Catchment Load Monitoring

During the 2000/01 Wet Season

(Berry Creek and Winnellie Drain Stations)

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Introduction

Different activities (land uses) in the catchment may result in contaminants being transported to waterways which eventually discharge to coastal waters. These contaminants affect the quality of water in the waterways as well as the quality of the receiving waters to which they flow. The total amount of contaminant (mass) transported by waterways (rivers, creeks and drains) is referred to as the load (mass/unit time).

Since the 1990/91 wet season the department has been engaged in monitoring contaminants in run-off from different catchments in the greater Darwin region (Padovan 2000; Kernohan and Townsend 2000; Townsend 1992). The purpose of this monitoring is to determine what effect different catchment activities may be having on the contaminant load to coastal waters, and to monitor these loads as the intensity of catchment land use increases with time.

Seven locations in the Darwin region have been monitored at different times to determine how load varies with catchment activity, and from year to year with differing wet seasons.

The aim of this report is to present the results of monitoring contaminant loads during the 2000-01 wet season at Berry Creek and the Winnellie drain. This report will summarise these results and will compare these to loads measured in previous years.

Methods

During the 2000/2001 wet season, monitoring was undertaken at Berry Creek (G8150028) and the Winnellie drain (G8150016). Each station was activated before the onset of the wet season, and was maintained until flow ceased towards the beginning of the dry season. This study therefore does not consider dry season flows to the harbour which are considered negligible when compared to the dominant wet season flows.

A data logger was used to continuously record flow at both sites, and was programmed to activate an automatic water sampler after a pre-determined volume of water flowed past the gauging station. Sampling was therefore volume proportional and representative of all flow regimes (base flows and storm events). Note that the rating curves used at each site are the best available at the time. These curves are upgraded from time to time and may result in changes to the discharge, and therefore loads, that are calculated for each site.

At each station, pumped aliquots were combined in a 30 L polyethylene container to give a single large composite sample. At one to two week intervals, composite samples were well mixed and sub-sampled for chemical analysis of total nitrogen (TN = total Kjeldhal nitrogen (TKN) + nitrate/nitrite (NO_x)), total phosphorus (TP), aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni) and zinc (Zn), and total and volatile suspended solids (TSS and VSS). Metals were all measured as totals.

Suspended solids were analysed at the DPIF laboratory using Standard Methods (APHA, 1998). TKN and nitrate/nitrite was analysed at the Australian Water Quality Centre in Adelaide. Heavy metals were measured at the Australian Government Analytical Laboratory in Sydney.

The load for each contaminant (mass per wet season) at each site was calculated using the discharge data and chemical concentration data at each gauging station. For each sampling interval (one to two weeks) the mass of each contaminant exported from the catchment was calculated as the product of discharge volume and concentration. The mass for every sampling interval for the wet season was then summed to give the total load exported for the year. This load divided by the catchment area gives the export coefficient (or aerial load, mass per unit area per wet season). Therefore each contaminant for each site can be represented by a specific export coefficient.

If the concentration of a contaminant was reported by the laboratory to be below the level of detection, half the detection level was used for load calculations. If samples were not collected during a sampling period, the concentration was estimated as the average of the concentrations measured immediately before and after the period.

At Berry Creek there is no flow data for the period 12-15 February 2001 due to equipment failure. The missing period corresponded to falling water level after heavy sustained rainfall, and was estimated by linear interpolation.

Results and Discussion

Table 1 summarises the sampling intervals, and the corresponding number of sub-samples, discharge and concentration of constituents for both sites. Wet season flow commenced at Winnellie drain on October 15 2000 and ceased on 17 May 2001. Over this time 77% of the total discharge was sub-sampled. Berry Creek flowed from 4 December 2000 to 25 May 2001 with 72% of the total discharge sub-sampled.

Table 2 summarises total rainfall in Darwin as measured at the airport Bureau of Meteorology site. Rainfall during the 2000/01 wet season was 1,386 mm. This value is below the Darwin average of 1,600 mm, and is the driest year loads have been measured at Berry Creek and Winnellie Drain.

Table 3 summarises aerial loads measured during the 2000/01 wet season at Berry Creek and Winnellie drain. Aerial loads measured this wet season at both sites were consistent with values measured in past years. Loads measured at Winnellie were 1-2 orders of magnitude greater than those measured at Berry Creek. In general, loads were towards the low end of the range measured in the past for each respective land use. At Berry Creek, the loads for TN, As, Cd, Fe and VSS were the lowest measured to date. At Winnellie drain, with the exception of Cr and Zn, the loads for all contaminants were the lowest measured. This is the result of this wet season being the driest monitored to date. In past years, especially the 1996/97 wet season, wetter years have resulted in higher aerial loads being measured.

