MINERAL RESOURCES TASMANIA

STORYS CREEK / ROSSARDEN

ACID DRAINAGE REMEDIATION STUDY

FINAL REPORT

John Miedecke and Partners Pty Ltd • September 2000

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Summary

Introduction

The Storys Creek/Rossarden remediation project is a cooperative project between Mineral Resources Tasmania (MRT), the Department of the Primary Industry Water and Environment (DPIWE) and the Commonwealth Department of the Environment. The aim is to design and implement a remediation strategy for the Storys Creek and Rossarden abandoned mine sites to reduce acid and heavy metal discharge into the South Esk River system.

Nature and Source of Contaminants

The study has included a survey of water quality within the Storys Creek and Aberfoyle creek catchments.

The data confirms that the primary indicators of acid drainage and sulphide oxidation at Storys Creek are pH, sulphate, iron, aluminium, zinc, cadmium and copper. Acidity in drainage waters is due mainly to iron, aluminium, manganese and zinc. The Aberfoyle Creek waters are neutral, with mine drainage contributing metals, but at an alkaline pH, with residual alkalinity. This is an important buffering source for the acid Storys Creek waters prior to the South Esk River junction.

The overall message from the water quality data is:

- Storys Creek above Aberfoyle Creek and Aberfoyle Creek upstream of Storys Creek are significantly contaminated with zinc, cadmium, copper and aluminium in both total and dissolved (i.e. filterable at 0.45 micron) forms;
- Storys Creek downstream of the Junction with Aberfoyle Creek has contributed and continues to contribute environmentally significant loads and concentrations of zinc, copper, cadmium and aluminium to the South Esk River.
- However, there are no elevated metal concentrations which exceed aquatic life guidelines in the South Esk which can be attributed to the Storys Creek catchment input, except for possibly cadmium (detection limits not low enough). Metals which exceed the guidelines are also exceeded above the junction.
- The concentrations of metals decrease downstream in the South Esk River from the Storys Creek junction (except for Al which increases).

The main sources of acid drainage and water contamination have been identified within the Storys Creek catchment in Storys Creek above Rossarden.

The data shows that Storys Creek is the major pollutant source and contributes over 70% of the total Zn, Cd and Cu loads from the catchment, and most of the acidity. Aberfoyle Creek contributes lower loads of metals, but is a significant source of alkalinity, which buffers the Storys Creek acid drainage prior to the junction with the South Esk River.

Most of the loads are in Storys Creek above Rossarden, and therefore contribute most of the loads from the study area.

The data shows that the major metal loads are from seepage from the Jig Tailings, the Precipitate Dam and from the materials deposited in the creek. The trials and investigations have identified that the Jig Tailings – both the existing dumps on the edge of the creek, and the large amounts of material which is now incorporated in the creek banks and floor, are a major pollutant source. They contribute high loads of acidity, sulphate and metals.

A review of water quality indicates that there is an improving trend. This is partly attributed to a reduction in the overall oxidation rate as physically stable oxidation profiles develop over time in the creek-bank deposited tailings.

Remediation Trials

The acidity data indicated that the introduction of systems to provide alkalinity could be highly effective in ameliorating the residual acid drainage impacts in the Storys Creek catchment. Treatment of point sources would also have beneficial effects.

Remediation trials conducted in 1998-1999 have investigated methods of alkalinity addition. All trials have demonstrated that alkalinity addition is both feasible and effective.

Remediation Works

As a result of recommendations in the draft Final Report, the following remediation works were carried out in Autumn 2000:

- access roads were constructed to allow periodic limestone addition;
- the Precipitate Dam tailings were removed and the contents encapsulated in a new dump and the site was rehabilitated;
- the Eastern Hill adit was blocked. These works are reported in JMP 2000b.
- crushed limestone was applied to the surface of the jig tailings dumps;
- crushed limestone was applied to tailings deposits on the creek banks between Rossarden and Storys Creek;
- drainage works to reduce infiltration to the Rossarden mine workings were carried out;
- a design study was completed for a large scale anoxic limestone drain to generate alkalinity addition to the Storys Creek mine workings; and

- a design study was completed for the removal and encapsulation of the jig tailings.

Aquatic Fauna Assessment and Environmental Quality Objectives (EQO's)

The overall weight of evidence suggests that the South Esk River is not heavily impacted from Storys Creek for its entire length from the junction to Perth, as has historically been believed.

It was also determined that the biological integrity of the South Esk River can be restored only by a combination of management of Storys Creek impacts and improved catchment management and riparian condition.

Given the scale of the Storys Creek related water quality problems, it is recommended that the above EQO should be targeted in the following order of priority:

- South Esk more than 30 km downstream of Storys Creek;
- South Esk 0 - 30 km downstream of Storys Creek;
- Aberfoyle Creek;
- Storys Creek upstream of Aberfoyle Creek.

The objective is to restore those aspects of the trout fishery impacted by Storys Creek to a condition that would be expected in an unpolluted environment, and to ensure that water in the South Esk River is suitable for primary and secondary contact and other agricultural and drinking water uses.

As the nature of the impact on the aquatic fauna and trout fishery is uncertain, a monitoring program is recommended

Remediation Recommendations

The mine rocks and waste materials are essentially devoid of any acid neutralising capacity. The water in Storys Creek above the mine also contains very little buffering capacity. As a result, even a small acid input from the mine site lowers the pH sufficiently and any released metals from the site will remain mobile.

The Storys Creek Mine area has been identified as the main source of acid drainage. The main source loads have been identified as jig tailings on the slopes, the Precipitate Dam, and waste rock materials in the floor of the creek and in creek bank deposits. Other less significant sources have been identified as Side Creek Adit drainage (including Story mine workings) and Eastern Hill Adit.

Pollutant loads, including acidity, are generally low and are amenable to alkalinity addition to buffer acid drainage for the non point sources, raise pH, and remove metals from solution. Some point sources are amenable to encapsulation and blocking.

Specific recommendations are:

- yearly limestone sand addition to Storys Creek flows to raise the pH of the waters;
- alkalinity addition to the Storys Creek mine workings by the construction of an anoxic limestone drain upstream;
- removal and encapsulation of the jig tailings to the new tailings disposal area;
- progressive removal of Jig Tailings deposits in the creek itself and encapsulation of the jig tailings to the new tailings disposal area;
- annual application of crushed limestone to tailings deposits on the creek banks ;
- continued water quality monitoring at Station 14 and other stations; and
- aquatic fauna monitoring in the S Esk river.

1.0 INTRODUCTION

The Storys Creek/Rossarden remediation project is a cooperative project between Mineral Resources Tasmania (MRT), the Department of the Primary Industry Water and Environment (DPIWE) and the Commonwealth Department of the Environment. The aim is to design and implement a remediation strategy for the Storys Creek and Rossarden abandoned mine sites to reduce acid and heavy metal discharge into the South Esk River system. Mineral Resources Tasmania is supervising the acid drainage remediation works at the old abandoned mine workings at Storys Creek and Rossarden.

The remediation works are being funded by the State Government though the Rehabilitation of Mining Lands Trust. The Commonwealth through Riverworks Tasmania funded the investigations and trials.

Figure 1.1 shows the location of the study area and major catchments.

An interim data report was completed and submitted in September 1997 (John Miedecke and Partners Pty Ltd (JMP) , 1997) and a Preliminary Report in March 1998 (JMP, 1998). The Preliminary Report has been followed by on site trials and remediation works and this Final Report (after submission as a draft in 1999 (JMP 1999b), consists of a final report on the remediation of the study area up until June 2000.

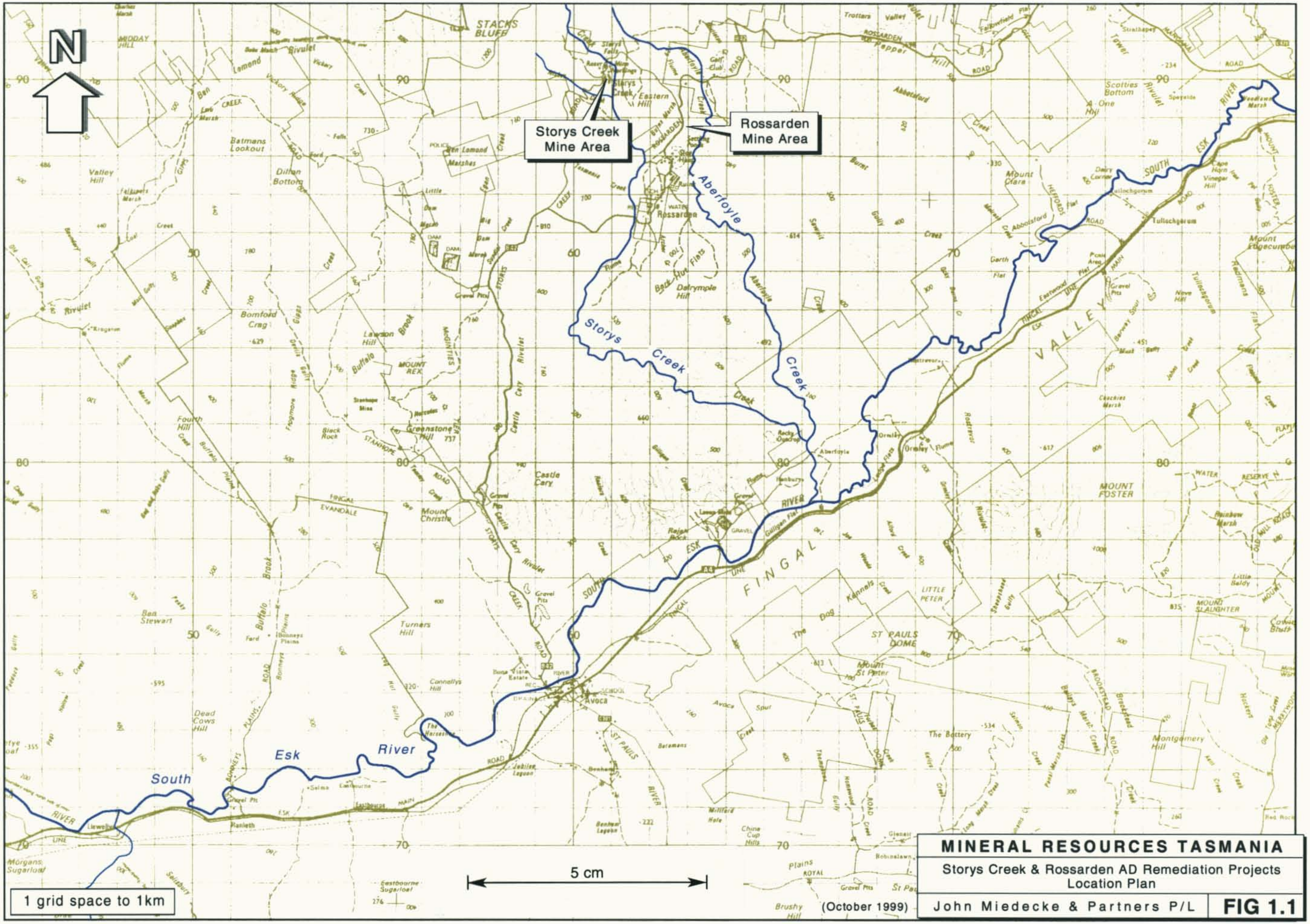
2.0 SCOPE AND CONDUCT OF STUDY

2.1 Scope

The consultancy brief set out by MRT was as follows:

- Review historical data and literature and design remediation works.
- Identify any gaps in data which must be filled to permit design work.
- Design and quote on instrumentation and analysis required.
- Identify potential options for managing effluent water from the adits, mine sites, tailings and other waste materials in the general vicinity of the creeks.
- Recommend site works to control metal and acid discharges.
- In the event of doubt of the success of recommended options design demonstration programs.
- Construction and evaluation of pilot works if required.

Items 1 to 5 have been completed and have been reported in the interim data report (JMP 1997) and the Preliminary Report (JMP 1998). This Final Report contains the balance of the findings and recommendations for remediation of contaminant loads from the study area.



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Storys Creek & Rossarden AD Remediation Projects
Location Plan

John Miedecke & Partners P/L

FIG 1.1

Reports of specific works conducted as part of the remediation, include the following:

- Precipitate Dam Relocation Design Report. March 1999 (JMP 1999a).
- Final Report (Draft), October 1999 (JMP 1999b)
- Report on Remediation Works Autumn 2000. July 2000 (JMP 2000a).
- Precipitate Dam Relocation Construction Report John Miedecke and Partners, July 2000 (JMP 2000b).
- Jig Tailings Relocation Design Report John Miedecke and Partners, July 2000 (JMP 2000c).
- Anoxic Limestone Drain Design Report John Miedecke and Partners, July 2000 (JMP 2000d).

2.2 Reports Contents

The Preliminary Report was prepared as the preliminary report into the investigations.

It contained the following;

- Section 1- an introduction
- Section 2 - a description of the scope and conduct of the study;
- Section 3 - a description of the study area acid drainage, metal loads and sources;
- Section 4 - an evaluation of downstream effects on the downstream environment, and a discussion of environmental quality objectives;
- Section 5 - a general discussion of remedial technologies, including a review of the Mount Lyell study findings;
- Section 6 - a selection of appropriate remedial technologies and a discussion of site specific trials, and recommended monitoring and investigations.
- Appendices with detailed information.

As discussed above, this final report contains some of the information from the Preliminary Report, for completeness. A copy of the contents pages of both the Interim Report and the Preliminary Report are included in Appendix A.

This Final Report contains the following Sections:

- Section 2 - a description of the scope and conduct of the study;
- Section 3 - a description of the study area acid drainage, metal loads and sources;
- Section 4 - an evaluation of the results of the remediation trials;
- Section 5 - a discussion of aquatic fauna effects in the South Esk and environmental quality objectives;
- Section 6 – recommendation for remediation in the study area and recommended monitoring and investigations; and
- Appendices with detailed information.

2.3 Study Team

The study was conducted by a project team consisting of John Miedecke and Partners Pty Ltd (JMP), Environmental Geochemistry International Pty Ltd (EGi), Hydro Electric Corporation (HEC), Freshwater Systems (Dr P Davies), William Wood and Associates and MPA Williams Consulting Engineers.

John Miedecke and Partners were the primary consultant and project managers,

The Project Team consisted of;

John Miedecke (JMP)	Project Manager, hydrology, environmental engineering, remediation options.
Simon Wheeler (JMP).	Field work, data base, support services.
Dr Stuart Miller	Chemistry, geochemistry, remediation
David Wilson (HEC)	Hydrology, hydrogeology.
Mark Johnson (HEC)	Hydrology, field work, monitoring.
Helen Locher (HEC)	Data gathering, data base.
Dr Bill Wood	Site data, investigations, preliminary report.
Dr Peter Davies	Water quality criteria, aquatic life.
Keith Seddon (MPA, Williams)	Geotechnical and civil engineering
Dr Robert Hedin	Limestone alkalinity addition.

2.4 Conduct of the Study

The study commenced in July 1997 and has included site visits by the study team, additional sample collection to identify acid drainage sources and to quantify loads from the site and project team meetings to review remediation options and the study program.

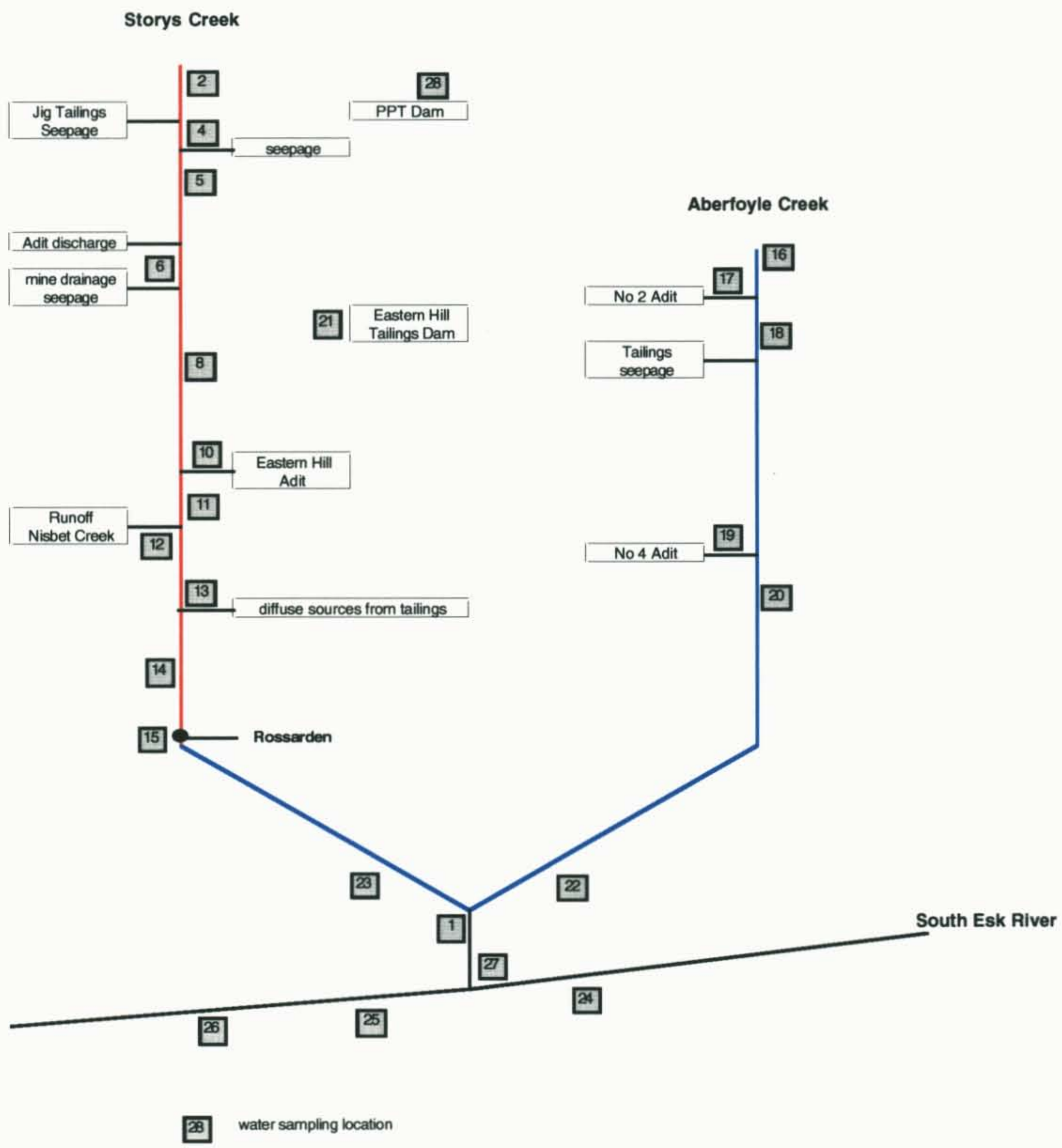
A preliminary report was prepared in March 1998, and following acceptance of some of the recommendations, trials were constructed in August – September 1998. Additional trials were conducted in Autumn 2000, these included crushed limestone addition to river bank deposits and to Jig tailings dumps. A major remediation work also completed, was the relocation and rehabilitation of the tailings dam (Precipitate Dam) from a site adjoining the creek to a new site. Drainage works were also carried out at Rossarden.

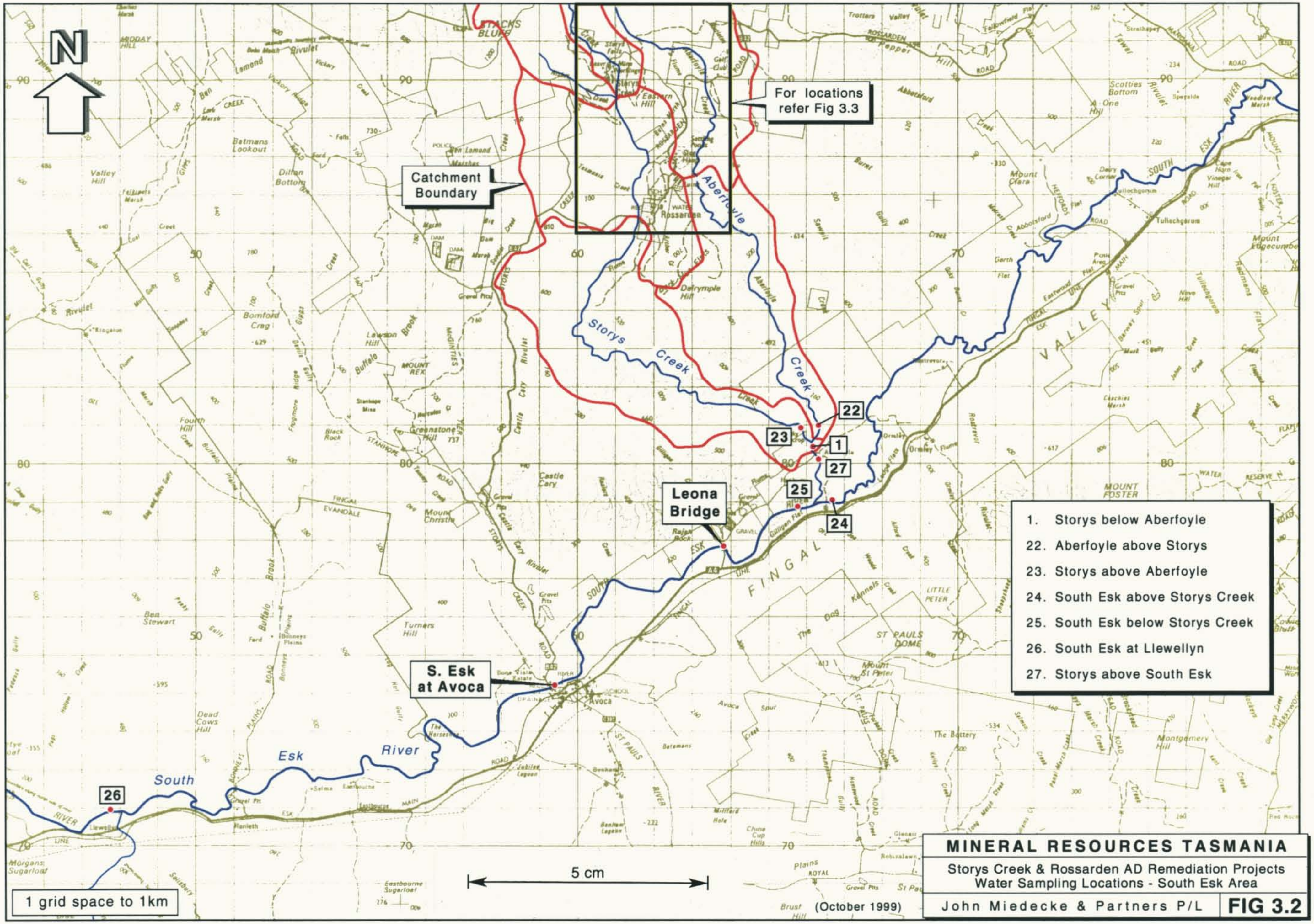
A number of monitoring sites were established and water quality analysis carried out to determine metal loads in Storys and Aberfoyle Creeks, and to assist in monitoring trials.

The trials are discussed in detail in this report. Additional monitoring data has been used to update previous information on contamination sources and metal loads. Recommendations are made into remediation of the contamination sources.

Water quality monitoring and remediation works are continuing.

Figure 3.1: Concept Drainage Model.





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Storys Creek & Rossarden AD Remediation Projects
Water Sampling Locations - South Esk Area

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FIG 3.2

3.0 Study Area Acid Drainage and Metal Loads

3.1 Introduction

The Preliminary Report and the Interim Report, (mostly the former) document all the available background water quality data and also include data collected during the study period up until the Preliminary Report was prepared (March 1998).

As part of the trial construction and evaluation, additional site investigations and water quality monitoring has been carried out. This data is included in Appendix B at the rear of the report and the following sections contain an updated review of this data.

Monitoring has been concentrated on opportunistic sampling as the detailed monitoring program proposed in the Preliminary Report was not adopted.

3.2 Pollutant Sources

Figure 3.1 is a conceptual drainage model of the system which incorporates the study area. All of the water sampling sites are shown on this Figure.

The study has focused on the mine sites and immediate surrounds downstream to the South Esk River. This area consists of the two main catchments as follows:

- Storys Creek and;
- Aberfoyle Creek.

The catchments combine to join the South Esk River which eventually flows to the Tamar River at Launceston.

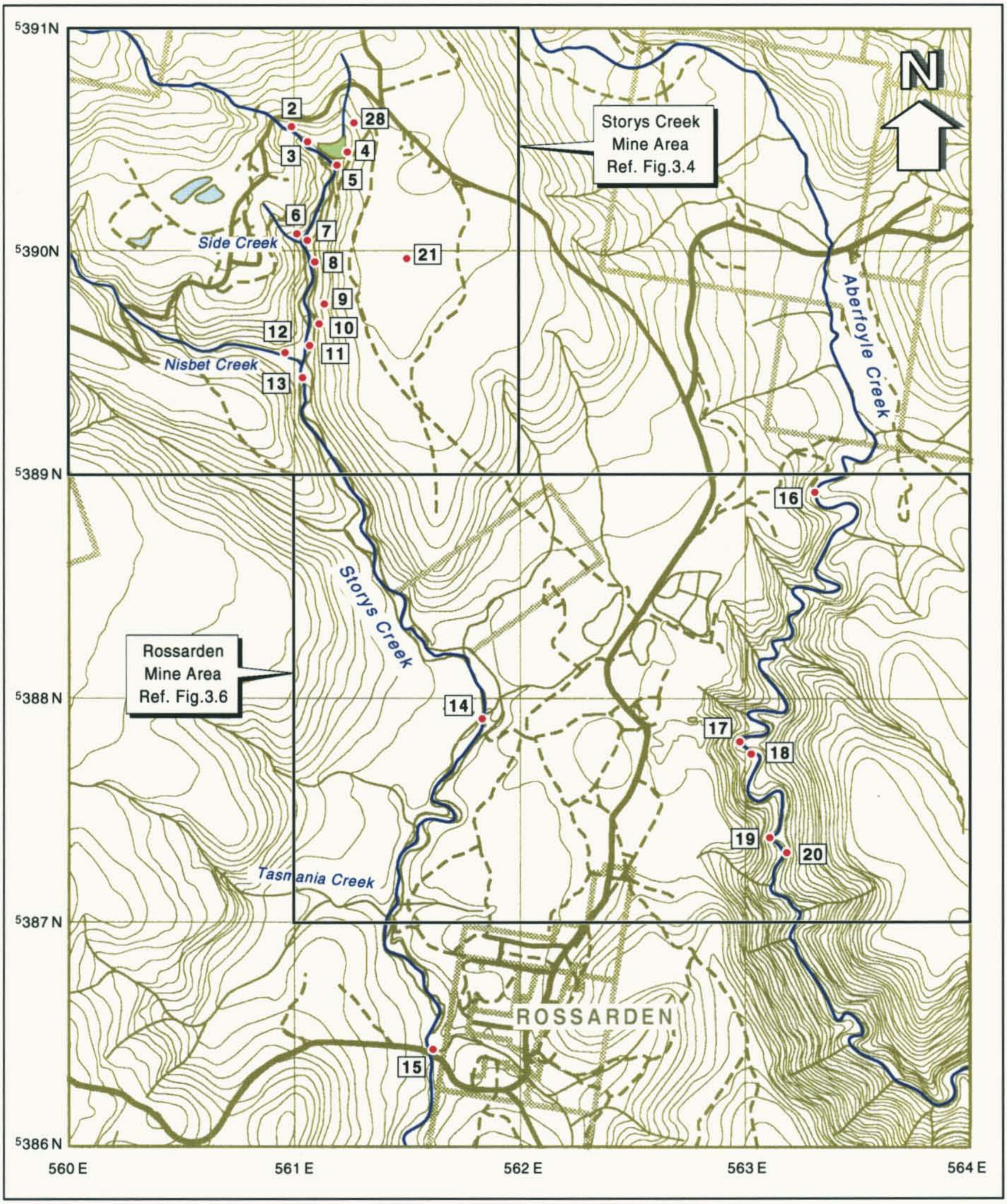
Figures 3.2 and 3.3 show the catchments and sampling sites.

As the trials were all constructed in the Storys Creek mine area, all additional monitoring was conducted in this catchment and there is no additional data from the Rossarden catchment area (Aberfoyle Creek), other than near the South Esk River junction.

3.3 Water Quality and Pollutant Indicators

3.3.1 Pollutant Indicators

From the results of the analyses conducted as part of the Preliminary Report and the more recent monitoring data, the data confirms that aluminium, cadmium, iron, copper, manganese and zinc are the main soluble metals and sulphate is the dominant anion. Calcium and magnesium are also major cations with magnesium generally occurring at higher concentrations than calcium. Sodium and chlorine are generally low, but fluorine is elevated.



2. Storys above mine
3. Inflow to Storys near old workings
4. Tailings Dam outflow
5. Storys below Tailings Dam
6. Side Creek - wetlands inflow
7. Side Creek - wetlands outflow
8. Storys below Side
9. Eastern Hill - wetlands inflow
10. Eastern Hill - wetlands outflow
11. Storys below Eastern Hill
12. Nisbet Creek
13. Storys below Nisbet Creek
14. Storys below mine managers residence
15. Storys at Rossarden Bridge
16. Aberfoyle Creek above workings
17. No.2 Adit
18. Aberfoyle below No.2 Adit
19. No.4 Adit
20. Aberfoyle below No.4 Adit
21. Eastern Hill Tailings Dam - pond only
28. Diversion Channel above Tailings Dam

1 grid space to 1km

5 cm

(October 1999)

MINERAL RESOURCES TASMANIA

Storys Creek & Rossarden AD Remediation Projects
Water Sampling Locations Storys Creek Area

John Miedecke & Partners P/L

FIG 3.3

The concentration of other elements of potential environmental concern such as Pb, As and Hg are generally below detection or at very low concentrations.

The data confirms that the primary indicators of acid drainage and sulphide oxidation at Storys Creek are pH, sulphate, iron, aluminium, zinc, cadmium and copper. Manganese is a secondary indicator. Acidity in drainage waters is due mainly to iron, aluminium, manganese and zinc.

The Aberfoyle Creek waters are neutral, with mine drainage contributing metals, but at an alkaline pH, with residual alkalinity. This is an important buffering source for the acid Storys Creek waters prior to the South Esk River junction.

The overall message from the water quality data is:

- Storys Creek above Aberfoyle Creek and Aberfoyle Creek upstream of Storys Creek are significantly contaminated with zinc, cadmium, copper and aluminium in both total and dissolved (i.e. filterable at 0.45 micron) forms;

- Storys Creek downstream of the Junction with Aberfoyle Creek has contributed and continues to contribute environmentally significant loads and concentrations of zinc, copper, cadmium and aluminium to the South Esk River.

- However, there are no elevated metal concentrations which exceed aquatic life guidelines in the South Esk which can be attributed to the Storys Creek catchment input, except for possibly cadmium (detection limits not low enough). Metals which exceed the guidelines are also exceeded above the junction.

- Most of the above metals are in filterable form, but the degree to which these metals are truly in dissolved form and hence toxic to aquatic life is unknown.

- Significant loads of iron and aluminium, in flocculated hydroxide forms, are present within Aberfoyle and lower Storys Creeks, and these are deposited both within the Creek channels and in the South Esk River.

- The concentrations of metals decrease downstream in the South Esk River from the Storys Creek junction (except for Al which increases).

- Inputs from Storys Creek have been responsible for metal contaminated sediments deposited within and outside the South Esk River channel, the environmental significance of which is unknown.

The Interim Report documents all the historical data and Appendix B contains all data collected during the later part of the study period.

3.3.2 Water Quality Guidelines

Table 3.1 contains the water quality data for the station near the South Esk River. Table 3.2 shows a summary of the exceedances of water quality guidelines for Storys Creek, Aberfoyle Creek and the South Esk River above and below the confluence.

Based on this water quality sampling, zinc, cadmium and copper exceed the Environmental Quality Objectives as discussed in the Interim Report for aquatic life for these metals in Aberfoyle Creek and Storys Creek.

In the South Esk, only copper and aluminium slightly exceeds the EQOs (cadmium detection limits are not low enough for comparison). Copper is also elevated above the confluence and exceeds the EQO's. Therefore, the contribution fro Storys Creek is not significant. Aluminium, both above and below Storys Creek, (therefore also not contributed by Storys Creek) also exceeds aquatic life and drinking water quidelines.

Story Creek waters near the South Esk exceed aquatic life standards for zinc, copper and cadmium. They also exceed drinking water, livestock and irrigation guidelines for cadmium and aluminium.

TABLE 3.2 SUMMARY OF WATER QUALITY AND ANZECC GUIDELINES

		South Esk above	Storys Creek	Aberfoyle Crk	South Esk below
Aquatic Life	Al	x	x		x
	Cd		x	x	x?
	Cu	x	x	x	x
	Zn		x	x	
Drinking Water	Al	x	x		x
	Cd		x	x	
	Cu				
	Fe		x	x	
	Mn		x	x	
	Zn				
Irrigation	Al				
	Cd		x		
	Cu				
	Zn				
Livestock	Al				
	Cd		x		
	Cu				
	Zn				

x exceeds ANZECC guidelines

In Aberfoyle Creek only cadmium, copper and zinc exceeds aquatic life guidelines and cadmium, iron and manganese exceed drinking water standards. The waters are suitable for other uses.

