REHAB2013_01

Dundas Mineral Field Remediation Strategy

Prepared for:	Mineral Resources Tasmania
Date:	July 2013 Rev 00

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Report Revision History					
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A	Dundas Mineral Field Remediation Strategy	J. Lockley	-	-	17/06/2013

Executive Summary

Mineral Resources Tasmania (MRT) commissioned pitt&sherry on the 31 March 2013 to provide a remediation strategy for the abandoned mines in the Dundas mineral field located in the Dundas River catchment area.

A review of information at Mineral Resources Tasmania was undertaken prior to a two day safety and environmental field investigation of the Dundas mining field. The desk top review informed the field investigation and assisted the design of the safety survey and the water monitoring undertaken in the mining field.

There are 47 historical mine sites in the Dundas mining field, 11 that are located on mining leases and 36 that can be termed 'abandoned'. 24 are located in the upper Dundas River catchment, 8 are located in the Adelaide Mine Creek catchment and 15 in the Comet Creek catchment. There are also 2 operating mines and 1 occasionally operating mine in the mining field, namely the Adelaide Mine, Red Lead Mine and Comet Extended respectively.

The land tenure is Crown Land managed by Forestry Tasmania, Crown Land managed by the Parks and Wildlife Service and private freehold land. The land managed by Forestry Tasmania is located north of the Comet Creek and the land managed by the Parks and Wildlife Service is located to the south of Comet Creek. There are 14 private properties in the mining field, most being located in the former township area, but only one property has permanent residents.

The mining field investigation was undertaken on the 16 and 17 April 2013. Three adits (Razorback open cut), two shafts (South Comet Mine) one glory hole (South Comet Mine) and one shaft past the Maestries station site, which are not located on mining leases, were identified from the survey as sites of safety concern. Capping of all the sites is recommended especially the roadside shaft on the road to the South Comet Mine and the roadside shaft past the Maestries station site.

The adoption of the 80% protection of aquatic ecosystems water quality objectives was deemed to be appropriate for the environmental assessment. At the time of the survey, zinc was the key contaminant that was preventing the achievement of that objective.

The South Comet Mine is the primary source of the zinc loads in the Dundas River contributing, at the time of the survey, approximately 60% to 70% of the zinc load. The Razorback open cut is the source of approximately 40% to 50% of the zinc loads. The percentage overlap of the loads is indicative of the level of accuracy of the flow measurement and rudimentary stream gauging but is deemed acceptable for the purposes of the investigation.

The sulphate emission rates from the South Comet Mine accounted for approximately 80% to 90% of the sulphate emission rates in the Dundas River. The sulphate emission rates from below the Razorback Mine accounted for approximately 30% to 40% sulphate emission rate to the Dundas River. The manganese emission rates in the Dundas River were made up from approximately 50/50 from the South Comet Mine and possibly from the Razorback open cut.

The onsite mitigation of the acid drainage from the South Comet Mine is limited by the available area and steep topography. It is recommended that the existing mitigation area be upgraded to improve effectiveness and efficiency. The acid drainage from the Razorback open cut can be mitigated by diversion to the available area of the existing wetlands. A survey to confirm the emission sites and rate of emissions from the Razorback open cut would be required before this option could be pursued further.

While undertaking the survey a discharge with high solids loading was observed entering Adelaide Mine Creek from the Red Lead Mine. The discharge was contributing a significant lead load to the Dundas River catchment and the emission appeared to be in the particulate form, possibly as chromate given the elevated chromium level.

Gorse infestation exists across the mining field. The feasibility and viability of an eradication program should be undertaken in consultation with the West Coast Council, Forestry Tasmania and the Parks and Wildlife Service.

1. Introduction

Mineral Resources Tasmania (MRT) commissioned pitt&sherry on the 31 March 2013 to provide a remediation strategy for the abandoned mines in the Dundas mineral field located in the Dundas River catchment area.

There are 47 historical mines in the Dundas mining field, 36 of which are deemed abandoned. The abandoned mines present a potential risk to public safety and an environmental risk to the quality of the Dundas River receiving waters.

Two remediation programs were undertaken in the Dundas area in the mid 1990s. The remediation programs related to the Razorback Mine and the South Comet Mine.

The documentation for the Razorback and South Comet mines remediation programs are archived with MRT. The success and sustainability of these remediation activities have not been fully verified since implementation.

The objectives of the 2013 Dundas mineral field remediation strategy were to:

- Review available remediation information
- Undertake a field survey of the mining field
- Identify and prioritise potential site safety and environmental risks to inform future projects in the Dundas mining field
- Supply a report to MRT providing a basis on which to prioritise future mine remediation works.

Tasmanian abandoned mine remediation strategies and remediation works are funded through the Rehabilitation of Abandoned Mining Lands Trust Fund administered by MRT.

1.1 Scope of Work

The scope of works undertaken by pitt&sherry was to:

- Identify abandoned mine sites in the Dundas mining field within the Dundas River catchment utilising the MRT library information
- Identify and report on the abandoned mines and their safety risks and/or adverse environmental impacts
- Undertake site investigations of the identified abandoned mines to identify open shafts, stopes, adits and acid drainage discharges to the receiving waters
- Draft a report to MRT with risk rankings and recommendations for the Dundas mining field remediation strategy including any identified information gaps
- Develop the risk rankings for the report using the principles outlined in the *Tasmanian Geological Survey Record 2001/04: Strategy - The rehabilitation of abandoned mining lands (Revision 1)*
- Finalise a remediation strategy report for MRT.

1.2 Methodology

The following methodology was adopted in undertaking the project:

- The number and location of abandoned mine sites in the Dundas mining field of the Dundas River catchment were reviewed using the MRT historical information and library documents

- Abandoned mines that had the potential to presented a risk to safety and/or the environment were identified for further field investigation
- A two day site investigation was undertaken on the 16 and 17 April 2013 to ensure that as many sites of environmental and safety significance were assessed
- GPS readings in GDA94 were taken for the key safety and environmental sites in the mining field, for GIS mapping and for reporting and future referencing.
- The coordinates were taken using a Garmin *etrex*, high sensitivity, GPS unit. The coordinates had an accuracy of approximately 5 m
- Water flow measurements were taken at accessible sites, to quantify to a reasonable degree, the pollutant emission loads from key areas of the mining field for the remediation strategy
- The measurements were taken using a General Oceanics, G.O. Environmental Flowmeter (with standard rotor). Rudimentary stream gaugings and measurements were undertaken at the monitoring sites for the flow estimates
- Field water quality measurements were taken at key water quality monitoring sites using a field water quality meter
- The meter used was a TPS 90-FLT Field Lab Analyser, which measured dissolved oxygen (DO), electrical conductivity (EC), pH, oxidation reduction potential (ORP) and temperature (T°C)
- The field water measurements were field logged and saved in the Field Lab meter memory and later downloaded for inclusion and interpretation in the monitoring report
- Water samples were collected at the key identified sites for analysis by Australian Laboratory Services, a NATA accredited laboratory
- The laboratory analytes were pH, EC, total dissolved solids, turbidity, hardness, total alkalinity, acidity, major cations, major anions and heavy metals. All samples were analysed for total metals. At the ambient water sites, 0.43 microns field filtered 'dissolved' metal analyses was also undertaken
- Two people undertook the site investigation to ensure that any potential safety risks were minimised
- The remediation strategy report was drafted using the GIS mapping, water quality data, photographs, analytical results, flow results, investigation findings and recommendations based on the *Tasmanian Geological Survey Record 2001/04: Strategy - The rehabilitation of abandoned mining lands (Revision 1)*
- The draft report was submitted to MRT for comment
- The report was finalised taking into consideration the comments of MRT.

1.3 Limitations

The following limitations existed for the Dundas mineral field remediation strategy:

- The time to review relevant historical documents
- The time to fully explore the Dundas mining field area
- The variability of the flow measurements and mass emission rates due to the water flow measurements being taken over the two days of the investigation
- The rudimentary field stream gauging for the flow measurements.

1.4 Acknowledgement

pitt&sherry would like to acknowledge the assistance and advice of the following people for the Dundas remediation strategy site investigations.

- K. Lau at MRT
- J. Lawrence MRT (for use of a Dundas research thesis)
- M. Phelan
- E. Phelan
- M. Harvey
- M. Hanson
- J. Bishop
- B. Stark
- T. Akerman.

2. Background Information

2.1 Dundas Mineral Field Setting

The Dundas mineral field setting is shown in Figure 1 below and in the Map 1 contained in Appendix A. The Dundas mining field lies approximately 7 km to the east of the Zeehan township and approximately 9 km south of the Renison Bell mine.

The area is characterised by steep hills and mountains. The mining field is located in the Dundas River catchment. The hydrological setting is characterised by the Dundas River which flows from its origin on the north to western slopes of Mt Dundas. The river flows in a westerly direction to its confluence with the Little Henty River, which also flows westwards to the coast and the ocean.

2.2 Historical Reference Documents

The following MRT reference documents were reviewed to inform the design of the field investigations for the remediation strategy report.

- Environmental Geology of the Dundas Drainage Basin, Jeremy S. Lawrence, Centre for Ore Deposits and Exploration Studies, UTAS, May 1996
- The Great South Comet Mine – Dundas, B.L. Taylor
- South Comet Mine, D.J. Barrell, Narrow Vein Mining Seminar, Bendigo VIC, 1993
- CRA Exploration P/L, EL10/93, Razorback, Final Report, CRAE Report No. 22651
- MRT – South Comet Mine plan.

The documents are contained in Appendix B.

2.3 Current Mining Leases

There are 8 mining leases in the region, with 7 mining leases in the Dundas River catchment. The 7 Dundas River catchment mining leases are named below.

- 19M/94 – B.D. Stark
- 9M/2001 – S.L. Dohnt
- 18M/2001 – M. & E. Phelan

- 16M/2000 – J.B. Bishop
- 9M/2004 – Australian Mineral Mines Pty Ltd
- 25M/2000 – M. & E. Phelan
- 74M/74 – Adelaide Mining Company Pty Ltd.

The mining lease (ML) sites are shown in Maps 2 and Map 3 contained in Appendix A.

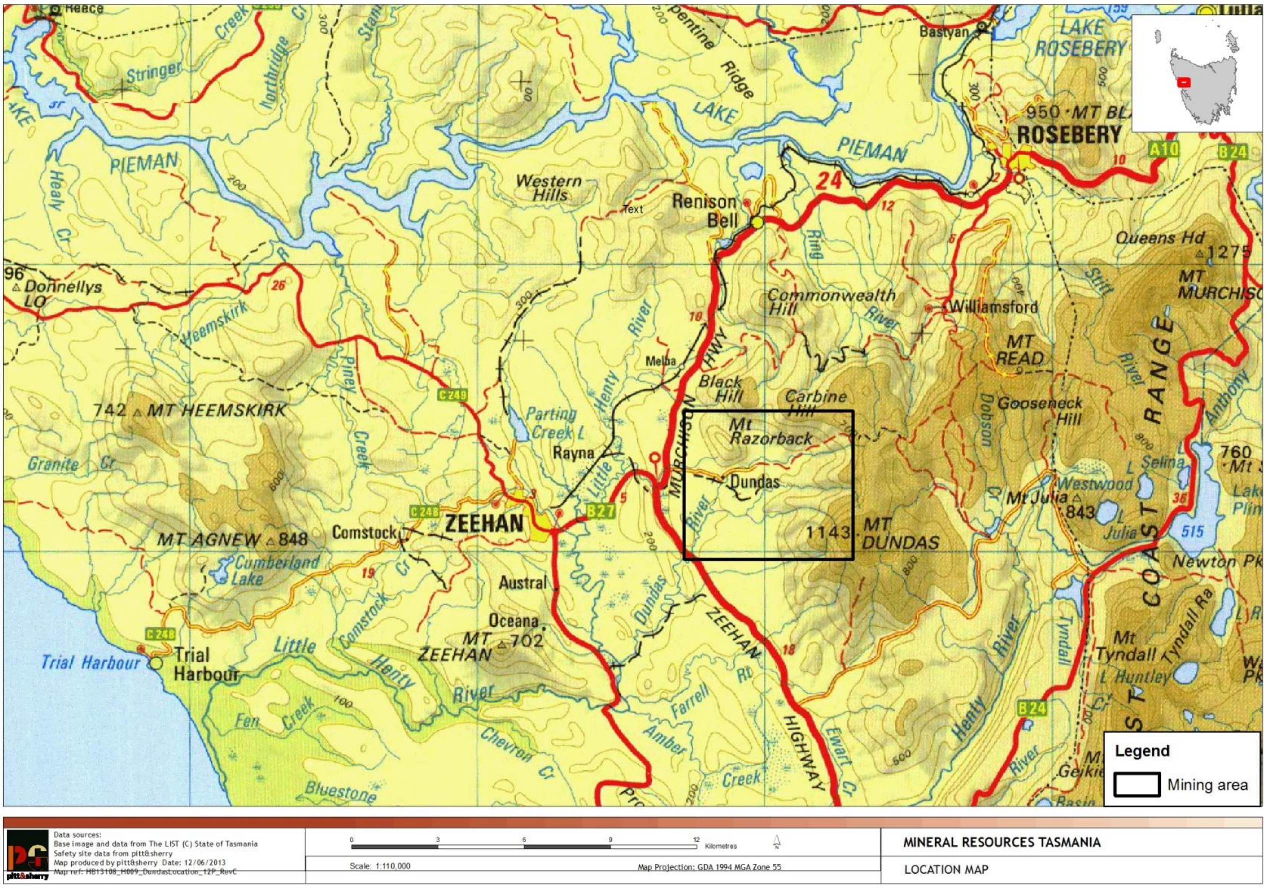


Figure 1 - Dundas mineral field setting

2.4 Heritage

No heritage values were identified during the Dundas reference document review or during the field investigation. A mining rail wagon has been left on the main adit roadway level at the South Comet Mine.

2.5 Historical Water Monitoring Sites

J.S. Lawrence undertook water quality monitoring of the Dundas River from November 1995 to April 1996. The water monitoring sites are shown in Map 4 in Appendix A. The 2013 Dundas survey adopted several of the Lawrence 1995/1996 sites for continuity and future scientific reference. The 1995/1996 water monitoring sites are shown in Map 5 in Appendix A.

The opportunity was taken to place the 1995/96 water quality data onto new spreadsheets along with the new 2013 data. The updated water quality monitoring database is contained in Appendix C.

2.6 Land Tenure

The land tenures in the Dundas mining field are private freehold land, Crown Land managed by Forestry Tasmania (FT) and Crown Land managed by the Park and Wildlife Service (PWS). The area managed by FT is north of the Comet Creek. The area managed by PWS is south of the Comet Creek. The private properties are mainly located in the former township area.

2.6.1 Private Properties

There are 14 private properties in the Dundas mining field with 14 owners. A list of the owners and property details are outlined in Table 1 below (Courtesy of LIST).

Volume	Folio	PID	Owners
128678	10	-	Sweet, Robert Lewis
128678	8	-	Fitzgerald, George Parker
128677	29	-	Ward, Barbara
128678	11	-	Jenkins, Henry Alfred
128678	9	6028856	Blacklow, Caroline Joy
128676	9	6028899	Wilkinson, Amy Jane
128676	18	6029007	J Boag & Son Brewing Ltd
128676	14	-	Kingsley, Oscar Charles
128678	12	-	O'Byrne, Martin
128676	15	6028928	Phelan, Michael Frank & Phelan, Eleanor Patricia
128676	1	6028987	Woodward, Enoch
128800	5	-	Fitzgerald, George Parker
128678	13	-	White, William
231877	1	-	The Commonwealth Bank of Tasmania Ltd

Table 1 - Private freehold properties in the Dundas mining field

The locations of the private properties are shown in Map 6 contained in Appendix A.

2.7 Identified Sites for Investigation

The historical Dundas sites identified as being of interest during the reviewing of the MRT information for the field investigation were placed onto a GIS. The large amount of information relating to the Dundas mineralised areas, prospective areas and mineral occurrences was not included in the GIS for the sites for field investigation and reporting.

The current and historical mining sites are shown in Map 7 in Appendix A with an overlay of the current mining leases shown in Map 8 in Appendix A. The names of the historical mine sites taken from the MRT database are shown in Map 9 in Appendix A.

The key Dundas safety risk areas selected from the review of the MRT information for the survey are outlined below.

- Razorback Mine area
- Comet & Maestries mining areas

- South Comet Mine area.

These areas were selected because they are not on existing mining leases and because they have historical workings that are safely accessible.

The key Dundas water monitoring sites selected to be included in the survey are outlined below.

- Dundas River at Zeehan highway (DR01)
- Dundas River at the township bridge (DR16)
- Razorback Mine area (RB03 and RB04)
- Maestries 'railway station' drainage (DR17)
- South Comet Mine discharge (SCM13)
- Adelaide Mine Creek below the Red Lead Mine (AMC09)
- Comet Creek above the Adelaide Mine (CC10).

It was proposed to inspect the following discharges because of the close proximity of these discharges to the receiving water monitoring sites.

- Adelaide Mine discharge (AM18)
- Red Lead Mine (RL19).

Many of the historical workings are located on MLs and are the responsibility of the lease holders and not the Crown. Hazards identified on MLs are not eligible for the rehabilitation under the Rehabilitation of Abandoned Mining Lands Trust Fund as the leases are not 'abandoned'.

Two of the surface water monitoring sites are located on MLs, and access onto the leases was required for the monitoring.

2.8 GIS Mapping Information

The locations of the historical and field identified sites were placed into a GIS. The GIS maps are contained in Appendix A. The map descriptions are as follows.

- Map 1 – Dundas mining field setting
- Map 2 – Dundas mining leases
- Map 3 – Dundas mining leases
- Map 4 – 1995/96 water monitoring sites
- Map 5 – 2013 water monitoring sites
- Map 6 – Private properties sites
- Map 7 – Historical mine sites
- Map 8 – Historical mine sites with ML overlay
- Map 9 – Historical mine site names
- Map10 – Identified safety risk sites
- Map 11 – Identified safety sites with ML overlay.

2.9 Preliminary Risk Assessment

A safety risk assessment was undertaken for the sites with reference to AS/NZS 4360:1999. The risk assessment is summarised below.

2.9.1 Hazard Analysis

Identified Hazards

The key potential hazards identified are listed below.

- Steep slopes
- Thick scrub
- Road and track condition variability
- Weather variability
- Ground stability variability
- Site infrastructure condition including, embankments, dams and bridges etc
- Open workings including stopes, shafts, adits and open cuts
- Mineral exploration, mining and traffic activities in the area.

Potential Risks

The key potential risks identified are listed below.

- Land slip and erosion
- Flood
- Fire
- Failure of infrastructure including, embankments dams and bridges.

Potential Impacts

The key potential impacts identified are listed below.

- Loss of life
- Falls and injuries including bites and exposure
- Reduced downstream water quality
- Reduced aquatic habitat
- Sediment deposition on land in other ownership
- Damage to downstream values and uses and infrastructure
- Loss of equipment
- Contravention of the EMPCA and the State water quality policy
- Contravention of the LUPAA
- Amenity impact on residents now living in the Dundas mining area
- Hindrance to existing mining and exploration works.

2.9.2 Risk Assessment

The inherent risks in the mining field, as outlined in the hazard analysis above, indicated that the area had a high risk ranking.

Although the likelihood was unlikely or rare, the ranking was high due to the potentially major or catastrophic impact consequences (e.g. loss of life) (refer to AS/NZS 4360:1999 risk level matrix).

The high risk ranking was used in the rehabilitation criteria for the public safety risk section of the *Tasmanian Geological Survey Record 2001/04: Strategy - The rehabilitation of abandoned mining lands (Revision 1)*.

2.10 State Policy on Water Quality Management 1997

2.10.1 Protected Environmental Values

The protected environmental values (PEVs) for surface waters in the Dundas River catchment area have been establish by the West Coast Council and the Department of Primary Industries, Parks, Water and Environment in accordance with the *State Policy on Water Quality Management 1997*.

The document outlining the PEVs is the *Environmental Management Goals for Tasmanian Surface Waters, West Coast Municipal Area (Excluding the Gordon and Pieman River Catchments) December 2000*.

The PEVs for the Dundas River are specified in the West Coast municipality PEV document and are summarised as follows:

A: Protection of Aquatic Ecosystems

    (ii) Protection of modified (not pristine) ecosystem

        (a) from which edible fish are not harvested

B: Recreational Water Quality & Aesthetics

    (i) Primary contact water quality (Dundas River at Zeehan Highway bridge)

    (ii) Secondary contact water quality

    (iii) Aesthetic water quality.

That is, as a minimum, water quality management strategies should provide water of a physical and chemical nature to support a modified ecosystem from which edible fish may not be harvested; which will allow people to safely engage in recreation activities such as swimming (Dundas River at Highway Bridge), paddling or boating in aesthetically pleasing waters.

2.10.2 Water Quality Objectives

The water quality objectives (WQO) for the Dundas River catchment have not been established by the Board of the EPA. Site specific WQOs can be established where sufficient scientific data is available.

Where data is not available, the WQOs default to the trigger values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (known as the ANZECC guidelines). Currently the establishment of WQOs for the Dundas River would require the ANZECC guideline trigger values.

Given the history of the site and the historical impacts, it is reasonable to assume that the ANZECC guidelines WQOs trigger values for the 80% protection for aquatic ecosystems should apply for the Dundas River.

2.10.3 Key Water Quality Indicators

The trigger values for 80% protection of aquatic ecosystems will be used for the assessment of environmental risks for the remediation strategy. The key indicators and the WQOs for the Dundas River are outlined in Table 2 below.

Parameter	ANZECC trigger values 80% protection
pH	6.5 – 7.5
Electrical Conductivity (EC) uS/cm	30 – 350
Turbidity (NTU)	2 – 25
Dissolved oxygen (DO) % saturation	90 - 110
Aluminium (Al) mg/L	0.150
Cadmium (Cd) mg/L	0.0008
Chromium (Cr) mg/L	0.040
Copper (Cu) mg/L	0.0025
Lead (Pb) mg/L	0.0094
Manganese (Mn) mg/L	3.600
Nickel (Ni) mg/L	0.017
Zinc (Zn) mg/L	0.031
Mercury (Hg) mg/L	0.0054

Table 2 - Assumed water quality objectives

3. Site Investigations

Prior to the site investigations, the contactable people associated with the mining leases, the mining operations, exploration drilling activities and private property owners were consulted.

The site investigations were undertaken on 16 and 17 April 2013. The investigations proceeded in the order of the selected sites as shown in section 2.7.

This involved working on the first day from the Dundas River at the highway bridge up through the township area including a visit to a private land owner, around the Razorback Mine area, across to the Maestries and Comet areas and finally to the South Comet Mine area. The second day involved working on the Adelaide Mine area and the Red Lead Mine area.

The weather on both days was fine and mild with no rainfall. The rainfall data leading up to the site investigations is summarised in Table 3 below (courtesy Bureau of Meteorology – Zeehan Post Office station).

Date	Rainfall - mm	Long term averages - mm
January 2013	113	131 for month January
February 2013	56	98 for month February
March 2013	161	143 for month March
1 to 16 April 2013	82	199 for month April
9 to 16 April 2013	55	2440 annually
14 April 2013	25	

Table 3 - Rainfall data before site investigation

Given the weather conditions leading up to the area investigation, the measured surface water flows and concentrations and associated pollutant mass emission rates can be deemed reasonably representative of normal Dundas flows and emissions.

Photographs were taken at certain sites during the site investigations and included in the report for site appreciation and future reference. The photographs are contained in Appendix D.

3.1 Site Measurements

3.1.1 Field Flow Measurements

Water flow measurements were taken at the monitoring sites during the two day investigation. The flow information is contained in Appendix E.

A summary of the flow measurements are contained in Table 4 below.

Site	Date	Flow L/s
Dundas River at Zeehan highway DR01	16 April 2013	598
Dundas River at township bridge DR16	16 April 2013	230
Razorback road culvert drainage to lower wetlands RB03	16 April 2013	2
Razorback tailings dam spillway RB04	16 April 2013	76
Maestries mill road culvert drain DR17	16 April 2013	3
South Comet Mine road pond drainage SCM13	16 April 2013	3
Comet Creek above Adelaide Mine bridge CC10	17 April 2013	371
Adelaide Mine Creek AMC09	17 April 2013	54
Red Lead Mine discharge RL19	17 April 2013	2

Table 4 - Flow measurement dates

Findings

The flow of the Dundas River at the Zeehan Highway DR01 was approximately 600 L/s. This was made up of flow from the flow at the old township bridge DR16, Comet Creek CC10 and Adelaide Mine Creek AMC09.

The measured flows from these three creeks totalled approximately 370 L/s. The difference of approximately 230 L/s would be coming from Climie Creek, Fernfield Creek and local groundwater seepage. This flow difference appears reasonable. The flow rates were used to give an indication of the mass emission rate of the key water quality indicators.

3.1.2 Field Water Quality Measurements

The field water quality measurements were taken at the same time as flow measurements were taken. A summary of the field water quality data is contained in Table 5 below.

Date	Site ID	Oxygen %	EC uS/cm	pH	ORP mV	Turbidity NTU	Temp. Degree C
16/04/2013	DR01	96.9	75.4	6.04	180	-1	7.5
16/04/2013	DR16	85.4	84.3	6.22	195	-1	9.2
16/04/2013	RB03	89.9	237.0	6.46	215	-3	13.7
16/04/2013	RB04	86.3	107.3	6.74	205	-1	12.8
16/04/2013	DR17	86.1	98.7	6.17	124	23	12.3
16/04/2013	SCM13	88.2	1750.0	3.17	365	54	13.0
17/04/2013	AM18	46.4	118.5	5.76	237	2	9.5
17/04/2013	RL19	94.0	98.2	5.88	236	2668	10.3
17/04/2013	AMC09	83.9	102.0	6.01	247	2	8.8
17/04/2013	CC10	108.4	71.3	6.40	277	0	9.0

Table 5 - Field measured water quality data

Findings

The field measured water quality measurements indicated that in the main the physical parameters were acceptable and aesthetically pleasing.

The exceptions were the discharge from the South Comet Mine which had a low pH and high salinity reflecting the acid drainage (AD) from the old workings, and the discharge from the Red Lead Mine which contained very high suspended solids loads.

3.2 Analytical Results

The analytical report for the water samples taken for each site is contained in Appendix F. The water samples were taken on the same days as the flow measurements. A summary of the key water quality parameters is contained in Table 6 below.

The 2013 water monitoring results were included in a database along with the 1995/96 monitoring results. The updated database is contained in Appendix C.

The total metal analysis was undertaken on all the waters samples. The total metal analysis was deemed to give a more accurate assessment of the mass emission rates and mass balances across the mining field.

The dissolved metal analyses were also requested on the receiving water samples, namely the Dundas River at the Zeehan Highway and the former Dundas township bridge, the Comet Creek and the Adelaide Mine Creek. These samples were field filtered on 0.43 micron filters. The filtered water sample analyses gave a more representative indication of the toxicity risk to the aquatic ecosystems. The Red Lead Mine discharge water was also field filtered due to the very high solids loading in the discharge.

3.2.1 Findings

The 2013 results were consistent with the previous results and were of a similar order of magnitude. The updated database does indicate the highly variable concentrations of contaminants in the surface waters in the Dundas River catchment.

This variation is most likely due to the variability of the surface water flows and the different times of concentration for surface water and groundwater into the lower catchment as well as the infiltration rates in to the different mine workings.

The chloride/sulphate ratio in surface water due to seawater mist fallout is typically 7:1. Surface waters in the Dundas River catchment were much lower than the 7:1 which indicates sulphide oxidation activity and acid range (AD) in the catchment.

The stream alkalinity and acidity results were acceptable with the exception of the South Comet Mine discharge. The high calcium and magnesium levels are indicative of the partial neutralisation of AD by the alkalinity in the surrounding geological material. The mining field geology has reasonable acid buffering and neutralisation capacity. Only the direct discharge from the South Comet Mine showed the low pH and high acidity and EC associated with AD.

The analyses indicate that there is negligible arsenic, mercury, fluoride emissions in the catchment. The analytical results show a reasonable agreement with the field water quality readings.

Table 6 below shows that the Dundas River exceeded the ANZECC guidelines zinc trigger values for the 80% protection of aquatic ecosystems. The Adelaide Mine Creek also exceeded the zinc trigger values. Comet Creek did not exceed the zinc values.

Sites/Parameters	SO4	Cl	T/Al	D/Al	T/Cd	D/Cd	T/Cr	D/Cr	T/Cu	D/Cu	T/Pb	D/Pb	T/Mn	D/Mn	T/Ni	D/Ni	T/Zn	D/Zn	T/Fe	D/Fe
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1. Dundas @ highway	7.0	16.0	0.120	0.070	0.0004	0.0004	0.002	0.002	0.004	0.002	0.006	0.004	0.152	0.153	0.007	0.006	0.133	0.134	0.350	0.270
3. Razorback Mine drainage	58.0	16.0	<0.010		0.0009		<0.001		<0.001		<0.001		0.032		0.062		0.194		<0.05	
4. Razorback tailings dam	6.0	18.0	0.120		0.0002		0.003		0.002		0.006		0.271		0.035		0.024		0.600	
9. Adelaide Mine Ck below Red Lead	16.0	18.0	0.110	0.050	0.003	0.0028	0.004	0.003	0.003	0.002	0.025	0.008	0.983	0.938	0.015	0.013	1.03	1.010	0.320	0.200
13. South Comet Mine tailings dam	1180.0	14.0	0.480		0.327		0.001		0.029		1.27		<0.001		0.361		111.0		19.700	
16. Dundas @ township bridge	7.0	16.0	0.100	0.060	0.0006	0.0003	<0.001	<0.001	0.008	0.002	0.007	0.005	0.205	0.140	0.011	0.009	0.174	0.100	0.420	0.290
17. Maestries culvert to DR	18.0	15.0	0.220		0.0094		0.003		0.004		0.297		2.390		0.007		2.61		2.690	
18. Adelaide Mine adit pond water	8.0	14.0	0.020		0.0013		0.006		0.002		0.019		0.169		0.052		0.209		0.140	
19. Red Lead Mine discharge	22.0	17.0	5.620	<0.01	0.0046	<0.0001	0.950	0.104	0.127	<0.001	57.4	<0.001	15.400	0.042	0.427	0.017	1.05	0.009	22.200	<0.5
CC10 Comet above Adelaide Mine	5.0	14.0	0.040	0.020	<0.0001	<0.0001	<0.001	<0.001	0.002	0.002	0.024	0.003	0.142	0.127	0.004	0.003	0.02	0.015	0.260	0.150
ANZECC WQ guidelines 80%			0.150		0.0008		0.040		0.0025		0.0094		3.600		0.017		0.031			

Table 6 - Analytical results for key water quality parameters

Results of interest in Table 6 are highlighted and shown in bold font.

3.3 Mass Emission Rates

The mass emission rate for each parameter at each site was calculated using the site flow and the water concentration. The emission rate calculations and graphs are contained in Appendix C. A summary of the emission rates is contained in Table 7.

The emission rates were indicative only as no rating curves and gauges were available for the sites and only basic field gaugings were done at the time of measurement. The flow measurements were taken across two days, which also contribute to inaccuracies. However for the purposes of the investigation, the measurements gave a reasonable indication of the emission loads from key areas.

The mass emission rates for arsenic, cadmium, chromium, copper and nickel were too low to give a reasonable indication of AD sources and are not be discussed further.

The sulphate emissions rates were used as a primary indicator of AD loads as the sulphate anion is stable in the aerobic environment with most sulphates being soluble minimising particulate settling while monitoring.

The iron and aluminium levels can vary due to settling and remobilisation of iron and aluminium hydroxide particles during different flow regimes. Regardless, the iron and aluminium levels and emission rate calculations were still used as general indicators of the oxidation of pyrite and other iron sulphide minerals.

The emission rates for secondary AD metals such as zinc, lead and manganese are also indicators of AD. The zinc and manganese are soluble in ambient waters with pH levels <7. Lead sulphate is insoluble and presents potential errors also.

3.3.1 Mass Emission Findings

Acid Drainage

The major source of the AD into the Dundas River was the South Comet Mine. This was reflected in the measured emission rates in the downstream Adelaide Mine Creek. It was also evident that the Red Lead Mine was a significant source of particulate lead and dissolved chromium into the Adelaide Mine Creek and the Dundas River, but this discharge was not an AD emission.

The next highest contributor to the AD loads in the Dundas River was the Razorback Mine. The likely cause of the elevated AD loads and poor mass balance at DR16 may be undetected fugitive emissions from around the Razorback open cut area. The envisaged significant input into the Dundas River from the Maestries mill area was not reflected in the Maestries area monitoring undertaken during the investigation.

The suspected Razorback open cut emissions may be from drill holes to the south of the open cut. The desk top design of the investigation indicated that the open cut drainage would report to the wetlands area, hence the location of the 2013 RB03 monitoring site.

Based on the analytical results, it is likely that the source from the Razorback open cut reports to the Dundas River to the south or southeast of the open cut and not to the northeast. Further monitoring at the former Dundas River bridge site to the Razorback Mine, at another site further upstream on the Dundas River and a site on the small tributary that flows to the south on the western side of the open cut would confirm and delineate the emissions from the Razorback as measured at DR16.

The Comet Creek catchment had the lowest AD mass emissions into the Dundas River.

Dundas	Mass Emission Rates										
Sites/Parameters	SO4	T/Al	T/As	T/Cd	T/Cr	T/Cu	T/Pb	T/Mn	T/Ni	T/Zn	T/Fe
1. Dundas @ highway											
Emission rate kg/d	361.7	6.2	0.0	0.0	0.1	0.2	0.3	7.9	0.4	6.9	18.1
3. Razorback Mine drainage											
Emission rate kg/d	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Razorback tailings dam											
Emission rate kg/d	39.4	0.8	0.0	0.0	0.0	0.0	0.0	1.8	0.2	0.2	3.9
9. Adelaide Mine Ck below Red Lead											
Emission rate kg/d	74.6	0.5	0.0	0.0	0.0	0.0	0.1	4.6	0.1	4.8	1.5
13. South Comet Mine tailings dam											
Emission rate kg/d	305.9	0.1	0.0	0.1	0.0	0.0	0.3	0.0	0.1	28.8	5.1
16. Dundas @ township bridge											
Emission rate kg/d	137.9	2.0	0.0	0.0	0.0	0.2	0.1	4.0	0.2	3.4	8.3
17. Maestries culvert to DR											
Emission rate kg/d	4.2	0.1	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.6	0.6
19. Red Lead Mine discharge											
Emission rate kg/d	3.2	0.8	0.0	0.0	0.1	0.0	8.4	2.3	0.1	0.2	3.3
CC10 Comet above Adelaide Mine											
Emission rate kg/d	38.9	0.3	0.0	0.0	0.0	0.0	0.2	1.1	0.0	0.2	2.0

Table 7 - Mass emission rates for key parameters

Results of interest in Table 7 are highlighted and shown in bold font.

Individual Indicators

The mass emissions rates at the time of the monitoring, for each key impact indicator, at the targeted monitoring sites, are summarised in the graphs in Figure 2 below.

The mass emissions rates are calculated from the site flows and are therefore affected by the site flow variations, but still give an indication of the mass emissions and information gaps.

The vertical axes in each graph show the mass emission rate in kilograms per day for the key impact indicators. The horizontal axes in each graph uses site numbers to identify the actual site names and locations.

The site numbers in the horizontal axes and their corresponding site locations and names are tabulated below.

Site Numbers	Site Locations and Names
1	Dundas R at Zeehan highway (DR01)
3	Razorback drainage (RB03)
4	Razorback tailings spillway (RB04)
9	Adelaide Mine Creek (AMC09)
10	Comet Creek (CC10)
13	South Comet Mine drainage (SCM13)
16	Dundas R at township bridge (DR16)
17	Maestries mill road culvert (DR17)
18	Adelaide Mine lower adit pond (AM18)
19	Red Lead Mine lower adit discharge (RL19)

The key points emanating from the study of the individual impact indicators can be summarised as follows:

- Sulphate: The major sulphate emission rate was coming from the South Comet Mine (site #13 on the sulphate graph). An estimated 80% to 90% of the sulphate was coming from this mine. The emission rate was also reflected in the elevated sulphate rate in the downstream Adelaide Mine Creek (site #9).

  A lesser sulphate rate was measured at the Dundas township bridge site below the Razorback Mine (site #16 on the sulphate graph). An estimated 30% to 40% of the catchment sulphate was originating from this section of the catchment.

  Upstream monitoring at the Maestries (DR17) site did not detect the sulphate load required for the DR16 load. The extra load may be coming from the Razorback open cut in between. The Comet Creek, Maestries, Razorback tailings dam and Razorback wetlands had lower sulphate emission rates

- Zinc: The major zinc emission rate was coming from the South Comet Mine (site #13 on the zinc graph). An estimated 60% to 70% was coming from the mine. This emission rate was reflected in the elevated zinc emission rate measured in the Adelaide Mine Creek.

  There was a lesser zinc mass rate measured at the Dundas township bridge site below the Razorback Mine (site #16 on the zinc graph). An estimated 40% to 50% was coming from this area of the catchment. Upstream monitoring of the Maestries area (DR17) did not identify any significant zinc emission rate.

The source of the zinc mass emission measured at DR16 may be coming from a Razorback open cut discharge in between the two monitored sites. The Comet Creek, Maestries and Razorback tailings dam and the Razorback wetlands had lower zinc emission rates

- Lead: The major lead mass emission rate into the catchment was coming from the operating Red Lead Mine (site #19 on the lead graph). The lead emission was caused by the high solids loadings in a discharge from that mine's settling pond. The pond was under designed even for the lowest discharge flows. The filtered discharge sample contained no lead, so the lead emission was particulate
- Manganese: The main manganese mass emissions were split approximately 50/50 between the Dundas below the Razorback (site #16 on the manganese graph) and the Adelaide Mine Creek (site #9 on the manganese graph). The manganese emission at DR16 (site #16) was not identified upstream apart from an input from the Razorback tailings dam and the source is likely to be from a Razorback open cut discharge in between.
- Iron and Aluminium: The main iron and aluminium mass emission rates were coming from the Dundas township bridge site below Razorback Mine (site #16 on the iron and aluminium graphs). As discussed for the sulphate, zinc and manganese, the upstream emission rate at DR17 did not account for the emission rate at DR16 and the Razorback open cut may be the source of the unaccounted emission rates.

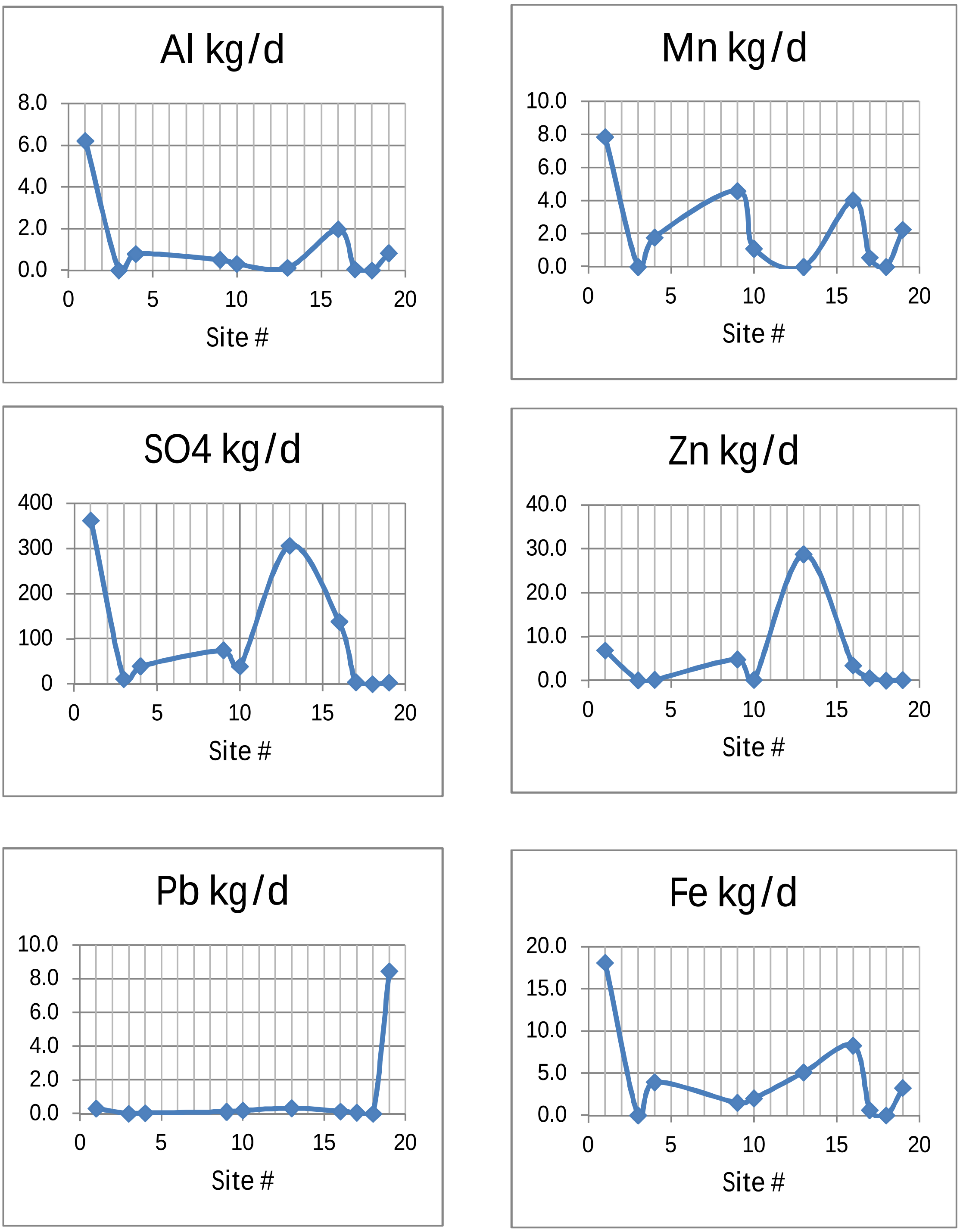


Figure 2 - Mass emission rate graphs

The mass emission rates can be assumed to be indicative of the loads after normal rainfall. The mass emission rates may vary at different times and the rates are likely to be much higher during high rainfall events, and therefore during high creek and river flows, but the contaminant concentrations are likely to be lower.

4. Safety Assessment

The locations of the safety risk sites identified from the MRT review and from the field investigation were placed onto a GIS. The safety risk sites are contained in Map 10 in Appendix A. The safety risk sites with the MLs overlaid are shown in Map 11 in Appendix A.

4.1 Razorback Mine

The Razorback tailings dam and wetland areas appeared quite stable and sound. The rehabilitation appeared quite successful. Key tracks were of reasonable quality. It was apparent that vehicles had been accessing the Razorback mining area. It is not known whether this access was by the general public, land managers or exploration activities personnel.

There were several adits in the open cut that remain open. One of the adits contained hydrogen sulphide gas and would be quite dangerous if entered out of interest or for fossicking for geological samples, even for a short period.

It is recommended that these adits should be permanently closed either using an excavator to bury the adits or by blasting overhanging rock or both. The site of the adits is shown as site #1 in Map 10 in Appendix A.

The access bridge to the mining area was removed during the rehabilitation plan but an alternative track accesses the mining area via a rough river ford crossing just downstream of the former bridge. Any river crossing can be risky but the Dundas River crossing at this site may be challenging for inexperienced four wheel drive drivers. It is likely that the stream level can change quickly and is susceptible to flash flooding.

The switchback road to the open cut is becoming eroded due to the AD emissions down the road damaging the road. Refer to site #2 in Map 10 in Appendix A.

