
Storys Creek Water Quality Monitoring Results

10 February 2005

March 2005

A Report to Mineral Resources Tasmania

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Technical Advice on Water



1 Introduction

Mineral Resources Tasmania (MRT) has implemented large-scale remediation works at the historic Storys Creek mine site in eastern central Tasmania, including the removal of the contents of a precipitation dam, closure of adits, removal of some tailings and implementation of an anoxic limestone drain. A 3-year water quality monitoring program was initiated in September 2003 to determine the concentrations and fluxes of pollutants leaving the site and evaluate the efficacy of the remediation works.

This report summarises the results from the sixth water quality-monitoring run completed on February 10, 2005 and compares results to previous findings.

2 Sampling details

Water quality and flow monitoring was completed on 10 February 2004 by L. Koehnken of Technical Advice on Water and W. Grunn of Mineral Resources Tasmania. All sites in Table 1 were visited and at each pH, conductivity and temperature was measured *in situ* and a water sample was collected for subsequent analysis of metals, sulphate, fluoride and alkalinity.

At the Storys below Precipitate Dam site, Storys below Nisbet Creek, Storys at Managers, Storys above Aberfoyle and Aberfoyle above Storys site, the dimensions of the channel were measured (width, depth at various points) and flow measurements were made using a flow-meter at 2 – 3 points across a transect at a depth of 0.6 of the water depth (from the surface). The flow estimates were used to establish fluxes at each of the sites. The ‘Storys below Precipitation Dam’ site flow measurement was used in the flux calculations for three sites (Storys Creek above mine, Storys below PPT dam, and Storys above Side Creek) because flow varies little between the sites and the site yields the most accurate flow estimate due to the presence of bedrock, resulting in a stable channel with confined flow.

Flow from the ALD was measured using a calibrated bucket and stopwatch. Flow from the Precipitate Dam was estimated because flow from the dam was not confined to the outflow pipe. Flow from the Eastern Adit was determined using the height of the water in the V-notch weir, and a generalised USGS equation for calculating V-notch flow. Sedimentation of iron floc in the portal of the Eastern Adit is presently affecting the accuracy of the V-notch.

Conditions during sampling on February 10 were fine, and followed 5 rain-free days. Between February 1st and February 6th, however, 68.8 mm of rain was recorded at Fingal and 30.4 mm at Powranna with the maximum fall (47 mm at Fingal) occurring on the 2nd, associated with a large south eastern storm system.

Table 1. Site number and location of monitoring points.

Site Number	Site Location	Justification
ALD	Anoxic Drain outflow at Storys Creek	Provide indication of alkalinity input to underground workings
2	Storys Cr above mine workings	Provides background water quality and indication of upstream changes
5	Storys Cr below Precipitation Dam	Provide record of changes since dam removal – should continue to change as groundwater ‘flushes’ through system
7	Storys above Side Creek	Indicate pollutant load from tailings deposit located upstream Side Cr
8	Storys Cr below Side Creek	Significant pollutant load enters via Side Creek
10	Eastern Adit outflow	Adit plugged, monitoring of pH indicates effectiveness of works
13	Storys below Nisbet	Indicates inputs from diffuse sources downstream of Side Creek and dilution from entrance of Nisbet Cr
14	Storys at Managers*	Continue best long-term data collection point; indicates diffuse load entering between Nisbet and Pumphouse
21	Storys Above Aberfoyle	Final measurement of pollutant load in Storys Creek
23	Storys below Aberfoyle	Indicative of water entering South Esk
22	Aberfoyle Creek	Has elevated zinc levels and contributes to loads entering S. Esk
24	South Esk above Storys	‘Background’ water quality in South Esk River
25	South Esk d/s Storys	Estimate of Storys Creek impact on S. Esk
4	Precip. dam outflow	Historic pollutant source
6	Side Creek	Historic pollutant source

*This site has been referred to as both Storys below Pumphouse and Storys at Manager’s. In this and subsequent reports ‘Storys at Manager’s’ will be used.

3 Results and discussion

Water quality results are presented in Table 2 -Table 4, and discussed in the following sections.

3.1 Flows

Flows in February 2005 were moderately low, with ~70L/s recorded at the mine site, ~120 L/s recorded at the Managers Residence and ~160 L/s measured at Storys above Aberfoyle. Flow from the ALD was very low due to a broken pipe feeding water to the ALD holding pond. Discharge was also very low (<1 L/s) from the Precipitate Dam, and Eastern Adit. There was a trickle of water present in Side Creek, however the flow did not reach the wetlands at the confluence with Storys Creek.

Photos 1-4 compare flow in February 2005 (Photo 4) with low flow conditions in November 2003, high flow conditions in September 2003, and the previous monitoring conditions in July 2004.



Photo 1. & Photo 2 Storys Creek at Managers Residence, view upstream. Photo 1 (left) shows lowest flow ever monitored (50 L/s) recorded in February 2004, and Photo 2 (right) shows highest flow monitored (1,000 L/s), recorded in September 2003.