Table 3.1: Storys Creek, Aberfoyle Creek and South Esk River Water Quality- All Data (mg/L)

LOCATION	ANZECC Drinking	Aqu Life	Livestock	Irrigation	Aberfoyle above Storys				Storys above Aberfoyle				
PARAMETER (mg/l)		EQOs			976017	22	22	MEAN	976018	21	21	21	MEAN
SAMPLE DATE					3-Oct-97	1-Sep-98	17-Nov-98		3-Oct-97	1-Sep-98	1-Oct-98	17-Nov-98	
FLOW L/sec					174				220				
pH L	6.5-8.5			4.5-9.0	6.7	7.0	7.7	7.1	5.6	5.4	7.3	5.8	6.0
pH F					7.0			7.0	6.0				6.0
Cond mS/cm L				0-500	193	178	218	196.3	71	83	70	110	83.5
Cond F					197			197.0	72				72.0
TDS	1000		3000	0-800 ok	126	118	121	121.7	47	71	56	83	64.3
NFR (suspended solids)					<1	1	6	3.5	<1	2	1	5	2.7
Alkalinity (CaCO3)					43	28	4	25.0	1	1	2	1	1.3
Acidity (CaCO3)					<1	2	2	2.0	6	7	2	6	5.3
DOC mg/L					2.0			2.0	2.0				2.0
Hardness (CaCO3)	500				79			79.0	17				17.0
Ca T			1000		17.0	17.4		17.2	4.0	5.6			4.8
Cl					3.8			3.8	3.7				3.7
SO4	400		1000		48	40	37	41.7	19	24	17	48	27.0
F			2	1	0.78	0.81		0.8	0.29	0.44			0.4
K T					0.7	0.6		0.6	0.5	0.3			0.4
Mg T			600		9.0	9.1		9.1	2.0	2.3			2.2
Na T	300				4.0	3.3		3.6	4.0	2.4			3.2
Metals													
Al F		**0.1**			0.10	0.06	0.05	0.07	0.20	0.30	0.09	0.13	0.18
Al T	0.2		5	5	0.20	0.19	0.05	0.15	0.40	0.70	0.40	0.19	0.42
Cd F		**0.0002**			0.012	0.011	0.006	0.010	0.046	0.058	0.043	0.064	0.053
Cd T	0.005		0.01	0.01	0.014	0.015	0.008	0.012	0.048	0.065	0.046	0.063	0.056
Cr F		**0.01**			<0.001	0.002		0.002	<0.001	<0.001	<0.001	<0.001	
Cr T	0.05		1	1	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	
Cu F		**0.005**			0.013	0.014	0.012	0.013	0.080	0.187	0.048	0.135	0.113
Cu T	1		0.5	0.2	0.028	0.057	0.028	0.038	0.097	0.215	0.073	0.157	0.136
Fe F		**1**			<0.1	0.0	0.0	0.027	<0.1	0.1	0.0	0.0	0.041
Fe T	0.3			1	0.5	0.8	0.6	0.631	0.1	0.3	0.3	0.1	0.194
Mn F					0.4	0.3	0.3	0.347	0.2	0.2	0.2	0.2	0.199
Mn T	0.2			2	0.4	0.4	0.3	0.359	0.2	0.2	0.2	0.2	0.202
Ni F					<0.001	0.005	0.003	0.004	<0.001	0.004	0.002	0.005	0.004
Ni T	0.1		1	0.2	0.007	0.006	0.005	0.006	0.004	0.005	0.004	0.004	0.004
Pb F		**0.001-0.005**			<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001
Pb T	0.05		0.1	0.2	<0.001	<0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	0.001
Zn F		**0.05**			0.457	0.485	0.276	0.406	1.380	1.740	1.100	2.270	1.623
Zn T	5		20	2	0.549	0.646	0.412	0.536	1.420	1.760	1.100	2.170	1.613

LOCATION	**23** Storys below Aberfoyle				**27** Storys above South Esk	**24** South Esk above Storys				South Esk below Storys				South Esk at Lewellyn
PARAMETER (mg/l)	975997	23	23	MEAN	976022	976019			MEAN	976020			MEAN	976021
SAMPLE DATE	3-Oct-97	1-Sep-98	17-Nov-98		3-Oct-97	3-Oct-97	1-Sep-98	17-Nov-98		3-Oct-97	1-Sep-98	17-Nov-98		3-Oct-97
FLOW L/sec	394				470	10230				10701				12540
pH L	6.0	6.8	7.5	6.8	6.4	6.5	6.6	6.9	6.7	6.4	6.7	4.6	5.9	6.4
pH F	6.9			6.9	6.9	7.2			7.2	7.2			7.2	7.3
Cond mS/cm L	107	147	183	145.7	119	74	67	109	83.3	76	71	109	85.3	81
Cond F	109			109.0	122	76			76.0	78			78.0	83
TDS	80	109	115	101.3	87	48	58	58	54.7	56	65	71	64.0	59
NFR (suspended solids)	<1	2	7	4.5	<1	2	6	22	10.0	2		11	6.5	1
Alkalinity (CaCO3)	13	18	3	11.3	16	17	10	2	9.7	17	10	21	16.0	18
Acidity (CaCO3)	<1	3	2	2.5	<1	<1	3	5	4.0	<1	4	4	4.0	<1
DOC mg/L	2.3			2.3	1.7	2.4			2.4	2.3			2.3	2.6
Hardness (CaCO3)	35			35.0	42	17			17.0	18			18.0	20
Ca T	8.0	13.5		10.8	9.0	3.0	3.0		3.0	3.0	3.0		3.0	4.0
Cl	3.7			3.7	3.7	11.0			11.0	10.0			10.0	11.0
SO4	27	35	50	37.3	30	2	2	45	16.1	3	2	2	2.4	3
F	0.47	0.88		0.7	0.48	<0.02	0.02		0.0	0.03	0.04		0.0	0.03
K T	0.6	0.5		0.6	0.6	0.6	0.5		0.6	0.6	0.5		0.5	0.6
Mg T	4.0	6.9		5.4	5.0	2.0	2.2		2.1	2.0	2.2		2.1	3.0
Na T	4.0	2.9		3.5	4.0	7.0	5.7		6.3	7.0	5.3		6.1	8.0
Metals														
Al F	0.10	0.08	0.07	0.08	0.10	0.20	0.10	0.07	0.12	0.20	0.10	0.10	0.13	0.20
Al T	0.40	0.33	0.13	0.29	0.30	0.30	0.21	0.24	0.25	0.30	0.18	0.16	0.21	0.40
Cd F	0.034	0.027	0.03	0.030	0.030	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Cd T	0.038	0.034	0.034	0.035	0.033	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Cr F	<0.001	<0.001			<0.001	<0.001				<0.001	<0.001			<0.001
Cr T	<0.001	<0.001			<0.001	<0.001	0.002			<0.001	<0.001			<0.001
Cu F	0.044	0.032	0.030	0.035	0.029	0.002	0.010	0.006	0.006	0.004	0.01	0.008	0.007	0.004
Cu T	0.067	0.126	0.065	0.086	0.058	0.001	0.007	0.009	0.006	0.004	0.019	0.008	0.010	0.005
Fe F	<0.1	0.261	0.0	0.142	<0.1	0.1	0.075	0.11	0.096	0.1	0.1	0.1	0.101	0.1
Fe T	0.3	0.654	0.4	0.453	0.3	0.3	0.203	0.5	0.350	0.3	0.2	0.3	0.278	0.3
Mn F	0.3	0.004	0.3	0.205	0.2	<0.1	0.005	0.0	0.005	<0.1	0.0	0.0	0.005	<0.1
Mn T	0.3	0.28	0.3	0.306	0.2	<0.1	0.028	0.1	0.046	<0.1	0.0	0.0	0.026	<0.1
Ni F	<0.001	<0.001	0.004	0.004	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001		<0.001
Ni T	0.004	0.003	0.004	0.004	0.005	0.002	0.001	<0.001	0.002	0.001	<0.001	<0.001	0.001	0.001
Pb F	<0.001	<0.001	0.001	0.001	<0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001		<0.001
Pb T	0.001	0.001	0.001	0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.002	<0.001	0.002	<0.001
Zn F	1.030	0.893	0.854	0.926	0.896	0.007	0.027	0.005	0.013	0.034	0.046	0.027	0.036	0.035
Zn T	1.120	0.990	1.010	1.040	0.991	0.003	0.004	0.004	0.004	0.040	0.050	0.020	0.037	0.032

3.4 Pollutant Loads and Source Evaluation

In the Preliminary Report, the "snap shot" survey results (October 1997) were used to calculate load estimates for zinc, cadmium, copper, iron, sulphate, acidity and alkalinity.

These provided the data to evaluate the pollutant sources and their significance. More recent sampling is contained in Appendix B, at the same locations. This data supports the conclusions of the Preliminary Report.

However, more recent data and information from trial construction and site investigations has allowed a more definitive identification of pollutant sources.

The data is summarised in the following section and Section 3.5 contains details of identified sources.

3.4.1 Pollutant Load Summary

3.4.1.1 South Esk Catchment

Figure 3.4 summarises the acidity, alkalinity, sulphate, iron, zinc, cadmium and copper load data for both the Storys Creek catchment and the study area. This is essentialy the same data as presented in the Interim Report.

The data shows that Storys Creek is the major pollutant source and contributes over 70% of the total Zn, Cd and Cu loads from the catchment, and most of the acidity. Aberfoyle Creek contributes lower loads of metals, but is a significant source of alkalinity, which buffers the Storys Creek acid drainage prior to the junction with the South Esk River.

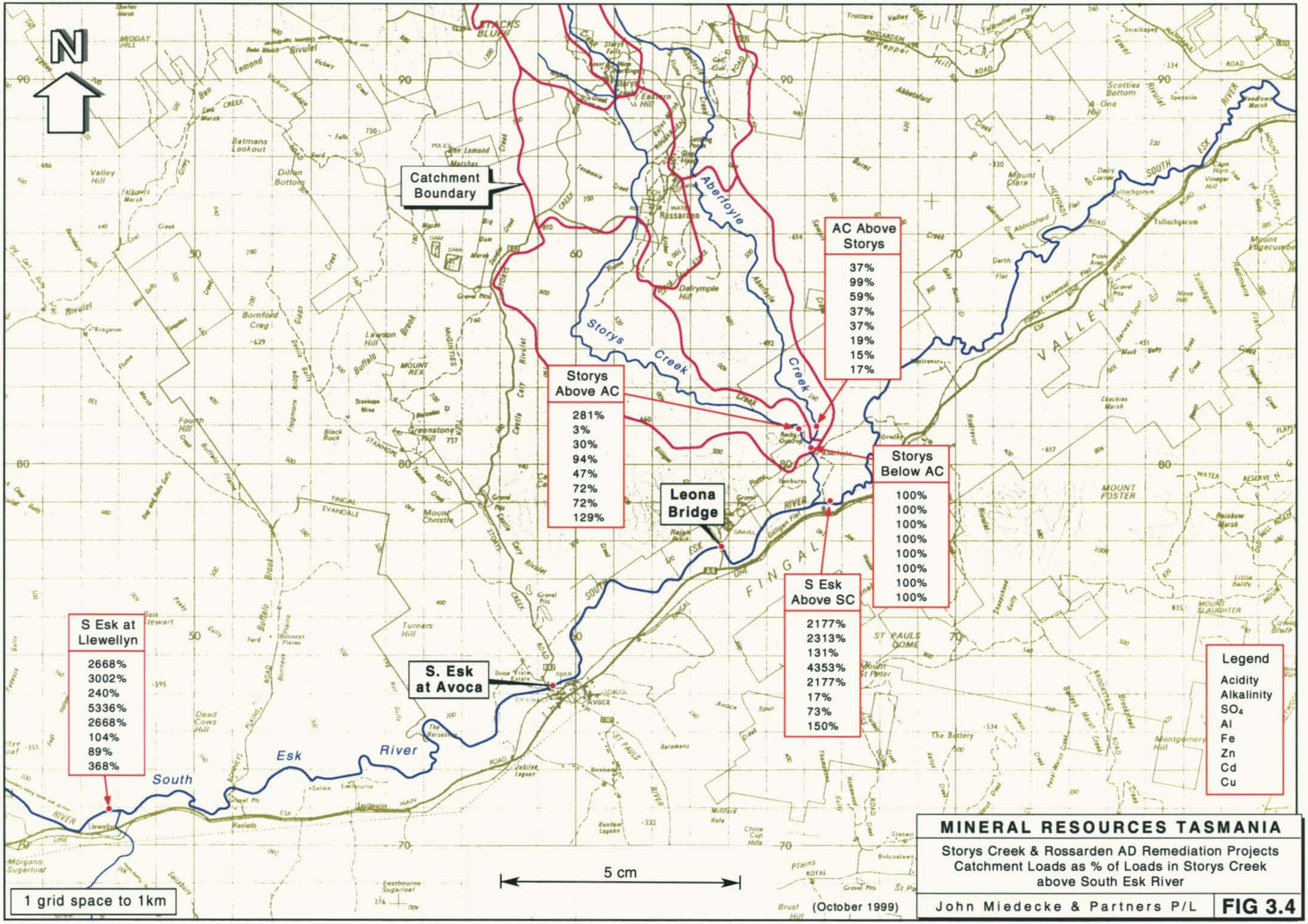
The South Esk is a significant contributor of sulphate, acidity, alkalinity, aluminium iron, and copper.

The monitoring of water quality and flows in Storys Creek and to the South Esk, show that the majority of the contaminant loads are not in the major flood events, but are after the flood peak has passed. This is attributed to seepage from jig tails and bank materials as the effects of direct rainfall and higher water tables are expressed as seepage to the creek. High flows have relatively good water quality.

3.4.1.2 Storys Creek Catchment

All the water quality data from the October sampling and for each monitoring site along Storys Creek to the South Esk River is included in Appendix B.

Figure 3.5 shows the estimated loads in Storys Creek as the % of the loads at Rossarden. This is essentially based on the data collected at the comprehensive October 1997 sampling. Later data is similar. The data has been updated with water quality data available from the lysimeter trials on the Jig Tailings.



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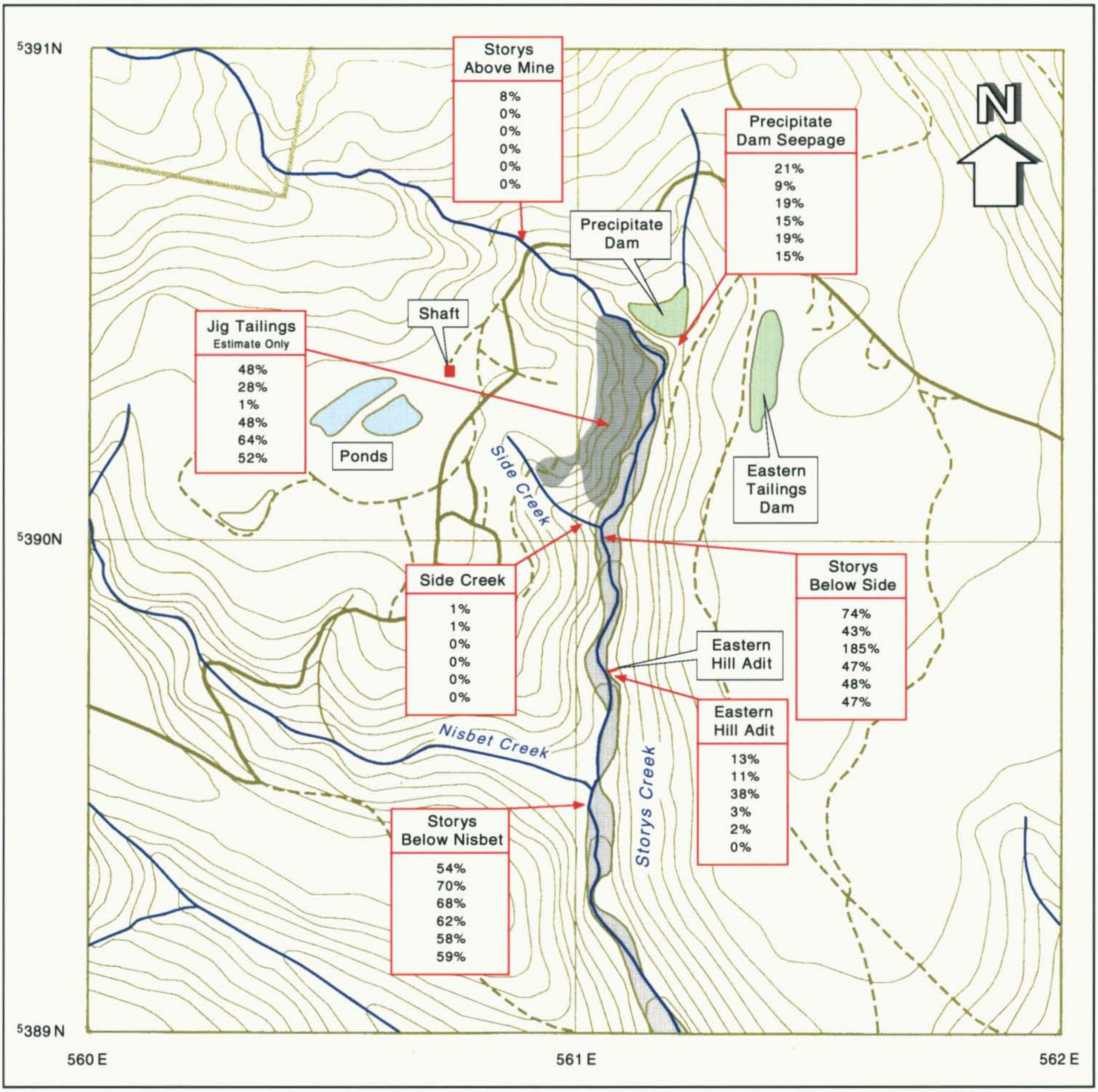
Storys Creek & Rossarden AD Remediation Projects
Catchment Loads as % of Loads in Storys Creek above South Esk River

John Miedecke & Partners P/L

FIG 3.4



1 grid space to 1km

Storys Below Rossarden	Legend
100%	Acidity
100%	SO_4
100%	Fe
100%	Zn
100%	Cd
100%	Cu

5 cm

MINERAL RESOURCES TASMANIA

Storys Creek & Rossarden AD Remediation Projects
Storys Creek -Sources & Loads
(% of loads in Storys Creek at Rossarden)

(October 1999) John Miedecke & Partners P/L **FIG 3.5**

Most of the loads are above Rossarden, and therefore contribute most of the loads from the study area.

The data shows that the major metal loads are from seepage from the Jig Tailings, the Precipitate Dam and from the materials deposited in the creek. The trials and investigations have identified that the Jig Tailings – both the existing dumps on the edge of the creek, and the large amounts of material which is now incorporated in the creek banks and floor, are a major pollutant source. They contribute high loads of acidity, sulphate and metals.

Drainage from the Jig Tailings on the slopes above the creek near the mine has now been identified as the single biggest identified source of contaminants. Assuming a surface area of 4 ha and 75% of all rainfall eventually reaches the creek, an average of 0.8L/sec would contribute to the creek baseflow. This would of cause, be concentrated over rainfall events and would not be evenly distributed all year round. However, an average inflow of 0.8 l/sec has been used to calculate loads for comparison figures and this is shown in Figure 3.5. The sulphate loads corroborate these estimates.

The data indicates that the deposited tailings in Storys Creek contribute about 280 kgSO4/day, while the Storys mine site (ie Storys Creek below the mine) contributes approximately 200 kgSO4/day. Of the mine site sources, approximately 66% are from the Jig Tailings.

It is estimated that the area of deposited tailings in the creek deposits is about 17ha, and therefore the sulphate release rate is about 16 kgSO4/day. This indicates only a very low oxidation rate that is equivalent to the practical design target for closure of reactive sulphide waste rock and tailings at other major contamination sites (such as Mount Lyell etc).

The previous works carried out in the Storys Creek catchment - such as the capping of the Precipitate Dam and the wetlands treatment of acid drainage from Side Creek and Eastern Hill Adit, are not believed to have significantly ameliorated the acid drainage. The use of aerobic wetlands to treat AD is not an appropriate technology and the capping of the Precipitate Dam neither reduced the oxidation processes or infiltration significantly. This is attributed to the failure to construct a cut of drain in the Creek draining into the dam.

The acidity data indicates that the introduction of systems to provide alkalinity could be highly effective in ameliorating the residual acid drainage impacts in the Storys Creek catchment. Treatment of point sources would also have beneficial effects and the trials have demonstrated that this is feasible and effective.

3.4.1.3 Aberfoyle Creek Catchment

In the Aberfoyle Creek catchment, loads are lower and not due to acid conditions. The single largest source is the drainage from the mine workings via the No4 Adit. Treatment of the No 4 Adit drainage would have beneficial effects on water quality, but the use of the passive input of alkalinity is unlikely to be effective. More diffuse sources will be difficult to ameliorate.

3.4.2 Water Quality Trends

While the historical data is deficient in relation to certain parameters (notable sulphate) and flows, there is sufficient data to obtain trends in water quality, particularly at Storys Creek.

A review of water quality at Rossarden indicates that there is an improving trend. Table 3.3 shows that virtually all water quality parameters are indicating a reduction in concentrations, many improving by up to 50%.

This is partly attributed to a reduction in the overall oxidation rate as physically stable oxidation profiles develop over time in the creek-bank deposited tailings. These are evident as quite hard cemented oxidised zones, oxygen then has to diffuse to greater depths, reducing the oxygen flux to the unoxidised tailings. Re-exposure of the unoxidised underlying tailings could, however, result in a reversal of this decreasing trend.

There is a similar pattern for the Storys Creek above Aberfoyle Creek Station (although with reduced data), where there is also an observed trend of improved water quality. Cd, Zn, Cu have reduced by greater than 50%. (See Table 3.3).

3.5 Pollution Sources - Storys Creek Catchment

The Storys Creek catchment comprises the main acid drainage sources and contributes over 70% of the total Zn, Cd and Cu loads from the catchment, and most of the acidity.

In all cases sulphate and acidity loads are low and amenable to passive treatment and insitu neutralisation to remove metals from solution.

The sources have been identified in the Preliminary Report as the diffuse sources from tailings and waste materials on the edge (such as the jig tailings) and within the creek itself, Precipitate Dam leachates, Side Creek Adit discharges, Eastern Hill Adit discharges. These are discussed below and are shown in Figure 3.5.

3.5.1 Precipitate Dam

Leachates from the Precipitate Dam were identified as the major point source of acidity and metals (approximately 20%) of loads in Storys Creek.

It was concluded that the previous remedial had been largely ineffective in reducing infiltration, but may have had beneficial effects on surface runoff quality.

Site investigations (JMP 1999a) were conducted as part of the design work for the possible relocation of the Precipitate Dam materials. The investigations revealed that the dam wall was composed principally of spigotted tailings materials, with the walls of highly permeable coarse tailings, grading into tailings sludges in the centre and along the old creek bed. Water tables were high towards the centre of the dam and decline markedly at the embankment as free draining conditions occur (due to

Table 3.3 Storys Creek Water Quality Trends

Storys Creek below Rossarden Bridge

	Date from	to	pH	TDS mg/L	SO4 mg/L	F mg/L	Cd mg/L	Cu mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Median	Apr-82	May-90	5.4	100	51	0.9	0.109	0.700	3.105		0.6
No samples	15										
Median	Apr-95	Oct-97	5.9	61	26	0.4	0.063	0.202	2.200	0.71	0.5
No samples	13										
		believed to be total metals.									
Median	Oct-97	Jun-00	5.5	64	31		0.067	0.208	1.795	0.79	0.3
No samples	8										
		total metals									

Storys Creek above Aberfoyle Creek

	Date from	to	pH	TDS mg/L	SO4 mg/L	F mg/L	Cd mg/L	Cu mg/L	Zn mg/L	Fe mg/L	Mn mg/L
Median	Apr-82	May-90	5.9	115	52.2	0.895	0.085	0.298	4.1		0.4
No samples			11	29	29	28	8	14	15		15
	Date from	to									
Median	15/11/96	2/10/97	6.0	47	19	0.29	0.048	0.094	1.43	0.28	
No samples			1	1	1	1	4	4	4	3	
	Date from	to	Lab pH								
Median	2/10/97	May-99	5.5	59	20	0.4	0.050	0.160	1.41	0.2	0.21
No samples	3		3	3	3	1	3	3	3	3	3

jmp

spigotted tailings). The tailings were covered with a shallow 200-300mm cap of precipitate materials resulting from the treatment of acid mine waters from the Storys Creek mine.

The water quality of water samples taken from a pit excavated in the dam and the leachate from the dam is shown in Table 3.4. This showed that the water quality was poor, but with only moderate acidity and sulphate loads. The lower pH in the waters leaching from the embankment was attributed to the oxidation processes in the coarser wall materials.

Geochemical testwork was carried out on tailings samples (JMP 1999a). This showed that the tailings samples had water extracts pH's in the range of 6.6 to 6.8, with a near neutral pH. Electrical conductivity indicates that the tailings were only moderately saline. Acidity (by titration to pH 8.3) ranged from 8 to 70 mg CaCO3/kg. The tailings materials are therefore not a major source of acidity and this is readily buffered by the addition of limestone and hydrated lime.

The designs for the removal and encapsulation of the tailings materials in a storage constructed at the site of the old eastern tailings dam are discussed in Section 6.2.2. The tailings were relocated in Autumn 2000 (see JMP2000b . Photographs are enclosed at the rear of the report

3.5.2 Jig Tailings

Large quantities of jig tailings have been deposited on the slopes of Storys Creek near the mine (see photographs). While the quantities are difficult to estimate because of a lack of accurate topographic ground survey, they have been estimated by a surveyor to be in the vicinity of 45,000 cubic metres.

The load calculations (see Section 3.4.1.2), indicate that the Jig Tailings are a major source of contamination in Storys Creek. The updated figures for the sources and loads are shown in Figure 3.5.

Seepages from the Jig Tails are therefore the largest single source of contamination, using these figures.

Laboratory trials using jig tailings and large scale lysimeter trials have been conducted (refer Section 4.3). These trials have demonstrated that the addition of alkalinity can significantly reduce the contaminant loads. Eighty tonnes of crushed limestone was added in Autumn 2000 (see Miedecke 2000a). A design study has been completed to relocate the tailings to the new tailings encapsulation site (JMP 2000c)

3.5.3 Side Creek Adits (Story Mine)

The Side Creek Adit discharges have generally been low in flows and were not evident during the study period. It is concluded that the works in Storys Creek creek bed have resulted in affects on the groundwater regime and that mine drainage from the abandoned mine workings are now expressing themselves as subsurface discharges to the creek bed, rather than obvious surface flows.

TABLE 3.4 PRECIPITATE DAM WATER QUALITY

LOCATION	4		
	PPT Dam outflow	PPT Dam outflow	PPte dam Pit near NE
PARAMETER (mg/l)	976000		
SAMPLE DATE	2-Oct-97	1-Sep-98	1-Sep-98
FLOW L/sec	1		
pH L	3.4	3.4	6.1
pH F	3.6		
Cond mS/cm L	908	881	606
Cond F	826		
TDS	692	606	479
NFR	59	45	337
Alkalinity (CaCO3)	<1	<1	49
Acidity (CaCO3)	227	174	158
DOC mg/L	1.8		
Hardness (CaCO3)	197		
Ca T	44.0		69.5
Cl	17.0		
SO4	498	420	240
F	12.00	9.40	6.00
K T	0.9	0.9	1.6
Mg T	21.0	25.1	23.9
Na T	4.0	3.7	2.7
Metals			
Al F	9.0	6.6	0.8
Al T	10.0	6.8	2.7
Cd F	2.45	1.28	2.52
Cd T	2.55	1.39	2.60
Cu F	5.420	3.640	0.089
Cu T	5.620	3.830	0.426
Fe F	8.0	1.3	0.02
Fe T	30.0	26.7	7.7
Mn F	6.0	4.9	5.9
Mn T	6.0	5.4	6.3
Zn F	58.40	39.00	67.10
Zn T	61.80	39.20	75.60

It is therefore not possible to quantify the loads, but these are still expected to be significant.

3.5.4 Creek Bed and Bank Deposits

The creek has a long history of disturbance and transport of mine waste materials, being disturbed by past alluvial mining, massive flooding and various tailings and mine water discharges. The majority of waste materials are deposited in the stream bed between the mine and Rossarden township. The water quality data indicates that the major metal inputs occur prior to Rossarden.

A number of pits were excavated in the river banks as part of the trials and also for the installation of groundwater monitoring bores and lysimeters. The pits have indicated that the majority of the materials in the river banks are dolerite boulders and pebbles, but with a major component the jig tailings sourced from Storys Creek (see Photographs). Finer tailings type sludges have generally been identified as a smaller component.

Water quality sampling from the bores and pits located in the river bank deposits show a variable but poor water quality. All data is shown in Table 3.5. The data shows that the waters are typically acidic with pH between 3 and 4, with elevated sulphates and metals, particularly Al and Zn.

This data confirms that a major source of contaminants in Storys Creek are from these waters contained in the bank deposits and sediments. As the creek rises and falls, a significant flux of metals is expected to be released into the creek waters.

The laboratory and creek bank trials, plus the jig tailings lysimeter tests also confirm that the coarser jig tailings materials sourced from the eroding jig tails adjoining the creek are the major source of contamination. These trials are described in Section 4.2.

Pemeability tests have been conducted on two types of materials- the finer grey sludges and also the jig tailings.

The jig tailings, as expected, are highly permeable and any rainfall or water will rapidly pass through, carrying with them high pollutant loads. The finer sludges are relatively impermeable and as a consequence will not be a major pollutant source.

Geochemical testwork on the tailings materials showed that they had a low sulphur content, have negligible ANC and are non-acid forming. However, since the tailings are essentially devoid of ANC, the decrease in pH of materials as they oxidise, can result in relatively high metal solubility. They are therefore a major ongoing potential source of soluble metals in the stream.

Approximately 240 tonnes of crushed limestone was spread on the banks between Storys Creek mine and Rossarden in Autumn 2000 (see Miedecke 2000a). The road and access works have indicated that there are substantial quantities of jig tailings deposited in river banks, These will be practical to recover.

TABLE 3.5 CREEK BANK PIEZOMETER and PITS WATER QUALITY

SAMPLE DATE	22/7/99	22/7/99	22/7/99	22/7/99	8/10/99	8/10/99	8/10/99	8/10/99	Story Pit in	Story Pit in
LOCATION	NW	NE	SE	SW	NW	NE	SE	SW	River bank	in w bank
									17-Nov-98	17-Nov-98
PARAMETER (mg/l)									seepage	fine tails
FLOW L/sec										
pH L	4.5	3.0	3.6	3.0	4.6	3.4	3.8	3.5	3.3	4.3
Cond µS/cm L	223	1440	519	1070	45	274	104	174	640	330
TDS	155	1050	343	668	169	1210	397	663	431	258
Alkalinity (CaCO3)	1	1	1	1	1				1	1
Acidity (CaCO3)	22	226	63	147	25	296	87	153	112	68
NFR (suspended solids)					7	37	2	17	3	68
F										4.50
Ca T	19.2	111.0	38.0	74.6	19.5	119.0	40.6	70.2		26.2
Cl	1.9	3.9	2.7	3.2						
K T	0.2	2.2	0.6	1.5	0.2	2.3	0.5	1.4		0.7
Mg T	6.5	46.9	14.7	29.6	6.5	50.7	15.5	28.3		9.6
Na T	2.4	8.7	3.5	5.0	2.5	9.9	3.7	4.7		2.7
SO4	94	1100	220	1000	150	1300	370	890	68	160
Metals all fiterable										
Al	1.6	15.0	5.1	4.1	1.6	13.6	6.1	4.1	4.7	5.6
Cd	0.089	0.324	0.184	0.204	0.087	0.316	0.209	0.196	0.297	0.292
Cu	0.115	0.683	0.456	0.160	0.113	0.596	0.492	0.145	0.290	1.010
Fe	0.0	11.5	0.4	8.6	0.0	18.3	0.4	26.4	2.35	20.00
Mn	1.2	12.4	3.0	6.7	1.2	14.9	3.4	7.4	2.5	2.0
Ni	0.019	0.162	0.046	0.075	0.021	0.157	0.046	0.067	0.035	0.04
Pb	0.011	0.146	0.073	0.094	0.011	0.072	0.073	0.044	0.029	<0.001
Zn	2.550	22.100	5.890	9.310	2.970	25.100	7.040	9.910	10.90	8.38
Water Level					6.56	6.62	7.5	6.83		

3.4.5 Eastern Hill Adit

The Adit contributes significant metal loads to Storys Creek (mainly Fe) and the constructed wetlands are having no beneficial effects on water quality.

Site investigations and a design of a plug are discussed in Section 6.2.6. The adit was blocked in Autumn 2000. (see Miedecke 2000b)

3.6 Pollution Sources - Aberfoyle Creek

No new data was collected within this catchment and additional sampling at the Story Creek confluence have confirmed the water quality data (see Figure 3.6 for locations).

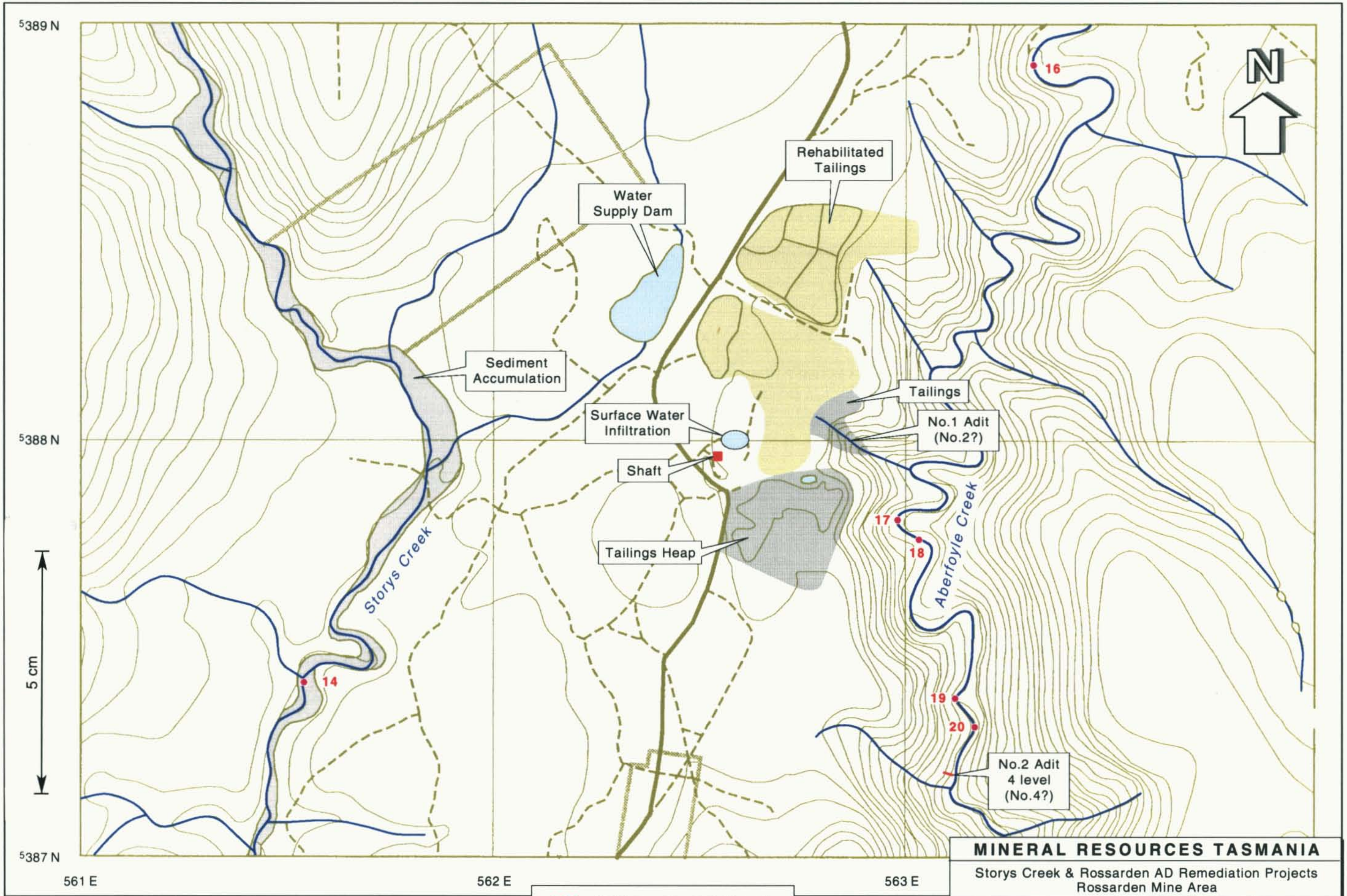
The previous data indicates that the major sources of metals, sulphate and alkalinity are the mine drainage, in particular the No 4 Adit drainage, with a significant input from No 2 adit drainage and probably diffuse tailings leachates.

While sulphate loads are quite high, there is no indication that the large quantities of jig tailings are contributing acid drainage to the drainage system. It is also noted that the significant loads of zinc may well be in a fine floc form (ie passing the 0.43µ filters used).

The creek alkalinity load is significant, with No 4 Adit contributing significant alkalinity.

Drainage control works were constructed in Autumn 2000 (see Miedecke 2000a).

An obvious area of acid generating materials was evident at the NW corner of the tailings dams



1 grid space to 1km

• 14 October water sampling site

(October 1999)

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Storys Creek & Rossarden AD Remediation Projects
Rossarden Mine Area

John Miedecke & Partners P/L

FIG 3.6

4.0 REMEDIATION TRIALS

4.1 Background

Following recommendations in the Preliminary Report (Miedecke 1998) a series of onsite trials were conducted at Storys Creek. These evaluated the feasibility of remediation options at various sites (refer Figure 4.1). These trials were concentrated on the Storys Creek mine area, as this was the major source of contaminants.