It is recommended that a security gate be installed at the river to prevent motor vehicle access. The area did not appear to present any major risk to trail bike or quad bike access so the gate could be designed to prevent motor vehicles only.

Photographs 2 to 8 in Appendix D give an appreciation of the site observations at the Razorback Mine.

4.2 Maestries Mine and Comet Mine Areas

The known shaft sites were inspected and found to be safe. No new shaft sites were identified in the area. The access road through this area was in good condition and was being used by exploration companies in the Kosminski Hill area and South Comet Mine areas. The road had a sound security gate. There were no safety sites identified in this area.

4.3 Site ‘Past’ Maestries Station

Following the site investigations, further information was supplied by local residents regarding an open shaft ‘past’ the Maestries station/mill site. The site is located on the northern side of the track past the former 1995/96 Dundas River water monitoring site #06. This site has been flagged for future identification and it is recommended that the shaft is capped.

Refer to site #17 on Map 10 in Appendix A.

4.4 Kosminski Hill

A shaft exists next to the refurbished drill track heading east off the main track to South Comet Mine up Kosminski Hill. That shaft has been concrete capped by contractors working for MRT since the site investigation. The approximate location is shown on Map 3 in Appendix A.

4.5 South Comet Mine

The road from the Maestries area to the South Comet Mine was in reasonable condition and fit for purpose. Exploration companies were using the road to get to Kosminskis Hill and the South Comet Mine exploration areas.

There were two shafts located in the South Comet Mine area that were open, not readily visible, deep and dangerous. The first was next to the road before reaching the mine. It was on the uphill or NE side of the road. The second shaft was located towards the top of the hill south of the South Comet Mine. It was likely to have been a shaft for the ventilation of the mine or part of the extended mine on the other side of the hill.

The location of the shafts is shown as site #9 and site #4 respectively in Map 10 in Appendix A. It is recommended that these two shafts and the glory hole be capped.

Access to the road side shaft is obviously easy, while the access to the upper shaft is more challenging. One strand of barbed wire had been placed around the upper shaft. The opportunity was taken to place high visibility safety tape around the shaft. Both shafts should be capped.

There is an open cut or glory hole half way up the hill behind the South Comet Mine. This historical opening may have been used as an air shaft for the last mine operations (pers. comm. T Akerman).

This disturbance is not as dangerous as the two shafts due to a road side berm wall but is still a potential hazard, and may be a water ingress point to the mine. The location of the open working is shown as site #5 in Map 10 in Appendix A.

The historical mine workings are located in very steep country. Rehabilitation measures were implemented on closure and there is evidence of some on going success. However, several other areas of the historical workings on the side of the hill are still eroding and landslides in these areas are inevitable over time.

Photographs 19 and 20 in Appendix D give an appreciation of the safety sites at the South Comet Mine.

4.6 Red Lead Mine

No safety issues were observed in the Red Lead Mine area while undertaking water monitoring. The access road appeared fit for purpose if travelled at an appropriate speed and in a responsible manner.

4.7 Adelaide Mine

An open, deep, highly visible historical shaft was inspected at the Adelaide Mine. The shaft is located on a mining lease and any safety aspects are the responsibility of the lease holder. The location of the shaft is site #3 shown in Map 10 in Appendix A.

Refer to Photographs 33 to 36 in Appendix D.

4.8 West Comet Mine Area

Two shafts are known to exist on the West Comet Mine. One has a head frame and the other is a conical depression. Both shafts are visible and easily fenced. They are located on an ML and any safety aspects are the responsibility of the lease holder.

4.9 Other Areas

During consultation with lease holders, the possibility of shafts in the lower West Comet area was mentioned. These possible shafts were noted during discussions and placed on the safety GIS map for future reference (refer to sites #6, #10 and #11 in Map 10 in Appendix A).

All but one of these possible shafts are located on mining leases and were not inspected under the investigation program. However some historical safety risks can exist on the leases without the lease holder being aware.

It is recommended that lease holders be contacted to discuss the potential for historical open shafts to exist on Dundas MLs and to request that lease holders document, make safe any open shafts and adits and notify MRT.

5. Environment Assessment

5.1 Razorback Mine

AD was observed running down the access tracks to the open cut. The location of the drainage is shown as site #3 on Map 4 and as site #2 on Map 10 in Appendix A.

It was envisaged that the AD from the open cut would report to a wetlands remediation system. However the open cut AD may be bypassing the monitoring site used for this survey, as indicated by the mass balance discussed in section 3.3. It is recommended that the mass emission rate and discharge pathway for this AD source be confirmed.

There is ample of room and elevation in this area to divert and/or treat the AD emissions. It is possible that the drainage can be diverted to the existing wetland treatment system. A passive treatment system such as aeration and open limestone drain neutralisation would appear the most effective passive treatment option for the mine site.

However the design of the passive treatment would be undertaken with reference to MEND Report 3.43.1 and GARDGuide Chapter 7 if future AD treatment was deemed necessary. Photographs 5 to 8 in Appendix D give an appreciation of the environmental observations at the Razorback open cut mine.

The safety recommendation to bury the open adits at the open cut, along with some surface water drainage away from the open cut, will assist minimise water ingress into the mine workings and hence the volume of AD from the area.

The culvert drain connecting the settling area below the mill site with the lower wetlands area is constructed with a metal pipe which is slowly corroding. It is suggested that the culvert is renewed with PVC, ABS or fibreglass.

Installing a second culvert at the same time would ensure the physical stability of the roadway in this area. Refer to Photographs 9 and 10 in Appendix D.

Photographs 11 to 17 in Appendix D give further appreciation of the other environmentally relevant sites at the Razorback.

5.2 Maestries Mine and Comet Mine Areas

The emission from this section of the Maestries and Comet areas was measured at the road culvert below the historical Maestries 'railway station or mill site'. Refer to site location DR17 in Map 5 in Appendix A. The monitoring indicated that the mass emission rate from this area was lower than the other sites.

5.3 South Comet Mine

The mine site is very steep and there is no room for major AD treatment or remediation works. Any attempts to plug the bottom adits or to seal up the mine are likely to result in emissions from other holes in the hillside with different concentrations and flow rates.

No recommendations to plug or seal the mine can be made without a sound hydrogeological understanding of the site. Surveys to gather information to further this understanding would appear to be technically very difficult and dangerous.

The area of roadway at the lower section of the mine is the only flat area in the region. This road way is currently used as a site for AD remediation.

The remediation area consists of a shallow pond constructed with a low containment bund wall on the edge of the area to facilitate iron oxidation, aeration and some neutralisation. Hydraulic short circuiting was evident at the site. Refer to Photographs 22 to 26 in Appendix D.

Currently road traffic goes through the settling pond and this can lead to slug emissions when vehicles enter the pond. The road and its usage should be separated from the pond operations, either vertically, horizontally or both, by civil engineering works.

It is recommended that the available area for AD remediation be maximised and that a passive treatment system, as currently exists, be optimised by designing a properly design treatment system with reference to MEND Report 3.43.1 and GARDGuide Chapter 7, to minimise hydraulic short circuiting and maximise retention time.

The addition of alkalinity using limestone treatment is not recommended on a large scale. Any treatment system would need to take into account the high rainfall and frequent snowfalls that occur during winter.

Gorse infestation exists at this mine as it does across the mining field. A feasibility assessment should be undertaken to determine if further action is viable for the area.

5.4 Red Lead Mine

While accessing the water monitoring site below the Red Lead Mine site, a discharge containing a significant amount of solids was observed coming from the new lower adit drive at the mine.

The high solid loading was resulting from the development of the adit drive further into the mine. A bob cat was being used for the excavation, transport and disposal of the waste drive material. Refer to Photographs 37 to 42 in Appendix D.

A conical glory hole is located above this new adit and significant rainwater ingress and subsequent adit flows would be expected during high rainfall. It was apparent that the lay down area in front of the adit and the adit drainage settling pod were undersized.

The mass emission rate of particulate matter from the mine was high but the filtered water quality was reasonable. The discharge is located on a mining lease and the discharge is the responsibility of the lease holder.

5.5 Adelaide Mine

No discharge was evident from the mine so no discharge flow measurement was possible. However some drainage must leave the mine and enter the Comet Creek by fugitive or diffuse pathways.

A sample of the adit pond water was taken for analysis (sample #AM18 at site AM18). The quality of the pond water was unsatisfactory, mainly due to the zinc level, but the risk would be low if the flow rate is low. Refer to Photographs 27 to 32 in Appendix D.

The discharge is located on a mining lease and is therefore the responsibility of the lease holder.

5.6 West Comet Mine Area

Drainage from the West Comet mining area reports to the Comet Creek. The emission load from the Comet Creek was relatively low compared to the other inputs.

6. Risk Rankings

The Rehabilitation of Abandoned Mining Lands Trust Funds prioritises the safety and environmental risks on abandoned mines throughout Tasmania.

To prioritise risks at different sites on the same abandoned mine as well as between abandoned mine sites in a consistent manner, the Trust Fund utilises the Tasmanian Geological Survey Record 2001/04, Strategy – The Rehabilitation of abandoned mining lands (Revision1).

The strategy outlines the following criteria.

- Public safety
- Off site impacts
- Extent of degradation and potential for further onsite degradation
- Visibility and social impacts.

The public safety criteria risk focuses on the risk of shafts, excavations and stopes and the likely exposure and proximity to people and access.

The offsite impact criteria looks at the severity or potential for weeds, siltation and acid drainage and the likely extent of exposure to wind and catchments

Extent of degradation targets the impact from weeds, erosion, soil loss, vegetation and contamination and the extent of this risk

Visibility concentrates on the risk of intrusion and exposure to population, traffic and perceptions and complaints.

Appendix 2 in the Tasmanian Geological Survey Record 2001/04 outlines a risk matrix and this matrix is used for the risk rankings for the sites in the Dundas mining field.

The general matrix is shown in Figure 3 below.

Risk/severity/degradation/visibility			
H	L	M	H
M		L	M
L			L
Exposure/extent/area	L	M	H

Figure 3 - Tasmanian Geological Survey Record 2001/04 risk assessment matrix

6.1 Razorback Mine

Public Safety

The risk is low due the low exposure despite the high consequence.

Off Site Impacts

The risk is low due to the moderate severity and low extent.

Extent of Degradation

The risk is low due to the moderate degradation and low area.

Visibility and Social Impact

The risk is low due to the low visibility and low exposure.

6.2 Maestries Mine and Comet Mine Areas

Public Safety

The risk is low due the low exposure despite the high consequence.

Off Site Impacts

The risk is low due to the low severity and low extent.

Extent of Degradation

The risk is low due to the moderate degradation and low extent.

Visibility and Social Impact

The risk is low due to the low visibility and low extent.

6.3 Site ‘Past’ Maestries Station

Public Safety

The risk is low due the low exposure despite the high consequence.

Off Site Impacts

The risk is low due to the moderate severity and moderate extent.

Extent of Degradation

The risk is low due to the moderate severity and moderate extent.

Visibility and Social Impact

The risk is low due to the low visibility and low extent.

6.4 South Comet Mine

Public Safety

The risk is low due the low exposure despite the high consequence.

Off Site Impacts

The risk is low due to the moderate severity and moderate extent.

Extent of Degradation

The risk is low due to the moderate severity and moderate extent.

Visibility and Social Impact

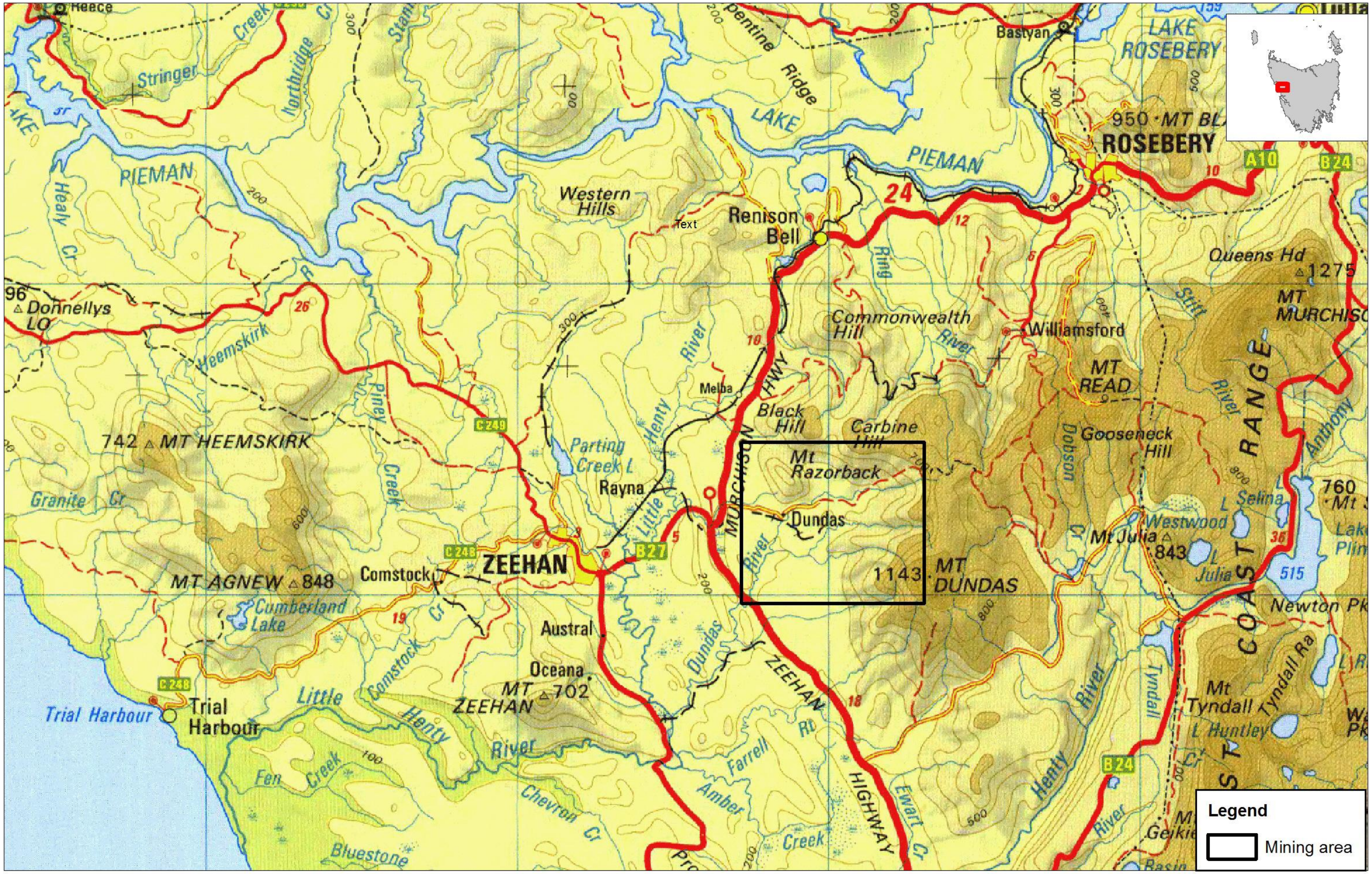
The risk is low due to the low visibility and low extent.

7. Recommendations

- The adits at the Razorback open cut should be permanently closed
- A security gate should be installed on the access road to the Razorback Mine near the Dundas River ford crossing
- The open shaft 'past' the Maestries station/mill site located on the northern side of the track past the former 1995/96 Dundas River water monitoring site #06 has been flagged for future identification and it is recommended that the shaft is capped
- The two shafts and the one glory hole at the South Comet Mine should be capped
- Dundas mining lease holders should be contacted by MRT to discuss the potential for historical open shafts to exist on their eases and to request that any shafts be made safe and the details supplied to MRT
- The source, pathway and emission rate for the unaccounted acid drainage emission(s) from above the Dundas township bridge should be confirmed and assessed to complete the environmental assessment
- Two new chemically resistant culvert pipes should be installed in the roadway to the Razorback tailings dam
- The existing acid drainage settling and mitigation pond at the South Comet Mine should be upgraded and expanded to improve sustainability, stability, efficiency and effectiveness
- the road through the pond should be upgraded by moving it out of the settling pond
- A feasibility assessment should be undertaken to determine if further action is viable for gorse management in the Dundas mining area.

Appendix A

Dundas Maps



Data sources:
Base image and data from The LIST (C) State of Tasmania
Safety site data from pitt&sherry
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H009_DundasLocation_12P_RevC

0 3 6 9 12 Kilometres

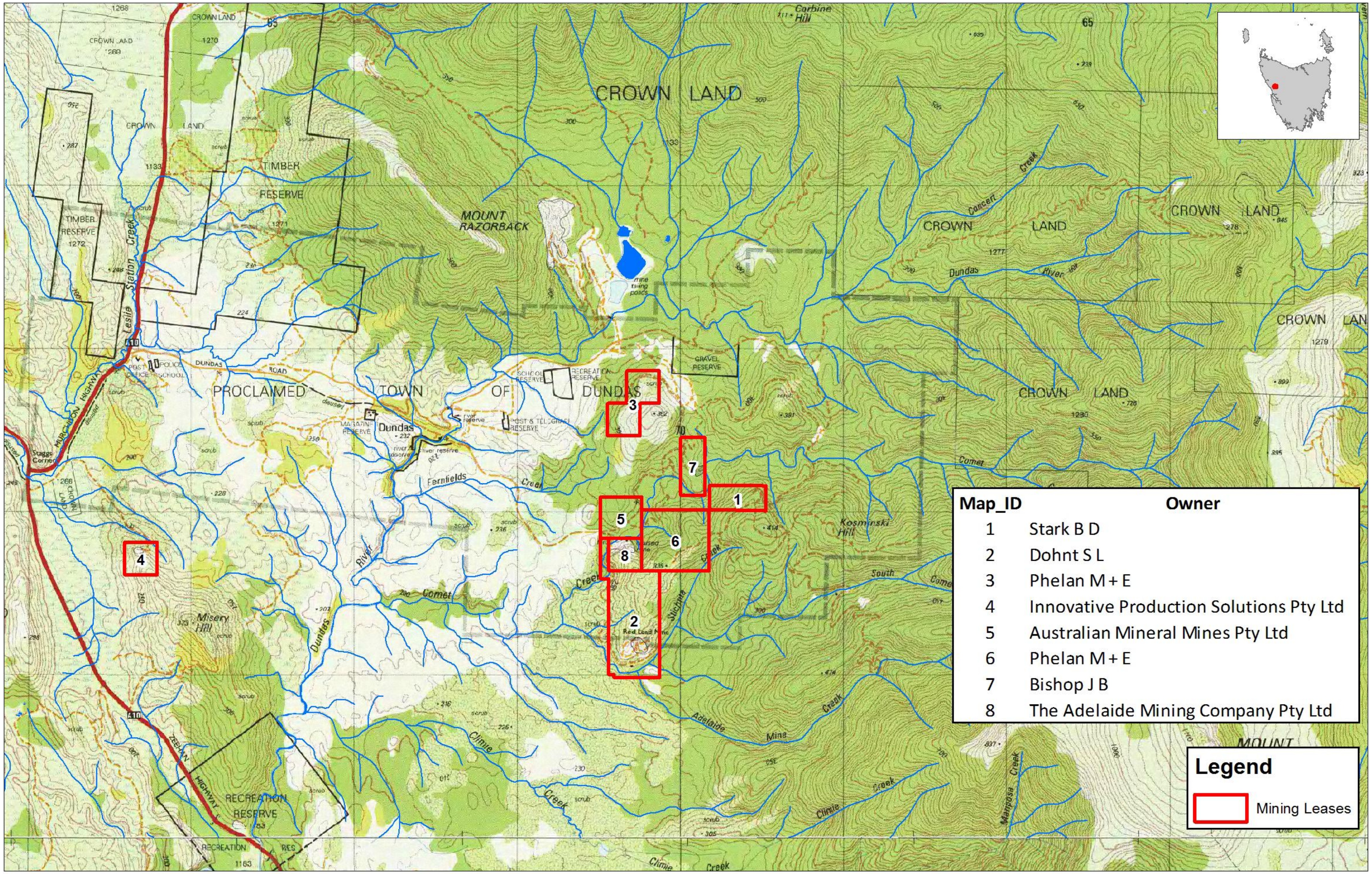
N

Scale: 1:110,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

LOCATION MAP



Map_ID	Owner
1	Stark B D
2	Dohnt S L
3	Phelan M + E
4	Innovative Production Solutions Pty Ltd
5	Australian Mineral Mines Pty Ltd
6	Phelan M + E
7	Bishop J B
8	The Adelaide Mining Company Pty Ltd

Legend

🟥 Mining Leases

Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 7/06/2013
Map ref: HB13108_H007_MiningLeases_12P_RevA

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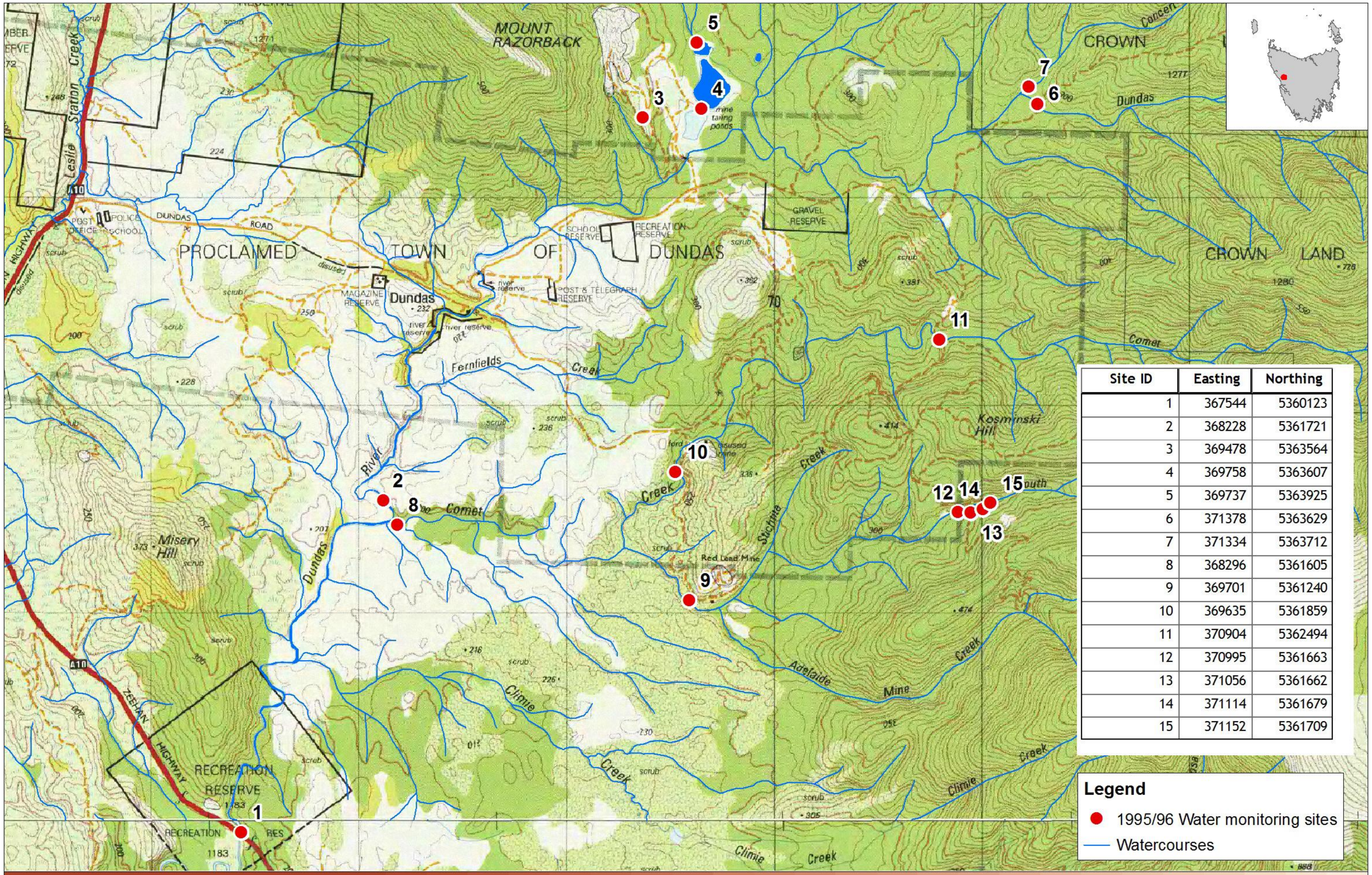
Scale: 1:21,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS MINING LEASES



Site ID	Easting	Northing
1	367544	5360123
2	368228	5361721
3	369478	5363564
4	369758	5363607
5	369737	5363925
6	371378	5363629
7	371334	5363712
8	368296	5361605
9	369701	5361240
10	369635	5361859
11	370904	5362494
12	370995	5361663
13	371056	5361662
14	371114	5361679
15	371152	5361709

Data sources:
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Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H002_WMpts_12P_RevC

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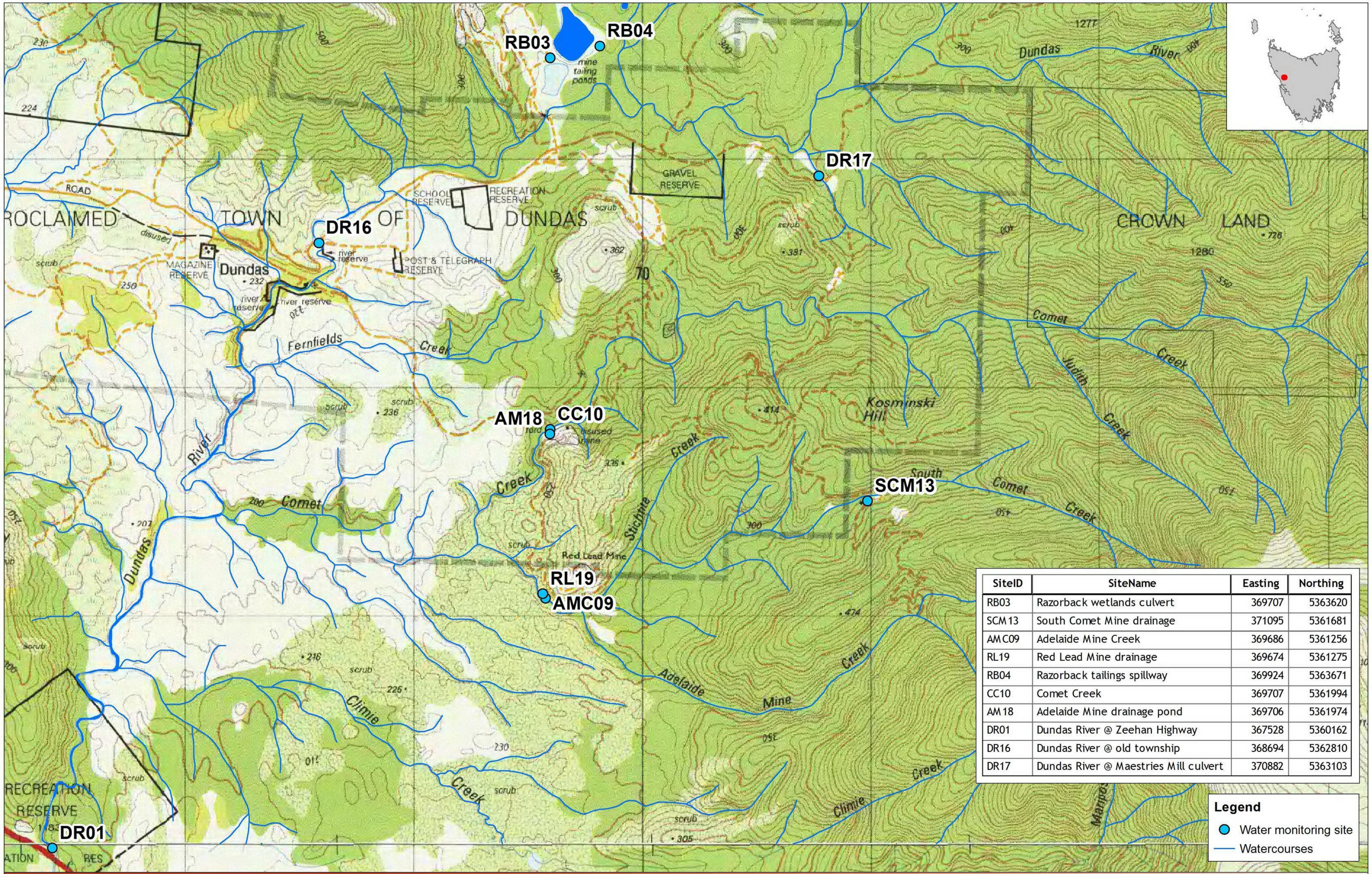
Scale: 1:16,519

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

1995/96 DUNDAS WATER MONITORING POINTS



SiteID	SiteName	Easting	Northing
RB03	Razorback wetlands culvert	369707	5363620
SCM13	South Comet Mine drainage	371095	5361681
AMC09	Adelaide Mine Creek	369686	5361256
RL19	Red Lead Mine drainage	369674	5361275
RB04	Razorback tailings spillway	369924	5363671
CC10	Comet Creek	369707	5361994
AM18	Adelaide Mine drainage pond	369706	5361974
DR01	Dundas River @ Zeehan Highway	367528	5360162
DR16	Dundas River @ old township	368694	5362810
DR17	Dundas River @ Maestries Mill culvert	370882	5363103

Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from pitt&sherry
Map produced by pitt&sherry Date: 2/05/2013
Map ref: HB13108_H006_WMSites_12P_RevA

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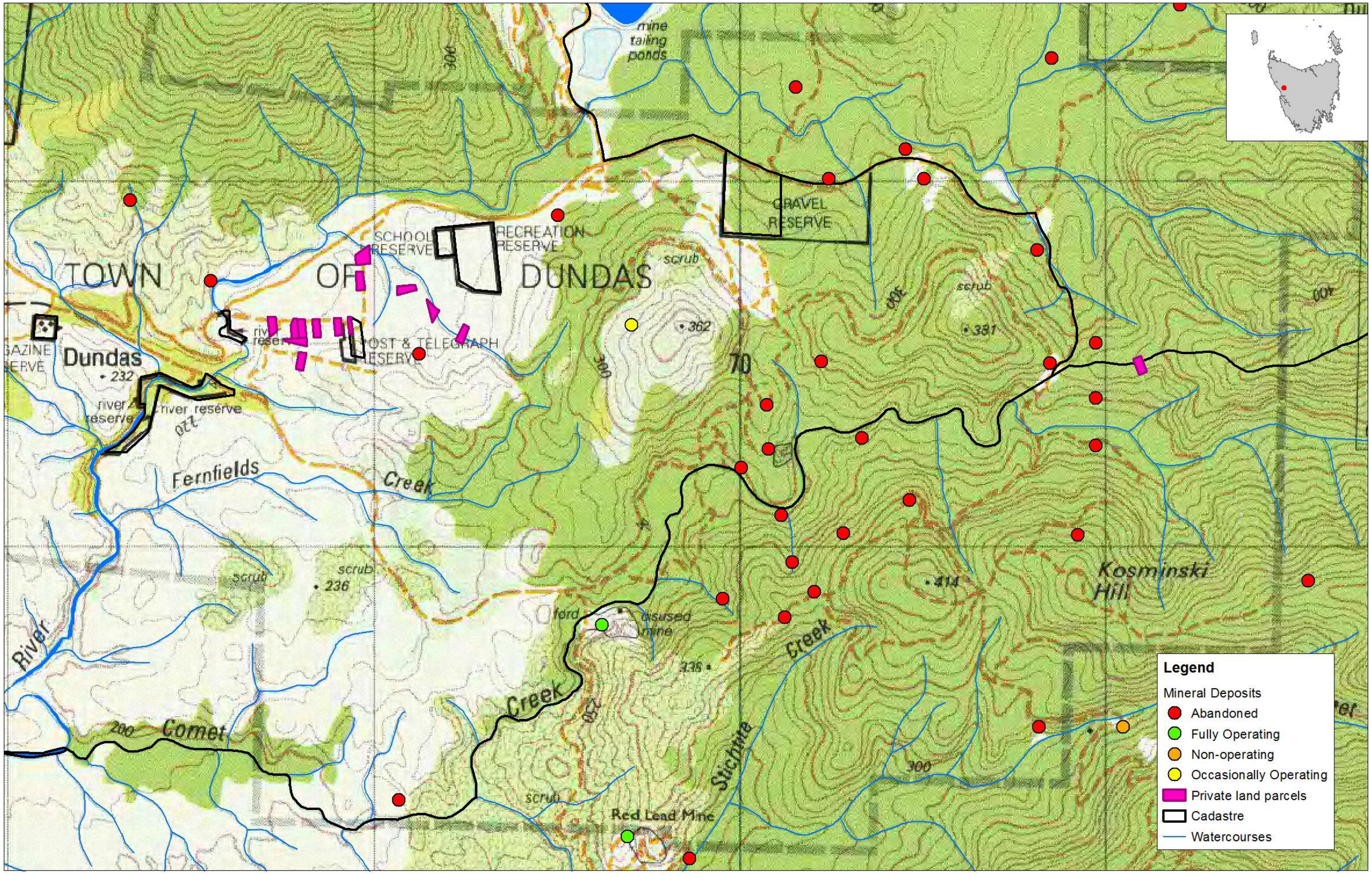
Scale: 1:15,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS WATER MONITORING SITES



Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H012_Tenure_12P_RevB

0 0.2 0.4 0.6 0.8 1 Kilometres

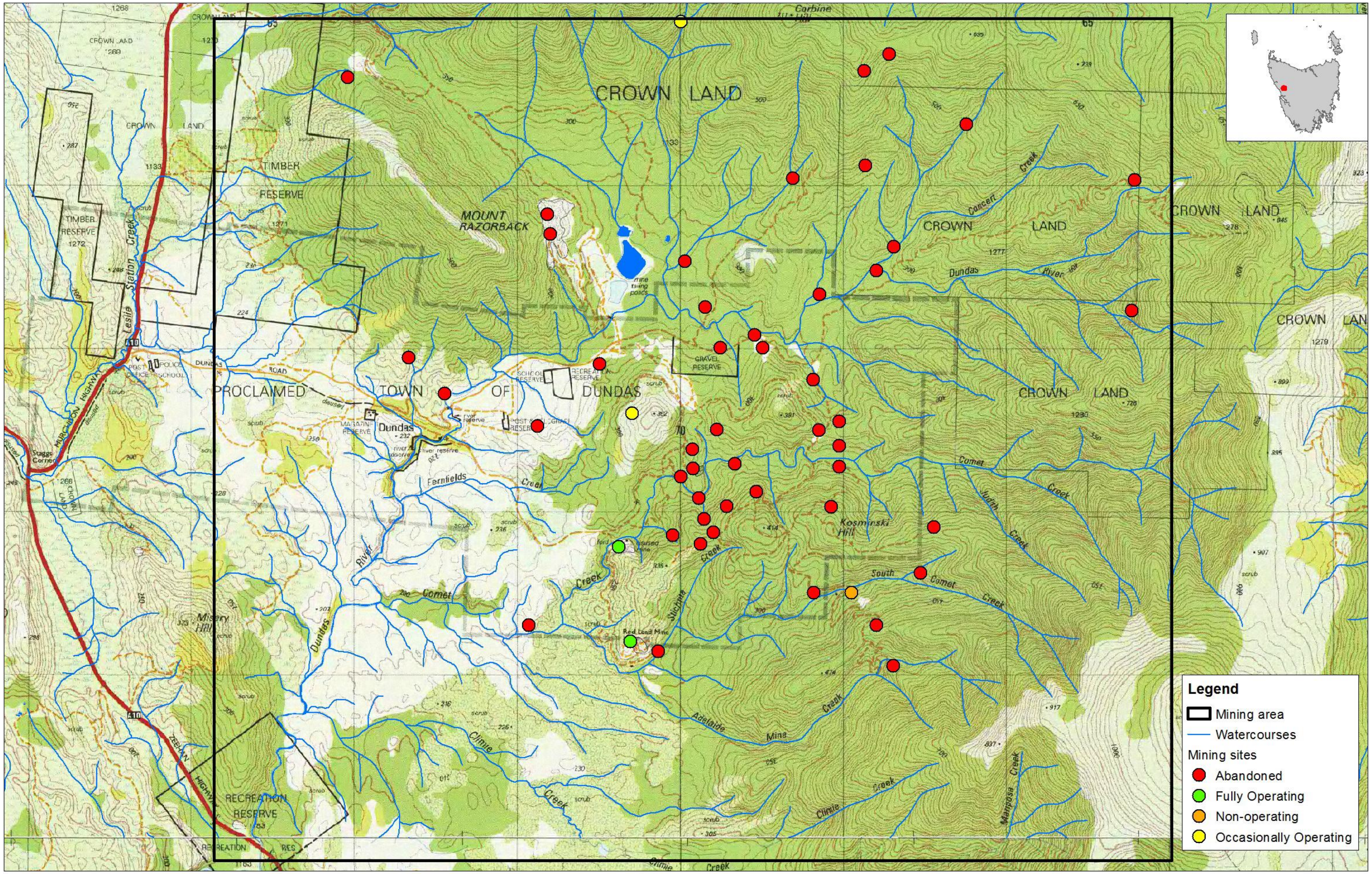
N

Scale: 1:9,362

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS OLD MINES WITH PROPERTY BOUNDARIES



Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H003_WMpts_MinDepV1_12P_RevD

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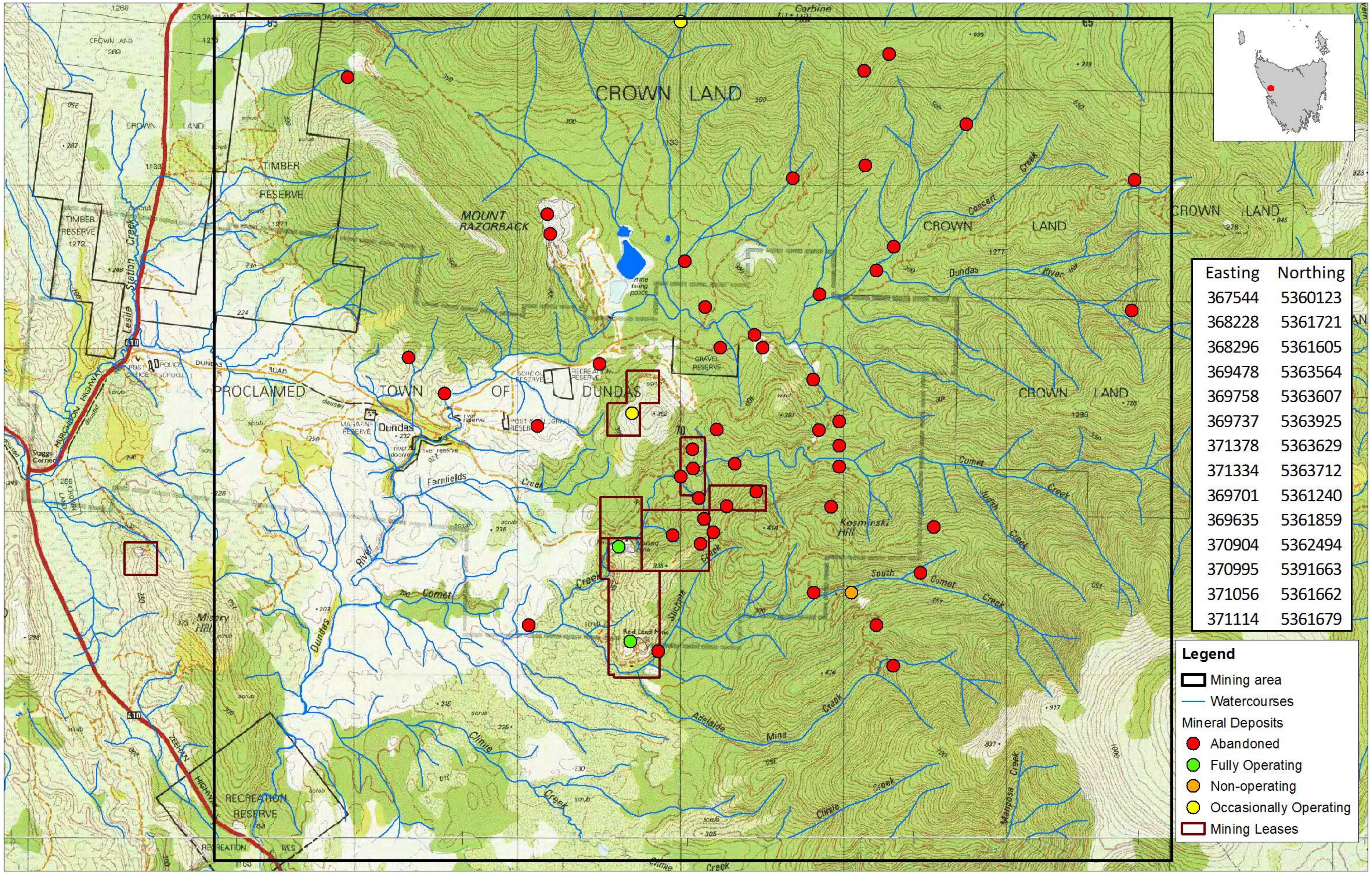
Scale: 1:21,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS OLD MINES



Easting	Northing
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368228	5361721
368296	5361605
369478	5363564
369758	5363607
369737	5363925
371378	5363629
371334	5363712
369701	5361240
369635	5361859
370904	5362494
370995	5391663
371056	5361662
371114	5361679

pitt&sherry

Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H010_OldMines_Leases_12P_RevB

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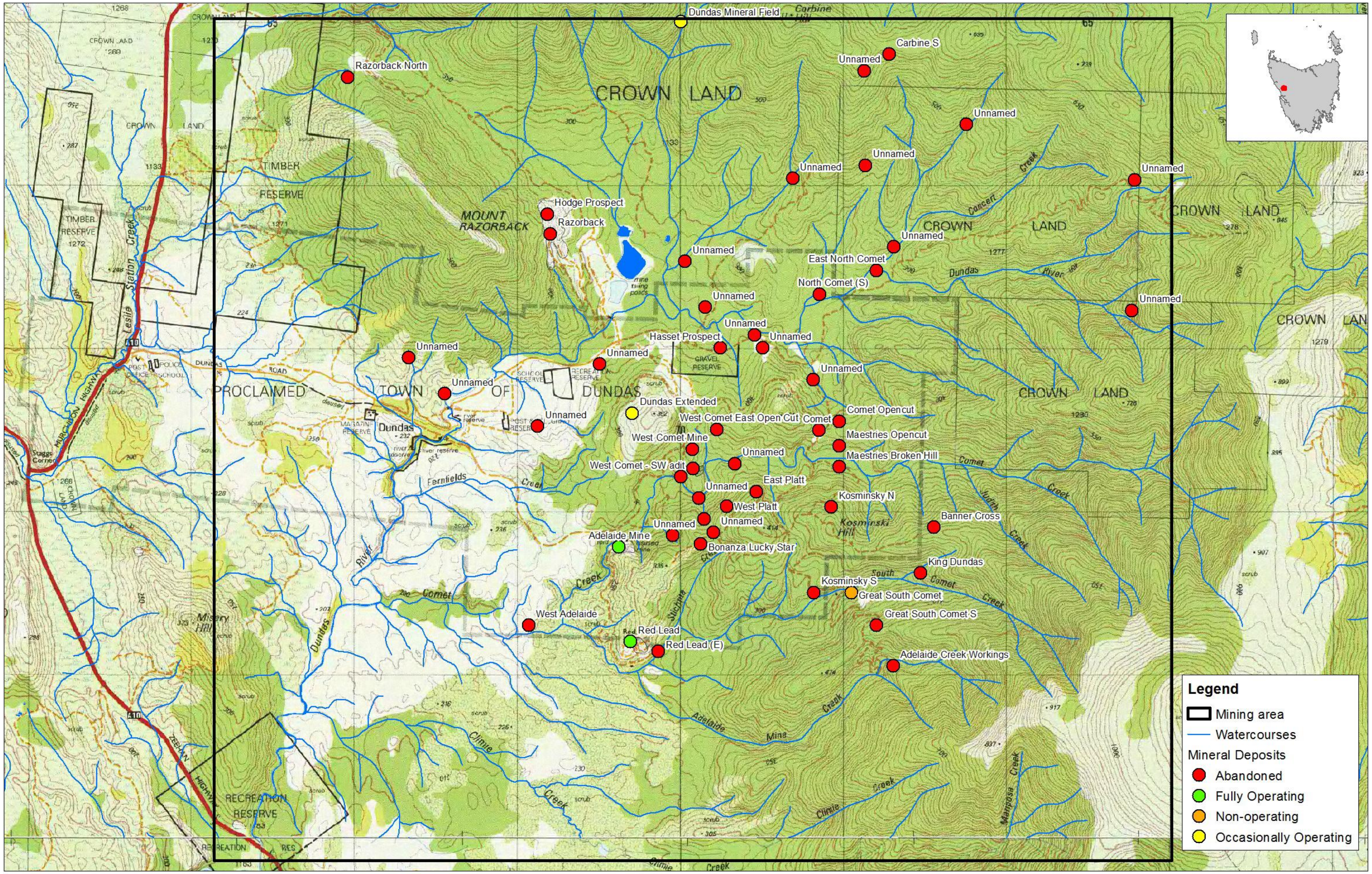
Scale: 1:21,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS OLD MINES