The flow-weighted mean concentration (FWMC) is a measure of contaminant levels that takes into account the importance of high flows to the total discharge. Table 4

summarises the FWMC for Berry Creek and Winnellie drain and compares these to values measured in past years. FWMC measured during the 2000/2001 wet season is consistent with values from the past, and are generally at the lower end of the range expected.

References

APHA (1998). Standard Methods for the Examination of Water and Wastewater 20th Edition.

Kernohan. A.K. and Townsend, S.A. (2000). Runoff water quality from an urban catchment (Karama, Darwin). Resource Management Branch, Natural Resources Division, Department of Lands, Planning and Environment. Report NR 2000/11.

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Townsend, S.A. (1992). Nutrient suspended solid and metal inputs, from point and non-point sources, into Darwin Harbour, November 1990 – October 1991. Water Resources Division, Power and Water Authority. Report 38/92.

Winnellie Drain (G8150016)

Interval Start		Interval End		No. Sub-	Discharge	TKN	Nox	TN	TP	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Zn	TSS	VSS
Date	Time	Date	Time	Samples	(ML)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(mg/L)	(mg/L)
15-Oct-00	12:00	16-Nov-00	8:53	-	29	1.11	0.878	1.988	0.416	2100	2.9	0.58	87	38	1800	45	86	4.9	500	97	25
16-Nov-00	8:53	01-Dec-00	11:00	58	31	1.11	0.878	1.988	0.416	2100	2.9	0.58	87	38	1800	45	86	4.9	500	97	25
01-Dec-00	11:00	06-Dec-00	10:30	91	38	0.25	0.111	0.361	0.109	470	1.4	0.16	9	7.2	340	8.8	22	1.2	170	19	5
06-Dec-00	10:30	12-Dec-00	9:55	0	15	0.52	0.417	0.932	0.287	1335	2.2	0.37	25	17.6	1170	25.9	57.5	2.75	265	60.5	13
12-Dec-00	9:55	20-Dec-00	9:15	32	7	0.78	0.722	1.502	0.465	2200	3	0.58	41	28	2000	43	93	4.3	360	102	21
20-Dec-00	9:15	22-Dec-00	8:50	4	1	0.68	0.582	1.262	0.410	1700	2.35	0.425	31	22.5	1650	33.5	69.5	3.35	305	83.5	18
22-Dec-00	8:50	03-Jan-01	9:50	55	44	0.58	0.442	1.022	0.355	1200	1.7	0.27	21	17	1300	24	46	2.4	250	65	15
03-Jan-01	9:50	12-Jan-01	8:50	110	93	0.2	0.458	0.658	0.11	1100	1.4	0.21	10	11	970	18	26	1.7	180	60	10
12-Jan-01	8:50	15-Jan-01	12:35	?	19	0.2	0.458	0.658	0.11	1100	1.4	0.21	10	11	970	18	26	1.7	180	60	10
15-Jan-01	12:35	05-Feb-01	14:05	84	73	0.3	0.198	0.498	0.195	450	1.1	0.11	12	9.8	690	11	18	3	160	29	8
05-Feb-01	14:05	12-Feb-01	9:00	101	129	0.19	0.302	0.492	0.188	630	0.98	0.12	1.8	5.3	480	7.2	11	1.3	200	21	4
12-Feb-01	9:00	19-Feb-01	9:50	101	151	0.27	0.195	0.465	0.08	710	0.99	0.14	8.3	8.1	570	9.8	16	1.2	150	34	8
19-Feb-01	9:50	05-Mar-01	14:45	0	102	0.19	0.138	0.328	0.073	410	0.785	0.095	6.7	6.15	365	6.05	10.75	1.3	160	19	5
05-Mar-01	14:45	16-Mar-01	8:40	101	53	0.11	0.081	0.191	0.065	110	0.58	0.05	5.1	4.2	160	2.3	5.5	1.4	170	4	2
16-Mar-01	8:40	25-Mar-01	15:25	100	50	0.2	0.211	0.411	0.073	500	0.75	0.15	7.2	5.5	460	7.8	16	1.2	170	20	6
25-Mar-01	15:25	26-Mar-01	8:50	0	3	0.2	0.244	0.474	0.075	435	0.4	0.13	5.55	6	400	6.55	13.5	1.03	145	20.5	5.5
26-Mar-01	8:50	31-Mar-01	19:15	101	22	0.26	0.277	0.537	0.076	370	0.05	0.11	3.9	6.5	340	5.3	11	0.86	120	21	5
31-Mar-01	19:15	12-Apr-01	8:25	0	39	0.19	0.215	0.400	0.129	275	0.32	0.105	5.2	6.1	300	4.6	9.55	1.83	155	14	3.5
12-Apr-01	8:25	23-Apr-01	14:00	98	37	0.11	0.152	0.262	0.182	180	0.59	0.1	6.5	5.7	260	3.9	8.1	2.8	190	7	2
23-Apr-01	14:00	09-May-01	8:34	?	46	0.27	0.213	0.483	0.28	200	0.25	0.05	15	8	460	4.3	16	0.9	160	8	3
09-May-01	8:34	17-May-01	10:10	0	20	0.27	0.213	0.483	0.28	200	0.25	0.05	15	8	460	4.3	16	0.9	160	8	3
End of Sampling					1,002																