Photo 3 & Photo 4. Storys Creek at Managers Residence, view upstream. Photo 3 (left) 14 July 2004. Flow rate 400 L/s. Photo 4 (right). 10 February 2005, flow rate = 120L/s

Flow in Storys Creek above Aberfoyle (155 L/s) was about twice the flow in Aberfoyle Creek (70 L/s). These flows are consistent with the zinc concentrations measured in Storys above Aberfoyle, Aberfoyle Creek and Storys below Aberfoyle, and provides confidence in the flow estimates.

3.2 Water quality results – concentrations

Water quality results for February 2005 are presented in Table 2, Table 3 and Table 4. Table 2 contains the water quality results from the regular monitoring sites on Storys Creek, Aberfoyle Creek and the South Esk River. Table 3 shows the pH, conductivity and temperature data collected in the field, and an estimate of metal and sulphate fluxes for each of the regular monitoring sites. Table 4 shows results for samples from the ALD, Side Cr, Eastern Adit, and samples collected from the lower Storys and Aberfoyle Creeks by a local resident during a moderate flood event in November 2004.

3.3 Anoxic Limestone Drain (ALD)

Alkalinity concentrations in the ALD and upper Storys Creek for February are shown in Figure 3.1 along with previous results. The alkalinity concentration in the ALD was very high in February while the levels in upper Storys Creek were consistent with

previous results. Flow in the drain was very low, due to a rupture in the pipeline that directs water into the pond feeding the ALD. This very low water flow resulted in low alkalinity fluxes exiting the drain, in spite of the very high concentrations. As shown in Figure 3.2, the fluxes are the lowest recorded, with <0.7 kg of alkalinity exiting the drain each day. Due to clogging of the surface drain which directs the ALD outflow into the under ground workings, it is not clear where or if the alkalinity rich water is entering the mine.

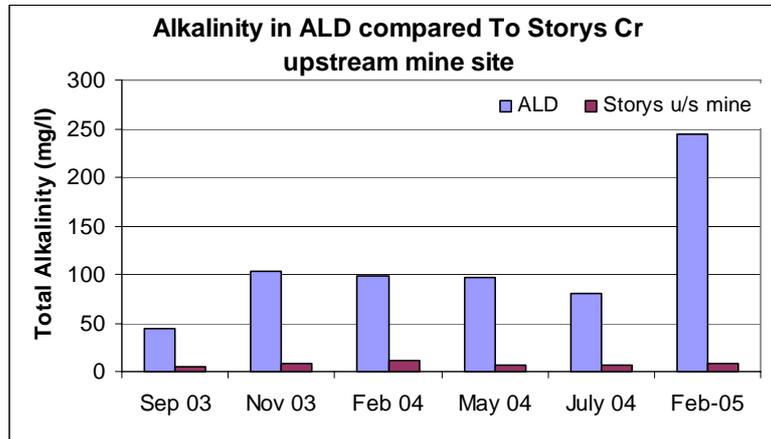


Figure 3.1. Alkalinity levels in water from the ALD compared to alkalinity levels in Storys Creek above the mine site.

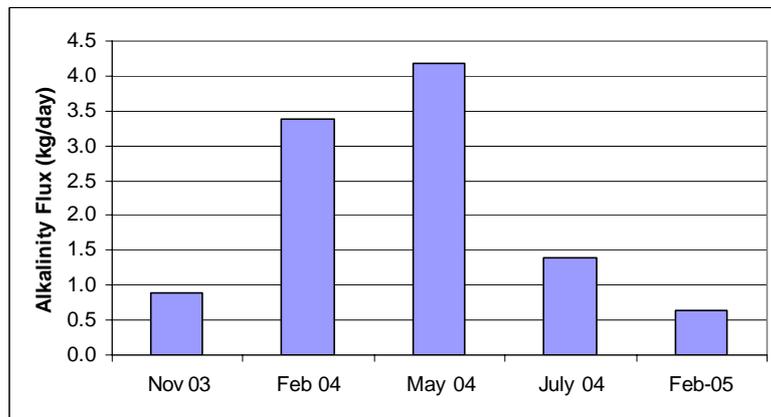


Figure 3.2 Alkalinity flux from ALD at Storys Creek.

Table 2. Water quality results and flow for Storys Creek monitoring, February 26, 2004. All units µg/L except Fluoride, Sulphate and Alkalinity, which are mg/l.
*Flow calculated by adding Storys above Aberfoyle, and Aberfoyle Creek flows