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Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 12/06/2013
Map ref: HB13108_H011_WMpts_MinDep_named_12P_RevA

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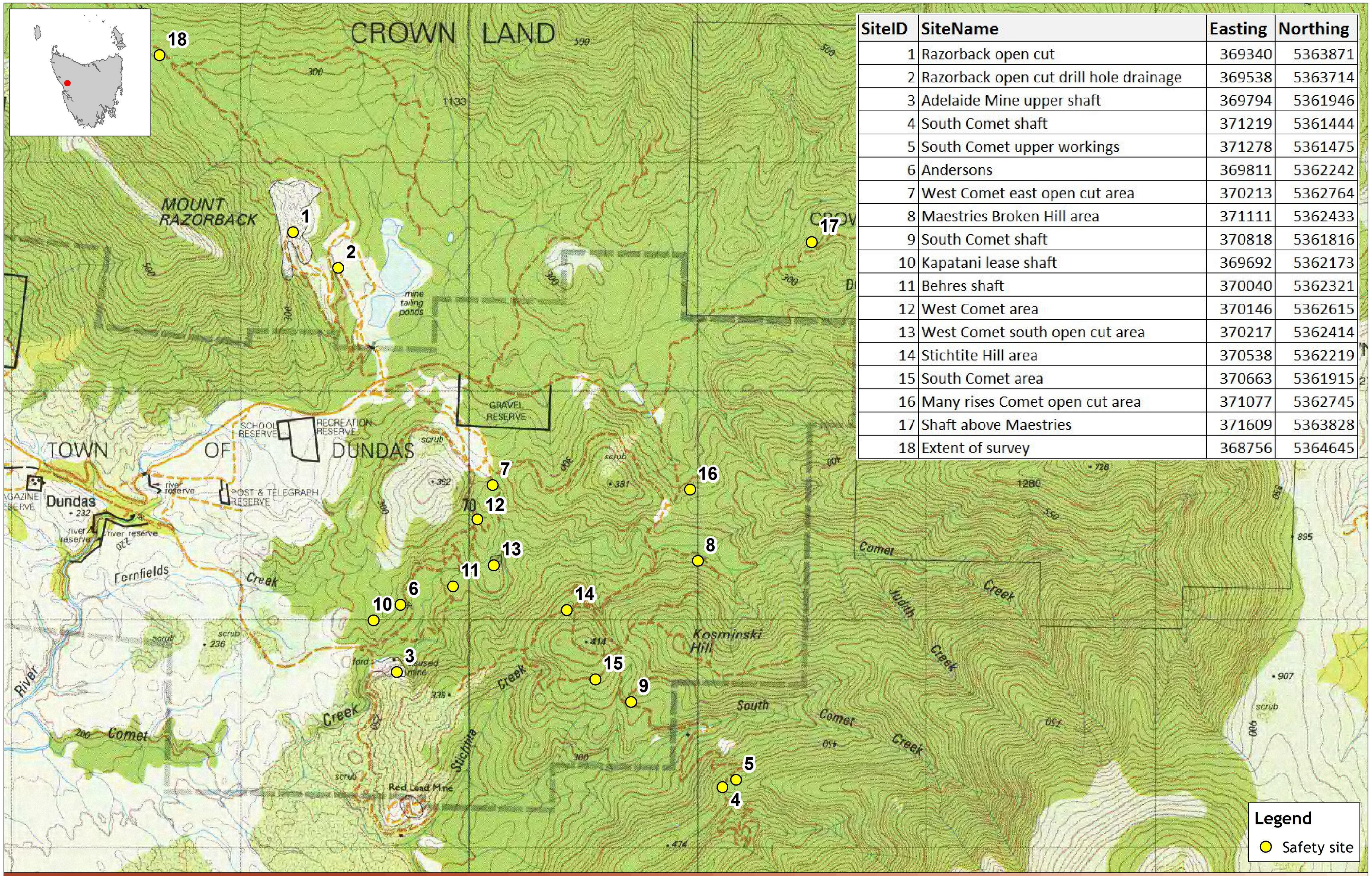
Scale: 1:21,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS OLD MINES



SiteID	SiteName	Easting	Northing
1	Razorback open cut	369340	5363871
2	Razorback open cut drill hole drainage	369538	5363714
3	Adelaide Mine upper shaft	369794	5361946
4	South Comet shaft	371219	5361444
5	South Comet upper workings	371278	5361475
6	Andersons	369811	5362242
7	West Comet east open cut area	370213	5362764
8	Maestries Broken Hill area	371111	5362433
9	South Comet shaft	370818	5361816
10	Kapatani lease shaft	369692	5362173
11	Behres shaft	370040	5362321
12	West Comet area	370146	5362615
13	West Comet south open cut area	370217	5362414
14	Stichtite Hill area	370538	5362219
15	South Comet area	370663	5361915
16	Many rises Comet open cut area	371077	5362745
17	Shaft above Maestries	371609	5363828
18	Extent of survey	368756	5364645

Legend

● Safety site

Data sources:
Base image and data from The LIST (C) State of Tasmania
Safety site data from pitt&sherry
Map produced by pitt&sherry Date: 3/07/2013
Map ref: HB13108_H005_SafetySites_12P_RevC

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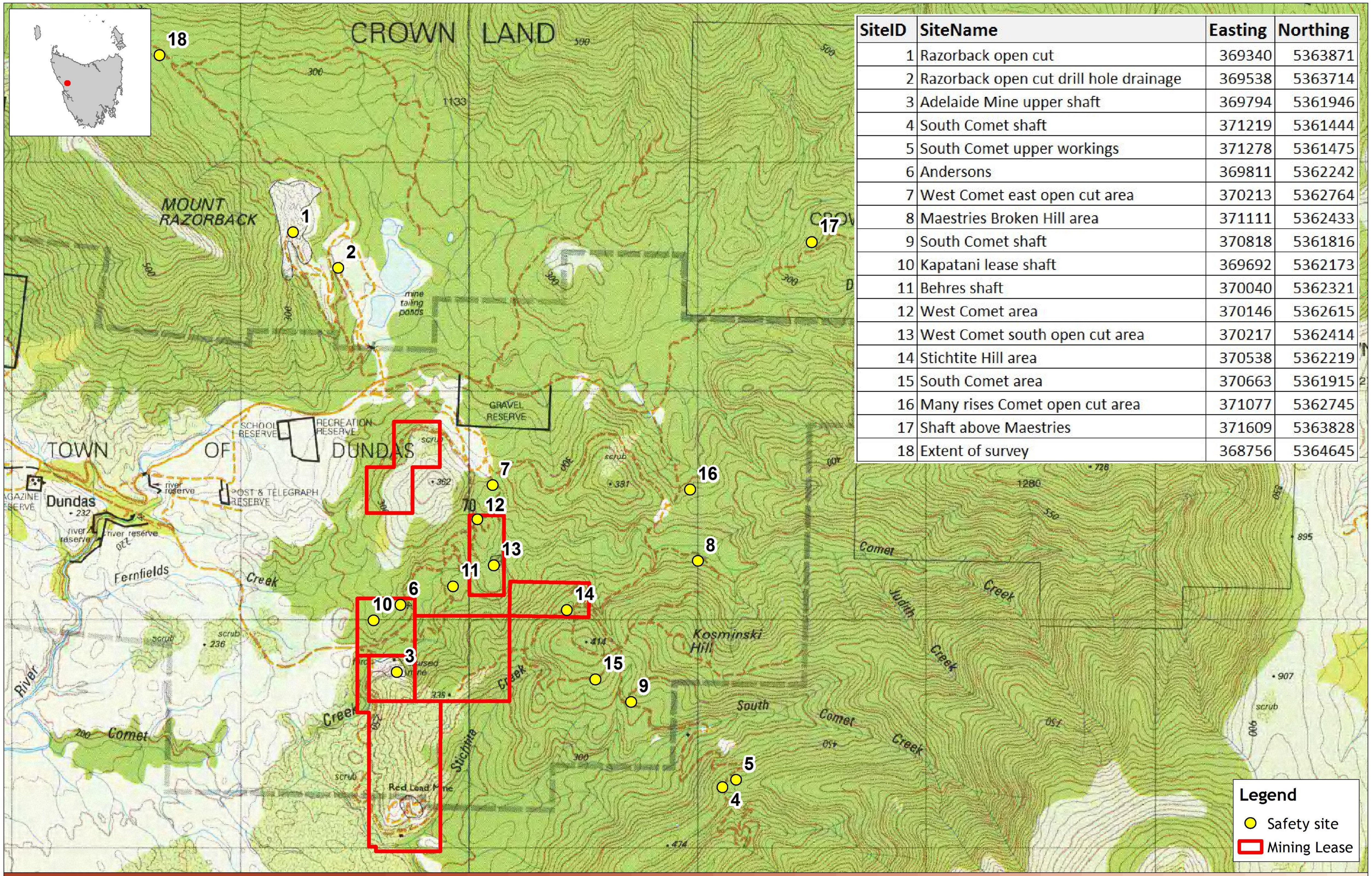
Scale: 1:15,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS SAFETY SITES



SiteID	SiteName	Easting	Northing
1	Razorback open cut	369340	5363871
2	Razorback open cut drill hole drainage	369538	5363714
3	Adelaide Mine upper shaft	369794	5361946
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5	South Comet upper workings	371278	5361475
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15	South Comet area	370663	5361915
16	Many rises Comet open cut area	371077	5362745
17	Shaft above Maestries	371609	5363828
18	Extent of survey	368756	5364645

Legend

- ● Safety site
- 🟥 Mining Lease

Data sources:
Base image and data from The LIST (C) State of Tasmania
Safety site data from pitt&sherry
Map produced by pitt&sherry Date: 3/07/2013
Map ref: HB13108_H008_SafetySites_MiningLeases_12P_RevB

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Scale: 1:15,000

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS SAFETY SITES

Appendix B

Reference Documents

1140 TRANS
or
1498.

24/5

UR 1950/21-41

The Great South Comet Mine - DUNDAS

B.L. Taylor B.Sc.(N.Z.) A.M.A.I.M.M.

GEOLOGIST

TABLE OF CONTENTS

INTRODUCTION

The Great South Comet area consists of two consolidated 20 acre leases. The Mine, which is a zinc-lead show, is at present being operated by Lead and Nickel Co. (Zeehan) N.L. who are recovering lead concentrates only. This investigation has been undertaken to serve as a basis for recommendations to the operating company in regard to mining and milling practice.

Accompanying this report is a general plan showing topography and surface features on a scale of 80 feet to the inch, and an underground plan with long and cross sections on a scale of 40 feet to the inch. The origin of surveys was the NW corner peg of lease 5829M and the initial true bearing was taken from the western boundary of that lease. The main survey from the South Comet Creek to the Adelaide Creek was carried out by theodolite and stadia. An underground plan of Nos. 1, 2, and 3 adit drives prepared by G.A. Laffer was available. This survey was picked up and included in the present work. Crosscuts and stopes were tied in by compass and tape survey.

Initial height was obtained from Mt. Zeehan triangulation station (2270') and the assumed R.L. of the NW corner peg is fairly close to the actual height above sea level.

LOCATION AND ACCESS

The South Comet Mine is located some seven miles east of Zeehan township, on the western side of Mount Dundas, and on the lower slopes thereof. Access is by 9½ miles of road from Zeehan. The first eight miles of this road as far as Maestrie's Mill (the end of the old Zeehan-Dundas Railway) is fairly level and, though rough, is passable to normal vehicles in all weathers. The remaining 1½ miles from Maestrie's to the mine was put in about two years ago by the syndicate. This section of the road crosses two steep ridges, has a maximum grade of 1 in 3, and can only be negotiated by four-wheel drive vehicles fitted with dual gear ranges. The foundation of the road are solid, however, and it is passable for the above type of vehicle in all weathers. The journey from Zeehan to the mine takes about 50 minutes and the workmen travel from Zeehan each day.

GENERAL TOPOGRAPHY

From Mount Dundas a divide of average elevation 2500 feet runs in a general northerly direction to Mount Read. On the western fall of this divide flow several creeks each separated by ridges. These creeks, from south to north are - Adelaide Creek, South Comet Creek, Comet Creek, and the various unnamed headwaters of the Dundas Rivulet. In their upper reaches, these creeks are subparallel and flow in a westerly direction. The Comet, South Comet and Adelaide Creeks converge about a mile south of the site of Dundas township, join the Dundas Rivulet and flow on to the Little Henty River. In the upper reaches, the streams have a steep gradient and the dividing ridges are sharp - where they leave the main divide there is a sudden flattening of gradient but the dividing ridges still maintain fairly steep sides.

The main divide is covered with heavy rain forest of the usual West Coast type. On the lower slopes and around the Dundas area where a large number of mines were formerly operating, the forest has been cleared and is now clad with second growth - manuka, bauera and associated scrub - about thirty years old. In contrast to the rain forest which is reasonably open, the second growth is thick and difficult to penetrate.

TOPOGRAPHY OF THE SOUTH COMET LEASES

The South Comet area consists of two consolidated 20 acre leases numbered 5628M and 5629M the original survey of which is dated 27/1/1912. 5628M adjoins the southern boundary of 5629M and is offset 353 links to the east. The South Comet Creek cuts across the extreme NW corner of the area and the Adelaide Creek crosses the eastern boundary of 5628M at 624 links from the SE corner peg and the southern boundary at 1290 links from the same peg. Between these two creeks which flow parallel at about the same elevation, rises a sharp E-W trending ridge rising 550 feet above creek level. The crest of this ridge lies slightly north of the boundary line between the two leases. The northern side of this ridge has been cleared and, except for some patches of scrub is reasonably open. The southern side is clothed with rain forest.

PREVIOUS LITERATURE

The only published report dealing with the area is Bulletin No. 36 of the Tasmanian Department of Mines entitled "The Dundas Mineral Field" by A.M. Reid and published in 1925. The South Comet Mine is dealt with on pages 85 to 88. Reid briefly describes the mineral assemblage and the development of the adits as at the time of his visit. Dealing with reserves of ore he states "The rather extensive workings have proved the length of the vein over 800 feet and have provided evidence to indicate its existence in the intervening unexplored part. Moreover, these workings show that the vein maintains its width and the quality of its ores to a depth of 400 feet. Allowing for 50 per cent of poor ore it is estimated that 72000 tons of crude ore is available above No. 1 adit level. The average value of the crude ore has not been determined ...."

GENERAL GEOLOGY

The General geology of the Dundas area as a whole is complex and far from being completely understood at the present time. It appears, however, that representatives of the Davey Group, Pieman Group, and the Dundas Series are present associated with intrusive ultrabasic rocks much serpentinised. It is not clear at present whether there is unconformity between each of the three groups of sediments. There is, however, evidence of decreasing grade of metamorphism as one passes upwards from the oldest(Davey) rocks to the youngest (Dundas).

Over the area of the South Comet leases, rocks of the Dundas Series only occur. On the crest of the ridge and near the eastern boundary of 5629M is a prominent outcrop of breccia which includes narrow bands of sandstone and grit and thus shows a rude stratification. Observations on the finer layers indicate that the breccia strikes NE and dips south at 54°. The breccia grades downwards into coarse and then fine greyish-yellow micaceous sandstones which show marked cleavage crossing the bedding planes at high angles. This material can best be observed underground at the end of No. 1 E crosscut.

On the western side of the lease there occurs a series of consolidated mud and silt stones best exposed underground in No. 1 and 2 W crosscuts. This series consists of a large number of thin layers varying from a fraction of an inch to several inches in thickness. The bands are alternations of fine and very fine grained sediment and are alternately light and dark grey in colour. Individual layers sometimes show fine lamination. This series shows no sign of the development of cleavage or metamorphism - they are merely compacted. Apart from the underground exposures, this series is well developed along the bed of Adelaide Creek where they strike from NE to E and dip south at 40° to 60°.

Crossing the lease in a general SW direction is a major fault zone of variable width. It is convenient to refer to this as the "South Comet Fault". From the crest of the ridge, the direction of the fault zone swings south to Adelaide Creek. The average dip of the zone is 65° to the west. No. 1 E crosscut and No. 2 W crosscut provide the only complete section across the fault zone underground. The country rock on the east is the micaceous sandstone and on the west the mud and silt stones described above. From the fact that the sandstones show marked cleavage while the mudstonesdo not, it is inferred that the latter are younger than the former and therefore that the western is the downthrow side of the zone. There is no evidence to show whether the fault is normal or reverse.

This fault zone continues north as far as the South Comet Creek where it ends abruptly. Along the northern side of the access road opposite the entrance to No. 1 adit drive a series of grey and black phyllites of the Pieman Group appear for a distance of 200 feet. This series is bounded on the east and west by grey quartzites and serpentinised sediments respectively. The contact on each side of the phyllites is a fault, each fault agreeing in strike and dip with those of the main South Comet Fault. Both these faults are cut off at the South Comet Creek. Downstream some 800 feet from the bridge the Kosminski lodes (not shown on the plan) are developed on the north side of the creek along a fault zone paralleling the South Comet Fault. The composition and structural features of the Kosminski lodes appear similar to those of the South Comet lodes. The Kosminski lodes also are cut off by the creek.

It is clear, therefore, that there are a series of NW-trending fractures each dipping about 60°-70° to the west. Each fracture is mineralised as will be indicated later and each is cut off by the South Comet Creek. It is evident that there is a transverse fault along the course of the South Comet Creek which has offset the lodes on either side. This transverse fault is younger than the NW-trending series and is evidently subsequent to the period of mineralisation. From the similarities between the South Comet and the Kosminski lodes it is deduced that they are actually along the same fracture plane. The horizontal displacement of the transverse fault is therefore of the order of 800 feet in this area. It is probable of course, that there is a vertical displacement also but there is no evidence of the amount of such displacement.

DEVELOPMENTAL WORK

On the crest of the ridge between the two creeks are numerous shallow trenches along and across the lode zone and near the gossan outcrops. These were undoubtedly the first workings in the area and were designed to indicate the direction and extent of the lode in the gossan area. They are not shown on the present plan. Also on the crest of the ridge and 140 feet west of the first gossan outcrop is a shaft about 50 feet in depth. This depth was not measured and is deduced from the size of the dump heap. The shaft was apparently put down to intersect the lodes. The dump heap shows only fine mudstones with no sign of ore so it is presumed that work in the shaft was abandoned before the lodes were met.

On the northern side of the ridge four adit drives have been driven and on the southern side, a little above the level of Adelaide Creek, three further adits are located.

No. 1 Adit Drive

This commences at a height of 25 feet above the level of the South Comet Creek and is a drift along the lode zone. At a distance of 180 feet from the entrance, No. 3 lode is intersected and the drive then follows the lode. At 850 feet from the portal, a rise follows the lode for a vertical distance of about 130 feet from rail level. Ten feet past the foot of the rise, the roof of the drive has fallen and it is not known how far the drive penetrates past this point. At 520 feet from the portal, No. 1 West Crosscut penetrates country rock for 172 feet. No sign of lode material appears in this crosscut. Thirty feet north of the foot of the rise, No. 2 West Crosscut cuts No. 3 lode for 8 feet and continues about 30 feet in country rock. The entrance to this crosscut is almost filled with mullock and the actual length could not be measured. Twelve feet from the entrance of the crosscut, a short drive parallel to the main drive is at present being put in. The object of this drive is to bypass the fallen portion of the main drive and it is intended to crosscut back to the main lode a little further on. At the time of writing, the face of this drive was almost opposite the foot of the rise and a chamber had been driven 6 feet east. No. 1 East

Crosscut leaves the main drive opposite the entrance to No. 2 West Crosscut and penetrates a distance of 44 feet. At 18 feet from the entrance a nine inch pyritic lode (No.2 lode) has been cut. At 34 feet No. 1 lode was intersected and short drives put along it. The north drive is 21 feet in length and the south drive 26 feet. Along the main drive occur six stopes numbered one to six on the plan. They rise to a maximum height of 30 feet above rail level.

No. 2 Adit Drive

The portal of this drive is 280 feet SE of No. 1 portal and 122 feet vertically higher. The drive is only 40 feet long and while the lode material shows in the drive, the values are very poor. There are no crosscuts or stopes.

No. 3 Adit Drive

The portal is 440 feet SE of No. 1 portal and 210 feet vertically higher. At 110 feet from the portal, No. 1 lode is intersected by the main drive and followed for 210 feet. The main drive then crosscuts west to No. 3 lode and continues along it a further 140 feet. At this point, 460 feet from the portal, the roof of the drive has fallen. From the point at which the drive intersects No. 1 lode, a drive has been put northwards a distance of 46 feet. Twenty feet from the end of this drive a rise has been put through to the surface. From the point where the main drive crosscuts to No. 3 lode, a short drive follows No. 1 lode a further 46 feet. No. 1 lode has therefore been opened up along a distance of 302 feet. 200 feet from the portal, No. 3 West Crosscut has been driven 34 feet and has revealed the presence of Nos. 2 and 3 lodes in short drives. At 320 feet from the portal, No. 4 West Crosscut also shows these two lodes. At 16 feet north from the present end of the drive a winze is at present being sunk to connect to the rise from No. 1 Adit Drive. At the time of writing, the connection had not been made.

It will be seen that the total length of drive open from portal to fall is 460 feet. A.M. Reid in "The Dundas Mineral Field" page 87 states (1924) that this drive is 605 feet in length. There is therefore at least a further 145 feet of drive though it is of course impossible to estimate how much of this length is fallen.

Almost the whole length of the exposed portion of the drive has been stoped. The stopes are numbered 7 and 8 on the plan.

No. 4 Adit Drive

The portal of the drive is 670 feet SE of No. 1 portal and 350 feet vertically higher. The drive penetrates the lode almost straight for 143 feet. At 78 feet from the portal, a chamber has been cut in the east wall and a winze sunk to a depth of 50 feet. No stoping occurs. It will be seen from the plan that No. 4 Adit Drive is almost vertically above No. 3 Adit Drive and the winze in No. 4, if continued downwards would strike No. 3 very near the entrance to No. 4 West Crosscut.

Nos. 5, 6 and 7 Adit Drives

These all occur in the lode zone at or near the level of Adelaide Creek. Nos. 5 and 6 are on the north side of the creek and are both inaccessible. No. 5 is at creek level and No. 6 is 12 feet higher. The dump heaps are quite small and it is estimated that these drives do not penetrate more than 100 feet each. No.7, at creek level on the south bank has been driven 30 feet.

DESCRIPTION OF LODE OCCURRENCES

It has been shown that a fault, or fault zone with a downthrow of some 600 feet to the west traverses the leases in a NNW-SSE direction. Mineralizing solutions have risen along this zone and have formed three well-defined zinc-lead lodes. These lodes are exposed in the crosscuts and in the main drives. In general, the lodes maintain fairly straight and parallel courses but pinch and swell from time to time. The walls are well-defined and are sometimes marked by several inches of bluish pug. The structure of the zone as a whole is very "tight" and only rarely are vughs or cavities seen. It may be classed as a "sheeted zone". Although the walls are well-defined, ore is not confined entirely to the lodes themselves. During the course of the fracturing the walls of the fracture were naturally shattered and are traversed by numerous small discontinuous cracks. The mineralizing solutions have penetrated these cracks in places and given rise to thin stringers and blebs of ore. In places, it is worth while mining the country rock for ore. Numerous measurements show that the lodes dip west at an average of 65° but local variations from this occur. In No. 1 East Crosscut, for instance, No. 1 lode dips east at 85°. These variations are not considered of major importance.

There is considerable variation in the width of the lodes. The maximum width noted as that of No. 3 lode at the foot of the rise in No. 1 Adit Drive where the width is 12 feet. At the top of No. 1 stope, this same lode is only 6 inches in width. Similarly, No. 2 lode is present in No. 1 East crosscut showing a width of only 9 inches whereas the same lode in No. 3 West Crosscut is 4 feet in width. The average widths of Nos. 1

and 3 lodes throughout the workings are 3 feet and 4 feet respectively. No. 2 lode is exposed in three places only and its width is estimated at an average of 3 feet.

The width of the lode zone is also variable. The full width can be measured in three places only and is as follows:-

(a) No. 1 East Xcut and No. 2 West Xcut - 60 feet
(b) No. 3 West Crosscut - 20 feet
(c) No. 4 West Crosscut - 35 feet

With only three measurements it is difficult to form an accurate estimate of average. It is suggested, however, that the average width of the zone is between 30 and 40 feet.

As far as can be ascertained, the compositions of the three lodes are similar. The lode matrix is mainly siderite and other carbonate minerals such as barite with probably some secondary calcite. Veins of calcite **half an** inch in width occur in the country rock near the hanging wall in No. 1 Adit bypass. The siderite is paler than is usual for this mineral being a very pale yellow. It is dense, compact and hard.

Associated with the siderite are sphalerite and galena. The sphalerite is deep brown in colour and has a resinous lustre. It appears to be mainly the iron-rich variety marmatite. Assays **show** that there is a minor amount of silver present also. No silver minerals were noted in the hand specimens, however, and they are probably present in a finely divided state. Very fine-grained pyrite occurs in blebs sparsely distributed throughout the lodes. In places it is present in importance amount as, for instance, in No. 2 lode exposed in No. 1 East Crosscut. However, on an average, there is only a very minor amount of this mineral.

A.M. Reid (page 86) refers to the presence of jamesonite. A little of this mineral was noted in the dump heap at the mouth of No. 1 Adit but it was not seen in any of the faces or backs examined. Assays show that traces only of antimony occur and its presence can be disregarded in calculations of ore reserves.

The only economic minerals present, therefore, are sphalerite and galena which, on an averagem occur in roughly equal amounts. The two minerals are fairly coarse grained and easily distinguishable by eye. In this respect they differ from the Rosebery type of ore in which there is a very fine intergrowth of the two minerals. In general, stringers of ore lie parallel to the lode walls and vary from a fraction of an inch to several inches in width. The stringers are discontinuous and more in the nature of flat lenses, the lenses being separated by the lode matrix - siderite. In only one case was clean metal (galena) seen in a vein of more than six inches width. This occurs in the floor of No. 1 Adit at the base of the rise where 2'6" of fairly clean metal is showing.

The sphalerite and galena do not normally occur as intergrowths of subequal amounts of both minerals, though it is equally true to say that no stringers or blebs of one mineral occurs unassociated with the other. In general, each stringer consists almost entirely of one mineral with very small blebs of the other. Intimate intergrowths do not normally occur. The content of the lodes vary along their length. Rich patches or shoots of ore occur and appears to be alternately of galena and sphalerite. Such shoots of galena as have been met with have been stoped out. When the mine was worked earlier on, there was no sale for zinc ore - in fact the miners were penalised for zinc content in the galena. Consequently shoots of sphalerite have not been stoped. Also when the shoots of galena which were being stoped became rich in sphalerite, the stopes were stopped. As a result, samples taken along the backs show reasonable zinc values but poor lead values (see samples 1 to 5 and 22, 23 of Table 1). For this reason also, the crosscuts such as No. 1 East and Nos. 3 and 4 West were not proceeded with. They cut lodes which were predominantly of zinc ore.

The results of assays are given in Table 1 which also shows width of sample and lode number. The average value of each lode is shown in Table II. Positions of samples are shown on the accompanying underground plans and long section.

It was stated to the writer that, when excavating for the mill site a lode zone was exposed paralleling the course of the main lodes. The zone was "27 feet in width and showed stringers of zinc ore over the whole width the width of zinc being about one third of the total width of the zone". This exposure is now covered by a concrete floor and could not be seen. However, careful search was made in the vicinity both above and below the mill site and no sign of ore, or indeed of any fracture could/be noted. The writer is unable, therefore, to express an opinion on this alleged occurrence.

Two further mineralized zones must be described both of which occur just north of the lease boundary. Mention has been made (page 4) of an outcrop of phyllites occurring north of the South Comet Creek bounded on each side by a fault. The eastern fault cuts the access road quite near the bridge and in the road cutting it is seen that there are several inches of pyritic material developed in the fault. No zinc or lead ore occurs but the lode may "make" further north. On the western boundary fault, two prospecting drives have been put in one above and one below the access road. The upper drive penetrates for 60 feet. On the dump heap some good coarse galena is showing but at the face only a few inches of pyritic material markes the presence of the lode. The lower drive penetrates for about 30 feet but is inaccessible.

TABLE 1 ASSAY RESULTS

Sample No.	Lode No.	Width in inches	Pb	Zn	Sb	Ag
1	1	42	3.4	12.4	Tr	1.2
2	1	41	2.6	7.2	Tr	0.9
3	1	59	3.0	10.6	Tr	0.1
4	1	24	7.5	15.8	Tr	0.5
5	1	23	1.7	4.7	Tr	1.0
6	1	48	17.0	13.4	0.08	18.3
7	3	108	0.4	5.1	--	0.3
8	2	60	1.4	4.5	--	0.4
9	3	56	5.1	4.3	Tr	3.5
10	2	40	1.3	2.8	--	0.5
11	3	31 x	11.7	2.2	0.03	12.9
12	3	30 x	18.1	6.4	--	13.3
13	3	38 x	3.3	1.5	--	2.6
14	3	33 x	6.9	5.0	Tr	5.4
15	3	37 x	7.0	5.4	Tr	7.2
16	3	34 x	8.9	3.1	0.03	8.9
17	3	72 x	8.6	5.9	Tr	8.5
18	3	54 x	6.0	3.7	--	4.1
19	3	120	3.7	9.0	--	2.1
20	1	27	3.0	13.2	0.03	1.8
21	3	30 x	46.2	12.6	0.18	42.4
22	3	68	1.3	9.9	--	1.7
23	3	48	0.6	4.8	--	0.4
24	3	72	10.7	7.8	0.11	10.4
25	3	33	1.4	3.8	--	0.8
26	3	46	7.6	29.1	0.03	7.1

TABLE II AVERAGE VALUES OF LODES

Lode No.	Pb	Zn	Ag
1	5.5	11.0	3.4
2	1.4	3.7	0.5
3	8.4	7.4	8.0

NOTES

(a) Assays by Mines Department Laboratory, Launceston
(b) Calculation of average values by B.L. Taylor
(c) "x" indicates sample not taken over full width of lode
(d) Pb, Zn and Sb expressed in percentage. Ag expressed in ounces per ton.

ORESHOOTS

An endeavour was made to trace some systematic relationship between shoots of galena and of sphalerite. It is regretted that no success was achieved. Beyond repeating that statement made earlier on that shoots of one mineral appear to alternate with those of the other no assistance can be given. There is considerable variation in the size of shoots also as will be seen by reference to the size of stopes shown on the long section. Again here in the size of shoots, no systematic variation could be found. It appears that a rule of thumb method would have to be followed in dealing with the shoots which could be stoped out as they made their appearance along the drives. Diamond drilling in advance of mining would give valuable information.

ORE RESERVES

In calculation of tonnages, it is always necessary to make a number of assumptions. It is stressed at the outset, therefore that the following figures are approximately correct only and are included to show the order of quantities of ore available. It is convenient to divide the reserves into three classes - ore proved, ore probable and ore possible - and to apply the classification to each of the three lodes.

Ore Proved

Ore can be considered proved when it has been blocked out by drives etc. or when it has been revealed by closely spaced diamond drill holes. In the present case, no drilling has been done. Taking the ore which has been blocked out by drives therefore, the following quantities are available.

No. 1 Lode - This is exposed in No. 3 Adit only and in one crosscut. There is therefore no blocking out and no proved reserves can be given.

No. 2 Lode Exposed only in three crosscuts - no proved reserves.

No. 3 Lode This has been blocked out by No. 1 Adit, portion of No. 3 adit and by the winze and rise. Assuming that the ore extends from No. 1 Adit level to midway between Nos. 3 and 4 adits there is available 60,000 tons of ore bulking 8% lead. 4% zinc and 8 oz. silver.

Ore Probable

Into this class fall portions of the lodes which have been cut in various places but which have not been fully blocked out.

No. 1 Lode Assuming the same vertical and lateral extent as for the proved ore in No. 3 Lode, there is a probable 45,000 tons of ore bulking 5% lead. 11% zinc and 3 oz silver.

No. 2 Lode Assuming the same lateral and vertical extent, a further 45,000 tons of probable ore occurs. Only two assays are available from this lode and they are insufficient on which to indicate bulk percentages.

No. 3 Lode No probable ore.

Ore Possible

This falls naturally into two divisions.

(a) Assuming that the lode zone continues through the hill to Adelaide Creek - a very reasonable assumption - and that the lodes maintain their average width. In this case there would be a further 45,000 tons of ore available in each of Nos. 1 and 2 lodes and 60,000 tons in No. 3 Lode. It is impossible to give bulk figures as no assays are available, but the figures are not likely to

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deviate markedly from those given above.

(b) Assuming that the ore goes underfoot in No. 1 Adit. This, of course, actually happens.

It is quite impossible with the data available to give any estimate of the depth to which the lodes are likely to extend and thus of the quantities of possible ore which may occur.

MINING PRACTICE

These lodes are ideally situated for working by means of adits and full advantage has been taken of this fact. From the floor of No. 1 adit level, nearly 500 feet of backs are available up to the level of the gossan outcrops on the crest of the ridge. Also it is a "dry" mine, makes very little water, and the working conditions are not unpleasant. Both the lode material and the country rock are hard and solid and there are no cross fractures causing shatter zones. Thus there are no problems of timbering to be solved. The immediate plan of developmental work outlined in the following section appears to be a sound and efficient method of developing the proved reserves of ore in No. 3 Adit.

PROSPECTIVE DEVELOPMENTAL WORK

The intentions of the management as stated to the writer are as follows:-

(a) When the winze-rise connection is made a northerly drive will be put in 100 feet below the level of No. 3 Adit along the course of No. 3 lode. Ore shoots will be stoped and the ore sent down the ore pass in the rise and trucked out to the mill along No. 1 Adit. This plan allows a maximum of 100 feet of backs along the prospective drive. Either subsequently or simultaneously, a further drive will be put out from the same point following the lode in a southerly direction.

(b) Mention has been made of the intention to put a drive parallel to No. 1 Adit drive from near the foot of the rise and thus to bypass the fallen portion and later crosscut back to the lode. This work is in progress at the present time.

(c) If good ore is met with in the chamber being cut opposite the foot of the rise, it is intended to winze down on this ore and, at a later date drive along the lode north and south.

CONCLUSIONS AND RECOMMENDATIONS

(1) The outstanding conclusion which the intelligent observer reaches in a very short time and which is confirmed by assay data is that this mine is a zinc-lead show and must be considered as such. With wise planning and efficient operation there is every possibility that it will become a profitable small mine. It is equally definite that, if it is regarded as a lead show only as has been done in the past and if it continues to be operated for lead content, it will struggle along for a period consuming increasing quantities of capital for decreasing returns and will eventually fail.

(2) In the section blocked out there is 60,000 tons of ore with a further probable 90,000 tons. In the section between the crest of the ridge and Adelaide Creek there is a further possible 150,000 tons. If the probable and possible ore can be proved, there would be approx 300,000 tons of ore available. This would be sufficient to give a considerable life to the mine.

(3) The assays are fairly low but much lower ore is worked profitably in other parts of the world. It is stressed however that with lower grade ore correspondingly higher grade methods of mining and milling must be adopted. If this is not done in the present instance the mine will fail.

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(4) For profitable working all three lodes must be worked, perhaps simultaneously, in order to provide a constant feed to the mill. This is more a problem for a mining engineer rather than for a geologist.

Recommendations arising out of the above conclusions may be classified into two divisions:-

(1) Short-term Policy

(a) Continuation of the present acheme to put in drives 100 feet down from the top of the winze.

(b) Further exploration of the lodes by means of crosscuts east from No. 1 Adit and west from No. 3 Adit to get a better idea of their extent and content with a view to proving them for future work.

(c) Carrying out of the above programme by diamond drilling is much to be recommended if drilling plant is available.

(d) The formulation of a comprehensive plan of working by a competent mining engineer after these lodes have been proved.

(2) Long-term Policy

This should be devoted to proving the whole of the lodes in the fracture zone and can only be done efficiently by means of diamond drilling. Drilling from the surface on the southern fall of the ridge should be undertaken in order to prove the extension of the lodes to Adelaide Creek. Subsequently drilling from No. 1 Adit Level underground should be undertaken in order to prove the existence of the lodes at depth.

Sgd. B.L. Taylor B. Sc.(N.Z.) A.M.A.I.M.M.
GEOLOGIST

The Director of Mines,
HOBART

Zeehan 24th May, 1950

South Comet Mine

D J Barrell[1]

INTRODUCTION

The South Comet mine is an underground silver-lead-zinc mine located on the West Coast of Tasmania with an annual production in the order of 35 000 tonne per year. All ore mined is shipped to the Rosebery mill by road, a distance of 17 km.

Originally known as the Great South Comet mine it was one of the many operating mines on the now extinct Dundas field. It was first mined in 1895. At this time the contained zinc was regarded as a contaminent and discarded as waste whenever possible. It was for this reason that the original operation was abandoned in 1900.

Since this time the mine has been worked, sold, explored and abandoned several times over. Despite extensive diamond drilling programs, insufficient ore reserves were located to justify the building of a mill or treatment works.

In 1990 with the closure of the Que River mine, the nearby Rosebery mill was left with surplus capacity. The opportunity therefore arose to supplement the mill feed from suitable nearby deposits.

Consequently the South Comet Mine was bought by Minetech Pty Ltd and then operated and managed by F W Lannen and Associates who also held an interest in Minetech.

Since reopening in 1990, 75 000 tonne has been mined from underground and surface with an average grade of 11 per cent Zn five per cent Pb. During this same period, the price of zinc fell from a high of $US2000 to a low of nearly $US900 per tonne. The consequential near halving of expected revenue, has fostered the development of a multitude of mining methods and extreme cost cutting measures. It is these features that are to be discussed in the following paper.

GEOLOGY

Geologically the ore body is hosted by the Dundas Group contained within the Mt Reid volcanic belt that stretches along the west coast of Tasmania.

The ore body itself is a sideritic hosted fissure filled fault zone of Devonian age. The surrounding country rock is a competent interlaminated carbonate bearing siltstone and sandstone suite dating from the earlier Cambrian period.

The ore body is fully contained within the fault zone and mineralisation is localised to where two major faults meet. This gives rise to an ore body approximately 100 m in strike and of indeterminant depth. Deep drill holes have indicated that the ore continues well below the current workings. The ore generally dips at 80° and varies in width from 0.5 m to 6 m, the thicker intersections being found where the two main faults intersect.

MINING

Development

The steep topography of the area has allowed underground access to the orebody via five surface adits running directly into the spur along the line of load (Figure 2). Several of these adits date from the original period of mining and required some rehabilitation.

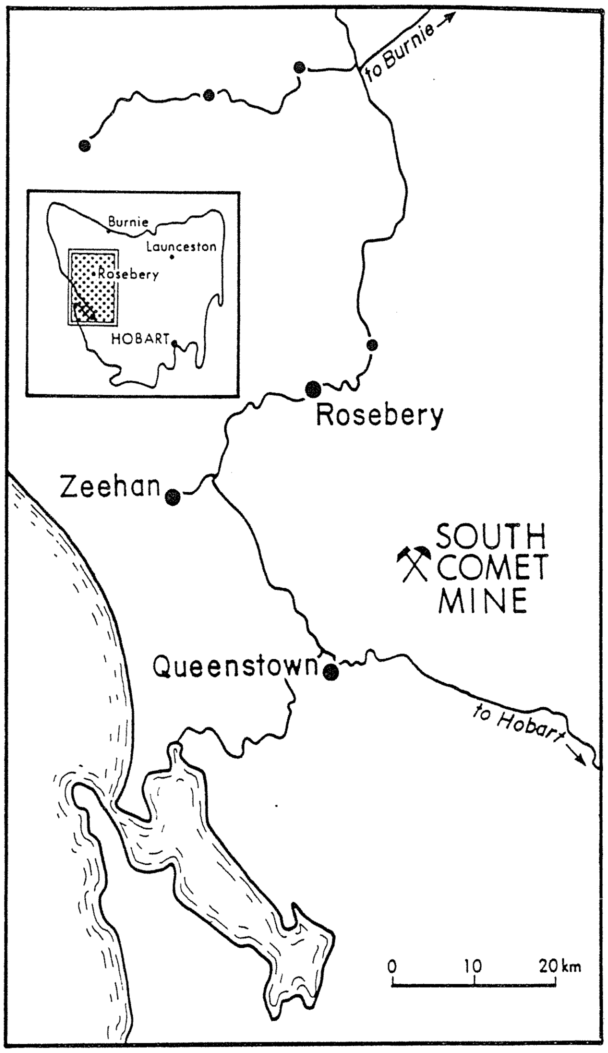

FIG 1 - Location of the South Comet Mine.

All underground development is done with airleg and machine and mucked with one to two cubic metre LHDs. Typical drive sizes are in the order of 2.5 m x 2.5 m. Ground conditions are generally good with little need for bolting.

Initial mining

When re-opened the first production tonnes were won from cut and fill methods on 5 level and 8 level using development waste from the newly established 6 level as fill (Figure 3).

Concurrently with this production, draw point development was taking place on 3 level accessing an old stope that had been backfilled with zinc rich fill (greater than seven per cent Zn).

Uphole retreat stopes were mined on 2 level and 3 level, using a converted ROC 601 airtrack. Meanwhile an open cut was mined at the top of the spure, using the voids created by underground mining to stow the waste.