The poor water quality data base was expanded by site specific monitoring to establish effectiveness of the trials. However, the recommended program was not accepted by the steering committee and a more restricted water sampling program was implemented. This is discussed in Section 4.2.3.

The trials concentrated on methods of adding alkalinity to the ground and surface waters and to acid generating sources to reduce oxidation and neutralise and precipitate released metals at the source.

4.2 Water Quality Monitoring

4.2.1 Flow Gauging

The HEC was engaged to establish a gauging station at Station 14, located just above Rossarden (refer Figure 3.6). The HEC has established a rating curve for the Station and the station has been used to correlate water quality and creek flows. The station rating curve is included in Appendix C.

4.2.2 Rainfall

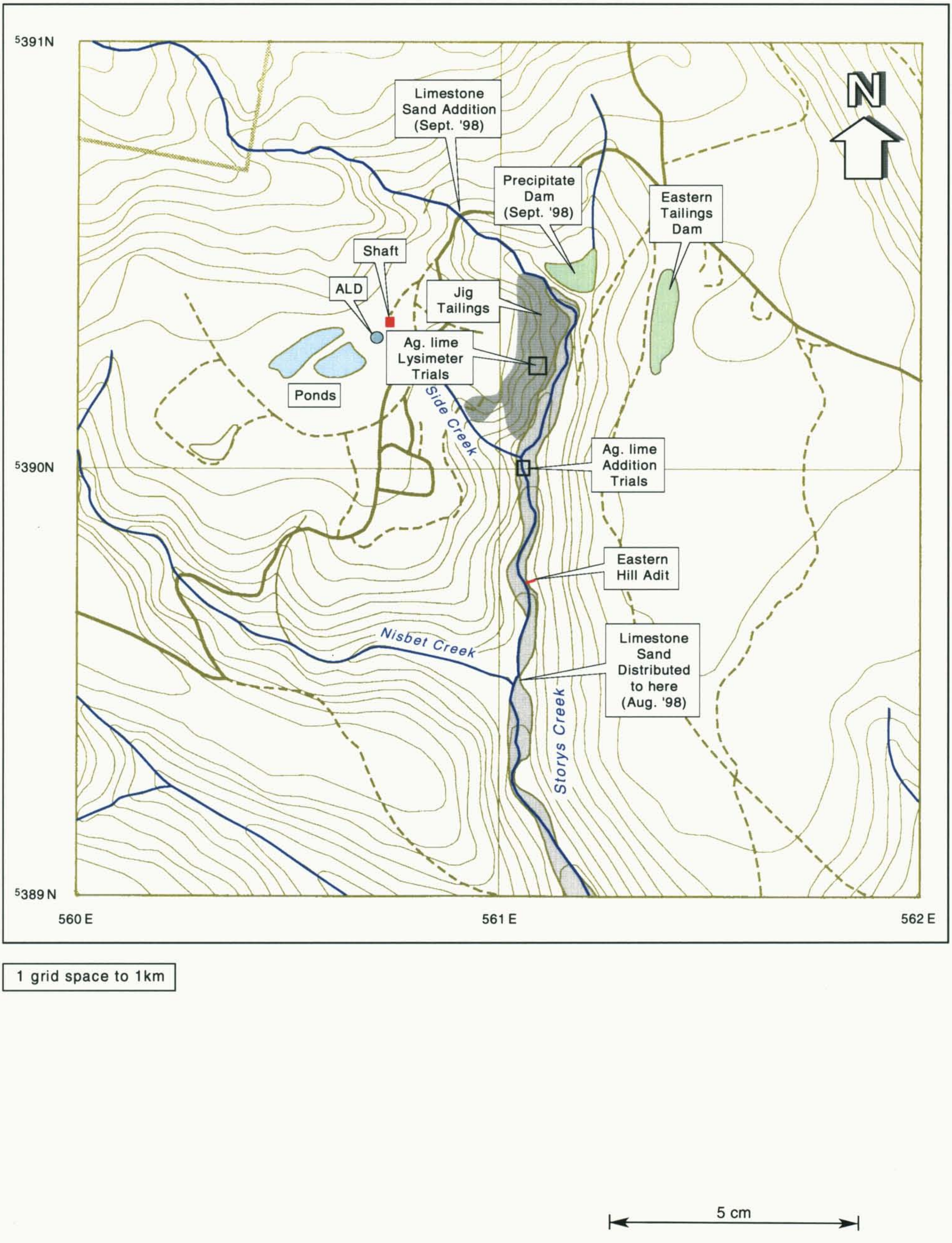
A rainfall gauging station was operated at Rossarden (Station 92100) by the Bureau of Meteorology. However, this Station was closed in January 1998 and the station could not be used with the flow gauging and water quality monitoring.

The nearest active gauging station was at Avoca. However, a comparison of the two revealed that historically the two stations did not have a good correlation as topography clearly had a marked effect on rainfall events.

Therefore, a qualitative estimate of rainfall was used for monitoring purposes.

4.2.3 Water Quality Monitoring

As the recommended water quality program contained in the Preliminary Report was not accepted, an opportunistic sampling program is being carried out. This consisted of spot sampling at various locations. These samplings were correlated with the reading of the gauge heights at Station 14, notes on creek flows and appearance, and a subjective measure of rainfall in the preceeding few days, from either evidence of rain, local contacts or rainfall records.



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Storys Creek & Rossarden AD Remediation Projects
Storys Creek Mine Area Remediation Trials

(October 1999)

John Miedecke & Partners P/L

FIG 4.1

Water samples were collected in plastic bottles provide by the DPIWE University Laboratory, and stored in ice until delivered to the laboratory. A standard suite of parameters and metals (both filterable and non filterable) was measured. All data is contained in Appendix A. Samples from piezometers were collected by a pump after evacuation of over 3 volumes.

All water quality data is enclosed in Appendix B.

It was noted that the addition of alkalinity to Storys Creek itself by the additional of limestone sand, resulted in the creation of an obvious white precipitate in the creek bed. This is believed to be an aluminium hydroxide floc. This precipitate was removed in high flow periods, presumably being carried further downstream and ultimately to the South River system.

4.3 Storys Creek Alkalinity Addition

4.3.1 Purpose

Alkalinity addition is a viable technology because of the low acid loads and dispersed pollution sources.

Water flowing over limestone creates alkalinity when the acidic water contacts the limestone and the pH of the waters are raised resulting in metals in solution being removed as particulates.

Limestone in the form of sands which are mobilised and dispersed under high flow conditions have been successfully applied proven in eastern USA and in particular in West Virginia (refer Preliminary Report).

The armouring and passivation which typically coats the limestone is removed due to continual movement and abrasion. The rates of alkalinity generated in an atmospheric environment are not large, but limestone sands are cheap, easily applied and suitable to steep topography.

This trial was conducted to establish the effectiveness of this treatment.

4.3.2 Trial Details

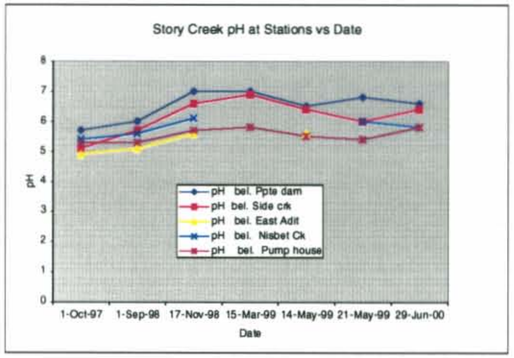
Approximately 240 tonnes of limestone sands (screened and generally 6mm) from Beams Brothers Flowery Gully quarry were added to Storys Creek at the bridge above the mine site in August - September 1998.

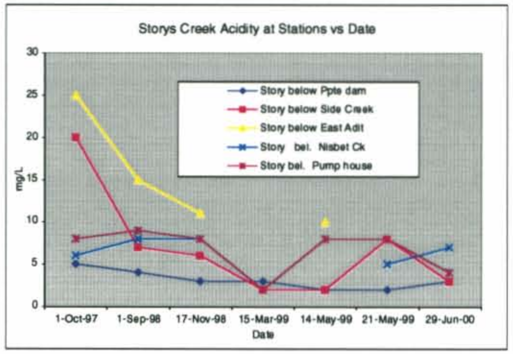
The movement of these limestone materials was monitored and periodic water sampling was conducted downstream at Storys Creek monitoring stations.

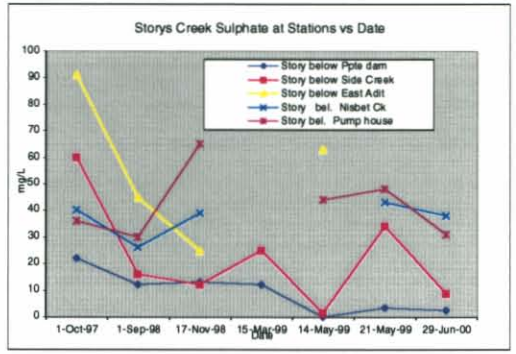
4.3.3 Results

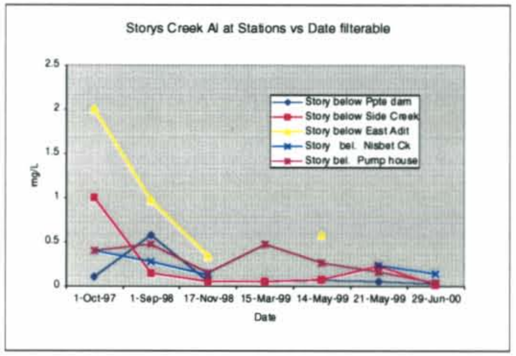
The limestone sands were observed to progressively move approximately 3 km downstream to near the Nisbett Creek - Story Creek junction after high flow events. The main deposits were in the vicinity of the jig tailings adjoining the creek. The sands were well distributed over the creek bottom and banks.

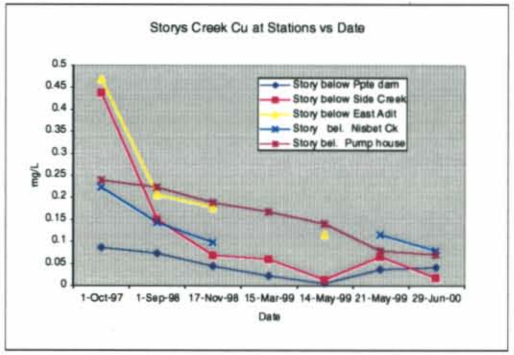
Figure 4.2 Storys Creek Water Sampling - before and after limestone sand addition in September 1998.

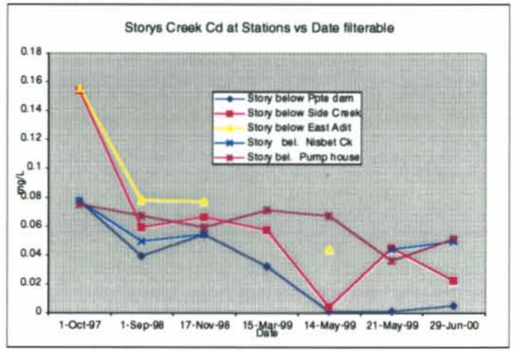


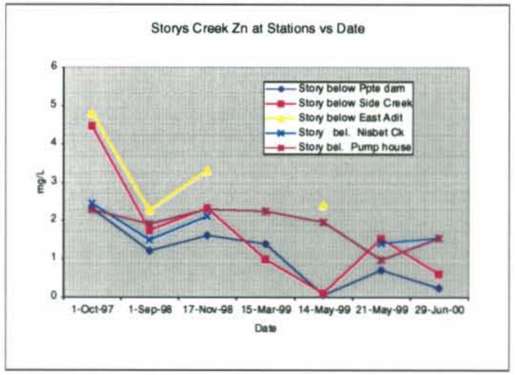












Station Locations	Station No
Story Below Precipitate Dam	5
Story Below Side Creek	8
Story Below Eastern Adit	11
Story Below Nisbet Creek	13
Story Below Pump House	14

There was no sign of armouring of the limestone materials. Water samples were collected at downstream stations on an opportunistic basis.

Water quality monitoring results are discussed below.

All monitoring data is included in Appendix B. Figure 4.2 shows a summary of the results in a graph format for all Stations below the Storys Creek Bridge to the gauging station at Site 14, just above Rossarden. Additional graphs and data are included in Appendix B.

The results show an increase in pH to approximately 7 in the Precipitate Dam area and a general increase downstream. There was a marked reduction in metals in solution and significantly reduced acidity and sulphate loads. There is a progressive reduction in effect down to the Nisbett Creek Junction (see Figure 4.2). This correlates well with the observation of sand distribution. There are no obvious improvements in water quality at the Story below Pump House Station (Station 14).

There would appear to be an approximate 25% to 75% reduction in metal, acidity and sulphate loads in the area of the Creek which has been treated.

There is an excellent correlation of metal concentrations with sulphates, which indicates the metal source is from acid seepages.

Monitoring also shows there is an increase in metal concentrations following rainfall events. However, the best water quality coincides with high flows, due to the contribution of clean water further up the catchment, which is steep and flows vary rapidly following rainfall events.

The increase in metal contribution following these events is attributed to seepage from contamination sources such as jig tailings and creek bank materials.

4.3.4 Conclusions

It is concluded that the addition of limestone sands has been effective, but limited to the actual area where the sands have been distributed.

Further downstream, contribution from bed and bank deposits continue to raise contaminant concentrations.

Therefore, sand need to be added at a number of locations to ensure the sand are distributed evenly and preferably supplemented, with limestone bank addition.

4.4 Agricultural Limestone Addition to Jig Tailings

4.4.1 Purpose

Geochemical control of AD can be achieved by the addition of crushed limestone ($CaCO_3$) to the source materials. Placement of limestone in direct contact with oxidising material provides immediate neutralisation and precipitation of any released metals at the source. Also, an increase in pH will further reduce the oxidation rate.

The results of the geochemical characterization of the tailings suggested that improving the buffering capacity of the tailings by the addition of crushed limestone (at rates of only about 1 to 2 tonnes per hectare), would significantly reduce the metal release rate from the creek-bank deposited tailings.

Separate trials were conducted on both stream bank deposits (consisting of at least some jig tailings) and the jig tailings themselves. Laboratory scale trials were also carried out (see Section 4.5)

4.4.2 Trial Details

Crushed agricultural grade limestone (comprising limestone dust and sands) was added at a rate of 5kg/tonne to jig tailings located above a 1.9m diameter lysimeter located in the jig tailing pile at Storys Creek. A control lysimeter with untreated tailings was constructed next to the treated one. Figure 4.3 shows the trial layout.

The leachates from the two lysimeters were collected in polythene containers buried below ground surface in 200L polythene drums (see Photographs).

Water samples were collected periodically from the containers and analysed for the standard parameters.

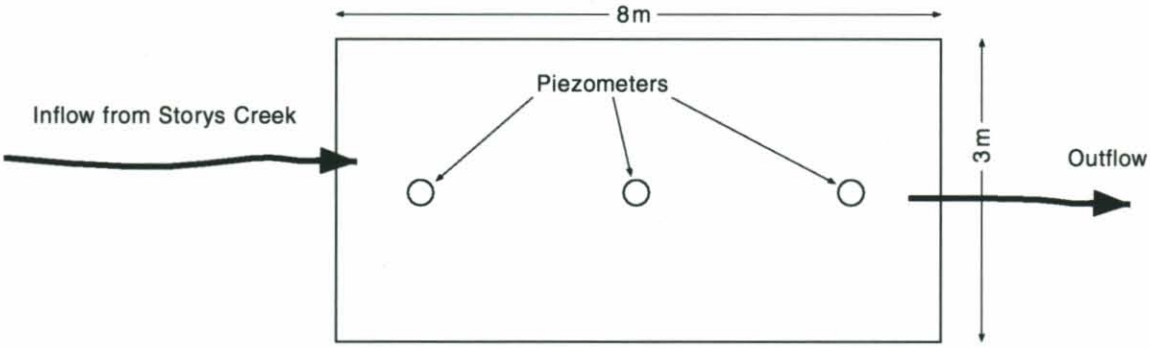
4.4.3 Results

Samples were collected over a 12 month period and the results are shown in Table 4.1. Volumes collected frequently exceeded greater than 200L which indicated that the infiltration rate was very high, as expected. It is estimated that almost 100% of rainfall reported to the sample containers.

The water quality data shows that the leachates from the untreated Jig Tailings are of very poor quality, with low pH, and very high metal concentrations. The treated tailings showed an improvement with reductions in the order of 50%. However, the pH in the treated tailings was slightly less, with significant residual acidity, indicating that the alkalinity provided was insufficient to raise the pH and buffer the acidity.

4.4.4 Conclusions

The lysimeter trial has shown that the water quality of leachates from the tailings is of very poor quality (the worst recorded in the study). The water quality is worse than reported in previous work by Mineral Resources Tasmania and the Department of Environment, or the laboratory trials (see next section). This is attributed to the other work being confined to the surficial materials. It was noted on excavation of the lysimeters (to a depth of approximately 1.8m) that there were finer materials at depth.



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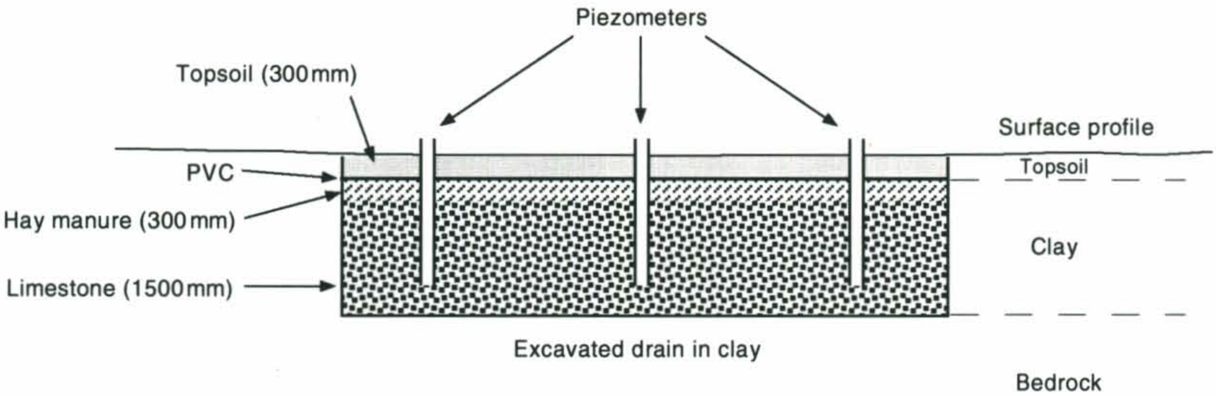


SECTION

NOT TO SCALE

5 cm

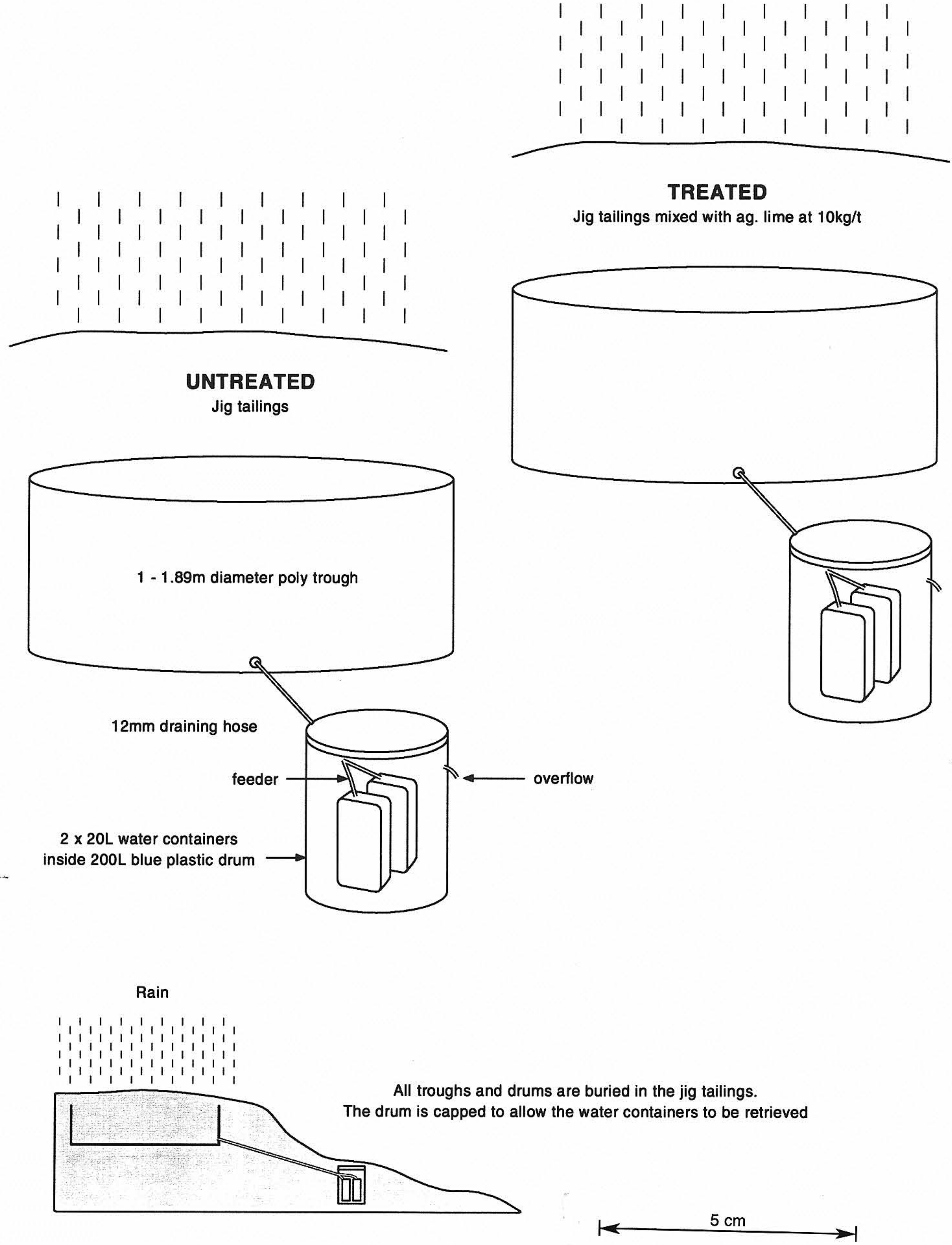
MINERAL RESOURCES TASMANIA	
Storys Creek & Rossarden AD Remediation Projects Anoxic Limestone Drain	
John Miedecke & Partners P/L	**FIG 4.4**

(October 1999)

TABLE 4.1 Jig Tailings Lysimeter Trial Results

LOCATION / PARAMETER (mg/l)	Jig Tails Lysim untreated	Lysim treated	% change	Lysim untreated	Lysim treated	% change	Lysim untreated	Lysim treated	% change	Lysim untreated	Lysim treated	% change	means untreated	means treated	% change
SAMPLE DATE	Oct-98	Oct-98		Dec-98	Dec-98		Apr-99	Apr-99		Aug-99	Aug-99				
FLOW L/sec															
				part full			full, seds	full, seds		full, seds	full, seds				
pH L	5.6	3.3	59%	3.1	7.6	245%	4.9	3.1	63%	4.2	3.3	79%	4.46	4.33	97%
pH F															
Cond µS/cm L	3320	2620	79%	2280	2150	94%	2310	2210	96%	448	296	66%	2090	1819	87%
Cond F															
TDS	4330	2690	62%				5290	2090	40%	2700	1290	48%	4107	2023	49%
NFR (suspended soli	263	8	3%				7	4	57%	8	2	25%	93	5	5%
Alkalinity (CaCO3)	1	1	100%				1	1	100%	1	1	100%	1.00	1.00	100%
Acidity (CaCO3)	1120	461	41%	312	292	94%	585	282	48%	621	234	38%	660	317	48%
Hardness (CaCO3)															
Ca T	365.0	399.0	109%							247.0	205.0		306	302	99%
SO4	2700	1800	67%	1400	550	39%	2100	1500	71%	1900	920	48%	2025	1193	59%
K T							0.9	1.5	159%	0.6	0.6	100%	0.76	1.04	136%
Mg T							109.0	42.7	39%	81.7	25.1	31%	95.35	33.90	36%
Na T							2.0	1.6	79%	1.7	1.4	83%	1.88	1.53	81%
Metals															
Al F	87.8	25.2	29%	13.3	8.5	64%	28.2	12.8	45%	24.3	10.8	44%	38.40	14.32	37%
Al T	90.6	24.9	27%	11.6	9.0	77%	29.3	12.8	44%				43.83	15.55	35%
Cd F	18.800	4.050	22%	5.120	1.880	37%	9.840	2.650	27%	8.310	1.610	19%	10.52	2.55	24%
Cd T	18.600	4.050	22%	4.930	1.890	38%	9.950	3.120	31%				11.16	3.02	27%
Cr F	0.047	0.022	47%	0.013	0.005	38%	0.009	0.001	11%				0.02	0.01	41%
Cr T	0.051	0.023	45%	0.013	0.005	38%	0.01	0.003	30%				0.02	0.01	42%
Cu F	56.900	29.500	52%	7.480	10.700	143%	19.800	14.200	72%	26.000	8.350	32%	27.55	15.69	57%
Cu T	54.400	30.100	55%	6.510	11.600	178%	20.500	14.200	69%				27.14	18.63	69%
Fe F	0.02	11.90	59500%	0.02	4.42	22100%	0.04	8.26	20146%	0.33	9.71	2925%	0.10	8.57	8303%
Fe T	2.0	11.3	557%	0.0	4.6	22850%	0.1	11.0	13580%				0.71	8.96	1261%
Mn F	138.0	19.5	14%	44.9	10.6	24%	98.4	15.5	16%	94.7	10.6	11%	94.00	14.05	15%
Mn T	142.0	18.8	13%	42.3	11.0	26%	100.0	15.6	16%				94.77	15.13	16%
Ni F	1.21	0.293	24%	0.33	0.107	32%	0.703	0.15	21%	0.405	0.073	18%	0.66	0.16	24%
Ni T	1.25	0.331	26%	0.319	0.113	35%	0.722	0.147	20%				0.76	0.20	26%
Pb F	0.078	0.211	271%	0.02	0.169	845%	0.186	0.197	106%	0.283	0.135	48%	0.14	0.18	126%
Pb T	0.117	0.219	187%	0.019	0.172	905%	0.224	0.262	117%				0.12	0.22	181%
Zn F	442.00	109.00	25%	118.00	48.30	41%	24.50	67.60	276%	362.000	67.900	19%	236.63	73.20	31%
Zn T	430.00	101.00	23%	112.00	45.90	41%	25.50	84.10	330%				189.17	77.00	41%

Indicates that insufficient alkalinity has been added



MINERAL RESOURCES TASMANIA

Storys Creek & Rossarden AD Remediation Projects
Jig Tailings Lysimeter Trial

(October 1999) John Miedecke & Partners P/L **FIG 4.3**

The alkalinity addition did reduce contaminant loads by approximately 50%, but the rate of 5kg/tonne was insufficient to buffer the acidity and approximately 10kg/tonne is required (as used in laboratory trials). However, adequately mixing the limestone with all the jig tailings would be impractical.

4.5 Limestone to Stream Bank Deposits (Tailings)

4.5.1 Purpose

The trial was similar to the previous trials (ie the Jig Tailings) and was intended to assess the feasibility of achieving geochemical control of AD for the river banks deposits, consisting of both coarse and fine tailings materials. A laboratory trial and a larger scale trial on the creek banks were conducted.

4.5.2 Laboratory Trial with Tailings

The laboratory scale trial was conducted over the period from September 1998 to May 1999 by the DPIWE laboratory and the report and results are enclosed in Appendix D.

An oxidised (brown colour) and unoxidised (grey colour) sample of creek-bank deposited tailings was collected from Storys Creek below the mine managers residence (Site 14, Figure 3.1). The jig tailings were collected from the surface of the jig tailings heaps at Storys Creek. The samples were mixed with various rates of limestone and subjected to leaching tests in the laboratory, in accordance with the procedures set out by EGi (see Appendix D)

Results

The results are summarised in Table 4.2. Metal contents of the tailings are shown in Appendix D.

The trials were very successful for the jig tailings, but only moderately successful for the fine tailing materials. There were problems with maintaining water flows through the fine tailings samples. It is believed that due to the low acidity, the limestone reacted only very slowly and therefore did not provide sufficient alkalinity to affect a reduction in the dissolved metals.

The jig tailings treated at a rate of 10kg/tonne with crushed limestone, had leachates with a pH of over 7, low acidity and very low concentrations of metals.

Permeability testing of materials gave 10^{-8} cm/ sec, for the fine tails and 10^{-4} cm/ sec for jig tails. This indicates that nearly 300% of annual rainfall will infiltrate the jig tails (based on an annual rainfall of 960mm), but only 0.03% for fine tailings. The main source of contamination is therefore believed to be from Jig Tailings materials in the creek bed and banks.

TABLE 4.2 SUMMARY OF LABORATORY TRIALS

Parameter Sample No	 Date	 Descript	Water added	pH	Cond µS/cm	Alk mg/L	Acidity mg/L	Sulph. mg/L	Al µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Zn µg/L	Ca µg/L	K µg/L	Mg µg/L	Na µg/L
19 weeks of data																						
Oxidised tails																						
01	Mean	untreated	328	4.5	149	1	18	67	521	230	15	1	700	37	697	8	1	4668	6	2	3	4
02	Mean	5kg/t	326	4.6	160	1	13	71	365	184	11	1	515	40	570	6	1	3573	15	2	3	
03	Mean	10kg/t	334	4.8	175	1	14	76	404	197	13	1	522	43	649	10	1	3794	13	2	3	4
%change				108%	117%	100%	75%	114%	77%	86%	83%	100%	75%	117%	93%	115%	100%	81%	212%	107%	106%	108%
Unoxidised																						
UO1	Mean	untreated	345	5.7	109	1	5	29	492	73	1	1	15	174	281	4	1	1024	7	1	3	3
UO2	Mean	5kg/t	355	6.0	112	1	4	38	255	61	1	1	18	97	311	2	1	790	8	1	3	3
UO3	Mean	10kg/t	424	6.1	124	1	6	42	185	95	5	1	38	97	555	4	1	1361	9	1	3	3
%change				106%	114%	100%	119%	143%	38%	130%	318%	100%	248%	55%	197%	91%	100%	133%	134%	110%	106%	115%
Jig Tails																						
05	Mean	untreated	475	3.8	175	1	30	87	1809	166	29	1	576	46	3154	23	47	3907	6	1	3	0
06	Mean	10kg/t	471	7.3	187	10	2	69	63	1	1	1	2	23	28	2	1	4	22	0	2	0
% change				191%	106%	1000%	5%	79%	3%	1%	3%	78%	0%	50%	1%	7%	2%	0%	377%	89%	61%	102%

4.5.3 Creek Bank Trials

Following the demonstration of success with the laboratory scale trial, a larger scale trial was constructed on the banks of Storys Creek below Side Creek. This site was selected because it was composed of coarser materials - principally dolerite boulders, pebbles and jig tailings material. Crushed limestone (agricultural grade) at a rate of 10 tonnes per hectare was spread by a lime spreader over an area of approximately 2 ha, after clearing and access track construction (see Figure 4.1) (see Photographs).

A similar trial was commenced at Station 14 near Rossarden but poor ground conditions (saturated fine tailings) resulted in the excavator becoming bogged and the site was abandoned.

Four groundwater piezometers were installed at the trial for monitoring purposes. Two porous cup lysimeters were also installed to measure water quality in the vadose zone (ie above the water table) at both the treated site and an untreated site.

A similar site was selected near the water monitoring Station 14 (Story below Pump House). However, this site was composed of principally fine tailings and after the excavator became bogged, the site was abandoned (see Photographs).

Results

Water quality data from the piezometers is shown in Table 4.3.

The piezometer water quality data shows a variable water quality. The groundwater table was established by survey of the water levels and this indicates a movement as indicated. It is probable that the variations in water quality are due to groundwater movements from the adjoining hills (ie clean groundwaters), and also due to rainfall and fluctuations in creek levels.

Unfortunately the porous cup lysimeters were not effective and water samples could not be obtained from pore water in the materials above the water table. This is attributed to the coarse size of the sediments and high permeability.

4.5.4 Conclusions

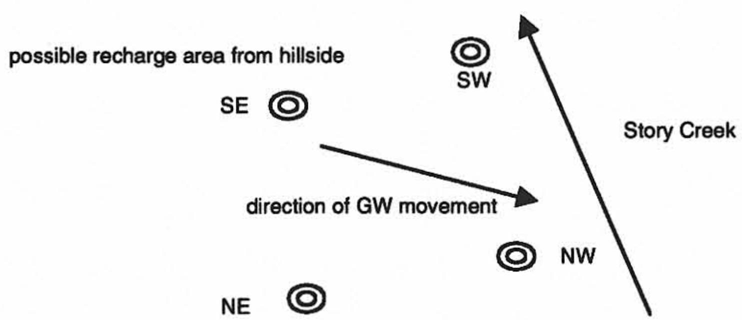
The major materials which have been identified in the creek banks are the jig tailings and the fine tailings are a much smaller component. Based on permeability results, the major source of contamination will be from leachates from coarse jig tailings.

No meaningful information was obtained from the water monitoring data for the creek bank trials. However, both the laboratory trials and the Jig Tailings Lysimeter trials both showed that the addition of crushed limestone was very effective in reducing metal leaching.

Therefore, the placement of limestone in direct contact with oxidising material has been demonstrated to provide immediate neutralisation and

TABLE 4.3 CREEK BANK TRIALS PIEZOMETER WATER QUALITY

SAMPLE DATE	22/7/99	22/7/99	22/7/99	22/7/99	8/10/99	8/10/99	8/10/99	8/10/99
LOCATION	NW	NE	SE	SW	NW	NE	SE	SW
PARAMETER (mg/l)								
FLOW L/sec								
pH L	4.5	3.0	3.6	3.0	4.6	3.4	3.8	3.5
Cond µS/cm L	223	1440	519	1070	45	274	104	174
TDS	155	1050	343	668	169	1210	397	663
Alkalinity (CaCO3)	1	1	1	1	1			
Acidity (CaCO3)	22	226	63	147	25	296	87	153
NFR (suspended solids)					7	37	2	17
F								
Ca T	19.2	111.0	38.0	74.6	19.5	119.0	40.6	70.2
Cl	1.9	3.9	2.7	3.2				
K T	0.2	2.2	0.6	1.5	0.2	2.3	0.5	1.4
Mg T	6.5	46.9	14.7	29.6	6.5	50.7	15.5	28.3
Na T	2.4	8.7	3.5	5.0	2.5	9.9	3.7	4.7
SO4	94	1100	220	1000	150	1300	370	890
Metals all fiterable								
Al	1.6	15.0	5.1	4.1	1.6	13.6	6.1	4.1
Cd	0.089	0.324	0.184	0.204	0.087	0.316	0.209	0.196
Cu	0.115	0.683	0.456	0.160	0.113	0.596	0.492	0.145
Fe	0.0	11.5	0.4	8.6	0.0	18.3	0.4	26.4
Mn	1.2	12.4	3.0	6.7	1.2	14.9	3.4	7.4
Ni	0.019	0.162	0.046	0.075	0.021	0.157	0.046	0.067
Pb	0.011	0.146	0.073	0.094	0.011	0.072	0.073	0.044
Zn	2.550	22.100	5.890	9.310	2.970	25.100	7.040	9.910
Water height					6.56	6.62	7.5	6.83



precipitation of any released metals at the source. An increase in pH will further reduce the oxidation rate.