		Storys Ab Mine	Precip Dam Outflow	Storys Bel Precip	Storys Ab Side Cr	Storys Bel Side Cr	Storys Bel Nisbet	Storys at Manage r	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys	S. Esk Ab Storys	S. Esk Bel Storys
Date		10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05
Alkalinity Total	mg/l CaCO ₃	8	8	8	6	<1	6	1	2	9	26	21	20
Fluoride	mg/l	<0.02	1	<0.02	0.26	0.95	0.24	0.17	0.21	0.48	1	<0.02	<0.02
Sulphate	mg/l	0.42	120	2.6	14	49	27	31	30	42	70	3.2	5.6
Al Dis	µg/l	<20	<20	<20	<20	421	21	41	<20	<20	<20	96	82
Al Total	µg/l	27	199	42	88	515	100	81	48	42	<20	285	310
As Dis	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
As Total	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cd Dis	µg/l	<1	392	3	52	81	41	60	48	29	12	<1	1
Cd Total	µg/l	<1	399	4	51	80	42	58	47	36	13	<1	2
Co Dis	µg/l	<1	25	<1	<1	6	1	<1	<1	<1	<1	<1	<1
Co Total	µg/l	<1	26	<1	<1	6	1	<1	<1	<1	<1	<1	<1
Cr Dis	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr Total	µg/l	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	1
Cu Dis	µg/l	<1	9	<1	52	82	16	54	13	7	5	<1	1
Cu Total	µg/l	<1	16	2	59	85	24	56	15	12	7	1	3
Fe Dis	µg/l	<20	<20	<20	<20	196	24	<20	<20	<20	<20	271	266
Fe Total	µg/l	<20	279	22	20	885	108	29	29	26	21	450	452
Mn Dis	µg/l	<5	2320	12	43	532	116	66	31	19	15	<5	<5
Mn Total	µg/l	<5	2340	12	43	526	118	64	30	24	15	14	12
Ni Dis	µg/l	<1	32	<1	2	7	2	3	1	1	<1	<1	<1
Ni Total	µg/l	<1	34	1	3	9	3	4	2	2	1	<1	<1
Pb Dis	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pb Total	µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zn Dis	µg/l	<1	9060	91	1060	1910	1000	1370	1050	631	306	<1	27
Zn Total	µg/l	<1	9220	93	1040	1890	1020	1340	1030	776	313	<1	36
Flow	l/s	70	0.5	70	70	70	115	120	155	250*	70		

Table 3. Flow, pH conductivity and temperature results collected in situ, 14 July 2004 and flux calculations based on flows and analytical results.

*Flow estimate from Storys below Precip dam used to estimate fluxes.

#Calculated based on Storys above Aberfoyle & Aberfoyle above Storys

		Storys Ab Mine*	Precip Dam Outflow	Storys Bel Precip	Storys Ab Side Cr*	Storys Bel Side Cr*	Storys Bel Nisbet	Storys at Manager	Storys Ab Aber	Storys Bel Aber	Aber Ab Storys#	S. Esk Ab Storys	S. Esk Bel Storys
Parameter	Unit	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05
Flow	l/s	70	0.5	70	70	70	115	120	155	255	70		
pH (field)	pH units	7.7	7.1	7.6	6.8	6.0	6.8	6.3	6.6	7.08	7.3	7.09	7.3
Temp	°C	9.1	16.4	11.0	11.1	12.0	11.3	16.1	21.0	21.6	21.9	19.9	20.5
Zn tot flux	kg/d	0.00	0.40	0.56	6.29	11.43	10.13	13.89	13.79	15.09	1.89		
Cd tot flux	kg/d	0.00	0.02	0.02	0.31	0.48	0.42	0.60	0.63	0.70	0.08		
Mn tot flux	kg/d	<0.03	0.10	0.07	0.26	3.18	1.17	0.66	0.40	0.47	0.09		
Fe tot flux	kg/d	<0.12	0.01	0.13	0.12	5.35	1.07	0.30	0.39	0.51	0.13		
SO ₄ flux	kg/d	2.5	5.2	15.7	84.7	296.4	268.3	321.4	402	816	423		

		ALD	Nisbet Cr	Side Creek	Eastern Adit
Date		10 Feb 05	10 Feb 05	10 Feb 05	10 Feb 05
Flow		0.03		trickle	0.01
pH (field)	pH units	7.2	6.8	3.8	6.4
Conductivity	µS/cm	572	32.3	255	363
Temperature	°C	15.5	8.3	14.3	16.1

Table 4. Water quality results for the anoxic limestone drain (ALD), the minor flows present in Side Creek and Eastern Adit. Also shown are water quality results from samples collected by Doug Loane form Storys above Aberfoyle and Aberfoyle above Storys during a moderate flood event on 7 November 2004.

		ALD	Side Cr	Eastern Adit	Storys Above Aberf	Aber ab Storys
Date		10 Feb 05	10 Feb 05	10 Feb 05	7 Nov 04	7 Nov 04
Alkalinity Total	mg/l CaCO ₃	245	<1	6		
Fluoride	mg/l		4.4	2.1		
Sulphate	mg/l		110	150		
Al Dis	µg/l	<20	2700	291		
Al Total	µg/l	<20	2600	1280	227	363
As Dis	µg/l	<5	<5	<5		
As Total	µg/l	<5	<5	70	<5	<5
Cd Dis	µg/l	<1	127	30		
Cd Total	µg/l	<1	123	39	17	9
Co Dis	µg/l	<1	16	25		
Co Total	µg/l	1	15	55	<1	<1
Cr Dis	µg/l	<1	<1	<1		
Cr Total	µg/l	<1	<1	<1	<1	<1
Cu Dis	µg/l	2	113	<1		
Cu Total	µg/l	3	110	2	29	34
Fe Dis	µg/l	23	331	<20		
Fe Total	µg/l	389	488	45600	179	893
Mn Dis	µg/l	<5	1030	2580		
Mn Total	µg/l	159	999	3490	21	98
Ni Dis	µg/l	<1	34	55		
Ni Total	µg/l	<1	34	62	<1	2
Pb Dis	µg/l	<5	<5	<5		
Pb Total	µg/l	<5	<5	<5	<5	<5
Zn Dis	µg/l	<1	3680	1900		
Zn Total	µg/l	8	3550	2410	378	304