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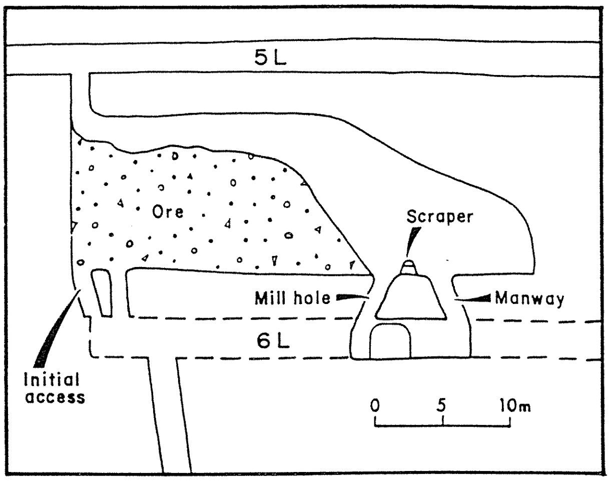
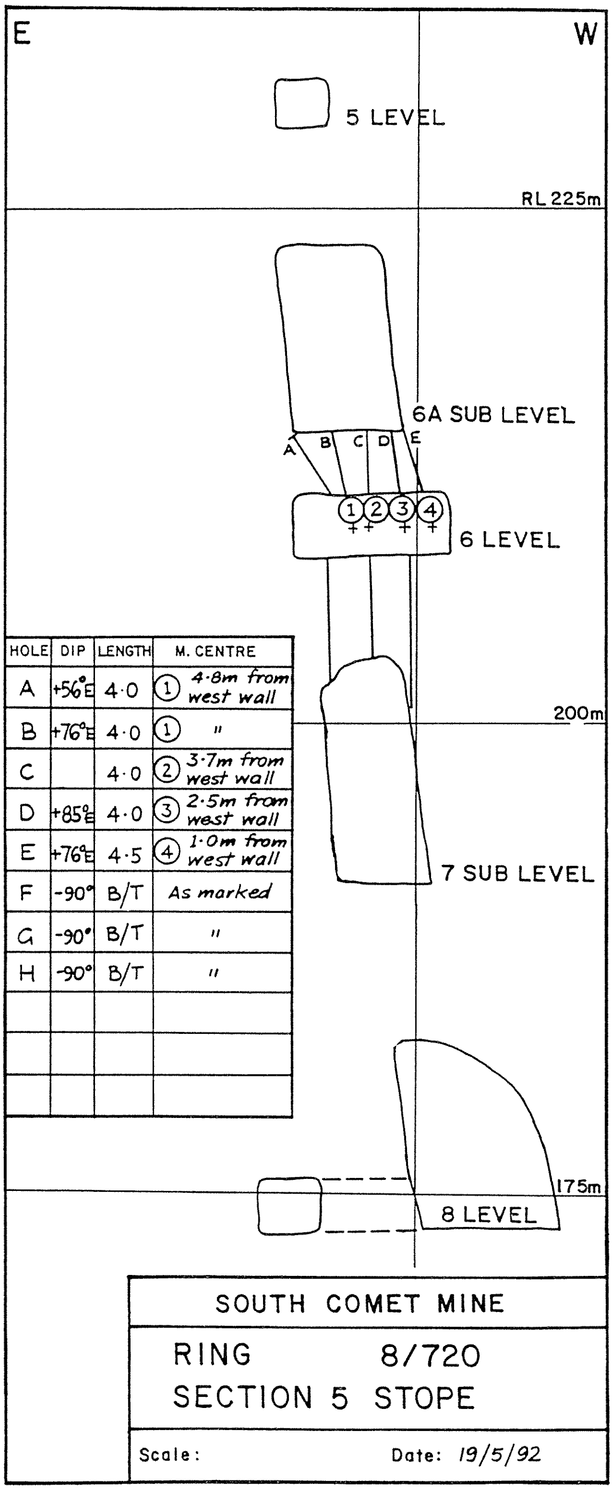


FIG 4 - 6 level stope being mined.



HOLE	DIP	LENGTH	M. CENTRE
A	+56°E	4·0	① 4·8m from west wall
B	+76°E	4·0	① "
C		4·0	② 3·7m from west wall
D	+85°E	4·0	③ 2·5m from west wall
E	+76°E	4·5	④ 1·0m from west wall
F	-90°	B/T	As marked
G	-90°	B/T	"
H	-90°	B/T	"

FIG 3 - Typical cross-section showing the 5 level crown pillar drilling after the 6 level and 7 level, handheld stopes have been mined.

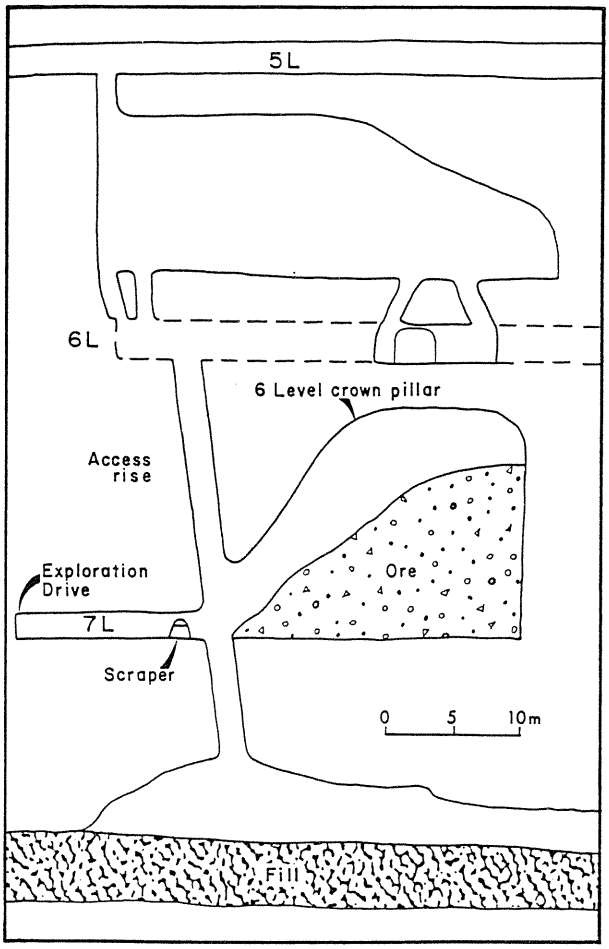


FIG 5 - 7 level stope being mined.

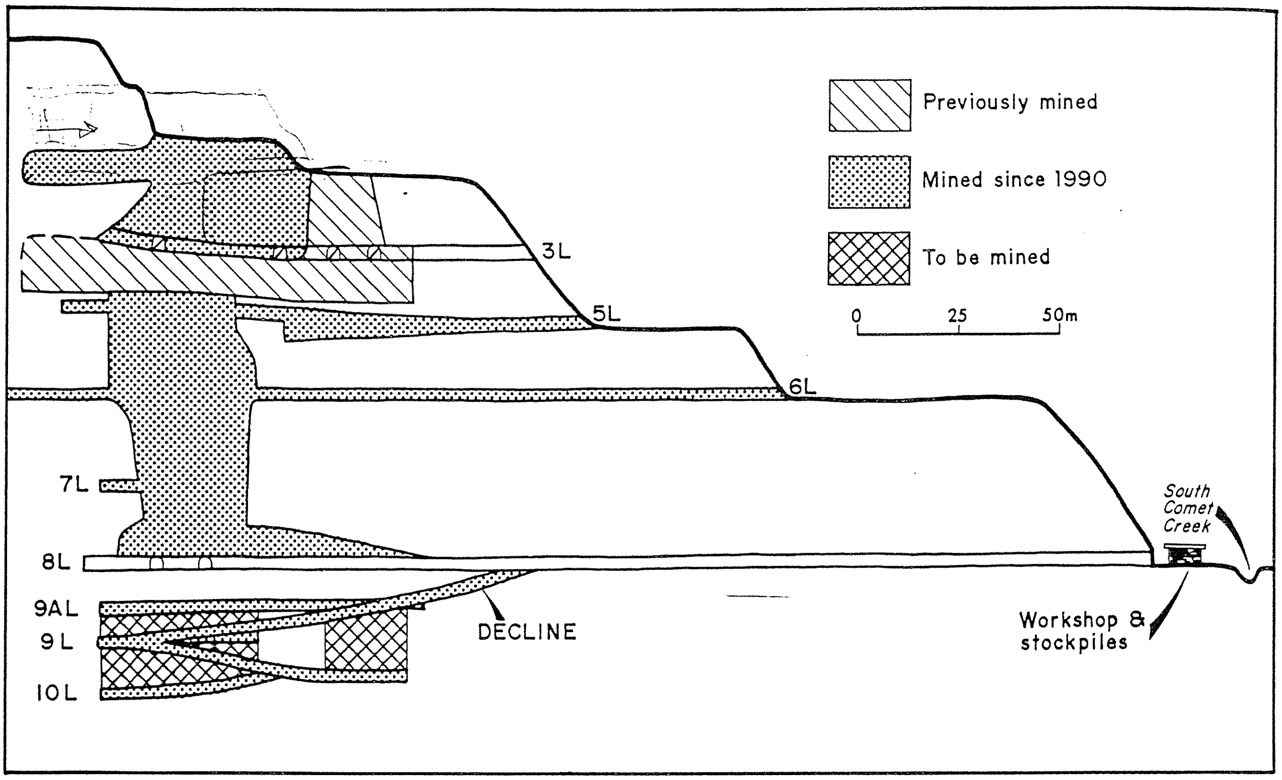


FIG 2 - Schematic, long projection of the South Comet Mine looking West.

8/820 stope

Approximately a year after beginning production an unmined ore block had been delineated running from the 5 level down to below 8 level. Having a strike length in the order of 30 m, a width of three to four metres and a height of 60 metres this represented approximately 20 000 tonnes. Access was now available on 5 level, 8 level and the newly developed 6 level. At the far end a rise already existed from 8 level up to 5 level. The hangingwall and footwall both appeared to be regular and straight with a sharp change in dip approximately ten metres above 8 level (Figure 3).

Production constraints demanded that mining of this ore begin immediately. Therefore, a small hand held stope was begun above 6 level, leaving a crown pillar of approximately 3 m above 6 level and mining within 4 m of 5 level (Figure 4).

Due to the constraints of the available drill rig, and the uncertainty of the ore outlined between 6 level, and 8 level it was decided to put in a small sublevel right at the change in dip of the ore. This was accessed from the existing rise between the two levels.

Once again production demands meant that the backs of this sublevel were stripped up to within five metres of 6 level leaving a pillar around the rise. This dirt was scraped down the rise to be picked up on 8 level, the main production level (Figure 5).

A mass firing of the 6 level floor and back pillar was now designed. Prior to drilling and blasting 27 cable bolts were grouted into the hangingwall on 6 level to act as a support mid stope. These were not tensioned.

Upholes and downholes were then drilled from 6 level. A total of 163 64 mm holes were drilled with a total drilling meterage of 815 m to break an estimated 4900 tonne of ore. Several wet upholes and downholes were encountered. These downholes were loaded using Anfo poured into lay-flat tubing and upholes loaded with packaged product. An attempt was made to blow load layflat tubing in the wet upholes, but the layflat was torn to shreds by the air and Anfo. Downholes were blocked off using shuttlecocks and bailing twine.

All holes were initiated using a combination of short period and long period Nonel detonators to give the required number of delays. Prior to firing this shot a second rise was put through between 6 level and 8 level to maintain through ventilation after firing and for exploration.

This broken dirt was then mucked from 8 level. When the original rise was once again open the 8 level brow was retreated by firing 10 m upholes. This also allowed recovery of the ore caught on the original 7 level (Figure 6).

The final stage of the stope was to fire out the 5 level crown pillar. It was decided to take out both the floor of 5 level and the backs to break through into the old 4 level stope. It was then expected that the original fill contained in the stope above would cave onnto the blasted ore at the bottom of the stope. The stope would then be drawn from two additional drawpoints driven off an 8 level bypass under caving conditions. It was expected that this cave fill would also be zinc rich.

Unfortunately because of inaccurate historical survey data and difficult drill rig set up the resultant blast did not break through into the old stopes and an undeterminant skin of ore was left above 5 level.

The final as reconciled stope and development tonnage of this block was 23 300 tonne which was mined out over a period of six months.

Future mining

Diamond drilling has shown that the ore body continues at depth. A decline has been driven down to gain access to 9 level and 10 level and two blocks of ore are to be stoped out. Development

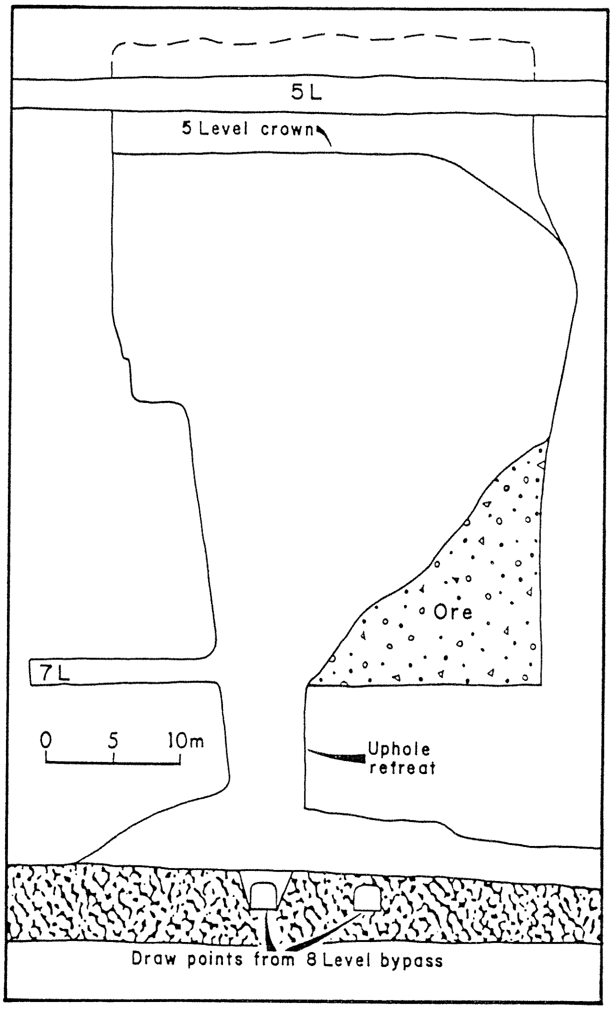


FIG 6 - Stope outline after firing 6 level pillar and during 8 level uphole retreat. Note 5 level pillar still to be mined.

further through the spur has been carried out on both 6 level and 8 level with little encouragement.

Owing to the record low zinc prices and the ever-increasing tramming distances, up the decline further development below this point or further into the spur appears unlikely in the near future.

SERVICES

All electric power is generated on site by a 250 kVA Dorman gen set, and reticulated at 240 volt to both surface and underground.

Compressed air is produced from two mobile diesel air compressors, capable of producing a total air load in the order of 2000 cfm. Generally only one unit is required at any time. Air is reticulated to the upper adits and underground on each level through 64 mm poly pipe.

Water is collected from further up the Comet creek and gravity-fed to two header tanks using rural poly pipe. From the header tanks it is gravity fed throughout the mine in 25 mm poly pipe. This supply has never run dry and can supply well in excess of current requirements.

Primary ventilation is achieved using a 35 kW exhaust fan mounted at the adit on 5 level. Air is then drawn in through the other portals. Auxiliary air is provided by either a 40 kW or 15 kW fan as required or by air driven fans during development.

Pumping is only required in the decline since each level is self draining.

EQUIPMENT

Three underground mucking units are currently on site:

- Wagner ST2D Diesel load haul dump unit,
- Wagner ST1.3 Diesel Load Haul Dump unit, and
- Toro 250 Diesel Load Haul Dump unit.

All of the above are used for development when required. The larger two being primarily used for production.

The 2.1 km surface haulage from the mine site to the main ore stockpiles over steep terrain is carried out using 25 tonne Moxy six wheel drive trucks. From this stockpile the ore is shipped to Rosebery using contracted 25 tonne semi-tippers.

BUILDINGS AND OTHER INFRASTRUCTURE

On site, two shipping containers have been modified into storage areas, change room and crib room. The containers are separated by a distance of ten metres and the area between has been roofed over to form a workshop.

A mobile office has been established with a radio telephone link.

Two licensed transportable magazines are on site for explosive storage. Anfo is mixed on site.

Diesel is brought onto site and stored in two mobile 5000 litre trailer tanks.

MANPOWER

Currently nine men are employed on surface and underground including the foreman and two fitters. All men are on an hourly rate. A five-day week is worked on a two-shift basis as needed. Overtime is worked as required. This workforce is based in Zeehan and Rosebery and commutes daily to the mine.

Additional technical and planning requirements are provided as needed by F W Lannen and Associates.

ENVIRONMENTAL

Originally a temperate rainforest area, the landscape has been degraded by a succession of previous mining operations from the 1890 onwards. The area has been recognised for protection.

Although not a pristine wilderness the site still requires considerable environmental awareness. Before mining commenced a detailed environmental management plan was written internally and submitted to the Mines Department.

Fortunately this document was able to draw upon examples of the existing natural revegetation that had taken place after successive known and dated mining phases. These provided a unique opportunity to study the actual revegetation sequences over given time periods. This meant that a plan could be produced that was supported by actual proven examples of revegetation.

On-going monitoring of mine discharge is carried out with regular down river water samples being taken and analysed for metal contamination. All mine runoff is collected by sediment dams and drains to prevent silting of the river. Extensive batter re-contouring has been carried out in the open cut and topsoil replaced. An on-going revegetation program around all distributed portal areas and surface roads is also carried out. From the documented examples around the site the most effective method to achieve rehabilitation is by laying a mat of tea-tree onto the soil and planting the tea-tree seed. This initiates the first revegetated sequence. From the protection of the thick stands of tea-tree the original temperate rainforest is able to grow.

CONCLUSION

Our company was established in early-1990 with the following corporate goals:

- development and operation of small underground mines;
- provision of mining and geological consulting services; and
- provision of mine contracting services.

The start up and production from the South Comet mine, despite the depressed zinc market and small size of the orebody has proven the concept, that small scale mining of orebodies, often overlooked by the larger mining houses, can be mined well and profitably in a professional and technical manner.

We are now actively seeking, through our contract mining subsidiary, Mancala Pty Ltd, other small orebodies in eastern Australia, to operate on a similar basis to the South Comet Mine.

REFERENCES

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Environmental Geology of The Dundas Drainage Basin

Jeremy S. Lawrence BSc.

A research thesis submitted for partial fulfilment of the requirements of the degree of Bachelor of Science with Honours.

Centre for Ore Deposits and Exploration Studies
University of Tasmania

May 1996

Abstract

Mining and associated activities in the Dundas region, north-west of Zeehan, have disturbed the natural environment. The area around the old town of Dundas has been mined since the 1880's mostly for lead-zinc and silver, and tin.

The lead-zinc-silver deposits are vein style, found in the numerous faults in the area. The most recently mined deposits of this type are the South Comet, Red Lead and Adelaide Mines. The Razorback Mine is the largest mine in the region and was worked by opencut for tin.

ARC-INFO was used to store and manipulate the data compiled for this study. The database contains height contours, drainage, roads, mine sites, geology, a digital elevation model (DEM), flow direction, flow accumulation and water sampling data. This database will be stored at the Mines Department and DELM as part of a statewide database concerned with mining related environmental problems

The geology of the area consists of Precambrian and Cambrian sediments and Cambrian serpentinised ultramafics and Jurassic dolerite. The mineralisation is fault controlled and zoned around the Pine Hill Granite. The South Comet Mine was mineralised in three stages. Stage I mineralisation is dominated by sphalerite and pyrite with minor galena. Stage's II and III are dominated by siderite. Stage III containing minor sphalerite and galena. The Red Lead and Adelaide Mines are Lead zinc vein deposits, now mined for the supergene ornamental mineral Crocoite. The Razorback mineralisation is tin in massive pyrrhotite, the richest ore in the supergene zone.

The major aesthetic impacts in the Dundas region results from the denudation of areas surrounding the South Comet, Red Lead and Razorback mines. The Adelaide Mine contributed minor aesthetic impact in comparison.

Fifteen water sample sites characterised the water quality in the Dundas Basin. The sample sites were concentrated around the South Comet, Razorback, Red Lead and Adelaide Mines. Acidified (2% HNO_3)and unacidified samples were analysed for Al, Mn, Fe, Cu, Zn, Cd, Sn, Pb, pH, temperature, sulphate and alkalinity (ppm $CaCO_3$). The discharge of the rivers was measured while sampling so mass load of metals could be

calculated. Rainfall data was compared with the water analyses to determine variation of contaminants under differing climatic conditions.

Elevated metal values of 1-6 ppm Fe, 0.5-15 ppm Mn, 0.76-13 ppm Zn, 0.51 ppm Cd and 0.02 ppm Pb found in South Comet Creek were attributed to South Comet Mine. Also a pH decrease of 0.6 units and a sulphate increase of 2-117 ppm in South Comet Creek originated at South Comet Mine. A 1 ppm increase in iron in the Dundas river was attributed to the Razorback mine

Duplicate samples revealed that Mn, Zn, Sn, and Fe were reliably sampled. Variations in Cd and Pb was attributed to particulate matter in the samples.

Rehabilitation at the Red Lead and Razorback mines requires consultation with the lease holders to design an environmental management. This should address the denudation, topographical alteration, waste dump placement at the mine sites.

Revegetation, construction of a wetland filter system and removal of waste rock from South Comet Creek will alleviate the heavy metal pollution problems at South Comet Mine.

The Denudation at the Razorback mine is being rehabilitated by an intensive revegetation program, this revegetation should be expanded to include the opencut. Fencing the hazardous areas of the opencut, and capping the open adits will remove the safety problems at this site.

basin, above the point where the Dundas river and the Murchison Highway intersect (Figure 1.2).

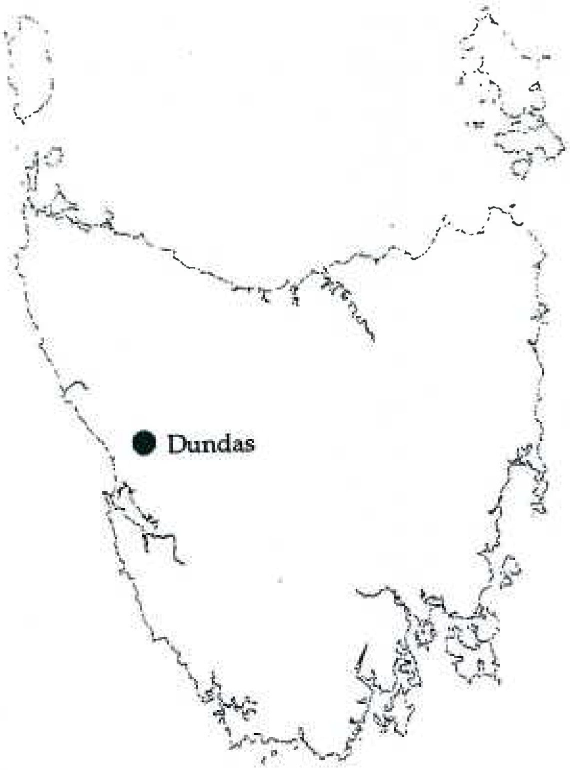


Figure 1.1 Location of Dundas

Access to all major mine sites was gained by two wheel drive vehicles along unsealed roads which leave the Murchison Highway approximately 500m north of the Zeehan turnoff (Figure 1.2). A number of the water sampling sites required walking through thick scrub to gain access.

1.4 Mining History

Most of the economic mineralisation in the Dundas Mineral Field was associated with the intrusion of the Devonian Pine Hill granite (Blissett, 1962; Kitto, 1994; Innes, 1995). The most economically important mineralisation in the area is tin in massive pyrrhotite. The largest producer of tin in the field area is the Razorback Mine. Alluvial gold was discovered near the present location of the Razorback Mine in 1909. In 1918 a processing mill was installed and the mine has been worked on and off until its closure in 1978. In this time the mine produced 180,000 tons or ore at 0.6% Sn and it still contains estimated reserves of 590,000 tons at 0.85% Sn (Collins et al., 1989).

The other major mineralisation worked in the Dundas area is polymetalic vein styles on the foothills of Mt Dundas. Galena was first discovered in the Dundas district in 1889. After this a large number of sites were pegged and subsequently Dundas was connected by a branch line to the Zeehan-Strahan railway. The major mines in the area were the Comet, Maestries, West Comet, Adelaide, and South Comet mines. After 1913 all of the mines except for the South Comet had ceased production. The only mining activity which remains in the region today is the extraction of crocoite from the Red Lead and Adelaide mines. The production from these mines up to 1962 is summarised in Table 1.1

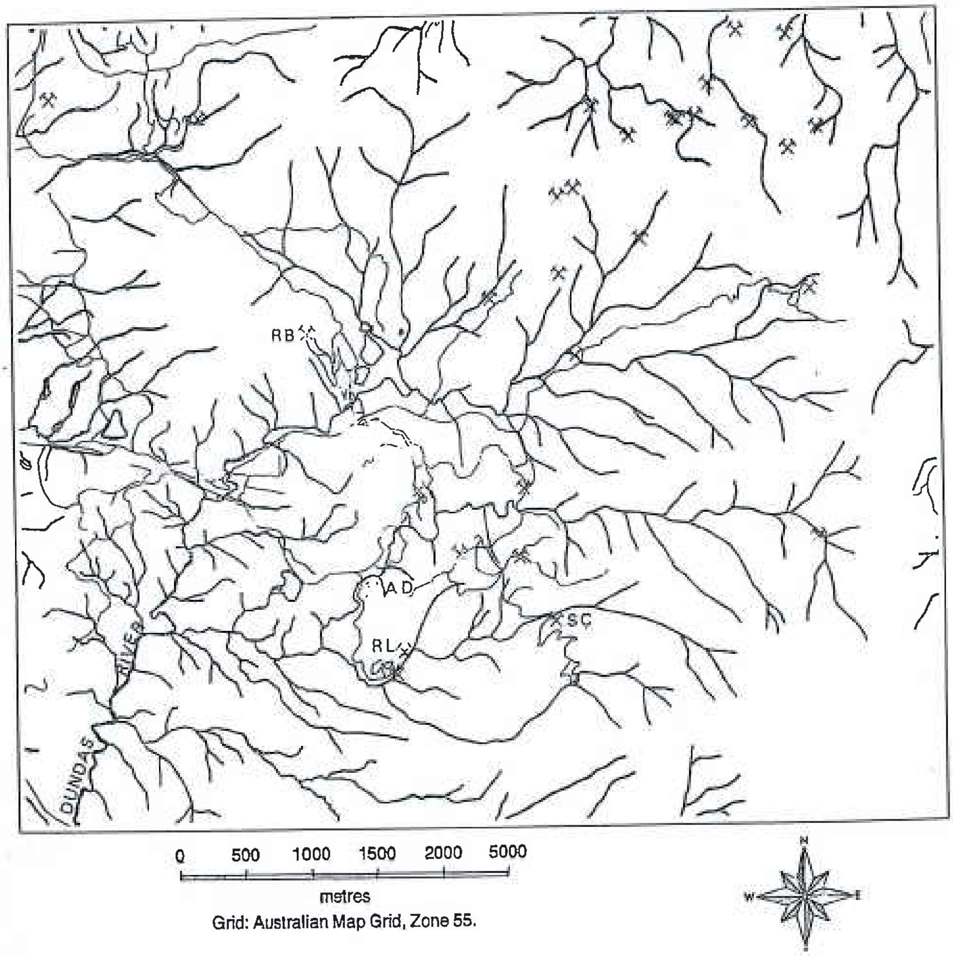


Figure 1.2 The studies field area shown with rivers and access roads.

Table 1-1 Lead, Zinc and Silver production in the Dundas Field (from Blissett, 1962).

Mine	Lead (Tons)	Silver (Ozs)	Zinc (Tons)
Comet-Maestries	21,850	1,510,000	
West Comet	2,700	270,000	
South Comet	428	27,718	618.5
Kominski	10	480	
Miscellaneous	62	7,394	11
	25,050	**1,815,592**	**629.5**

1.5 Aims

The project aims to

1) Produce a GIS data base for the Dundas mining district, with emphasis on information useful to the environmental assessment of the region. This information will be integrated into new databases being established at the Department of the Environment and Land Management (DELM) and Mineral Resources Tasmania.

2) Review the geology of the Red Lead, South Comet, and Razorback mines.

3) Assess the environmental impact of mining at these three sites concentrating on the differences in water quality above and below the sites.

4) Make recommendations for the environmental rehabilitation and remediation required in the region, in particular around the Red Lead South Comet and Razorback Mines.

pollution is prone to remobilisation if a pulse of high acid water flows down the waterway, causing a burst of highly polluted water.

ANZECC (1992) has provided guidelines for acceptable levels of various heavy metal toxins (Table 2.6). Some of these guidelines are considered unsuitable for Tasmanian waters, especially with regards to iron and manganese (Thomas and Brett, 1995; Koehnken, 1992a). The ANZECC guidelines provide information regarding the harmful effects of each of these toxicants, as summarised below.

2.5.4.1 Aluminium

The bio-availability and toxicity of aluminium is greatest in acidic waters, reaching a maximum at pH 5-5.2. Aluminium in acidic waters is known to be toxic to fish (Dillon et al., 1984 in ANZECC, 1992), amphibians (Andren et al., 1988 in ANZECC, 1992) and phytoplankton (Folsom et al. 1986; Claesson and Tornqvist, 1988 in ANZECC, 1992). Under neutral pH conditions, the toxicity of aluminium is greatly reduced.

Metal	*Minimum pH–hydroxides*	*Minimum pH–other salts*
Sn	4·2	
Fe(III)	4·3	
Al	5·2	
Pb(II)	6·3	6·0
Cu(II)	7·2	5·3
Zn	8·4	7·0
Ni	9·3	
Fe(II)	9·5	
Cd	9·7	
Mn(II)	10·6	

[a] Compiled from data in Down and Stocks (1977) and Eyres and Pugh-Thomas (1978).

Table 2-5 Minimum pH values for complete precipitation of metal ions as hydroxides or other salts (from Kelly, 1988).

5. Aesthetic Impact

5.1 Introduction

Visual impact assessment is essential in evaluating the environmental impact of any mining activities. Such assessment is subjective, therefore, in this chapter I will attempt to describe the visual impacts associated with mining activities in the Dundas Mineral Field, without drawing value judgments.

The denudation of ground related to surface mining and land clearance represents the major form of visual alteration in the Dundas region. This denudation is both directly and indirectly related to mining activity. Directly, where clearance has been required for extraction of ore; and indirectly, where land has been cleared in the old township for the purpose of dwellings, and where roads have been made to allow access.

Within the abandoned township of Dundas recolonisation, by the local flora has been extensive. This leads to optimism that if the rehabilitation of the major mine sites is adequate, their visual impact will be minimal in the long term.

5.2 South Comet

Activity at the South Comet Mine (1880-1992) has resulted in denudation of vegetation along the fault lineation on which the mine is situated. This has left an exposure of red soil 20 - 40 m wide and approximately 750 m long, on the NW flank of Mt Dundas. This bare red soil is visible from much of the higher ground to the west, see Plate 5.1.

Plate 5.1 View of the South Comet Mine from the west.

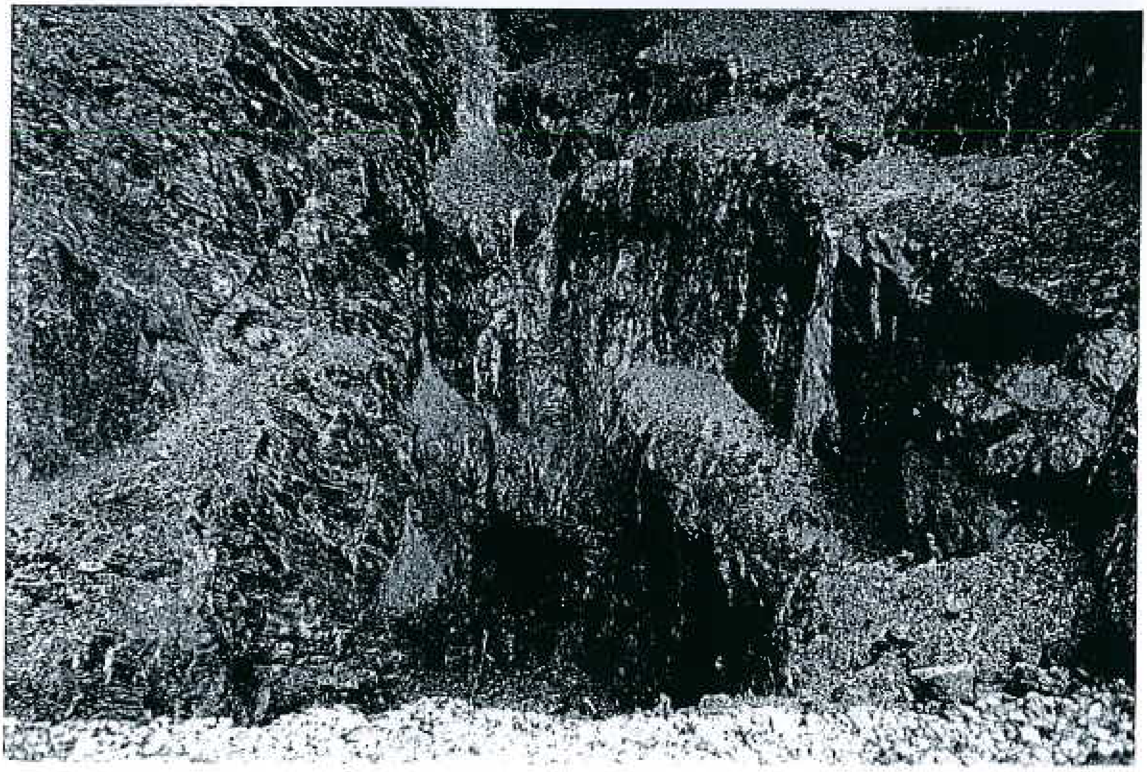


Plate 5.2 Small opencut 300m south east of the main adit at the South Comet Mine

At the crest of the ridge on which the mine is situated the topography has been altered by construction of a trench and a small open cut (Plate 5.2). At the lowest level an area of land approximately 50 m^2 has been leveled for car parking facilities and machinery movement. The road which cuts its way up the hill is the most prominent visual feature associated with the mine (Plate 5.1).

Relict buildings and machinery (Plates 5.3 and 5.4) remain around the mine site and some old hosing and wiring litters the area. A distinctive red sediment coats the bed of the stream draining the mine adits and waste dumps (Plate 5.5).

Plate 5.3 Relict building at the South Comet Mine

Plate 5.4 Old machinery left at the South Comet Mine site

Plate 5.5 Red stained drainage systems at the South Comet Mine. The rehabilitated adit entrance occurs at the upper right hand side of this plate, behind the black soil.

5.3 Razorback

The Razorback Mine is visible for some distance to the south and south-east (Plate 5.6). The dominant visual feature is the open cut which cuts parallel to the eastern flank of Mt Razorback. The visual impact of the opencut is minimised to the north east because of this parallel nature. From the south and south-east of the mine the open cut is clearly visible both as a change in the natural topography and as a denudation of the hill (Plate 5.6)

Activity at the Razorback Mine has resulted in the exposure of a broad area of bare earth related to mining and the processing of the ore. Large concrete slabs remain at the front of mine site. These slabs have been made to fit the local topography however they will not facilitate regrowth. Much of the bare ground surrounding the opencut has been contoured to fit the local topography and regrowth, both natural and planted, is proceeding well.

There are three large tailings ponds associated with the Razorback mine, creating a large alteration of the natural environment. However, they are rarely visible because they are flat lying and well vegetated (Plate 5.7).

5.4 Red Lead

The Red Lead Mine represents the largest surface mining activity in the field area. The extraction of ore from this area involved the removal of approximately 20,000 m^3 of earth. The areal extent of clearance is approximately 2.5km^2 area (Fig 5.8). Because of the mine's position on a south facing slope it is not clearly visible from any access roads.

As the Red Lead Mine is still active, no attempt has yet been made to rehabilitate the site. From an aesthetic point of view this will pose the greatest rehabilitation challenge in the field area.

Plate 5.6 The opencut at the Razorback Mine viewed from the south east.

Plate 5.7 The middle Razorback Tailings Dam

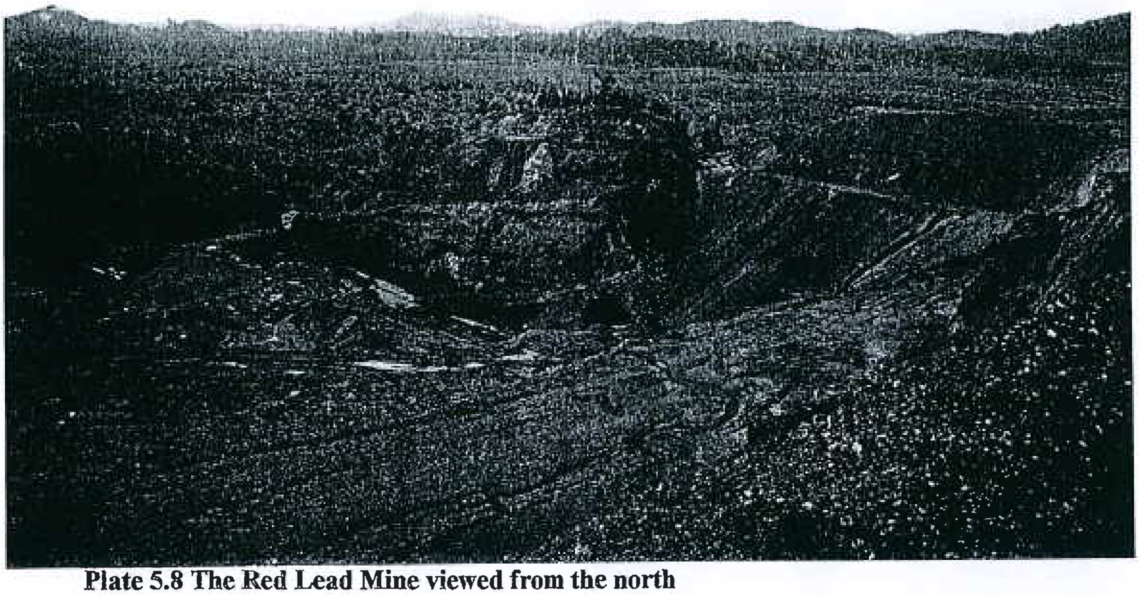


Plate 5.8 The Red Lead Mine viewed from the north

6. Water Quality

6.1 Water Sampling

Fifteen sampling sites were chosen within the study area. The main objectives of this sampling was to allow a characterisation of the drainage basin and attempt to identify potential point sources of water pollution. The selected site locations are shown with respect to the drainage and mine locations on Figure 6.1.

Sampling locations were more heavily concentrated around the recently abandoned South Comet and Razorback Mines, and the active mine sites at the Red Lead and Adelaide Mines. This was done to ascertain the environmental impact of these mining activities. The assumption was made at the beginning of the project that these larger sulphide mines would contain the largest amount of exposed sulphides, and therefore represent the largest threat of contamination to the fresh water environment in the Dundas area.

The river beds at all of the following water sample locations consisted of boulders and sand sized sediments, except those which are specifically noted to have been otherwise.

Site 1 was located at the point where the Murchison Highway crosses the Dundas River (Figure 6.1). This site represents the total output from the Drainage basin. Site 1 was used to identify all AMD and heavy metal pollution emanating from the basin, and to identify any water pollution problems which may be incurred outside the field area.

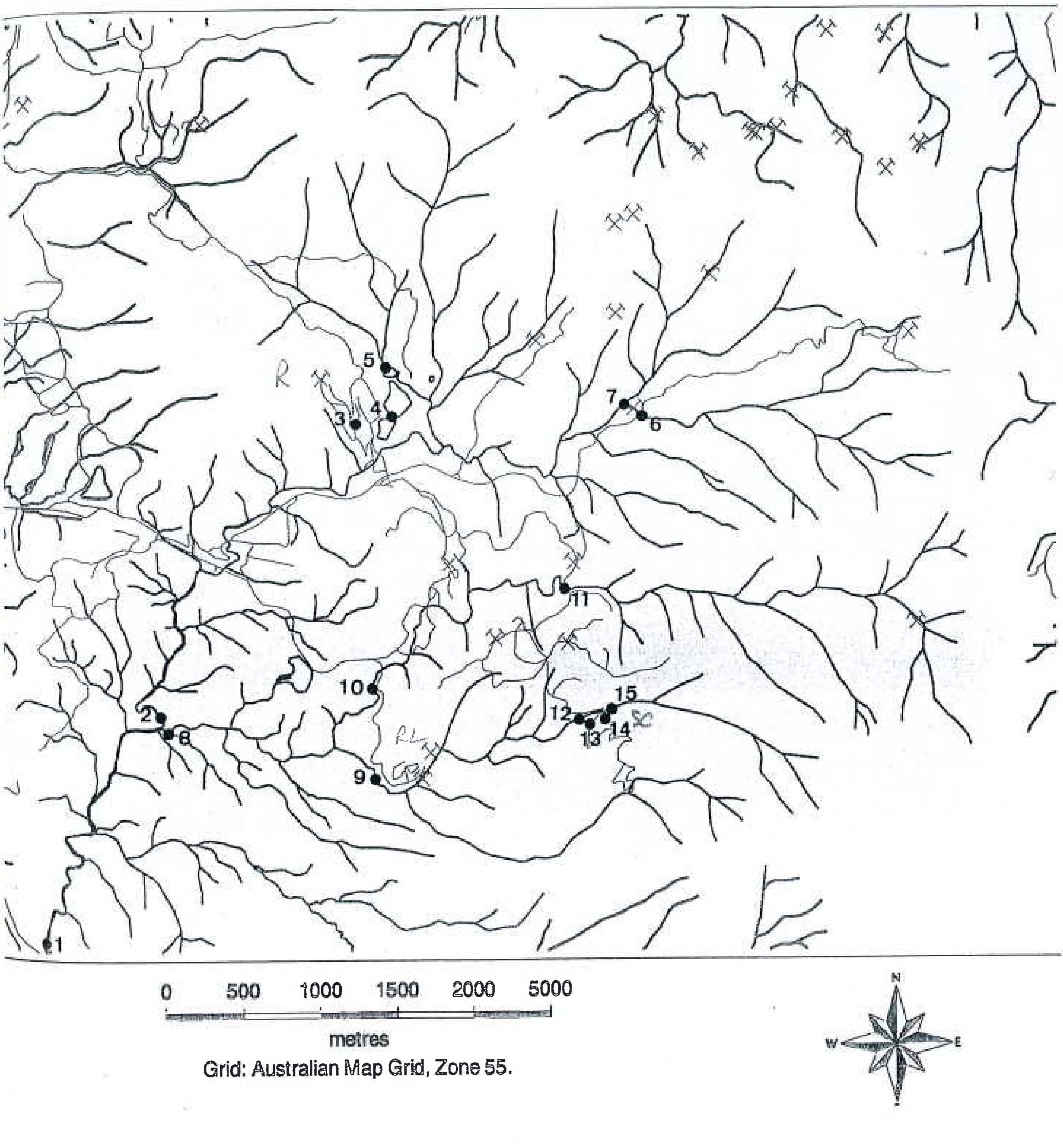


Figure 6-1 Sampling site locations

R Razorback
6+7 Ambient water quality
RL Read Lead
SC South Comet

Site 2 was located in the Dundas River above Comet Creek (Figure 6.1). This site was selected to characterise waters from the northern most extremities of the drainage basin.

Site 3 was located in the mine drainage flowing from the Razorback Open Cut (Figure 6.1). This water was predominantly clear, but a thick orange precipitate, and not boulders and sand, lined the stream bed. This stream flows into the bottom tailings dam at the Razorback Mine, which is adjacent to the Dundas River. No surface water was seen flowing between this dam and the Dundas River.

Site 4 was located at the southern end of the middle tailings dam at the Razorback Mine (Figure 6.1). This dam is located approximately 200m from the Dundas River. At the northern end of the tailings dam water flows from this dam, via a creek, into the Dundas River.

Site 5 was located in the creek above the highest tailings pond at the Razorback Mine (Figure 6.1). It generally has low flow rate, and under low flow conditions no surface water is present.

Site 6 was located in the Dundas River above Concert Creek (Figure 6.1). This site was chosen to give an ambient background water quality for the NE of the drainage basin, and to ascertain if any significant pollution emanates from this region.

Site 7 was located in Concert Creek above the Dundas River (Figure 6.1). It was used to ascertain the ambient background water quality for the NW of the field area, and identify water pollution problems in this area.