While complete mixing of limestone with all the oxidising material will not be possible, the surface addition to creek bank deposits will provide beneficial effects – as demonstrated by the addition of limestone sands to Storys Creek itself. The selective removal of the major deposits if feasible will have beneficial effects.

The construction of anoxic limestone drains adjacent to the hill slopes and recharging groundwater with alkalinity is a possible remediation method.

4.6 Anoxic Limestone Drain (ALD) in Area Above Storys Mine

4.6.1 Purpose

The use of anoxic drains to add alkalinity to the surface waters infiltrating into the Storys Creek mine workings have not previously been trailed. Their use has been restricted to treatment of acidic waters as it was not believed that they would be effective in generating significant alkalinity in "clean"waters.

The trial was designed to test if significant alkalinity could be generated.

4.6.2 Trial Details

The drain was constructed up-slope from the main shaft and in an area which is saturated from leakage from the ponds constructed in the area for mine use. The drain was excavated and filled with approximately 20 tonnes of limestone (size approx 75-100mm), then a layer of hay and horse manure (stable waste), a polythene sheet, then covered with topsoil (Figure 4.2).

The design is similar to designs for anoxic limestone drains which have been constructed in the United States, with a retention time of an estimated 16 hours (based on a 10% void area). The horse stable manure with the polythene cap provides the seal so that inputs of atmospheric oxygen are minimised and the accumulation of $CO2$ within the ALD is maximised and therefore assists in alkalinity generation.

Water was directed to one end of the drain by a pipe, and samples collected at the outflow. Flow rates were controlled at approximately 4L per minute.

4.6.3 Results

The results are shown in Table 4.4. Alkalinity generation rates have ranged from approximately 50 to 300mg/L. The variation is attributed to inflows of other waters in winter and rain events.

TABLE 4.4 ANOXIC LIMESTONE DRAIN MONITORING RESULTS

PARAMETER (mg/l)		Outflow				
SAMPLE DATE	Oct-98	Oct-98	Nov-98	Dec-98	Apr-99	Jun-99
Notes	Inflow		pipe blocked cleared to 4L/min		approx 4l/min	4L/min
pH L	5.8	7.2	7.1	5.3	6.7	6.5
Cond mS/cm L	23	604	673	235	345	120
TDS		387			238	164
NFR (suspended solids)						
Alkalinity (CaCO3)	11	145	291	113	327	51 affected by other waters

4.6.4 Conclusions

The drain has proven very effective at generating alkalinity in clean waters and has application for alkalinity recharge. It is believed to be the first such application of such a design, which traditionally have only been believed to be effective in buffering acid drainage sources.

The results were reviewed by Dr Robert Hedin (Pennsylvania USA base consultant) who believes the results are very promising.

The most alkalinity he had seen consistently produced by ALDs (constructed for mine water) is 300-320 mg/L ($CaCO_3$) The current theory on ALD alkalinity generation is that it is largely controlled by high CO_2 in the influent mine water. Dr Hedin has done experimental anoxic limestone incubations of surface water (low CO_2) and found that, after 12 hours, alkalinity values were only 40-50 mg/L. The same devices and conditions produce 280-300 mg/L alkalinity with "fresh" CO_2-rich mine water.

Therefore, Dr Hedin believes that the organic cap on the ALD may be an important source of CO_2 and high alkalinity. He has recommended additional monitoring of influent and discharge pH (measured in the field) and the use a simple carbonate model to calculate CO2 partial pressures, as well as Ca and Mg and concentrations. If CO_2 partial pressures are much higher at the effluent, it is suspected that the organic matter is playing more of a role than just acting as an oxygen barrier.

With respect to the life, the alkalinity generation rates indicate that the life of the drain would be approximately 20 years. The life of the anoxic layer which is the organic substrate in your system -- is not readily calculated. However, If data from the SAPS systems is indicative, the organic layer might be exhausted in 5-10 years.

5.0 AQUATIC FAUNA ASSESSMENT AND ENVIRONMENTAL QUALITY OBJECTIVES

5.1 Summary

A summary of the aquatic fauna section of the preliminary report prepared by Freshwater Systems is produced below for completeness of the report (for the complete report see Miedecke 1998).

The overall weight of evidence suggests that the South Esk River is not heavily impacted from Storys Creek for its entire length from the junction to Perth, as has historically been believed.

The evidence indicates that:

- Storys Creek has and continues to have a major impact on water quality downstream of Storys Creek, primarily through the input of zinc and possibly through input of cadmium, metal hydroxide flocs and coarse sediment;
- The overall pattern of biological impact appears to have been sustained at least between the 1970s and 1990s, but insufficient data exists to assess the extent of any recovery or further decline;
- The biological impact of Storys Creek is significant within the reach approximately 30 km downstream of Storys Creek, but not necessarily beyond that;
- There is a significant biological degradation associated with general catchment land use (including the riparian zone), which is significant both upstream and downstream of Storys Creek and that appears to be cumulative in a downstream direction;
- The level of biological impact from catchment land use practices is similar and possibly more severe than that experienced in the Meander River;
- Fish (brown trout, redfin perch, eels, tench, pygmy perch) are resident in the river reaches downstream of Storys Creek, though possibly not immediately downstream;
- A significant recreational brown trout fishery exists in the South Esk River, with some 35-40% of the angling effort being expended in the reach between Storys Creek and Perth and with an average catch per unit effort marginally lower than for the Meander River;
- Biological integrity of the South Esk River can be restored only by a combination of management of Storys Creek impacts and improved catchment management and riparian condition.
- That EQOs for the South Esk River catchment should be established separately for the reach 30 km downstream of Storys Creek, and for the remainder of the river.

5.2 Environmental Quality Objectives (EQO's)

5.2.1 Introduction

The Environmental Quality Objectives for the aquatic values of Storys/Aberfoyle Creek and South Esk River catchments, as they relate to the possible remediation of the catchments are discussed below. The recommendations are not exhaustive and are not the result of a community consultation process. Rather they are a technical series of recommended EQO targets, focussed on the restoration/remediation of environmental health in the South Esk River and Storys/Aberfoyle Creeks.

They do not address issues of riparian or stream channel management, land use, management of exotic plants and animals or diffuse water quality impacts. They are also different from those EQOs recommended by Davies et al. (1996) for the South Esk River in their report on environmental flow needs for the river.

It is recommended that these be subject to review following collection and analysis of further data (see below) and be used and reviewed as part of any larger community based process for developing EQOs for water quality and quantity for the South Esk catchment that may be initiated by DPIWE under the State Water Quality Management Policy and the Water Reform Process. It is understood that DPIWE are in the process of developing Protected Environmental values for the South Esk Catchment and it is expected that these will be established in the future and replace the EQO's set out below

For the purposes of the study, three catchments compartments have been identified:

- Storys Creek catchment (divided into the catchments of Aberfoyle and Storys Creeks);
- South Esk River catchment downstream of Storys Creek to 30 km downstream; and
- South Esk River from 30 km downstream of Storys Creek to Perth.

5.2.2 Overall Objectives

The overall objective is to restore the biological condition of Storys Creek (or a section thereof), Aberfoyle Creek and the South Esk River downstream of its junction with Storys Creek to a natural state, or to a level commensurate with background catchment conditions by:

- Decreasing total and filterable water concentrations of zinc, cadmium, copper and aluminium to concentrations which allow aquatic life to at least partially return toward a natural state;
- Reducing overall instream and floodplain sediment concentrations of zinc, cadmium and copper to background levels which allow aquatic life to at least partially return toward a natural state;

- Partially restoring stream substrate conditions where they are shown to be detrimental to aquatic health.

Given the scale of the Storys Creek related water quality problems, it is recommended that the above EQO should be targeted in the following order of priority:

- South Esk more than 30 km downstream of Storys Creek ;
- South Esk 0 - 30 km downstream of Storys Creek ;
- Aberfoyle Creek;
- Storys Creek upstream of Aberfoyle Creek.

With the objective to restore those aspects of the trout fishery impacted by Storys Creek to a condition that would be expected in an unpolluted environment, and to ensure that water in the South Esk River is suitable for primary and secondary contact and other agricultural and drinking water uses.

5.2.3 Water Quality Objectives

Table 5.1 presents target maximum concentrations of priority pollutants in the streams mentioned above, for the achievement of the EQOs, as set out by Dr P Davies.

These are largely based on ANZECC (1992) guidelines for soft waters, taking into account the potential for limited complexation of dissolved metals by dissolved organics. DOC levels found in the 1997 HEC survey ranged between 1.5 and 2.5 mg/l for Aberfoyle and lower Storys Creeks and the South Esk River. This suggests only limited complexation capacity which may need investigation. In addition, it must the noted that most of the metal levels reported below (as totals) may not be dissolved, i.e. are either in non-filterable (> 0.45 micron) or filterable but fine flocculate forms, and hence non-toxic. Thus the use of ANZECC (1992) guidelines may be unnecessarily conservative, but they are used in the absence of other evidence.

The ANZECC guidelines are currently being revised and a draft is being circulated for comment before being finalised.

As noted in Section 3.3.2 the guideline values for some metals (notably Cu and Al are being exceeded in the South Esk River above the Storys Creek Junction.

Using ambient metal data combined with biological data from the existing survey work to develop targets for metals is not possible, due to:

- The previously mentioned problem of unknown dissolved fractions;

- The presence of modified stream substrate due to historical tailings etc. inputs from Storys Creek causing potential impacts on biota independent of pollutant impacts; and

- The lack of a comprehensive current water quality and biological data set.

Additional studies are required in the vicinity of the Storys Creek – South Esk Junction.

Table 5.1. Recommended water quality targets for Storys Creek and South Esk River, and ambient median and maximum concentrations (based on DELM 1996-97, 1997 HEC data and more recent data). ? indicates only one or three ambient values available (modified from Freshwater Systems 1997). All data µg/L.

		South Esk	South Esk	Storys Creek Catchment		
Analyte		0 – 30 km d/s SCJ	> 30 km d/s SCJ	SC u/s Aberfoyle	SC u/s S. Esk River	Aberfoyle Ck.
Zinc	Maximum	50	50	50	50	50
	Current Median, Maximum	70, 110	Unknown, Unknown	2000, 4300	1130 1010	646 550
Cadmium	Maximum	0.2	0.2	0.2	0.2	0.2
	Current Median, Maximum	2, 5	Unknown, Unknown	40, 90	33, 30	15 10
Copper	Maximum	5	5	5	5	5
	Current Median, Maximum	5, 9	Unknown, Unknown	200, 370	58, 29	57 30
Aluminium	Maximum	100	100	100	100	100
	Current Median, Maximum	400 Unknown	Unknown, Unknown	700 402	400 332	200 190

5.2.4 Biological Health Objectives

Remediation targets for aquatic biota has been developed in a different manner than for water quality. With biological data it is possible to develop targets:

- Using historical data due to its quality and demonstrated continued relevance; and

- Taking background levels of impact into account, due to the existing downstream gradient in macroinvertebrate community composition which is believed to be due to catchment landuse impacts.

With water quality, it is believed that the only major source of metal toxicants such as zinc and cadmium is Storys Creek, whether currently through water quality or historically through deposited sediments.

With aquatic biota, however, background conditions are believed to be already degraded due to poor land use and riparian management practices. Targets for remediation of Storys Creek should therefore not unrealistically be set for a pristine or reference condition but rather take this background impact into account. If targets were being set for catchment management, then they would of course aim to restore biota to a higher level, but this study is focussed on the remediation of Storys Creek impacts within the current catchment context.

Targets are discussed in the Preliminary Report.

5.3 Probable Effects of Neutralisation

Neutralisation of mine waters within the Storys Creek catchment is aimed at reducing the dissolved metal concentrations and loads discharged into the South Esk River. A consequence of this will be the increase in loads of precipitated metals either as fine colloids/suspensions, flocs or deposited films. While it is unlikely that the resulting concentrations of suspended material will represent a physical disturbance to biota, it is uncertain what the resulting effect will be on benthic habitat suitability for macroinvertebrates and epilithic algae. In Storys Creek it is likely, as happens at present, that the deposition of flocculated hydroxide materials will penetrate the bed matrix, filling interstices and occluding suitable habitat within the bed. In South Esk, the relative load of the precipitated material will be significantly lower and the potential for this to happen will be greatly reduced.

Biological recovery in the South Esk river downstream of Storys Creek is likely to occur if:

- the precipitated metal hydroxides are not toxic in themselves - this is highly likely, with the exception of adsorbed or precipitated cadmium which may be taken up by filter feeders;

- the load of precipitated materials is low enough not to cause significant occlusion of bed matrices;

- the residual toxicity of existing in-stream sediments is low (this has not been determined).

Unfortunately, there is no up to date aquatic fauna data with which to measure either the existing state of the river ecology or to act as a baseline with which to monitor future change. This is required.

6.0 REMEDIATION OPTIONS

6.1 Introduction

Based on the review of the water quality data and the results of the trials, it is apparent that the mine rocks and waste materials are essentially devoid of any acid neutralising capacity. The water in Storys Creek above the mine also contains very little buffering capacity. The pH of this water is naturally neutral to slightly acidic but has a very low dissolved solids content. The SO4 concentration is about 0.5 mg/L. As a result, even a small acid input from the mine site lowers the pH and any released metals from the site will remain mobile.

The Storys Creek Mine area has been identified as the main source of acid drainage. The main source loads have been identified as jig tailings on the slopes, the Precipitate Dam, and waste rock materials in the floor of the creek and in creek bank deposits. Other less significant sources have been identified as Side Creek Adit drainage (including Story mine workings) and Eastern Hill Adit.

Pollutant loads, including acidity, are generally low and are amenable to alkalinity addition to buffer acid drainage for the non point sources, raise pH, remove metals from solution and precipitate metals in the creek bed as colloids and precipitates. Some point sources are amenable to encapsulation and blocking.

Alkalinity addition to raise the pH has been demonstrated to reduce the dissolved concentration of the metals of concern.

The trials have demonstrated that it is feasible to raise the pH of the waters draining the area to approximately pH 7. While the pH – solubility plots indicate that for Zn the pH needs to be increased to at least pH 7.5 to significantly reduce the 'dissolved' concentration, while for Cu and Al a pH of 7 is adequate. However, even at pH 7 the Zn concentration and load will be significantly less than at pH 5.

The Aberfoyle Mine area has non-acid mine drainage, with low but still significant metal concentrations. The topography and main source of pollution via an adit in close proximity to Aberfoyle Creek limits possible remediation options.

6.2 Storys Creek Mine Area

6.2.1 Storys Creek Flows

The water in Storys Creek contains very little buffering capacity. As a result, even a small acid input from the mine site lowers the pH sufficiently and any released metals from the site will remain mobile.

The limestone sand additions have been proven in the trial to be effective in raising the pH and buffering acidity, and reducing filterable metal concentrations in the creek waters.

Assuming a flow of about 40 L/s in Storys Creek below Side Creek, the alkalinity requirement is about 120 kgCaCO3/day to raise the pH to 7.5. This is only about 45 tonnes per year.

It is recommended that limestone sands be added at four locations in Storys Creek (refer Figure 6.1) at a rate of 25 tonnes per annum at each site, or as required (as indicated by water quality monitoring). This should be effective in buffering the existing acidity loads. It is anticipated that these rates could be reduced after the sands are distributed down the creek bed and banks.

The addition of limestone sands has been deferred to allow the monitoring of the effectiveness of the creek bank limestone addition.

Access roads were constructed to the creek at the following locations:

- Near the Precipitate Dam:
- Nisbett Creek;
- Above Station 14; and
- Rossarden Bridge.

The location of these roads is shown in Figure 6.1. These were also used for access for the limestone spreading on the Creek banks and are now available for periodic limestone sand addition direct to the creek.

6.2.2 Precipitate Dam

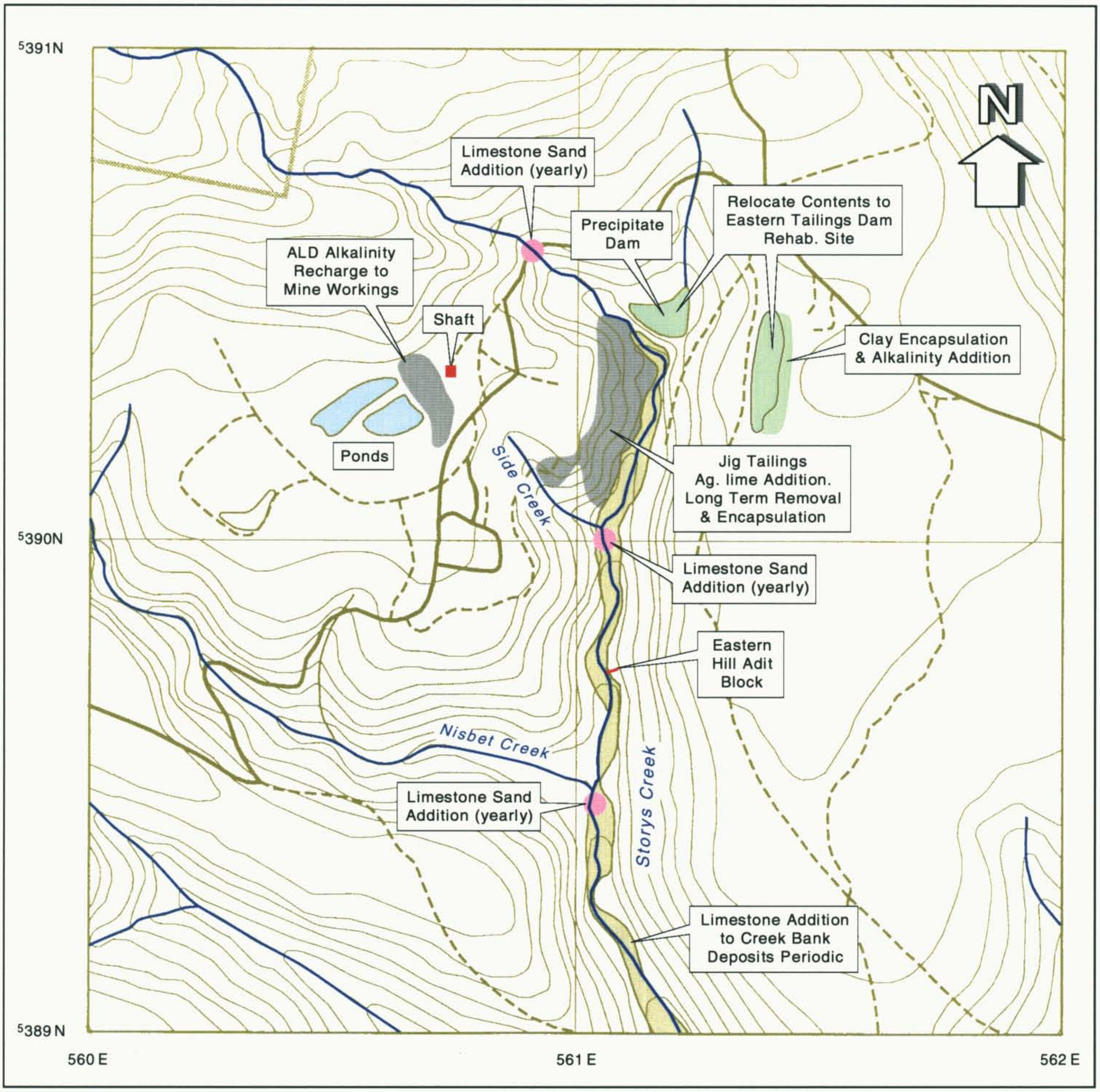
The Precipitate Dam had been capped but this proved ineffective, as water levels were still high, with continued oxidation. Water ingress into the dam has subsequently been revealed to have come from the creek inflow below ground surface. A cutoff drain may have been effective if constructed.

It would have been possible to cap the dam with a new design, however this was difficult due to the location of the dam wall very close (and being undermined) to Storys Creek itself. The risk of dam failure and consequences of any dam failure was assessed as high.

A design for the removal of the materials and encapsulation in a new storage located at the site of the Eastern Tailings Dam was completed and funds were allocated for the works Miedecke 1999a). The work was completed in the summer of 2000 and the contaminant source eliminated (see JMP 2000b).

A plan of new storage plan is shown in Figure 6.2.

The cover consists of a clay cap to limit water infiltration and control oxidation processes. The tailings were dosed with lime as they were placed to buffer the limited acidity.



1 grid space to 1km

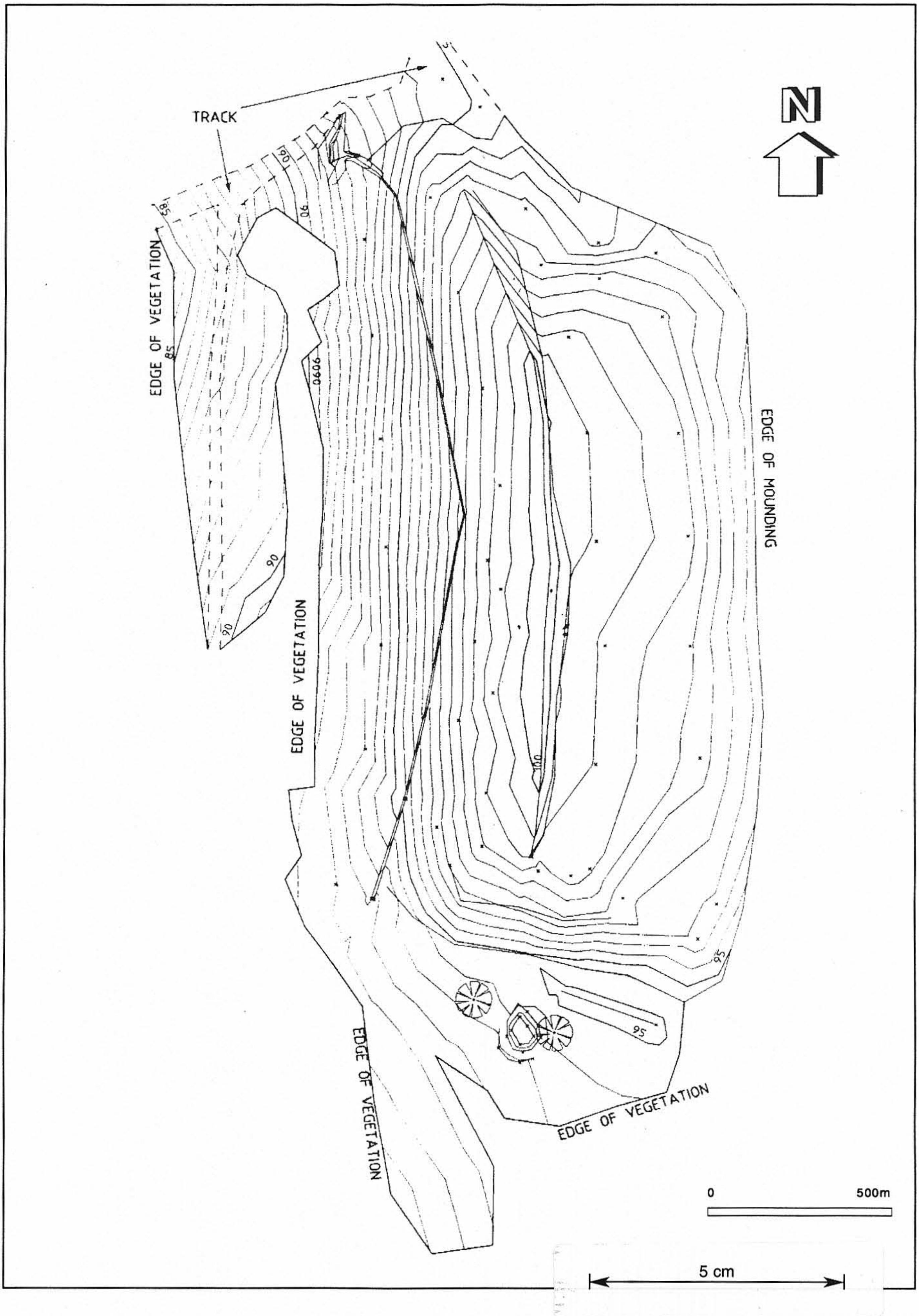
Limestone Sand Addition (yearly) at creek above pump house.

5 cm

MINERAL RESOURCES TASMANIA

Storys Creek & Rossarden AD Remediation Projects
Storys Creek Mine Area Remediation Works

(October 1999) John Miedecke & Partners P/L **FIG 6.1**



(June 2000)

MINERAL RESOURCES TASMANIA

Storys Creek & Rossarden AD Remediation Projects
Tailings Disposal Area - As Constructed

John Miedecke & Partners P/L | **FIG 6.2**

6.2.3 Storys Mine Workings (Side Creek)

The Storys workings are extensive and have a number of open adits, shafts and stopes. It is also suspected that workings may have exposed cavities that are now below the existing creek floor. These are believed to be allowing acid drainage via leakage to the creek under the creek sediments.

As such, the plugging and flooding of the old workings (even if this were practical) will be ineffective.

The alkaline recharge of mine workings via construction of alkaline drains upslope of the workings is recommended, now that the effectiveness and the feasibility of the construction of the alkaline generation systems have been proven by trials. For example, at Side Creek approximately 220 mgCaCO3/L to required to raise the pH to 7.5.

Assuming that the mine workings generate a similar acid loading to the Precipitate Dam, a drain containing approximately 1100 tonnes of limestone would be required. The drain with outflows directed to the area near the shaft that is known to flow into mine workings. This would provide alkalinity at a rate of approximately 13.6g/sec.

A design study has been completed and the ALD is expected to be constructed in late 2000 (see JMP 2000d).

6.2.4 Jig Tailings Dumps

These materials are located on steep slopes above Storys Creek. They are estimated to contain approximately 45,000 cubic meters of coarse tailings, over an area of approximately 4ha.

The preferred remediation method is to remove these materials to a secure storage area and encapsulate to limit oxidation. The costs are estimated at approximately $400,000 and a design study has been completed for relocation to the existing new Precipitate Dam disposal area (JMP 2000c). The removal can be staged as budgets permit.

The alternative of geochemical control by crushed limestone addition was also recommended as an option, however this is not likely to be fully effective. This would involve the application of agricultural lime to the tailings surface at a rate of at least 10 tonnes to the hectare. The treatment would be repeated at two yearly intervals, or as required (as indicated by water quality monitoring). The first application was completed in Autumn 2000 (see JMP 2000a).

A dozer was used to construct access roads over the surface of the Jig Tailings dumps. Eighty (80) tonnes of limestone was applied over accessible parts of the dump by a MAN fertiliser spreader. As this machine was only capable of spreading a distance of 6 to 7 metres each side of the truck and to the rear, some areas could not be treated.

6.2.5 Creek Bank Deposits

The application of crushed limestone to tailings deposits and trials on the creek banks, have demonstrated the success of this remediation technology.

The results of the geochemical characterization of the tailings suggest that improving the buffering capacity of the tailings by the addition of crushed limestone, would significantly reduce the metal release rate from the creek-bank deposited tailings.

The application of crushed limestone ("ag lime") can readily be achieved by the construction of an access tracks and limestone spreading using a lime spreader machine. A rate of 10 tonnes per hectare was recommended as an initial application. The first application was completed in Autumn 2000.

A dozer was used to construct access roads over the surface of the creek banks and in the base of the Creek from the Rossarden Bridge to Storys Creek.

A total of 170 tonnes of limestone was applied over accessible areas by a MAN fertiliser spreader (see Figure 6.1). Most areas were treated, however some were impractical to treat because of access and topography.

The treatment would be repeated at two yearly intervals at a lower rate, or as required (as indicated by water quality monitoring).

It was noted that the major Jig Tailings deposits in the creek itself, as expected, were located between Storys creek and Station 14. It may be practical to remove these materials and encapsulate them at the existing dump site.

6.2.6 Eastern Hill Adit

Site investigations including cleaning of the Adit and a geological inspection resulted in a design for a concrete plug to block the adit and eliminate or at least significantly reduce drainage and pollutant loads from this source

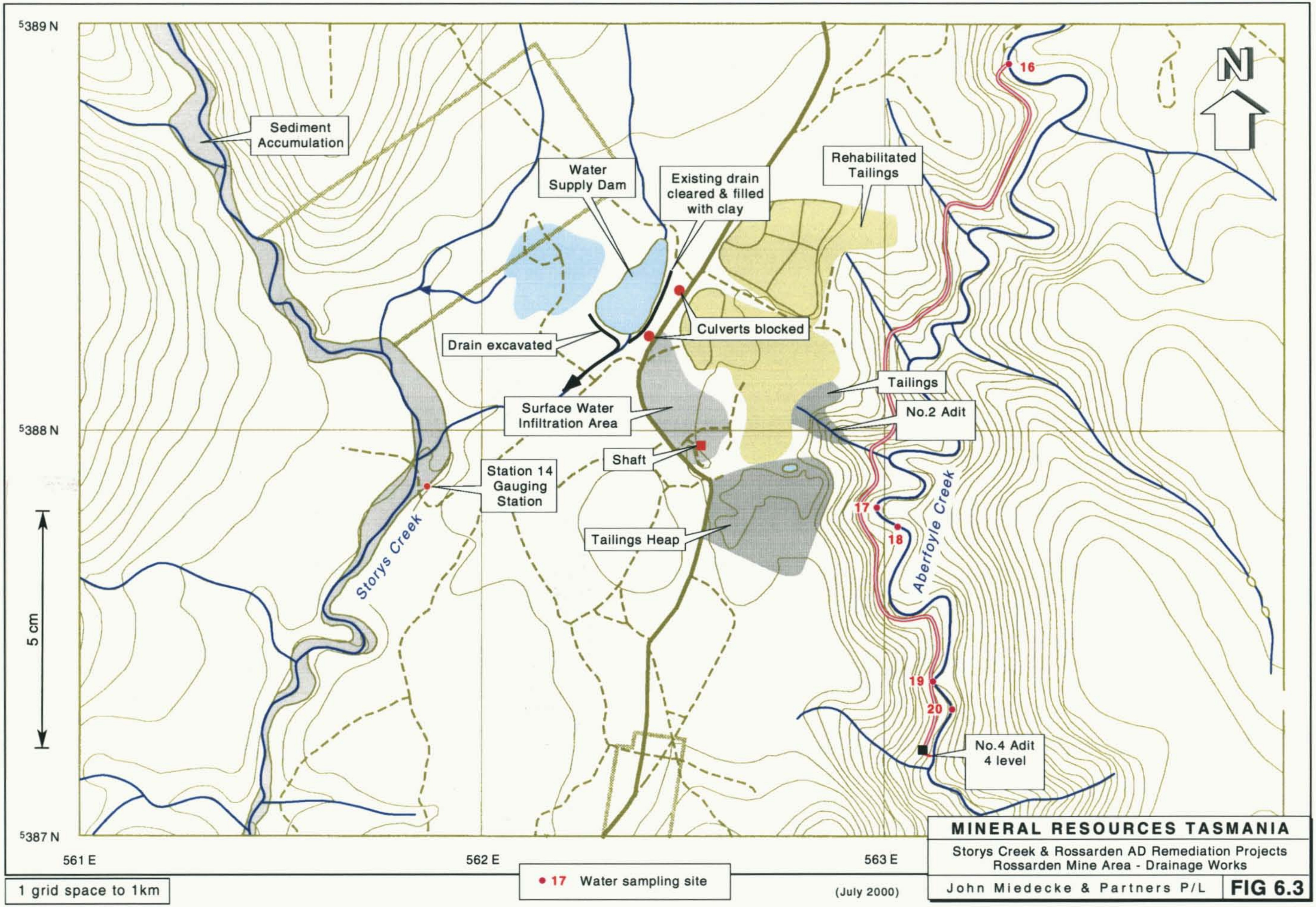
The plug was constructed in May 2000. These works are reported in JMP 2000b.

6.3 Aberfoyle Mine Area

6.3.1 Mine Infiltration

Drainage works to reduce infiltration to the Rossarden mine workings were carried out near the Rossarden water supply dams. The main area of infiltration the workings has been identified as near the main shaft (refer Figure 6.3).

Bedrock in the area is only covered by a shallow clay layer and infiltration through the exposed bedrock is suspected.


5389 N
5388 N
5387 N
561 E
562 E
563 E
Sediment Accumulation
Water Supply Dam
Existing drain cleared & filled with clay
Rehabilitated Tailings
Culverts blocked
Drain excavated
Surface Water Infiltration Area
Tailings
No.2 Adit
Shaft
Station 14 Gauging Station
Tailings Heap
Storys Creek
Aberfoyle Creek
16
17
18
19
20
No.4 Adit 4 level
N
5 cm
1 grid space to 1km
• 17 Water sampling site
(July 2000)
MINERAL RESOURCES TASMANIA
Storys Creek & Rossarden AD Remediation Projects
Rossarden Mine Area - Drainage Works
John Miedecke & Partners P/L
FIG 6.3

It had been noted that the embankments of the water supply dam were leaking and seepage was ponding in channels around the embankments. A channel was excavated to drain the area and the channel on the eastern side excavated and backfilled with clay to provide free draining and cover bedrock (refer Figure 6.3) (see Photographs). Excavated materials were used to construct a wetland in the Precipitate Dam area.

6.3.2 Mine Drainage

The workings are extensive and have at least two adits which exit to Aberfoyle Creek. No 4 Adit on 4 level is a drainage adit, and significant flows occurs direct to Aberfoyle Creek.

No 2 Adit, is also located close to Aberfoyle creek and is believed to be covered with tailings and scree.

It is considered practical to plug No 4 Adit (4 Level adit) however, drainage is then likely to occur from No 2 adit. If this adit was blocked there still remains the possibility of failure and the mass releases to Aberfoyle Creek, due to the uncertain nature of the geology and the mass of water likely to build up in the old workings

Therefore, the blocking of No 4 Adit is recommended only if a controlled release is allowed.

A surface pipeline could be constructed from No 2 level and 4 level adits, a distance of some 6km downstream by helicopter access to an area where a wetland could be constructed. This is estimated to cost some $ 525,00, plus annual operating (maintenance costs) of an estimated $10,000. The pipeline would be subject to vandalism and damage from fire.

The diversion by pumping and treatment at another location was considered more practical and preferable. The pumping to a location near the Rossarden water supply dams was considered feasible, where the waters could be treated in a large aerobic wetland to remove Fe, Mn and some Zn and Cd.

HEC Consulting was engaged by MRT to conduct a preliminary feasibility study. This study (HEC, 2000) identified the following costs;

	Capital	Annual Operating Cost
Hydro powered pump	$700,000	$13000
Electric pump at Adit	$170,000	$17,000

These costs do not include wetland construction.

Another option is the use of a submersible pump in a shaft. This has not been costed in detail.

Some alkalinity addition may be required to raise the pH sufficiently to remove Zn and Cd. However, most would be expected to co-precipitate or adsorb onto iron floc that will naturally form as the mine water oxidised in the wetland.

Speciation of the drainage to determine Al and Fe is also recommended, as it is possible that some of the Zn which is reported as in solution is a fine colloid.

6.3.3 Tailings Dumps

The tailings dams at Rossarden have recently been covered and revegetated, but the cover design is not sufficient to reduce infiltration, or oxidation. However, most of the tailings are believed to be non acid generating and the loads are likely to be small.

An area of acid generation has been identified in the NW corner adjoining the Storys Creek road. Effects on drainage water quality and significance has not been established.

Further monitoring of water quality is recommended. This should also include the coarse tailings.

6.4 Further Monitoring and Investigations

6.4.1 Introduction

Additional environmental data is recommended for two primary purposes:

- Clarifying existing relationships between water quality, biological health, hydrology and sediment quality to refine remediation targets (and EQOs);
- Establishing a database against which the future success of remediation or other events in achieving the EQO's can be assessed.

