to be analysed, as per Appendix 2 A (c), for oil and grease, pH, arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), suspended solids, polycyclic aromatic hydrocarbons (PAHs) and *E. coli*.

Samples collected from outfalls and manholes, as indicated in Table 1.1, during dry periods were sent to Citilab for analysis for *E. coli* and were analysed on site for fluorescent whitening agents (FWAs) using a hand-held fluorimeter. FWAs are used in laundry detergents and indicate possible sewage infiltration to the stormwater system (Petch 1996, Gilpin *et al.* 2004).

Harbour water samples were sent to Hill Laboratories in Hamilton and to Citilab in Dunedin to be analysed for arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), and enterococci.

2.2 Sediments

Samples were collected from the top 20mm of sediment at the locations shown in Figure 2.1 at GPS points listed in Table 2.1.

Table 2.1 *GPS co-ordinates for sediment sampling sites.*

Site	Easting	Northing
Halsey Street (H1)	E2317198	N5478510
Kitchener Street (H2)	E2316380	N5477405
Orari Street (H3)	E2316462	N5477034
Shore Street (H4)	E2317435	N5476408

The Halsey Street site is in deep water (~5-7m deep) so sediment was collected using a petit ponar grab with a subsample being obtained from the top 20mm of the contents of the grab.

Samples were chilled and sent to Citilab for analysis for total arsenic, total cadmium, total chromium, total copper, total nickel, total mercury, total lead, total zinc, total petroleum hydrocarbons (TPH), organochlorine pesticides, and PAHs.

2.3 Biological Monitoring

Biological monitoring is not due until 2015.

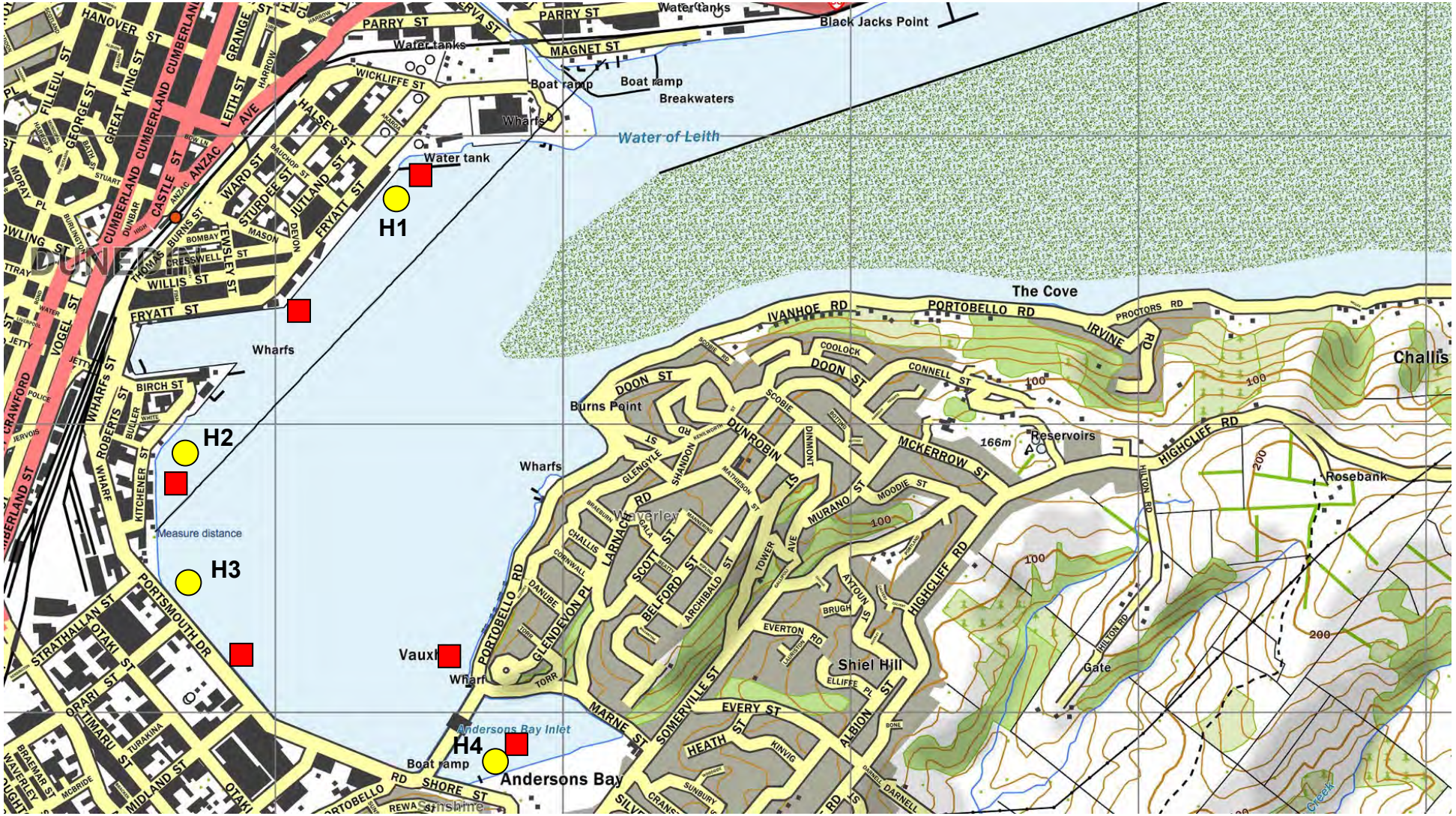

Figure 2.1 *Upper Harbour Basin seawater and sediment sampling sites. Red squares are harbour water quality sites; Yellow circles are sediment sites (see Table 2.1).*

3. Results

3.1 Stormwater

The ISCO automated sampler installed in the Portobello Road pumping station triggered during storm events on 28th February 2014, 25th March 2014 and 19 June 2014. The events generated 18.2 mm, 18.0 mm and 3.8 mm of rainfall respectively. The sampler triggered on an additional five occasions, but on each of these the rainfall event was either too small (i.e. <2.5mm) or occurred on a Friday evening or Saturday, which precluded getting samples to the laboratory within the prescribed 24 hour period between collection and analysis.

Concentrations for most contaminants follow the expected pattern for the first flush of rainfall events i.e. start low, then rise and gradually fall away as time progresses (Figure 3.1). This is especially pronounced for the 28 February event.