3.4 Metal concentrations in Storys Creek

The water quality monitoring results from February 2005 show similar trends as previous runs:

- Arsenic, chromium and lead are present at or below the reporting limit of the laboratory at all the regular monitoring sites. Total arsenic levels are elevated in the Eastern Adit sample (70 µg/L) although dissolved levels are below the reporting limit of 5 µg/L.
- Cobalt and nickel concentrations are low at the monitoring sites within Storys Creek. Both metals are present at higher concentrations in the Precipitate Dam outflow, Side Creek and Eastern Adit;
- The major sources of fluoride to Storys Creek are the Precipitate Dam, the area around Side Creek and Aberfoyle Creek;
- There is a pH and alkalinity minimum in Storys Creek downstream of Side Creek. Values of both parameters increase at Storys below Nisbet, but again decrease at the Storys at Manager site, suggesting additional diffuse sources are entering the river between these sites;
- The water quality of the trickle of flow in Side Creek is consistent with the oxidation of sulphides, having low pH, high sulphate, high conductivity and elevated temperature;
- Figure 3.3 - Figure 3.5 show there are increases in zinc, cadmium and sulphate concentrations at the Storys above Side Creek and Storys below Side Creek monitoring site.. As the flow does not change appreciably over this reach of the river, the increase in concentrations indicates metals and sulphate are entering in this area;
- Downstream of the Storys below Side Creek, there is a gradual decrease in metal and sulphate levels;
- Compared to ANZECC trigger values, arsenic, cadmium, copper and zinc are elevated at the Managers Residence site, and cadmium, copper and zinc are elevated at Storys below Aberfoyle just upstream from where the river enters the South Esk.

The zinc and cadmium concentrations measured in February 2005 are compared with previous zinc results for the Precipitate Dam, Storys below Side Creek and Storys at the Managers Residence in Figure 3.6. Levels of zinc and cadmium at all three sites are consistent with previous low flow monitoring periods.

The zinc load from Storys Creek increased zinc concentrations in the South Esk from <1 µg/L to 36 µg/L (Table 2). As shown in Figure 3.7, this increase is similar to previous monitoring results.

The water samples collected by Doug Loane on 7 November 2004 during a moderate flood event show metal concentrations similar to the high flow sampling completed in September 03. During both of these events, zinc concentrations in Aberfoyle Creek were 80% to 90% of those present in lower Storys Creek, as opposed to low flow

monitoring, when zinc concentrations in Aberfoyle are less than half of those in Storys. This suggests that a greater proportion of the total zinc flux entering the Storys Creek is derived from Aberfoyle during periods of high flow.

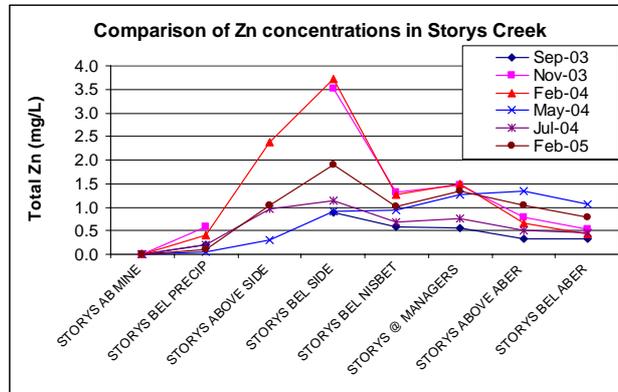


Figure 3.3. Total zinc concentrations at monitoring sites in Storys Creek by date.

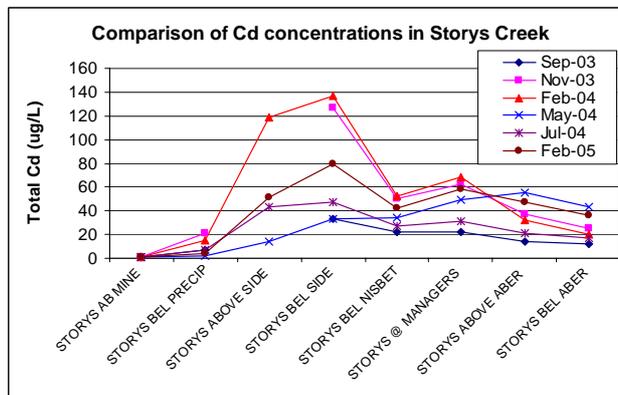


Figure 3.4. Total cadmium concentrations at monitoring sites in Storys Creek by date.