An integrated assessment of chemical and biological conditions is recommended for the Storys Creek and South Esk catchments with sampling conducted at the same sites over an extended period.

6.4.2 Water Quality

The historical water quality data was limited in the elements analysed, the detection limits and lacked supporting flow data. As such the data allowed only a cursory assessment of patterns, loads and priority contaminants in the system. The trends in water quality over time, relationships with flood events and seasonal variations are uncertain.

Therefore, benefits and changes in water quality due to the implementation of remediation works will be difficult to determine, because of these deficiencies, particularly in the South Esk River.

A monitoring program is recommended which will allow;

- Direct measurements of the efficacy of reduction of metal loads/concentrations in Storys Creek and to the South Esk River;

- Measurement of the efficacy of reduced metal loads/concentrations in restoring environmental (biological and water quality) values in the Storys Creek and South Esk catchments.

Thus a monitoring program for the remediation should have two sequential stages, with primary water quality assessment in the Storys Creek catchment, followed by secondary environmental assessment in both Storys Creek and South Esk catchments, as follows:

1 Routine monitoring of water quality within and at the downstream end of the Storys-Aberfoyle Creek drainage. This should desirably consist of three permanent stations at each of Storys Creek upstream of Rossarden, and Aberfoyle Creek, and Aberfoyle Creek upstream of Storys Creek. Each station should continuously record conductivity, pH and stage. In addition, routine collection of water samples for pH, sulphate, total zinc, iron, cadmium and copper analyses should be conducted. Where possible, relationships between ion concentrations and conductivity should be developed to estimate continuous concentration records.

When conditions are judged to have changed significantly, or funds are not available for the above, then:

2 Periodic monitoring of water quality (e.g. monthly) and biota (yearly) in the Storys Creek and South Esk catchments. This should replicate the baseline data program outlined above and should coincide with flow recordings at Station 14 on Storys Creek.

An accurate assessment of variation in both total and dissolved metal concentrations in the South Esk is required at several locations. Data sets which adequately describe variations in metal concentration with season and flood stage are desirable. This may be conducted as part of other monitoring.

6.4.3 Sediment Quality

There is little data on sediment quality in either the Storys Creek catchment and the South Esk river.

Such an investigation is desirable to:

- develop a more comprehensive database of total and extracted metals from instream and floodplain sediments at a number of sites and several sediment size fractions;
- assess the bioavailability of the metals to aquatic organisms;
- identify any sites that may need active clean-up.

6.4.4 Biological Health

6.4.4.1 Invertebrates

Current data on invertebrates is insufficient. A combined quantitative-qualitative survey of invertebrates is recommended at all South Esk sites previously sampled as well as sites in upper and lower Storys and Aberfoyle Creeks.

This would provide a base for measuring both the existing effects on the riverine biota and as a measure of change.

6.4.4.2 Fish

Fish data is also inadequate. Any effects on trout populations in the South Esk river are currently unquantified.

A quantitative survey of fish populations at the invertebrate sampling sites should be conducted once in January-March. Sampling is recommended semi-quantitatively at the same time to allow rapid electrofishing assessment to be used in the future to reduce the resources required.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Nature and Source of Contaminants

The study has included a survey of water quality within the Storys Creek and Aberfoyle creek catchments.

The data confirms that the primary indicators of acid drainage and sulphide oxidation at Storys Creek are pH, sulphate, iron, aluminium, zinc, cadmium and copper. Manganese is a secondary indicator. Acidity in drainage waters is due mainly to iron, aluminium, manganese and zinc. The Aberfoyle Creek waters are neutral, with mine drainage contributing metals, but at an alkaline pH, with residual alkalinity. This is an important buffering source for the acid Storys Creek waters prior to the South Esk River junction.

The overall message from the water quality data is:

- Storys Creek above Aberfoyle Creek and Aberfoyle Creek upstream of Storys Creek are significantly contaminated with zinc, cadmium, copper and aluminium in both total and dissolved (i.e. filterable at 0.45 micron) forms;

- Storys Creek downstream of the Junction with Aberfoyle Creek has contributed and continues to contribute environmentally significant loads and concentrations of zinc, copper, cadmium and aluminium to the South Esk River.

- However, there are no elevated metal concentrations which exceed aquatic life guidelines in the South Esk which can be attributed to the Storys Creek catchment input, except for possibly cadmium (detection limits not low enough). Metals which exceed the guidelines are also exceeded above the junction.

- The concentrations of metals decrease downstream in the South Esk River from the Storys Creek junction (except for Al which increases).

- Story Creek waters near the South Esk junction exceed aquatic life standards for zinc, copper and cadmium. They also exceed drinking water, livestock and irrigation guidelines for cadmium and aluminium.

- In Aberfoyle Creek only cadmium, copper and zinc exceeds aquatic life guidelines and cadmium, iron and manganese exceed drinking water standards. The waters are suitable for other uses.

The main sources of acid drainage and water contamination have been identified within the Storys Creek catchment in Storys Creek above Rossarden.

The data shows that Storys Creek is the major pollutant source and contributes over 70% of the total Zn, Cd and Cu loads from the catchment, and most of the acidity. Aberfoyle Creek contributes lower loads of metals, but is a significant source of alkalinity, which buffers the Storys Creek acid drainage prior to the junction with the South Esk River.

Most of the loads are in Storys Creek above Rossarden, and therefore contribute most of the loads from the study area.

The data shows that the major metal loads are from seepage from the Jig Tailings, the Precipitate Dam and from the materials deposited in the creek. The trials and investigations have identified that the Jig Tailings – both the existing dumps on the edge of the creek, and the large amounts of material which is now incorporated in the creek banks and floor, are a major pollutant source. They contribute high loads of acidity, sulphate and metals.

A review of water quality indicates that there is an improving trend. This is partly attributed to a reduction in the overall oxidation rate as physically stable oxidation profiles develop over time in the creek-bank deposited tailings.

7.2 Remediation Trials

The acidity data indicated that the introduction of systems to provide alkalinity could be highly effective in ameliorating the residual acid drainage impacts in the Storys Creek catchment. Treatment of point sources would also have beneficial effects.

Remediation trials conducted in 1998- 1999 have investigated methods of alkalinity addition.

They consisted of:

- Limestone sand addition to Storys Creek;
- Construction of an anoxic limestone drain; and
- Agricultural lime application to jig tailings and tailings deposits.

All trials have demonstrated that alkalinity addition is both feasible and effective.

7.3 Aquatic Fauna Assessment and Environmental Quality Objectives (EQO's)

The overall weight of evidence suggests that the South Esk River is not heavily impacted from Storys Creek for its entire length from the junction to Perth, as has historically been believed.

It was also determined that the biological integrity of the South Esk River can be restored only by a combination of management of Storys Creek impacts and improved catchment management and riparian condition.

The overall Environmental Quality Objective is to restore the biological condition of Storys Creek (or a section thereof), Aberfoyle Creek and the

South Esk River downstream of its junction with Storys Creek to a natural state, or to a level commensurate with background catchment conditions.

Given the scale of the Storys Creek related water quality problems, it is recommended that the above EQO should be targeted in the following order of priority:

- South Esk more than 30 km downstream of Storys Creek ;
- South Esk 0 - 30 km downstream of Storys Creek ;
- Aberfoyle Creek;
- Storys Creek upstream of Aberfoyle Creek.

With the objective to restore those aspects of the trout fishery impacted by Storys Creek to a condition that would be expected in an unpolluted environment, and to ensure that water in the South Esk River is suitable for primary and secondary contact and other agricultural and drinking water uses.

As the nature of the impact on the aquatic fauna and trout fishery is uncertain, a monitoring program is recommended.

7.4 Remediation Recommendations

7.4.1 Introduction

Based on the review of the water quality data and the results of the trials, it is apparent that the mine rocks and waste materials are essentially devoid of any acid neutralising capacity. The water in Storys Creek above the mine also contains very little buffering capacity. As a result, even a small acid input from the mine site lowers the pH sufficiently and any released metals from the site will remain mobile.

The Storys Creek Mine area has been identified as the main source of acid drainage. The main source loads have been identified as jig tailings on the slopes, the Precipitate Dam, and waste rock materials in the floor of the creek and in creek bank deposits. Other less significant sources have been identified as Side Creek Adit drainage (including Story mine workings) and Eastern Hill Adit.

Pollutant loads, including acidity, are generally low and are amenable to alkalinity addition to buffer acid drainage for the non point sources, raise pH, remove metals from solution and precipitate metals in the creek bed as colloids and precipitates. Some point sources are amenable to encapsulation and blocking.

7.4.2 Draft Report Recommendations

Specific recommendations made in the Draft Final Report (JMP 1999b) were:

- periodic limestone sand addition to Storys Creek flows to raise the pH of the waters;
- Precipitate Dam relocation and encapsulation;
- alkalinity addition to the Storys Creek mine workings by the construction of an anoxic limestone drain upstream;
- removal and encapsulation of the jig tailings (with a short term remediation by crushed limestone addition to the surface);
- application of crushed limestone to tailings deposits on the creek banks;
- blocking of Eastern Hill Adit ;
- works to reduce infiltration to the Rossarden mine workings.

7.4.3 Works Completed in 2000

The addition of limestone sands was deferred to allow the monitoring of the effectiveness of the creek bank limestone addition. Access roads were constructed to allow periodic limestone addition. These are discussed in Section 6.2.1.

The Precipitate Dam tailings were removed and the contents encapsulated in a new dump and the site was rehabilitated. The Eastern Hill adit was blocked. These works are reported in JMP 2000b.

A design study was completed for a large scale anoxic limestone drain to generate alkalinity addition to the Storys Creek mine workings These works are reported in JMP 2000d.

A design study was completed for the removal and encapsulation of the jig tailings. These works are reported in JMP 2000c. Crushed limestone was applied to the surface of the tailings. This is discussed in Section 6.2.4.

Crushed limestone was applied to tailings deposits on the creek banks between Rossarden and Storys Creek. This is discussed in Section 6.2.5.

Drainage works to reduce infiltration to the Rossarden mine workings were carried out. These are discussed in Section 6.3.1.

7.4.4 Recommendations for Further Remediation

The remediation works which were carried out in Autumn this year (2000) were successfully implemented and water quality monitoring is continuing.

In all cases, the works were found to be feasible and the following recommendations are made. These will be subject to review after water quality monitoring.

Specific recommendations are:

- yearly limestone sand addition to Storys Creek flows to raise the pH of the waters;
- alkalinity addition to the Storys Creek mine workings by the construction of an anoxic limestone drain upstream;
- removal and encapsulation of the jig tailings to the new tailings disposal area;
- progressive removal of Jig Tailings deposits in the creek itself and encapsulation of the jig tailings to the new tailings disposal area;
- annual application of crushed limestone to tailings deposits on the creek banks ;
- continued water quality monitoring at Station 14 and other stations; and
- aquatic fauna monitoring in the S Esk river.

The recommendations (with estimates of costs) are summarised in Table 7.1

Table 7.1 Summary of Recommendations

Location	Treatment	Cost
	Storys Creek Catchment	
Storys Creek flows	Limestone sand addition to creek for creek flows at four locations. Initial 100 tonnes Periodic replenishment on yearly basis	$5500
Mine drainage	Alkalinity addition via Anoxic Limestone Drain alkalinity generation cells to drain to mine workings	$70,000
Jig Tailings Deposits	Long term relocation and encapsulation	$410,000
Creek Bank Deposits	Limestone to creek banks. Periodic replenishment on yearly basis	$12,000
Monitoring	Periodic water quality and flow monitoring at Station 14, other stations and SEsk river. Biological monitoring at S Esk river, Storys Creek and Aberfoyle Creek to measure improvements.	$5000 $7500

	Aberfoyle Creek Catchment	
No 4 Adit Mine Drainage	Continue investigations	
	Water quality investigations	

REFERENCES

JMP 1997; John Miedecke and Partners, 1997. Storys Creek/Rossarden Acid Drainage Remediation Study - Stage 1 Interim Report. September 1997.

JMP 1998. Storys Creek/Rossarden Acid Drainage Remediation Study – Preliminary Report . John Miedecke and Partners, March 1998.

JMP 1999a. Storys Creek/Rossarden Acid Drainage Remediation Study – Precipitate Dam Relocation Design Report. John Miedecke and Partners, 1997 March 1999.

JMP 1999b. Storys Creek/Rossarden Acid Drainage Remediation Study – Draft Final Report John Miedecke and Partners, October 1999.

JMP 2000ba. Storys Creek Remediation. Report on Remediation Works Autumn 2000. John Miedecke and Partners, July 2000.

JMP 2000b. Storys Creek Remediation . Precipitate Dam Relocation Construction Report John Miedecke and Partners, July 2000.

JMP 2000c. Storys Creek Remediation . Jig Tailings Relocation Design Report John Miedecke and Partners, July 2000.

JMP 2000d. Storys Creek Remediation . Anoxic Limestone Drain Design Report John Miedecke and Partners, July 2000.

PHOTOGRAPHS

Photograph 1 : Storys Creek below Jig Tails Dumps

Photograph 2 : Storys Creek with limestone sand deposits

Photograph 3 : Precipitates at Station 14 (near Rossarden)

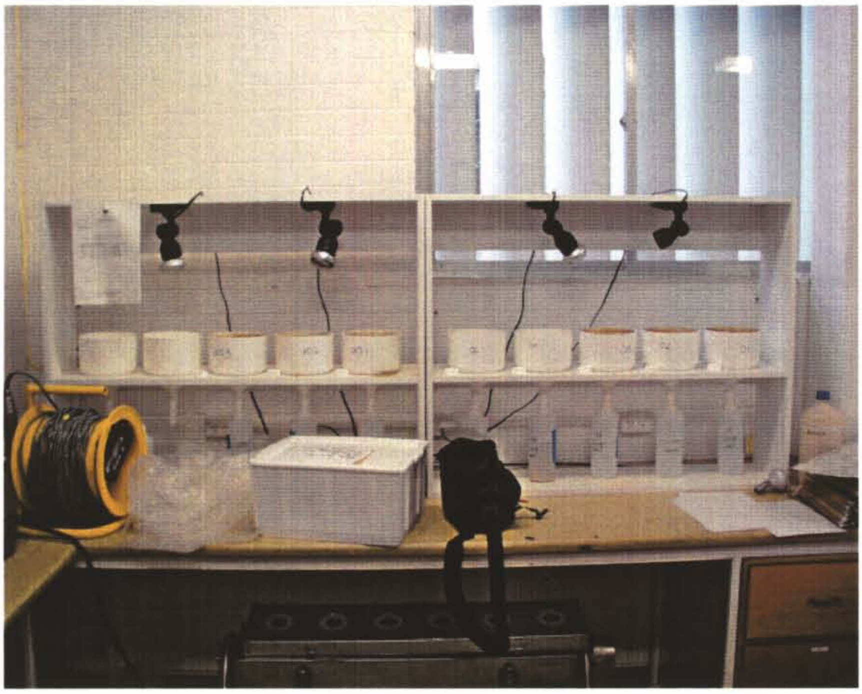
Photograph 4 : Storys Creek near mine. Cemented oxidised materials in Creek banks.

Photograph 5 : Storys Creekbank deposits - near Side Creek

Photograph6 : Storys Creekbank deposits - near Rossarden

Photograph 7 : Jig Tailings lysimeter location

Photograph 8 : Jig Tailings lysimeter sampling



Photograph 9 : Tailings Laboratory Trials

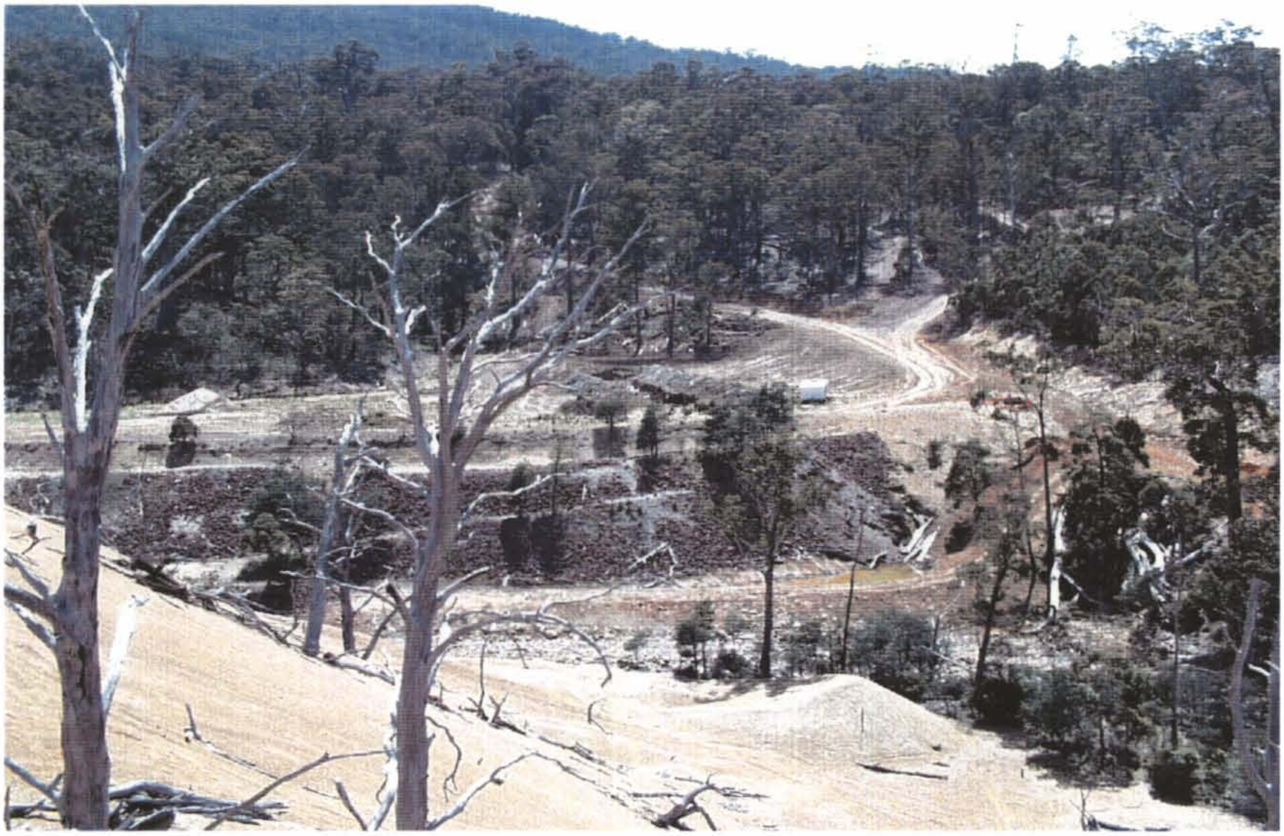
Photograph 10 : Eastern Adit entrance - after cleaning and investigations

Photograph 11 : Rossarden Dam drain

Photograph 12 : ALD surface

Photograph 13 : Precipitate Dam Embankment

Photograph 14 : Precipitate Dam Tailngs Materials on New Disposal Area



Photograph 15: Precipitate Dam - Tailings removal underway. Tailings allowed to consolidate Feb. 2000.

Photograph 16: Precipitate Dam - completed tailings removal. April 2000

Photograph 17: New Disposal Site - site preparation commencing. Dec 2000.

Photograph 18: Disposal Site - Compaction of clay cap. May 2000.

Photograph 19: Jig Tailings deposits viewed from the east. April 2000. Dozer establishing access roads for limestone spreading.

Photograph 20 : Adit Entrance in Jig Tailings Deposits . April 2000

Photograph 21: Spreading limestone in Storys Creek April 2000

Photograph 22: Spreading limestone on Creek Banks April 2000. Note tailings deposits.

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APPENDIX B WATER QUALITY DATA

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

(mg/L)

LOCATION	ANZECC Drinking		Aqu Life	ANZECC Livestock	Irrigation	2 Storys above mine				3 inflow	4 PPT Dam outflow	PPT Dam outflow	PPT Dam outflow	PPte dam Pit near Fe pptates	Story Pit in river tails	Story Pit in river tails?.	Adit Y above Eastern
PARAMETER (mg/l)	Toxicant	Non Toxic.	EQOs			975998		2a	2a	975999	976000		after works			on w bank	
SAMPLE DATE						2-Oct-97	1-Sep-98	1-Oct-98	14-May-99	3-Oct-97	2-Oct-97	1-Sep-98	29-Jun-00	1-Sep-98	17-Nov-98	1-Sep-98	17-Nov-98
FLOW L/sec Observations See Station 14 comments and flows						41				0.2	1						
pH L		6.5-8.5			4.5-9.0	5.8	6.3	7.1	6.4	6.1	3.4	3.4	6.3	6.1	3.3	4.3	6.7
pH F			app			7.6				7.2	3.6						
Cond mS/cm L					0-500	23	20	55	20	42	908	881	550	606	640	330	108
Cond F						24				42	826						
TDS		1000		3000	0-800 ok	26	18	51	26	44	692	606		479	431	258	67
NFR (suspended solids)						<1	<1	553	8	<1	59	45		337	3	68	5
Alkalinity (CaCO3)						11	5	14	1	20	<1	<1		49	1	1	0.001
Acidity (CaCO3)						2	1	1	2	<1	227	174	32	158	112	68	0.029
DOC mg/L						1.4				1.0	1.8						
Hardness (CaCO3)		500				7				14	197						
Ca T				1000		2.0	1.6			3.0	44.0		48.4	69.5		26.2	
Cl						1.6				2.3	17.0						
SO4		400		1000		0.5	0.3	0.3	0.3	1	498	420	240	240	68	160	3
F				2	1	<0.02	<0.02			0.02	12.00	9.40		6.00		4.50	
K T						0.1	0.0			0.2	0.9	0.9		1.6		0.7	
Mg T				600		0.7	0.7			2.0	21.0	25.1	19.4	23.9		9.6	
Na T		300				2.0	1.1			2.0	4.0	3.7		2.7		2.7	
Metals																	
Al F			**0.1**			<0.1	<0.050	<0.050	0.068	0.1	9.0	6.6	0.3	0.8	4.7	5.6	0.6
Al T		0.2		5	5	0.1	0.054	0.055	0.187	0.1	10.0	6.8	1.0	2.7	4.9	7.3	0.7
Cd F			**0.0002**			<0.001	<0.001	<0.001		0.010	2.450	1.280	0.790	2.520	0.297	0.292	0.011
Cd T	0.005			0.01	0.01	<0.001	<0.001	<0.001		0.001	2.550	1.390	0.792	2.600	0.274	0.307	0.012
Cu F			**0.005**			0.001	0.016	0.009		0.002	5.420	3.640	0.096	0.089	0.290	1.010	0.036
Cu T		1		0.5	0.2	<0.001	0.009	0.005		0.003	5.620	3.830	0.142	0.426	0.290	1.090	0.042
Fe F			**1**			<0.1	<0.1	<0.02	0.034	<0.1	8.0	1.3	0.0	0.02	2.35	20.00	0.02
Fe T		0.3			1	<0.1	<0.1	0.028	0.159	<0.1	30.0	26.7	0.7	7.7	4.0	1.4	0.2
Mn F						<0.1	<0.1	<0.005	0.006	<0.1	6.0	4.9	4.7	5.9	2.5	2.0	0.5
Mn T		0.2			2	<0.1	<0.1	<0.005	0.011	<0.1	6.0	5.4	4.7	6.3	2.5	2.1	0.5
Zn F			**0.05**			0.004	0.003	<0.001	0.014	0.051	58.400	39.000	15.100	67.10	10.90	8.38	0.51
Zn T		5		20	2	<0.001	0.007	0.005	0.012	0.052	61.800	39.200	15.300	75.600	10.800	8.39	0.52

EQOs in BOLD

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

(mg/L)

LOCATION	5 Storys below PPT Dam							6 Side Creek	8 Storys below Side	8		8				11 Storys below Eastern Hill			
PARAMETER (mg/l)	976001		After Lstone					976002	976003		After Lstone					976006		After Lstone	
SAMPLE DATE	1-Oct-97	1-Sep-98	1-Oct-98	17-Nov-98	14-May-99	21-May-99	29-Jun-00	2-Oct-97	1-Oct-97	1-Sep-98	17-Nov-98	15-Mar-99	14-May-99	14-May-99	29-Jun-00	1-Oct-97	1-Sep-98	17-Nov-98	14-May-99
FLOW L/sec Observations See Station 14 comments and flows	42	see Station 14						0.3	40										
pH L	5.7	6.0	7.0	7.0	6.5	6.8	6.6	3.7	5.1	5.7	6.6	6.9	6.4	6.0	6.4	4.9	5.1	5.6	5.6
pH F	6.2							3.7	5.3							4.9			
Cond mS/cm L	64	45	68	69	20	43	41	254	141	57	95	96	23	111	52	197	121	174	163
Cond F	67							291	145							201			
TDS	54	38	44	58	19	35		149	99	41	55		22	103		155	73	123	135
NFR (suspended solids)	11	4	721	6	8	6		<1	5	8	3		9	9		5	5	15	11
Alkalinity (CaCO3)	4	3	12	13	1	5		<1	1	1	7		2	3		<1	<1	<1	1
Acidity (CaCO3)	5	4	3	3	2	2	3	35	20	7	6	2	2	8	3	25	15	11	10
DOC mg/L	0.5							2.2	0.8							0.4			
Hardness (CaCO3)	17							53	37							56			
Ca T	4.0						2.9	12.0	9.0	4.4					4.9	14.0	8.6		
Cl	1.8							3.4	1.8							2.0			
SO4	22	12	13	12	0	3	2	94	60	16	12	25	1	34	9	91	45	25	63
F	0.56	0.47						5.30	1.40	0.58						1.40	1.10		
K T	0.2	0.1						0.9	0.3	0.2						0.3	0.2		
Mg T	2.0	1.4					0.8	6.0	3.0	1.5					1.0	5.0	3.3		
Na T	2.0	1.3						3.0	2.0	1.4						3.0	1.5		
Metals																			
Al F	0.1	0.6	<0.050	<0.050	0.06	0.05	0.02	3.0	1.0	0.1	0.1	0.1	0.1	0.223	0.017	2.0	1.0	0.3	0.6
Al T	0.7	0.5	0.8	0.2	0.20	0.13	0.05	3.0	2.0	1.1	0.8	0.9	0.3	0.892	0.338	2.0	1.3	1.3	1.3
Cd F	0.077	0.039	0.054	0.032	0.001	<0.001	0.005	0.139	0.154	0.059	0.066	0.057	0.004	0.045	0.022	0.155	0.078	0.077	0.044
Cd T	0.083	0.040	0.055	0.029	0.001	<0.001	0.005	0.143	0.158	0.065	0.072	0.059	0.004	0.052	0.024	0.158	0.079	0.077	0.059
Cu F	0.086	0.072	0.043	0.022	0.005	0.036	0.004	0.169	0.438	0.149	0.068	0.06	0.013	0.066	0.017	0.468	0.206	0.178	0.116
Cu T	0.194	0.113	0.167	0.092	0.005	0.046	0.005	0.174	0.464	0.214	0.271	0.184	0.019	0.127	0.070	0.487	0.242	0.29	0.139
Fe F	<0.1	<0.2	0.1	0.0	0.5	0.04	0.04	0.1	2.0	<0.02	0.0	<0.02	0.0	0.063	0.020	3.0	<0.02	0.1	0.4
Fe T	3.0	0.3	0.7	0.5	0.2	0.25	0.07	0.2	3.0	0.3	0.7	0.4	0.2	3.290	0.160	4.0	2.4	4.9	5.1
Mn F	0.2	0.1	0.2	0.1	0.01	0.19	0.04	0.9	0.6	0.1	0.2	0.2	0.0	0.411	0.079	1.0	0.6	0.6	1.0
Mn T	0.2	0.1	0.2	0.1	0.0	0.2	0.0	0.9	0.6	0.2	0.2	0.2	0.0	0.422	0.082	1.0	0.6	0.7	1.0
Zn F	2.300	1.210	1.600	1.380	0.051	0.708	0.228	4.070	4.460	1.730	2.330	0.988	0.107	1.520	0.597	4.790	2.280	3.310	2.410
Zn T	2.430	1.300	1.600	1.420	0.058	0.725	0.223	4.140	4.540	1.810	2.510	1.910	0.127	1.680	0.666	4.920	2.390	3.250	2.580

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

(mg/L)

LOCATION	12		13					14									
refer Hydro report	Nisbet Creek		Storys below Nisbet					Storys below pumphouse (managers)									
PARAMETER (mg/l)	976007		976008		After Lstone			976009			After Lstone						
SAMPLE DATE	1-Oct-97	1-Sep-98	1-Oct-97	1-Sep-98	17-Nov-98	21-May-99	29-Jun-00	3-Oct-97	7-Aug-98	1-Sep-98	1-Oct-98	17-Nov-98	1-Dec-98	15-Mar-99	6-Apr-99	21-May-99	29-Jun-00
Gauge Ht									0.39	0.3	0.3	0.3	0.35	0.3	0.28	0.28	0.34
FLOW L/sec	37		98					153	420	284	284	284	360	285	107	107	345
Observations See Station 14 comments and flows									clear falling after rain	clear no rain	clear low rain	low,clear, some rain prev wend	low,clear, some rain prev 2 days	low clear no rain obvious ppt.	low clear little rain obvious ppt.	clear after rain prev few days	clear mod flow falling
pH L	5.7	6.5	5.4	5.6	6.1	6.0	5.8	5.3	5.8	5.3	6.9	5.7	6.3	5.8	5.5	5.4	5.8
pH F	6.6		5.9					5.8									
Cond mS/cm L	35	35	109	84	135	125	117	98	59	92		128	68	143	146	127	102
Cond F	39		115					100									
TDS	24	19	85	67	98	328		63		65		84			90	257	
NFR (suspended solids)	<1	1	7	5	18	15		6	5	5		7			5	8	
Alkalinity (CaCO3)	13	9	2	1	2	2		1		1	3	1			1	1	
Acidity (CaCO3)	<1	3	6	8	8	5	7	8		9	3	8	2	2	8	8	4
DOC mg/L	0.8		0.4					1.2									
Hardness (CaCO3)	11		32					27									
Ca T	2.0	2.7	8.0	6.5			11.1	6.0		6.5							8.6
Cl	2.0		2.0					2.3							1.9		
SO4	2	2	40	26	39	43	38	36	15	30		65	16		44	48	31
F	0.02	0.03	0.77	0.56				0.56		0.53							
K T	0.1	0.1	0.2	0.3				0.3		0.2							
Mg T	1.0	1.3	3.0	2.6			3.3	3.0		2.7							2.6
Na T	2.0	1.5	2.0	1.6				3.0		1.6							
Metals																	
Al F	0.1	0.1	0.4	0.3	0.1	0.2	0.1	0.40	0.08	0.47	<0.05	0.146	0.05	0.47	0.26	0.16	0.0
Al T	0.1	0.1	1.0	0.9	1.5	1.3	0.8	0.90	0.38	1.00	1.38	0.814	0.05	0.82	0.94	0.65	0.5
Cd F	<0.001	0.002	0.077	0.049	0.054	0.044	0.049	0.075	0.034	0.067	0.059	0.059	0.016	0.071	0.067	0.036	0.05
Cd T	<0.001	0.002	0.080	0.050	0.054	0.046	0.050	0.079	0.034	0.072	0.062	0.068	0.02	0.074	0.080	0.055	0.051
Cu F	0.001	0.003	0.223	0.143	0.098	0.115	0.079	0.238	0.064	0.222	0.074	0.187	0.012	0.167	0.139	0.079	0.07
Cu T	0.001	0.07	0.259	0.172	0.244	0.117	0.103	0.262	0.093	0.249	0.288	0.254	0.017	0.192	0.193	0.185	0.119
Fe F	<0.1	<0.02	0.3	<0.02	0.0	0.2	0.0	0.4	0.02	0.0	0.0	0.029	0.02	0.3	1.4	0.1	0.0
Fe T	<0.1	0.2	1.0	1.1	3.0	1.6	1.2	0.8	0.33	0.8	1.4	1.75	0.075	1.2	0.5	0.9	1.1
Mn F	<0.1	<0.005	0.5	0.3	0.5	0.4	0.4	0.4	0.15	0.3		0.338	0.136	0.5	0.5	0.4	0.3
Mn T	<0.1	<0.005	0.6	0.7	0.2	0.5	0.4	0.4	0.16	0.4		0.384	0.152	0.5	0.5	0.4	0.3
Zn F	0.020	0.061	2.434	1.490	2.100	1.400	1.540	2.280	0.934	1.910	1.580	2.29	0.501	2.240	1.960	0.966	1.530
Zn T	0.015	0.070	2.500	1.540	2.320	1.420	1.580	2.330	0.959	1.890	1.570	2.43	0.697	2.230	2.400	2.040	1.580

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

(mg/L)

LOCATION	15 Storys at Rossarden Bridge								15 after lstne				22 Aberfoyle above Storys		
PARAMETER (mg/l)	dpiwe	dpiwe	dpiwe	dpiwe	976010	dpiwe	dpiwe	15	15	dpiwe	15	15	976017	22	22
SAMPLE DATE	15-Nov-96	23-Dec-96	3-Feb-97	19-Aug-97	1-Oct-97	30-Apr-98	21-Aug-98	1-Sep-98	6-Apr-99	7-Jul-99	16-Sep-99	29-Jun-00	3-Oct-97	1-Sep-98	17-Nov-98
Gauge Ht															
FLOW L/sec					216								174		
Observations See Station 14 comments and flows															
pH L					5.7			5.2	5.3			5.7	6.7	7.0	7.7
pH F					5.9								7.0		
Cond mS/cm L					82			92	136			104	193	178	218
Cond F					84								197		
TDS					61			64	93				126	118	121
NFR (suspended solids)					3			5	5				<1	1	6
Alkalinity (CaCO3)					1			<1	1				43	28	4
Acidity (CaCO3)					5			9	8			6	<1	2	2
DOC mg/L					2.4								2.0		
Hardness (CaCO3)					13								79		
Ca T					5.0			6.5			5.9	8.9	17.0	17.4	
Cl					3.0				2.1				3.8		
SO4					26			28	41			33	48	40	37
F					0.40			0.51					0.78	0.81	
K T					0.4			0.6			0.3		0.7	0.6	
Mg T					2.0			2.7			1.9	2.6	9.0	9.1	
Na T					3.0			2.8			2.8		4.0	3.3	
Metals															
Al F					0.3			0.5	0.4			0.2	0.1	0.1	0.1
Al T					0.6	1.4	0.6	0.9	0.4	1.1		0.4	0.2	0.2	0.1
Cd F					0.060			0.069	0.091			0.058	0.012	0.011	0.006
Cd T	0.043	0.090	0.140	0.032	0.060	0.118	0.067	0.068	0.087	0.024		0.060	0.014	0.015	0.008
Cu F					0.172			0.242	0.205			0.1	0.013	0.014	0.012
Cu T	0.138	0.23	0.37	0.101	0.193	0.396	0.215	0.248	0.208	0.134		0.119	0.028	0.057	0.028
Fe F					0.2			0.2	0.3			0.0	<0.1	0.0	0.0
Fe T	0.7	1.5	1.1	0.5	0.4	1.2	0.6	0.8	0.3	0.9		0.9	0.5	0.8	0.6
Mn F					0.3			0.3	0.4			0.3	0.4	0.3	0.3
Mn T	0.3	0.5	0.7	0.1	0.3	0.6	0.3	0.3	0.6	0.1		0.3	0.4	0.4	0.3
Zn F					1.770			1.910	2.550		1.190	1.720	0.457	0.485	0.276
Zn T	1.400	2.800	4.300	0.998	1.810	3.940	1.710	1.890	3.110	0.740	1.220	1.780	0.549	0.646	0.412

