Hillgrove Copper Pty Ltd

Program for Environment Protection and Rehabilitation
Life of Mine

ML6345 and ML6436

Kanmantoo Copper Mines

6 May 2016

Appendices Volume 1

In a
turbulent
world
we provide
clear thinking

Hillgrove Copper Pty Ltd
Program for Environment Protection and Rehabilitation – Life of Mine
ML6345 and ML6436

Kanmantoo Copper Mines

May 2016

Appendices Volume 1

Report Reference No. ENAUDARW09119_02_v5

Tenements	ML6345 and ML6436
Commodity	Copper, gold, silver and garnet (although garnet will report to tailings)
Operation Name	Kanmantoo Copper Mines
Proponent	Hillgrove Copper Pty Ltd
Contact	Steven McClare, General Manager Catherine Davis, Environment Manager

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Approvals and Conditions

Appendix 1A

Mining Lease Conditions ML6345

MINING LEASE

Mineral Lease Number 6345

1. The Minister for Mineral Resources Development ("the Minister"), in the exercise of the powers and authorities conferred upon him by the South Australian *Mining Act 1971* ("the Act") and the Regulations hereby leases to **Hillgrove Copper Pty Ltd (ACN 105 074 762)** ("the Lessee") of **Level 41, Australian Square Tower, 264-278 George Street, Sydney** in the state of **New South Wales** all those lands containing 436.02 hectares or thereabouts and situate **Allotment 20 DP 80644 and Allotment 59 DP 20509 Hd Kanmantoo** in the State of South Australia more particularly described and delineated on the plan annexed hereto and marked 'A' ("the land") and being mineral lands within the meaning of the Act.

2. The Lessee together with his servants and agents shall have the following rights and liberties during the continuance of this lease, namely:

   (1) to conduct mining operations and obtain for the Lessee's own use and benefit the minerals as specified in the First Schedule hereto, in the manner described in the Second Schedule

   (2) for or incidental to the purposes aforesaid to cut and construct races, drains, dams, reservoirs, roads and tramways;

   (3) To sell and dispose of the minerals obtained, from the land in pursuance of this lease or to utilise any such minerals for any commercial or industrial purpose.

3. This lease shall be for a term of **ten (10) years** ("the term") commencing on the **seventh day of September 2009**.

4. The Lessee shall use the land for the purposes of mining therein and thereon for minerals as specified in the First Schedule hereto, together with the rights and liberties hereinbefore granted and for no other purpose.

5. The Lessee shall pay to the Minister:-
   (1) In advance a yearly rental fee as prescribed by the Regulations for each year during the term commencing on the **seventh day of September** or such other date as agreed to by the Minister upon renewal; and,

   (2) A further sum during the term, being a royalty on the minerals recovered under the Lease as provided for by the Act.

6. The Lessee hereby further covenants with the Minister as follows:

   (1) to pay or cause to be paid to the Director of Mines ("the Director") at the offices of the Department of Primary Industries and Resources South Australia on behalf of the Minister, the rent and other sum hereby reserved at the times and in the manner hereinbefore appointed for payment thereof free and clear of all rates, taxes, impositions, outgoings and deductions whatsoever;

REF: T02757

(2) to pay and discharge all rates, taxes, assessments, impositions and outgoings which shall become payable in respect of the land:

(3) to maintain in position all posts, boundary indicator markers and notices required by the Regulations to be erected or placed on the land in the manner prescribed by the Act and the Regulations:

(4) to mine the land in a fair, orderly, skilful and workmanlike manner in accordance with the First Schedule hereto and bona fide exclusively for the purpose for which it is demised so as to effect maximum recovery of the mineral resources consistent with economic practicability:

(5) to supply the Director, forthwith upon written request, with a copy of such records kept pursuant to Section 77 of the Act:

(6) to make a survey of the land and cause a map or plan of such survey to be sent to the Director whenever the Director so requires, and any and every such survey shall be at the Lessee's own cost and, shall be carried out in the manner required by the regulations (whether under the Act or otherwise):

(7) at all times to keep and preserve the mines and premises in good order, repair and condition and in such good order, repair and condition at the end or other sooner determination of the term deliver peaceable possession thereof and of all and singular the land hereby leased unto the Minister or to some officer duly authorised by him to receive possession thereof:

(8) to furnish all returns prescribed by the Act and Regulations:

(9) to permit the pastoral lessee (if any) of the land to have free access and use at all times for domestic purposes, and for the purposes of watering stock from any surface water on the land which shall not have been provided or stored by artificial means by the Lessee:

(10) not to use or occupy the land or permit the same to be used or occupied otherwise than for the purpose of exercising the rights and liberties hereinbefore granted without first obtaining the written consent of the Minister:

(11) not to assign, transfer, sublet the land, or make the land the subject of any trust or other dealing, whether directly or indirectly, for the whole or any part of the term without first obtaining the written consent of the Minister:

(12) to observe, perform and carry out the provisions of the Act and Regulations and the provisions of any other Act or regulations for the time being in force relating to the use, enjoyment or occupation of mineral lands:

(13) to perform and comply with all of the conditions set out in the Second Schedule annexed hereto:

(14) to permit the Minister or the Director or any person duly appointed by either of them at all proper and reasonable times without any interruption from the Lessee or the Lessee's agents or servants to enter into and upon the land to view and examine the mining operations conducted in pursuance of this lease and to use all reasonable means to achieve such purpose and to examine and take extracts from all books, accounts, vouchers or documents appertaining to the Lessee's mining operations in pursuance of this lease:

(15) that the Minister, may at any time, require the Lessee to pay to any person an amount of compensation, stipulated by the Minister, to which that person is, in the opinion of the Minister, entitled in consequence of the conduct of mining operations in pursuance of this lease and the Lessee shall comply forthwith with such requirement:

(16) that if the Lessee shall fail to comply with any covenant, conditions or proviso herein contained this lease shall be liable to forfeiture in the manner hereinafter provided:

(17) that if the rent or royalty shall be in arrear and unpaid for more than three calendar months after the day on which the same is payable it shall be lawful for the Minister to cancel this lease and the Minister may thereupon insert a notice in the *Government Gazette* declaring this lease to be forfeited:

(18) that if the Minister has reason to believe that there has been a breach of or non-compliance with any of the covenants, conditions or provisos herein contained, other than a breach of the covenant for payment of the rent or royalty, the Minister may give or cause to be given by any duly authorised officer of the Minister, written notice to the Lessee specifying the covenants, conditions or provisos which he has reason to believe are not being complied with and notifying the Lessee that this lease will be liable to forfeiture at the expiration of one month from the date of such notice unless in the meantime such covenant, conditions or provisos are duly complied with and if at the expiration of such notice such covenants, conditions or provisos are still not being complied with by the Lessee, the Minister may cancel this lease notwithstanding that the rent or royalty payable under this lease for the period during which such breach is committed may have been paid and notwithstanding any implied waiver of such breach by the Minister and the Minister shall thereupon cause to be inserted by any duly authorised officer of the Minister a notice in the *Government Gazette* declaring this lease to be forfeited. In case of a breach of the covenant for payment of the rent or royalty the Minister may exercise the power of cancellation without giving the written notice hereinbefore mentioned:

(19) that a notice of forfeiture as hereinbefore mentioned in the last two preceding provisos so published in the *Government Gazette* shall be taken to be conclusive evidence that this lease has been legally cancelled and forfeited:

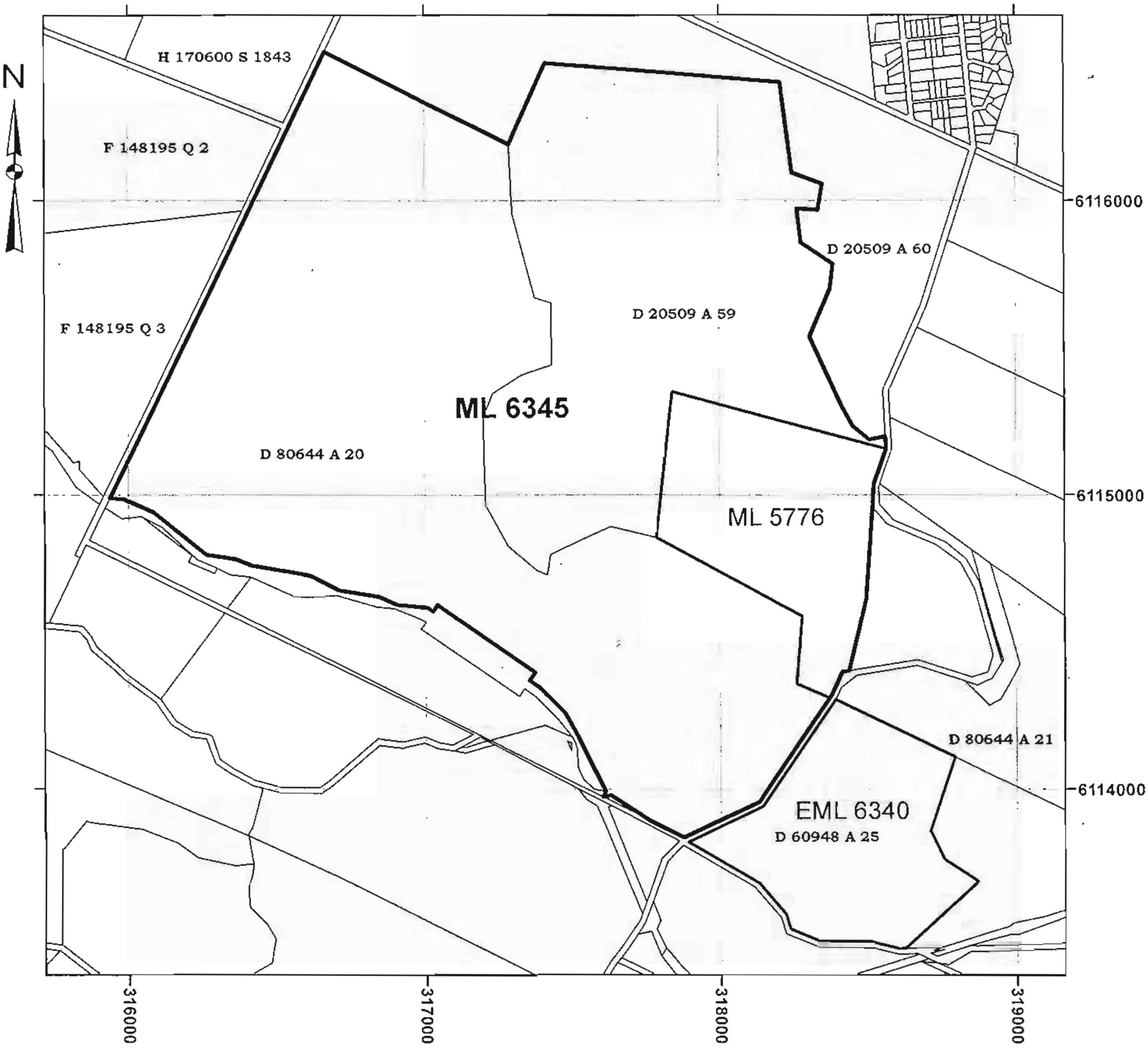
7. Any notice to be given to or demand to be made upon the Lessee by or on behalf of the Minister shall be deemed to be duly given or made if the same be left at or sent through the post in a prepaid envelope addressed to the Lessee at the address of the Lessee shown in the Mining Register and any such mode of service shall in all respects be valid and effectual and any such notice or demand if sent through the post as aforesaid shall be deemed to have been received by the Lessee within three days following the day on which the envelope containing such notice or demand is posted.

8. In the construction of these presents each and every word, term or expression defined in the Act shall have the same meaning where used in these presents, the masculine shall include the feminine, words importing persons shall include corporations, and the singular shall include the plural when the context or circumstances require and unless inconsistent with or repugnant to the context the following words shall have the meanings set opposite to them respectively –

   (i) "amendment" includes an addition, excision or substitution;
   (ii) "the land" includes any part thereof;
   (iii) "the Lessee" means and includes:
      (a) in the case of a natural person the executors, administrators and assigns of that person;
      (b) in the case of a body corporate the successors, administrators or permitted assigns thereof;
   (iv) "the Regulations" means the Regulations under the Act in force for the time being;
   (v) "the term" includes any renewal or extension thereof.