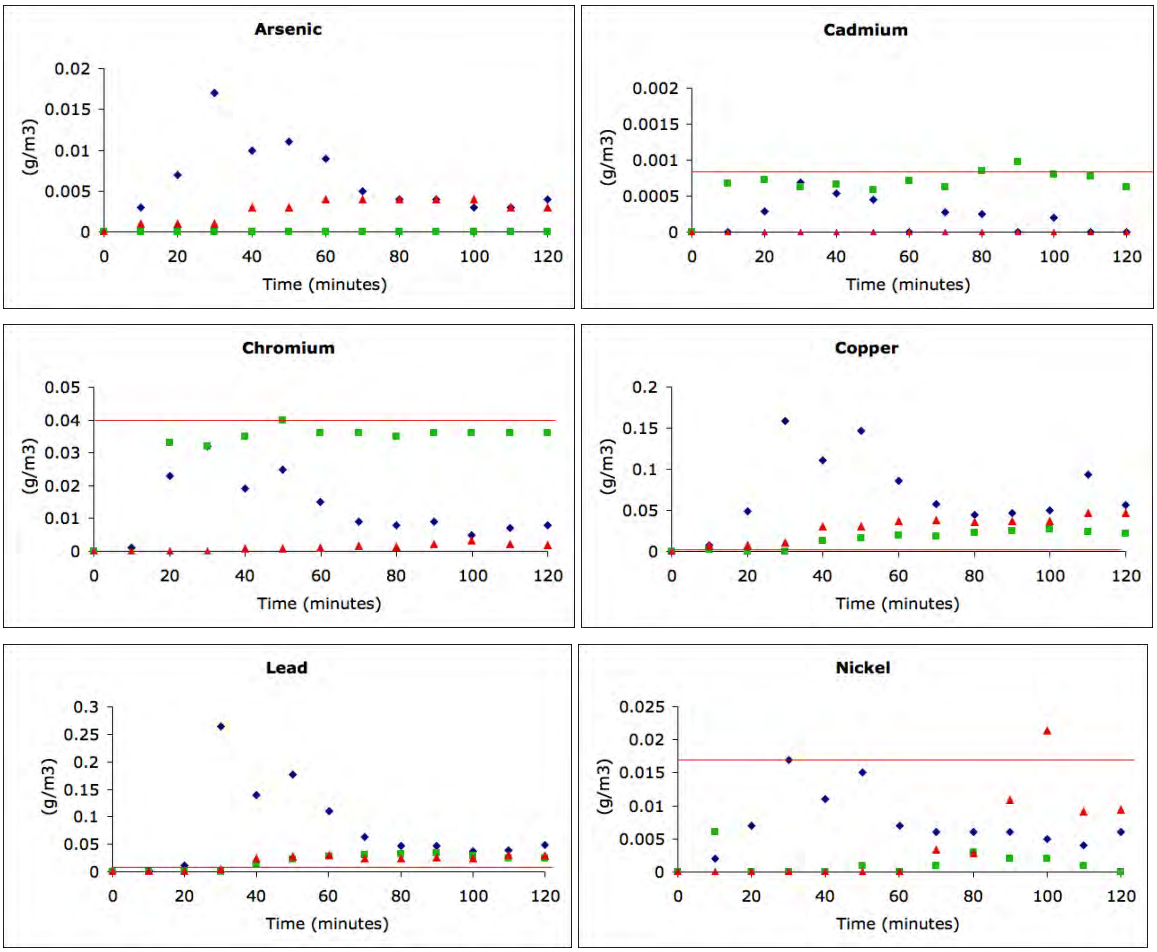

Figure 3.1 *Contaminant concentration during the first flush of three rainfall events. Black diamond = 28 February; green square = 25 March; red triangle = 19 June. Red line indicates ANZECC guideline value for protection of 80% of species.*

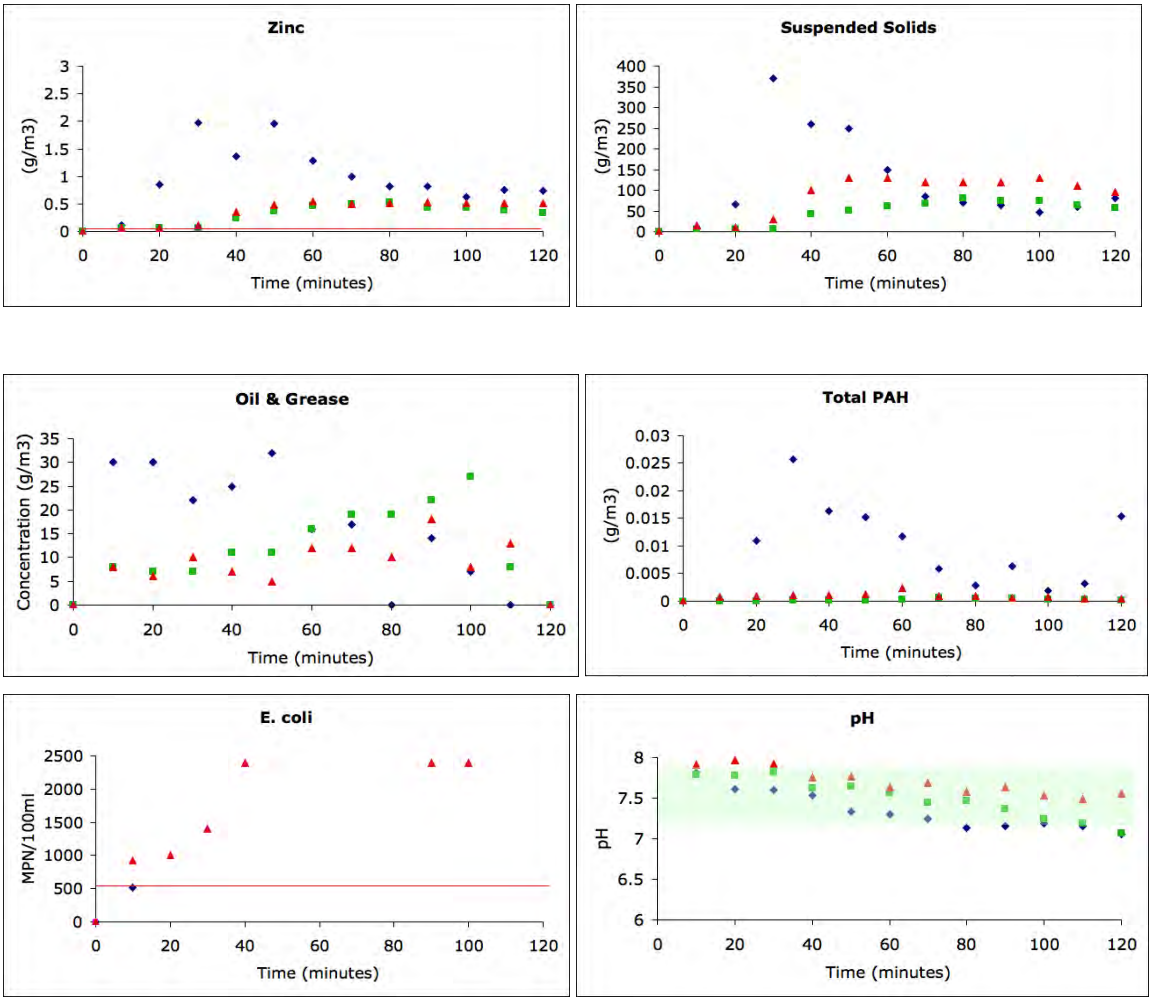

Figure 3.1 (cont'd) *Contaminant concentration during the first flush of three rainfall events. Black diamonds = 28 February; green squares = 25 March; red triangles = 19 June. Note that lack of symbols on E. coli graphs indicates values >2400. . Red line indicates ANZECC guideline value for protection of 80% of species. Green band on pH graph shows acceptable limits.*

However, it needs to be recognised that the intensity of the rainfall event and rate of onset have a bearing on values and have resulted in three curves for each contaminant that differ accordingly.

For arsenic, cadmium, chromium and nickel, levels are generally below ANZECC trigger values for protection of 80% of species. For copper, lead and zinc, however, levels exceed ANZECC trigger values for much of all rainfall events, irrespective of rainfall intensity (Figure 3.1)

Levels of contaminants observed during the three sampled rainfall events generally compare reasonably well with values observed for the Portobello Road outfall through time since 2007. However, it should be noted that the highest observed

value for each contaminant over the three rainfall events lies above the range observed over past years, with the exception of *E. coli* and pH (Stewart 2013). This is likely due to the fact that past sampling, although targeted at first flush flows, has been a single grab sample that may have missed the particular slug of stormwater carrying the highest level of contaminants.

Dry weather flow sampling has been carried out on 5th November 2013, 4th December 2013, 4th February 2014, 3rd April 2014, and 3rd June 2014. As already stated, sampling at a number of outfalls was changed from monthly sampling to 6 monthly sampling after three rounds due to there either being no flow or consistently low results for both *E. coli* and FWAs. A number of outfalls have consistently high readings for *E. coli* and/or FWAs (Table 3.2). The DCC has implemented investigation of the outfall at Magnet Street (SWX02623) in an attempt to ascertain a likely source of such contamination.

E. coli levels frequently exceed trigger levels, with numbers often exceeding 2400 MPN/100ml at the Orari Street, Halsey Street and Wickliffe Street catchments (Table 3.2). However, the fact that FWAs at the same sites are not always high suggests that contamination may not be from human sewage, but rather from other, as yet unkown, sources. Further investigation of these sites and comparison with wet weather flows is warranted.