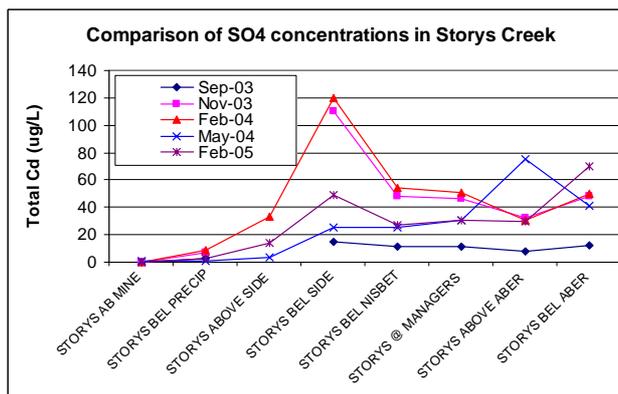


Figure 3.5. Sulphate concentrations at monitoring sites in Storys Creek by date

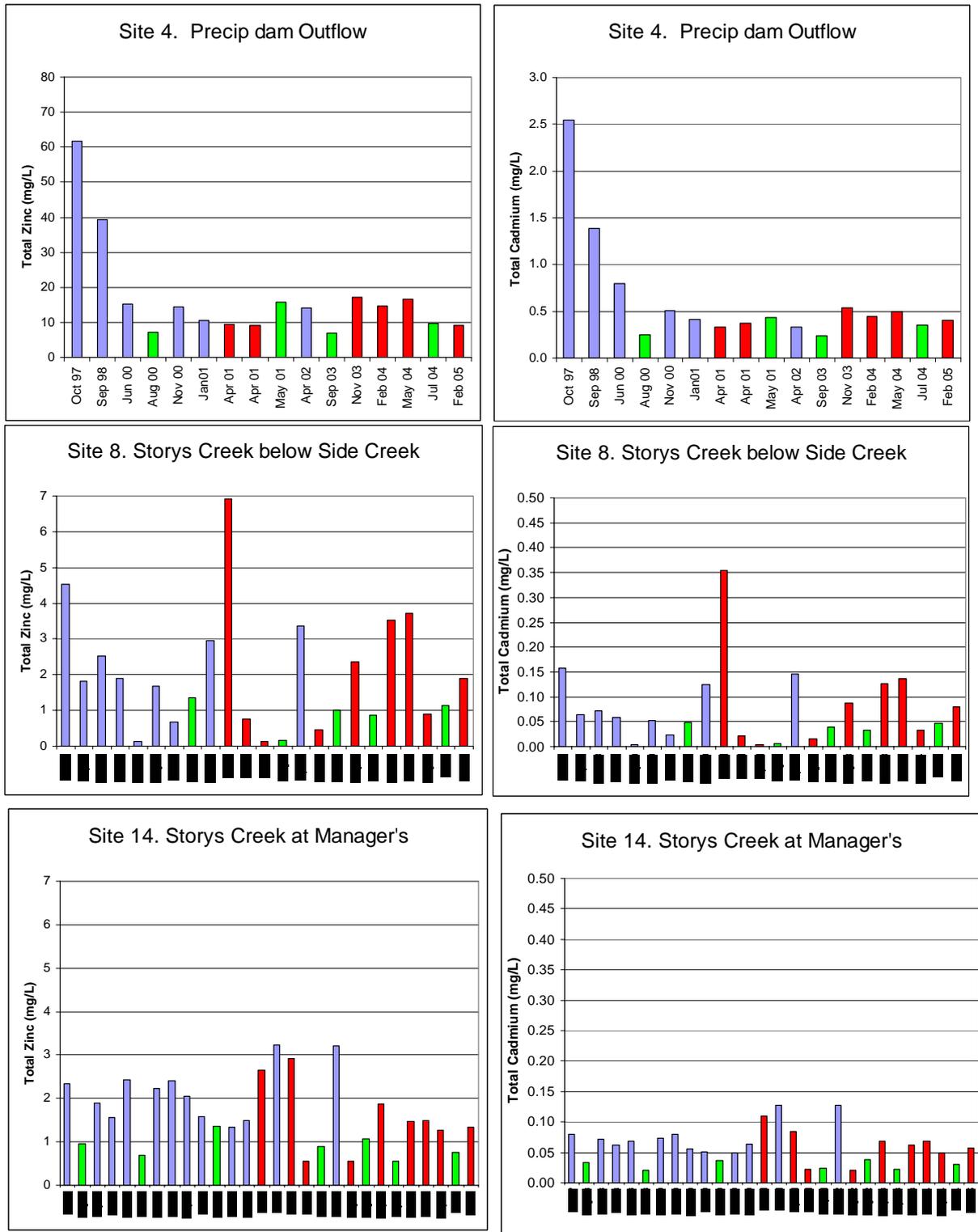


Figure 3.6 . Total zinc (left) and total cadmium (right) graphs comparing the Feb 2005 results with previous monitoring results. Red bars denote low flow (<250 L/s), blue bars denote medium flows (250 – 350 L/s), and green bars denote high flow (>350 L/s). Note different scale for the Precipitate dam results.