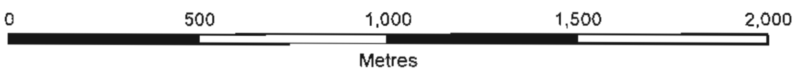
ANNEXURE 'A'

HUNDRED OF KANMANTOO



SCALE

1 : 20 000



Data supplied by lessee
Coordinates MGA Zone 54

FIRST SCHEDULE

1. Mining operations authorised by this lease must only be for the recovery of metallic mineral ores (copper, silver & gold) and garnet from the area of the Lease.

2. The Lessee understands and accepts the pursuant to Section 80(2) of the *Mining Act, 1971*, the rights granted by this lease are modified by, and are subject to, the terms of the Consent Agreement between Hillgrove Resources Ltd and Hillgrove Copper Pty Ltd made on 20 February 2009 ("the Consent Agreement") annexed to this lease.

3. The Lessee must not commence or undertake any mining operations on the land until a Mining and Rehabilitation Program (MARP) has been approved by the Minister and a bond has been paid in accordance with Section 62 of the *Mining Act, 1971*.

4. The Lessee must prepare a MARP that complies with the requirements of guidelines approved by the Director of Mines and include environmental outcomes and criteria that are developed in consultation with relevant stakeholders.

5. The criteria included in the MARP must demonstrate clear and unambiguous achievement of the environmental and mine closure outcomes specified in schedule 2 by:

   - Including the specific parameters to be measured and monitored by the Lessee
   - Specifying the locations that the parameters will be measured, or how these locations will be determined
   - Clearly stating the acceptable values for demonstrating achievement of the outcome , with consideration of any inherent errors of measurement
   - Specifying the frequency of monitoring by the Lessee
   - Identifying what background or control data are to be used or specify how it will be acquired (if necessary).

6. The Lessee must implement and comply with the approved MARP.

7. The Lessee must review the MARP on request of the Director of Mines within a time specified in the request and submit the revised MARP for approval to the Director of Mines.

8. The Lessee agrees to the approved MARP being made available for public inspection.

9. The lessee must keep accurate records of the quantity, value, manner of deposition and costs associated with selling all minerals mined, and whenever required to do so, submit the records for inspection by any person authorised by the Director of Mines. This clause is to be taken as a notice by the Director of Mines in accordance with Section 77 of the Act.

10. The Lessee must demonstrate upon request and to the Director of Mines, the Lessee's capability and competence to comply with the requirements of the *Mining Act, 1971*, the conditions of this Lease, and the MARP.

11. The Lessee must provide to the Director of Mines a Mining and Rehabilitation Compliance Report (MARCR) on operations carried out on the Lease and compliance with the approved MARP. The MARCR must be submitted every year, within 2 months after the anniversary of the date the Lease was granted, or at some other time agreed with the Director of Mines in accordance with guidelines approved by the Director of Mines. The Lessee agrees to the MARCR being made available for public inspection.

12. The Lessee must, if requested by the Director of Mines, undertake an independent audit of achievement of the environmental outcomes in the MARP, by an independent expert approved by the Director of Mines and submit the audit to the Director. The audit will be made available to the public, in a manner and form as determined by the Director of Mines.

13. At least 3 months prior to Lease relinquishment or expiry, the Lessee must provide to the Minister a Mine Completion Report prepared in consultation with the landowner and in accordance with guidelines approved by the Director of Mines, which demonstrates achievement of the closure criteria as specified in the current MARP.

14. The Lessee must, prior to commencing operations under this Lease and for the duration of the lease maintain public liability insurance to cover all operations under the Lease (including sudden and accidental pollution) in the name of the Lessee for a sum not less than $ 50 million or such greater sum as specified by the Director of Mines, and make such amendments to the terms and conditions of the insurance as the Director of Mines may require.

    A copy of the cover note of certificate of currency for the insurance must be provided to the Director of Mines upon request.

    If requested by the Director of Mines, the Lessee must engage an independent and reputable risk assessor to prepare a risk assessment report detailing the public liability risks arising out of the conduct of operations on the Lease, and recommending the level of amount of public liability cover (in respect of any one occurrence) that should be effected and maintained by the Lessee. In preparing the risk assessment report, the assessor must consult with the landowner and the Director of Mines.