Table 3.2 *Contaminant (*E. coli *expressed as MPN/100ml and FWAs) levels in dry weather flow samples taken from DCC stormwater outfalls. Pink shaded cells denote trigger levels exceeded. Orange shaded cells denote trigger level approached. NF = no flow. Grey cells = sampling now 6 monthly.*

Outfall	DCC ref	Location	Catchment	FWAs November	FWAs December	FWAs February	FWAs April	FWAs June	*E. coli* November	*E. coli* December	*E. coli* February	*E. coli* April	*E. coli* June
1	SWX03979	Second Beach	St Clair	0.033	0.032	0.049	0.035	0.065	440	770	1700	2400	460
2	SWX00011 & SWX00012	St Clair Beach	St Calir	NF	NF	NF			-	-	-		
3	SWX04625	Shore Street	Shore Street	0.039	0.042	0.057	0.079	.060	6500	1400	330	25.3	19.9
4	SWX03649	Portobello Rd	Portobello Rd	0.004	0.000	0.019	0.145	0.174	10	2400	240	1300	90.7
5	SWX03644	Teviot St	Foreshore	0.095	0.093	0.088	0.103	0.104	140	690	440	1300	130
6	SWX03640	Midland St	Foreshore	0.093	0.095	0.079	0.151	0.145	500	41	2400	9.6	25.6
7	SWX03631	Orari St	Orari St	0.015	0.001	0.029	0.121	0.012	180	730	2400	>2400	<1.0
8	SWX03635 & SWX70740	Orari St	Orari St	0.064	0.067	0.076	0.033	0.089	770	2400	200	180	1300
9	SWX03579	Kitchener St	Kitchener St	0.085	0.077	0.064	0.078	0.09	200	24	1600	68	98.7
10	SWX03568	Kitchener St	Kitchener St	0.010	0.044	0.021			210	55	4.1		
11	SWX70102	French St	Foreshore	0.072	0.042	0.025	0.034	0.068	440	22	980	220	23.8
12	SWX03547	Kitchener St	Foreshore	0.026	0.032	0.046			10	1	7.0		
13	SWX03562	Birch St	Foreshore	NF	NF	NF			-	-	-		
14	SWX03556	Birch St	Foreshore	NF	NF	NF			-	-	-		
15	SWX03559	Wharf St	Foreshore	NF	NF	NF			-	-	-		
16	SWZ70569	Fryatt St	Foreshore	NF	NF	NF			-	-	-		
17	SWX03540	Fryatt St	Foreshore	NF	NF	NF			-	-	-		
18	SWX03536	Fryatt St	Foreshore	NF	NF	NF			-	-	-		

Outfall	DCC ref	Location	Catchment	FWAs November	FWAs December	FWAs February	FWAs April	FWAs June	*E. coli* November	*E. coli* December	*E. coli* February	*E. coli* April	*E. coli* June
19	SWX03532	Fryatt St	Foreshore	NF	NF	NF			-	-	-		
20	SWX70370	Fryatt St	Foreshore	NF	NF	NF			-	-	-		
21	SWX03489	Mason St	Mason St	0.005	0.008	0.010			310	120	34.6		
22	SWX03506	Mason St	Bauchop St	NF	NF	0.196	NF	0.164	-	-	24,000	NF	>2400
23	SWX03466	Mason St	Bauchop St	0.025	0.021	0.033	0.014	0.054	280	46	1300	45.9	>2400
24	SWX03455	Halsey St	Halsey St	0.016	0.009	0.020	0.007	0.098	24000	2400	2400	>2400	>2400
25	SWX03450	Halsey St	Wickliffe St	0.056	0.043	0.078	0.056	0.031	24000	2400	2400	>2400	>2400
26	SWX03472	Halsey St	Wickliffe St	0.058	0.054	0.118	0.059	0.056	52	2400	920	2.0	39.7
27	SWX03718	Wickliffe St	Wickliffe St	0.020	0.046	0.079	0.064	0.052	2100	2400	2400	1700	>2400
28	SWX02628	Magnet St	Magnet St	0.077	0.074	0.080			120	130	100		
29	SWX02623	Magnet St	Magnet St	0.155	0.146	0.180			8200	35	520		
30	SPN02502	Ravensbourne Rd	Gas Works	NF	NF	NF			-	-	-		
31	SWX12941	George St/SH88	Port Chalmers	0.056	0.054	0.052			86	100	6.0		
32	SWX12994	Sawyers Bay, western side of Watson Park	Port Chalmers	0.060	0.055	0.062			10	310	180		
33	SWX12879	George St (Port Otago)	Port Chalmers	0.087	0.047	0.074	0.050	0.105	510	1600	1100	260	49

Wet weather grab samples were collected on 12th May 2014 during a storm event that yielded 8.2 mm of rainfall. Levels of some contaminants, notably arsenic, cadmium, chromium, nickel, oil and grease, suspended solids and polycyclic aromatic hydrocarbons was very low at most sites (Table 3.3). However, levels of *E. coli* were high at all outfalls except Bauchop Street and Shore Street. This is not unusual during sampling of the first flush of rain events with runoff from impervious surfaces often carrying quantities of faecal matter from mammals and birds along with much decaying vegetation.

Table 3.3 *Contaminant levels in stormwater at ten key Dunedin City outfalls.*

Catchment	Outfall	Consent ref.	As (g/m3)	Cd (g/m3)	Cr (g/m3)	Cu (g/m3)	Pb (g/m3)	Ni (g/m3)	Zn (g/m3)
St Clair	1	RM11.313.10	0.009	<0.00001	0.0085	0.018	0.0236	<0.0005	0.286
Shore Street	3	RM11.313.04	0.005	0.00005	0.0034	0.002	0.0056	<0.0005	0.092
South Dunedin	4	RM11.313.09	0.01	<0.00001	0.0034	0.015	0.0121	<0.0005	0.482
Orari Street	8	RM11.313.08	0.008	<0.00001	0.0031	0.004	0.0041	<0.0005	0.194
Kitchener Street	10	RM11.313.06	0.011	<0.00001	0.0071	<0.001	0.0126	<0.0005	0.226
Mason Street	21	RM11.313.05	0.012	<0.00001	0.0066	0.001	0.0013	<0.0005	0.17
Bauchop Street	23	RM11.313.03	0.007	0.00005	0.0144	0.01	0.0097	<0.0005	0.126
Halsey Street	24	RM11.313.03	0.008	<0.00001	0.0039	0.018	0.0056	<0.0005	0.409
Wickliffe Street	27	RM11.313.03	0.008	0.00143	0.0153	0.041	0.0443	0.0089	0.548
Port Chalmers	31	RM11.313.01	0.006	<0.00001	0.0022	0.015	0.0163	<0.0005	0.32
ANZECC trigger value			0.36	0.0008	0.04	0.0025	0.0094	0.017	0.031

Catchment	Outfall	Consent ref.	O&G (g/m3)	pH	SS (g/m3)	PAH (g/m3)	E. coli (MPN/100ml)	
St Clair	1	RM11.313.10	20	7.56	54	0.000372	>2400	
Shore Street	3	RM11.313.04	11	8.02	49	0.000066	91.4	
South Dunedin	4	RM11.313.09	17	7.6	47	0.007091	2000	
Orari Street	8	RM11.313.08	17	7.84	27	0	920	
Kitchener Street	10	RM11.313.06	22	8.01	58	0.000008	500	
Mason Street	21	RM11.313.05	22	8.01	71	0	330	
Bauchop Street	23	RM11.313.03	36	7.97	92	0.000229	19.1	
Halsey Street	24	RM11.313.03	42	7.32	38	0.00009	>2400	
Wickliffe Street	27	RM11.313.03	48	6.76	340	0.000503	>2400	
Port Chalmers	31	RM11.313.01	42	7.51	43	0.000395	>2400	
ANZECC trigger value				7.2-7.8			>260	Primary contact
							>550	Secondary contact

When compared with results from rain events through time, we see that the levels of contaminants in stormwater during the 24th May rain event were generally within the range of values observed at the various outfalls that have been sampled annually since 2007 (Table 3.4). There were some exceptions however. Oil and grease at Wickliffe Street, Halsey Street, Port Chalmers (George Street) and Bauchop Street were higher this year than in the past, as were chromium and suspended solids, both at Wickliffe Street (Table 3.4). PAHs at South Dunedin (Portobello Rd) were also higher this year than in the past (Table 3.5).

Table 3.4 *Levels of contaminants detected in stormwater from outfalls in and around Dunedin during a storm events on 11 April 2007, 17 June 2008, 12 May 2009, 23 April 2010, 3 May 2011, 29 February 2012 and 13 June 2013. BDL indicates Below Detectable Limits. Pink shaded cells indicate levels above the ANZECC 2000 trigger level for protection of 80% of species.*