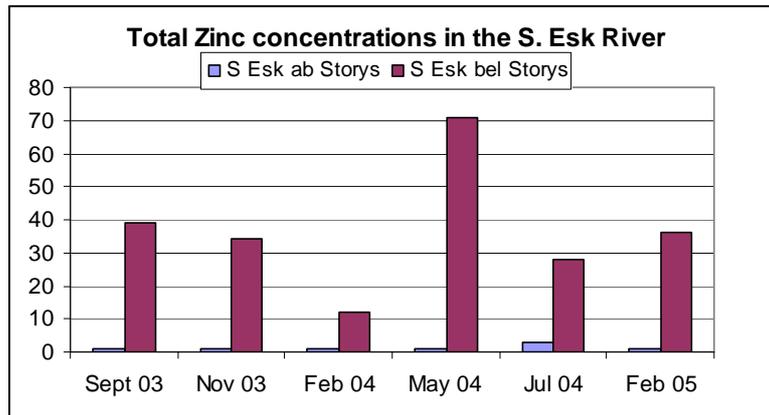


Figure 3.7. Comparison of total zinc concentrations in the South Esk River upstream and downstream of the confluence with Storys Creek.

3.5 Water quality – fluxes

Using the flow estimates and water quality results, fluxes for zinc, cadmium, iron, manganese and sulphate were determined, and are presented in Table 3. Figure 3.8, Figure 3.9 and Figure 3.10 show zinc, cadmium and sulphate fluxes at each of the monitoring sites in Storys Creek compared to previous results since September 2003. Figure 3.11 compares the fluxes from February 2005 with results between 1997 and the present.

Figure 3.8 shows that in February 2005, the largest total zinc flux from the mine site entered in the area downstream of the Precipitation Dam inflow, and upstream of Side Creek, consistent with previous results. Between the Managers Residence and the Storys above Aberfoyle site there was no change in zinc flux. This is consistent with other low flow monitoring results which do not show an increase in zinc fluxes downstream of the Managers site, but is interesting in light of the fact there were considerable rains during the week prior to monitoring, and newly deposited fine-material was present on the banks and bars. These results suggest that the increased fluxes with distance downstream observed during May 04 and July 04 may be short lived phenomena, with downstream inputs diminishing once base flow is re-established.

Figure 3.11 shows that the zinc flux in February 2005 at the Managers Residence site is consistent with low flow monitoring results since September 2003, but considerably lower than pre-remediation low flow results.

The contribution of zinc to lower Storys Creek from Aberfoyle Creek in February was ~1.9 kg/day or about 12% of the total load in lower Storys Creek. As shown in Figure 3.8, this is the smallest contribution from Aberfoyle since monitoring began in September 2003.

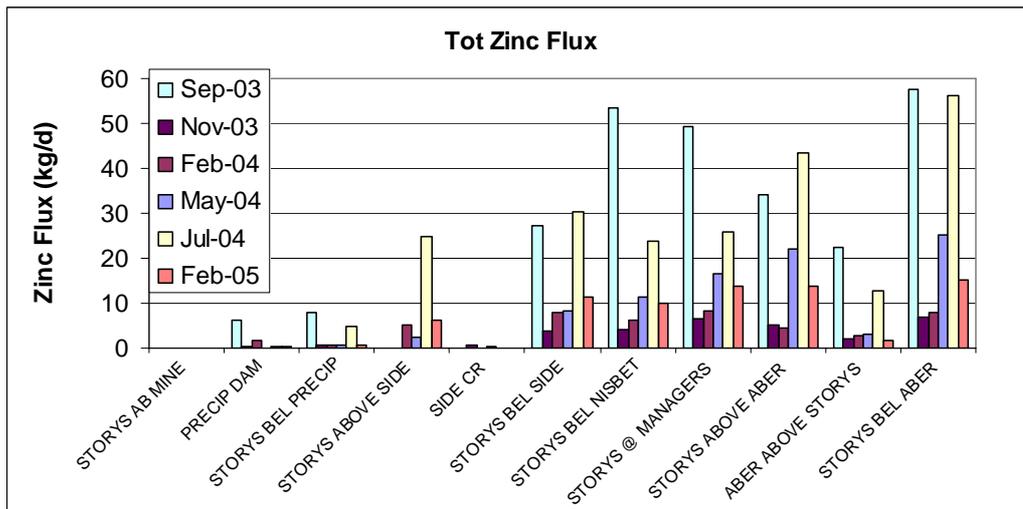


Figure 3.8. Total zinc fluxes for sites in Storys Creek for all sampling runs since September 2003. Note, Storys above Side Creek was not monitored in September 2003.