    In specifying the level of insurance required, the Director of Mines accepts no liability for the completeness, adequacy of the sum insured, the limit of liability, the scoped coverage, the conditions or exclusions of the insurance in respect of how the Lessee may or may not respond to any loss, damage or liability.

15. The Lessee must report any non-compliance with the Act, these conditions and approved MARP to the Director of Mines. A verbal notification must be provided within 24 hours, after the Lessee becomes aware of the non-compliance. A written report must be provided within 3 days or such time period as approved by the Director of Mines.

16. In requesting a review of the bond required under the *Mining Act, 1971*, the Minister may request that written quotes from a third party are obtained by the Lessee for the cost of rehabilitating the site to the requirements specified in the approved MARP.

    The Lessee must meet all the charges and costs in obtaining and maintaining the Bond.

SECOND SCHEDULE

Visual Amenity

1. The Lessee must in constructing and operating the Lease, ensure that the visual impact of the process plant from the South Eastern Freeway is minimised to the satisfaction of the Director of Mines. If any areas are visible to the public and where it is not possible to completely ameliorate visual impacts, bunding and/or vegetation should be used to improve visual impact and all external materials, colours and finishes should be non-reflective and a colour to blend in with the landscape.

Noise

2. The Lessee must in constructing and operating the Lease, ensure that there are no public nuisance impacts from noise emanating from the operating site. Noise must at all times comply with the relevant environment protection policy under the *Environment Protection Act, 1993.*

Blasting

3. The Lessee must in constructing and operating the Lease, ensure that there are no adverse public health and/or nuisance impacts from airblast, flyrock and vibration caused by blasting.

Air Quality

4. The Lessee must in constructing and operating the Lease ensure that there are no adverse public health and nuisance impacts to local residents from air emissions, dust and odour generated by mining operations.

Fire

5. The Lessee must ensure that no uncontrolled fires caused by mining operations effect remnant vegetation on or off the mine site.

Unauthorised Access

6. The Lessee must in constructing and operating the Lease ensure that there are no public injuries and or deaths resulting from unauthorised entry to the site that could have been reasonably prevented.

Transport

7. The Lessee must, in constructing and operating the Lease, ensure that traffic movements, noise, dust and/or dragout to and from the mine site cause no adverse public impacts.

Community Consultation

8. The Lessee must take responsibility for developing and operating a community engagement plan, as a part of the MARP, to the satisfaction of the Director of Mines which ensures effective communication and exchange of information between the operator and stakeholders including but not restricted to landowners, Callington/Kanmantoo communities or individuals.

Public Complaints

9. The Lessee will be responsible for recording and addressing in manner and form specified by the Director of Mines any complaints received from the public.

Land Use

10. The Lessee must in constructing and operating the Lease, ensure that there are no adverse impacts to adjacent public roads, railway, and adjacent land use.
    - The Lessee must maintain a buffer zone of 10 meters from the Lease boundary with no workings within that zone;
    - The Lessee must ensure that the current disturbed areas are stabilized to prevent sediment from leaving the Lease area.

Infrastructure

11. The Lessee must, in constructing and operating the Lease, ensure that there is no unauthorised damage to adjacent public or private infrastructure.

Aboriginal and European Heritage

12. The Lessee must in constructing and operating the Lease, ensure that there is no disturbance to Aboriginal or European artefacts or sites of significance unless prior approval under the relevant legislation is obtained.

Fauna

13. The Lessee must in constructing and operating the Lease ensure that there are no net adverse impacts from the site operations on native fauna abundance or diversity in the Lease area and in adjacent areas.

Flora

14. The Lessee must, in constructing and operating the Lease, ensure that all clearance of native vegetation is authorised under appropriate legislation and ensure no permanent loss of abundance or diversity on or off the Lease.

Weeds and Pests

15. The Lessee must in constructing and operating the Lease ensure no introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weed or pest species in the Lease area and adjacent areas caused by mining operations.

Topsoil

16. The Lessee must in constructing and operating the Lease ensure that the existing soil quality and quantity is maintained.

Groundwater and Hydrology

17. The Lessee must, in constructing and operating the Lease ensure that there is no adverse impact to the quality and quantity of surface or groundwater caused by mining operations to water dependent ecosystems or existing users unless adequate alternate supplies are provided in accordance with Condition 18.