Stormwater																							
Parameter	As							Cd							Cr								
units	g/m^3							g/m^3							g/m^3								
Outfall	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013		
Second Beach	BDL	0.0013	0.0015	BDL	0.002	BDL	BDL	BDL	0.00006	0.00006	0.00007	8E-05	BDL	BDL	0.0007	0.0028	0.0035	0.00086	0.0038	0.00148	0.0023		
George St	BDL	0.0031	BDL	BDL	0.001	0.0016	0.0042	0.00028	0.00140	0.00011	0.00033	0.0002	0.0006	0.0004	0.005	0.012	0.0031	0.00136	0.0045	0.0053	0.0132		
Watson Pk	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0002	BDL	0.0064	BDL	BDL	BDL	0.0016	0.0025		
Shore Street	0.04	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL		
Portobello Road	BDL	0.002	BDL	BDL	BDL	BDL	BDL	BDL	0.00023	BDL	BDL	BDL	BDL	BDL	BDL	0.002	BDL	BDL	BDL	BDL	BDL		
Teviot Street	BDL	0.002	BDL	BDL	BDL	BDL	0.0017	BDL	0.00008	BDL	0.00026	BDL	0.0001	0.0002	BDL	0.0018	BDL	BDL	BDL	0.0019	0.005		
Midland Street	BDL	0.0033	BDL	BDL	BDL	BDL	0.0042	BDL	0.00013	BDL	BDL	BDL	BDL	BDL	BDL	0.0035	0.0031	BDL	BDL	BDL	0.0043		
Orari Street	BDL	BDL	0.032	0.00149	BDL	BDL	BDL	BDL	BDL	BDL	0.000164	BDL	BDL	BDL	BDL	0.0032	BDL	0.00183	BDL	BDL	BDL		
Kitchener Street	BDL	BDL	0.0096	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.004	0.002	BDL	BDL	BDL	BDL	BDL		
Mason Street	0.006	BDL	0.0077	BDL	BDL	BDL	BDL	BDL	BDL	0.0077	0.00051	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL		
Ravensbourne Rd		BDL	BDL	BDL	BDL	BDL	0.0014		BDL	BDL	BDL	BDL	BDL	0.0001		0.00061	BDL	BDL	BDL	BDL	0.0028		
Bauchop Street	0.03	BDL	0.021	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.00049	BDL	BDL	BDL	BDL	0.0015	BDL	BDL	BDL	BDL	BDL		
Halsey Street	0.03	BDL	0.01	0.0044	BDL	BDL	BDL	BDL	0.00022	BDL	0.00026	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0019		
Wickliffe Street	0.03	BDL	0.003	BDL	0.004	0.0027	BDL	BDL	BDL	0.00052	0.00078	0.0009	0.0002	BDL	BDL	0.0017	0.0076	0.00157	0.0046	0.0028	0.0026		
Protection for 80% of species ANZECC guidelines	0.36							0.0008							0.04								

Stormwater																							
Parameter	Cu							Ni							Pb								
units	g/m^3							g/m^3							g/m^3								
Outfall	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013		
Second Beach	0.0027	0.012	0.019	0.0054	0.0172	0.0026	0.0099	0.0009	0.0021	0.0022	0.0013	0.0026	0.0011	0.0023	0.001	0.011	0.013	2E-04	0.013	0.00101	0.0053		
George St	0.0213	0.039	0.025	0.0148	0.0197	0.027	0.041	0.0029	0.0093	0.0026	0.006	0.0037	0.0061	0.0145	0.0342	0.041	0.018	0.005	0.004	0.029	0.048		
Watson Pk	0.009	0.0025	BDL	BDL	BDL	0.008	0.0118	BDL	BDL	BDL	0.0035	BDL	0.0019	BDL	0.0141	0.0018	BDL	BDL	0.004	0.0057	0.0127		
Shore Street	0.01	0.014	0.02	0.0118	BDL	BDL	0.0159	0.01	BDL	BDL	BDL	BDL	BDL	BDL	0.003	0.0085	0.0069	BDL	BDL	BDL	0.0038		
Portobello Road	BDL	0.026	0.01	0.0057	0.029	0.012	0.0072	BDL	0.0035	0.0028	0.0035	BDL	BDL	BDL	BDL	0.019	0.0067	6E-04	0.026	0.0081	0.0086		
Teviot Street	BDL	0.0094	BDL	0.0136	0.031	0.0104	0.03	BDL	0.0019	BDL	0.0033	BDL	0.0017	0.0027	BDL	0.0066	BDL	BDL	0.007	0.0028	0.0092		
Midland Street	0.02	0.031	0.057	0.021	BDL	0.0134	0.028	BDL	0.0016	BDL	0.0075	BDL	BDL	0.0024	0.005	0.0054	0.0083	BDL	BDL	0.0023	0.0092		
Orari Street	BDL	0.014	BDL	0.0096	BDL	0.0024	0.0057	BDL	0.0033	BDL	0.0011	BDL	0.0008	BDL	BDL	0.023	BDL	2E-04	BDL	0.00118	0.0041		
Kitchener Street	0.034	0.0056	0.023	0.0118	BDL	BDL	0.015	0.003	BDL	0.0036	0.0035	BDL	BDL	BDL	0.0442	0.007	0.018	0.002	BDL	0.0028	0.0055		
Mason Street	0.022	0.012	0.021	0.0157	0.043	0.026	0.0065	0.004	BDL	0.0055	BDL	0.0039	BDL	BDL	0.0258	0.0089	0.014	0.001	0.019	0.0101	0.0042		
Ravensbourne Rd		0.0023	BDL	0.0031	BDL	0.0032	0.0028		0.0007	BDL	0.0015	BDL	0.0007	0.002		0.0015	0.0029	2E-04	0.025	0.0039	0.0094		
Bauchop Street	0.029	0.0096	BDL	0.0026	BDL	0.021	0.0131	0.01	BDL	BDL	BDL	BDL	BDL	BDL	0.01	0.0035	BDL	BDL	BDL	0.021	0.0026		
Halsey Street	0.024	0.0043	0.021	0.00162	0.029	0.0043	0.0183	0.009	BDL	0.0035	BDL	BDL	BDL	BDL	0.021	0.0022	0.0097	0.002	0.009	0.0043	0.0064		
Wickliffe Street	0.01	0.013	0.059	0.0058	0.022	0.025	0.0107	0.01	BDL	0.0042	BDL	0.0021	0.0046	BDL	0.006	0.0084	0.033	BDL	0.013	0.0153	0.0092		
Protection for 80% of species ANZECC guidelines	0.0025							0.017							0.0094								

Table 3.4 *continued…*

Stormwater																							
Parameter	Zn							pH							Suspended Solids								
units	g/m^3														g/m^3								
Outfall	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013		
Second Beach	0.038	0.16	0.15	0.092	0.25	0.026	0.166	7.7	7.3	7.4	7.3	7.4	8	7.7	BDL	37	41	BDL	57	5	34		
George St	0.288	0.66	0.19	0.42	0.25	0.43	0.76	6.9	7.1	7.3	6.8	6.8	6.3	7.4	87	150	26	170	140	180	430		
Watson Pk	0.231	0.027	BDL	0.29	0.24	0.27	0.4	6.8	7.9	8.2	7.1	7.5	7.5	7.5	37	39	7.4	240	24	24	58		
Shore Street	0.02	0.44	0.21	0.115	BDL	0.071	0.2	7.9	7.2	7.3	7.4	7.9	7.5	7.5	41	24	20	9.5	12	10	9		
Portobello Road	0.08	0.94	0.64	0.153	0.87	0.15	0.57	7.9	7.3	7.6	7.6	7.4	8.1	7.6	18	46	30	8.1	53	43	27		
Teviot Street	BDL	0.13	BDL	1.79	0.61	1.22	1.26	7.9	7.1	7.9	7	8	7.1	7.4	25	33	12	84	66	32	67		
Midland Street	0.1	0.35	0.18	0.22	BDL	0.21	0.36	7.7	7.7	7.7	7.5	7.8	7.6	7.4	30	19	30	52	14	12	57		
Orari Street	BDL	0.22	0.031	0.3	BDL	0.0157	0.07	7.8	7.4	8.1	7.1	7.9	7.9	7.6	28	77	16	130	4	BDL	38		
Kitchener Street	0.445	0.036	0.38	0.62	BDL	0.082	0.23	7.1	7.7	7.4	6.9	8	7.6	7.7	104	41	45	50	BDL	27	37		
Mason Street	0.25	0.16	0.35	0.43	0.63	0.43	0.095	7.1	7	7.4	7	7	7.1	7.6	62	37	37	138	30	31	63		
Ravensbourne Rd		0.053	0.047	0.144	0.27	0.32	0.231		7	8.1	7.3	8	7.8	7.9		8.5	18	61	5	6	60		
Bauchop Street	0.23	0.12	0.13	0.121	BDL	0.94	0.2	7.6	7.8	8.1	7.4	8	7.4	7.9	44	16	13	53	5	38	47		
Halsey Street	0.12	0.033	0.3	0.136	0.36	0.089	0.23	7.3	7.9	7.2	6.8	7.1	7.8	7.3	119	35	27	50	24	22	46		
Wickliffe Street	0.1	0.2	0.53	0.24	0.82	1.57	0.161	7.7	7.5	8.0	7.3	9.7	7.0	7.5	35	27	100	86	46	30	92		
Protection for 80% of species ANZECC guidelines	0.031							7.2-7.8															