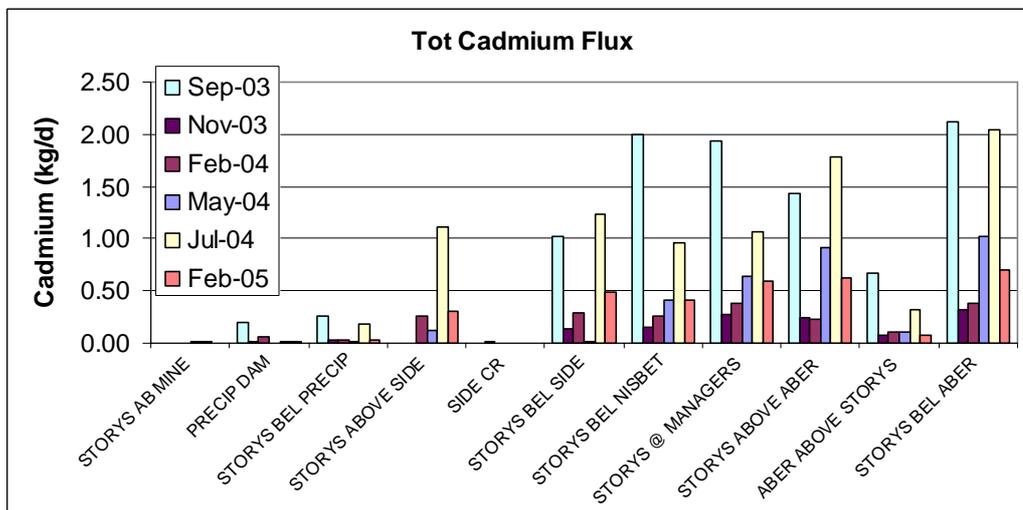


Figure 3.9. Total cadmium fluxes in Storys Creek since September 2003.

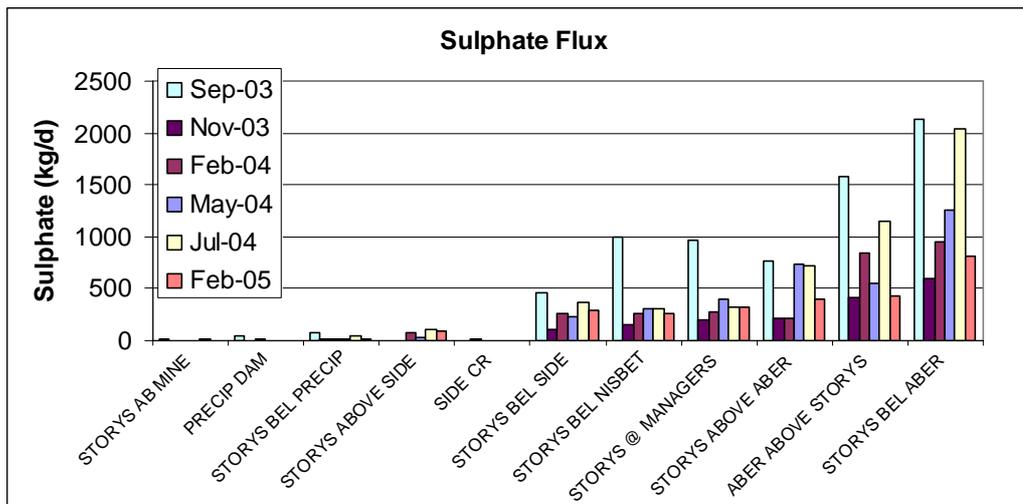


Figure 3.10. Sulphate fluxes in Storys Creek since September 2003. Storys above Side Cr was not monitored in September 2003.

Cadmium fluxes (Figure 3.9) show similar trends to zinc, with the fluxes increasing above and below Side Creek and at the Managers Residence site. Of the total flux of ~0.5 kg/day exiting the mine site, about 0.02 kg/day are attributable to the discharge from the Precipitation Dam, with the remainder associated with diffuse sources entering near Side Creek. Storys Creek is the major contributor of cadmium to the South Esk, with only about 10% of the 0.7 kg/day entering the South Esk attributable to Aberfoyle Creek. The input from Storys Creek increases cadmium concentrations in the South Esk from below detection levels to 1 µg/L. Similar to zinc, the cadmium flux at the Managers Residence is within the range of monitoring results obtained since September 2003, but lower than previous results.

Within Storys Creek, sulphate results show similar trends to zinc and cadmium, with increases above and below Side Creek, and at the Managers Residence. The relative contribution of sulphate from Aberfoyle Creek is much greater as compared to zinc or cadmium, with Aberfoyle contributing an equivalent flux (~423 kg/day) as Storys Creek (402 kg/day). The total input from lower Storys Creek into the South Esk increases concentration in the larger river from 3 mg/L to ~6 mg/L. The sulphate concentrations at the Managers Residence are also within the range of recent monitoring results (Figure 3.11).