18. If the Lessee adversely affects the ability of other persons to take water from any watercourse, well or dam, the lessee must replace or deepen existing wells if they are substantially affected by dewatering activities, or provide alternative water sources for the affected users regardless of cessation of mining operations whereby:
    - A 'substantial affect' is determined to be the movement of physical or chemical parameters of the water in the subject well beyond normal seasonal variation. This is to be determined by the relevant authority, and;
    - An 'alternative water source' includes the potential to lower pumps, deepen wells, extend supply from one of the Lessee's wells, or connection to SA Water mains. In the case of any dispute, the final decision on an alternative water source is to be determined by PIRSA in consultation with the affected landholder and the Lessee.

19. The Lessee must ensure that the contaminated water within the pit does not alter groundwater systems outside of the extent of mining operation.

Stormwater

20. The Lessee must, in constructing and operating the Lease ensure no stormwater contaminated as a result of mining operations is to leave the Lease area or result in contamination of soil at closure within Lease area.

Flooding/Runoff

21. The Lessee must, in constructing and operating the Lease ensure no water runoff from the Lease results in flooding of adjacent areas, to an extent greater than that that could reasonably be expected to occur prior to mining operations being established on the Lease.

Waste Disposal & Hazardous Substances

22. The Lessee must, in constructing and operating the Lease ensure that no contamination and/or pollution of natural water drainage systems, streams and rivers, groundwater, land and soils occurs either on or off site is caused by waste products (other than mine waste and tailings) and hazardous materials used in the mine operations.

23. The Lessee must ensure that no demolition, industrial or solid domestic (other than treated sewage) wastes are to be disposed of within the Lease.

24. The Lessee must ensure that fuel and liquid chemical storage is adequately bunded to capture spillage and to prevent the migration or infiltration of any spillage or leakage to the surrounding environment in conformance with relevant Environment and Protection Authority guidelines.

Acid Mine Drainage (AMD)

25. The Lessee must, in constructing and operating the Lease, ensure that no contamination of natural water drainage systems, streams and creeks, and no contamination beyond approved EPA limits for groundwater, land and soils occurs either on or off site resulting from permanent disposal or temporary storage of the mine waste and tailings.

Backfilling of Mine Pits

26. The Lessee must backfill with waste rock into the Emily Star Pit and the O'Neil Zone to the extent it is technically feasible.

Rehabilitation

27. The Lessee must demonstrate prior to lease expiry or surrender that the following outcomes will be achieved indefinitely post mine closure to the satisfaction of the Director of Mines: -
    - The external visual amenity of the site is comparable with the surrounding areas and in accordance with the reasonable expectations of relevant stakeholders including removal of all mine related infrastructure (unless otherwise approved by the Director of Mines in consultation with relevant stakeholders);
    - The risks to the health and safety of the public and fauna are as low as reasonably practical;
    - Ecosystem and landscape function is resilient, self-sustaining and indicating that an ecosystem and landscape function comparable to the surrounding areas will ultimately be achieved;
    - No compromise of the quality and quantity of surface water to existing users and water dependent ecosystems;
    - No compromise of the quantity or quality of ground water to existing users unless adequate alternate supplies are provided in accordance with Condition 18;
    - The site is physically stable;
    - All mining waste and tailings left onsite are chemically and physically stable.

Leading Indicators

28. The MARP must include additional leading indicator criteria for the following outcomes: -
    - Groundwater and Hydrology
    - Acid Mine Drainage (AMD)
    - Topsoil
    - Stormwater
    - Public Safety
    - Infrastructure
    - Transport

EXECUTED

this 23rd day of September 2009

SIGNED for and on behalf of the
MINISTER FOR MINERAL RESOURCES DEVELOPMENT
under delegated authority

....
signature

Name JUNESSE MARTIN
Title A/MINING REGISTRAR

SIGNED SEALED AND DELIVERED BY
THE LESSEE/S

this 21 day of SEPTEMBER 2009

the Common seal of **Hillgrove Copper Pty Ltd (ACN 105 074 762)**
was hereto affixed by

....
~~DIRECTOR~~/SECRETARY

Common Seal
Hillgrove Copper Pty Limited
A.C.N.105 074 762
Common Seal

....
DIRECTOR

INSTRUMENTS

Rental at commencement of lease
for stamp duty assessment.