	Stormwater														
Three Waters Project ICMP Catchment	Parameter	Oil & Grease							FWA						
	units	g/m^3							µg/L						
	Outfall	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
St Clair	Second Beach	5	BDL	BDL	BDL	BDL	11	5	0.147	0.19	0.098	0.04	0.075	0.069	0.064
Port Chalmers	George St	10	8.7	BDL	BDL	8	13	9	BDL	BDL	0.03	0.079	0.082	0.124	0.078
Port Chalmers	Watson Pk	8	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.003	0.124	0.105	0.092	0.147	0.084
Shore Street	Shore Street	BDL	BDL	BDL	BDL	BDL	10	5	0.081	0.031	0.142	0.98	0.142	0.156	0.104
South Dunedin	Portobello Road	4	9.7	BDL	BDL	BDL	BDL	BDL	0.003	0.049	0.177	0.151	0.045	0.096	0.207
Andersons Bay	Teviot Street	8	4.4	BDL	6.4	BDL	7	8	BDL	0.006	0.096	0.135	0.117	0.103	0.112
Andersons Bay	Midland Street	BDL	BDL	BDL	BDL	4	BDL	5	BDL	0.004	0.132	0.218	0.197	0.174	0.145
Orari Street	Orari Street	BDL	11	BDL	BDL	17	BDL	BDL	BDL	0.005	0.11	0.052	0.081	0.094	0.038
Kitchener Street	Kitchener Street	9	BDL	BDL	BDL	22	11	BDL	0.18	0.029	0.072	0.023	0.047	0.052	0.027
Mason Street	Mason Street	5	7.9	BDL	BDL	BDL	BDL	BDL	0.007	0.07	0.051	0.156	0.026	0.043	0.058
Ravensbourne	Ravensbourne Rd		8.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.096	0.136	0.014	0.23	0.088
Halsey Street	Bauchop Street	4	BDL	BDL	BDL	BDL	BDL	BDL	2.028	4.92	0.031	0.067	0.017	0.019	0.033
Halsey Street	Halsey Street	9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.004	0.011	0.061	0.025	0.038	0.027
Halsey Street	Wickliffe Street	6	9.5	9.5	BDL	7	BDL	BDL	0.024	0.003	0.021	0.048	0.094	0.121	0.052

Table 3.4 *continued… For E. coli, green cells indicate acceptable levels; orange cells indicate a level that would trigger an amber alert; pink cells indicate a level that would trigger a red alert according to MoH/MfE guidelines. For FCs orange cells exceed guidelines for primary contact recreation; pink cells exceed levels for secondary contact recreation.*

		Stormwater													
Three Waters Project ICMP Catchment	Parameter	E. coli							Faecal Coliforms						
	units	MPN/100ml							cfu/100ml						
	Outfall	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
St Clair	Second Beach	560	6800	14000	4800	9000	300	1300	560	8300	14000	92000	9000	300	1300
Port Chalmers	George St	1400	930	1000	1100	600	6000	2300	1400	1400	1000	1100	600	6000	2300
Port Chalmers	Watson Pk	14000	150	10	>1600	1000	5900	1300	39000	150	10	>1600	1000	5900	1300
Shore Street	Shore Street	300	5100	16000	7000	110	11000	780	300	5100	16000	9400	110	11000	780
South Dunedin	Portobello Road	460	5000	2800	54000	6000	280	3300	590	5000	2800	54000	6000	280	3300
Andersons Bay	Teviot Street	7	120000	210	16000	300	3000	200	7	240000	210	16000	300	3000	200
Andersons Bay	Midland Street	290	130	6000	3500	600	3700	2300	290	130	6000	5400	600	4900	2300
Orari Street	Orari Street	50	6000	210	1700	BDL	1800	3300	80	7000	210	3500	BDL	1800	3300
Kitchener Street	Kitchener Street	13000	70	10000	92000	110	150	7900	13000	70	10000	160000	110	230	7900
Mason Street	Mason Street	22000	26000	50000	350000	48000	32000	200	22000	26000	50000	350000	48000	32000	200
Ravensbourne	Ravensbourne Rd		120	90	11000	130	1300	450	150	130	90	11000	130	1300	450
Halsey Street	Bauchop Street	2200	400	3000	7900	450	17000	1100	2200	400	3000	35000	450	17000	2200
Halsey Street	Halsey Street	9000	1700	70000	17000	78000	26000	92000	9000	1700	70000	92000	78000	26000	92000
Halsey Street	Wickliffe Street	25000	10000	220000	35000	43000	96000	15000	30000	10000	220000	54000	43000	96000	15000
	Primary	Amber	>260						>150						Primary
	Secondary	Red	>550						>1000						Secondary

Table 3.5 *PAHs (g/m^3) detected in stormwater from the Kitchener Street, Orari Street and Portobello Road outfalls in 2007, 2008, and 2009, 2010, 2011, 2012 and 2013. BDL indicates Below Detectable Limits.*

Total PAHs							
Year	2007	2008	2009	2010	2011	2012	2013
Kitchener Street	0.00	0.00	BDL	0.0001	BDL	BDL	BDL
Orari Street	0.00	0.00025	BDL	0.0005	BDL	BDL	BDL
Portobello Road	BDL	0.00132	0.00017	0.00016	0.00168	0.000166	0.00183

Harbour water was collected during two separate rainfall events that occurred on 23rd May 2014 and 20th June 2014. These events generated 9.0 mm and 3.8 mm of rain respectively. Samples were collected at mid flood tide and again at mid ebb tide. Dry weather samples were collected on 5th June 2014 and 18th June 2014 with samples again being collected at mid flood tide and again at mid ebb tide.

Contamination of harbour water was generally low for most metals (e.g. As, Cd, Cr, Pb and Ni) with just copper and zinc having concentrations above the Consent trigger levels, which are also the ANZECC (2000) trigger values for protection of 95% of species. However, even for these metals contamination was neither universal across all sites nor consistent throughout the tidal cycle (Tables 3.6 and 3.7).

Levels for enterococci contamination often exceed guidelines for marine waters (i.e. >140 MPN/100ml = amber alert; >280 MPN/100ml = red alert). Levels appear to be correlated with rainfall, with the intensity of the event also having a bearing (Table 3.6). However, there is also evidence of bacterial contamination during dry spells, notably off Portsmouth drive in the substation area, in Andersons Bay Inlet and in the vicinity of the Wickliffe Street outfall.

It should be noted that the Consent condition (Appendix 2 B(c)) requires re-sampling of harbour water if trigger values are exceeded. However, has not been carried out because of the difficulty in replicating tide and weather conditions once results have been known.

Harbour water quality has not been specifically targeted in past annual stormwater sampling rounds. However, there are limited historic data available (Stewart and Ryder 2005) (Table 3.8). Levels of Cd, Cu and Pb fall within ranges observed in the past, but Cr, Ni, Zn and Enterococci do not. Unfortunately, there are no data on the state of the tide when these samples were collected, nor on whether or not it

was raining at the time. Consequently, any comparisons must be viewed with caution.

Table 3.6 *Contaminants in upper harbour basin water during a rain event on 23/5/14 that yielded 9mm of rainfall. Pink shaded cells indicate exceedence of ANZECC trigger values.*

ANZECC 95% (g/m3)	Wet		Dry	
As (0.036)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.004	<0.001	<0.0042	<0.004
Mason (H2)	<0.001	0.001	<0.0042	<0.004
Kitchener (H3)	0.002	0.004	<0.0042	<0.004
Substation (H6)	<0.001	0.003	<0.0042	<0.004
Vauxhall (H4)	<0.001	0.004	<0.0042	<0.004
Andy Bay Inlet (H5)	<0.001	0.001	<0.0042	<0.004

	Wet		Dry	
Cd (0.0055)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.00007	0.00005	<0.00021	<0.0002
Mason (H2)	<0.00001	0.00005	<0.00021	<0.001
Kitchener (H3)	<0.00001	<0.00001	<0.00021	<0.001
Substation (H6)	0.0001	<0.00001	<0.00021	<0.0002
Vauxhall (H4)	0.00005	0.00005	<0.00021	<0.001
Andy Bay Inlet (H5)	<0.00001	0.0001	<0.00021	<0.0002

	Wet		Dry	
Cr (0.004)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0005	0.001	<0.0011	<0.0011
Mason (H2)	0.0027	0.0011	<0.0011	<0.0011
Kitchener (H3)	0.0016	0.0005	<0.0011	<0.0011
Substation (H6)	0.0021	0.0006	<0.0011	<0.0011
Vauxhall (H4)	0.0025	0.0013	<0.0011	<0.0011
Andy Bay Inlet (H5)	0.0014	0.0022	<0.0011	<0.0011