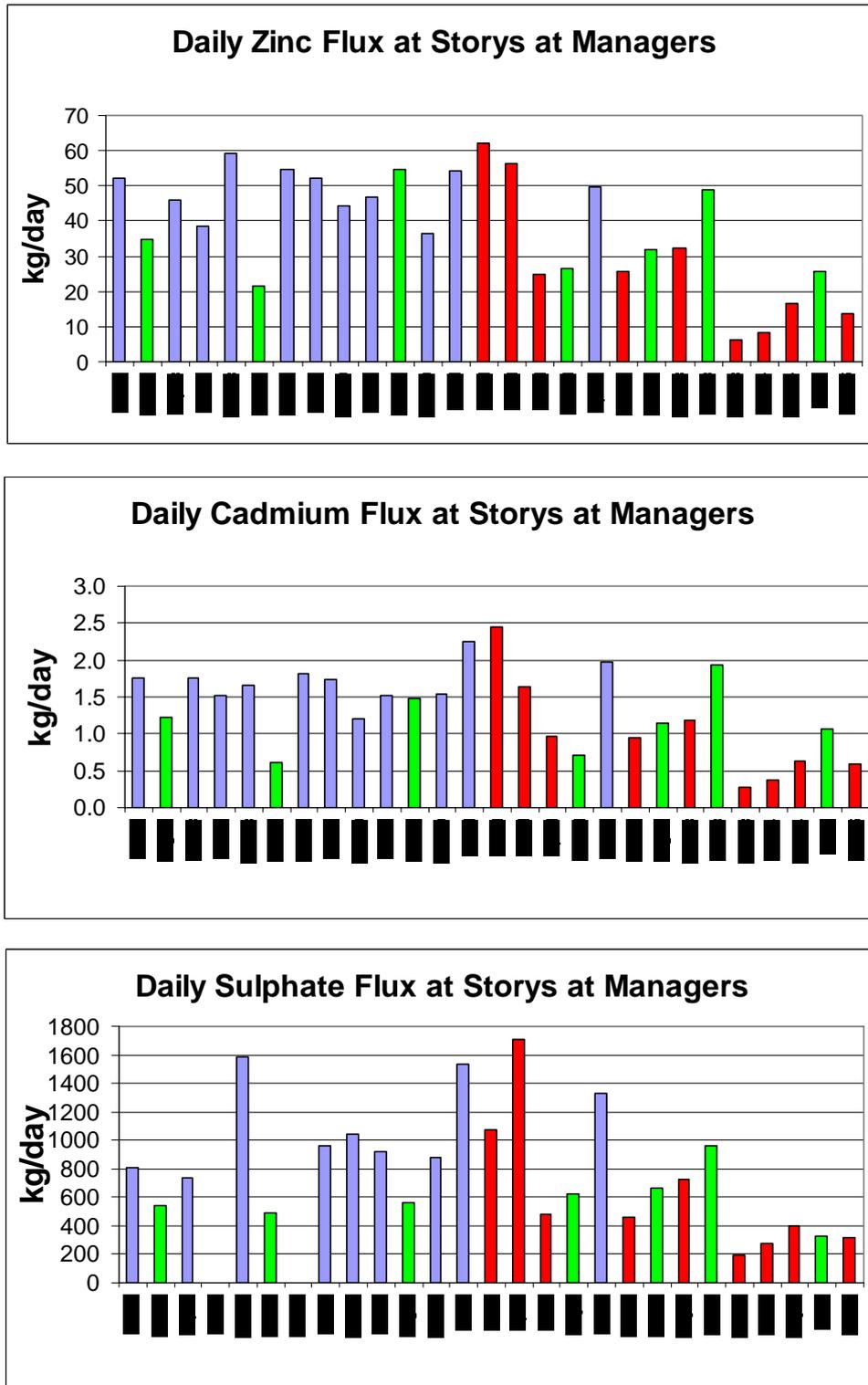


Figure 3.11. Daily total zinc, total cadmium and sulphate fluxes at Managers Site. Red denotes low flow (<250 l/s); blue denotes moderate flow (250 -350 l/s) and green denotes high flow (>350 l/s)

3.6 Impact of remediation works

The February 2005 results are consistent with previous monitoring and show that the largest input of metals on the lease site continues to occur upstream and downstream of Side Creek, in the area of the remaining tailings deposit and Side Creek adits. Fluxes from the Precipitation Dam and Eastern Adit, two remediation sites, continue to be low in spite of elevated concentrations of metals. The lack of increased metal fluxes downstream of the Managers Residence supports the hypothesis that metal fluxes increase downstream during periods of high flow due to the reworking and flushing of previously deposited tailings and fine sediments. During low flow periods, the mine site is the major source of metals to the river.

3.7 Future monitoring

It is recommended that future monitoring target high flow events, as most of the monitoring over the past 18 months has coincided with low flows. Monitoring early and late winter high flow events would provide useful information about how fluxes change over the course of winter. It is recommended the next monitoring occur in May 2005, with a subsequent run in August.

4 Related References

ANZECC/ARMCANZ, 2000, Australian Water Quality Guidelines for Fresh and Marine Waters.

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