$17,767.81

Appendix 1B

Mining Lease Conditions ML6436

Our Ref: T02971
Contact: Tracy Carpentieri
Telephone: 08 8463 3462

Government of South Australia
Department of State Development

ABN 83 524 915 929

4 July 2014

Mr Steven McClare
General Manager
Hillgrove Copper Pty Ltd
Eclair Mine Road
KANMANTOO SA 5252

Dear Mr McClare

Offer of Mineral Lease

I refer to your application for a Mineral Lease over Mineral Claim 4365.

The Executive Director, Mineral Resources in accordance with delegated Ministerial powers and functions has approved a proposal to grant a Mineral Lease over the above mentioned Mineral Claim. The lease is offered over an area of 1.96 hectares for a term of approximately four (4) years and three (3) months, with the expiry date of the Lease to align with the expiry of surrounding leases on 6 September 2019.

The Lease will authorise the operations specified in the First Schedule and subject to the *Mining Act 1971* (the Act), the *Mining Regulations 2011* (the Regulations) thereunder and the special conditions set out in the Second Schedule. The First and Second Schedules for the Lease being offered are enclosed. By accepting this offer you are also accepting these Schedules.

Please advise within 21 days of the date of this letter, using the attached form, whether the proposal is acceptable. Please note that the acceptance is to be signed by the applicant for the Lease as indicated on the form. Pursuant to Regulation 40 of the Regulations under the Act the Minister may assume that the application has been withdrawn if the applicant fails to provide notification within 21 days.

The following annual fees in advance are now payable and should be forwarded to this office together with your acceptance form.

Qty	Annual Fees	Total (GST exempt)
1	Annual Rent 1.96 ha @ $56 /ha (or minimum rental = $214.00) = $214	$214.00
1	Administration Component (per tenement)	$143.00
1	Regulation Component (per tenement)	$283.00
TOTAL		**$640.00**

This document will be a tax invoice when you make payment
(Please retain a copy of this invoice for your records)

Section 70B(1) of the Act requires that you must not operate this Lease unless a Program for Environment Protection and Rehabilitation (PEPR) has been approved by the Minister and Regulation 65(10) requires that this Program be provided within 12 months of the date of grant of the lease. Regulation 35 further requires that mining operations must commence within 12 months after the PEPR has been approved in writing by the Minister. Please note that the PEPR approval is currently delegated to Greg Marshall, Director, Mining Regulation.

Please contact Mr Andrew Querzoli, Manager Mining Assessments, Department of State Development on telephone 08 8226 1928 if you need further information in preparing this Program, or if you would like to understand the current status of a previously submitted Program.

Please note that if the tenement is subject to Exempt Land under the provisions of section 9 of the Act, no mining operations are to be undertaken on Exempt Land until a Waiver of Exemption has been negotiated and a copy lodged with the Mining Registrar.

Please also note that the operations of any mining tenement are subject to other legislation. I draw your attention to the following Acts:

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Development Act 1993*
- *Dangerous Substances Act 1979*
- *National Parks and Wildlife Act 1972*
- *Natural Resources Management Act 2004*
- *River Murray Act 2003*
- *Public and Environmental Health Act 1987*
- *Radiation Protection and Control Act 1982*
- *Aboriginal Heritage Act 1988*
- *Occupational Health, Safety and Welfare Act 1986*
- *Environment Protection Act 1993*
- *Native Vegetation Act 1991 (Reprint No. 4)*

The above list is intended only to bring your attention to other Acts that may impinge upon your mining operation and is not exhaustive. The onus is on you as the holder of the mining tenement to comply with any other relevant piece of legislation.

You should read these guidelines carefully before accepting this offer.

In addition to these arrangements, the Director of Mines may, in accordance with section 62 of the Act, require that a bond be entered into to ensure the satisfactory rehabilitation of land disturbed by mining operations.

Yours sincerely

Junesse Martin
MINING REGISTRAR

Enc

T02971

TO: JUNESSE MARTIN, MINING REGISTRAR

RE: APPLICATION FOR MINING LEASE OVER MINERAL CLAIM 4365

In reply to your letter of 4 July 2014, I wish to advise that I am:

* **prepared to accept** a mineral lease authorising the operations described in the First Schedule and under the special conditions specified in the Second Schedule.