	Wet		Dry	
Cu (0.0013)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.001	0.001	<0.0011	<0.0011
Mason (H2)	0.001	<0.001	<0.0011	0.0013
Kitchener (H3)	0.002	<0.001	<0.0011	<0.0011
Substation (H6)	0.003	<0.001	0.0012	<0.0011
Vauxhall (H4)	<0.001	<0.001	<0.0011	<0.0011
Andy Bay Inlet (H5)	0.001	0.003	<0.0011	0.0021

	Wet		Dry	
Pb (0.0044)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.00092	0.00059	<0.0011	<0.0011
Mason (H2)	0.00136	0.00037	<0.0011	<0.0011
Kitchener (H3)	0.0013	0.0002	<0.0011	<0.0053
Substation (H6)	0.00196	0.00039	<0.0011	<0.0011
Vauxhall (H4)	0.00031	0.00042	<0.0011	<0.0053
Andy Bay Inlet (H5)	0.00077	0.00099	<0.0011	<0.0011

	Wet		Dry	
Ni (0.07)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.001	0.0028	<0.0063	<0.0063
Mason (H2)	<0.0005	<0.0005	<0.0063	<0.032
Kitchener (H3)	0.0023	<0.0005	<0.0063	<0.032
Substation (H6)	<0.0005	0.0011	<0.0063	<0.0063
Vauxhall (H4)	<0.0005	<0.0005	<0.0063	<0.032
Andy Bay Inlet (H5)	<0.0005	0.0034	<0.0063	<0.0063

	Wet		Dry	
Zn (0.015)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.016	0.017	<0.0042	<0.0042
Mason (H2)	0.013	<0.005	<0.0042	0.0046
Kitchener (H3)	0.012	0.005	0.0064	<0.032
Substation (H6)	0.048	<0.005	0.0094	0.0101
Vauxhall (H4)	0.009	0.012	<0.0042	0.0134
Andy Bay Inlet (H5)	0.011	0.01	<0.0042	0.032

	Wet		Dry	
Enterococci (140 MPN/100ml)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	190	750	110	<10
Mason (H2)	590	180	20	<10
Kitchener (H3)	500	330	86	10
Substation (H6)	>2400	1100	>2400	560
Vauxhall (H4)	98	210	30	98
Andy Bay Inlet (H5)	150	2000	170	1100

Table 3.7 *Contaminants in upper harbour basin water during a rain event on 20/6/14 that yielded 3.4mm of rainfall. Pink shaded cells indicate exceedence of ANZECC trigger values.*

ANZECC 95% (g/m3)	Wet		Dry	
As (0.036)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0042	<0.0042	<0.0042	<0.0042
Mason (H2)	<0.0042	<0.0042	<0.0042	<0.0042
Kitchener (H3)	<0.0042	<0.0042	<0.0042	<0.0042
Substation (H6)	<0.0042	<0.0042	<0.0042	<0.0042
Vauxhall (H4)	<0.0042	<0.0042	<0.0042	<0.0042
Andy Bay Inlet (H5)	<0.0042	<0.0042	<0.0042	<0.0042

	Wet		Dry	
Cd (0.0055)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.00021	<0.00021	<0.00021	<0.00021
Mason (H2)	<0.00021	<0.00021	<0.00021	<0.00021
Kitchener (H3)	<0.00021	<0.00021	<0.00021	<0.00021
Substation (H6)	<0.00021	<0.00021	<0.00021	<0.00021
Vauxhall (H4)	<0.00021	<0.00021	<0.00021	<0.00021
Andy Bay Inlet (H5)	<0.00021	<0.00021	<0.00021	<0.00021

	Wet		Dry	
Cr (0.004)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0011	<0.0011	<0.0011	<0.0011
Mason (H2)	<0.0011	<0.0011	<0.0011	<0.0011
Kitchener (H3)	<0.0011	<0.0011	<0.0011	<0.0011
Substation (H6)	<0.0011	<0.0011	<0.0011	<0.0011
Vauxhall (H4)	<0.0011	<0.0011	<0.0011	<0.0011
Andy Bay Inlet (H5)	<0.0011	<0.0011	0.0015	<0.0011

	Wet		Dry	
Cu (0.0013)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.002	<0.0011	<0.0011	0.0019
Mason (H2)	0.0015	0.0035	<0.0011	<0.0011
Kitchener (H3)	<0.0011	0.0013	<0.0011	<0.0011
Substation (H6)	<0.0011	0.0017	<0.0011	<0.0011
Vauxhall (H4)	0.0018	<0.0011	<0.0011	<0.0011
Andy Bay Inlet (H5)	0.0013	0.0016	0.0021	<0.0011

	Wet		Dry	
Pb (0.0044)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0011	<0.0011	<0.0011	<0.0011
Mason (H2)	<0.0011	0.0013	<0.0011	<0.0011
Kitchener (H3)	<0.0011	<0.0011	<0.0011	<0.0011
Substation (H6)	<0.0011	<0.0011	<0.0011	<0.0011
Vauxhall (H4)	<0.0011	<0.0011	<0.0011	<0.0011
Andy Bay Inlet (H5)	0.0012	<0.0011	0.0019	<0.0011

	Wet		Dry	
Ni (0.07)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	0.0072	0.0066	<0.0063	<0.0063
Mason (H2)	0.0072	0.007	<0.0063	<0.0063
Kitchener (H3)	<0.0063	0.0066	<0.0063	<0.0063
Substation (H6)	<0.0063	0.0079	<0.0063	<0.0063
Vauxhall (H4)	<0.0063	0.0063	<0.0063	<0.0063
Andy Bay Inlet (H5)	<0.0063	0.0074	<0.0063	<0.0063

	Wet		Dry	
Zn (0.015)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	<0.0042	0.0068	<0.0042	0.0082
Mason (H2)	0.0044	0.0117	<0.0042	<0.0042
Kitchener (H3)	0.0065	<0.0042	<0.0042	<0.0042
Substation (H6)	<0.0042	<0.0042	<0.0042	0.0052
Vauxhall (H4)	0.0091	<0.0042	<0.0042	0.005
Andy Bay Inlet (H5)	0.0104	<0.0042	0.0196	0.0065

	Wet		Dry	
Enterococci (140 MPN/100ml)	Flood	Ebb	Flood	Ebb
Wickliffe (H1)	10	740	220	340
Mason (H2)	20	<10	<10	20
Kitchener (H3)	10	<10	10	10
Substation (H6)	63	63	10	20
Vauxhall (H4)	330	20	10	41
Andy Bay Inlet (H5)	230	360	310	63

Table 3.8 *Range of contaminant values observed in harbour water column historically. Data from Royds Garden (1990); ORC (1991); Stevenson (1998); Grove & Probert (1997); Wells (1996).*

Cd (g/m3)	Cr (g/m3)	Cu (g/m3)	Ni (g/m3)	Pb (g/m3)	Zn (g/m3)	Enterococci (MPN/100ml)
0.000018-0.00091	0.0005-0.002	0.00018-0.019	0.00078-0.00083	0.00024-0.0019	0.000025-0.0064	40-640

3.2 Sediments

Sediments were sampled on 19th May 2014 at sites detailed in Figure 2. As in the past, surface sediments (where visible) were generally clean with little surface detritus apart from a thick layer of organic material, mainly beach cast red algae (*Lenormandia chauvinii*) at the Orari Street site.

The levels of some contaminants were found to be higher than the trigger values stated in Appendix 2, Table C 1 (Table 3.9). However, levels of mercury, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and organochlorine pesticides were all very low. Sediment re-sampling of areas with high values awaits a suitable tide at an appropriate time of day.

Table 3.9 *Contaminant concentration in sediments sampled at the head of the Otago Harbour Basin. All concentrations are expressed as mg/kg dry weight. Pink shaded cells indicate where concentration exceeds ANZECC high trigger value and consent trigger value.*

Site	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	TPH	PAH	Organochlorines
Halsey Street	208	4.25	987	522	630	0.165	525	2380	<300	1.225	BDL
Kitchener Street	339	10.7	931	783	1760	0.28	402	8200	<150	4.591	0.017
Orari Street	77	2.07	246	124	318	0.033	113	1380	<130	1.077	BDL
Shore Street	79	3.31	293	314	1010	0.058	150	3220	<120	7.934	BDL

It is worthwhile pointing out that levels of most contaminants in sediments are higher at these sites than at other sites analysed within the upper harbour basin in the past (Table 3.10). However, historically, sediments were sampled much closer to stormwater outfalls that in 2014 so, once again, comparisons must be viewed with caution. This is particularly so for PAHs where the historic maximum is obtained from sediments collected close to the South Dunedin (Portobello Road) outfall, a site of particular concern with respect to PAH contamination (Stewart 2005, 2006).