Site 8 was located in Comet Creek above the Dundas River (Figure 6.1). It was selected to characterise the waters originating in the south of the field area, with attention given to the severity of any pollution problems.

Site 9 was located in the Adelaide Mine Creek below the Red Lead Mine (Figure 6.1). In combination with data from below the South Comet Mine (site 12), the impact of mining at the Red Lead Mine may be ascertained.

Site 10 was located approximately 50m down stream from the Adelaide Mine in Comet Creek (Figure 6.1). When compared with data from the upper Comet Creek (site 11), an assessment of the effect of the Adelaide Mine on water quality can be made.

Site 11 was located in Comet Creek below the road to the South Comet Mine (Figure 6.1). It was chosen to characterise waters above the Adelaide Mine, and to identify any water pollution up stream of this site. The waters at this site were clear at all sampling times. Under low flow conditions a minor amount of orange precipitate lined the creek bed.

Site 12 was located approximately 100m downstream of the South Comet Tailings Dam (site 13) in the South Comet Creek (Figure 6.1). This site was chosen to determine the effect of the South Comet Mine on the water quality of South Comet Creek through comparison with data from South Comet Creek above South Comet Mine (Site 15). After relatively dry periods the creek bed was lined with an orange precipitate, but following periods of high flow the precipitate was removed.

Site 13 was located in the South Comet Mine Tailings Dam (Figure 6.1). Drainage from the mine (site 14) is directed into this dam. It is located 20m south of South Comet Creek, and under high rainfall conditions, the water level rises and over flow is expelled into an area adjacent to the creek.

Site 14 was located at the exit from the 8 level adit at the South Comet Mine (Figure 6.1). This sample site was chosen to determine the water quality of the AMD emanating from the mine. The water was predominantly clear, but an orange precipitate lined the stream bed. The creek bed contained no boulders, with the sediment being silt sized. Flow rates from this adit were generally very low.

Site 15 is located in the South Comet Creek above the South Comet Mine (Figure 6.1). It was chosen to give an ambient background water quality before the influence of the South Comet Mine.

During the first two sampling runs (8th of November and 15th of December) only sites 1,2,3,6,12,14 and 15 were sampled. Upon revaluation of results the remaining sampling sites were added for the remainder of the project.

6.2 Sampling

Single water samples were collected from each site in acid washed polypropylene containers. These bottles were rinsed three times in the water which was to be sampled, and then filled from as near as practical to the centre of the creek. Where possible, the nozzle of the bottle was held beneath the water surface, avoiding the collection of surface borne debris.

Upon return to the laboratory these samples were agitated and then divided into two bottles. One sample was acidified with laboratory standard concentrated HNO_3, so that it contained 2% acid. The other sample was left unacidified. Where possible, the pH, conductivity and temperature were measured in the field. When this was not possible measurements were obtained back at the laboratory. Some duplication of sampling was done in the field to check the sample repeatability.

6.3 Analysis

The acidified samples were left for at least 48 hours to ensure that any metals which may have precipitated out of solution , or been adsorbed onto the plastic bottle were redissolved into the sample. The acidified samples were then quantitatively analysed at the Central Science Laboratory (CSL), University of Tasmania, for heavy metals. This was done using the inductively coupled mass spectrometer (ICP-MS) with samples diluted at 1:50 in distilled water. The metals analysed were Al, Cu, Pb, Zn, Sn, Cd, Fe and Mn.

The unacidified samples were quantitatively analysed at the Government Analysts Laboratories for sulphate and alkalinity. The alkalinity was measured as ppm of $CaCO_3$.

6.4 Discharge

The discharge at any site is an important factor in determining the level of pollution, because it allows a conversion of data from concentrations to mass loads (unit weight/unit time). Hence, a knowledge of the weight of pollutant being discharged into the receiving environment is gained.

To measure the discharge of a river two variables are required. The cross sectional area, and flow rate. These two variables can be combined to calculate the discharge, as follows

(Dunne and Leopold, 1978):

$$Q = (v \times F \times c) \div 1000 \quad \text{(Equation 6.1)}$$

Where Q = discharge (L/s)
v = velocity of flow (cm/s)
F = cross section of flow
c = constant (accounting for turbulence)
c = 0.5 (dense undergrowth)
= 0.8 - 0.9 (no dense undergrowth or coarse pebbles)

The cross sectional area of the streams were recorded in the field by recording an average depth, and a width measurement. Where the majority of flow (>95%, estimated) was through one major channel, the cross section of that channel was recorded.

The flow rate was measured in the field using a variation of the float method described in Dunne and Leopold (1978). This method is primitive, however, in the absence of flow meters and permanent flow measuring devices, such as weirs, it was the only method available. The method described by Dunne and Leopold (1978) required the measurement of the time taken for the float to travel 30m. In this study the distance was reduced to 2 or 3m because the highly variable stream geometry.

Once the discharge has been calculated and the pollutant concentrations measured the conversion into mass loads was calculated using the following equation:

$$ML = Q \times C \qquad \text{(Equation 6.2)}$$

where ML = mass load (mg/unit time)
Q = discharge
C = concentration (mg/L)

6.5 Rainfall Data

The daily rainfall data for Zeehan (the nearest manned rain gauge) was obtained from the Bureau of Meteorology, Hobart, for the six months prior to 16th May. This data was compared with water quality data to ascertain if their are any correlations which can be drawn. The rainfall data set is incomplete, with some days remaining unmeasured.

6.6 Results

The heavy metal concentrations, pH, conductivity, temperature, sulphate concentrations, and alkalinity are shown in Table 6.1. The spatial variation of the measured chemical and physical analysis are shown in Figures 6.2-6.12. For the purpose of displaying the data spatially, the data from each sample run was grouped (ie., the data marked 8/2/1996 represents the data from the 8th to the 10th of February). Therefore, some of the variation seen in Figures 6.2-6.12 may be related temporal events. The variation of elements over time at each site is shown in Figure 6.13. The rainfall for the 20 days prior to each sampling run is shown in Figure 6.14. The discharge for each sampling time is shown in Table 6.2. The spatial variation in metal mass loads are shown in Figures 6.15-6.20.

Table 6.1 Chemical and physical results of testing

location number		location name	date	Al	Mn	Fe	Cu	Zn	Cd	Sn	Pb	pH	Cond	Eh	Temp	Sulphate	Alkalinity
		Units		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		uS	mV	C	ppm	ppm CaCO3
		Blank Water		0.004	0.006	0.01	0.007	0.005	<0.001	0.003	0.001						
		2% HNO3		0.006	0.005	0.008	0.008	0.016	<0.001	0.002	0.002						
1		Dundas River at Murchison Hwy	8/11/95	0.050	0.387	0.305	0.001	0.254	0.001	0.001	0.001	6.41	105.0	29	12.1		
1		Dundas River at Murchison Hwy	15/12/95	0.073	0.217	0.274	0.001	0.187	0.001	0.001	0.001		55.7				
1	1	Dundas River at Murchison Hwy	10/2/96	0.001	0.700	0.001	0.001	1.400	0.001	0.001	0.001			428	13.5	7.440	1.4
1	2	Dundas River at Murchison Hwy	10/2/96	0.001	0.600	0.900	0.001	1.400	0.001	0.300	0.001					9.502	4.9
1		Dundas River at Murchison Hwy	16/3/96	0.210	0.177	0.782	0.001	0.111	0.001	0.001	0.039	6.50	212.0	190	11.8	4.270	7.8
2	2	Dundas River above Comet Creek	8/11/95	0.001	0.295	0.469	0.001	0.182	0.001	0.001	0.006	6.67	78.0	47	11.5		
2	2	Dundas River above Comet Creek	15/12/95	0.087	0.190	0.389	0.001	0.121	0.001	0.001	0.001		65.0				
2		Dundas River above Comet Creek	9/2/96	0.800	0.600	1.300	0.001	0.001	0.001	0.001	0.100	5.40		35	11.3	4.236	2.8
2		Dundas River above Comet Creek	16/3/96	0.415	0.912	2.737	0.001	0.348	0.006	0.001	0.204	6.40	119.0	153	12.5	4.794	4.8
3		Razorback Mine Drainage	8/11/95	0.001	1.110	7.201	0.001	1.013	0.006	0.001	0.037	5.80	151.0	12	10.2		
3		Razorback Mine Drainage	15/12/95	0.001	1.188	8.279	0.001	0.919	0.011	0.001	0.028		117.0				
3		Razorback Mine Drainage	10/2/96	0.800	4.800	81.000	0.001	4.300	0.400	0.300	0.300			390	11.2	357.600	0.0
3		Razorback Mine Drainage	16/3/96	0.164	1.608	7.355	0.001	1.203	0.010	0.001	0.059	6.20	875.0	100	10.6	74.580	34.3
4	1	Razorback Tailings Dam	10/2/96	0.001	1.200	1.200	0.001	1.400	0.001	0.300	0.001			390	16.5	10.090	8.1
4	2	Razorback Tailings Dam	10/2/96	0.001	0.900	1.100	0.001	0.900	0.001	0.300	0.100					6.988	0.0
4		Razorback Tailings Dam	16/3/96	0.001	0.926	0.305	0.001	0.178	0.001	0.001	0.024	6.80	415.0	20	14.8	16.306	18.6
5		River above Razorback Tailings Dam	16/3/96	0.059	<0.100	0.443	<0.050	0.040	<0.006	<0.015	<0.005	5.50	306.0	10	12.8	2.566	26.7
6		Dundas River above Concert Creek	8/11/95	0.050	0.269	0.582	0.001	0.254	0.001	0.001	0.008	5.30	67.0	31	10.1		
6		Dundas River above Concert Creek	15/12/95	0.118	0.125	0.456	0.001	0.159	0.001	0.001	0.001		56.0				
6	1	Dundas River above Concert Creek	10/2/96	0.800	0.001	1.100	0.001	0.500	0.300	0.300	0.001			430	11.0	3.334	0.0
6	2	Dundas River above Concert Creek	10/2/96	0.900	0.001	0.001	0.001	0.800	0.001	0.001	0.100					1.844	0.0
6		Dundas River above Concert Creek	15/3/96	0.109	0.001	0.428	0.001	0.064	0.001	0.001	0.001	7.00	120.0	19	10.7	6.668	7.7
7		Concert Creek above Dundas River	10/2/96	0.001	0.800	0.001	0.001	1.300	0.001	0.200	0.001			452	11.0	3.844	1.5
7		Concert Creek above Dundas River	15/3/96	0.001	0.138	0.197	0.001	0.064	0.001	0.001	0.001	6.40	287.0	65	10.7	5.588	14.2
8		Comet Creek above Dundas River	10/2/96	0.500	1.000	1.200	0.001	1.900	0.100	0.300	0.200	5.40		80	10.7	8.388	2.8
8		Comet Creek above Dundas River	16/3/96	0.278	0.991	1.352	0.001	0.539	0.001	0.001	0.249	6.30	223.0	225	13.4	9.910	4.5
9		Adelaide Mine Creek below Red Lead Mine	8/2/96	0.001	1.400	0.001	0.800	3.200	0.001	0.001	0.001	5.60		80	11.1	19.644	9.1
9		Adelaide Mine Creek below Red Lead Mine	16/3/96	0.551	2.134	2.429	0.001	1.393	0.010	0.001	0.441	6.40	283.0	250	13.4	18.144	4.8
10	1	Comet Creek below Adelaide Mine	8/2/96	0.001	0.500	0.001	0.001	0.500	0.001	0.001	0.001	5.30		111	11.3	9.036	11.8
10	2	Comet Creek below Adelaide Mine	8/2/96	0.001	0.800	0.001	0.001	1.000	0.001	0.001	0.001					5.078	8.1
10		Comet Creek below Adelaide Mine	16/3/96	1.006	1.017	3.815	0.001	0.102	0.001	0.001	0.263	6.60	146.0	131	13.4	2.674	4.3
11		Comet Creek Below last Road Crossing	10/2/96	0.001	0.500	0.001	0.001	1.000	0.001	0.300	0.001			285	10.8	4.126	1.2
11	1	Comet Creek Below last Road Crossing	15/3/96	0.096	0.926	0.890	0.001	0.083	0.001	0.001	0.012	6.50	318.0			5.916	21.7
11	2	Comet Creek Below last Road Crossing	15/3/96	0.001	0.690	0.812	0.001	0.045	0.001	0.001	0.013	6.30	324.0	52	10.5	6.470	21.2
12		South Comet Creek below South Comet mine	8/11/95	0.050	0.821	0.351	0.001	0.778	0.006	0.001	0.039	5.80	50.0	6	8.5		
12		South Comet Creek below South Comet mine	15/12/95	0.064	2.921	0.339	0.001	2.628	0.015	0.001	0.024		87.0				
12	1	South Comet Creek below South Comet mine	10/2/96	0.001	2.000	0.001	0.001	1.900	0.300	0.300	0.200			349	10.0	6.038	1.7
12	2	South Comet Creek below South Comet mine	10/2/96	0.500	0.800	0.001	0.001	0.900	0.100	0.200	0.100					8.762	0.0
12		South Comet Creek below South Comet mine	15/3/96	0.001	15.001	0.413	0.001	13.266	0.051	0.001	0.057	6.00	1242.0	40	11.2	176.500	7.9
13		South Comet Mine Tailings Dam	10/2/96	0.800	101.000	3.000	0.001	57.000	0.600	0.300	1.000			392	15.0	739.600	0.0
13		South Comet Mine Tailings Dam	15/3/96	0.001	0.873	1.121	0.001	75.956	0.267	0.001	0.071	6.00	4810.0	152	13.5	954.600	19.5
14		Drainage From bottom adit South Comet Mine	8/11/95	0.073	77.370	4.584	0.001	61.700	0.228	0.001	0.129	5.66	771.0	15	11.7		
14		Drainage From bottom adit South Comet Mine	15/12/95	0.001	79.996	5.278	0.001	61.700	0.254	0.001	0.088		980.0				
14		Drainage From bottom adit South Comet Mine	10/2/96	0.001	1,020.000	6.000	0.001	66.000	0.600	0.200	0.300			350	16.7	1,068.800	18.2
14		Drainage From bottom adit South Comet Mine	15/3/96	0.001	79.996	4.892	0.001	64.558	0.229	0.001	0.075	6.10	1739.0	100	10.3	919.800	27.4
15		South Comet Creek Above South Comet Mine	8/11/95	0.050	0.001	0.197	0.001	0.001	0.001	0.001	0.001	6.18	40.0	13	7.6		
15		South Comet Creek Above South Comet Mine	15/12/95	0.073	0.001	0.212	0.001	0.035	0.001	0.001	0.001		39.0				
15		South Comet Creek Above South Comet Mine	10/2/96	0.001	0.500	1.000	0.001	0.001	0.300	0.300	0.100			275	10.0	4.514	2.3
15	1	South Comet Creek Above South Comet Mine	15/3/96	0.001	0.001	0.105	0.001	0.001	0.001	0.001	0.001	6.40	246.0			4.460	9.1
15	2	South Comet Creek Above South Comet Mine	15/3/96	0.001	0.001	0.105	0.001	0.049	0.001	0.001	0.001	6.80	240.0	115	9.8	4.194	9.2

6.7 Discussion

6.7.1 Rainfall

The rainfall prior to the first sampling run was relatively consistent, consequently, the rivers were constantly flushed. On the day of sampling the rainfall was only minor, 2.8 mm. This sampling run represents waters from a consistently rainy period.

The fortnight prior to the second sampling run was relatively dry, and with the exception of the 11th of December (25.2 mm) the 10 days prior to sampling all received less than 10 mm of rain. This sampling run is therefore representative of dry spells in the Dundas area.

The rainfall at the time of the third sampling run was minimal with only 0.8 mm. In the week preceding this sampling run there was considerable rain with over 30 mm on both the 1st and 2nd of February. Hence, this sampling run represents a dry spell after a period of considerable rain.

The week prior to the third sampling run was relatively dry, however on the second day of sampling (16th of March) 53.6 mm of rain fell. Therefore samples taken on the 16th of march represent the initial surge in waters after a dry spell and the samples from the 15th of March represent waters during a dry spell.

6.7.2 Metals

The analysis for metals was done in two separate batches with the samples from the third sampling run being done first. This was one of the first times the technicians at the CSL had used the ICP-MS, and some of the metal concentration reported for this sampling run seem to be abnormally high. Therefore, the concentrations from this set of analyses should be treated with some caution.

The sampling was done without the use of filters under the advice of DELM officers, to attempt to detect the total (dissolved and suspended) metal content of the waters. One downfall of this method is the possible contamination of the sample by large particular matter, causing the result of the analysis to be unrepresentative.

6.7.2.1 Aluminium

The Aluminium concentrations ranged from undetectable to 1.006 ppm (Site 10, Comet Creek below Adelaide Mine, 16th March 1996). The detection of aluminium is difficult on the ICP-MS (Townsend, verbal comm.) making the reliability of these results at such low concentrations dubious.

The Adelaide Mine Creek below Red Lead (Site 9) and the sites at and below South Comet Mine (Sites 12, 13 and 15) were periodically elevated in aluminium under medium to high rainfall conditions (Figure 6.2). No aluminium was detected at the South Comet Mine on the 15th of March, indicating that under low flow conditions the output of aluminium from this site may be lowered, however, on the 16th of March relatively high concentrations were detected downstream of South Comet Mine at sites 1 (0.21 ppm), 8 (0.30 ppm) and 9 (0.551 ppm). With the concentration being gradually lowered as sample becomes more distal to the source, possibly through dilution from entering streams. Periodically, the drainage (Site 3) and tailings dams (Site 4) at the Razorback Mine show slightly elevated aluminium values with the highest being 0.8 ppm in the mine drainage on the 8th of February. The Dundas River above Comet Creek (Site 2) showed elevated values (0.05 ppm to 0.118 ppm) on all sampling runs indicating a source of aluminium pollution in the north-east of the field area.

The problems with detection of aluminium on the ICP-MS in combination with the low detected concentrations leads to the assumption that the detectable aluminium pollution in the field area is negligible.

6.7.2.2 Manganese

Manganese ranged in concentration from undetectable in the pristine waters at sites 6 and 15 to 1020 ppm in the South Comet Mine drainage (site 14). All of the waters which pass through the recently mined areas contain elevated manganese values (Figure 6.3). The highest concentrations being detected at and downstream of the South Comet Mine. Figure 6.3 shows that with the exception of the 8th of February the South Comet Creek upstream of the South Comet Mine (Site 15) contained no detectable Manganese, and South Comet Creek below the mine contained between 15 and 0.8 ppm. This indicates that the manganese pollution of South Comet Creek is caused by South Comet Mine. The Manganese concentrations at all sites showed little variation with differing rainfall conditions (Figure 6.13), indicating that the concentration of manganese in the water is independent of the amount of rainfall. Consequently, the mass load of manganese is greatly increased under high rainfall conditions (Figure 6.16).

6.7.2.3 Iron

Those samples which were analysed for metals first (8th to the 10th of February) had a detection limit for iron of 0.9 ppm and in some cases iron remained undetected. However, the remainder of the samples had a lower iron detection limit and iron was detected in all samples. Discounting the samples with high detection limits, gives an iron concentration range of 0.105 ppm (South Comet Creek above South Comet Mine; 15th of March) to 91 ppm (Razorback Mine drainage, Site 3; 10th of February).

The variation in iron concentrations can be clearly seen in Figure 6.4. The highest concentrations consistently occurred at the Razorback Mine, especially in the mine drainage (Site 3; 2.37-91 ppm) and high concentrations of iron were detected downstream (1.3-2.7 ppm; Site 2). Waters from upstream (Sites 5, 6 & 7) consistently showed iron concentrations of approximately 1 ppm. This indicates that there is iron pollution occurring at the site of the Razorback Mine. This is clearly visible in the mass flow results (Figure 3.17) for the 8th of February (40 mg/s above the mine site and 4095 mg/s downstream at site 2).

Elevated iron concentrations were detected in the South Comet Mine drainage of up to 6.2 ppm. Iron concentrations below the mine (Site 12) were consistently two to three times higher than those measured above (Site 15), indicating that the South Comet Mine is another source of iron pollution in the South Comet Creek. Figure 6.13 shows that iron concentrations increase at most sites on the 16th of February (sites 1, 2, & 8 -11), indicating that the initial flushing associated with high rainfall, after a dry spell, results in iron concentration increases. This is probably due to the removal of iron hydroxide precipitates from stream beds by scouring, or an increase in the general sediment load.

6.7.2.4 Copper

No copper was detected in this study.

6.7.2.5 Zinc

Zinc ranged in concentration from undetected to 76 ppm (Site 13; 8th of February). Figure 6.5 shows that the highest zinc concentrations are found in the South Comet Mine drainage (Site 14; 61 - 66 ppm) and tailings dam (Site 13; 57 - 75 ppm), and in South Comet Creek below the mine (Site 12; 0.076 - 13 ppm). Only once was zinc detected above the mine (Site 15; 15th of December; 0.035 ppm). This indicates that zinc from the South Comet Mine is polluting the South Comet Creek. The source of this zinc is the sphalerite within the mine. Mobilisation and migration of the zinc would be the result of interaction between AMD and zinc. This Zn appears to stay in solution to the bottom of the field area (Site 1), suggesting that Zn pollution from the South Comet Mine is affecting the waters outside the field area.

Minor amounts of zinc were found in the Razorback Mine drainage (site 3; 1 - 4.3 ppm), and Tailings pond (site 4; 0.04 ppm). However, zinc concentrations from down and upstream of the mine appear to be consistent (0.5 - 1 ppm; Figure 6.5). This indicates that the Razorback Mine is not a major contributing factor in Zn pollution of the Dundas River.

Zn concentrations showed no significant variation with sampling time (Figure 6.13), and hence the mass loads were far greater under high rainfall/flow rate conditions (Figure 6.18).

6.7.2.6 Cadmium

The analysis results from the 8th and 10th of February will be discounted for the sake of this discussion. They show anomalously high Cd concentrations which are assumed to be the result of analysis difficulties discussed at the beginning of this chapter. Cadmium concentrations ranged from undetectable to 12 ppm (site 13; 15th of March).

It is clear from Figure 6.6 that there are two sources of elevated cadmium values in the field areas; the South Comet Mine and the Razorback Mine. At the Razorback Mine cadmium was only detected in the mine drainage (Site 3; 0.06 - 0.4 ppm). No detectable pollution was entering the Dundas River from this site. At the South Comet Mine the detection of elevated cadmium values was consistent (Figure 6.6). Water samples from upstream of the South Comet Mine (Site 15) contained no detectable cadmium. The South Comet Mine drainage (site 14), had cadmium concentrations ranging from 0.254 to 0.229 ppm, and the Tailings dam (Site 13) contained 0.267 ppm Cd. Samples downstream from the South Comet Mine also had elevated Cadmium concentrations; 0.006 to 0.051 ppm. Elevated cadmium concentrations were also detected in the Adelaide Mine Creek, downstream of the South Comet Mine (Site 9; 0.11 ppm) and in the Comet Creek (Site 8; 0.01 ppm). This indicates that cadmium from the South Comet Mine drainage and Tailings dam is polluting the South Comet Creek and Comet Creek in detectable ranges until it meets the Dundas River. The mass flow data (Figure 6.19) shows a relatively consistent mass load down the river system until the cadmium became undetectable indicating that the cadmium was diluted below the detection limit and does not precipitate out of solution.

The concentration of cadmium was consistent at all sampling times (Figure 6.13) indicating that its concentration is independent of rainfall and flow rate. This results in elevated mass loads under high flow conditions (Figure 6.19).

6.7.2.7 Tin

Tin was detected in insignificant concentrations of approximately 0.3 ppm at irregular intervals and showed no systematic variation.

6.7.2.8 Lead

The lead concentrations ranged from undetectable to 1 ppm at Site 13 (10th February). It can be clearly seen from figure 6.7 that the relatively high lead concentrations are found around the South Comet and Razorback mines. Under high flow conditions (16th March), increases in the concentration of lead in Adelaide Mine Creek (Site 9) and Comet Creek (Site 8) may come from the Red Lead and Adelaide mines. The elevated lead concentrations result from reaction between galena and AMD, mobilising the lead, and hence, allowing its migration into the river system. Galena is present at the South Comet, Red Lead, Adelaide and Razorback Mines, making them all potential sources of lead pollution.

Lead was undetectable with the exception of one sample (10th February) above the South Comet Mine (Site 15). The mine drainage (Site 14) contained between 0.075 and 0.129 ppm lead. and the tailings dam between 0.057 and 1 ppm. South Comet Creek below South Comet Mine contained between 0.012 ppm and 0.039 ppm lead, identifying, South Comet Mine as a source of lead contamination.

Under high flow conditions (16th March) 0.441 ppm lead was found in the Adelaide Mine Creek below the Red Lead Mine (Site 9; Fig. 6.7, 6.13). There are two possible causes of this elevated lead concentration:

- The output of lead from the South Comet Mine increased under high flow conditions and/ or
- The Red Lead Mine is a significant source of pollution under conditions of high flow conditions

Also on the 16th of March elevated lead concentrations were detected in Comet Creek below the Adelaide Mine (0.263 ppm; Figures 6.7, 6.13) indicating that either the Adelaide Mine is a significant lead pollution source, or there is a source of lead upstream of the Adelaide mine.

Since, the concentrations along with the flow rate, there is a two fold increase in the mines mass loads of lead under conditions of high flow conditions (Figure 6.20).

6.7.3 Other Water Quality Attributes

6.7.3.1 pH

Technical difficulties with pH meters meant that the pH readings for all sampling runs except for the last were incomplete and unreliable. Therefore I will discuss the results from that last run only. It can be seen from Figure 6.8 that very little variation was observed in pH in the region.

pH readings in the region ranged from 7 (Site 7) to 5.5 (Site 5). Above the South Comet Mine (Site 15), the pH was 6.6. The mine drainage (Site 14) had a pH of 6.1 and the tailings dam (Site 13) had a pH of 6. The waters below the South Comet Mine (Site 12) had a pH of 6. This would indicate that the South Comet Mine is contributing acid to South Comet Creek.

The Razorback Mine drainage (site 3) had a pH of 6.2. This value was quite high considering the amount of pyrite and pyrrhotite in the deposit. The possible reason for this high reading could be that the carbonate gangue is neutralising any acid produced. The Razorback Mine tailings dam (Site 4) had a high pH of 6.8. The waters above and below the Razorback Mine showed no relative differences, indicating that the Razorback Mine did not alter the pH of the Dundas River.

6.7.3.2 Conductivity

Conductivity was measured to give a relative level of salinity the sampled waters. Figure 6.9 identifies that the conductivity was consistently higher at the Razorback and South Comet Mines, indicating relatively high salinities in these waters. Conductivities at the mine sites ranged from between 4810 μs at the South Comet Mine Tailings Dam (site 13, 15th March 1996) to 117 μs (Razorback Mine drainage, 15th December 1995).

The rivers and creeks in the area were difficult to measure, displaying highly variable conductivities during testing.

6.7.3.3 Temperature

The temperatures of the streams and creeks were consistent between 11.3 °C and 12.5 °C (Figure 6.10). Elevated temperatures were observed in the Razorback tailings dam (14.8 °C - 12.8 °C) and in the South Comet tailings dam (Site 13; Figure 6.10). These elevated temperatures could indicate increased chemical activity, or solar heating. Most probably, the elevated temperatures are the result of solar heating, as the ponds are broad and shallow, so they have a large surface area to heat on and only a small volume to heat.

At times, the drainage's from the mines also displayed increased temperatures (Razorback, 16.5 °C and South Comet 16.7 °C) on 10th February Figure 6.10).

These results are not likely to be the result of chemical heating, as these increased temperatures were not regularly observed.

6.7.3.4 Sulphate

The sulphate values were elevated at the two major mine sites (Figure 6.11), probably due to the generation of sulphate in the formation of AMD. The Razorback Mine drainage (site 3) contained 375 ppm and 74 ppm sulphate on the second two sampling runs, and the tailings dam (site 4) contained from 10 to 16 ppm. However the samples taken from Dundas River below the mine (Site 8) displayed only background levels of 4 ppm sulphate, indicating that there is no sulphate pollution from the Razorback Mine.

The South Comet Mine tailings dam (site 13) contained between 740 and 950 ppm sulphate, and the mine drainage (site 14) contained between 919 and 1069 ppm. The waters above South Comet Mine (site 15) contained approximately 4 ppm sulphate, and those below showed readings from 6 to 176 ppm sulphate, indicating that South Comet Creek is polluted with sulphate from South Comet Mine. Elevated concentrations of approximately 19 ppm sulphate were sampled in the Adelaide Mine Creek below the Red Lead Mine (site 9), indicating that AMD processes are occurring at the Red Lead Mine and that the sulphate produced is contaminating the Adelaide Mine Creek.

6.7.3.5 Alkalinity

The major trend which can be seen in figure 6.12 is the apparent fall in alkalinity downstream from the South Comet, Red Lead, Adelaide, and Razorback Mines. However the downstream sites were sampled on the 16th March under high rainfall/ high flow rate conditions. These high water volumes would cause the dilution of carbonate species in the rivers, lowering the alkalinity.

From Figure 6.12 it can be seen that the drainages at the South Comet Mine (site 14; 27 and 18 ppm $CaCO_3$) and Razorback (site 3; 34 and 0 ppm $CaCO_3$) usually contain high alkalinity values, indicating that they are more likely to add alkalinity to the water than remove it. This is due to the fact that both of these deposits are hosted in, and contain, carbonate rocks. No consistent substantial falls in alkalinity were observed in the streams and rivers in the region.

6.7.4 Comparison with ANZECC guidelines

The samples which exceed the ANZECC guidelines for fresh water environments are highlighted in Table 6.5. It can be seen, from the table, that all the sites except for the Razorback Tailings Dam (Site 4) and Concert Creek above Dundas river (Site 7) exceeded the ANZECC guidelines for aluminium concentrations at some time.

All of the sites downstream of the Razorback mine, except for the Dundas River at the Murchison Highway (Site 1), often exceeded the guidelines for iron concentrations. The rivers above (Sites 5, 6 and 7) only exceeded the guidelines once. South Comet Creek downstream of South Comet Mine does not exceed the guidelines for iron, even though the drainage and Tailings Dam do exceed the recomended levels.

All waters in the region regularly exceed the recommended levels for zinc.

Due to the high toxicity of cadmium all sites where it was detected exceeded the guidelines. Dangerous levels of cadmium were detected in the natural river system below the South Comet Mine.

All sites, except Concert Creek above the Dundas River, exceed the recommended levels for lead at least once. South Comet Creek, above South Comet Mine exceeded this value only once, by a minor amount, which was possibly due to

Table 6.5 Comparison of ANZEC standards with metal concentrations from the Dundas Field

location number	location name	date	Al	Fe	Zn	Cd	Pb
1	Dundas River at Murchison Hwy	8/11/95	X		X		
1	Dundas River at Murchison Hwy	15/12/95	X		X		
1	1 Dundas River at Murchison Hwy	10/2/96			X		
1	2 Dundas River at Murchison Hwy	10/2/96			X		
1	Dundas River at Murchison Hwy	16/3/96	X		X		X
2	Dundas River above Comet Creek	8/11/95			X		X
2	Dundas River above Comet Creek	15/12/95	X		X		
2	Dundas River above Comet Creek	9/2/96	X	X			X
2	Dundas River above Comet Creek	16/3/96	X	X	X	X	X
3	Razorback Mine Drainage	8/11/95		X	X	X	X
3	Razorback Mine Drainage	15/12/95		X	X	X	X
3	Razorback Mine Drainage	10/2/96	X	X	X	X	X
3	Razorback Mine Drainage	16/3/96	X	X	X	X	X
4	1 Razorback Tailings Dam	10/2/96		X	X		
4	2 Razorback Tailings Dam	10/2/96		X	X		X
4	Razorback Tailings Dam	16/3/96			X		X
5	River above Razorback Tailings Dam	16/3/96	X		X	X	X
6	Dundas River above Concert Creek	8/11/95	X		X		X
6	Dundas River above Concert Creek	15/12/95	X		X		
6	1 Dundas River above Concert Creek	10/2/96	X	X	X	X	
6	2 Dundas River above Concert Creek	10/2/96	X		X		X
6	Dundas River above Concert Creek	15/3/96	X		X		
7	Concert Creek above Dundas River	10/2/96			X		
7	Concert Creek above Dundas River	15/3/96			X		
8	Comet Creek above Dundas River	10/2/96	X	X	X	X	X
8	Comet Creek above Dundas River	16/3/96	X	X	X		X
9	Adelaide Mine Creek below Red Lead Mine	8/2/96			X		
9	Adelaide Mine Creek below Red Lead Mine	16/3/96	X	X	X	X	X
10	1 Comet Creek below Adelaide Mine	8/2/96			X		
10	2 Comet Creek below Adelaide Mine	8/2/96			X		
10	Comet Creek below Adelaide Mine	16/3/96	X	X	X		X
11	Comet Creek Below last Road Crossing	10/2/96			X		
11	1 Comet Creek Below last Road Crossing	15/3/96	X		X		X
11	2 Comet Creek Below last Road Crossing	15/3/96			X		X
12	South Comet Creek below South Comet mine	8/11/95	X		X	X	X
12	South Comet Creek below South Comet mine	15/12/95	X		X	X	X
12	1 South Comet Creek below South Comet mine	10/2/96			X	X	X
12	2 South Comet Creek below South Comet mine	10/2/96	X		X	X	X
12	South Comet Creek below South Comet mine	15/3/96			X	X	X
13	South Comet Mine Tailings Dam	10/2/96	X	X	X	X	X
13	South Comet Mine Tailings Dam	15/3/96		X	X	X	X
14	Drainage From bottom adit South Comet Mine	8/11/95	X	X	X	X	X
14	Drainage From bottom adit South Comet Mine	15/12/95		X	X	X	X
14	Drainage From bottom adit South Comet Mine	10/2/96		X	X	X	X
14	Drainage From bottom adit South Comet Mine	15/3/96		X	X	X	X
15	South Comet Creek Above South Comet Mine	8/11/95	X				
15	South Comet Creek Above South Comet Mine	15/12/95	X		X		
15	South Comet Creek Above South Comet Mine	10/2/96				X	X
15	1 South Comet Creek Above South Comet Mine	15/3/96					
15	2 South Comet Creek Above South Comet Mine	15/3/96			X		

sample contamination.

From Table 6.5 it can be seen that many of the "natural" waters in the Dundas region regularly exceed the ANZECC guidelines, this supports Koehnken's (1992) argument that guidelines specific to Tasmanian waters are required.

6.7.5 Classification of South Comet and Razorback Mine drainage

The drainages from South Comet and Razorback Mines were classified using Ficklin's (1992) classification system. Additional data was obtained from the CSL Laboratories on the concentration of Nickel and Cobalt. In the Razorback Mine drainage, the concentration of Cobalt was 350 ppb and Nickel was 3500 ppb. In the South Comet Mine drainage Cobalt was 380 ppb and Nickel was 3000 ppb. In combination with the average values for Zinc, Copper, Cadmium and Lead, and the pH's from the fourth sampling run (the most reliable), the classification was determined (Figure 6.21). Figure 6.21 shows that both mine drainages can be classified as near-neutral high metal.

Polymetallic vein-style deposits plotted by Ficklin et al (1992) are marked Yak, Ruby, and Bandora. It can be seen in Figure 6.21 that the South Comet Mine plots closely to these other similar deposits.

Carbonate replacement deposits plotted by Ficklin et al (1992) comprise Leadville Drain and Dauntless Mine. Razorback Mine plots closely to these on Figure 6.21.

These close relationships infer that through the study of ore deposit-types, the pollution characteristics of particular deposits can be reliably calculated. This may serve to be a useful tool to be used in the future.

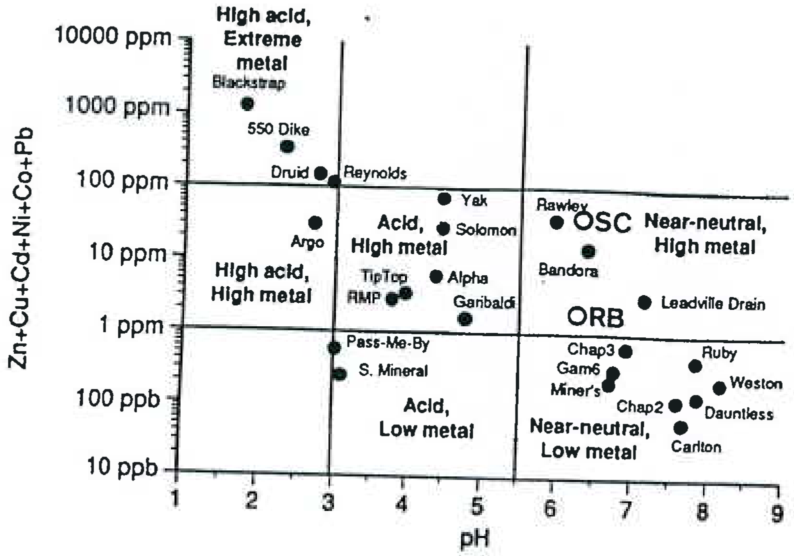


Figure 6.21 Ficklins (1992) classification system with South Comet S.C. and Razorback plotted on it

6.7.6 Quality Assurance

Duplicate samples were collected on seven occassions in order to determine the reliability of the sampling methods. The results for these duplicate samples are listed in Table 6.4.

6.7.6.1 Aluminium

The problems associated with the detection of aluminium were discussed in section 6.7.2.1. Most of the samples contain no detectable aluminium. The concentrations that were detected for the repeats were only just above the detection limit of 0.4 ppm. Therefore the difference between samples where aluminium was, and was not detected may be minimal.

6.8 Summary

Fifteen sites were selected and sampled in the attempt to charaterise the water quality in the Dundas drainage basin. The water was analysed for Al, Cu, Pb, Zn, Sn, Cd, Fe, and Mn. In addition they were analysed for alkalinity (ppm $CaCO_3$) and sulphate. Temperature, pH and conductivity were measured in the field. The discharge was measured at each site allowing the calculation of metal mass loads. Daily rainfall data was obtained so the variation in pollution levels could be correlated with climatic variation.

Aluminium was only present in low levels (up to 1 ppm). As these levels were close to the analysing equipments detection limits aluminium pollution for the area was deemed negligible. All of the sample site except for the Razorback Tailings Dam and Concert Creek exceeded the ANZECC recomended guidlines at some time. The reliability of the Aluminium results is put in doubt because of the difficulties with its detection at low concentrations.

Manganese pollution concentrations of between 0.8 and 15 ppm were found in South Comet Creek and were interpreted to be sourced from South Comet Mine. The concentration of manganese entering the system did not vary with differing flow rates, hence, under high rainfall conditions the mass load of manganese increases. Duplicates showed that manganese results were generally reliable. However, the inclusion of coarse particulate matter may result in anomolously high readings.

The Dundas River displayed a 1 ppm difference accross the Razorback Mine. This contamination was attributed to the Razorback Mine. It causes the down stream waters to exceed the recommended iron concentrations. Samples below the South Comet Mine consistantly contained 2 to 3 times the iron concentrations from upstream. The pollution in South Comet Creek has, therefore, been attributed to waters from the South Comet Mine. Duplication of samples revealed that Iron concentrations were consistent making the results reliable. The Dundas River directly below

Zinc contamination of between 0.076 and 13 ppm was detected South Comet Creek below the South Comet Mine, with negligable values detected upstream of the mine. This pollution has been attributed to South Comet Mine. Most waters in the Dundas region exceed the recomended zinc concentrations, even those considered "pristene". The reliability of the zinc concentrations is good as the duplications displayed a high degree of correlation.

Cadmium from the South Comet Mine is polluting South Comet Creek with cadmium levels of up to 0.051 ppm. This cadmium appears to be remaining in the water way at least to the point where Comet Creek meets the Dundas River. The mass load increases with rises in flow rates, hence cadmium pollution is more dangerous under high rainfall conditions. All detectable readings of cadmium exceeded the ANZECC guidelines, and all results appeared to be reliable with the exception of those read between the 8th and 10th of Febuary.

Tin concentrations were insignificant and showed no systematic patterns. When detected in duplicates the tin values appeared to good correlation.

South Comet Creek is being polluted by lead from the South Comet Mine to concentrations of approximately 0.02ppm. Elevated lead values were also found downstream of the Adelaide and Red Lead Mines. The concentration of lead increased with flow rate and under high flow conditions there is a two fold increase in lead pollution. All of the site execpt for Concert creek exceeded the recommended levels of lead concentrations at least once. The lead values showed poor correlation when detected in duplicates.

pH in the drainage of the South Comet and Razorback Mines was slightly lower than in the natural waters. At the South Comet Mine a lowering of the pH in South Comet Creek by 0.6 units was attributed to the mine site.

No salinity contamination of rivers and creeks in the Dundas region was detectable. However the mine drainages and tailings had consistantly high conductivities. The temperature revealed no systematic variation except for changes due to solar heating and the alkalinity also showed consistent no mine related variation.

Sulphate pollution of between 2 and 170 ppm was detected as originating from South Comet Mine. This is substantial considering that there the sulphate levels were only negligable in the area

Having identified the environmental problems within the field area, some form of remediation and rehabilitation should be designed to impare their influence on the environment.

7. Remediation & Rehabilitation

7.1 Introduction.

Rehabilitation refers to the operations where by unavoided, mining related, impacts to the environment are repaired (AMIC, 1990). Since mining is only a temporary land use the objective of rehabilitation is to restore the effected area so it is suitable for projected future landuses, or returned as near as possible to the original state prior to operations.

The primary proposed objective of rehabilitation in the Dundas area is to return the abandoned mining operations to a state as close as possible to their natural condition. Furthermore, to ensure the safety and health of people using the area, whilst maintaining the transport network to a degree where it is still available for future exploration (Ankerman, 1991) and access for other land uses.

7.2 Baseline Data

Ideally, baseline data should be collected prior to the commencement of mining, setting the goal for rehabilitation, and allowing a comprehensive assessment of the environmental impacts of the operations (Hannan, 1995). Due to the early history of mining in the Dundas area the collection of available baseline data is limited. Consequently, the actual preceding natural environment at the mine sites is poorly constrained and needs to be interpolated from comparable undisturbed environments.

AMIC (1990) outlines the important attributes of the environment which need to be noted as:

- Land forms
- Geology
- Soil types

- Surface and ground waters
- Flora and fauna components
- Land use
- Heritage, or other specific conservation values

7.3 Standard Rehabilitation Program

An approach to rehabilitation can be determined which highlights problem areas left after the completion of mining. Such a standard rehabilitation program includes (AMIC, 1990; Hannan, 1995):

- Site safety
- Landscaping
- Topsoil management
- Erosional control
- Revegitation

7.3.1 Site Safety

The safety of the site is of paramount importance if it is to be left unsupervised in the future. To ensure the safety of the site, the following procedures should be followed (AMIC, 1990; Harris 1995; EPA 1995a).