5.9

0.3
1.9
2.8

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

(mg/L)

LOCATION	21 Storys above Aberfoyle				23 Storys below Aberfoyle										27 Storys above South Esk	24 South Esk above Storys	24	24
PARAMETER (mg/l)	976018	21		21	dpiwe	dpiwe	dpiwe	dpiwe	975997	dpiwe	dpiwe	23	23	dpiwe	976022	976019		
SAMPLE DATE	3-Oct-97	1-Sep-98	1-Oct-98	17-Nov-98	15-Nov-96	23-Dec-96	3-Feb-97	19-Aug-97	3-Oct-97	30-Apr-98	21-Aug-98	1-Sep-98	17-Nov-98	7-Jul-99	3-Oct-97	3-Oct-97	1-Sep-98	17-Nov-98
Gauge Ht																		
FLOW L/sec	220								394						470	10230		
Observations See Station 14 comments and flows																		
pH L	5.6	5.4	7.3	5.8					6.0			6.8	7.5		6.4	6.5	6.6	6.9
pH F	6.0								6.9						6.9	7.2		
Cond mS/cm L	71	83	70	110					107			147	183		119	74	67	109
Cond F	72								109						122	76		
TDS	47	71	56	83					80			109	115		87	48	58	58
NFR (suspended solids)	<1	2	1	5					<1			2	7		<1	2	6	22
Alkalinity (CaCO3)	1	1	2	1					13			18	3		16	17	10	2
Acidity (CaCO3)	6	7	2	6					<1			3	2		<1	<1	3	5
DOC mg/L	2.0								2.3						1.7	2.4		
Hardness (CaCO3)	17								35						42	17		
Ca T	4.0	5.6							8.0			13.5			9.0	3.0	3.0	
Cl	3.7								3.7						3.7	11.0		
SO4	19	24	17	48					27			35	50		30	2	2	45
F	0.29	0.44							0.47			0.88			0.48	<0.02	0.02	
K T	0.5	0.3							0.6			0.5			0.6	0.6	0.5	
Mg T	2.0	2.3							4.0			6.9			5.0	2.0	2.2	
Na T	4.0	2.4							4.0			2.9			4.0	7.0	5.7	
Metals																		
Al F	0.2	0.3	0.1	0.1					0.1			0.075	0.1		0.1	0.2	0.099	0.1
Al T	0.4	0.7	0.4	0.2					0.4	0.6	0.3	0.332	0.1	0.3	0.3	0.3	0.211	0.2
Cd F	0.046	0.058	0.043	0.064					0.034			0.027	0.03		0.030	<0.001	<0.001	0.001
Cd T	0.048	0.065	0.046	0.063	0.041	0.050	0.080	0.022	0.038	0.081	0.041	0.034	0.034	0.035	0.033	<0.001	<0.001	0.001
Cu F	0.080	0.187	0.048	0.135					0.044			0.032	0.030		0.029	0.002	0.010	0.006
Cu T	0.097	0.215	0.073	0.157	0.072	0.09	0.17	0.059	0.067	0.219	0.106	0.126	0.065	0.072	0.058	0.001	0.007	0.009
Fe F	<0.1	0.1	0.0	0.0					<0.1			0.261	0.0		<0.1	0.1	0.075	0.1
Fe T	0.1	0.3	0.3	0.1	0.5	0.3	0.1	0.4	0.3	0.3	0.4	0.654	0.4	0.4	0.3	0.3	0.203	0.5
Mn F	0.2	0.2	0.2	0.2					0.3			0.004	0.3		0.2	<0.1	0.005	0.0
Mn T	0.2	0.2	0.2	0.2	0.4	0.3	0.4	0.1	0.3	0.4	0.3	0.28	0.3	0.2	0.2	<0.1	0.028	0.1
Zn F	1.380	1.740	1.100	2.270					1.030			0.893	0.854		0.896	0.007	0.027	0.005
Zn T	1.420	1.760	1.100	2.170	1.200	1.480	2.200	0.737	1.120	2.690	1.110	0.990	1.010	1.040	0.991	0.003	0.004	0.004

Table X : Storys and Aberfoyle Creek Water Quality- All Data to June 2000

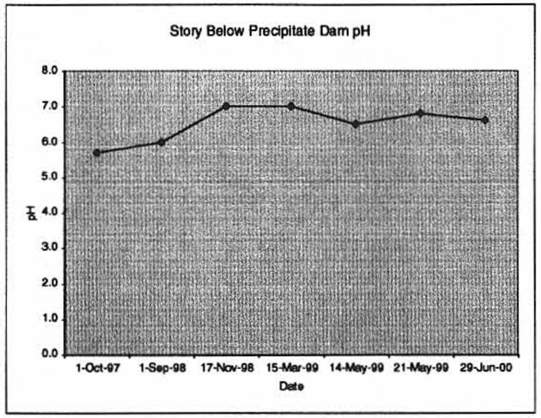
(mg/L)

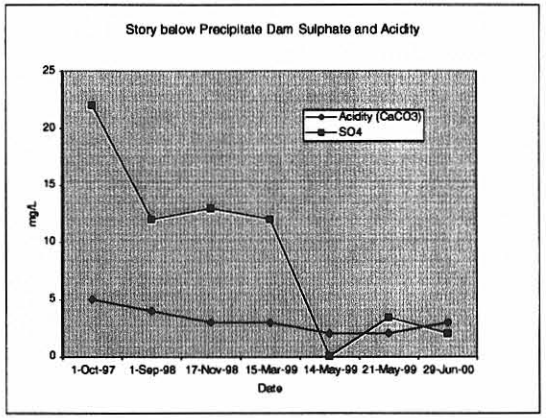
LOCATION	25 South Esk below Storys			South Esk At Avoca							26 South Esk at Lewellyn	28 Channel above PPT Dam
PARAMETER (mg/l)	976020			dpiwe	dpiwe	dpiwe	dpiwe	dpiwe	dpiwe	dpiwe	976021	976023
SAMPLE DATE	3-Oct-97		17-Nov-98	15-Nov-96	23-Dec-96	3-Feb-97	19-Aug-97	30-Apr-98	21-Aug-98	7-Jul-99	3-Oct-97	2-Oct-97
Gauge Ht												
FLOW L/sec	10701										12540	0.12
Observations See Station 14 comments and flows												
pH L	6.4	6.7	4.6								6.4	4.8
pH F	7.2										7.3	5.0
Cond mS/cm L	76	71	109								81	285
Cond F	78										83	290
TDS	56	65	71								59	246
NFR (suspended solids)	2		11								1	11
Alkalinity (CaCO3)	17	10	21								18	<1
Acidity (CaCO3)	<1	4	4								<1	35
DOC mg/L	2.3										2.6	1.4
Hardness (CaCO3)	18										20	85
Ca T	3.0	3.0									4.0	17.0
Cl	10.0										11.0	3.5
SO4	3	2	2								3	132
F	0.03	0.04									0.03	0.59
K T	0.6	0.5									0.6	0.8
Mg T	2.0	2.2									3.0	10.0
Na T	7.0	5.3									8.0	3.0
Metals												
Al F	0.2	0.1	0.1								0.2	2.0
Al T	0.3	0.2	0.2					0.1	0.1	0.1	0.4	3.0
Cd F	0.001	0.002	0.001								0.001	0.328
Cd T	0.001	0.002	0.001	0.003	0.005	0.005	0.001	0.005	0.002	0.001	0.001	0.339
Cu F	0.004	0.01	0.008								0.004	0.014
Cu T	0.004	0.019	0.008	0.009	0.005	0.005	0.005	0.014	0.018	0.003	0.005	0.014
Fe F	0.1	0.1	0.1								0.1	<0.1
Fe T	0.3	0.2	0.3	0.3	0.3	0.9	0.5	0.2	0.2	0.2	0.3	<0.1
Mn F	<0.1	0.0	0.0								<0.1	3.0
Mn T	<0.1	0.0	0.0	0.3	0.0	0.1	0.3	0.0	0.0	0.0	<0.1	3.0
Zn F	0.034	0.046	0.027								0.035	17.700
Zn T	0.040	0.050	0.020	0.096	0.070	0.060	0.049	0.169	0.052	0.049	0.032	17.000

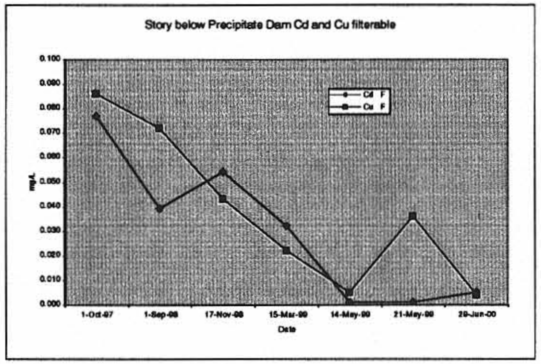
nothing exceeds EQO
CD limits too high

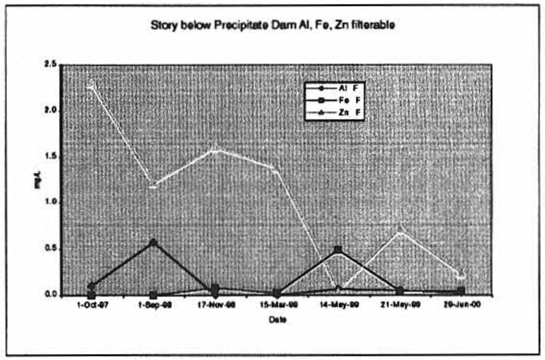
LOCATION	5						
	Storys below PPT Dam						0.34
PARAMETER (mg/l)	976001						
SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	15-Mar-99	14-May-99	21-May-99	29-Jun-00
FLOW L/sec at Station14	153??	284	284	285	481	107	345
Notes	some rain	clear no rain	low,clear, some rain prev wend	low clear no rain obvious ppt.	After storm falling level	clear after rain prev few days	clear mod flow
FLOW L/sec	40						
Acidity (CaCO3)	5	4	3	3	2	2	3
SO4	22	12	13	12	0	3	2
pH L	5.7	6.0	7.0	7.0	6.5	6.8	6.6
pH F	6.2						
Cond mS/cm L	64	45	68	69	20	43	41
Cond F	67						
TDS	54	38	44	58	19	35	
NFR (suspended solids)	11	4	721	6	8	6	1
Alkalinity (CaCO3)	4	3	12	13	1	5	1
DOC mg/L	0.5						
Hardness (CaCO3)	17						
Ca T	4.0						
Cl	1.8						
F	0.56	0.47					
K T	0.2	0.1					
Mg T	2.0	1.4					
Na T	2.0	1.3					
Metals							
Al F	0.1	0.6	<0.050	<0.050	0.06	0.05	0.02
Al T	0.7	0.5	0.8	0.2	0.20	0.13	0.05
Cd F	0.077	0.039	0.054	0.032	0.001	0.001	0.005
Cd T	0.083	0.040	0.055	0.029	0.001	<0.001	0.005
Cu F	0.086	0.072	0.043	0.022	0.005	0.036	0.004
Cu T	0.194	0.113	0.167	0.092	0.005	0.046	0.005
Fe F	<0.1	<0.2	0.1	0.0	0.5	0.04	0.04
Fe T	3.0	0.3	0.7	0.5	0.2	0.25	0.07
Mn F	0.2	0.1	0.2	0.1	0.01	0.19	0.04
Mn T	0.2	0.1	0.2	0.1	0.0	0.2	0.0
Zn F	2.300	1.210	1.600	1.380	0.051	0.708	0.228
Zn T	2.430	1.300	1.600	1.420	0.058	0.725	0.223

Figure XX : Story Below Precipitate Dam









LOCATION	8	Storys below Side Creek					
PARAMETER (mg/l)							
SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	15-Mar-99	14-May-99	21-May-99	29-Jun-00
FLOW L/sec at Station14	153??	284	284	285	481	107	345
Notes	some rain	clear no rain	low,clear, some rain prev wend	low clear no rain obvious ppt.	After storm falling level	clear after rain prev few days	clear mod flow
FLOW L/sec	40						
pH L	5.1	5.7	6.6	6.9	6.4	6.0	6.4
Cond mS/cm L	141	57	95	96	23	111	52
TDS	99	41	55		22	103	
NFR (suspended solids)	5	8	3		9	9	
Acidity (CaCO3)	20	7	6	2	2	8	1
Alkalinity (CaCO3)	1	1	7		2	3	3
SO4	60	16	12	25	1	34	9
DOC mg/L	0.8						
Hardness (CaCO3)	37						
Ca T	9.0	4.4					4.9
Cl	1.8						
F	1.40	0.58					
K T	0.3	0.2					
Mg T	3.0	1.5					1.0
Na T	2.0	1.4					

Metals

SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	15-Mar-99	14-May-99	21-May-99	29-Jun-00
Al F	1.00	0.14	0.05	0.05	0.08	0.22	0.017
Al T	2.000	1.140	0.753	0.850	0.270	0.892	0.338
Cd F	0.154	0.059	0.066	0.057	0.004	0.045	0.022
Cd T	0.158	0.065	0.072	0.059	0.004	0.052	0.024
Cu F	0.438	0.149	0.068	0.060	0.013	0.066	0.017
Cu T	0.464	0.214	0.271	0.184	0.019	0.127	0.070
Fe F	2.00	0.02	0.02	0.02	0.03	0.06	0.020
Fe T	3.000	0.343	0.744	0.392	0.214	3.290	0.160
Mn F	0.600	0.149	0.194	0.173	0.012	0.411	0.079
Mn T	0.600	0.157	0.206	0.185	0.019	0.422	0.082
Zn F	4.46	1.73	2.33	0.99	0.11	1.52	0.597
Zn T	4.540	1.810	2.510	1.910	0.127	1.680	0.666
			after rain and leachates ?		Low con of metals and SO4 after rain and clean		

NOTES after rain periods and high flows the conc decrease beca
Severel days after there is continued leaching and metals are higher thgen ?

Figure XX : Story Below Side Creek

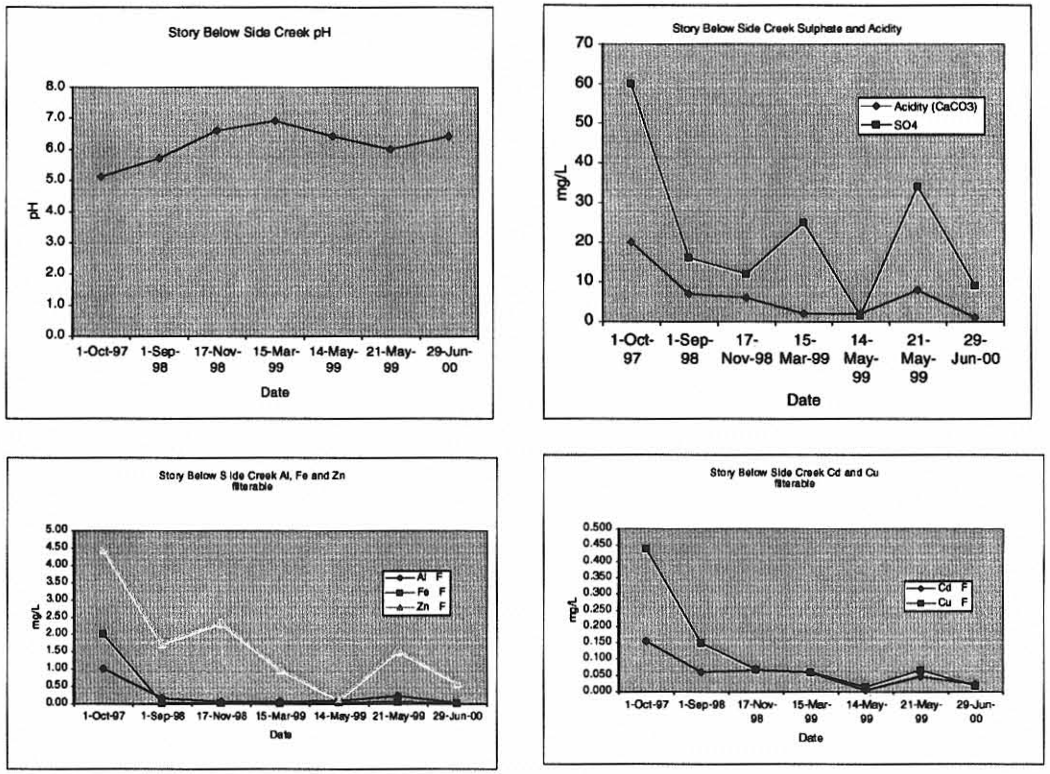
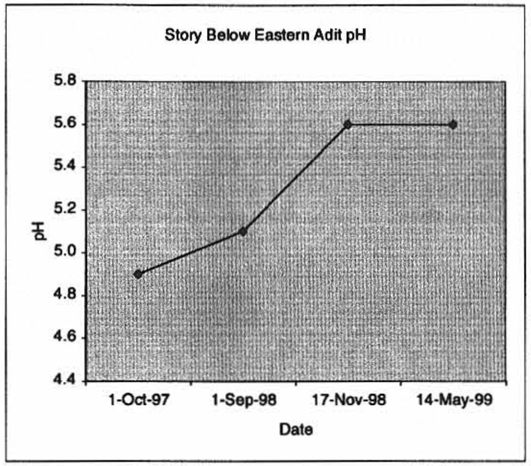
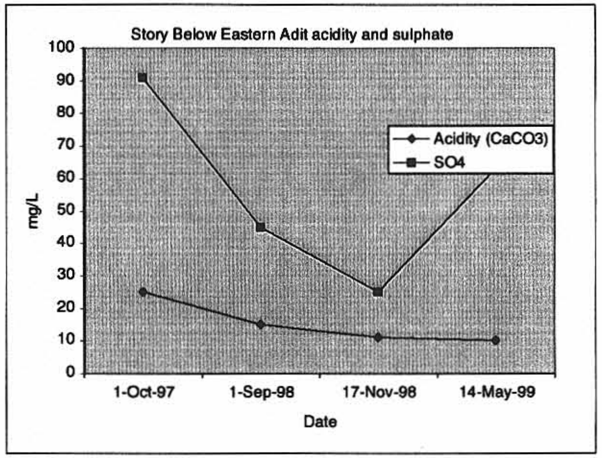


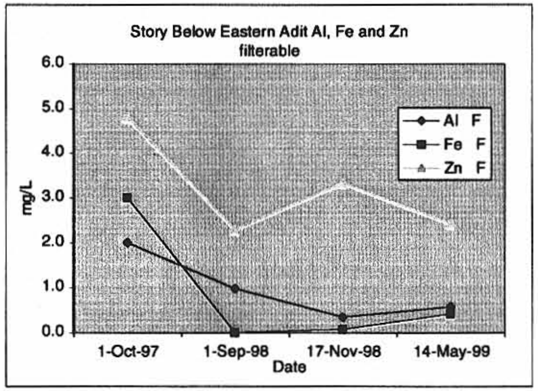
Figure XX : Storys Creek Below Eastern Adit

LOCATION	11	Storys below Eastern Adit		
PARAMETER (mg/l)				
FLOW L/sec at S14	153	284	284	481
SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	14-May-99
Acidity (CaCO3)	25	15	11	10
Notes	some rain	clear no rain	low,clear, some rain prev wend	low clear no rain obvious ppt.
pH L	4.9	5.1	5.6	5.6
Cond mS/cm L	197	121	174	163
TDS	155	73	123	135
NFR (suspended sol	5	5	15	11
Alkalinity (CaCO3)	<1	<1	<1	1
Acidity (CaCO3)	25	15	11	10
SO4	91	45	25	63
DOC mg/L	0.4			
Hardness (CaCO3)	56			
Ca T	14.0	8.6		
Cl	2.0			
F	1.40	1.10		
K T	0.3	0.2		
Mg T	5.0	3.3		
Na T	3.0	1.5		

Metals				
SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	14-May-99
Al F	2.0	1.0	0.3	0.6
Al T	2.0	1.3	1.3	1.3
Cd F	0.155	0.078	0.077	0.044
Cd T	0.158	0.079	0.077	0.059
Cr T	<0.001	<0.001	<0.001	0.009
Cr F	<0.001	<0.001	<0.001	0.008
Cu F	0.468	0.206	0.178	0.116
Cu T	0.487	0.242	0.29	0.139
Fe F	3.0	<0.02	0.1	0.4
Fe T	4.0	2.4	4.9	5.1
Mn F	1.0	0.6	0.6	1.0
Mn T	1.0	0.6	0.7	1.0
Ni F	0.015	0.01	0.01	0.012
Ni T	0.018	0.009	0.009	0.012
Pb F	0.010	<0.001	<0.001	0.001
Pb T	0.012	0.006	0.008	0.006
Zn F	4.790	2.280	3.310	2.410
Zn T	4.920	2.390	3.250	2.580
			High con of metals and SO4 after rain	







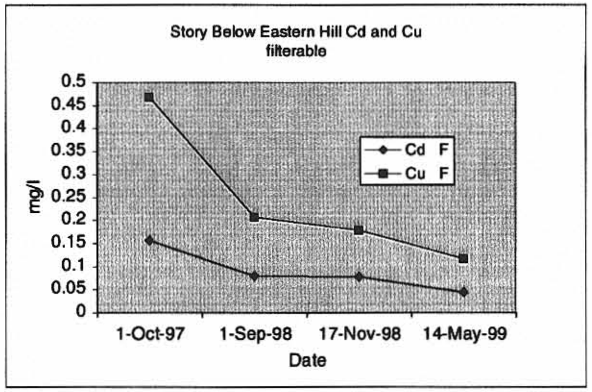
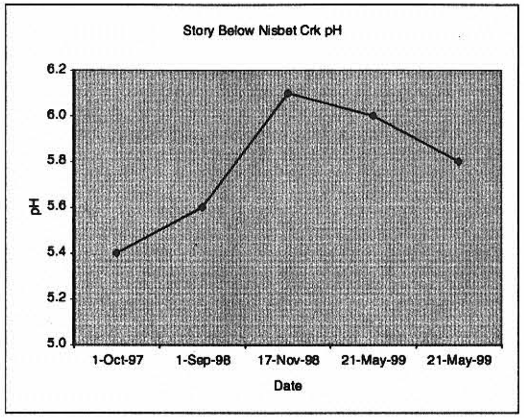
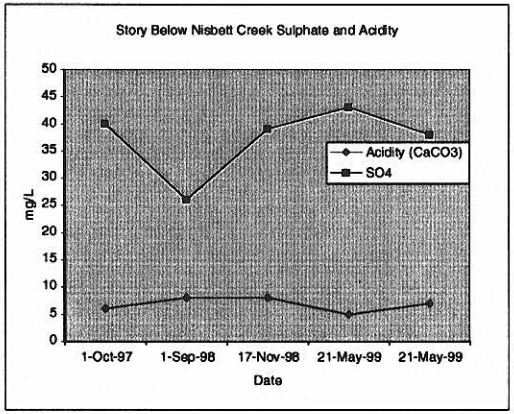
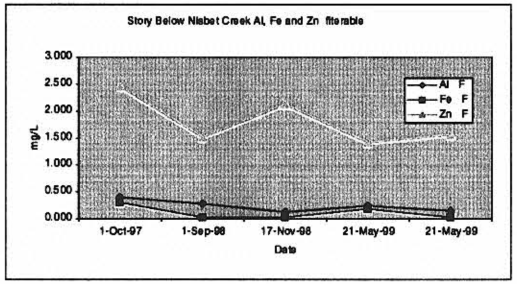


Figure XX : Story Creek Below Nisbet Creek

LOCATION	13				
SAMPLE DATE	1-Oct-97	1-Sep-98	17-Nov-98	21-May-99	21-May-99
	Storys below Nisbet Creek				
PARAMETER (mg/l)					
FLOW L/sec	98				
SAMPLE DATE	3-Oct-97	1-Sep-98	17-Nov-98	21-May-99	29-Jun-00
Acidity (CaCO3)	6	8	8	5	7
SO4	40	26	39	43	38
Gauge Ht		0.3	0.3	0.28	0.34
FLOW L/sec	153	284	284	107	345
Notes		clear no rain	low,clear, some rain prev wend	clear after rain prev few days	clear mod flow
pH L	5.4	5.6	6.1	6.0	5.8
Cond mS/cm L	109	84	135	125	117
TDS	85	67	98	328	328
NFR (suspended solids)	7	5	18	15	15
Alkalinity (CaCO3)	2	1	2	2	2
DOC mg/L	0.4				
Hardness (CaCO3)	32				
Ca T	8.0	6.5			
Cl	2.0				
F	0.77	0.56			
K T	0.2	0.3			
Mg T	3.0	2.6			
Na T	2.0	1.6			
Metals					
Al F	0.400	0.278	0.121	0.234	0.1
Al T	1.000	0.936	1.500	1.250	0.8
Cd F	0.077	0.049	0.054	0.044	0.049
Cd T	0.080	0.050	0.054	0.046	0.050
Cu F	0.223	0.143	0.098	0.115	0.079
Cu T	0.259	0.172	0.244	0.117	0.103
Fe F	0.300	0.020	0.020	0.181	0.0
Fe T	1.000	1.100	3.020	1.610	1.2
Mn F	0.500	0.344	0.461	0.413	0.4
Mn T	0.600	0.720	0.177	0.506	0.4
Zn F	2.434	1.490	2.100	1.400	1.540
Zn T	2.500	1.540	2.320	1.420	1.580
	High con of metals and SO4 after rain		High con of metals and SO4 after rain		







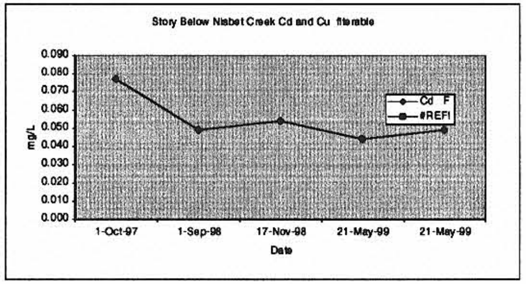
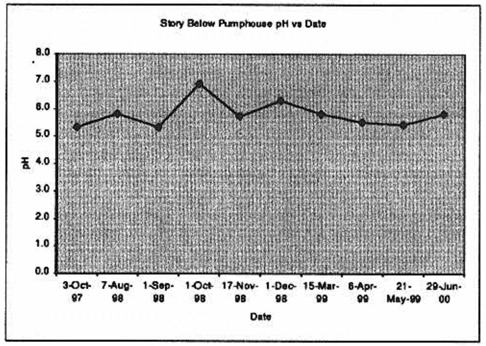
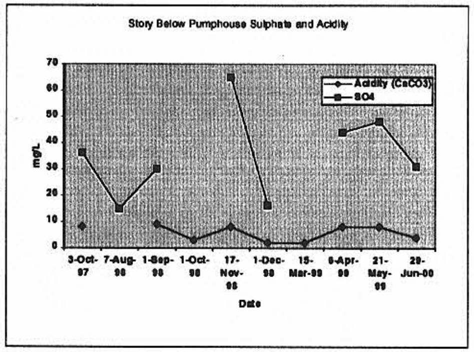
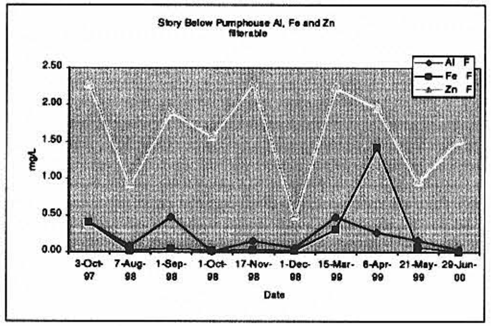


Figure XX : Story Below Pumphouse

LOCATION	14	Storys below pump-house(or managers)								
PARAMETER (mg/l)		prior	after							
SAMPLE DATE	3-Oct-97	7-Aug-98	1-Sep-98	1-Oct-98	17-Nov-98	1-Dec-98	15-Mar-99	6-Apr-99	21-May-99	29-Jun-00
Gauge Ht		0.39	0.3	0.3	0.3	0.35	0.3	0.28	0.28	0.34
FLOW L/sec	153	420	284	284	284	360	285	107	107	345
Notes		clear falling after rain	clear no rain	clear low rain	low,clear, some rain prev wend	low,clear, some rain prev 2 days	low clear no rain obvious ppt.	low clear little rain obvious ppt.	clear after rain prev few days	clear mod flow
pH L	5.3	5.8	5.3	6.9	5.7	6.3	5.8	5.5	5.4	5.8
Cond mS/cm L	98	59	92		128	68	143	146	127	102
TDS	63		65		84			90	257	
NFR (suspended solids)	6	5	5		7			5	8	
Alkalinity (CaCO3)	1		1	3	1			1	1	
Acidity (CaCO3)	8		9	3	8	2	2	8	8	4
SO4	36	15	30		65	16		44	48	31
DOC mg/L	1.2									
Hardness (CaCO3)	27									
Ca T	6.0		6.5							8.6
Cl	2.3							1.9		
F	0.56		0.53							
K T	0.3		0.2							
Mg T	3.0		2.7							2.6
Na T	3.0		1.6							
Metals										
Al F	0.40	0.08	0.47	<0.05	0.146	0.05	0.47	0.26	0.16	0.0
Al T	0.90	0.38	1.00	1.38	0.814	0.05	0.82	0.94	0.65	0.5
Cd F	0.075	0.034	0.067	0.059	0.059	0.016	0.071	0.067	0.036	0.05
Cu F	0.238	0.064	0.222	0.074	0.187	0.012	0.167	0.139	0.079	0.070
Cd T	0.079	0.034	0.072	0.062	0.068	0.02	0.074	0.080	0.055	0.051
Cu F	0.238	0.064	0.222	0.074	0.187	0.012	0.167	0.139	0.079	0.07
Cu T	0.262	0.093	0.249	0.288	0.254	0.017	0.192	0.193	0.185	0.1
Fe F	0.4	0.02	0.0	0.0	0.029	0.02	0.3	1.4	0.1	0.0
Fe T	0.8	0.33	0.8	1.4	1.75	0.075	1.2	0.5	0.9	1.1
Mn F	0.4	0.15	0.3		0.338	0.136	0.5	0.5	0.4	0.3
Mn T	0.4	0.16	0.4		0.384	0.152	0.5	0.5	0.4	0.3
SAMPLE DATE	3-Oct-97	7-Aug-98	1-Sep-98	1-Oct-98	17-Nov-98	1-Dec-98	15-Mar-99	6-Apr-99	21-May-99	29-Jun-00
Zn F	2.280	0.934	1.910	1.580	2.29	0.501	2.240	1.960	0.966	1.530
Zn T	2.330	0.959	1.890	1.570	2.43	0.697	2.230	2.400	2.040	1.580
	high con of metals and SO4 after	Low con of metals and SO4			high con of metals and SO4 after	Low con of metals and SO4				







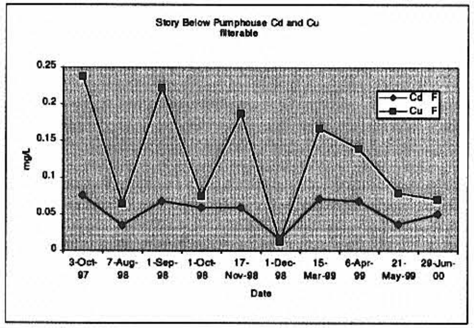
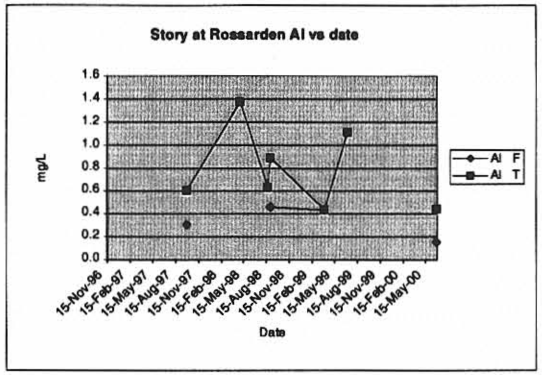
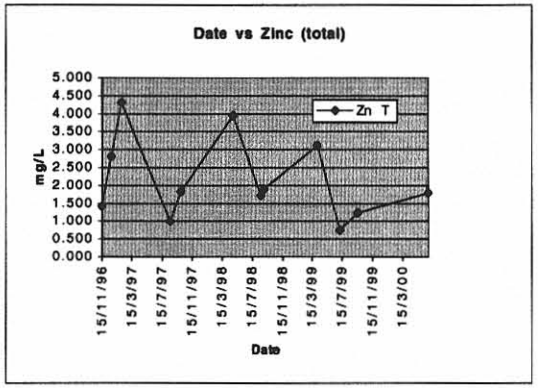
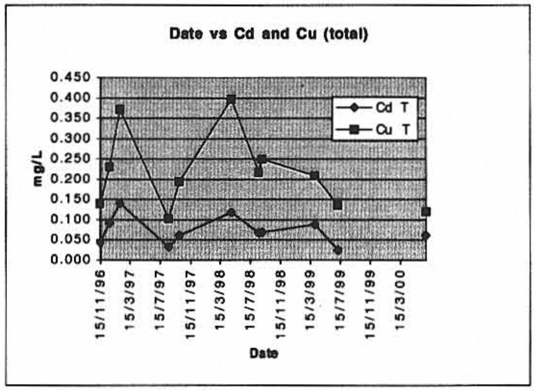


Table XX : Storys Creek at Rossarden Bridge

LOCATION	15								15				
refer Hydro report	Storys at Rossarden							after lstne					
PARAMETER (mg/l)	dpiwe	dpiwe	dpiwe	dpiwe	976010	dpiwe	dpiwe	15	15	dpiwe	15	15	median
SAMPLE DATE	15-Nov-96	23-Dec-96	3-Feb-97	19-Aug-97	1-Oct-97	30-Apr-98	21-Aug-98	1-Sep-98	6-Apr-99	7-Jul-99	16-Sep-99	29-Jun-00	
Gauge Ht													
FLOW L/sec					216								
Notes													
pH L					5.7			5.2	5.3			5.7	5.5
pH F					5.9								
Cond mS/cm L					82			92	136			104	98.0
Cond F					84								
TDS					61			64	93				64.0
NFR (suspended solids)					3			5	5				
Alkalinity (CaCO3)					1			<1	1				
Acidity (CaCO3)					5			9	8			6	7.0
DOC mg/L					2.4								
Hardness (CaCO3)					13								
Ca T					5.0			6.5			5.9	8.9	6.2
Cl					3.0				2.1				
SO4					26			28	41			33	30.5
F					0.40			0.51					
K T					0.4			0.6			0.3		
Mg T					2.0			2.7			1.9	2.6	2.3
Na T					3.0			2.8			2.8		
Metals													
Al F					0.3			0.5	0.4			0.2	0.366
Al T					0.6	1.4	0.6	0.9	0.4	1.1		0.4	0.628
Cd F					0.060			0.069	0.091			0.058	0.065
Cd T	0.043	0.090	0.140	0.032	0.060	0.118	0.067	0.068	0.087	0.024		0.060	0.067
Cu F					0.172			0.242	0.205			0.1	0.189
Cu T	0.138	0.23	0.37	0.101	0.193	0.396	0.215	0.248	0.208	0.134		0.119	0.208
Fe F					0.2			0.2	0.3			0.0	0.200
Fe T	0.7	1.5	1.1	0.5	0.4	1.2	0.6	0.8	0.3	0.9		0.9	0.788
Mn F					0.3			0.3	0.4			0.3	0.316
Mn T	0.3	0.5	0.7	0.1	0.3	0.6	0.3	0.3	0.6	0.1		0.3	0.311
Zn F					1.770			1.910	2.550		1.190	1.720	1.770
Zn T	1.400	2.800	4.300	0.998	1.810	3.940	1.710	1.890	3.110	0.740	1.220	1.780	1.795







APPENDIX C HEC FLOW GAUGING DATA

HYDRO

Hydro-Electric Corporation ARBN 072 377 158,
Incorporated in Tasmania

HYDRO-ELECTRIC CORPORATION
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CIVIL & WATER RESOURCES ENGINEERING GROUP

TELEPHONE (03) 6230 5382
FACSIMILE (03) 6230 5363

OUR REF

YOUR REF

ASK FOR

Wednesday, 28 July 1999

John Miedecke and Partners PTY LTD.
41 Tasma St
North Hobart
Tasmania 7001

Dear John,

STORYS CREEK FLOW RATING

Please find enclosed a copy of the streamflow rating curve for Storys Creek at the Mine Managers Residence. Also included is a rating table, which indicates the flow at corresponding gauge heights.