Table 3.10 *Maximum contaminant concentrations, expressed as mg/kg, in sediments sampled in 2014 and historically. Data from Royds Garden 1990); Grove (1995); Purdie and Smith (1994); Bioresearches (2002); Stewart and Ryder (2004); Stevenson (1998); Grove & Probert (1997);*

	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	PAH
2014 maximum	339	11	987	783	1760	0.28	525	8200	7.9
Historic maximum	46	6.2	98	433	800	0.17	44	4450	651

4. Discussion and Conclusion

Monitoring of stormwater quality in Dunedin this year differs in some respects from previous years due to changes in consent conditions linked to the new discharge permits RM11.313.01-RM11.313.10. Overall, however, the results provided in this report give a good indication of stormwater quality discharged from the city, with more comprehensive data available for the South Dunedin catchment and good coverage of catchment discharges in dry weather conditions.

The ISCO automated sampler installed at the Portobello Pumping Station worked extremely well in collecting time/flow proportional samples. The only issue was that of "false alarms", i.e. the sampler would trigger but samples collected had to be discarded due to either the rain event not resulting in sufficient rainfall or the rain event occurring at a time that precluded getting samples to the laboratory within 24 hours.

As already mentioned, results for contaminants in samples collected by the automatic sampler were broadly similar to what one would expect during the first flush of a rain event and were not dissimilar to values observed over past sampling rounds. The higher peaks for some contaminants attests to the value of time weighted sampling, with grab samples in the past perhaps not coinciding with maximum contaminant concentrations, despite first flush being targeted.

Of concern is the fact that copper, lead and zinc all exceed the ANZECC trigger value for protection of 80% of species. These three contaminants are often of concern in stormwater in most urban centres (Stewart and Ryder 2004, Kennedy and Sutherland 2008). Measures to reduce their concentration include street sweeping, mud tank cleaning, gradual replacement of galvanised and copper pipes, painting or replacement of galvanised roof structures, the removal of lead

from petrol and the adoption of swales or similar to help remove suspended solids from stormwater.

Bacterial contamination of stormwater remains a problem with levels of *E. coli* being high during all sampled rain events. Once again, this is a common problem with stormwater, especially after dry spells of more than a couple of days. The DCC is working to eliminate illegal cross connections of sewerage and stormwater conduits, but it is very difficult to control contamination from animal droppings on impervious surfaces, other than by street sweeping and the installations of swales.

Dry weather flow sampling was not a requirement of the previous consents. Based on the results obtained for *E. coli* and FWAs this year, however, the value of it is quite evident when trying to establish sources of contamination. Those outfalls that show no evidence of contamination after three rounds of sampling, or that have negligible flow, have been reduced to 6 monthly sampling. Results have been extremely variable from outfall to outfall. The outfall with the highest contaminant levels (Magnet Street) is currently under investigation to try to determine likely sources of contamination. Other outfalls that may merit further investigation include St Clair, Wickliffe Street, Bauchop Street, Halsey Street, Orari Street and Midland Street.

It must be noted that high *E. coli* levels are common in stormwater discharges and the catchments serviced by the outfalls listed above have all shown high levels of *E. coli* contamination during wet flow sampling as well as during dry flow sampling.

Grab samples obtained during rain event shows results much the same as during previously sampled rain events. As with the automated sampler rounds, copper, lead and zinc are all problematic for many catchments and it is hoped that continued attention to mitigation measures such street sweeping, mud tank cleaning, gradual pipe and roof upgrading, and installation of swales where practicable will see levels of these contaminants slowly diminish through time. Bacterial contamination is an issue for the majority of catchments. The DCC is currently working to eliminate illegal cross connections but prevention of ingress of faecal matters from other than human sources remains a problem.

As mentioned in the introduction to this report, the majority of Dunedin's stormwater is discharged to the Upper Otago Harbour Basin. The fact that the upper harbour takes 4-6 tidal cycles to flush completely (Smith and Croot 1993, 1994) means that contaminants introduced with stormwater discharges may reside in the basin for up to three days after the cessation of any rain event. For prolonged rain events there is the possibility that concentration of contaminants in harbour water may increase throughout the rain event. However, the sheer volume of water in the upper harbour basin allows a great deal of dilution despite the longish residence time.

The results of harbour water sampling tend to support this hypothesis, with levels of most contaminants being well below ANZECC guidelines and even below detection limits for some. Not unexpectedly, there appears to be a relationship between contaminant concentration and wet weather. There is also a suggestion that higher levels of contamination occur on the incoming tide than on the outgoing tide - once again, a not unexpected result.

The area of most concern, as one would expect, is the area that is least well flushed, Andersons Bay Inlet. Here, in wet weather, the levels of copper and enterococci exceeded ANZECC guidelines. However, there were instances of exceedance for copper and zinc at other sites, both for wet weather and dry weather conditions.

The concentration of contaminants in harbour sediments continues to be of concern. Otago Harbour has, since early settlement, been a repository for contaminants generated by a wide variety of activities within and around Dunedin City (Stewart and Ryder 2004). Many of those contaminants settled out and become incorporated in the sediments of the harbour floor, often with quite patchy distributions (Stewart and Ryder 2004). Removal of such contaminants can only be achieved by dredging, or by relying on natural flushing, which in turn, relies on wind, wave and tidal action and can be exceedingly slow,.

Latest results show that levels of mercury, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and organochlorine pesticides were all very low. The levels of arsenic, copper, nickel and zinc all exceed ANZECC guidelines at most sites, but previous results, obtained much closer to

stormwater outfalls, are generally lower than these most recent figures. This suggests that levels of contaminants entering the harbour at present may be lower than what was discharged historically.

This is not unexpected as many industries that used to contribute significant quantities of harmful contaminants to the harbour have closed down or moved (e.g. tanning, timber treatment, gasworks, electroplating). The separation of sewerage and stormwater systems has also played a part in reducing the amount of contaminants entering the harbour.

Over the years then, the amount of contaminants in harbour sediment has diminished somewhat and will continue to do so as fewer contaminants enter the harbour and existing contaminants are either flushed out, or become buried under newer non-contaminated sediments. However, there is still room for improvement and the steps taken in more recent years to limit further the amount of contaminants entering the harbour will ultimately be of benefit.

Overall, it is expected that the implementation of the long-term stormwater catchment management plans developed through the DCC's Three Waters Strategy will contribute to addressing the issue of future contaminants in stormwater. It will be of interest to see if any long-term trends in contaminant levels can be discerned as monitoring continues.

However, only after problem areas and problem contaminants have been identified can measures be taken to mitigate any effects. Future monitoring, as prescribed in the conditions associated with the new discharge permits, will assist in defining problem areas such that further mitigation measures may be undertaken.

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6. Appendix 1. Consent conditions.

Environmental Monitoring
Condition 7.

The following monitoring shall be undertaken as specified in Appendix 2 and as shown in the plan in Appendix 3 to this consent.

(a) Stormwater quality monitoring
(b) Harbour receiving water quality
(c) Harbour sediment monitoring.
(d) Biological monitoring including cockles

Appendix 2 specifies:

A Stormwater Quality

TIME/FLOW PROPORTIONAL SAMPLES

(a) The consent holder shall install an automated monitoring device to record stormwater discharge quality over a duration of one year, once every five years, at the following outfalls in turn, being one outfall in each of the ICMP catchments of South Dunedin, Halsey Street, Shore Street, Kitchener Street and Mason Street:

(i) The automated monitoring device shall be set to take time or flow proportional samples within the first 2 hours of the sampled storm event within the catchment prior to any mixing with seawater and:

1. The monitoring device shall be set to be triggered by connection to either a rain gauge or a flow/water level monitor. If flows are used as the trigger, flow monitoring or stormwater modelling shall be used to set the trigger corresponding to a rainfall intensity of 0.5mm per hour. A period of flow and rainfall monitoring is to be undertaken prior to setting this trigger value, to ensure that the trigger is set appropriately to capture a full storm hydrograph.

2. There must be at least 72 hours of dry weather before the monitoring device is activated.

(ii) The consent holder shall sample a minimum of 3 storm events over the 1 year sampling duration at each outfall commencing six months from the date of granting of this consent. Any further sampling of the catchment may be at the discretion of the consent holder.

GRAB SAMPLES

(b) Once per year the consent holder shall take a grab sample of stormwater from an outfall in each of the 10 catchments described in the 10 permits that are subject to this appendix.

(i) The grab samples in the non priority catchments, i.e those that are not listed in (a) above shall be taken from the outfall in the non priority catchments with the highest flows during rainfall events or otherwise from an alternative outfall in agreement with the consent authority.