Berry Creek (G8150028)

Interval Start		Interval End		No. Sub-	Discharge	TKN	Nox	TN	TP	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Zn	TSS	VSS
Date	Time	Date	Time	Samples	(ML)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(mg/L)	(mg/L)
04-Dec-01	12:00	12-Dec-00	11:00	3	6	0.39	0.003	0.393	0.018	920	0.25	0.05	1.4	1.5	1300	1	44	1	5.7	42	5
12-Dec-00	11:00	20-Dec-00	10:25	18	385	0.39	0.003	0.393	0.018	920	0.25	0.05	1.4	1.5	1300	1	44	1	5.7	42	5
20-Dec-00	10:25	03-Jan-01	12:52	50	1,188	0.35	0.003	0.353	0.013	650	0.25	0.05	1.1	2.4	1100	0.88	29	0.74	3.4	25	5
03-Jan-01	12:52	04-Jan-01	22:30	56	514	0.3	0.037	0.337	0.02	2300	0.25	0.05	3	2.4	2500	3.4	100	1.5	3	138	14
04-Jan-01	22:30	15-Jan-01	13:32	-	4,097	0.27	0.020	0.285	0.016	1390	0.25	0.05	1.9	1.9	1580	2.0	58	1.1	3.1	79	9
15-Jan-01	13:32	17-Jan-01	7:50	61	1,444	0.23	0.003	0.233	0.012	480	0.25	0.05	0.86	1.4	660	0.63	16	0.62	3.2	20	3
17-Jan-01	7:50	22-Jan-01	11:25	-	2,386	0.23	0.003	0.228	0.011	370	0.25	0.05	0.72	1.4	595	0.47	10.7	0.53	5.4	14	3
22-Jan-01	11:25	05-Feb-01	15:15	46	4,630	0.22	0.003	0.223	0.009	260	0.25	0.05	0.57	1.4	530	0.31	5.3	0.43	7.5	7	2
05-Feb-01	15:15	12-Feb-01	4:00	60	4,136	0.2	0.003	0.203	0.009	300	0.25	0.05	0.67	0.87	680	0.45	13	0.77	30	13	2
12-Feb-01	4:00	12-Feb-01	11:30	-	980	0.2	0.003	0.198	0.010	450	0.25	0.05	0.83	1.6	630	0.64	14	0.89	18.7	16	2
12-Feb-01	11:30	19-Feb-01	11:35	61	12,443	0.19	0.003	0.193	0.01	600	0.25	0.05	0.99	2.3	580	0.82	15	1	7.4	18	2
19-Feb-01	11:35	03-Mar-01	13:55	61	8,685	0.18	0.003	0.183	0.01	450	0.25	0.05	0.77	1.3	410	0.43	9.1	0.54	2.8	7	1
03-Mar-01	13:55	05-Mar-01	13:45	-	2,201	0.18	0.003	0.178	0.009	375	0.25	0.05	0.64	0.9	355	0.35	6.5	0.47	3.1	5	1
05-Mar-01	13:45	16-Mar-01	9:55	44	5,550	0.17	0.003	0.173	0.008	300	0.25	0.05	0.51	0.56	300	0.26	3.8	0.39	3.4	3	1
16-Mar-01	9:55	26-Mar-01	10:00	45	4,267	0.22	0.003	0.223	0.011	280	0.25	0.05	0.47	0.51	480	0.32	9.4	0.32	4.2	8	3
26-Mar-01	10:00	31-Mar-01	7:50	60	3,943	0.21	0.003	0.213	0.011	320	0.25	0.05	0.59	0.6	500	0.43	13	0.47	1.2	14	3
31-Mar-01	7:50	12-Apr-01	11:30	-	8,715	0.20	0.003	0.203	0.010	199	0.25	0.05	0.45	0.6	390	0.28	14	0.40	1.5	9	3
12-Apr-01	11:30	23-Apr-01	15:10	7	1,136	0.19	0.003	0.193	0.009	78	0.25	0.05	0.31	0.67	280	0.12	14	0.33	1.7	3	2
23-Apr-01	15:10	09-May-01	9:40	-	498	0.19	0.003	0.193	0.009	78	0.25	0.05	0.31	0.67	280	0.12	14	0.33	1.7	3	2
09-May-01	9:40	25-May-01	12:00	10	234	0.19	0.003	0.193	0.009	78	0.25	0.05	0.31	0.67	280	0.12	14	0.33	1.7	3	2
End of sampling					67,439																