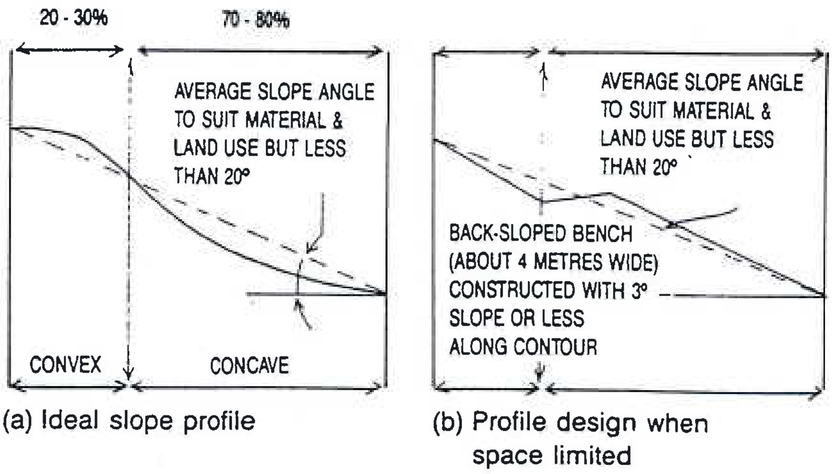
- Removal of infrastructure and equipment
- Removal of rubbish
- Removal of services
- Removal, or burial of concrete slabs and building foundations
- Securing of shafts, adits and costeans
- Restriction of public access to dangerous areas by removal and blocking of roads and tracks

7.3.2 Landscaping.

Landscaping of the site is necessary to minimise the visual impact, and to restrict the problems associated with erosion. In landscaping the mine site the following factors should be taken into account:

7.3.2.1 Stability and Erodeability of the Final Landform.

The final landform should be designed so it is stable. This means that it will not subside or slip under the pressures of the future predicted landuse (Yarbrough, 1983). The final landform must also be resistant to water erosion. This will involve consideration of the water movement at the site, and possibly modification of the hydrology at the site (Hossain, 1983). The advice of a geotechnical engineer is important when considering the landscaping of areas which are highly unstable (AMIC 1990).



(a) Ideal slope profile (b) Profile design when space limited

Figure 7.1 Methods for landscaping a slope to avoid erosion (from AMIC, 1990)

7.3.2.2 The drainage pattern on the site.

If possible the drainage pattern at the site should be left in an original state. This avoids the problems of downstream pollution by silt during the diversion, and the alteration of the in-situ ecology. However, under certain circumstances the diversion of the natural drainage system may be necessary to avoid water pollution associated with the mine (ie., AMD) or to stop erosion problems (Hossain, 1990). Such diversions should be designed to be stable, and compatible with the surrounding drainage network. Construction of the diversion should cause as little disturbance to the surrounding environment as possible.

7.3.2.3 Slope Angles.

When designing the final landform the slope of the embankment should be carefully considered. The angle of the final slope partially determines the stability of the slope and it's susceptibility to erosion (AMIC, 1990). The slopes should be designed so that the velocity of surface water is minimised. This restricts the kinetic energy of the water flow, and hence it's sediment carrying capacity. The ideal slope will be designed to suit the material used, and be in a form which allows natural sedimentary processes to restrict the removal of sediment by erosion (Figure 7.1). If the slope cannot be designed with adequately shallow slopes ($< 20^{O}$) back sloped benches may be necessary to reduce the flow rate (Figure 7.1).

7.3.3 Topsoil management

Topsoil is an important component in any rehabilitation scheme. This normally requires the stockpiling of existing soil and consequent replacement during rehabilitation (EPA, 1995a). The importation of topsoil can lead to many weed and disease problems (AMIC, 1990). The topsoil contains the seed bank and nutrients required for the revegetation of the site (EPA, 1995a, AMIC 1990). Removal of topsoil without replacement can lead to erosion, AMD, and revegetation problems. In the event of topsoil removal without stockpiling it may be necessary to use some form of growth medium to allow initial regrowth on the site (Holberg, 1983):

7.3.4 Erosional Control

Since major erosional problems at the sites in question are associated with water, as opposed to wind, the field of airborne erosional rehabilitation will be excluded. Inadequate erosional control can lead to the loss of topsoil and the degradation of water quality downstream. The effects of hydrological erosion can be minimised by the:

- Restriction of runoff entering the site
- Encouraging infiltration
- Management of water leaving the site

7.3.4.1 Restriction of Runoff Entering the Site.

Water is the primary erosional agent, therefore diversion of runoff entering the mine site can greatly reduce the potential for erosion. The drainage system should be designed so it does not create a new pollution or erosional problem.

7.3.4.2 Encouraging Infiltration

On slopes where surface water is freely flowing and causing erosional problems the infiltration of surface water into the soil may be required (Hussain, 1993). The most common practice for encouraging the infiltration of water is ripping the slope along the contours (AMIC, 1990). This increases the depth into which water can infiltrate and releases the compaction of the soil increasing it's permeability. This results in the enhanced infiltration of water into the soil layer. Ripping also discourages the down slope flow of water by creating a barrier.

7.3.4.3 Management of Water Leaving the Site.

To prevent the pollution of downstream water, associated with erosion, a management plan for water leaving the site should be developed. Erosion can cause the input of large quantities of sediment into adjacent watercourses. To stop this some form of sediment trap is required, usually some form of dam to slow the water velocity and allow the sediment to fall out of solution.

7.3.5 Revegetation.

Revegetation of a site should use, where possible, the natural vegetation present at the site (Holberg, 1983). This action avoids potential weed problems. The preceding rehabilitation steps need to be adequately completed for successful revegetation. In addition, the following factors need to be considered (EPA, 1995c).

- Plant nutrients and soil conditions
- Species selection
- Seed source
- Planting

7.4 Non Standard rehabilitation

There are many mining related problems which are specific to an individual site and outside the scope of the standard rehabilitation plan. In the Dundas region these site specific problems require the management of:

- Waste dumps
- Tailings dams
- AMD
- Heavy metals
- Noxious weeds
- Roads and tracks
- Final voids
- Abandoned adits and shafts

7.4.1 Waste dumps

The siting of waste dumps is an important factor in most modern mining operations. Considerations such as siting, shape, slope and runoff control all effect the impact such dumps will have. Rehabilitation by revegetation is the best long term control for most erosion and leaching problems associated with waste dumps EPA, 1995c).

7.4.2 Tailings Dams

Tailings dams are highly variable both chemically and physically. Commonly they are difficult to stabilise and vegetate. AMIC (1990) describes a successful tailings dam should be (AMIC, 1990; EPA, 1995b):

- Non-polluting in operation and after decommissioning
- Structurally stable
- Resistant to erosion
- Aesthetically compatible with the surrounding landscape
- Adequate, with respect to volumetric capacity

In areas where there is a reliably high rainfall a permanent cover of water can be used to stop the oxidisation of tailings.

7.4.3 Acid mine drainage

The components and processes of AMD are described in some detail in Chapter 2. The effect of AMD can be minimised in modern mining activities through careful planning and management. Innes (1993) divides AMD remediation options into three stratigies consisting of: primary (control of acid generation), secondary (control of acid migration), and tertiary (collection and treatment of AMD).

- Primary stratigies

  - Bactericides
  - Covers and seals
- Secondary stratigies
  - Diversion of surface waters
- Tertiary stratigies
  - Chemical treatment/neutralisation
  - Reverse osmosis
  - Ion exchange
  - Wetland filter system
  - BIO-FIX beads

7.4.4 Heavy metals

Mobilisation of heavy metals associated with mining activity can cause pollution problems in soils, overburden, and water. Commonly mobilisation of these metals is associated with AMD or acid conditions, see Chapter 2.

To prevent these problems, waste rocks which are a potential source of heavy metal pollution need to be selectively placed to avoid interaction with AMD. Water rock interactions within the mine needs to be minimised at sites of potential heavy metal mobilisation. Since the mobilisation of metals within these systems is commonly associated with AMD, the rehabilitation processes are the same. If the AMD is minimised the heavy metal pollution is also minimised.

7.4.5 Noxious weeds

Weeds can be a great problem, especially associated with accidental importation of soil during transport to and from the site (Holberg, 1983). They are also a problem if the rehabilitation program requires the importation of topsoil. Plant selection for rehabilitation should be a careful process which will not compromise the integrity of the surrounding bushland in any way. Weeds spreading to surrounding natural bushland is a situation which should be avoided.

7.4.6 Roads and tracks

Before proceeding into rehabilitation of roads it should be determined if they will be required in the future (AMIC, 1990). If they have no future use they should be rehabilitated to original bushland condition. The first step in rehabilitation is to install some barrier against unlawful use of the unwanted roads (EPA, 1995a), preventing rehabilitation processes from being hampered by activities such as recreational four wheel driving. Next, the stability of the road surface should be checked, normally these surfaces will be inherently stable (AMIC, 1990). The road should be covered in topsoil and ripped to relieve compaction. This discourages unlawful use and encourages revegetation. The drains associated with the road should be removed and the site returned to natural hydrological state. Rehabilitation of roads should be planned to occur last so rehabilitation equipment retains access for as long as possible through the rehabilitation process.

7.4.7 Final voids

Where filling of a void left as a consequence of open cut mining is not a viable option other alternatives are available (Hannan, 1995). These include, using the void as a water storage area, wetland wildlife habitat and as a waste disposal site. However, whether the site is to be used again or not, the primary objective means that we must make the void safe.

7.4.8 Abandoned adits and shafts

Abandoned adits and shafts should be left in a safe state. They should not allow potential problems such as illegal access, pollution of surface and groundwater and use as illegal rubbish dumps (AMIC, 1990). Before the adits are sealed consideration should be given to whether future access is required. This will determine whether the adit will be sealed, and the method of sealing. Sealing and closing of shafts can be done by the following methods (AMIC, 1990):

- Enclosure with a safety wall or fence

- Surface covers and caps
- Shaft plugs at depth
- Backfilling with selected materials

7.5 Rehabilitation at Large Mine Sites

7.5.1 Red Lead and Adelaide Mines

A rehabilitation plan which will actively address the environmental problems at these sites is required. This should be done through consultation with the current lease holders, and be designed so that the rehabilitation is active through the remaining life of the mines. The problems which need to be addressed in such a plan would be:

- Denudation of the sites especially at the Red Lead Mine.
- Large scale alteration of the natural topography at the Red Lead Mine, and
- The encroachment of the waste dump at the Adelaide mine into the Comet Creek.

7.5.2 South Comet Mine

The South Comet Mine has had a mining history since the early 1900's therefore very little baseline data is available. Consequently, the original state of the site needs to be interpolated from surrounding land. A vegetation list was compiled for natural sites in the Dundas region and is included in Appendix 1 for reference when selecting species for rehabilitation.

Most of the infrastructure from the site has been removed, except for one old shed and one old piece of machinery (see Chapter 5). Some old hosing and wiring litters the site. However, these items are not seen as causing a hazard. No services or building foundations remain at the site.

The bottom two adits (no 8) and (no 6) have been plugged with soil preventing access. However the no 6 adit has a gap between the soil plug and the roof of the adit which may allow access. These style plugs are also prone to removal and access could be gained by digging and therefore they still represent a possible hazard.

The roads into the site have remained open for use in future exploration (Ankerman; 1991).

The topography at South Comet Mine has not been altered to any great extent and the required landscaping has been undertaken. The small opencut on the top of the ridge has not been refilled allowing the interaction between water and sulphides in an oxidising environment If this site was filled with soil and rubble then the reducing environment created would hamper the production AMD. More deep ripping at base of the slope may be required to encourage infiltration of waters which are currently freely running down the denuded slope south-east of the main adit. These waters carry AMD down the slope and contribute to the waste water in the tailings dam. If the waters were forced to infiltrate into the soil erosion and AMD production would be reduced.

Revegetation at the South Comet Mine site is proceeding slowly in the cleared area at the bottom of the hill and along many of the disused roads Teatree slash along with other mulch has been used to encourage plant growth and act as a barrier to erosion, allowing soil accumulation. The astounding regrowth of other cleared areas in the Dundas region, tends to indicate that if the soil accumulation continues, regrowth will be quite successful. However, analysis of soil quality, especially the quality of soil directly effected by AMD should be assessed and compared with surrounding soils to determine its capacity for plant growth. If the soil is found to be inadequate some amendments (ie. the adding of lime) may be needed. As revegetation occurs at such a rapid rate in the area it could be assumed that only a minimal amount of human planting is required. Planting of selected trees on the bare slope would encourage regrowth and discourage erosion. It is suggested that on this steep slope, intervention by planting would be appropriate.

Waste dumps at the south comet mine have been poorly placed this is especially the case with the waste dump adjacent to the level 8 adit. This waste dump contains a substantial quantity of mineralised rocks and encroached upon the South Comet Creek, forming the bed and one bank of the creek. The dump has been covered with soil and mulch in an attempt to create a reducing environment and therefore stop acid mine drainage.

I suggest that the portion of the dump which encroaches onto the creek, which is approximately 60m long needs to be removed if economically and environmentally viable this would prevent the downstream pollution of the South Comet Creek by this waste dump.

The small tailings dam, which now accommodates AMD from the mine, is a possible source of pollution in the South Comet Creek. Revegetation of the walls of this dam would help to stabilise them, preventing the leakage of toxins into South Comet Creek. The overflow which emanates from this tailings Dam still appears to be acid in nature and is possible a source of heavy metal pollution entering the South Comet Creek. Alteration of the depth of this dam and conversion into a wetland may be a more appropriate treatment of these waters.

Although the acidity of waters leaving the South Comet Mine were not considerably lowered, the characteristic ferric hydroxide precipitates was present in the stream bed. This indicates that AMD processes are occurring within the mine, on the denuded area south west of the main adit, and the waste dumps. As stated above the proposed measure to alleviate this problem would be the construction of a wetland at or below the site of the tailings pond. This would stop the acid waters from entering the South Comet Creek and remove the associated heavy metals from the water.

7.5.3 Razorback Mine

All buildings and machinery have been removed from the Razorback site. However a large concrete slab still remains at the front of the site. It has been lowered to fit the local topography but it is still a potential hazard. Several mine adits leaving from the open cut remain unplugged allowing entry. This is obviously another hazard especially considering the highly weathered nature of the rocks into which the shafts are driven. Minor amounts of rubbish remain around the site, however this litter is not of significant proportions. It is proposed that the abandoned adits be blocked with a minimum fencing, however it is suggested that concrete caps would be more effective in preventing entry.

The altered land to the north and south of the opencut has been landscaped to fit the surrounds. The slopes created in this landscaping appear to be stable, and with the exception of a few isolated locations they have resisted erosion.

The opencut is still prominent and has not been filled. None of the previously mentioned options for alternative uses for the open cut seem to be appropriate for this site due to it's location on a steep slope of Mt Razorback. For safety purposes a fence should be constructed along the top of the opencut and the bare ground revegetated.

Revegetation around the site has been carried out by the planting of a variety of species and the coverage of disused roads with teatree slash. The plants have been protected by stakes and plastic. The abandoned roads have been covered and ripped and appear to be revegetating well. The seed mix, and volumes of seed used in the rehabilitation of this site by John Miedecke and Partners are shown in Table 7.1. Where the waste dumps were revegetated a medium consisting of lime and rubble was applied to negate the affect of AMD produced at the site.

Gorse is a major weed problem in the area. The current remediation program at the site includes the removal of any gauss encountered.

Table 7-1 Native seed mix used at the Razorback Mine (Miedeke, 1991)

Species	Razorback Seed Mix kg
Acacia dealbata	2.0
Acacia melanoxylon	1.0
Acacia mucronata	5.0
Acacia verticillata	5.0
Eucalyptus nitida	3.0
Eucalyptus brookerana	1.0
Hakea eppiglotis	
Hakea lissosperma	1.0
Leptospermum glaucescens	1.0
Leptospermum lanigerum	2.0
Leptospermum nitidum	0.8
Leptospermum scoparium	3.0
Melaleuca squamea	
Melaleuca squarrosa	1.0
	25.8

The major waste dump is to the north of the open cut it has been landscaped to fit the natural topography and all runoff from it is diverted into the top tailings dam. The surface of this waste dump is revegetating well with small plants and mosses and stabilising its sides. Some positions on the dump have acted as conduits for the surface flow of water, creating some erosion problems. They may require the construction of some along contour trenches to encourage infiltration of water. This should be done by hand, or light machinery to avoid the structural degradation of the slope which may be caused by the use of heavy machinery.

One of the significant issues the Razorback Mine site are the three large tailings dams. These dams not only contain the tailings left from the mining operations, but also catch any AMD emanating from the abandoned mine site. The bottom tailings dam acts as a wetland and receives the direct drainage from the open cut. The walls of these dams are revegetating well, but periodic monitoring of their structural intercity should be maintained into the future.

7.6 Summary

This chapter summarises standard rehabilitation practices and then applies these to the large recent mine sites in the Dundas region. The active Red Lead and Adelaide Mines requires a rehabilitation program which will address the problems of denudation, topographical alteration, and waste dump placement. Rehabilitation at these mines should be run in conjunction with mining activities

The South Comet Mine needs some form of AMD remediation to stop the heavy metal contamination of South Comet Creek. This would include the Revegitation of bare ground, removal of waste rock from the creek, and construction of a wetland filter system.

The major concerns at the Razorback mine are the denudation of the landscape and the safety of the mined areas. The current rehabilitation work is making good progress with respect to Revegitation of the mine site. However, no attempt has been made to solve the safety problems associated with the abandoned adits and opencut. I proposes that the adits should be capped with concrete to halt unlawful access, and the opencut should be fenced at dangerous points and revegetated

8. Summary and Conclusions

This study was designed to document the environmental impact of mining and related activities in the Dundas region, and to present some rehabilitation and remediation options. The field area is located 7 km north-west of Zeehan, around the old township of Dundas. The boundaries of the area studied are defined by the drainage basin above the point where the Dundas River and Murchison Highway intersect. The area has been mined since the 1880's mostly for lead-zinc and silver, and also for tin in massive pyrrhotite deposits. The lead-zinc-silver deposits are vein style, and are found in numerous faults in the area. The main deposits of this type which were researched in this study are the South Comet, Red Lead and Adelaide Mines. The South Comet Mine was worked by underground methods until 1992 for lead-zinc and silver. The Red Lead (opencut) and Adelaide (underground) are worked for the ornamental mineral, crocoite. The Razorback Mine is the largest operation in the region. It was worked by opencut for tin.

The data from this study, along with other environmentally important information, was compiled and stored in an ARC-INFO database. This compilation of data was done with the intention that this data would be added to and maintained in the future. This would include the addition of data from similar studied carried out else where in Tasmania.

The water sampling scheme was designed to characterise the drainage throughout the basin, concentrating on the larger more recent operations at the Razorback, South Comet, Red Lead and Adelaide Mines.

The main source of pollution, identified in the study, was the South Comet Mine. This mine was found to be contaminating South Comet Creek with manganese, iron, zinc, cadmium and lead. It also lowered the pH with the addition of acid, and polluted the creek with sulphate. Other sources of pollution in the region were the Razorback Mine polluting the Dundas River with the input of iron, and the Red Lead and Adelaide Mines contaminating Comet Creek with lead.

This study passes some doubt on the use of ANZECC guidelines, with many of the "pristine" waters regularly exceeding the suggested pollution limit.

The drainage from both the South Comet and Razorback Mines can be classified as high-metal to near-neutral. With both plotting near to similar deposits in Ficklin's (1992) classification scheme. This leads to the conclusion that through knowledge of ore deposit-types potential pollution levels can be quite accurately ascertained

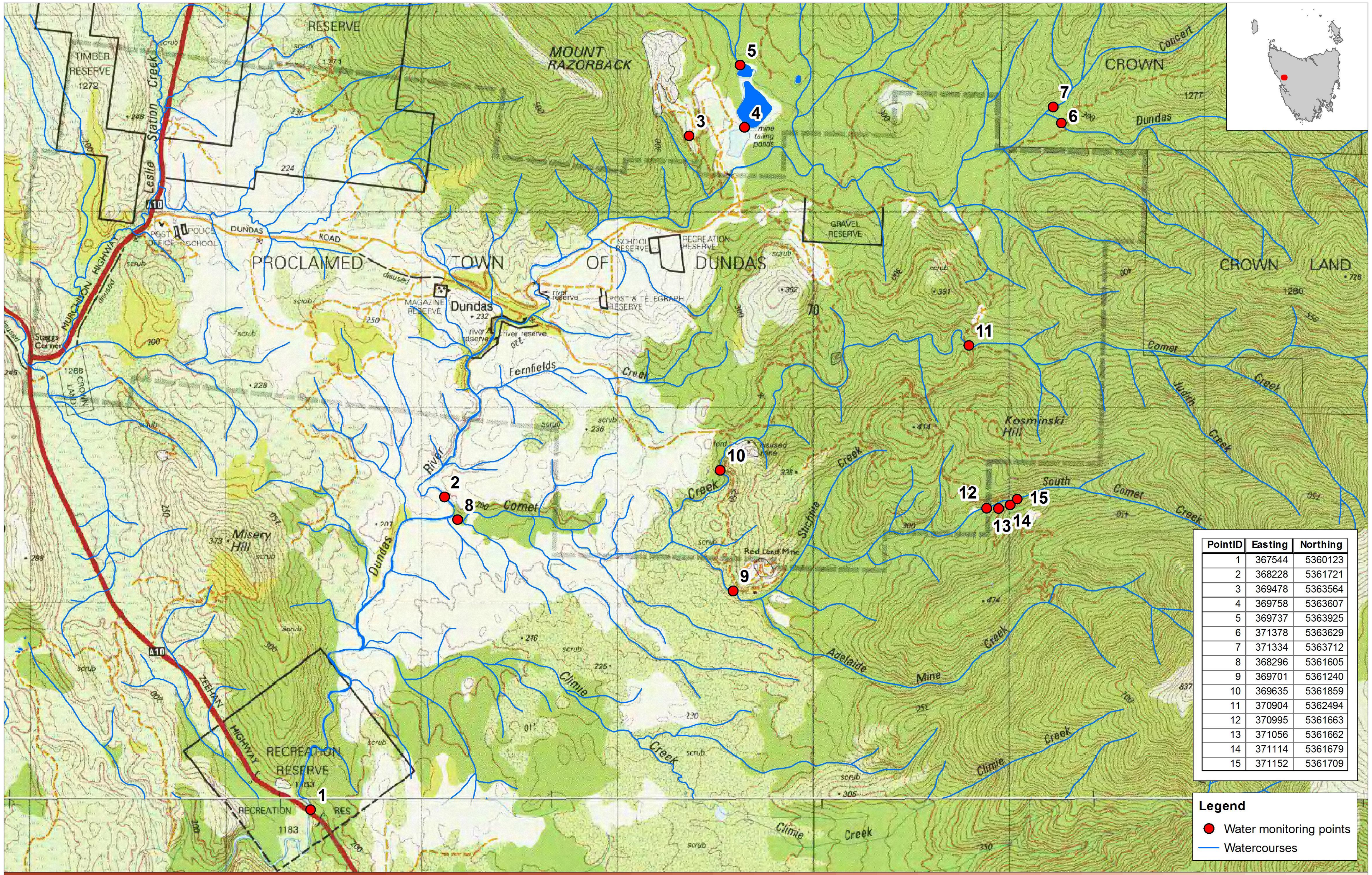
The long history of mining in the Dundas region has resulted in a lack of knowledge regarding the original condition of the mined sites. Therefore the state to which the major mines need to be returned must be interpolated from surrounding areas. The environmental problems in the area which need to be addressed through rehabilitation include:

- Pollution of streams and rivers from exposed sulphide minerals on the mined sites.
- Denudation of the vegetation by mining and related activities.
- Unsafe nature of many of the adits and shafts in the area.

To address the pollution of South Comet Creek by South Comet Mine three actions are recommended. The construction of a wetland, if economically and environmentally viable, to remove heavy metals from the drainage before it enters South Comet Creek. The removal of the sulphide rich waste rock from South Comet Creek, and the revegetation of all areas around the site, including the walls of the small tailings dam. The dam contains water rich in cadmium and if its walls were breached, South Comet Creek and downstream waters would detrimentally affected. The revegetation of the South Comet Mine site needs to be accelerated through active intervention. This would facilitate the accumulation of soil and hence impair the generation of AMD at the site.

An extensive revegetation program at the Razorback Mine is beginning to result in considerable regrowth and stabilisation of waste dumps. The large concrete slabs which are left over from the mill require breaking and removing to facilitate regrowth, and the abandoned adits at the Razorback Mine should be permanently sealed for safety reasons. The opencut requires revegetation to prevent the production of AMD and to minimise the aesthetic impact of the site. Periodic monitoring of the Razorback Tailings Dams walls, to inspect their structural integrity, is recommended.

In conclusion the environment of the Dundas mineral field has been adversely affected by mining related activities. Data presented in this study forms a basis for future rehabilitation and remediation in the area, and provides an outline for returning the area to a near natural state. Further monitoring of this type is required to assess rehabilitation and modify the program if necessary.



PointID	Easting	Northing
1	367544	5360123
2	368228	5361721
3	369478	5363564
4	369758	5363607
5	369737	5363925
6	371378	5363629
7	371334	5363712
8	368296	5361605
9	369701	5361240
10	369635	5361859
11	370904	5362494
12	370995	5361663
13	371056	5361662
14	371114	5361679
15	371152	5361709

Legend

- ● Water monitoring points
- — Watercourses

Data sources:
Base image and data from The LIST (C) State of Tasmania
Water monitoring data from J Lawrence UTAS (1996)
Map produced by pitt&sherry Date: 11/04/2013
Map ref: HB13108_H002_WMpts_12P_RevA

0 0.5 1 1.5 2 Kilometres

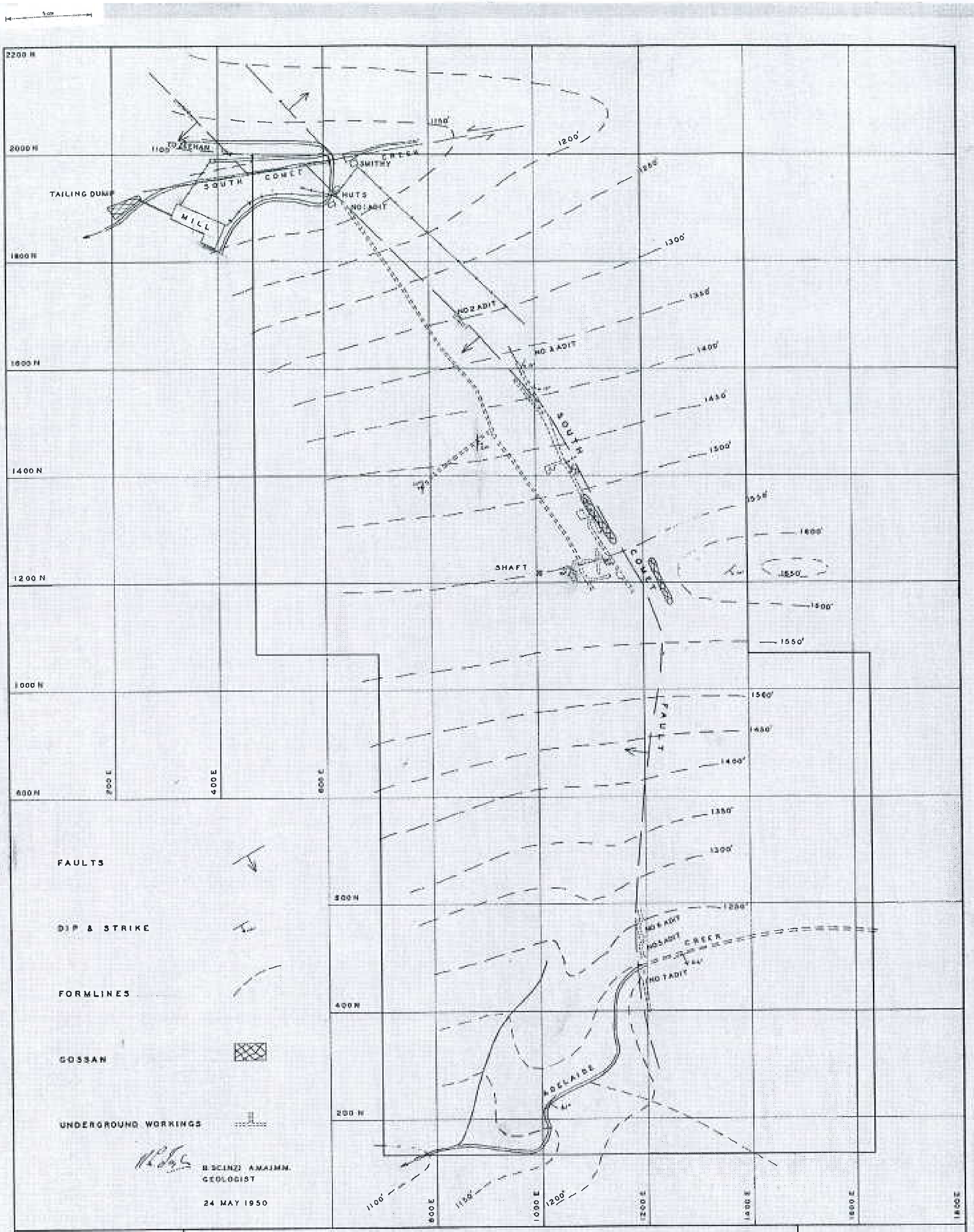
Scale: 1:17,500

Map Projection: GDA 1994 MGA Zone 55

MINERAL RESOURCES TASMANIA

DUNDAS WATER MONITORING POINTS

J.S. Lawrence Rep water monitoring map



B. SCINZI A.M.A.I.M.M.
GEOLOGIST

24 MAY 1950

SCALE
1 IN = 80 FT

TRUE BEARING

GENERAL PLAN
GREAT SOUTH COMET MINE

DEPARTMENT OF MINES - TASMANIA

PLAN NO
1140 — 50

Appendix C

Water Quality Database

Dundas					Surface water monitoring															
	Field						Laboratory													
Sites/Parameters	D.O.	E.C. field	pH field	ORP	Turb. (field)	Temp	pH lab	E.C. lab	TDS	SAR	Turbid (lab)	T/Alk	Acidity	SO4	Cl	T/Hardness	D/Ca	D/Mg	D/Na	D/K
	% sat.	uS/cm		mV	NTU	°C		uS/cm	mg/L		NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1. Dundas @ highway																				
Apr-13	97	75.4	6.04	180	-1	7.5	8.24	94	61	1.04	1.8	12.0	3	7.0	16.0	17	2.0	3.0	10.0	<1
3. Razorback mine drainage																				
Apr-13	90	237.0	6.46	215	-3	13.7	7.86	253	164	0.44	<0.1	43.0	6	58.0	16.0	100	7.0	20.0	10.0	<1
4. Razorback tailings dam																				
Apr-13	86	107.3	6.74	205	-1	12.8	7.90	124	81	0.78	1.9	27.0	3	6.0	18.0	31	1.0	7.0	10.0	<1
9. Adelaide Mine Creek below Red Lead Mine																				
Apr-13	84	102.0	6.01	247	2	8.8	7.43	125	81	0.84	<0.1	11.0	4	16.0	18.0	26	4.0	4.0	10.0	<1
13. South Comet Mine tailings dam																				
Apr-13	88	1750.0	3.17	365	54	13.0	3.63	1830	1190	0.19	113.0	<1	218	1180.0	14.0	618	89.0	96.0	11.0	2.0
16. Dundas @ township bridge																				
Apr-13	85	84.3	6.22	195	-1	9.2	7.01	103	67	0.94	<0.1	16.0	4	7.0	16.0	21	2.0	4.0	10.0	<1
17. Maestries culvert to DR																				
Apr-13	86	98.7	6.17	124	23	12.3	6.63	114	74	0.88	32.8	8.0	5	18.0	15.0	20	3.0	3.0	9.0	<1
18. Adelaide Mine adit pond water																				
Apr-13	46	118.5	5.76	237	2	9.5	6.81	135	88	0.61	<0.1	37.0	4	8.0	14.0	41	5.0	7.0	9.0	<1
19. Red Lead Mine discharge																				
Apr-13	94	98.2	5.88	236	2668	10.3	6.35	119	77	0.80	21300.0	3.0	28	22.0	17.0	30	2.0	6.0	10.0	<1
CC10 Comet above Adelaide Mine																				
Apr-13	108	71.3	6.40	277	0	9.0	7.64	90	58	0.78	0.9	15.0	2	5.0	14.0	20	3.0	3.0	8.0	<1
ANZECC WQ guidelines 80%	90-110	30-350	6.5-7.5		2-25															

Sites/Parameters	T/Al	D/Al	T/As	D/As	T/Cd	D/Cd	T/Cr	D/Cr	T/Cu	D/Cu	T/Pb	D/Pb	T/Mn	D/Mn	T/Ni	D/Ni	T/Zn	D/Zn	T/Fe	D/Fe	T/Hg	D/Hg	F
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1. Dundas @ highway																							
Apr-13	0.120	0.070	<0.001	<0.001	0.0004	0.0004	0.002	0.002	0.004	0.002	0.006	0.004	0.152	0.153	0.007	0.006	0.133	0.134	0.350	0.270	<0.0001	<0.0001	<0.1
3. Razorback mine drainage																							
Apr-13	<0.010		<0.001		0.0009		<0.001		<0.001		<0.001		0.032		0.062		0.194		<0.05		<0.0001		<0.1
4. Razorback tailings dam																							
Apr-13	0.120		<0.001		0.0002		0.003		0.002		0.006		0.271		0.035		0.024		0.600		<0.0001		<0.1
9. Adelaide Mine Creek below Red Lead Mine																							
Apr-13	0.110	0.050	<0.001	<0.001	0.003	0.0028	0.004	0.003	0.003	0.002	0.025	0.008	0.983	0.938	0.015	0.013	1.03	1.010	0.320	0.200	<0.0001	<0.0001	<0.1
13. South Comet Mine tailings dam																							
Apr-13	0.480		0.003		0.327		0.001		0.029		1.27		<0.001		0.361		111		19.700		<0.0001		<0.1
16. Dundas @ township bridge																							
Apr-13	0.100	0.060	<0.001	<0.001	0.0006	0.0003	<0.001	<0.001	0.008	0.002	0.007	0.005	0.205	0.140	0.011	0.009	0.174	0.100	0.420	0.290	<0.0001	<0.0001	<0.1
17. Maestries culvert to DR																							
Apr-13	0.220		0.002		0.0094		0.003		0.004		0.297		2.390		0.007		2.61		2.690		<0.0001		<0.1
18. Adelaide Mine adit pond water																							
Apr-13	0.020		0.002		0.0013		0.006		0.002		0.019		0.169		0.052		0.209		0.140		<0.0001		<0.1
19. Red Lead Mine discharge																							
Apr-13	5.620	<0.01	0.005	<0.001	0.0046	<0.0001	0.950	0.104	0.127	<0.001	57.4	<0.001	15.400	0.042	0.427	0.017	1.05	0.009	22.200	<0.5	<0.0001	<0.0001	<0.1
CC10 Comet above Adelaide Mine																							
Apr-13	0.040	0.020	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.002	0.002	0.024	0.003	0.142	0.127	0.004	0.003	0.02	0.015	0.260	0.150	<0.0001	<0.0001	<0.1
ANZECC WQ guidelines 80%	0.150		0.360		0.0008		0.040		0.0025		0.0094		3.600		0.017		0.031				0.0054		

Dundas					Surface monitoring																																								
	Field						Laboratory																																						
Sites/Parameters	D.O.	E.C. field	pH field	ORP	Turb. (field)	Temp	pH lab	E.C. lab	TDS	SAR	Turbid (lab)	T/Alk	Acidity	SO4	Cl	T/Hardness	D/Ca	D/Mg	D/Na	D/K	T/Al	D/Al	T/As	D/As	T/Cd	D/Cd	T/Cr	D/Cr	T/Cu	D/Cu	T/Pb	D/Pb	T/Mn	D/Mn	T/Ni	D/Ni	T/Sn	D/Sn	T/Zn	D/Zn	T/Fe	D/Fe	T/Hg	D/Hg	F
	% sat.	uS/cm		mV	NTU	°C		uS/cm	mg/L		NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1. Dundas @ highway																																													
Nov-95		105.0		29		12.1															0.050				0.001				0.001		0.001		0.387				0.001		0.254		0.305	0.305	0.254		0.305
Dec-95		55.7																			0.073				0.001				0.001		0.001		0.217				0.001		0.187		0.274	0.274	0.187		0.274
Feb-96				428		13.5						1.4		7.440							0.001				0.001				0.001		0.001		0.700				0.001		1.400		0.001	0.001	1.400		0.001
Feb-96												4.9		9.502							0.001				0.001				0.001		0.001		0.600				0.300		1.400		0.900	0.900	1.400		0.900
Mar-96		212.0	6.50	190		11.8						7.8		4.270							0.210				0.001				0.001		0.039		0.177				0.001		0.111		0.782	0.782	0.111		0.782
Apr-13	97	75.4	6.04	180	-1	7.5	8.24	94	61	1.04	1.8	12.0	3	7.0	16.0	17	2.0	3.0	10.0	<1	0.120	0.070	<0.001	<0.001	0.0004	0.0004	0.002	0.002	0.004	0.002	0.006	0.004	0.152	0.153	0.007	0.006			0.133	0.134	0.350	0.270	<0.0001	<0.0001	<0.1
2. Dundas above Comet																																													
Nov-95		8.0		47		11.5															0.001				0.001				0.001		0.006		0.295				0.001		0.182		0.489	0.489	0.182		0.489
Dec-95		65.0																			0.087				0.001				0.001		0.001		0.190				0.001		0.121		0.389	0.389	0.121		0.389
Feb-96				35		11.3						2.8		4.236							0.100				0.001				0.001		0.100		0.400				0.001		0.001		1.300	1.300	0.001		1.300
Mar-96		112.0	6.40	153		12.5						4.5		4.794							0.415				0.001				0.001		0.204		0.912				0.001		0.348		2.737	2.737	0.348		2.737
3. Razorback mine drainage																																													
Nov-95		151.0		12		10.2															0.001				0.006				0.001		0.037		1.110				0.001		1.013		7.201	7.201	1.013		7.201
Dec-95		117.0																			0.001				0.011				0.001		0.028		1.188				0.001		0.919		8.279	8.279	0.919		8.279
Feb-96				380		11.2						0.0		357.600							0.800				0.400				0.001		0.300		4.800				0.300		4.300		91.000	91.000	4.300		91.000
Mar-96		875.0	6.20	100		10.6						34.3		74.580							0.164				0.010				0.001		0.059		1.608				0.001		1.203		7.355	7.355	1.203		7.355
Apr-13	90	237.0	6.46	215	-3	13.7	7.86	253	164	0.44	<0.1	43.0	6	58.0	16.0	100	7.0	20.0	10.0	<1	<0.010		<0.001		0.0009		<0.001		<0.001		<0.001		0.032		0.062				0.194		<0.05		<0.0001		<0.1
4. Razorback tailings dam																																													
Feb-95				390		10.5						8.1		10.090							0.001				0.001				0.001		0.001		1.200				0.300		1.400		1.200	1.200	1.400		1.200
Feb-95												0.0		6.988							0.001				0.001				0.001		0.100		0.900				0.300		0.900		1.100	1.100	0.900		1.100
Mar-96		415.0	5.80	20		14.5						18.6		16.306							0.001				0.001				0.001		0.024		0.926				0.001		0.178		0.305	0.305	0.178		0.305
Apr-13	86	107.3	6.74	205	-1	12.8	7.90	124	81	0.78	1.9	27.0	3	6.0	18.0	31	1.0	7.0	10.0	<1	0.120		<0.001		0.0002		0.003		0.002		0.006		0.271		0.035				0.024		0.600		<0.0001		<0.1
5. Creek above Razorback tailings dam																																													
Mar-96		305.0	5.50	10		12.8						26.7		2.586							0.058				<0.005				<0.050		<0.005		<0.100				<0.015		0.040		0.443	0.443	0.040		0.443
6. Dundas above Concert																																													
Nov-95		67.0		31		10.1															0.050				0.001				0.001		0.008		0.269				0.001		0.254		0.582	0.582	0.254		0.582
Dec-95		58.0																			0.118				0.001				0.001		0.001		0.125				0.001		0.159		0.459	0.459	0.159		0.459
Feb-96				430		11.0						0.0		3.334							0.300				0.303				0.001		0.001		0.001				0.300		0.500		1.103	1.103	0.500		1.103
Feb-96		120.0										0.0		1.844							0.900				0.001				0.001		0.100		0.001				0.001		0.800		0.001	0.001	0.800		0.001
Mar-96			7.00	19		10.7						7.7		6.668							0.109				0.001				0.001		0.001		0.001				0.001		0.064		0.428	0.428	0.064		0.428
7. Concert above Dundas																																													
Feb-96				452		11.0						1.5		3.844							0.001				0.001				0.001		0.001		0.900				0.200		1.300		0.010	0.010	1.300		0.010
Mar-96		257.0	6.40	5		10.7						14.3		5.588							0.001				0.001				0.001		0.001		0.138				0.001		0.064		0.197	0.197	0.064		0.197
8. Comet above Dundas																																													
Feb-96				80		10.7						2.8		8.4							0.500				0.100				0.001		0.200		1.000				0.360		1.900		1.200	1.200	1.900		1.200
Mar-96		223.0	6.30	250		13.4						4.5		0.9							0.278				0.001				0.001		0.249		0.991				0.001		0.539		1.352	1.352	0.539		1.352
9. Adelaide Mine Creek below Red Lead Mine																																													
Feb-96				80		11.1						9.1		19.544							0.001				0.001				0.800		0.001		1.400				0.001		3.200		0.001	0.001	3.200		0.001
Mar-96		283.0	6.40	250		13.4						4.8		13.144							0.551				0.010				0.001		0.441		2.134				0.001		1.393		2.429	2.429	1.393		2.429
Apr-13	84	102.0	6.01	247	2	8.8	7.43	125	81	0.84	<0.1	11.0	4	16.0	18.0	26	4.0	4.0	10.0	<1	0.110	0.050	<0.001	<0.001	0.003	0.0028	0.004	0.003	0.003	0.002	0.025	0.008	0.983	0.938	0.015	0.013			1.03	1.010	0.320	0.200	<0.0001	<0.0001	<0.1
10. Comet below Adelaide Mine																																													
Feb-96				111.0		11.3						11.8		9.036							0.001				0.001				0.001		0.001		0.500				0.001		0.500		0.001	0.001	0.500		0.001
Feb-96												8.1		5.078							0.001				0.001				0.001		0.001		0.900				0.001		1.000		0.001	0.001	1.000		0.001
Mar-96		148.0	6.60	131		13.4						4.3		2.674							1.004				0.001				0.001		0.263		1.017				0.001		0.102		3.815	3.815	0.102		3.815
11. Comet @ crossing to South Comet Mine																																													
Feb-96				285		10.8						1.2		4.126							0.001				0.001				0.001		0.001		0.500				0.300		1.000		0.001	0.001	1.000		0.001
Mar-96		318.0										21.7		5.916							0.096				0.001				0.001		0.012		0.926				0.001		0.083		0.890	0.890	0.083		0.890
Mar-96		324.0	6.30	52		10.5						21.2		6.470							0.001				0.001				0.001		0.013		0.690				0.001		0.045		0.812	0.812	0.045		0.812
12. South Comet below South Comet Mine																																													
Nov-95		50.0		0		8.5															0.050				0.005				0.001		0.039		0.821				0.001		1.000		0.351	0.351	1.000		0.351
Dec-95		87.0																			0.064				0.015				0.001		0.024		2.921				0.001		0.083		0.335	0.335	0.083		0.335
Feb-96				340		10.0						1.7		6.010							0.001				0.303				0.001		0.200		2.000				0.300		0.045		0.001	0.001	0.045		0.001
Feb-96												0		8.762							0.500				0.100				0.001		0.100		0.800				0.200		0.900		0.001	0.001	0.900		0.001
Mar-96		1242.0	6.00	40		11.2						7.5		175.500							0.001				0.051				0.001		0.057		15.001				0.001		13.266		0.413	0.413	13.266		0.413
Sites/Parameters	D.O.	E.C. field	pH field	ORP	Turb. (field)	Temp	pH lab	E.C. lab	TDS	SAR	Turbid (lab)	T/Alk	Acidity	SO4	Cl	T/Hardness	D/Ca	D/Mg	D/Na	D/K	T/Al	D/Al	T/As	D/As	T/Cd	D/Cd	T/Cr	D/Cr	T/Cu	D/Cu	T/Pb	D/Pb	T/Mn	D/Mn	T/Ni	D/Ni	T/Sn	D/Sn	T/Zn	D/Zn	T/Fe	D/Fe	T/Hg	D/Hg	F
13. South Comet Mine tailings dam																																													
Feb-96				392		15.0						0.0		739.500							0.500				0.605				0.001		1.000		101.000				0.300		57.000		3.000	3.000	57.000		3.000
Mar-96		4810.0	6.00	152		13.5						19.5		954.600							0.001				0.707				0.001		0.071		0.573				0.001		75.956		1.121	1.121	75.956		1.121
Apr-13	88	1750.0	3.17	365	54	13.0	3.63	1830	1190	0.19	113.0	<1	218	1180.0	14.0	618	89.0	96.0	11.0	2.0	0.480		0.003		0.327		0.001		0.029		1.27		<0.001		0.361				111		19.700		<0.0001		<0.1
14. South Comet mine bottom adit drainage																																													
Nov-95		771.0		15.0		11.7															0.073				0.229				0.001		0.129		77.370				0.001		61.700		4.584	4.584	61.700		4.584
Dec-95		980.0																			0.001				0.254				0.001		0.088		79.995				0.001		61.700		5.273	5.273	61.700		5.273
Feb-96				350		16.7						18.2		1068.80							0.001				0.600				0.001		0.300		1020.00				0.200		56.020		6.000	6.000	56.020		6.000
Mar-96		1739.0	6.10	100		10.3						27.4		610.500							0.001				0.229				0.001		0.075		79.996				0.001		64.550		4.892	4.892	64.550		4.892
15. South Comet above mine																																													
Nov-95		40.0		13.0		7.6															0.050				0.001				0.001		0.001		0.001				0.001		0.001		0.197	0.197	0.001		0.197
Dec-95		39.0																			0.073				0.001				0.001		0.001		0.001				0.001		0.035		0.212	0.212	0.035		0.212
Feb-96				275		10.0						2.3		4.514							0.001				0.300				0.001		0.100		0.500				0.300		0.001		1.000	1.000	0.001		1.000
Mar-96		245.0	6.40									9.1		4.460							0.001				0.001				0.001		0.001		0.001				0.001		0.001		0.105	0.105	0.001		0.105
Mar-96		240.0	6.50	115		9.6						9.2		4.194							0.001				0.001				0.001		0.001		0.001				0.001		0.049		0.105	0.105	0.049		0.105
16. Dundas @ township bridge																																													
Apr-13	85	84.3	6.22	195	-1	9.2	7.01	103	67	0.94	<0.1	16.0	4	7.0	16.0	21	2.0	4.0	10.0	<1	0.100	0.060	<0.001	<0.001	0.0006	0.0003	<0.001	<0.001	0.008	0.002	0.007	0.005	0.205	0.140	0.011	0.009			0.174	0.100	0.420	0.290	<0.0001	<0.0001	<0.1
17. Maestries culvert to DR																																													
Apr-13	86	98.7	6.17	124	23	12.3	6.63	114	74	0.88	32.8	8.0	5	18.0	15.0	20	3.0	3.0	9.0	<1	0.220		0.002		0.0094		0.003		0.004		0.297		2.390		0.007				2.61		2.690		<0.0001		<0.1
18. Adelaide Mine adit pond water																																													
Apr-13	46	118.5	5.76	237	2	9.5	6.81	135	88	0.61	<0.1	37.0	4	8.0	14.0	41	5.0	7.0	9.0	<1	0.020		0.002		0.0013		0.006		0.002		0.019		0.169		0.052				0.209		0.140		<0.0001		<0.1
19. Red Lead Mine discharge																																													
Apr-13	94	98.2	5.88	236	2668	10.3	6.35	119	77	0.80	21300.0	3.0	28	22.0	17.0	30	2.0	6.0	10.0	<1	5.620	<0.01	0.005	<0.001	0.0046	<0.0001	0.950	0.104	0.127	<0.001	57.4	<0.001	15.400	0.042	0.427	0.017			1.05	0.009	22.200	<0.5	<0.0001	<0.0001	<0.1
CC10 Comet above Adelaide Mine																																													
Apr-13	108	71.3	6.40	277	0	9.0	7.64	90	58	0.78	0.9	15.0	2	5.0	14.0	20	3.0	3.0	8.0	<1	0.040	0.020	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.002	0.002	0.024	0.003	0.142	0.127	0.004	0.003			0.02	0.015	0.260	0.150	<0.0001	<0.0001	<0.1
Sites/Parameters	D.O.	E.C. field	pH field	ORP	Turb. (field)	Temp	pH lab	E.C. lab	TDS	SAR	Turbid (lab)	T/Alk	Acidity	SO4	Cl	T/Hardness	D/Ca	D/Mg	D/Na	D/K	T/Al	D/Al	T/As	D/As	T/Cd	D/Cd	T/Cr	D/Cr	T/Cu	D/Cu	T/Pb	D/Pb	T/Mn	D/Mn	T/Ni	D/Ni	T/Sn	D/Sn	T/Zn	D/Zn	T/Fe	D/Fe	T/Hg	D/Hg	F
ANZECC WQ guidelines 80%	90-110	30-350	6.5-7.5		2-25																0.150		0.360		0.0008		0.040		0.0025		0.0094		3.600		0.017		0.031		0.031				0.0054		