Unfortunately we have had little luck in measuring the flow through a range of levels. The good news is that flow measurements carried out in August last year still agree with measurements carried out in July 1999. This indicates that the natural control in the creek bed has changed little in this range. This also applies to the zero level on the control.

We can then be confident of the flow up to 0.4 metres on the gauge board. After this it is a straight line extrapolation until the flow breaks out over the creek bank and then starts to roll over.

I have issued an invoice to be processed through HECEC which is for $1940.00. The fee has been reduced as we did not complete the entire flow measuring regime.

Regards,

Mark Johnston

Mark Johnston
District Hydrographer
Resource Monitoring and Information

John Miedecke and Partners

Storys Creek Flow Rating

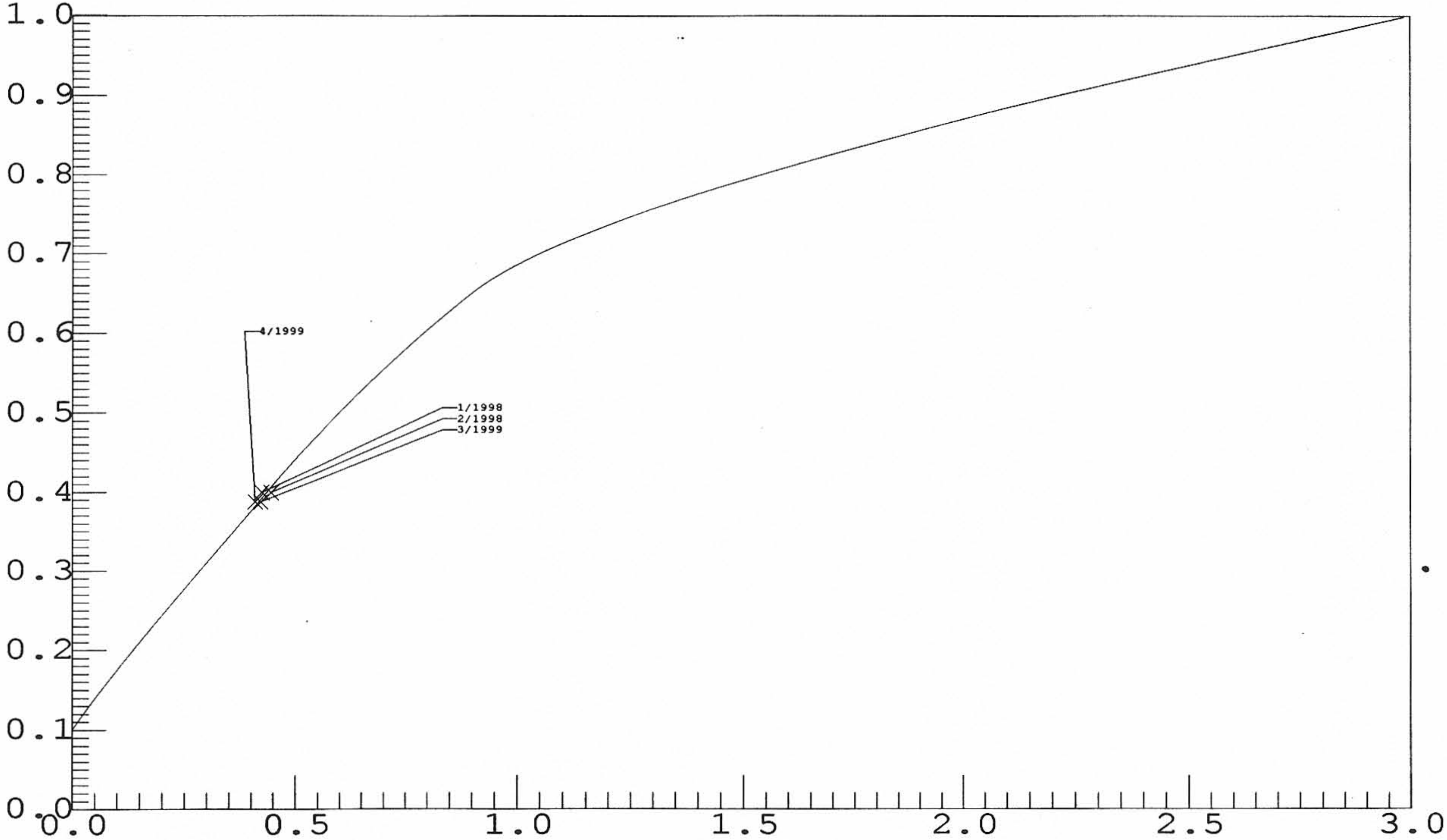
Rating Table 100.00 River Level (Metres) to 140.00 Stream Flow (Cumecs)
Steps:
1) Rating(1379.1 STORYS CREEK [MINE WATER]; 140.00 Stream Flow (Cumecs); R1; Grp 0)

Level (m)	+0.000	+0.001	+0.002	+0.003	+0.004	+0.005	+0.006	+0.007	+0.008	+0.009
0.10	0.000	0.001	0.002	0.004	0.005	0.006	0.008	0.009	0.010	0.011
0.11	0.013	0.014	0.015	0.016	0.018	0.019	0.020	0.022	0.023	0.024
0.12	0.025	0.027	0.028	0.029	0.031	0.032	0.033	0.034	0.036	0.037
0.13	0.038	0.040	0.041	0.042	0.044	0.045	0.046	0.048	0.049	0.050
0.14	0.052	0.053	0.054	0.056	0.057	0.058	0.060	0.061	0.062	0.064
0.15	0.065	0.066	0.068	0.069	0.071	0.072	0.073	0.075	0.076	0.077
0.16	0.079	0.080	0.082	0.083	0.084	0.086	0.087	0.088	0.090	0.091
0.17	0.093	0.094	0.095	0.097	0.098	0.100	0.101	0.102	0.104	0.105
0.18	0.107	0.108	0.109	0.111	0.112	0.114	0.115	0.116	0.118	0.119
0.19	0.121	0.122	0.124	0.125	0.126	0.128	0.129	0.131	0.132	0.134
0.20	0.135	0.137	0.138	0.139	0.141	0.142	0.144	0.145	0.147	0.148
0.21	0.150	0.151	0.152	0.154	0.155	0.157	0.158	0.160	0.161	0.163
0.22	0.164	0.166	0.167	0.168	0.170	0.171	0.173	0.174	0.176	0.177
0.23	0.179	0.180	0.182	0.183	0.185	0.186	0.188	0.189	0.191	0.192
0.24	0.194	0.195	0.197	0.198	0.199	0.201	0.202	0.204	0.205	0.207
0.25	0.208	0.210	0.211	0.213	0.214	0.216	0.217	0.219	0.220	0.222
0.26	0.223	0.225	0.226	0.228	0.229	0.231	0.232	0.234	0.235	0.237
0.27	0.238	0.240	0.241	0.243	0.244	0.246	0.247	0.249	0.250	0.252
0.28	0.253	0.255	0.257	0.258	0.260	0.261	0.263	0.264	0.266	0.267
0.29	0.269	0.270	0.272	0.273	0.275	0.276	0.278	0.279	0.281	0.282
0.30	0.284	0.285	0.287	0.288	0.290	0.291	0.293	0.294	0.296	0.297
0.31	0.299	0.301	0.302	0.304	0.305	0.307	0.308	0.310	0.311	0.313
0.32	0.314	0.316	0.317	0.319	0.320	0.322	0.323	0.325	0.326	0.328
0.33	0.329	0.331	0.332	0.334	0.335	0.337	0.339	0.340	0.342	0.343
0.34	0.345	0.346	0.348	0.349	0.351	0.352	0.354	0.355	0.357	0.358
0.35	0.360	0.361	0.363	0.364	0.366	0.367	0.369	0.370	0.372	0.373
0.36	0.375	0.376	0.378	0.379	0.381	0.383	0.384	0.386	0.387	0.389
0.37	0.390	0.392	0.393	0.395	0.396	0.398	0.399	0.401	0.402	0.404
0.38	0.405	0.407	0.408	0.410	0.411	0.413	0.414	0.416	0.417	0.419
0.39	0.420	0.422	0.423	0.425	0.426	0.428	0.429	0.431	0.432	0.434
0.40	0.435	0.436	0.438	0.439	0.441	0.442	0.444	0.445	0.447	0.449
0.41	0.450	0.452	0.453	0.455	0.456	0.458	0.459	0.461	0.462	0.464
0.42	0.465	0.467	0.468	0.470	0.472	0.473	0.475	0.476	0.478	0.479
0.43	0.481	0.483	0.484	0.486	0.487	0.489	0.490	0.492	0.494	0.495
0.44	0.497	0.498	0.500	0.502	0.503	0.505	0.507	0.508	0.510	0.511
0.45	0.513	0.515	0.516	0.518	0.520	0.521	0.523	0.525	0.526	0.528
0.46	0.530	0.531	0.533	0.535	0.536	0.538	0.540	0.541	0.543	0.545
0.47	0.546	0.548	0.550	0.551	0.553	0.555	0.557	0.558	0.560	0.562
0.48	0.564	0.565	0.567	0.569	0.570	0.572	0.574	0.576	0.577	0.579
0.49	0.581	0.583	0.584	0.586	0.588	0.590	0.591	0.593	0.595	0.597
0.50	0.599	0.600	0.602	0.604	0.606	0.608	0.609	0.611	0.613	0.615
0.51	0.617	0.618	0.620	0.622	0.624	0.626	0.628	0.629	0.631	0.633
0.52	0.635	0.637	0.639	0.640	0.642	0.644	0.646	0.648	0.650	0.652
0.53	0.654	0.655	0.657	0.659	0.661	0.663	0.665	0.667	0.669	0.671
0.54	0.672	0.674	0.676	0.678	0.680	0.682	0.684	0.686	0.688	0.690
0.55	0.692	0.694	0.695	0.697	0.699	0.701	0.703	0.705	0.707	0.709
0.56	0.711	0.713	0.715	0.717	0.719	0.721	0.723	0.725	0.727	0.729
0.57	0.731	0.733	0.735	0.737	0.739	0.741	0.743	0.745	0.747	0.749
0.58	0.751	0.753	0.755	0.757	0.759	0.761	0.763	0.765	0.767	0.769
0.59	0.771	0.773	0.776	0.778	0.780	0.782	0.784	0.786	0.788	0.790
0.60	0.792	0.794	0.796	0.798	0.800	0.803	0.805	0.807	0.809	0.811
0.61	0.813	0.815	0.817	0.819	0.822	0.824	0.826	0.828	0.830	0.832
0.62	0.834	0.836	0.839	0.841	0.843	0.845	0.847	0.849	0.852	0.854
0.63	0.856	0.858	0.860	0.862	0.865	0.867	0.869	0.871	0.873	0.876
0.64	0.878	0.880	0.882	0.884	0.887	0.889	0.891	0.893	0.896	0.898
0.65	0.900	0.902	0.905	0.907	0.909	0.912	0.914	0.916	0.919	0.921
0.66	0.924	0.926	0.929	0.932	0.934	0.937	0.940	0.942	0.945	0.948
0.67	0.951	0.954	0.957	0.959	0.962	0.965	0.968	0.971	0.974	0.978
0.68	0.981	0.984	0.987	0.990	0.993	0.997	1.000	1.003	1.007	1.010
0.69	1.013	1.017	1.020	1.024	1.027	1.031	1.034	1.038	1.042	1.045
0.70	1.049	1.053	1.056	1.060	1.064	1.068	1.072	1.075	1.079	1.083
0.71	1.087	1.091	1.095	1.099	1.103	1.107	1.111	1.116	1.120	1.124
0.72	1.128	1.132	1.137	1.141	1.145	1.149	1.154	1.158	1.163	1.167
0.73	1.171	1.176	1.180	1.185	1.190	1.194	1.199	1.203	1.208	1.213
0.74	1.217	1.222	1.227	1.232	1.236	1.241	1.246	1.251	1.256	1.261
0.75	1.266	1.271	1.275	1.280	1.286	1.291	1.296	1.301	1.306	1.311
0.76	1.316	1.321	1.326	1.332	1.337	1.342	1.347	1.353	1.358	1.363
0.77	1.369	1.374	1.380	1.385	1.391	1.396	1.401	1.407	1.413	1.418
0.78	1.424	1.429	1.435	1.441	1.446	1.452	1.458	1.463	1.469	1.475
0.79	1.481	1.486	1.492	1.498	1.504	1.510	1.516	1.522	1.528	1.533
0.80	1.539	1.545	1.551	1.557	1.564	1.570	1.576	1.582	1.588	1.594
0.81	1.600	1.606	1.613	1.619	1.625	1.631	1.638	1.644	1.650	1.656
0.82	1.663	1.669	1.675	1.682	1.688	1.695	1.701	1.708	1.714	1.720
0.83	1.727	1.733	1.740	1.747	1.753	1.760	1.766	1.773	1.780	1.786
0.84	1.793	1.799	1.806	1.813	1.820	1.826	1.833	1.840	1.847	1.853
0.85	1.860	1.867	1.874	1.881	1.888	1.894	1.901	1.908	1.915	1.922
0.86	1.929	1.936	1.943	1.950	1.957	1.964	1.971	1.978	1.985	1.992
0.87	1.999	2.006	2.014	2.021	2.028	2.035	2.042	2.049	2.056	2.064
0.88	2.071	2.078	2.085	2.093	2.100	2.107	2.114	2.122	2.129	2.136
0.89	2.144	2.151	2.158	2.166	2.173	2.180	2.188	2.195	2.203	2.210
0.90	2.218	2.225	2.232	2.240	2.247	2.255	2.262	2.270	2.277	2.285
0.91	2.292	2.300	2.308	2.315	2.323	2.330	2.338	2.345	2.353	2.361
0.92	2.368	2.376	2.384	2.391	2.399	2.407	2.414	2.422	2.430	2.437
0.93	2.445	2.453	2.461	2.468	2.476	2.484	2.492	2.499	2.507	2.515
0.94	2.523	2.530	2.538	2.546	2.554	2.562	2.570	2.577	2.585	2.593
0.95	2.601	2.609	2.617	2.625	2.632	2.640	2.648	2.656	2.664	2.672
0.96	2.680	2.688	2.696	2.704	2.712	2.719	2.727	2.735	2.743	2.751
0.97	2.759	2.767	2.775	2.783	2.791	2.799	2.807	2.815	2.823	2.831
0.98	2.839	2.847	2.855	2.863	2.871	2.879	2.887	2.895	2.903	2.911

Hydro Electric Corporation
Water Resources

XY Plotting

Rating: 0/1379.1/100.00/140.00/1 STORYS CREEK [MINE WATER]
Gaugings: 1379.1 STORYS CREEK [MINE WATER] Period(01/08/1998 @ 00:00:00,01/08/1999 @ 00:00:00)



APPENDIX D LABORATORY TRIALS - RIVER BANK TAILINGS DEPOSIT

JOHN MIEDECKE AND PARTNERS PTY LTD

environmental management and engineering consultants ACN 002.488128

Facsimile Message:

Date; 3/12/98
No. of Pages Transmitted (Including this page)

To: Wojciech Grun, MRT Fax. No. 62338338

From: John Miedecke Fax. No. 0362 311548

Subject: STORYS CREEK TAILINGS LABORATORY TRIALS PRELIMINARY RESULTS

Laboratory trials of limestone addition to tailings samples are being carried at the PIWE laboratory at the University. Set out below is a preliminary report on the results to date.

DESCRIPTION

Trials were set up in the PIWE laboratory at the University and consisted of samples of tailings contained in buchner funnels. The funnels were installed in stands with drying lamps. The procedures are documented in the EGi report which is an Appendix to the John Miedecke and Partners Pty Ltd report dated March 1998 (Mineral Resources Tasmania Storys Creek /Rossarden Acid Drainage Remediation Study Preliminary Report)

Samples were collected from tailings materials exposed in the bank from Storys Creek near the managers residence and Jig Tailings from the mine site. Samples from the Creek consisted of samples of both brown oxidised surface tailings and the grey underlying materials. These tailings are representative of the more consolidated fine tailings in the Creek floor while the Jig Tailings are taken as representative of the coarser jig tailings and the coarser materials in the creek

The tailings were dried and then mixed with limestone sands according to the required mixture rate of 5kg/tonne and 10kg/tonne. For the Jig Tailings, only the upper rate was used. Table 1 contains a description of the trial samples.

Predetermined quantities of deionised water was added to the samples and the leachate collected for the analysis. Because of the fine grained nature of the tailings, there were problems in obtaining leachate for the first few weeks and additional water was added.

RESULTS AND DISCUSSION

Oxidised and Unoxidised Fine Tailings

To date, there are only three sets of data which have been collected and analyzed by the laboratory for both the fine tailings materials. These results are shown in Tables 2 and 3, with only two dates complete.

Both fine tailings samples show an increased pH and in the initial sampling after mixing and set up, an increased rate of metal dissolution (see data from 28/9/98). There is a trend for reduced

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concentrations of the environmentally important elements, Cd, Cu, and Zn by factors between one half and one quarter, with increased alkalinity leading to reduced metal concentrations.

There is a more erratic behaviour for other metals, such as Al, Fe and Mn. Additional sample data is required to establish clear trends with these metals.

Jig Tailings

There is more complete data for the Jig tailings materials. These results are shown in Table 4, with six sampling dates complete.

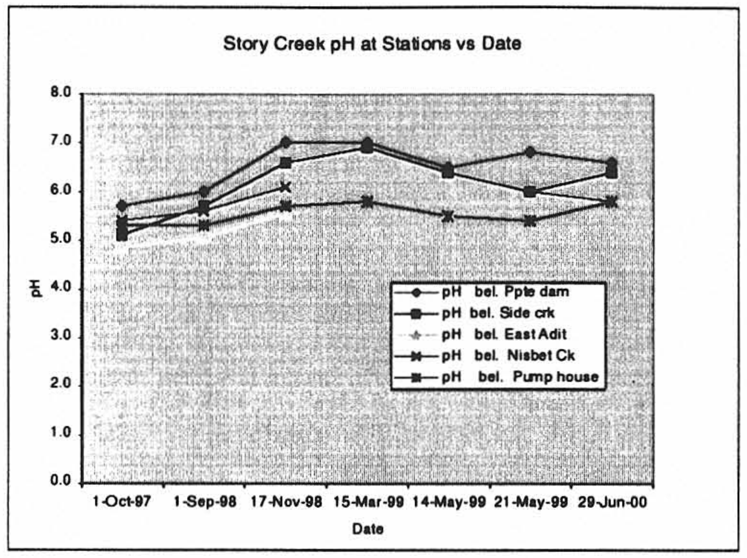
There is a clear trend for increased pH and significantly reduced concentrations of the environmentally important elements, Cd, Cu, and Zn by factors of up to 300. Similarly, the other metals are also reduced. Leachates are close to or meeting aquatic life water quality criteria.

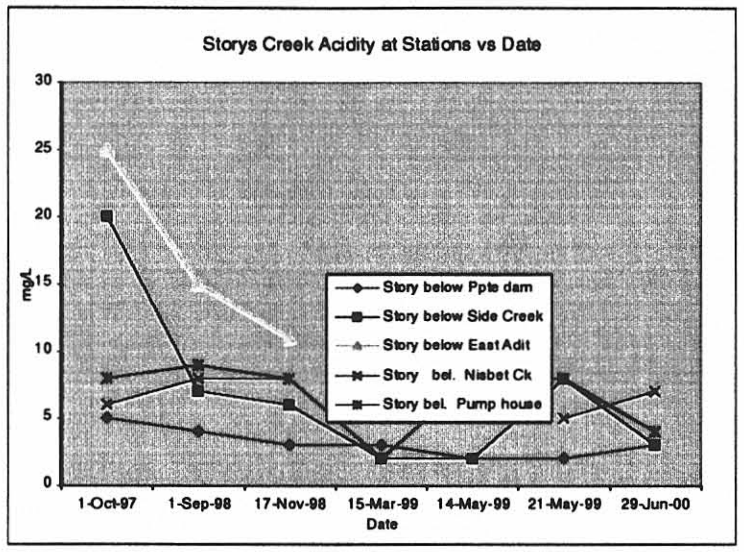
CONCLUSIONS AND RECOMMENDATIONS

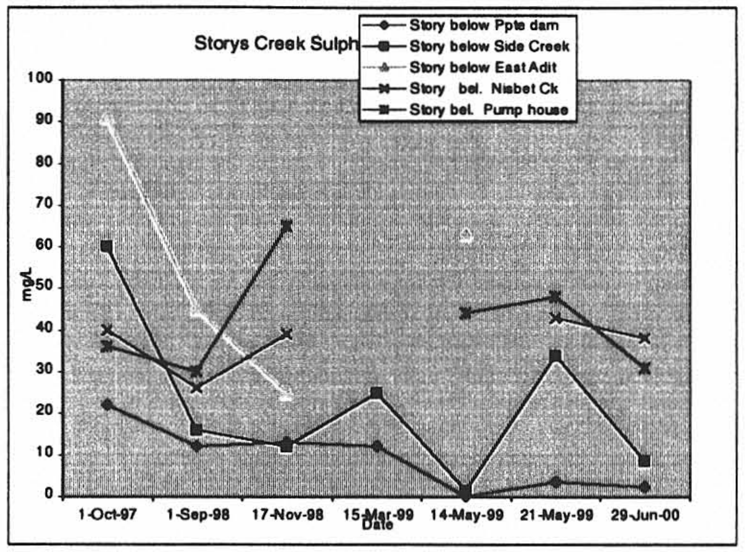
These preliminary results indicate that the laboratory trials have demonstrated that alkalinity addition by addition of crushed (sand and gravel sized) limestone is effective in reducing metal dissolution. This is most (and extremely effective) in the coarser more permeable Jig Tailings and less so in the fine grained tailings. The latter materials are the more impermeable, and therefore the pollutant flux could also be expected to be correspondingly less from these materials.

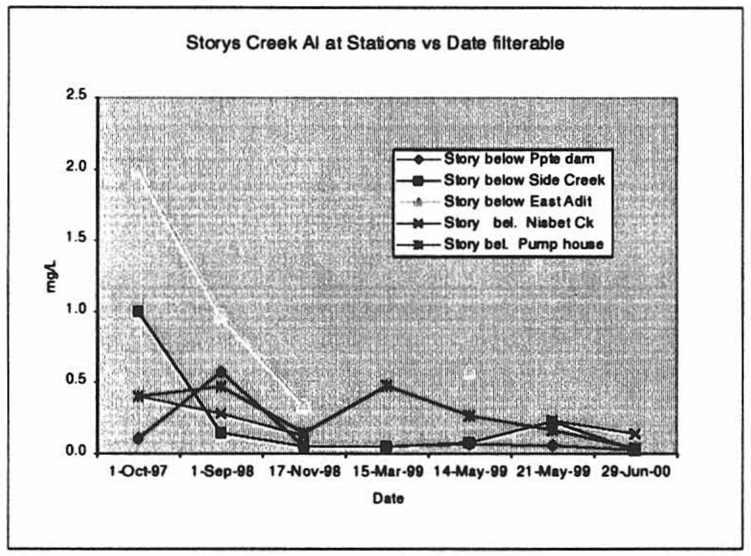
The tailings in the creek are a mixture of both large rock, grading to gravels, sands and to the fine relatively consolidated fine clay materials, therefore the addition of limestone sands in a larger scale trial is recommended, with the laboratory trials continuing until clear trends are evident.

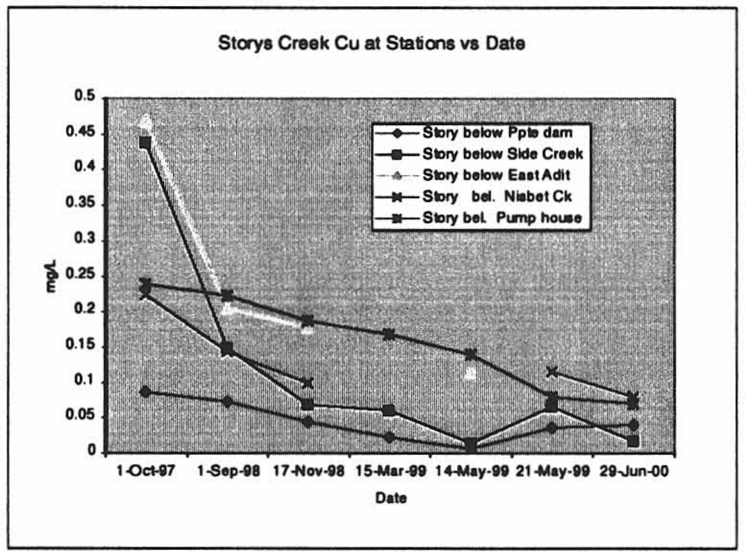
Figure [illegible] torys Creek Water Sampling - after limestone sand addition in S[illegible] ber 1998.

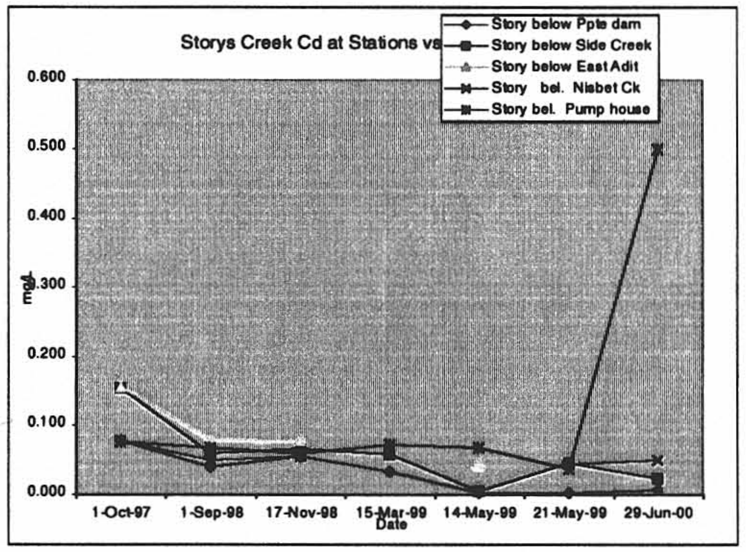


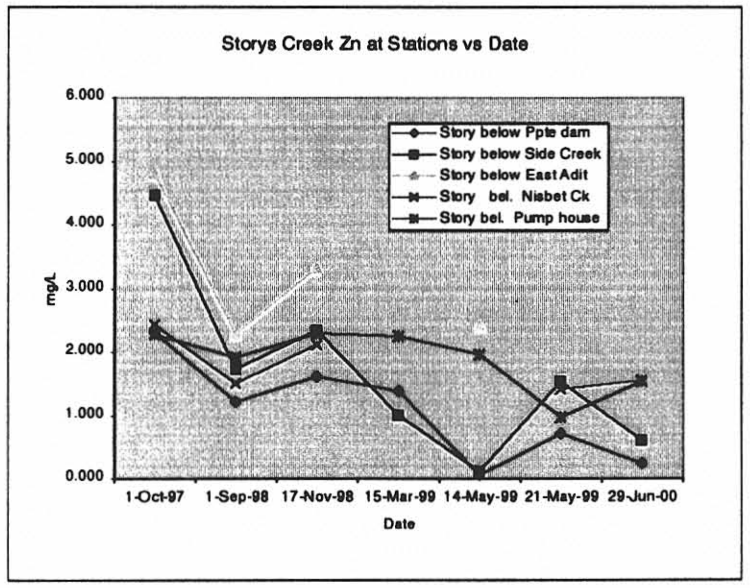






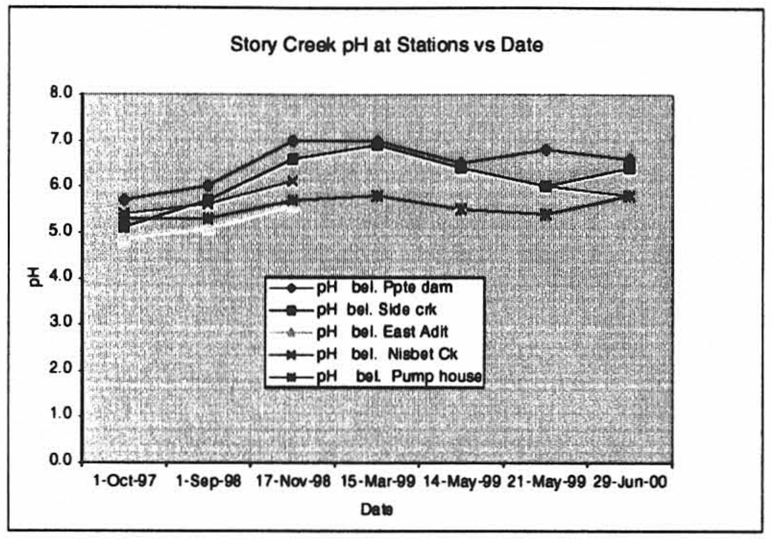


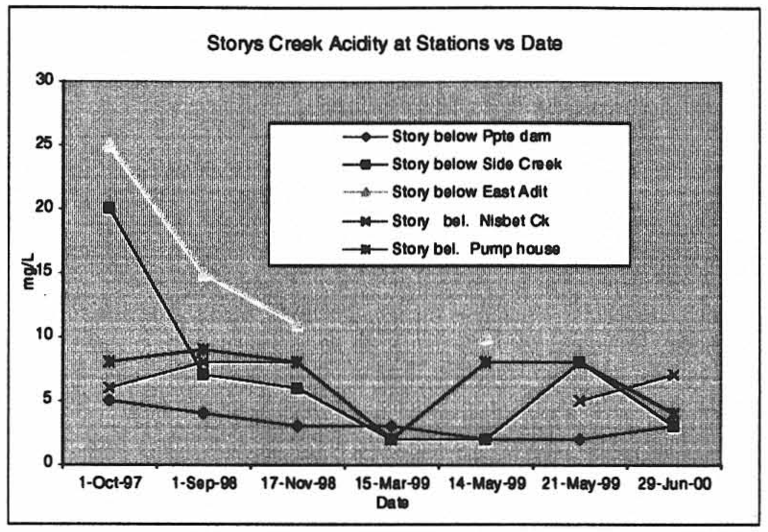


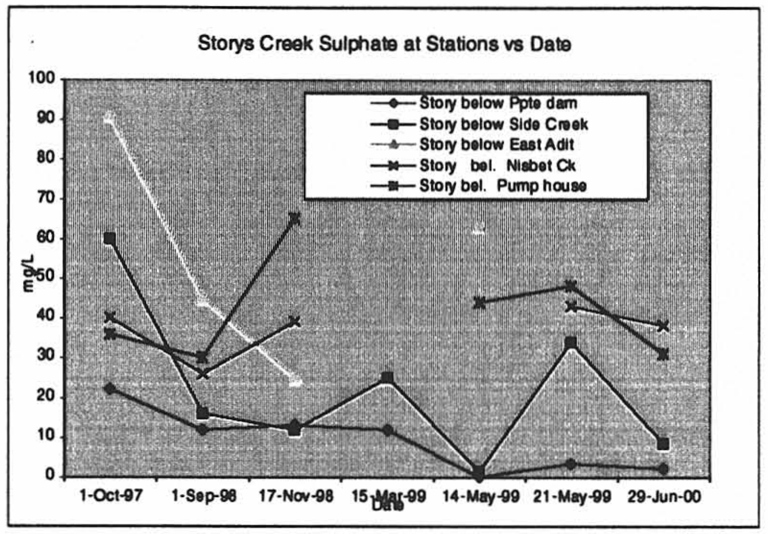


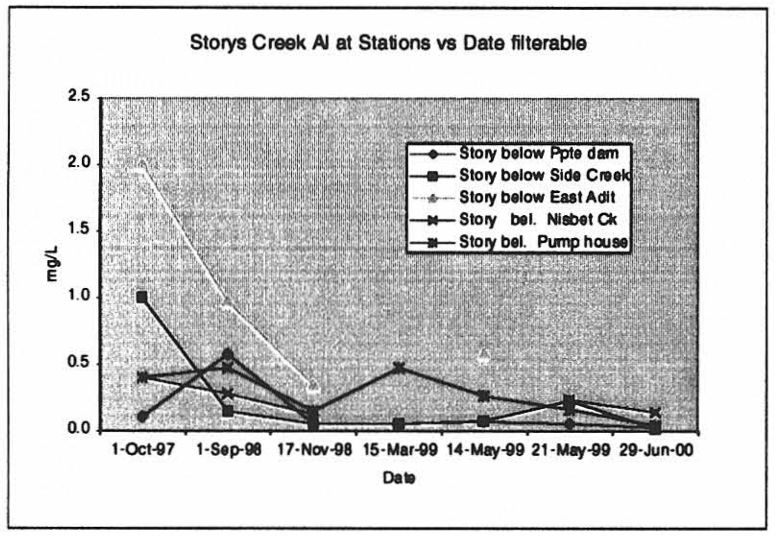
Station Locations	Station No
Story Below Precipitate Dam	5
Story Below Side Creek	8
Story Below Eastern Adit	11
Story Below Nisbet Creek	13
Story Below Pump House	14

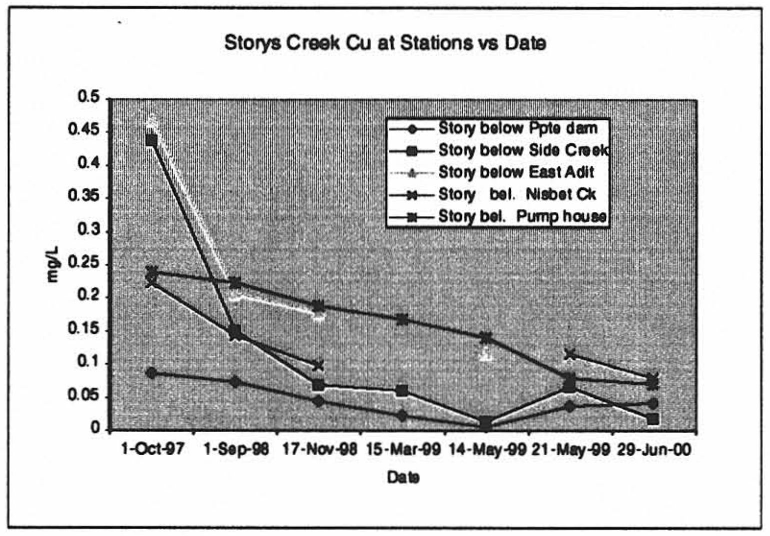
Figure , torys Creek Water Sampling - after limestone sand addition in S ber 1998.