Table 1. Summary of sampling intervals and corresponding discharge and water chemistry data for Winnellie Drain and Berry Springs gauging stations during the 2000-2001 wet season. Values in yellow shading were reported by the laboratory to be below their levels of detection and are presented as half the detection limits. Values in blue shading is missing data that have been estimated as the average of the values immediatley and after the missing interval. See methods for explanation of chemical symbols used.

Land use	Site	Year	Rain (mm)
Undisturbed	Celia Creek	1995/96	1,453
	Celia Creek	1996/97	2,374
	Manton River	1996/97	2,374
Rural	Elizabeth River	1990/91	2,217
	Elizabeth River	1995/96	1,453
	Elizabeth River	1996/97	2,374
	Berry Creek	1999/2000	2,209
	Berry Creek	2000/01	1,385
Urban	Karama drain	1990/91	2,217
	Karama drain	1991/92	1,038
	Moil drain	1995/96	1,453
	Moil drain	1996/97	2,374
Industrial	Winnellie drain	1995/96	1,453
	Winnellie drain	1996/97	2,374
	Winnellie drain	1999/2000	2,209
	Winnellie drain	2000/01	1,385

Table 2. Rainfall as measured at Darwin airport during each wet season export coeffients were measured. The average for Darwin is 1,600 mm. The 1996/97 wet season is a record wet year. New data presented in this this report is highlighted.

Land use	Site	Year	TP kg/Ha	TN kg/Ha	Al kg/Ha	As g/Ha	Cd g/Ha	Cr g/Ha	Cu g/Ha	Fe kg/Ha	Mn g/Ha	Pb g/Ha	Ni g/Ha	Zn g/Ha	TSS kg/Ha	VSS kg/Ha	Source
Undisturbed	Celia	95/96	0.0422	0.6914	-	0.4686	0.1340	2.227	5.968	-	-	1.338	1.539	2.767	47.91	8.322	Padovan (2000)
	Celia	96/97	0.5049	6.576	-	3.714	1.311	13.83	21.88	-	-	11.96	9.815	-	288.2	63.57	Padovan (2000)
	Manton	96/97	0.3007	4.346	-	9.344	0.4829	7.456	58.26	-	-	7.020	6.756	39.85	153.7	49.00	Padovan (2000)
Rural	Elizabeth	90/91	0.05	2.4	-	-	-	13	21	-	-	13	16	110	57	-	Townsend (1992)
	Elizabeth	95/96	0.0399	1.464	-	1.422	0.6331	2.538	20.81	-	-	1.847	2.095	116.2	60.13	16.17	Padovan (2000)
	Elizabeth	96/97	0.2931	5.197	-	4.818	0.7156	7.556	4.685	-	-	4.949	4.689	103.6	204.0	54.54	Padovan (2000)
	Berry	99/00	0.0758	2.171	1.386	1.763	0.4452	3.628	4.968	3.403	68.18	2.454	1.806	24.09	69.84	18.34	Padovan (2000)
	Berry	00/01	0.0510	1.029	2.240	1.232	0.2463	3.839	6.271	2.848	73.31	2.864	3.084	28.90	79.22	12.50	This report
Urban	Karama	90/91	0.7	11	-	-	-	81	110	-	-	320	66	1900	610	-	Townsend (1992)
	Karama	91/92	0.4	5	-	-	-	55	38	-	-	361	-	331.0	956	228.0	Kernohan and Townsend (2000)
	Moil	95/96	1.965	12.56	-	13.54	4.970	14.10	144.5	-	-	352.2	9.672	694.8	714.5	320.8	Padovan (2000)
	Moil	96/97	2.268	16.94	-	14.26	1.740	16.94	52.46	-	-	350.3	8.949	669.9	820.2	218.3	Padovan (2000)
Industrial	Winnellie	95/96	5.730	18.95	-	47.13	7.554	468.8	299.9	-	-	550.8	59.87	3750	1802	303.1	Padovan (2000)
	Winnellie	96/97	14.92	71.91	-	253.1	18.86	1723	793.9	-	-	900.8	138.2	9327	1798	422.0	Padovan (2000)
	Winnellie	99/00	5.098	16.50	21.75	41.18	21.57	246.7	233.6	19.33	529.3	337.9	40.28	4527	923.2	188.5	Padovan (2000)
	Winnellie	00/01	3.452	12.37	14.69	22.81	3.501	286.6	210.4	13.77	464.9	253.2	38.30	4147	697.2	161.3	This report