Dundas mine area																				
Parameter/Site	**1. Dundas @ highway**	**2. Dundas above Comet**	**3. Razorback mine drainage**	**4. Razorback tailings dam**	**5. Creek above Razorback tailings dam**	**6. Dundas above Concert**	**7. Concert above Dundas**	**8. Comet above Dundas**	**9. Adelaide Mine Ck below Red Lead Mine**	**10. Comet below Adelaide Mine**	**11. Comet @ crossing to South Comet Mine**	**12. South Comet below South Comet Mine**	**13. South Comet Mine tailings dam**	**14. South Comet mine bottom adit drainage**	**15. South Comet above mine**	**16. Dundas @ township bridge**	**17. Maestries culvert to DR**	**18. Adelaide Mine adit water**	**19. Red Lead Mine discharge**	**CC10 Comet above Adelaide Mine**
D.O. % field																				
Apr-13	**97**		**89.9**	**86.3**					**83.9**				**88.2**			**85.4**	**86.1**	**46.4**	**94**	**108**
E.C. uS/cm field																				
Nov-95	105.0	8.0	151.0			67.0						50.0		771.0	40.0					
Dec-95	55.7	65.0	117.0			58.0						87.0		980.0	39.0					
Feb-96						120.0														
Mar-96	212.0	112.0	875.0	415.0	305.0		257.0	223.0	283.0	148.0	318.0	1242.0	4810.0	1739.0	245.0					
Mar-96											324.0				240.0	84.3	98.7	118.5	98.2	71.3
Apr-13	**75.4**		**237.0**	**107.3**					**102.0**				**1750.0**			**84.3**	**98.7**	**118.5**	**98.2**	**71.3**
pH field																				
Mar-96	6.50	6.40	6.20	5.80	5.50	7.00	6.40	6.30	6.40	6.60	6.30	6.00	6.00	6.10	6.40					
Mar-96															6.50					
Apr-13	**6.04**		**6.46**	**6.74**					**6.01**				**3.17**			**6.22**	**6.17**	**5.76**	**5.88**	**6.40**
ORP mV field																				
Nov-95	29	47	12			31						0		15.0	13.0					
Feb-96	428	35	380	390		430				111.0	285	340		350	275					
Feb-96							452	80	80				392							
Mar-96	190	153	100	20	10	19	5	250	250	131	52	40	152	100	115					
Mar-96																				
Apr-13	**180**		**215**	**205**					**247**				**365**			**195**	**124**	**237**	**236**	**277**
Turbid. NTU (field)																				
Apr-13	**-1**		**-3**	**-1**					**2**				**54**			**-1**	**23**	**2**	**2668**	**0**
Temperature °C																				
Nov-95	12.1	11.5	10.2			10.1						8.5		11.7	7.6					
Feb-96	13.5	11.3	11.2	10.5		11.0				11.3	10.8	10.0		16.7	10.0					
Feb-96							11.0	10.7	11.1				15.0							
Mar-96	11.8	12.5	10.6	14.5	12.8	10.7	10.7	13.4	13.4	13.4	10.5	11.2	13.5	10.3	9.6					
Mar-96																				
Apr-13	**7.5**		**13.7**	**12.8**					**8.8**				**13.0**			**9.2**	**12.3**	**9.5**	**10.3**	**9.0**
pH labs																				
Apr-13	**8.24**		**7.86**	**7.90**					**7.43**				**3.63**			**7.01**	**6.63**	**6.81**	**6.35**	**7.64**
E.C. uS/cm labs																				
Apr-13	**94**		**253**	**124**					**125**				**1830**			**103**	**114**	**135**	**119**	**90**
TDS mg/L																				
Apr-13	**61**		**164**	**81**					**81**				**1190**			**67**	**74**	**88**	**77**	**58**
SAR																				
Apr-13	**1.04**		**0.44**	**0.78**					**0.84**				**0.19**			**0.94**	**0.88**	**0.61**	**0.80**	**0.78**
Turbid. NTU (lab)																				
Apr-13	**1.8**		**<0.1**	**1.9**					**<0.1**				**113.0**			**<0.1**	**32.8**	**<0.1**	**21300.0**	**0.9**
T/Alkalinity mg/L																				
Feb-96	1.4			8.1		0.0				11.8		1.7								
Feb-96	4.9	2.8	0.0	0.0		0.0	1.5	2.8	9.1	8.1	1.2	0	0.0	18.2	2.3					
Mar-96	7.8	4.5	34.3	18.6	26.7	7.7	14.3	4.5	4.8	4.3	21.7	7.5	19.5	27.4	9.1					
Mar-96											21.2				9.2					
Apr-13	**12.0**		**43.0**	**27.0**					**11.0**				**<1**			**16.0**	**8.0**	**37.0**	**3.0**	**15.0**

Acidity mg/L																				
Apr-13	3		6	3					4				218			4	5	4	28	2
Sulphate mg/L																				
Feb-96	7.440			10.090		3.334				9.036		6.010								
Feb-96	9.502	4.236	357.600	6.988		1.844	3.844	8.4	19.544	5.078	4.126	8.762	739.500	1068.80	4.514					
Mar-96	4.270	4.794	74.580	16.306	2.586	6.668	5.588	0.9	13.144	2.674	5.916	175.500	954.600	610.500	4.460					
Mar-96											6.470				4.194					
Apr-13	7.0		58.0	6.0					16.0				1180.0			7.0	18.0	8.0	22.0	5.0
Chloride mg/L																				
Apr-13	16.0		16.0	18.0					18.0				14.0			16.0	15.0	14.0	17.0	14.0
T/Hardness mg/L																				
Apr-13	17		100	31					26				618			21	20	41	30	20
Parameter/Site	1. Dundas @ highway	2. Dundas above Comet	3. Razorback mine drainage	4. Razorback tailings dam	5. Creek above Razorback tailings dam	6. Dundas above Concert	7. Concert above Dundas	8. Comet above Dundas	9. Adelaide Mine Ck below Red Lead Mine	10. Comet below Adelaide Mine	11. Comet @ crossing to South Comet Mine	12. South Comet below South Comet Mine	13. South Comet Mine tailings dam	14. South Comet mine bottom adit drainage	15. South Comet above mine	16. Dundas @ township bridge	17. Maestries culvert to DR	18. Adelaide Mine adit water	19. Red Lead Mine discharge	CC10 Comet above Adelaide Mine
T/Aluminium mg/L																				
Nov-95	0.050	0.001	0.001			0.050						0.050		0.073	0.050					
Dec-95	0.073	0.087	0.001			0.118						0.064		0.001	0.073					
Feb-96	0.001	0.100	0.800	0.001		0.300				0.001		0.001		0.001	0.001					
Feb-96	0.001			0.001		0.900	0.001	0.500	0.001	0.001	0.001	0.500	0.500							
Mar-96	0.210	0.415	0.164	0.001	0.058	0.109	0.001	0.278	0.551	1.004	0.096	0.001	0.001	0.001	0.001					
Mar-96											0.001				0.001					
Apr-13	0.120		<0.010	0.120					0.110				0.480			0.100	0.220	0.020	5.620	0.040
T/Arsenic mg/L																				
Apr-13	<0.001		<0.001	<0.001					<0.001				0.003			<0.001	0.002	0.002	0.005	<0.001
T/Cadmium mg/L																				
Nov-95	0.001	0.001	0.006			0.001						0.005		0.229	0.001					
Dec-95	0.001	0.001	0.011			0.001						0.015		0.254	0.001					
Feb-96	0.001	0.001	0.400	0.001		0.303				0.001		0.303		0.600	0.300					
Feb-96	0.001			0.001		0.001	0.001	0.100	0.001	0.001	0.001	0.100	0.605							
Mar-96	0.001	0.001	0.010	0.001	<0.005	0.001	0.001	0.001	0.010	0.001	0.001	0.051	0.707	0.229	0.001					
Mar-96											0.001				0.001					
Apr-13	0.0004		0.0009	0.0002					0.003				0.327			0.0006	0.0094	0.0013	0.0046	<0.0001
T/Chromium mg/L																				
Apr-13	0.002		<0.001	0.003					0.004				0.001			<0.001	0.003	0.006	0.950	<0.001
T/Copper mg/L																				
Nov-95	0.001	0.001	0.001			0.001						0.001		0.001	0.001					
Dec-95	0.001	0.001	0.001			0.001						0.001		0.001	0.001					
Feb-96	0.001	0.001	0.001	0.001		0.001				0.001		0.001		0.001	0.001					
Feb-96	0.001			0.001		0.001	0.001	0.001	0.800	0.001	0.001	0.001	0.001							
Mar-96	0.001	0.001	0.001	0.001	<0.050	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001					
Mar-96											0.001				0.001					
Apr-13	0.004		<0.001	0.002					0.003				0.029			0.008	0.004	0.002	0.127	0.002
T/Lead mg/L																				
Nov-95	0.001	0.006	0.037			0.008						0.039		0.129	0.001					
Dec-95	0.001	0.001	0.028			0.001						0.024		0.088	0.001					
Feb-96	0.001	0.100	0.300	0.001		0.001				0.001		0.200		0.300	0.100					
Feb-96	0.001			0.100		0.100	0.001	0.200	0.001	0.001	0.001	0.100	1.000							
Mar-96	0.039	0.204	0.059	0.024	<0.005	0.001	0.001	0.249	0.441	0.263	0.012	0.057	0.071	0.075	0.001					
Mar-96											0.013				0.001					
Apr-13	0.006		<0.001	0.006					0.025				1.27			0.007	0.297	0.019	57.4	0.024

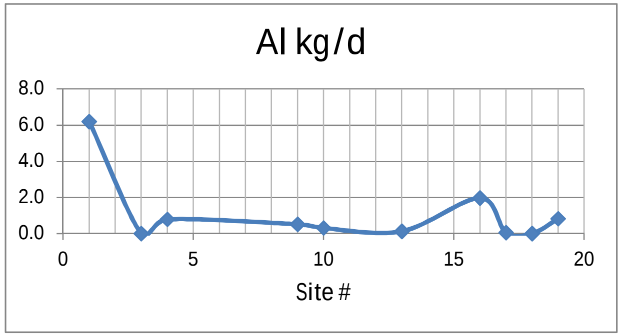
T/Manganese mg/L																				
Nov-95	0.387	0.295	1.110			0.269						0.821		77.370	0.001					
Dec-95	0.217	0.190	1.188			0.125						2.921		79.995	0.001					
Feb-96	0.700	0.400	4.800	1.200		0.001				0.500		2.000		1020.00	0.500					
Feb-96	0.600			0.900		0.001	0.900	1.000	1.400	0.900	0.500	0.800	101.000							
Mar-96	0.177	0.912	1.608	0.926	<0.100	0.001	0.138	0.991	2.134	1.017	0.926	15.001	0.573	79.996	0.001					
Mar-96											0.690				0.001					
Apr-13	**0.152**		**0.032**	**0.271**					**0.983**				**<0.001**			**0.205**	**2.390**	**0.169**	**15.400**	**0.142**
T/Nickel mg/L																				
Apr-13	**0.007**		**0.062**	**0.035**					**0.015**				**0.361**			**0.011**	**0.007**	**0.052**	**0.427**	**0.004**
T/Sn (tin) mg/L																				
Nov-95	0.001	0.001	0.001			0.001						0.001		0.001	0.001					
Dec-95	0.001	0.001	0.001			0.001						0.001		0.001	0.001					
Feb-96	0.001	0.001	0.300	0.300		0.300				0.001		0.300		0.200	0.300					
Feb-96	0.300			0.300		0.001	0.200	0.360	0.001	0.001	0.300	0.200	0.300							
Mar-96	0.001	0.001	0.001	0.001	<0.015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001					
Mar-96											0.001				0.001					
T/Zinc mg/L																				
Nov-95	0.254	0.182	1.013			0.254						1.000		61.700	0.001					
Dec-95	0.187	0.121	0.919			0.159						0.083		61.700	0.035					
Feb-96	1.400	0.001	4.300	1.400		0.500				0.500		0.045		56.020	0.001					
Feb-96	1.400			0.900		0.800	1.300	1.900	3.200	1.000	1.000	0.900	57.000							
Mar-96	0.111	0.348	1.203	0.178	0.040	0.064	0.064	0.539	1.393	0.102	0.083	13.266	75.956	64.550	0.001					
Mar-96											0.045				0.049					
Apr-13	**0.133**		**0.194**	**0.024**					**1.03**				**111**			**0.174**	**2.61**	**0.209**	**1.05**	**0.02**
T/Iron mg/L																				
Nov-95	0.305	0.489	7.201			0.582						0.351		4.584	0.197					
Dec-95	0.274	0.389	8.279			0.459						0.335		5.273	0.212					
Feb-96	0.001	1.300	91.000	1.200		1.103				0.001		0.001		6.000	1.000					
Feb-96	0.900			1.100		0.001	0.010	1.200	0.001	0.001	0.001	0.001	3.000							
Mar-96	0.782	2.737	7.355	0.305	0.443	0.428	0.197	1.352	2.429	3.815	0.890	0.413	1.121	4.892	0.105					
Mar-96											0.812				0.105					
Apr-13	**0.350**		**<0.05**	**0.600**					**0.320**				**19.700**			**0.420**	**2.690**	**0.140**	**22.200**	**0.260**
Hg mg/L																				
Apr-13	**<0.0001**		**<0.0001**	**<0.0001**					**<0.0001**				**<0.0001**			**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
F mg/L																				
Apr-13	**<0.1**		**<0.1**	**<0.1**					**<0.1**				**<0.1**			**<0.1**	**<0.1**	**<0.1**	**<0.1**	**<0.1**
Parameter/Site	**1. Dundas @ highway**	**2. Dundas above Comet**	**3. Razorback mine drainage**	**4. Razorback tailings dam**	**5. Creek above Razorback tailings dam**	**6. Dundas above Concert**	**7. Concert above Dundas**	**8. Comet above Dundas**	**9. Adelaide Mine Ck below Red Lead Mine**	**10. Comet below Adelaide Mine**	**11. Comet @ crossing to South Comet Mine**	**12. South Comet below South Comet Mine**	**13. South Comet Mine tailings dam**	**14. South Comet mine bottom adit drainage**	**15. South Comet above mine**	**16. Dundas @ township bridge**	**17. Maestries culvert to DR**	**18. Adelaide Mine adit water**	**19. Red Lead Mine discharge**	**CC10 Comet above Adelaide Mine**

Dundas												
ANZECC WQ guidelines 80%			0.1500	0.3600	0.0008	0.0400	0.0025	0.0094	3.6000	0.0170	0.0310	
Sites/Parameters	**Flow**	**SO4**	**T/Al**	**T/As**	**T/Cd**	**T/Cr**	**T/Cu**	**T/Pb**	**T/Mn**	**T/Ni**	**T/Zn**	**T/Fe**
	L/s	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
1. Dundas @ highway												
Apr-13	598	7.0	0.120	<0.001	0.0004	0.002	0.004	0.006	0.152	0.007	0.133	0.350
Mass emission rate kg/d		**361.7**	**6.2**	**0.0**	**0.0**	**0.1**	**0.2**	**0.3**	**7.9**	**0.4**	**6.9**	**18.1**
3. Razorback mine drainage												
Apr-13	2.2	58.0	<0.010	<0.001	0.0009	<0.001	<0.001	<0.001	0.032	0.062	0.194	<0.05
Mass emission rate kg/d		**11.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
4. Razorback tailings dam												
Apr-13	76	6.0	0.120	<0.001	0.0002	0.003	0.002	0.006	0.271	0.035	0.024	0.600
Mass emission rate kg/d		**39.4**	**0.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.2**	**0.2**	**3.9**
9. Adelaide Mine Creek below Red Lead Mine												
Apr-13	54	16.0	0.110	<0.001	0.003	0.004	0.003	0.025	0.983	0.015	1.03	0.320
Mass emission rate kg/d		**74.6**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**4.6**	**0.1**	**4.8**	**1.5**
13. South Comet Mine tailings dam												
Apr-13	3	1180.0	0.480	0.003	0.327	0.001	0.029	1.27	<0.001	0.361	111	19.700
Mass emission rate kg/d		**305.9**	**0.1**	**0.0**	**0.1**	**0.0**	**0.0**	**0.3**	**0.0**	**0.1**	**28.8**	**5.1**
16. Dundas @ township bridge												
Apr-13	228	7.0	0.100	<0.001	0.0006	<0.001	0.008	0.007	0.205	0.011	0.174	0.420
Mass emission rate kg/d		**137.9**	**2.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.1**	**4.0**	**0.2**	**3.4**	**8.3**
17. Maestries culvert to DR												
Apr-13	2.7	18.0	0.220	0.002	0.0094	0.003	0.004	0.297	2.390	0.007	2.61	2.690
Mass emission rate kg/d		**4.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.6**	**0.0**	**0.6**	**0.6**
18. Adelaide Mine adit pond water												
Apr-13	0.0	8.0	0.020	0.002	0.0013	0.006	0.002	0.019	0.169	0.052	0.209	0.140
Mass emission rate kg/d		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
19. Red Lead Mine discharge												
Apr-13	1.7	22.0	5.620	0.005	0.0046	0.950	0.127	57.4	15.400	0.427	1.05	22.200
Mass emission rate kg/d		**3.2**	**0.8**	**0.0**	**0.0**	**0.1**	**0.0**	**8.4**	**2.3**	**0.1**	**0.2**	**3.3**
CC10 Comet above Adelaide Mine												
Apr-13	90	5.0	0.040	<0.001	<0.0001	<0.001	0.002	0.024	0.142	0.004	0.02	0.260
Mass emission rate kg/d		**38.9**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**1.1**	**0.0**	**0.2**	**2.0**
Sites/Parameters	**Flow**	**SO4**	**T/Al**	**T/As**	**T/Cd**	**T/Cr**	**T/Cu**	**T/Pb**	**T/Mn**	**T/Ni**	**T/Zn**	**T/Fe**
Flow												
Total Dundas @ highway	598											
DR16 + CC10 + AMC 9	372											
Difference = Climie + Fernfield	226											
Total mass flux kg/d												
DR1		361.7	6.2	0.0	0.0	0.1	0.2	0.3	7.9	0.4	6.9	18.1
DR16 + CC10 + AMC 9		251.4	2.8	0.0	0.0	0.0	0.2	0.4	9.7	0.3	8.4	11.8
Difference		110.2	3.4	0.0	0.0	0.1	0.0	-0.1	-1.9	0.0	-1.5	6.3
DR16		137.9	2.0	0.0	0.0	0.0	0.2	0.1	4.0	0.2	3.4	8.3
RB03 + RB04 + DR17		54.6	0.8	0.0	0.0	0.0	0.0	0.1	2.3	0.2	0.8	4.6
		83.3	1.1	0.0	0.0	0.0	0.1	0.0	1.7	0.0	2.6	3.7
CC10		38.90	0.30	0.00	0.00	0.00	0.000	0.200	1.100	0.000	0.200	2.000
AMC9		74.6	0.5	0.0	0.0	0.0	0.0	0.1	4.6	0.1	4.8	1.5
SCM13 + RL19		309.1	0.9	0.0	0.1	0.1	0.0	8.8	2.3	0.2	28.9	8.4
		-234.4	-0.4	0.0	-0.1	-0.1	0.0	-8.6	2.3	-0.1	-24.1	-6.9

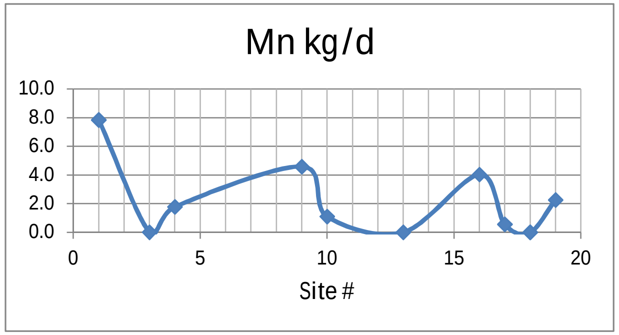
Dundas

16/17 April 2013

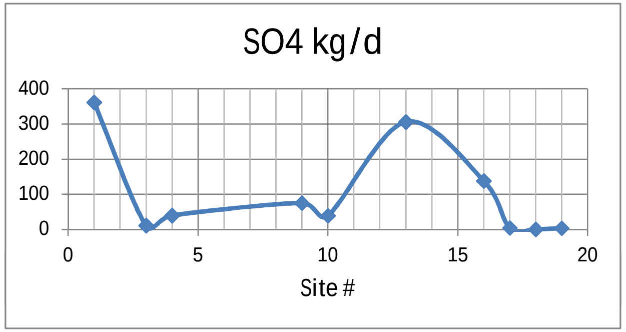
Site	Al kg/d
1	6.2
3	0.0
4	0.8
9	0.5
10	0.3
13	0.1
16	2.0
17	0.1
18	0.0
19	0.8



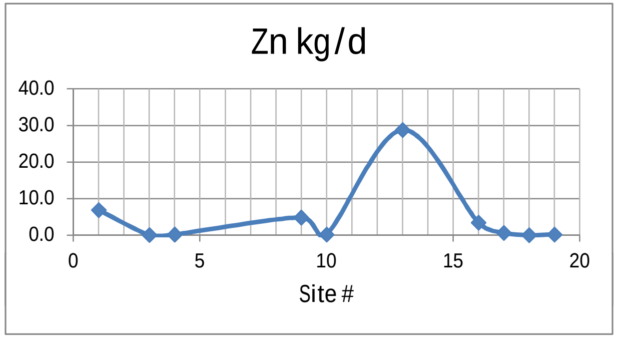
Site	Mn kg/d
1	7.9
3	0.0
4	1.8
9	4.6
10	1.1
13	0.0
16	4.0
17	0.6
18	0.0
19	2.3



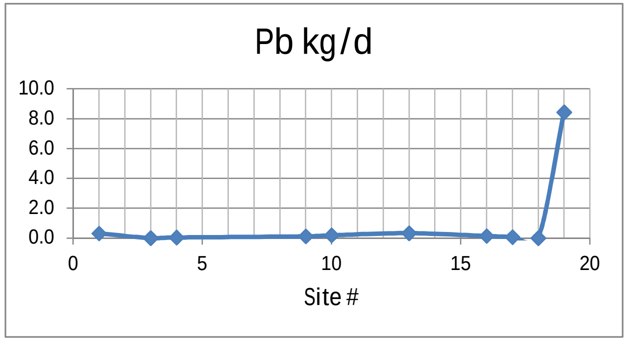
Site	SO4 kg/d
1	362
3	11
4	39
9	75
10	39
13	306
16	138
17	4
18	0
19	3



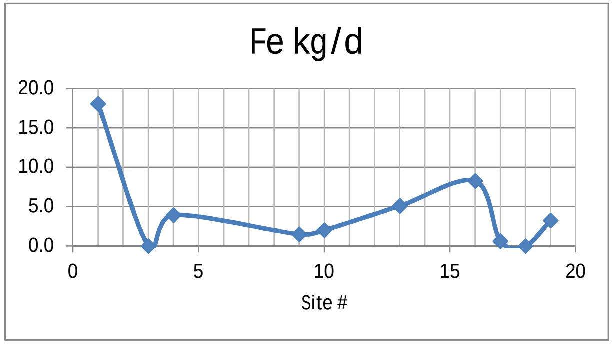
Site	Zn kg/d
1	6.9
3	0.0
4	0.2
9	4.8
10	0.2
13	28.8
16	3.4
17	0.6
18	0.0
19	0.2

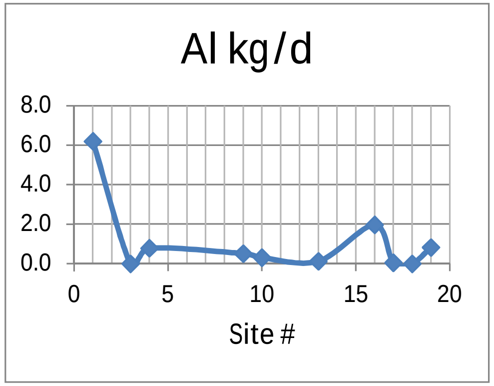


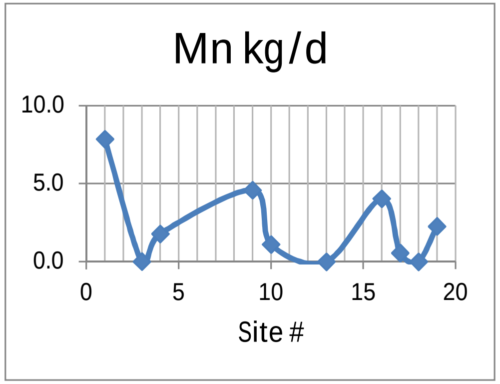
Site	Pb kg/d
1	0.3
3	0.0
4	0.0
9	0.1
10	0.2
13	0.3
16	0.1
17	0.1
18	0.0
19	8.4

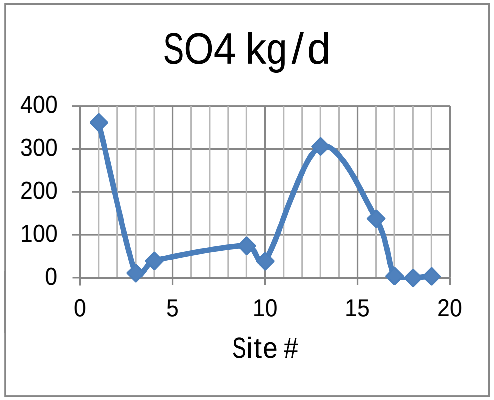


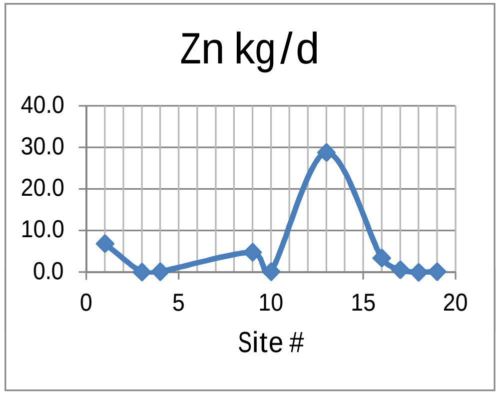
Site	Fe kg/d
1	18.1
3	0.0
4	3.9
9	1.5
10	2.0
13	5.1
16	8.3
17	0.6
18	0.0
19	3.3

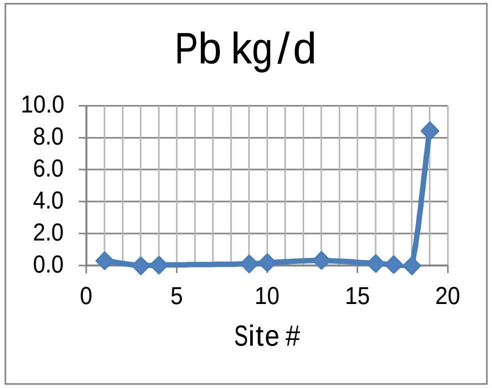


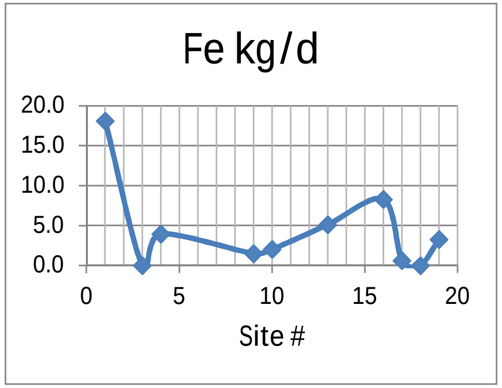

Al kg/d
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
Site #


Mn kg/d
10.0
5.0
0.0
0
5
10
15
20
Site #


SO4 kg/d
400
300
200
100
0
0
5
10
15
20
Site #


Zn kg/d
40.0
30.0
20.0
10.0
0.0
0
5
10
15
20
Site #


Pb kg/d
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
Site #


Fe kg/d
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
Site #

Appendix D

Site Photographs

1. Bridge over Dundas R before former township

2. Razorback open cut adits

3. Razorback open cut adit

4. Razorback open cut adits

5. Drill hole drainage on road to Razorback open cut

6. Drill hole drainage on road to Razorback open cut

16/04/2013

7. Drill hole drainage on road to Razorback open cut

16/04/2013

8. Drill hole drainage on road to Razorback open cut

9. Drainage culvert from Razorback open cut

10. Drainage culvert from Razorback open cut

11. Razorback tailings dam spillway looking NW

12. Razorback tailings dam spillway looking W

13. Razorback tailings dam spillway looking S

14. Razorback tailings beach looking N

15. Razorback tailings dam looking NW

16. Razorback spillway drainage line to Dundas R looking E

17. Razorback bottom wetlands drainage area to Dundas R looking S

18. Track above South Comet Mine looking W

19. Shaft on track above South Comet Mine

20. Open cut & adit on track above South Comet Mine

21. Track above South Comet Mine

22. South Comet Mine drainage pond

23. South Comet Mine drainage pond

24. South Comet Mine drainage from upper workings

25. South Comet Mine lower adit drainage

26. South Comet Mine lower adit drainage

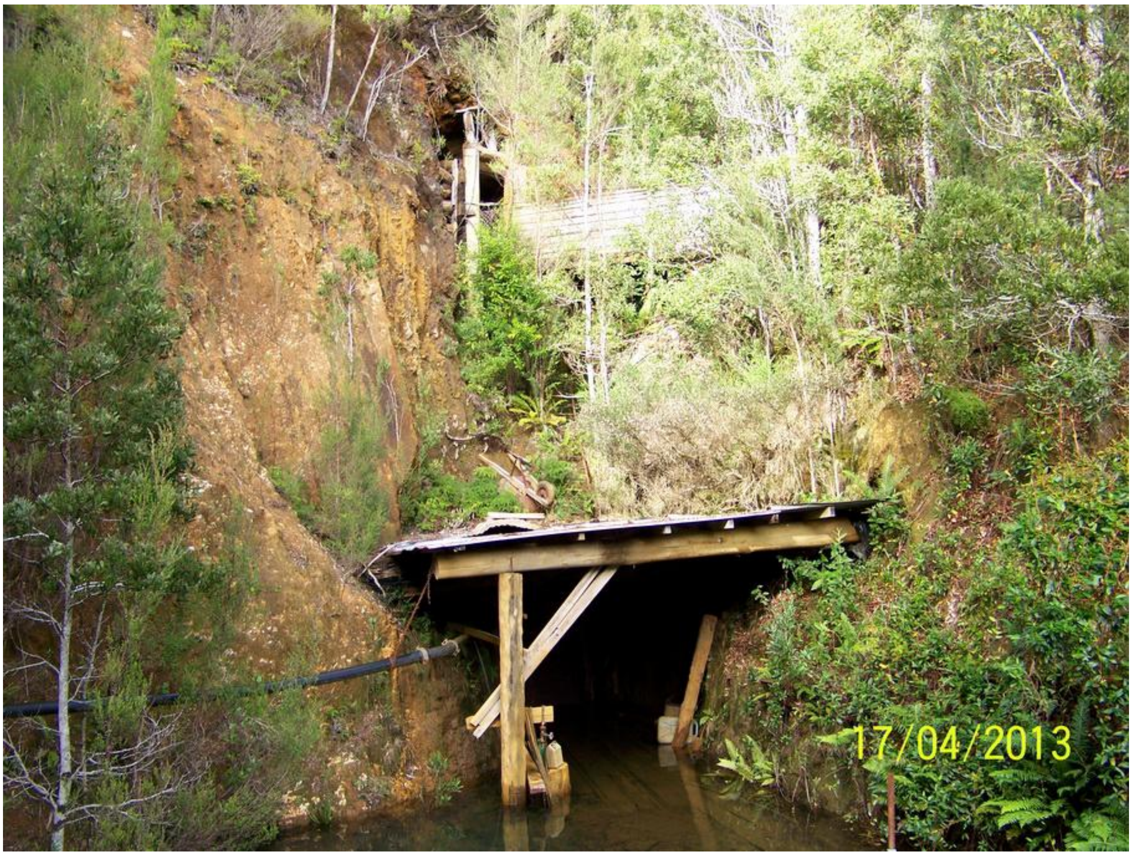
27. Adelaide Mine

28. Adelaide Mine flooded lower adit & shaft

29. Adelaide Mine flooded lower adit & shaft

30. Adelaide Mine flooded lower shaft pond

31. Adelaide Mine flooded lower adit



32. Adelaide Mine flooded lower adit with working adit above

33. Adelaide Mine historaical shaft above current workings looking down shaft

34. Adelaide Mine historical shaft & adits above current workings

35. Adelaide Mine shaft above current workings looking down shaft

36. Adelaide Mine shaft above current workings looking SE

17/04/2013

37.Red Lead Mine lower adit settlement pond


17/04/2013

38. Red Lead Mine lower adit entrance pad

39. Red Lead Mine lower adit

40. Red Lead Mine lower adit settling pond

41.Red Lead Mine lower adit settling pond

42. Adelaide Mine Creek monitoring site above Red Lead Mine lower adit discharge

Appendix E

Water Flow Data

Dundas R @ Zeehan Hwy DR01

Width m	0.000	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000	5.500	6.000	6.500	7.000	7.500	8.000
Depth m	0.000		0.330		0.400		0.430		0.450		0.450		0.400		0.410	0.200	0.000
Avg depth m			0.165		0.365		0.415		0.440		0.450		0.425		0.405	0.305	0.100
Avg area m2			0.165		0.365		0.415		0.440		0.450		0.425		0.405	0.153	0.050
Velocity cm/s	0.000		9.200		21.400		22.600		29.000		26.100		25.300		14.700	3.200	3.200
Avg velocity cm/s			4.600		15.300		22.000		25.800		27.550		25.700		20.000	8.950	3.200
Avg velocity m/s			0.046		0.153		0.220		0.258		0.276		0.257		0.200	0.090	0.032
Volume m3/s			0.008		0.056		0.091		0.114		0.124		0.109		0.081	0.014	0.002
Total m3/s		0.598															

Dundas R @ former town bridge DR16

Width m	0.000	0.500	1.000	1.500	2.000	2.500	3.000	3.500
Depth m	0.000	0.200	0.400	0.500	0.500	0.500	0.450	0.100
Avg depth m		0.100	0.300	0.450	0.500	0.500	0.475	0.275
Avg area m2		0.050	0.150	0.225	0.250	0.250	0.238	0.138
Velocity cm/s	0.000	3.200	8.400	14.400	25.100	30.600	18.600	3.200
Avg velocity cm/s		1.600	5.800	11.400	19.750	27.850	24.600	10.900
Avg velocity m/s		0.016	0.058	0.114	0.198	0.279	0.246	0.109
Volume m3/s		0.001	0.009	0.026	0.049	0.070	0.058	0.015
Total m3/s		0.228						

Razorback tailings dam spillway RB04

Width m	0.000	0.250	0.500	0.750	1.000
Depth m	0.000	0.300	0.300	0.300	0.000
Avg depth m		0.150	0.300	0.300	0.150
Avg area m2		0.038	0.075	0.075	0.038
Velocity cm/s	0.000	60.900	36.700	23.800	3.200
Avg velocity cm/s		30.450	48.800	30.250	13.500
Avg velocity m/s		0.305	0.488	0.303	0.135
Volume m3/s		0.011	0.037	0.023	0.005
Total m3/s		0.076			

Comet Creek @ Adelaide Mine bridge CC10

Width m	0.000	0.425	0.850	1.275	1.700
Depth m	0.180	0.150	0.230	0.260	0.180
Avg depth m		0.165	0.190	0.245	0.220
Avg area m2		0.070	0.081	0.104	0.094
Velocity cm/s	0.000	11.900	36.700	46.000	3.200
Avg velocity cm/s		5.950	24.300	41.350	24.600
Avg velocity m/s		0.060	0.243	0.414	0.246
Volume m3/s		0.004	0.020	0.043	0.023
Total m3/s		0.090			

Adelaide Mine Creek AMC09

Width m	0.000	0.125	0.250	0.375	0.500
Depth m	0.120	0.300	0.300	0.300	0.300
Avg depth m		0.210	0.300	0.300	0.300
Avg area m2		0.026	0.038	0.038	0.038
Velocity cm/s	0.000	40.700	60.900	46.800	3.200
Avg velocity cm/s		20.350	50.800	53.850	25.000
Avg velocity m/s		0.204	0.508	0.539	0.250
Volume m3/s		0.005	0.019	0.020	0.009
Total m3/s		0.054			

Total of DR16, CC10 and AMC10 0.371 m3/s

Razorback open cut culvert drain to lower wetlands RB03

litres	seconds	L/s	m3/s
19.000	8.000	2.37500	0.00238
19.000	9.000	2.11111	0.00211
17.000	8.000	2.12500	0.00213
18.000	9.000	2.00000	0.00200
17.000	8.000	2.12500	0.00213
Avg	8.400	2.14722	0.00215
			0.00220

Maestries Mill culvert discharge DR17

litres	seconds	L/s	m3/s
10.000	3.700	2.70270	0.00270
10.000	3.800	2.63158	0.00263
10.000	3.700	2.70270	0.00270
Avg	3.733	2.67899	0.00268
			0.0027

Red Lead Mine discharge RL19

litres	seconds	L/s	m3/s
6.000	3.600	1.66667	0.00167
7.000	6.050	1.15702	0.00116
7.000	4.500	1.55556	0.00156
8.000	3.500	2.28571	0.00229
Avg	4.413	1.66624	0.00167
			0.0017

South Comet Mine discharge SCM13

litres	seconds	L/s	m3/s
9.000	2.500	3.60000	0.00360
9.000	3.500	2.57143	0.00257
9.000	3.700	2.43243	0.00243
Avg	3.233	2.86795	0.00287
			0.003

Appendix F

Analytical Report

ALS Group

Food& Environmental Pharmaceutical

ALS Life Sciences

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EM1304160**	Page	: 1 of 6
Client	: **PITT & SHERRY**	Laboratory	: Environmental Division Melbourne
Contact	: MR JIM LOCKLEY	Contact	: Shirley LeCornu
Address	: PO BOX 94 199 MACQUARIE ST HOBART TAS, AUSTRALIA 7001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: jlockley@pittsh.com.au	E-mail	: shirley.lecornu@alsenviro.com
Telephone	: +61 62231800	Telephone	: +61-3-8549 9630
Facsimile	: +61 03 62231299	Facsimile	: +61-3-8549 9601
Project	: Dundas Mining Field HB13108	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: HBH5118		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: JL	Issue Date	: 01-MAY-2013
Site	: ----		
		No. of samples received	: 10
Quote number	: MEBQ/119/12	No. of samples analysed	: 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **ED041G : EM1304160-006 for Sulphate has ben confirmed by re-analysis.**
- **Ionic Balance out of acceptable limits for EM1304160 #3 due to analytes not quantified in this report.**
- **Ionic Balance out of acceptable limits for sample #6 as sample matrix is not deemed as potable or naturally occurring water and therefore ionic balance is not applicable**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **It is recognised that total metals is less than dissolved metals for samples EM1304160. However, the difference is within experimental variation of the methods.**

NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics Melbourne Inorganics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics Melbourne Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics Melbourne Inorganics

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

			Client sample ID	**DR01**	**RB03**	**RB04**	**AMC9**	**CC10**
			Client sampling date / time	16-APR-2013 15:00	16-APR-2013 15:00	16-APR-2013 15:00	17-APR-2013 15:00	17-APR-2013 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-001**	**EM1304160-002**	**EM1304160-003**	**EM1304160-004**	**EM1304160-005**
EA005: pH								
pH Value	----	0.01	pH Unit	**8.24**	**7.86**	**7.90**	**7.43**	**7.64**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**1.04**	**0.44**	**0.78**	**0.84**	**0.78**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**94**	**253**	**124**	**125**	**90**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	10	mg/L	**61**	**164**	**81**	**81**	**58**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**1.8**	<0.1	**1.9**	<0.1	**0.9**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**17**	**100**	**31**	**26**	**20**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**12**	**43**	**27**	**11**	**15**
Total Alkalinity as CaCO3	----	1	mg/L	**12**	**43**	**27**	**11**	**15**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**3**	**6**	**3**	**4**	**2**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**7**	**58**	**6**	**16**	**5**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**16**	**16**	**18**	**18**	**14**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	**7**	**1**	**4**	**3**
Magnesium	7439-95-4	1	mg/L	**3**	**20**	**7**	**4**	**3**
Sodium	7440-23-5	1	mg/L	**10**	**10**	**10**	**10**	**8**
Potassium	7440-09-7	1	mg/L	<1	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.07**	----	----	**0.05**	**0.02**
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0004**	----	----	**0.0028**	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.002**	----	----	**0.003**	<0.001
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	**0.002**	**0.002**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)	*Client sample ID*			**DR01**	**RB03**	**RB04**	**AMC9**	**CC10**
	Client sampling date / time			16-APR-2013 15:00	16-APR-2013 15:00	16-APR-2013 15:00	17-APR-2013 15:00	17-APR-2013 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-001**	**EM1304160-002**	**EM1304160-003**	**EM1304160-004**	**EM1304160-005**
EG020F: Dissolved Metals by ICP-MS - Continued								
Nickel	7440-02-0	0.001	mg/L	**0.006**	----	----	**0.013**	**0.003**
Lead	7439-92-1	0.001	mg/L	**0.004**	----	----	**0.008**	**0.003**
Zinc	7440-66-6	0.005	mg/L	**0.134**	----	----	**1.01**	**0.015**
Iron	7439-89-6	0.05	mg/L	**0.27**	----	----	**0.20**	**0.15**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.12**	<0.01	**0.12**	**0.11**	**0.04**
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0004**	**0.0009**	**0.0002**	**0.0030**	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.002**	<0.001	**0.003**	**0.004**	<0.001
Copper	7440-50-8	0.001	mg/L	**0.004**	<0.001	**0.002**	**0.003**	**0.002**
Nickel	7440-02-0	0.001	mg/L	**0.007**	**0.062**	**0.035**	**0.015**	**0.004**
Lead	7439-92-1	0.001	mg/L	**0.006**	<0.001	**0.006**	**0.025**	**0.024**
Zinc	7440-66-6	0.005	mg/L	**0.133**	**0.194**	**0.024**	**1.03**	**0.020**
Iron	7439-89-6	0.05	mg/L	**0.35**	<0.05	**0.60**	**0.32**	**0.26**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.84**	**2.52**	**1.17**	**1.06**	**0.80**
Total Cations	----	0.01	meq/L	**0.78**	**2.43**	**1.06**	**0.96**	**0.74**
Ionic Balance	----	0.01	%	**3.43**	**1.79**	**5.01**	**4.79**	**3.52**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**SCM13**	**DR16**	**DR17**	**AM18**	**RL19**
			Client sampling date / time	16-APR-2013 15:00	16-APR-2013 15:00	16-APR-2013 15:00	17-APR-2013 15:00	17-APR-2013 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-006**	**EM1304160-007**	**EM1304160-008**	**EM1304160-009**	**EM1304160-010**
EA005: pH								
pH Value	----	0.01	pH Unit	**3.63**	**7.01**	**6.63**	**6.81**	**6.35**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**0.19**	**0.94**	**0.88**	**0.61**	**0.80**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1830**	**103**	**114**	**135**	**119**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	10	mg/L	**1190**	**67**	**74**	**88**	**77**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**113**	<0.1	**32.8**	<0.1	**21300**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**618**	**21**	**20**	**41**	**30**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	**16**	**8**	**37**	**3**
Total Alkalinity as CaCO3	----	1	mg/L	<1	**16**	**8**	**37**	**3**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**218**	**4**	**5**	**4**	**28**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1180**	**7**	**18**	**8**	**22**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**14**	**16**	**15**	**14**	**17**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**89**	**2**	**3**	**5**	**2**
Magnesium	7439-95-4	1	mg/L	**96**	**4**	**3**	**7**	**6**
Sodium	7440-23-5	1	mg/L	**11**	**10**	**9**	**9**	**10**
Potassium	7440-09-7	1	mg/L	**2**	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	----	**0.06**	----	----	<0.01
Arsenic	7440-38-2	0.001	mg/L	----	<0.001	----	----	<0.001
Cadmium	7440-43-9	0.0001	mg/L	----	**0.0003**	----	----	<0.0001
Chromium	7440-47-3	0.001	mg/L	----	<0.001	----	----	**0.104**
Copper	7440-50-8	0.001	mg/L	----	**0.002**	----	----	<0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SCM13	DR16	DR17	AM18	RL19
			Client sampling date / time	16-APR-2013 15:00	16-APR-2013 15:00	16-APR-2013 15:00	17-APR-2013 15:00	17-APR-2013 15:00
Compound	CAS Number	LOR	Unit	EM1304160-006	EM1304160-007	EM1304160-008	EM1304160-009	EM1304160-010
EG020F: Dissolved Metals by ICP-MS - Continued								
Nickel	7440-02-0	0.001	mg/L	----	0.009	----	----	0.017
Lead	7439-92-1	0.001	mg/L	----	0.005	----	----	<0.001
Zinc	7440-66-6	0.005	mg/L	----	0.100	----	----	0.009
Iron	7439-89-6	0.05	mg/L	----	0.29	----	----	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.48	0.10	0.22	0.02	5.62
Arsenic	7440-38-2	0.001	mg/L	0.003	<0.001	0.002	0.002	0.005
Cadmium	7440-43-9	0.0001	mg/L	0.327	0.0006	0.0094	0.0013	0.0046
Chromium	7440-47-3	0.001	mg/L	0.001	<0.001	0.003	0.006	0.950
Copper	7440-50-8	0.001	mg/L	0.029	0.008	0.004	0.002	0.127
Nickel	7440-02-0	0.001	mg/L	0.361	0.011	0.007	0.052	0.427
Lead	7439-92-1	0.001	mg/L	1.27	0.007	0.297	0.019	57.4
Zinc	7440-66-6	0.005	mg/L	111	0.174	2.61	0.209	1.05
Iron	7439-89-6	0.05	mg/L	19.7	0.42	2.69	0.14	22.2
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	----	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	27.7	0.92	0.96	1.30	1.00
Total Cations	----	0.01	meq/L	12.9	0.86	0.79	1.22	1.03
Ionic Balance	----	0.01	%	----	2.98	----	3.34	1.52

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EM1304160**	Page	: 1 of 9
Client	: **PITT & SHERRY**	Laboratory	: Environmental Division Melbourne
Contact	: MR JIM LOCKLEY	Contact	: Shirley LeCornu
Address	: PO BOX 94 199 MACQUARIE ST HOBART TAS, AUSTRALIA 7001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: jlockley@pittsh.com.au	E-mail	: shirley.lecornu@alsenviro.com
Telephone	: +61 62231800	Telephone	: +61-3-8549 9630
Facsimile	: +61 03 62231299	Facsimile	: +61-3-8549 9601
Project	: Dundas Mining Field HB13108	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: JL	Issue Date	: 01-MAY-2013
Order number	: HBH5118		
		No. of samples received	: 10
Quote number	: MEBQ/119/12	No. of samples analysed	: 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

NATA Accredited
Laboratory 825

Accredited for
compliance with
ISO/IEC 17025.

WORLD RECOGNISED
ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics Melbourne Inorganics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics Melbourne Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics Melbourne Inorganics

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2837086)									
EM1304140-001	Anonymous	EA005: pH Value	----	0.01	pH Unit	7.16	7.15	0.1	0% - 20%
EM1304160-003	RB04	EA005: pH Value	----	0.01	pH Unit	7.90	7.91	0.1	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 2839224)									
EM1304160-001	DR01	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	94	96	2.4	0% - 20%
EM1304160-010	RL19	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	119	119	0.0	0% - 20%
EA045: Turbidity (QC Lot: 2836782)									
EM1304160-001	DR01	EA045: Turbidity	----	0.1	NTU	1.8	1.7	0.0	0% - 50%
EM1304160-010	RL19	EA045: Turbidity	----	0.1	NTU	21300	24400	13.8	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2839222)									
EM1303949-005	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1060	1060	0.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1060	1060	0.2	0% - 20%
EM1304107-008	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	112	113	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	112	113	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2839225)									
EM1304160-008	DR17	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	8	8	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	8	8	0.0	No Limit
EM1304190-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1180	1170	1.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1180	1170	1.0	0% - 20%
ED038A: Acidity (QC Lot: 2844523)									
EM1303955-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	162	171	5.4	0% - 20%
EM1304160-002	RB03	ED038: Acidity as CaCO3	----	1	mg/L	6	7	16.1	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2836520)									
EM1304156-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1760	1840	4.3	0% - 20%
EM1304160-003	RB04	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.0	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2836519)									
EM1304156-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	11600	11400	1.5	0% - 20%
EM1304160-003	RB04	ED045G: Chloride	16887-00-6	1	mg/L	18	18	0.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED093F: Dissolved Major Cations (QC Lot: 2836518)									
EM1304156-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	222	226	1.9	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	726	725	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	5850	5750	1.8	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	136	133	2.0	0% - 20%
EM1304160-003	RB04	ED093F: Calcium	7440-70-2	1	mg/L	1	1	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	7	7	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	10	10	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2839421)									
EM1303964-002	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.002	0.001	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.007	0.007	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.006	0.006	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EM1304143-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.88	0.86	0.0	0% - 20%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.82	0.86	4.7	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 2839408)									
EM1304087-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.002	0.005	102	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.027	0.027	0.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.006	0.008	18.2	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.008	0.010	25.2	0% - 50%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.465	0.490	5.2	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.16	0.17	0.0	0% - 50%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.24	0.29	19.6	No Limit
EM1304158-048	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 2839408) - continued									
EM1304158-048	Anonymous	EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2839420)									
EM1303964-002	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1304150-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2836439)									
EM1304128-015	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1304160-007	DR16	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2839223)									
EM1304155-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.2	0.0	No Limit
EM1304160-008	DR17	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA010P: Conductivity by PC Titrator (QCLot: 2839224)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	98	102
EA045: Turbidity (QCLot: 2836782)								
EA045: Turbidity	----	0.1	NTU	<0.1	40.0 NTU	102	92	106
ED037P: Alkalinity by PC Titrator (QCLot: 2839222)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	96.5	77	127
ED037P: Alkalinity by PC Titrator (QCLot: 2839225)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	97.2	77	127
ED038A: Acidity (QCLot: 2844523)								
ED038: Acidity as CaCO3	----	1	mg/L	----	20 mg/L	104	89	111
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	108	81	125
ED045G: Chloride Discrete analyser (QCLot: 2836519)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	113	89	117
ED093F: Dissolved Major Cations (QCLot: 2836518)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	102	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	103	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	104	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.9	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	97.4	90	110
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	93	109
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	94.7	85	111
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	105	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	94.4	86	110
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	98.0	88	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	100	86	112
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	97.6	83	113
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	99.8	88	112
EG020T: Total Metals by ICP-MS (QCLot: 2839408)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	105	93	115
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	108	94	114
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	106	90	112
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	102	88	116

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	***CAS Number***	***LOR***	***Unit***	***Result***	***Concentration***	***LCS***	***Low***	***High***
EG020T: Total Metals by ICP-MS (QCLot: 2839408) - continued								
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	104	89	113
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	113	91	115
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	114	90	116
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	106	87	113
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	105	91	117
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	108	78	126
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	98.8	78	124
EK040P: Fluoride by PC Titrator (QCLot: 2839223)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	101	78	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***Concentration***	***MS***	***Low***	***High***
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)							
EM1304156-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
ED045G: Chloride Discrete analyser (QCLot: 2836519)							
EM1304156-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)							
EM1303964-002	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	110	89	139
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	90.0	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	95.7	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	92.5	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	89.9	71	123
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	93.5	73	129
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	89.5	68	136
EG020T: Total Metals by ICP-MS (QCLot: 2839408)							
EM1304087-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	115	72	146
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	106	73	131
		EG020A-T: Chromium	7440-47-3	1 mg/L	84.3	65	131
		EG020A-T: Copper	7440-50-8	1 mg/L	97.7	71	125

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 2839408) - continued							
EM1304087-001	Anonymous	EG020A-T: Lead	7439-92-1	1 mg/L	111	68	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	96.1	72	128
		EG020A-T: Zinc	7440-66-6	1 mg/L	97.1	67	129
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)							
EM1303964-004	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	92.2	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)							
EM1304158-045	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	92.9	68	128
EK040P: Fluoride by PC Titrator (QCLot: 2839223)							
EM1304155-004	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	98.2	70	130

Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report

The quality control term Matrix Spike (MS) and Matrix Spike Duplicate (MSD) refers to intralaboratory split samples spiked with a representative set of target analytes. The purpose of these QC parameters are to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report						
				Spike	Spike Recovery (%)		Recovery Limits (%)		RPDs (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*MSD*	*Low*	*High*	*Value*	*Control Limit*
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)										
EM1304158-045	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	92.9	----	68	128	----	----
ED045G: Chloride Discrete analyser (QCLot: 2836519)										
EM1304156-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	----	70	130	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)										
EM1304156-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	----	70	130	----	----
EK040P: Fluoride by PC Titrator (QCLot: 2839223)										
EM1304155-004	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	98.2	----	70	130	----	----
EG020T: Total Metals by ICP-MS (QCLot: 2839408)										
EM1304087-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	115	----	72	146	----	----
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	106	----	73	131	----	----
		EG020A-T: Chromium	7440-47-3	1 mg/L	84.3	----	65	131	----	----
		EG020A-T: Copper	7440-50-8	1 mg/L	97.7	----	71	125	----	----
		EG020A-T: Lead	7439-92-1	1 mg/L	111	----	68	130	----	----
		EG020A-T: Nickel	7440-02-0	1 mg/L	96.1	----	72	128	----	----
		EG020A-T: Zinc	7440-66-6	1 mg/L	97.1	----	67	129	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)										
EM1303964-004	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	92.2	----	70	130	----	----

Sub-Matrix: **WATER**

				Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report						
				Spike	Spike Recovery (%)		Recovery Limits (%)		RPDs (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	MSD	Low	High	Value	Control Limit
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)										
EM1303964-002	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	110	----	89	139	----	----
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	90.0	----	75	131	----	----
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	95.7	----	70	130	----	----
		EG020A-F: Copper	7440-50-8	0.2 mg/L	92.5	----	71	127	----	----
		EG020A-F: Lead	7439-92-1	0.2 mg/L	89.9	----	71	123	----	----
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	93.5	----	73	129	----	----
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	89.5	----	68	136	----	----

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1304160**	Page	: 1 of 11
Client	: PITT & SHERRY	Laboratory	: Environmental Division Melbourne
Contact	: MR JIM LOCKLEY	Contact	: Shirley LeCornu
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Project	: Dundas Mining Field HB13108	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: JL	Issue Date	: 01-MAY-2013
Order number	: HBH5118		
		No. of samples received	: 10
Quote number	: MEBQ/119/12	No. of samples analysed	: 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005: pH							
Clear Plastic Bottle - Natural (EA005) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**24-APR-2013**	16-APR-2013	✘
Clear Plastic Bottle - Natural (EA005) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**24-APR-2013**	17-APR-2013	✘
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	14-MAY-2013	----	**30-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (EA010-P) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**30-APR-2013**	15-MAY-2013	✓
EA045: Turbidity							
Clear Plastic Bottle - Natural (EA045) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**24-APR-2013**	18-APR-2013	✘
Clear Plastic Bottle - Natural (EA045) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**24-APR-2013**	19-APR-2013	✘
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	30-APR-2013	----	**26-APR-2013**	30-APR-2013	✓
Clear Plastic Bottle - Natural (ED037-P) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	01-MAY-2013	----	**26-APR-2013**	01-MAY-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** / *Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation* ***Date extracted***	 *Due for extraction*	 *Evaluation*	*Analysis* ***Date analysed***	 *Due for analysis*	 *Evaluation*
ED038A: Acidity							
Clear Plastic Bottle - Natural (ED038) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**30-APR-2013**	30-APR-2013	✓
Clear Plastic Bottle - Natural (ED038) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**30-APR-2013**	01-MAY-2013	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	14-MAY-2013	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (ED041G) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**24-APR-2013**	15-MAY-2013	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural (ED045G) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	14-MAY-2013	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (ED045G) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**24-APR-2013**	15-MAY-2013	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation* ***Date extracted***	 *Due for extraction*	 *Evaluation*	*Analysis* ***Date analysed***	 *Due for analysis*	 *Evaluation*
EA065: Total Hardness as CaCO3							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F) DR01, DR16	**16-APR-2013**	**---**	13-OCT-2013	----	**30-APR-2013**	13-OCT-2013	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F) AMC9, CC10, RL19	**17-APR-2013**	**---**	14-OCT-2013	----	**30-APR-2013**	14-OCT-2013	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**26-APR-2013**	13-OCT-2013	✓	**26-APR-2013**	13-OCT-2013	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) AMC9, CC10, AM18, RL19	**17-APR-2013**	**26-APR-2013**	14-OCT-2013	✓	**26-APR-2013**	14-OCT-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) DR01, DR16	**16-APR-2013**	**---**	14-MAY-2013	----	**30-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) AMC9, CC10, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**30-APR-2013**	15-MAY-2013	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**24-APR-2013**	15-MAY-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	---	14-MAY-2013	----	**26-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (EK040P) AMC9, CC10, AM18, RL19	**17-APR-2013**	---	15-MAY-2013	----	**26-APR-2013**	15-MAY-2013	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Acidity as Calcium Carbonate	ED038	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	4	39	**10.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	2	14	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acidity as Calcium Carbonate	ED038	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	39	**5.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Turbidity	EA045	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity by PC Titrator	EA010-P	WATER	APHA 21st ed., 2510 B This procedure determines conductivity by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Calculated TDS (from Electrical Conductivity)	EA016	WATER	In-House - Calculation from Electrical Conductivity (APHA 21st ed., 2510 B) using a conversion factor specified in the analytical report. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Turbidity	EA045	WATER	APHA 21st ed., 2130 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Acidity as Calcium Carbonate	ED038	WATER	APHA 21st ed., 2310 B Acidity is determined by titration with a standardised alkali to an end-point pH of 8.3. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Mercury by FIMS	EG035T	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1304156-002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1304156-002	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005: pH							
Clear Plastic Bottle - Natural							
DR01, RB04, DR16,	RB03, SCM13, DR17	----	----	----	24-APR-2013	16-APR-2013	**8**
Clear Plastic Bottle - Natural							
AMC9, AM18,	CC10, RL19	----	----	----	24-APR-2013	17-APR-2013	**7**
EA045: Turbidity							
Clear Plastic Bottle - Natural							
DR01, RB04, DR16,	RB03, SCM13, DR17	----	----	----	24-APR-2013	18-APR-2013	**6**

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	**Days overdue**	Date analysed	Due for analysis	**Days overdue**
EA045: Turbidity - Analysis Holding Time Compliance							
Clear Plastic Bottle - Natural							
AMC9,	CC10,	----	----	----	24-APR-2013	19-APR-2013	**5**
AM18,	RL19						

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

ALS Group

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order : **EM1304160**

Amendment : **1**

Client : **PITT & SHERRY**

Contact : MR JIM LOCKLEY

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Telephone : +61 62231800

Facsimile : +61 03 62231299

Project : Dundas Mining Field HB13108

Order number : HBH5118

C-O-C number : ----

Sampler : JL

Site : ----

Quote number : MEBQ/119/12

Page : 1 of 6

Laboratory : Environmental Division Melbourne

Contact : Shirley LeCornu

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Telephone : +61-3-8549 9630

Facsimile : +61-3-8549 9601

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 23-APR-2013

Issue Date : 03-JUN-2013

No. of samples received : 10

No. of samples analysed : 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **(03/06/2013) It is recognised that total metals is less than dissolved metals for samples EM1304160. However, the difference is within experimental variation of the methods.**
- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **ED041G : EM1304160-006 for Sulphate has ben confirmed by re-analysis.**
- **Ionic Balance out of acceptable limits for EM1304160 #3 due to analytes not quantified in this report.**
- **Ionic Balance out of acceptable limits for sample #6 as sample matrix is not deemed as potable or naturally occurring water and therefore ionic balance is not applicable**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **This report has been amended and re-released to allow the reporting of additional analytical data.**

NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

WORLD RECOGNISED
ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics Melbourne Inorganics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics Melbourne Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics Melbourne Inorganics

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**DR01**	**RB03**	**RB04**	**AMC9**	**CC10**
			Client sampling date / time	16-APR-2013 14:00	16-APR-2013 14:00	16-APR-2013 14:00	17-APR-2013 14:00	17-APR-2013 14:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-001**	**EM1304160-002**	**EM1304160-003**	**EM1304160-004**	**EM1304160-005**
EA005: pH								
pH Value	----	0.01	pH Unit	**8.24**	**7.86**	**7.90**	**7.43**	**7.64**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**1.04**	**0.44**	**0.78**	**0.84**	**0.78**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**94**	**253**	**124**	**125**	**90**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	10	mg/L	**61**	**164**	**81**	**81**	**58**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**1.8**	<0.1	**1.9**	<0.1	**0.9**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**17**	**100**	**31**	**26**	**20**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**12**	**43**	**27**	**11**	**15**
Total Alkalinity as CaCO3	----	1	mg/L	**12**	**43**	**27**	**11**	**15**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**3**	**6**	**3**	**4**	**2**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**7**	**58**	**6**	**16**	**5**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**16**	**16**	**18**	**18**	**14**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	**7**	**1**	**4**	**3**
Magnesium	7439-95-4	1	mg/L	**3**	**20**	**7**	**4**	**3**
Sodium	7440-23-5	1	mg/L	**10**	**10**	**10**	**10**	**8**
Potassium	7440-09-7	1	mg/L	<1	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.07**	----	----	**0.05**	**0.02**
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0004**	----	----	**0.0028**	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.002**	----	----	**0.003**	<0.001
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	**0.002**	**0.002**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)	*Client sample ID*			**DR01**	**RB03**	**RB04**	**AMC9**	**CC10**
	Client sampling date / time			16-APR-2013 14:00	16-APR-2013 14:00	16-APR-2013 14:00	17-APR-2013 14:00	17-APR-2013 14:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-001**	**EM1304160-002**	**EM1304160-003**	**EM1304160-004**	**EM1304160-005**
EG020F: Dissolved Metals by ICP-MS - Continued								
Nickel	7440-02-0	0.001	mg/L	**0.006**	----	----	**0.013**	**0.003**
Lead	7439-92-1	0.001	mg/L	**0.004**	----	----	**0.008**	**0.003**
Zinc	7440-66-6	0.005	mg/L	**0.134**	----	----	**1.01**	**0.015**
Manganese	7439-96-5	0.001	mg/L	**0.153**	----	----	**0.938**	**0.127**
Iron	7439-89-6	0.05	mg/L	**0.27**	----	----	**0.20**	**0.15**
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.12**	<0.01	**0.12**	**0.11**	**0.04**
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	**0.0004**	**0.0009**	**0.0002**	**0.0030**	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.002**	<0.001	**0.003**	**0.004**	<0.001
Copper	7440-50-8	0.001	mg/L	**0.004**	<0.001	**0.002**	**0.003**	**0.002**
Nickel	7440-02-0	0.001	mg/L	**0.007**	**0.062**	**0.035**	**0.015**	**0.004**
Lead	7439-92-1	0.001	mg/L	**0.006**	<0.001	**0.006**	**0.025**	**0.024**
Zinc	7440-66-6	0.005	mg/L	**0.133**	**0.194**	**0.024**	**1.03**	**0.020**
Manganese	7439-96-5	0.001	mg/L	**0.152**	**0.032**	**0.271**	**0.983**	**0.142**
Iron	7439-89-6	0.05	mg/L	**0.35**	<0.05	**0.60**	**0.32**	**0.26**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.84**	**2.52**	**1.17**	**1.06**	**0.80**
Total Cations	----	0.01	meq/L	**0.78**	**2.43**	**1.06**	**0.96**	**0.74**
Ionic Balance	----	0.01	%	**3.43**	**1.79**	**5.01**	**4.79**	**3.52**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**SCM13**	**DR16**	**DR17**	**AM18**	**RL19**
			Client sampling date / time	16-APR-2013 14:00	16-APR-2013 14:00	16-APR-2013 14:00	17-APR-2013 14:00	17-APR-2013 14:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-006**	**EM1304160-007**	**EM1304160-008**	**EM1304160-009**	**EM1304160-010**
EA005: pH								
pH Value	----	0.01	pH Unit	**3.63**	**7.01**	**6.63**	**6.81**	**6.35**
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**0.19**	**0.94**	**0.88**	**0.61**	**0.80**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1830**	**103**	**114**	**135**	**119**
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	10	mg/L	**1190**	**67**	**74**	**88**	**77**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**113**	<0.1	**32.8**	<0.1	**21300**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**618**	**21**	**20**	**41**	**30**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	**16**	**8**	**37**	**3**
Total Alkalinity as CaCO3	----	1	mg/L	<1	**16**	**8**	**37**	**3**
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**218**	**4**	**5**	**4**	**28**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1180**	**7**	**18**	**8**	**22**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**14**	**16**	**15**	**14**	**17**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**89**	**2**	**3**	**5**	**2**
Magnesium	7439-95-4	1	mg/L	**96**	**4**	**3**	**7**	**6**
Sodium	7440-23-5	1	mg/L	**11**	**10**	**9**	**9**	**10**
Potassium	7440-09-7	1	mg/L	**2**	<1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	----	**0.06**	----	----	<0.01
Arsenic	7440-38-2	0.001	mg/L	----	<0.001	----	----	<0.001
Cadmium	7440-43-9	0.0001	mg/L	----	**0.0003**	----	----	<0.0001
Chromium	7440-47-3	0.001	mg/L	----	<0.001	----	----	**0.104**
Copper	7440-50-8	0.001	mg/L	----	**0.002**	----	----	<0.001

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**SCM13**	**DR16**	**DR17**	**AM18**	**RL19**
			Client sampling date / time	16-APR-2013 14:00	16-APR-2013 14:00	16-APR-2013 14:00	17-APR-2013 14:00	17-APR-2013 14:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1304160-006**	**EM1304160-007**	**EM1304160-008**	**EM1304160-009**	**EM1304160-010**
EG020F: Dissolved Metals by ICP-MS - Continued								
Nickel	7440-02-0	0.001	mg/L	----	**0.009**	----	----	**0.017**
Lead	7439-92-1	0.001	mg/L	----	**0.005**	----	----	<0.001
Zinc	7440-66-6	0.005	mg/L	----	**0.100**	----	----	**0.009**
Manganese	7439-96-5	0.001	mg/L	----	**0.140**	----	----	**0.042**
Iron	7439-89-6	0.05	mg/L	----	**0.29**	----	----	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.48**	**0.10**	**0.22**	**0.02**	**5.62**
Arsenic	7440-38-2	0.001	mg/L	**0.003**	<0.001	**0.002**	**0.002**	**0.005**
Cadmium	7440-43-9	0.0001	mg/L	**0.327**	**0.0006**	**0.0094**	**0.0013**	**0.0046**
Chromium	7440-47-3	0.001	mg/L	**0.001**	<0.001	**0.003**	**0.006**	**0.950**
Copper	7440-50-8	0.001	mg/L	**0.029**	**0.008**	**0.004**	**0.002**	**0.127**
Nickel	7440-02-0	0.001	mg/L	**0.361**	**0.011**	**0.007**	**0.052**	**0.427**
Lead	7439-92-1	0.001	mg/L	**1.27**	**0.007**	**0.297**	**0.019**	**57.4**
Zinc	7440-66-6	0.005	mg/L	**111**	**0.174**	**2.61**	**0.209**	**1.05**
Manganese	7439-96-5	0.001	mg/L	<0.001	**0.205**	**2.39**	**0.169**	**15.4**
Iron	7439-89-6	0.05	mg/L	**19.7**	**0.42**	**2.69**	**0.14**	**22.2**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	----	<0.0001	----	----	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**27.7**	**0.92**	**0.96**	**1.30**	**1.00**
Total Cations	----	0.01	meq/L	**12.9**	**0.86**	**0.79**	**1.22**	**1.03**
Ionic Balance	----	0.01	%	----	**2.98**	----	**3.34**	**1.52**

ALS Group

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EM1304160**
Amendment : **1**

Client : **PITT & SHERRY**
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Project : Dundas Mining Field HB13108
Site : ----
C-O-C number : ----
Sampler : JL
Order number : HBH5118

Quote number : MEBQ/119/12

Page : 1 of 9

Laboratory : Environmental Division Melbourne
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Facsimile : +61-3-8549 9601

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 23-APR-2013
Issue Date : 03-JUN-2013

No. of samples received : 10
No. of samples analysed : 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

NATA Accredited
Laboratory 825

Accredited for
compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics Melbourne Inorganics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics Melbourne Inorganics
Varsha Ho Wing	Non-Metals Team Leader	Melbourne Inorganics Melbourne Inorganics

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 2837086)									
EM1304140-001	Anonymous	EA005: pH Value	----	0.01	pH Unit	7.16	7.15	0.1	0% - 20%
EM1304160-003	RB04	EA005: pH Value	----	0.01	pH Unit	7.90	7.91	0.1	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 2839224)									
EM1304160-001	DR01	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	94	96	2.4	0% - 20%
EM1304160-010	RL19	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	119	119	0.0	0% - 20%
EA045: Turbidity (QC Lot: 2836782)									
EM1304160-001	DR01	EA045: Turbidity	----	0.1	NTU	1.8	1.7	0.0	0% - 50%
EM1304160-010	RL19	EA045: Turbidity	----	0.1	NTU	21300	24400	13.8	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2839222)									
EM1303949-005	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1060	1060	0.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1060	1060	0.2	0% - 20%
EM1304107-008	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	112	113	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	112	113	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2839225)									
EM1304160-008	DR17	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	8	8	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	8	8	0.0	No Limit
EM1304190-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1180	1170	1.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1180	1170	1.0	0% - 20%
ED038A: Acidity (QC Lot: 2844523)									
EM1303955-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	162	171	5.4	0% - 20%
EM1304160-002	RB03	ED038: Acidity as CaCO3	----	1	mg/L	6	7	16.1	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2836520)									
EM1304156-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1760	1840	4.3	0% - 20%
EM1304160-003	RB04	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.0	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 2836519)									
EM1304156-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	11600	11400	1.5	0% - 20%
EM1304160-003	RB04	ED045G: Chloride	16887-00-6	1	mg/L	18	18	0.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 2836518)									
EM1304156-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	222	226	1.9	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	726	725	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	5850	5750	1.8	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	136	133	2.0	0% - 20%
EM1304160-003	RB04	ED093F: Calcium	7440-70-2	1	mg/L	1	1	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	7	7	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	10	10	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2839421)									
EM1303964-002	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.002	0.001	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.007	0.007	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.006	0.006	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EM1304143-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.010	0.011	0.0	0% - 50%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.88	0.86	0.0	0% - 20%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.82	0.86	4.7	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 2839408)									
EM1304087-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.002	0.005	102	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.027	0.027	0.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.006	0.008	18.2	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.008	0.010	25.2	0% - 50%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.465	0.490	5.2	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.16	0.17	0.0	0% - 50%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.24	0.29	19.6	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 2839408) - continued									
EM1304158-048	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2839420)									
EM1303964-002	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1304150-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2836439)									
EM1304128-015	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM1304160-007	DR16	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2839223)									
EM1304155-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.2	0.0	No Limit
EM1304160-008	DR17	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010P: Conductivity by PC Titrator (QCLot: 2839224)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	98	102
EA045: Turbidity (QCLot: 2836782)								
EA045: Turbidity	----	0.1	NTU	<0.1	40.0 NTU	102	92	106
ED037P: Alkalinity by PC Titrator (QCLot: 2839222)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	96.5	77	127
ED037P: Alkalinity by PC Titrator (QCLot: 2839225)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	97.2	77	127
ED038A: Acidity (QCLot: 2844523)								
ED038: Acidity as CaCO3	----	1	mg/L	----	20 mg/L	104	89	111
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	12.5 mg/L	108	81	125
ED045G: Chloride Discrete analyser (QCLot: 2836519)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	113	89	117
ED093F: Dissolved Major Cations (QCLot: 2836518)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	102	83	129
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	103	80	124
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	104	77	125
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.9	77	123
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	97.4	90	110
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	93	109
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	94.7	85	111
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	105	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	94.4	86	110
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	98.0	88	112
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	102	86	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	100	86	112
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	97.6	83	113
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	99.8	88	112
EG020T: Total Metals by ICP-MS (QCLot: 2839408)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	105	93	115
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	108	94	114
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	106	90	112

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2839408) - continued								
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	102	88	116
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	104	89	113
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	113	91	115
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	107	88	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	114	90	116
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	106	87	113
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	105	91	117
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	108	78	126
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	98.8	78	124
EK040P: Fluoride by PC Titrator (QCLot: 2839223)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	101	78	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)							
EM1304156-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
ED045G: Chloride Discrete analyser (QCLot: 2836519)							
EM1304156-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)							
EM1303964-002	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	110	89	139
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	90.0	75	131
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	95.7	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	92.5	71	127
		EG020A-F: Lead	7439-92-1	0.2 mg/L	89.9	71	123
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	97.1	66	132
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	93.5	73	129
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	89.5	68	136
EG020T: Total Metals by ICP-MS (QCLot: 2839408)							
EM1304087-001	Anonymous						

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2839408) - continued							
EM1304087-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	115	72	146
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	106	73	131
		EG020A-T: Chromium	7440-47-3	1 mg/L	84.3	65	131
		EG020A-T: Copper	7440-50-8	1 mg/L	97.7	71	125
		EG020A-T: Lead	7439-92-1	1 mg/L	111	68	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	89.8	63	129
		EG020A-T: Nickel	7440-02-0	1 mg/L	96.1	72	128
		EG020A-T: Zinc	7440-66-6	1 mg/L	97.1	67	129
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)							
EM1303964-004	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	92.2	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)							
EM1304158-045	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	92.9	68	128
EK040P: Fluoride by PC Titrator (QCLot: 2839223)							
EM1304155-004	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	98.2	70	130

Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report

The quality control term Matrix Spike (MS) and Matrix Spike Duplicate (MSD) refers to intralaboratory split samples spiked with a representative set of target analytes. The purpose of these QC parameters are to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report Spike Concentration	Spike Recovery (%) MS	 MSD	Recovery Limits (%) Low	 High	RPDs (%) Value	 Control Limit
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2836439)										
EM1304158-045	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	92.9	----	68	128	----	----
ED045G: Chloride Discrete analyser (QCLot: 2836519)										
EM1304156-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	----	70	130	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2836520)										
EM1304156-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	----	70	130	----	----
EK040P: Fluoride by PC Titrator (QCLot: 2839223)										
EM1304155-004	Anonymous	EK040P: Fluoride	16984-48-8	5.0 mg/L	98.2	----	70	130	----	----
EG020T: Total Metals by ICP-MS (QCLot: 2839408)										
EM1304087-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	115	----	72	146	----	----
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	106	----	73	131	----	----
		EG020A-T: Chromium	7440-47-3	1 mg/L	84.3	----	65	131	----	----
		EG020A-T: Copper	7440-50-8	1 mg/L	97.7	----	71	125	----	----

Sub-Matrix: **WATER**

				Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report						
				Spike	Spike Recovery (%)		Recovery Limits (%)		RPDs (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	MSD	Low	High	Value	Control Limit
EG020T: Total Metals by ICP-MS (QCLot: 2839408) - continued										
EM1304087-001	Anonymous	EG020A-T: Lead	7439-92-1	1 mg/L	111	----	68	130	----	----
		EG020A-T: Manganese	7439-96-5	1 mg/L	89.8	----	63	129	----	----
		EG020A-T: Nickel	7440-02-0	1 mg/L	96.1	----	72	128	----	----
		EG020A-T: Zinc	7440-66-6	1 mg/L	97.1	----	67	129	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2839420)										
EM1303964-004	Anonymous	EG035F: Mercury	7439-97-6	0.0100 mg/L	92.2	----	70	130	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 2839421)										
EM1303964-002	Anonymous	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	110	----	89	139	----	----
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	90.0	----	75	131	----	----
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	95.7	----	70	130	----	----
		EG020A-F: Copper	7440-50-8	0.2 mg/L	92.5	----	71	127	----	----
		EG020A-F: Lead	7439-92-1	0.2 mg/L	89.9	----	71	123	----	----
		EG020A-F: Manganese	7439-96-5	0.2 mg/L	97.1	----	66	132	----	----
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	93.5	----	73	129	----	----
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	89.5	----	68	136	----	----

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EM1304160**	Page	: 1 of 11
Amendment	: **1**		
Client	: PITT & SHERRY	Laboratory	: Environmental Division Melbourne
Contact	: MR JIM LOCKLEY	Contact	: Shirley LeCornu
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Project	: Dundas Mining Field HB13108	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: JL	Issue Date	: 03-JUN-2013
Order number	: HBH5118		
		No. of samples received	: 10
Quote number	: MEBQ/119/12	No. of samples analysed	: 10

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005: pH							
Clear Plastic Bottle - Natural (EA005) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	----	----	----	**24-APR-2013**	16-APR-2013	✗
Clear Plastic Bottle - Natural (EA005) AMC9, CC10, AM18, RL19	**17-APR-2013**	----	----	----	**24-APR-2013**	17-APR-2013	✗
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	---	14-MAY-2013	----	**30-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (EA010-P) AMC9, CC10, AM18, RL19	**17-APR-2013**	---	15-MAY-2013	----	**30-APR-2013**	15-MAY-2013	✓
EA045: Turbidity							
Clear Plastic Bottle - Natural (EA045) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	----	----	----	**24-APR-2013**	18-APR-2013	✗
Clear Plastic Bottle - Natural (EA045) AMC9, CC10, AM18, RL19	**17-APR-2013**	----	----	----	**24-APR-2013**	19-APR-2013	✗
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	---	30-APR-2013	----	**26-APR-2013**	30-APR-2013	✓
Clear Plastic Bottle - Natural (ED037-P) AMC9, CC10, AM18, RL19	**17-APR-2013**	---	01-MAY-2013	----	**26-APR-2013**	01-MAY-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation* ***Date extracted***	 *Due for extraction*	 *Evaluation*	*Analysis* ***Date analysed***	 *Due for analysis*	 *Evaluation*
ED038A: Acidity							
Clear Plastic Bottle - Natural (ED038) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**30-APR-2013**	30-APR-2013	✓
Clear Plastic Bottle - Natural (ED038) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**30-APR-2013**	01-MAY-2013	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	14-MAY-2013	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (ED041G) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**24-APR-2013**	15-MAY-2013	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural (ED045G) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	14-MAY-2013	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Natural (ED045G) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**24-APR-2013**	15-MAY-2013	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)	**Sample Date**	Extraction / Preparation **Date extracted**	 Due for extraction	 Evaluation	Analysis **Date analysed**	 Due for analysis	 Evaluation
EA065: Total Hardness as CaCO3							
Clear Plastic Bottle - Natural (ED093F) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**---**	23-APR-2013	----	**23-APR-2013**	23-APR-2013	✓
Clear Plastic Bottle - Natural (ED093F) AMC9, CC10, AM18, RL19	**17-APR-2013**	**---**	24-APR-2013	----	**23-APR-2013**	24-APR-2013	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F) DR01, DR16	**16-APR-2013**	**---**	13-OCT-2013	----	**30-APR-2013**	13-OCT-2013	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020A-F) AMC9, CC10, RL19	**17-APR-2013**	**---**	14-OCT-2013	----	**30-APR-2013**	14-OCT-2013	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**26-APR-2013**	13-OCT-2013	✓	**26-APR-2013**	13-OCT-2013	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) AMC9, CC10, AM18, RL19	**17-APR-2013**	**26-APR-2013**	14-OCT-2013	✓	**26-APR-2013**	14-OCT-2013	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) DR01, DR16	**16-APR-2013**	**---**	14-MAY-2013	----	**30-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) AMC9, CC10, RL19	**17-APR-2013**	**---**	15-MAY-2013	----	**30-APR-2013**	15-MAY-2013	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) DR01, RB03, RB04, SCM13, DR16, DR17	**16-APR-2013**	**----**	----	----	**24-APR-2013**	14-MAY-2013	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) AMC9, CC10, AM18, RL19	**17-APR-2013**	**----**	----	----	**24-APR-2013**	15-MAY-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)		**Sample Date**	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P)								
DR01,	RB03,	**16-APR-2013**	---	14-MAY-2013	----	**26-APR-2013**	14-MAY-2013	✓
RB04,	SCM13,							
DR16,	DR17							
Clear Plastic Bottle - Natural (EK040P)								
AMC9,	CC10,	**17-APR-2013**	---	15-MAY-2013	----	**26-APR-2013**	15-MAY-2013	✓
AM18,	RL19							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Acidity as Calcium Carbonate	ED038	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	4	39	**10.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	2	10	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH	EA005	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	2	14	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acidity as Calcium Carbonate	ED038	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	39	**5.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	10	**10.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Turbidity	EA045	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity by PC Titrator	EA010-P	WATER	APHA 21st ed., 2510 B This procedure determines conductivity by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Calculated TDS (from Electrical Conductivity)	EA016	WATER	In-House - Calculation from Electrical Conductivity (APHA 21st ed., 2510 B) using a conversion factor specified in the analytical report. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Turbidity	EA045	WATER	APHA 21st ed., 2130 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Acidity as Calcium Carbonate	ED038	WATER	APHA 21st ed., 2310 B Acidity is determined by titration with a standardised alkali to an end-point pH of 8.3. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Mercury by FIMS	EG035T	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1304156-002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1304156-002	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005: pH						
Clear Plastic Bottle - Natural DR01, RB03, RB04, SCM13, DR16, DR17	----	----	----	24-APR-2013	16-APR-2013	**8**
Clear Plastic Bottle - Natural AMC9, CC10, AM18, RL19	----	----	----	24-APR-2013	17-APR-2013	**7**
EA045: Turbidity						
Clear Plastic Bottle - Natural DR01, RB03, RB04, SCM13, DR16, DR17	----	----	----	24-APR-2013	18-APR-2013	**6**

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA045: Turbidity - Analysis Holding Time Compliance						
Clear Plastic Bottle - Natural						
AMC9, CC10, AM18, RL19	----	----	----	24-APR-2013	19-APR-2013	**5**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

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