(ii) The grab samples in the priority catchments listed in (a) above shall not be required in the years when the automated monitoring device described in (a) above is operating in a catchment.

(iii) The grab sample shall be taken before the stormwater mixes with seawater, and shall be taken within the first 2 hours of a storm event, and following a period of 72 hours of no rainfall in the catchment.

ANALYTES

(c) All stormwater samples required under A(a) and (b) above shall be analysed for the following parameters:

(i) pH
(ii) suspended solids
(iii) Escherichia coli units
(iv) total copper
(v) total lead
(vi) total zinc
(vii) total arsenic
(viii) total nickel
(ix) total cadmium
(x) total chromium
(xi) polycyclic aromatic hydrocarbons
(xii) oil and grease

(d) The raw data results from each stormwater event shall be forwarded to the consent authority annually as part of the annual reporting required by condition 11.

B Harbour water quality monitoring

(a) Harbour water quality monitoring shall be undertaken annually to determine the effect the authorised stormwater discharge is having on water quality in the Otago Harbour and to determine whether the trigger values in table B 1 are being exceeded.

(b) Harbour water quality sampling shall be undertaken at the six locations as identified within the plan attached in Appendix 3 during wet and dry weather.

(i) Samples are to be taken on 4 occasions (two rounds (see below) annually.
(ii) Samples shall be taken no closer than 20 metres horizontal distance from the location of the confluence of the stormwater outlet and the waters edge if there are stormwater discharges occurring from the outfall at the time of sampling.
(iii) Samples must be taken 100-200mm below the surface of the water.
(iv) First round sampling shall be three hours apart following high tide, and at mid ebb tide during a period when there has been no measurable rainfall for at least 72 hours prior to sampling.
(v) The second round sampling will occur at the same state of tides as the first round, no less than three hours after the commencement of a rain event that is likely to produce at last 2 mm of rainfall and that has had an antecedent dry period of at least 72 hours.

(c) If harbour water quality sampling identifies the following contaminants at a level exceeding the trigger values set out below in table B 1, the level of contamination shall be confirmed by re-sampling and re-analysis.

(i) total cadmium
(ii) total copper
(iii) total lead
(iv) total zinc
(v) enterococci cfu/100ml (indicator organism)

Table B 1. Harbour Water Trigger Levels

Indicator	***Unit***	***ANZECC 95%Marine Guideline value***	***2013 Trigger***	***Description***
Total Arsenic	*(g/m$^{3)}$*		*0.036*	*USEPA chronic trigger*
Total Cadmium	*(g/m$^{3)}$*	*0.00550*	*0.00550*	*ANZECC guideline*
Total Chromium	*(g/m$^{3)}$*	*0.00440*	*0.00440*	*ANZECC guideline*
Total Copper	*(g/m$^{3)}$*	*0.00130*	*0.00130*	*ANZECC guideline*
Total Nickel	*(g/m$^{3)}$*	*0.07000*	*0.07000*	*ANZECC guideline*
Total Lead	*(g/m$^{3)}$*	*0.00440*	*0.00440*	*ANZECC guideline*
Total Zinc	*(g/m$^{3)}$*	*0.01500*	*0.01500*	*ANZECC guideline*
Enterococci	*Cfu/100ml*	*-*	*140*	*MfE guideline (amber alert)*

(d) If the harbour water quality is confirmed as exceeding the trigger values outlined in Table B 1, the protocol outlined in Condition 10 of the permits shall be implemented.

C Harbour sediment quality

(a) The consent holder shall undertake sediment quality sampling using sediment samples taken from the top 200 millimetres of the seabed. Samples shall be collected from the 5 locations as identified within the plan attached as Appendix 3. The sampling point shall be at or about 20 metres from the nearest stormwater outfall to each site marked on Appendix 3. Samples shall be collected between January and June, on an annual basis.

(b) The sediment properties and contaminants from each sample site are to be tested. At a minimum the consent holder shall for each of the sites collect and analyse one composite surface sediment sample made up of 5 sub-samples for:

(i) weak-acid extractable copper,
(ii) total lead,
(iii) total zinc,
(iv) total arsenic,
(v) total cadmium,
(vi) total chromium,
(vii) total copper,
(viii) total mercury,
(ix) total nickel,
(x) polycyclic aromatic hydrocarbons (the 16 USEPA priority compounds, retene, 2,6- and 1,7-methylated phenanthrene, and hopanes),
(xi) total petroleum hydrocarbons, and
(xii) organochlorine pesticides.

(c) The sample results obtained are to be forwarded to the Consent Authority along with a comparison with any previous monitoring in accordance with the annual reporting required by condition 11 of the permits that apply to this appendix.

(d) Table C 1 sets out the trigger levels for harbour sediments. The trigger levels may be changed with the written agreement of the consent authority, as new monitoring results or other information comes to hand. If agreement cannot be reached on (a) new trigger level/s the consent holder has the option of applying to vary the conditions under s127 of the Act.

(e) If harbour sediment sampling identifies the following contaminants at a level exceeding the trigger values set out below in table C 1, the level of contamination shall be confirmed by re-sampling and re-analysis. The effect of the trigger exceedance shall be assessed taking into account the results of biological monitoring that is nearest and/or most relevant to the sediment monitoring site.

Table C 1 Harbour Sediment Trigger Levels

Indicator	Unit	ANZECC Guideline		2013 Trigger	Reason for 2013 trigger	Amended Trigger Reason
		Low	High			
Total Arsenic	(mg/kg dry wt)	20	70	19	80th percentile of samples collected to date	
Total Cadmium	(mg/kg dry wt)	1.5	10	1.7	80th percentile of samples collected to date	
Total Chromium	(mg/kg dry wt)	80	370	80	ANZECC trigger most samples to date below ANZECC	
Total Copper	(mg/kg dry wt)	65	270	122	80th percentile of samples collected to date	
Total Nickel	(mg/kg dry wt)	21	52	21	ANZECC trigger most samples to date below ANZECC	
Total Lead	(mg/kg dry wt)	50	220	209	80th percentile of samples collected to date	
Total Zinc	(mg/kg dry wt)	200	410	902	80th percentile of samples collected to date	
Total PAH	(mg/kg dry wt)	4	45	183	80th percentile of samples collected to date	
TPH	(mg/kg dry wt)			To be determined	To be determined	
Enterococci	Cfu/100ml			108	80th percentile of samples collected to date	

(c) If the harbour sediment contamination is confirmed as exceeding the trigger values outlined in table C 1 and analysis of biological monitoring under (e) above supports that confirmation, the protocol outlined in Condition 10 of the permits shall be implemented.

D Biological Monitoring

EPIFAUNA, INFAUNA AND MACROFLORA

(a) The consent holder shall undertake biological sampling from the five locations identified on the plan attached as Appendix 3 to the permits. Samples shall be collected between the months of January and June at two yearly intervals. The monitoring shall include:

(b) Sampling is to be at 3 sites per location as follows: the waters edge at low tide; within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide, and a minimum of 50 metres from the confluence of the stormwater outlet and the waters edge at low tide.

(c) From the top 200 millimetres at each site, three randomly spaced 5 square metre quadrats shall be sampled for epifauna, infauna and macroflora.

(d) Sampling and species identification for each site shall include:

(i) For epifauna within each 5 square metre quadrat, the number of each species shall be recorded in five 0.1 square metre quadrats.

(ii) For infauna a sediment core shall be taken in three 0.1 square metre quadrats and the number of each species shall be recorded.

(iii) For macroflora, the percentage cover of each species shall be estimated in three 1.0 square metre quadrats.

COCKLES

(e) The consent holder shall undertake samples of the flesh of cockles (Austrovenus stutchburyi) at the 3 locations identified in Appendix 3 to the permits.

(i) Sampling shall be carried out at two yearly intervals.

(ii) Sampling from each location shall be at the waters edge at low tide and within 20 metres of the confluence of the stormwater outlet and the waters edge at low tide.

(iii) Analysis shall be from a composite sample from each location of at least 200 grams of cockle flesh. The number and size of cockles used shall be recorded.

(iv) If no cockles are present from in front of an outfall no sample to be taken at that location.

(v) The cockle flesh samples shall be analysed for:

1) total copper
2) total lead
3) total arsenic

4) total cadmium
5) total chromium
6) polycyclic aromatic hydrocarbons
7) Enterococcus Colony Forming Units in No/100 millilitres)

Dry weight sample results shall be recorded for each sample.

(f) The sample results from all biological monitoring shall be provided to the consent authority in accordance with the annual reporting required by condition 11 of the permits that apply to this appendix.