Table 3. Summary of export coefficients (aerial loads) from this and past studies for catchments in and around Darwin harbour.

Land Use	Site	Year	TP mg/L	TN mg/L	Al ug/L	As ug/L	Cd ug/L	Cr ug/L	Cu ug/L	Fe ug/L	Hg ug/L	Mn ug/L	Pb ug/L	Ni ug/L	Zn ug/L	TSS mg/L	VSS mg/L	
Undisturbed	Celia	95/96	0.021	0.34	-	0.23	0.07	1.09	2.92	-	<0.1	-	0.7	0.8	1	23	4	Padovan (2000)
	Celia	96/97	0.044	0.57	-	0.32	0.11	1.20	1.90	-	<0.1	-	1.0	0.9	-	25	6	Padovan (2000)
	Manton	96/97	0.031	0.45	-	0.97	0.05	0.77	6.03	-	<0.1	-	0.7	0.7	4	16	5	Padovan (2000)
										-		-						
Rural	Elizabeth	90/91	0.008	0.37	-	-	-	2.00	3.00	-	-	-	2	3	18	9	-	Townsend (1992)
	Elizabeth	95/96	0.008	0.31	-	0.30	0.13	0.54	4.40	-	<0.1	-	0.4	0.4	25	13	3	Padovan (2000)
	Elizabeth	96/97	0.020	0.36	-	0.34	0.05	0.53	0.33	-	<0.1	-	0.4	0.3	7	14	4	Padovan (2000)
	Berry	99/00	0.011	0.31	-	0.25	0.06	0.52	0.71	-	-	-	0.4	0.3	3	10	3	Padovan (2000)
	Berry	00/01	0.010	0.21	455	0.25	0.05	0.78	1.27	578	-	15	0.6	0.6	6	16	3	This report
										-		-						
Urban	Karama	90/91	0.037	0.6	-	-	-	5.00	6.00	-	-	-	18	4	100	34	-	Townsend (1992)
	Karama	91/92	0.062	0.81	-	-	-	8.50	5.90	-	-	-	56	-	51	149	35	Kernohan and Townsend (2000)
	Moil	95/96	0.107	0.68	-	0.74	0.27	0.77	7.87	-	<0.1	-	19	0.5	38	39	17	Padovan (2000)
	Moil	96/97	0.087	0.65	-	0.55	0.07	0.65	2.01	-	<0.1	-	13	0.3	26	31	8	Padovan (2000)
										-		-						
Industrial	Winnellie	95/96	0.270	0.89	-	2.22	0.36	22.10	14.14	-	<0.1	-	26	3	177	85	14	Padovan (2000)
	Winnellie	96/97	0.246	1.19	-	4.18	0.31	28.43	13.10	-	<0.1	-	15	2	154	30	7	Padovan (2000)
	Winnellie	99/00	0.159	0.53	678	1.28	0.67	7.69	7.28	602	<0.1	17	11	1	141	29	6	Padovan (2000)
	Winnellie	00/01	0.162	0.58	689	1.07	0.16	13.44	9.87	646	-	22	12	2	195	33	8	This report

Table 4. Flow weighted mean concentration of contaminants measured in this and past studies.