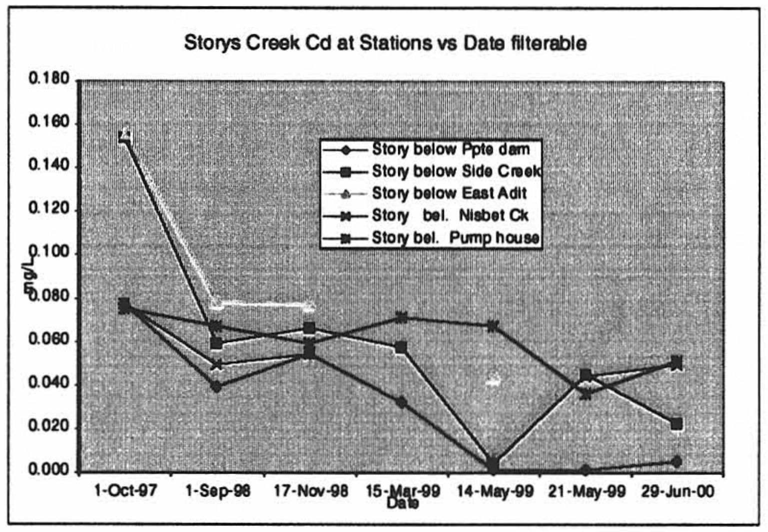


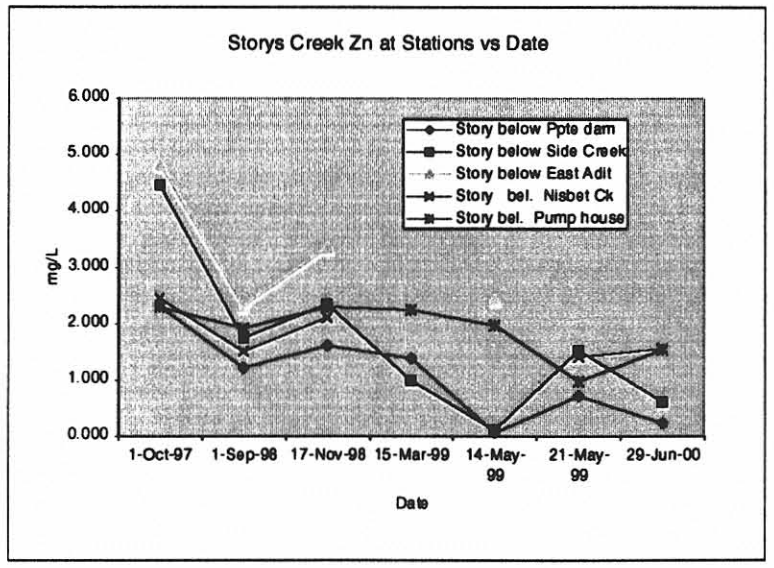












Station Locations	Station No
Story Below Precipitate Dam	5
Story Below Side Creek	8
Story Below Eastern Adit	11
Story Below Nisbet Creek	13
Story Below Pump House	14

TABLE 1 STORYS CREEK TAILINGS LAB TRIALS - SAMPLE DESCRIPTION

SAMPLED ID	01	02	03	05	06	UO1	U02	UO3
Description	Oxidised fine tailings	Oxid tails + 5kg/t limestone	Oxid tails + 10kg/t limestone	Jig Tails	Jig tails + 10kg/t limestone	Unoxidised fine tailings	Unox tails +5kg/t	Unox tails +10kg/t

Table 2 Oxidised Fine Tailings Laboratory Trial Results

Parameter Sample No	Date	Descript	Water added	pH	Cond µS/cm	Alk mg/L	Acidity mg/L	Sulph. mg/L	Al µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Zn µg/L	Ca µg/L	K µg/L	Mg µg/L	Na µg/L
Oxidised Tailing Results by Sample date																						
01	28-Sep	untreated		4.9	134		17	59	494	257	21	<1	715	<20	926	11	<1	4910	5.85	1.45	2.56	4.13
02	28-Sep	5kg/t		5.1	117		15	53	282	191	15	<1	446	<20	675	9	<1	4090	6.42	1.66	2.27	3.34
03	28-Sep	10kg/t		5.3	157		15	71	383	235	19	<1	664	<20	839	16	<1	5030	9.38	1.57	2.72	4.18
01	7-Oct	untreated							409	213	16	<1	608	31	791	9	<1	4350				
02	7-Oct	5kg/t							379	206	16	<1	559	37	774	11	<1	4030				
03	7-Oct	10kg/t							317	189	15	<1	490	30	713	11	<1	3930				
01	14-Oct	untreated		4.4			14	50	350	207	16	<1	550	21	684	8	<1	4200	4.72	1.31	1.97	2.98
02	14-Oct	5kg/t		4.2			16	77	395	200	15	<1	593	<20	725	10	<1	3740	8.13	1.72	2.33	3.46
03	14-Oct	10kg/t		5	133		12	57	308	180	14	<1	464	<20	715	9	<1	3620	8.34	1.43	2.19	3.36
01	21-Oct			4.3	130	1	15	51	353	175	11	1	528	20	553	7	1	3150	5.32	1.36	2.23	3.84
02	21-Oct			4.4	148	1	12	62	297	159	10	1	483	20	493	6	1	2560	9.51	1.71	2.38	4.28
03	21-Oct			4.5	182	1	14	79	350	196	12	1	529	20	618	13	1	3200	12.5	1.92	2.9	6.4
01	28-Oct						16	56	383	185	11	1	586	20	548	7	1	3370	5.65	1.63	2.26	4.49
02	28-Oct						13	72	322	163	10	1	515	20	489	7	1	2790	10.3	2.03	2.5	5.38
03	28-Oct						14	78	312	176	11	1	506	20	533	8	1	2970	11.9	1.76	2.72	5.52
01	4-Nov						20		499	242	13	1	776	20	642	8	1	4300	7.14	1.89	2.85	6.25
02	4-Nov						12	74	277	159	8	1	461	20	441	6	1	2480	9.56	1.9	2.17	4.7
03	4-Nov						16	94	371	203	11	1	541	20	10	1	1	3250	13	1.95	2.86	6.19
01	12-Nov								624	246	15	1	1010	20	694	9	1	5950	7.6	1.94	3.14	6.58
02	12-Nov								330	176	10	1	571	20	460	7	1	4090	107	1.95	2.48	5.4
03	12-Nov						16		372	184	11	1	569	20	539	8	1	4150	13.4	1.7	2.84	5.4
Oxidised Tailing Results by Sample																						
01	28-Sep	untreated	140	4.9	134		17	59	494	257	21	<1	715	<20	926	11	<1	4910	5.85	1.45	2.56	4.13
01	7-Oct	untreated	10						409	213	16		608	31	791	9		4350				
01	14-Oct	untreated	160	4.4			14	50	350	207	16		550	21	684	8		4200	4.72	1.31	1.97	2.98
01	21-Oct	untreated	330	4.3	130	1	15	51	353	175	11	1	528	20	553	7	1	3150	5.32	1.36	2.23	3.84
01	28-Oct	untreated	230				16	56	383	185	11	1	586	20	548	7	1	3370	5.65	1.63	2.26	4.49
01	4-Nov	untreated	120				20		499	242	13	1	776	20	642	8	1	4300	7.14	1.89	2.85	6.25
01	12-Nov	untreated	160						624	246	15	1	1010	20	694	9	1	5950	7.6	1.94	3.14	6.58
01	20-Nov	untreated	362	4.3	271		23	68	759	308	20	<1	930	22	906	10	<1	6640	7.75	1.83	3.38	5.59
01	12-Jan	untreated	375	4.7	37		5	90	88	43	3	<1	161	54	119	1	<1	905	1.22	0.4	0.47	1.07
01	19-Jan	untreated	375	4.14.5	190		24	87	788	312	20	<1	1120	97	926	10	<1	6020	8.22	2.43	3.54	5.49
01	7-Apr	untreated	140	4.2	169		18	77	639	272	19	<1	782	<20	817	9	<1	6040	7.26	1.62	3.01	4.2
01	16-Apr	untreated	302	4.5	162		29	74	634	271	17	<1	742	<20	757	10	<1	5330	7.38	1.63	3.01	4.48
01	21-Apr	untreated	573	4.4	165		24	80	698	277	18	<1	768	<20	808	11	<1	5640	7.39	1.71	3.14	5.29
01	26-Apr	untreated	630	4.5	153		21	75	675	281	19	<1	743	<20	830	12	<1	5470	7.16	1.5	3.11	3.48

Table 2 Oxidised Fine Tailings Laboratory Trial Results

01	30-Apr	untreated	594	4.4	138		19	65	547	225	15	<1	689	<20	649	8	<1	4670	6.36	1.54	2.7	3.62
01	6-May	untreated	584	4.4	123		17	56	476	208	14	<1	596	57	625	7	<1	4330	5.09	1.13	2.21	2.31
01	13-May	untreated	488	4.4	120		15	50	447	193	13	<1	594	43	573	6	<1	4080	5.14	1.18	2.19	2.22
01	Mean	untreated	327.8	4.5	149.3	1.0	**18.5**	67.0	**521**	**230**	15.4	1.0	**700**	36.8	696.9	8.4	1.0	**4668**	6.2	1.5	2.6	4.1
02	28-Sep	5kg/t	160	5.1	117		15	53	282	191	15		446	<20	675	9		4090	6.42	1.66	2.27	3.34
02	7-Oct	5kg/t	20																			
02	14-Oct	5kg/t	190																			
02	21-Oct	5kg/t	330	4.4	148	1	12	62	297	159	10	1	483	20	493	6	1	2560	9.51	1.71	2.38	4.28
02	28-Oct	5kg/t	230				13	72	322	163	10	1	515	20	489	7	1	2790	10.3	2.03	2.5	5.38
02	4-Nov	5kg/t	200				12	74	277	159	8	1	461	20	441	6	1	2480	9.56	1.9	2.17	4.7
02	12-Nov	5kg/t	190						330	176	10	1	571	20	460	7	1	4090	107	1.95	2.48	5.4
02	20-Nov	5kg/t	274	4.1	196		14	84	495	234	14	1	640	62	720	8	1	4940	1.7	1.98	3.1	5.53
02	12-Jan	5kg/t	255	4.7	78		5	26	80	85	5	1	284	73	259	1	1	1660	4.4	1	1.14	1.89
02	19-Jan	5kg/t	510	4.4	205		20	89	571	264	16	1	930	44	804	9	1	5150	13.9	2.83	3.73	5.53
02	7-Apr	5kg/t	172	4.5	189		14	87	478	214	14	1	551	59	689	7	1	4420	14.1	1.87	3.14	4.15
02	16-Apr	5kg/t	194	4.6	168		13	75	432	192	12	3	521	72	621	6	1	3830	12.8	1.7	2.82	3.73
02	21-Apr	5kg/t	454	4.7	178		13	79	458	214	13	2	550	25	697	7	1	3910	13.8	1.81	2.98	3.88
02	26-Apr	5kg/t	667	4.9	179		13	79	470	211	14	1	535	20	687	6	1	4420	14.7	1.6	3.31	3.6
02	30-Apr	5kg/t	531	4.4	159		11	65	355	186	11	1	459	20	551	6	1	3370	11	1.65	2.53	3.19
02	6-May	5kg/t	619	4.8	160		11	86	334	167	11	1	406	54	518	6	1	3010	10.6	1.44	2.2	2.51
02	13-May	5kg/t	541	4.9	144		10	58	287	142	9	1	376	54	450	6	1	2880	10.3	1.44	2.13	2.43
02	Mean	5kg/t	325.7	**4.6**	160.1	1.0	**13**	**71**	**365**	**184**	11.5	1.2	**515**	**40**	**570**	**6**	1	**3573**	15.4	1.7	2.6	
03	28-Sep	10kg/t	200	5.3	157		15	71	383	235	19		664		839	16	<1	5030	9.38	1.57	2.72	4.18
03	7-Oct	10kg/t	50						317	189	15	<1	490	30	713	11	<1	3930				
03	14-Oct	10kg/t	200	5	133		12	57	308	180	14	<1	464	<20	715	9	<1	3620	8.34	1.43	2.19	3.36
03	21-Oct	10kg/t	360	4.5	182	1	14	79	350	196	12	1	529	20	618	13	1	3200	12.5	1.92	2.9	6.4
03	28-Oct	10kg/t	270				14	78	312	176	11	1	506	20	533	8	1	2970	11.9	1.76	2.72	5.52
03	4-Nov	10kg/t	250				16	94	371	203	11	1	541	20	10	1	1	3250	13	1.95	2.86	6.19
03	12-Nov	10kg/t	240				16		372	184	11	1	569	20	539	8	1	4150	13.4	1.7	2.84	5.4
03	20-Nov	10kg/t	268	4.4	158		15	79	411	198	12	1	538	44	621	9	1	4110	13.1	1.64	2.71	4.66
03	12-Jan	10kg/t	220	4.9	140		10	54	477	197	12	1	612	41	642	11	1	3330	9.9	1.65	2.24	3.66
03	19-Jan	10kg/t	228	4.5	217		20	91	495	224	13	1	815	83	717	10	1	4290	14.4	2.37	3.09	5.34
03	7-Apr	10kg/t	229	4.7	203		15	82	419	171	11	1	381	89	996	9	1	3960	13.4	1.46	3.55	5.83
03	16-Apr	10kg/t	269	4.5	193		13	82	397	180	11	1	410	69	626	10	1	3380	11.9	1.31	2.3	3.4
03	21-Apr	10kg/t	518	4.8	202		14	89	627	271	18	1	582	54	921	14	1	4810	16.6	1.62	3.14	4.01
03	26-Apr	10kg/t	661	4.9	200		14	90	546	236	15	1	558	24	794	10	1	4590	18.4	1.59	3.44	4.26
03	30-Apr	10kg/t	557	4.9	175		12	73	418	187	12	1	448	29	629	9	1	3550	16.2	1.54	2.76	3.58
03	6-May	10kg/t	604	5	164		11	68	368	180	11	1	423	37	618	8	1	3470	15.6	1.44	2.69	2.9
03	13-May	10kg/t	547	5	154		10	59	291	148	9	1	346	65	507	9	1	2860	12.8	1.3	2.18	2.73
03	Mean	10kg/t	333.6	4.8	175.2	1.0	**14**	**76**	**404**	**197**	12.8	1.0	**522**	43.0	649.3	9.7	1.0	**3794**	13.2	1.6	2.8	4.5

Table 3 Unoxidised Fine Tailings Laboratory Trial Results

Parameter Sample No	Date	Water	Descript	pH	Cond µS/cm	Alk mg/L	Acidity mg/L	Sulph. mg/L	Al µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Zn µg/L	Ca µg/L	K µg/L	Mg µg/L	Na µg/L
Unoxidised Tailing Results by Sample date																						
UO1	28-Sep		untreated	5.8	106		6	33	536	69	<1		3	231	256	2	<1	791	6	0.83	2.9	2.97
UO2	28-Sep		5kg/t						876	94	2		7	419	529	4	<1	1370	9.05	0.99	3.85	3.46
UO3	28-Sep		10kg/t	6.1	140		8	44	117	147	7		15	<20	833	4	<1	2390	9.67	1.02	4.21	4.12
UO1	7-Oct		untreated						968	76	1	<1	7	352	308	2	<1	1060				
UO1	14-Oct		untreated	5.9	186		9	58	204	191	8	<1	28	34	1070	5	<1	2940	11.9	1.06	5.81	4.78
UO2	14-Oct		5kg/t	6.5	145		5	51	147	105	1	<1	10	44	530	2	<1	1520	10	1	4.25	3.6
UO3	14-Oct		10kg/t	6.8	134		4	42	1420	81	<1	<1	6	537	241	3	<1	1020	8.23	1.04	3.98	3.58
UO1	21-Oct		untreated	5.5	124	1	4	40	1250	77	<1	<1	7	428	189	2	1	865	7.91	0.94	3.62	3.46
UO2	21-Oct		5kg/t	5.7	144	1	4	46	247	64	1	1	6	74	296	2	1	757	10.1	0.88	4.09	3.59
UO3	21-Oct		10kg/t	5.1	167	1	7	59	89	135	5	1	23	20	660	4	1	1740	12.2	0.87	4.4	4.31
UO1	28-Oct		untreated	5.4	118		4	38	1180	46	1	1	3	419	121	2	1	499	7.57	0.96	3.36	3.27
UO2	28-Oct		5kg/t	5.8	142		4	47	406	75	1	1	8	141	330	2	1	776	9.75	0.98	3.87	3.74
UO3	28-Oct		10kg/t	5.3	143		6	52	168	110	4	1	22	540	2	1	1	1460	9.43	0.9	3.65	4.16
UO1	4-Nov		untreated	6	111		5	36	1370	50	1	1	9	456	132	3	1	576	6.4	1.29	2.84	4.16
UO2	4-Nov		5kg/t	5.8	136		4	47	372	62	1	1	8	112	284	2	1	668	8.95	0.98	3.51	3.67
UO3	4-Nov		10kg/t	4.8	132		6	48	182	104	4	1	19	31	504	3	1	1330	8.64	0.75	3.21	3.86
UO1	12-Nov		untreated				6	37	1200	64	1	1	6	524	144	2	1	726	6.66	0.87	3.02	3.06
UO2	12-Nov		5kg/t				5	47	718	61	1	1	10	310	269	2	1	895	8.57	0.95	3.48	3.56
UO3	12-Nov		10kg/t	5	125		6	46	226	92	4	1	20	61	460	4	1	1550	8.33	0.82	3.1	4.1
Unoxidised Tailing Results by																						
UO1	28-Sep	150	untreated	5.8	106		6	33	536	69	<1		3	231	256	2	<1	791	6	0.83	2.9	2.97
UO1	7-Oct	10	untreated						968	76	1	<1	7	352	308	2	<1	1060				
UO1	14-Oct	220	untreated	5.9	186		9	58	204	191	8	<1	28	34	1070	5	<1	2940	11.9	1.06	5.81	4.78
UO1	21-Oct	320	untreated	5.5	124	1	4	40	1250	77	<1	<1	7	428	189	2	1	865	7.91	0.94	3.62	3.46
UO1	28-Oct	290	untreated	5.4	118		4	38	1180	46	1	1	3	419	121	2	1	499	7.57	0.96	3.36	3.27
UO1	4-Nov	250	untreated	6	111		5	36	1370	50	1	1	9	456	132	3	1	576	6.4	1.29	2.84	4.16
UO1	12-Nov	280	untreated				6	37	1200	64	1	1	6	524	144	2	1	726	6.66	0.87	3.02	3.06
UO1	20-Nov	372	untreated	4.5	118		9	36	340	82	1	1	20	68	241	5	1	1260	6.61	0.77	3.07	2.62
UO1	12-Jan	424	untreated	7.1	66		2	16	50	40	1	1	11	20	159	1	1	538	3.61	0.47	1.75	1.48
UO1	19-Jan	204	untreated	7.1	129		4	36	50	75	1	1	22	20	311	11	1	1020	7.41	1	3.46	2.56
UO1	7-Apr	233	untreated	6.2	120		3	33	196	71	1	1	28	75	288	6	1	1050	6.76	0.5	3.04	2.2
UO1	16-Apr	316	untreated	5.1	108		5	28	221	77	1	1	25	71	297	10	1	1070	6.41	0.71	3.01	2.48
UO1	21-Apr	504	untreated	5	95		5	24	177	64	1	1	20	54	271	5	1	1110	5.81	0.6	2.61	2.35
UO1	26-Apr	618	untreated	5.1	85		4	20	377	47	1	1	19	123	195	5	1	749	4.43	0.42	2.01	1.82
UO1	30-Apr	566	untreated	5.7	75		4	15	60	50	1	1	19	31	197	4	1	784	4.53	0.49	2.06	1.62
UO1	6-May	598	untreated	5.8	89		3	11	78	63	1	1	19	29	247	2	1	960	5.27	0.45	2.45	1.56
UO1	13-May	506	untreated	6	108		4	7.4	111	99	1	1	16	30	353	1	1	1410	8.16	0.52	3.81	1.76
UO1	Mean	344.8	untreated	5.7	109.2	1.0	**4.8**	29.3	**482**	**73**	1.5	1.0	**15**	174.4	281.1	4.0	1.0	**1024**	6.6	0.7	3.1	2.6
UO2	28-Sep	130	5kg/t						876	94	2		7	419		4	<1	1370	9.05	0.99	3.85	3.46
UO2	14-Oct		5kg/t	6.5	145		5	51	147	105	1	<1	10	44		2	<1	1520	10	1	4.25	3.6
UO2	21-Oct	330	5kg/t	5.7	144	1	4	46	247	64	1	1	6	74	296	2	1	757	10.1	0.88	4.09	3.59
UO2	28-Oct	290	5kg/t	5.8	142		4	47	406	75	1	1	8	141	330	2	1	776	9.75	0.98	3.87	3.74
UO2	4-Nov	280	5kg/t	5.8	136		4	47	372	62	1	1	8	112	284	2	1	668	8.95	0.98	3.51	3.67
UO2	12-Nov	320	5kg/t				5	47	718	61	1	1	10	310	269	2	1	895	8.57	0.95	3.48	3.56
UO2	20-Nov	333	5kg/t	5.3	118		4	43	438	78	1	1	20	119	430	2	1	1070	8.41	0.68	3.36	2.81
UO2	12-Jan	295	5kg/t	7	100		3	30	50	55	1	1	19	20	334	1	1	644	6.81	0.71	2.77	2.08
UO2	19-Jan	226	5kg/t	7	135		5	46	50	79	1	1	39	20	523	2	1	885	10.1	1.09	4.06	3.35
UO2	7-Apr	319	5kg/t	5.5	122		4	42	192	58	1	1	22	79	141	2	1	812	7.87	0.59	3.18	2.44
UO2	16-Apr	238	5kg/t	6.2	113		4	38	50	49	1	1	33	20	342	1	1	622	6.63	0.68	2.68	2.68
UO2	21-Apr	324	5kg/t	6.4	104		3	35	193	48	1	1	24	60	340	1	1	609	6.86	0.66	2.67	2.34
UO2	26-Apr	427	5kg/t	5.1	81		4	34	77	46	1	1	22	24	339	2	1	661	7.46	0.54	2.84	2.23
UO2	30-Apr	582	5kg/t	6	78		3	25	140	31	1	1	22	64	231	3	1	450	5.12	0.57	1.94	2
UO2	6-May	656	5kg/t	5.2	77		3	23	68	35	1	1	20	30	263	1	1	469	5.56	0.48	2.1	1.83
UO2	13-May	573	5kg/t	6.2	71		2	17	50	34	1	1	16	20	237	1	1	441	4.86	0.47	1.86	1.59
UO2	Mean	354.9	5kg/t	6.0	111.9	1.0	**3.8**	38.1	**255**	**61**	1.1	1.0	**18**	97.3	311.4	1.9	1.0	**790**	7.9	0.8	3.2	2.8
UO3	28-Sep	170	10kg/t	6.1	140		8	44	117	147	7		15	<20	833	4	<1	2390	9.67	1.02	4.21	4.12
UO3	14-Oct		10kg/t	6.8	134		4	42	1420	81	<1	<1	6	537	241	3	<1	1020	8.23	1.04	3.98	3.58
UO3	21-Oct	430	10kg/t	5.1	167	1	7	59	89	135	5	1	23	20	660	4	1	1740	12.2	0.87	4.4	4.31
UO3	28-Oct	360	10kg/t	5.3	143		6	52	168	110	4	1	22	540	2	1	1	1460	9.43	0.9	3.65	4.16
UO3	4-Nov	280	10kg/t	4.8	132		6	48	182	104	4	1	19	31	504	3	1	1330	8.64	0.75	3.21	3.86
UO3	12-Nov	330	10kg/t	5	125		6	46	226	92	4	1	20	61	460	4	1	1550	8.33	0.82	3.1	4.1
UO3	20-Nov	322	10kg/t	5.4	120		8	47	221	106	5	1	38	51	721	4	1	1860	9.39	0.47	3.52	2.91
UO3	12-Jan	309	10kg/t	6.4	84		5	29	50	73	3	1	32	21	487	2	1	1080	6.63	0.85	2.36	2.17
UO3	19-Jan	214	10kg/t	7	143		6	52	50	123	6	1	72	20	805	17	1	1700	11.3	1.51	4.11	4.08
UO3	7-Apr	230	10kg/t	5.7	140		5	50	117	102	5	1	42	42	756	4	1	1670	10.2	0.79	3.67	2.92
UO3	16-Apr	451	10kg/t	6	135		6	46	77	95	6	1	94	25	732	4	1	1390	9.15	0.68	3.23	2.7
UO3	21-Apr	675	10kg/t	6.3	133		5	43	50	86	5	1	68	20	639	2	1	1110	8.67	0.69	2.88	2.51
UO3	26-Apr	679	10kg/t	7.2	120		4	37	50	83	5	1	44	20	630	2	1	1140	8.25	0.69	2.79	2.07
UO3	30-Apr	637	10kg/t	7	97		5	29	50	68	4	1	45	20	520	2	1	901	7.67	0.68	2.42	1.93
UO3	6-May	661	10kg/t	7	92		6	24	50	61	4	1	35	20	479	1	1	784	6.94	0.63	2.32	1.55
UO3	13-May	616	10kg/t	6.5	84		5	22	50	55	3	1	36	20	412	1	1	711	6.94	0.69	2.12	1.53
UO3	Mean	424.3		6.1	124.3	1.0	**5.8**	41.9	**185**	**95**	4.7	1.0	**38**	96.5	555.1	3.6	1.0	**1361**	8.9	0.8	3.2	3.0

Table 4 Jig Tailings Laboratory Trial Results

Parameter Sample No	Date	Descript	Water added	pH	Cond µS/cm	Alkal. mg/L	Acidity mg/L	Sulph. mg/L	Al µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Zn µg/L	Ca µg/L	K µg/L	Mg µg/L	Na µg/L
Jig Tailing Results by Sample date																						
05	Sept	untreated							2450	261	31	<1	1050	<20	3440	31	73	6460				
06	Sept	10kg/t							<50	<1	<1	<1	<1	<20	<5	<1	<1	<1				
05	4-Sep	untreated		3.6	463		103	230	6050	601	64	2	2330	54								
06	4-Sep	10kg/t		7.9	913		3	450	<50	2	<1	<1	<1	<20								
05	10-Sep	untreated							1830	182	20	<1	627	<20	2380	21	51	4240				
06	10-Sep	10kg/t							<50	<1	<1	<1	<1	<20	<5	<1	<1	<1				
05	18-Sep	untreated							2440	223	30	2	950	133	4060	37.45	45	6980	6.25	0.39	3.19	0.15
06	18-Sep	10kg/t							<50	1	<1	<1	<1	61	71	<1	<1	6	27.6	0.36	3.17	0.06
05	7-Oct	untreated			225			120	3100	280	41	2	1090	23	5610	45	45	9650	7.43	0.59	4.49	0.15
06	7-Oct	10kg/t			163			55	<50	2	<1	<1	<1	<20	118	<1	<1	17	18.5	0.55	2.68	0.09
05	14-Oct	untreated		4	214		43	110	3140	279	44	2	987	64	5770	45	40	8930	6.58	0.69	4.44	0.09
06	14-Oct	10kg/t		7.8	193		1	72	<50	3	<1	<1	<1	<20	172	1	<1	30	25.8	0.8	3.86	0.23
05	21-Oct	untreated		3.8	175	1	33	91	1790	160	24	1	459	20	3130	21	27	4070	5.63	0.68	3.11	0.25
06	21-Oct	10kg/t		6.9	179	10	2	62	50	<1	<1	<1	<1	<20	6	<1	<1	<1	22.6	0.65	2.02	0.07
05	28-Oct	untreated		3.8	221	1	38	90	1910	211	31	2	463	20	3890	27	30	4470	9.22	0.97	3.88	0.33
06	28-Oct	10kg/t		7.4	270	10	1	87	50	2	1	1	1	20	26	1	1	3	41.2	0.73	2.3	0.11
05	4-Nov	untreated		3.8	142	1	22	79	1050	108	17	1	254	20	2210	14	20	2240	5.47	0.58	2.08	0.1
06	4-Nov	10kg/t		7.4	154	11	1	49	50	1	1	1	1	20	5	1	1	1	24	0.5	1.22	0.03
05	12-Nov	untreated		3.8	152	1	24	71	1050	104	19	1	346	20	2130	15	22	3070	5.14	0.65	2.21	0.07
06	12-Nov	10kg/t		7.6	150	9	4	50	50	1	1	1	1	20	5	1	1	1	21.7	0.65	1.16	0.05
Jig Tailing Results by Sample																						
05	Sept	untreated	60						2450	261	31	<1	1050	<20	3440	31	73	6460				
05	4-Sep	untreated	50	3.6	463		103	230	6050	601	64	2	2330	54								
05	10-Sep	untreated	190						1830	182	20	<1	627	<20	2380	21	51	4240				
05	18-Sep	untreated	70						2440	223	30	2	950	133	4060	37.45	45	6980	6.25	0.39	3.19	0.15
05	7-Oct	untreated	310		225			120	3100	280	41	2	1090	23	5610	45	45	9650	7.43	0.59	4.49	0.15

Table 4 Jig Tailings Laboratory Trial Results

05	14-Oct	untreated	500	4	214		43	110	3140	279	44	2	987	64	5770	45	40	8930	6.58	0.69	4.44	0.09
05	21-Oct	untreated	610	3.8	175	1	33	91	1790	160	24	1	459	20	3130	21	27	4070	5.63	0.68	3.11	0.25
05	28-Oct	untreated	630	3.8	221	1	38	90	1910	211	31	2	463	20	3890	27	30	4470	9.22	0.97	3.88	0.33
05	4-Nov	untreated	640	3.8	142	1	22	79	1050	108	17	1	254	20	2210	14	20	2240	5.47	0.58	2.08	0.1
05	12-Nov	untreated	620	3.8	152	1	24	71	1050	104	19	1	346	20	2130	15	22	3070	5.14	0.65	2.21	0.07
05	20-Nov	untreated	514	3.9	148		28	55	1440	123	27	1	345	83	3240	23	51	3220	5.57	0.52	2.22	0.39
05	12-Jan	untreated	558	3.8	166		23	74	909	107	27	1	330	33	2910	22	64	2810	6.2	0.57	1.9	0.7
05	19-Jan	untreated	588	3.8	176		25	81	905	108	32	1	330	35	3330	21	63	2870	6.73	0.62	2.1	0.37
05	7-Apr	untreated	566	3.8	142		20	73	938	80	23	1	263	60	2410	19	56	2040	4.88	0.54	1.7	0.45
05	16-Apr	untreated	562	3.9	157		28	82	1540	95	30	1	287	72	3000	25	49	2480	5.4	0.65	2.23	0.23
05	21-Apr	untreated	590	3.9	159		24	85	1970	122	36	1	401	23	3680	22	63	3520	4.79	0.6	2.62	0.2
05	26-Apr	untreated	639	4	139		21	79	1600	103	31	1	365	40	3200	17	55	2730	6	0.43	2.17	0.26
05	30-Apr	untreated	652	3.4	116		18	62	764	70	20	1	232	28	2410	11	52	1730	5.25	0.4	1.85	1.1
05	6-May	untreated	608	4.1	95		16	52	777	55	17	1	238	36	1780	9	48	1560	3.56	0.31	1.36	0.2
05	13-May	untreated	535	4.1	90		13	48	521	42	12	1	178	66	1350	6	38	1160	3	0.22	1.05	0.23
05	Average	untreated	474.6	**3.8**	175.3	1.0	**29.9**	**87.2**	**1809**	**166**	**28.8**	1.3	**576.3**	**46.1**	**3154**	**22.7**	**46.9**	**3907**	5.7	0.6	2.5	0.3
05	Median																					
06	Sept	10kg/t	70						<50	<1	<1	<1	<1	<20	<5	<1	<1	<1				
06	4-Sep	10kg/t	110	7.9	913		3	450	<50	2	<1	<1	<1	<20								
06	10-Sep	10kg/t	220						<50	<1	<1	<1	<1	<20	<5	<1	<1	<1				
06	18-Sep	10kg/t	30						<50	1	<1	<1	<1	61	71	<1	<1	6	27.6	0.36	3.17	0.06
06	7-Oct	10kg/t	330		163			55	<50	2	<1	<1	<1	<20	118	<1	<1	17	18.5	0.55	2.68	0.09
06	14-Oct	10kg/t	520	7.8	193		1	72	<50	3	<1	<1	<1	<20	172	1	<1	30	25.8	0.8	3.86	0.23
06	21-Oct	10kg/t	550	6.9	179	10	2	62	50	<1	<1	<1	<1	<20	6	<1	<1	<1	22.6	0.65	2.02	0.07
06	28-Oct	10kg/t	540	7.4	270	10	1	87	50	2	1	1	1	20	26	1	1	3	41.2	0.73	2.3	0.11
06	4-Nov	10kg/t	590	7.4	154	11	1	49	50	1	1	1	1	20	5	1	1	1	24	0.5	1.22	0.03
06	12-Nov	10kg/t	480	7.6	150	9	4	50	50	1	1	1	1	20	5	1	1	1	21.7	0.65	1.16	0.05
06	20-Nov	10kg/t	561	6.9	117		3	38	226	1	1	1	1	20	13	1	1	1	20	0.55	1.28	0.19
06	12-Jan	10kg/t	580	7.1	136		2	46	50	1	1	1	1	20	5	1	1	1	26	0.6	1.01	0.33
06	19-Jan	10kg/t	588	7.4	105		1	28	50	1	1	1	1	20	5	1	1	1	18.2	0.63	1.06	0.36
06	7-Apr	10kg/t	552	7.3	95		1	28	50	1	1	1	3	20	5	1	1	1	13.1	0.41	0.86	1.8
06	16-Apr	10kg/t	590	7.2	101		1	30	50	1	1	1	3	20	11	1	1	1	13.9	0.37	0.91	0.23
06	21-Apr	10kg/t	633	7.3	132		1	40	50	1	1	1	3	20	6	1	1	1	18.8	0.44	1.29	0.29
06	26-Apr	10kg/t	630	7.1	144		1	47	50	1	1	1	2	20	5	1	1	1	22.2	0.37	1.01	0.43
06	30-Apr	10kg/t	664	7.4	133		1	40	50	1	1	1	4	20	5	3	1	1	21.2	0.28	0.83	0.2
06	6-May	10kg/t	594	7.4	101		1	28	50	1	1	1	2	20	5	7	1	1	17.6	0.32	0.71	0.55
06	13-May	10kg/t	578	7.3	87		1	24	50	1	1	1	5	20	5	2	1	1	13.3	0.2	0.53	0.33
06	Mean	10kg/t	470.5	**7.3**	186.6	10.0	**1.6**	**69.1**	**62.6**	**1.3**	1.0	1.0	**2.2**	**22.9**	**27.5**	1.6	1.0	**4.3**	21.5	0.5	1.5	0.3

TABLE D1 TAILINGS METAL CONCENTRATIONS

Sample	Guideline	As ppm	Al %	Al ppm	Cd ppm	Cu %	Cu ppm	Fe %	Fe ppm	Mn %	Mn ppm	Ni ppm	Pb %	Pb ppm	Zn %	Zn ppm
	Anzecc A	**100**			**20**						**1500**	**600**		**300**		**7000**
	Anzecc E	**400**			**80**						**3000**	**2400**		**1200**		**28000**
	Anzecc F	**500**			**100**		**5000**				**7500**	**3000**		**1500**		**35000**
Fine tails		10	6.3	63000	**21**	0.05	500	5.53	55300	0.052	520	31	0.002	20	0.051	510
Jig Tails		**150**	1.4	13500	10	0.01	100	1.58	15800	0.025	250	10	0.022	220	0.008	80

jig tails from deposit beside creek
Finetails from near Stn 14