OR

* ~~**not prepared to accept** a mineral lease under the terms and conditions set out in the Schedules. I hereby identify the conditions I have used to base my refusal of this offer.~~

* ***Delete whichever is inapplicable.***

4 / 7 / 2014

BMClare

Applicant – Hillgrove Copper Pty Ltd (ACN 105 074 764)

OFFICE USE ONLY	
Rent:	$214.00
Administration:	$143.00
Regulation Component:	$283.00
Total	$640.00

FIRST SCHEDULE

1. Mining operations authorised by this Lease must only be for the recovery of copper, gold and silver from this Lease as outlined in the mining lease proposal document dated 4 April 2014 and subsequent response document dated 27 May 2014.

2. The Lessee agrees to the approved PEPR (section 70B(5)) and the Compliance report (regulation 86) and any reportable incident reports (Regulation 87) being made available for public inspection.

3. In accordance with Regulation 90(1) the Lessee must, prior to commencing operations under this Lease and for the duration of the Lease maintain public liability insurance to cover all operations under the Lease (including sudden and accidental pollution) in the name of the Lessee for a sum not less than $50 million per occurrence and unlimited in annual aggregate or such greater sum as specified by the Minister, and make such amendments to the terms and conditions of the insurance as the Minister may require.

4. In requesting a review of the bond required under the *Mining Act 1971* the Minister may request that written quotes from an independent third party approved by the Minister are obtained by the Lessee for the cost of rehabilitating the site to the requirements specified in the approved Program under Regulation 65(2).

5. The Lessee must meet all the charges and costs in obtaining and maintaining the Bond.

SECOND SCHEDULE

ENVIRONMENTAL OUTCOMES

1. For the purposes of preparation of the Program for Environment Protection and Rehabilitation under section 70B(2) and associated Regulations of the *Mining Act 1971*, the following environmental and mine rehabilitation outcomes must be included:

Blasting
The Lessee must, in constructing and operating the Lease, ensure that there are no public health and/or nuisance impacts from airblast, flyrock and vibration caused by blasting.

Air quality
The Lessee must, in constructing and operating the Lease, ensure that there are no public health and/or nuisance impacts to local residents from air emissions, dust and odour generated by mining operations.

Soil
The Lessee must, in constructing and operating the Lease, ensure that the existing soil quality and quantity is maintained.

Stormwater
The Lessee must in constructing and operating the Lease, ensure no stormwater contaminated as a result of mining operations is to leave the Lease area or result in contamination of soil at closure within the Lease area.

Acid Mine Drainage (AMD)
The Lessee must in constructing and operating the Lease, ensure that no contamination of natural drainage systems, streams and creeks, and no contamination beyond approved EPA limits for groundwater, land and soils occurs either on or off the site resulting from permanent or temporary storage of the mine waste and tailings.

Adjacent land use
The Lessee must, in constructing and operating the Lease, ensure that there are no adverse impacts to adjacent land use.

Visual Amenity
The Lessee must, in constructing and operating the Lease and post completion, ensure that the form, contrasting aspects and reflective aspects of mining operations are visually softened to blend in with the surrounding landscape.

Other Environmental Conditions

2. ***Backfilling of Mine Pits***
The Lessee must backfill the O'Neil/Nugent pit void with waste rock, suitably rehabilitated for future industrial use, with any PAF material encapsulated to ensure achievement of the outcome specified in second schedule Environmental Outcome 1.5.

Appendix 1C

EPBC Act Approval Conditions

Australian Government

Department of the Environment

APPROVAL

Kanmantoo Copper Mine Expansion, Kanmantoo, South Australia (EPBC 2013/6965).

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Proposed action

person to whom the approval is granted	HILLGROVE RESOURCES LIMITED
proponent's ACN (if applicable)	ACN: 004 297 116
proposed action	To expand the copper mining operations at the Kanmantoo Copper Mine, located approximately 1.5 kilometres south-west of Kanmantoo, and 44 km east of Adelaide in the southern Mount Lofty Ranges of South Australia [See EPBC Act referral 2013/6965].

Approval decision

Controlling Provision	Decision
Listed threatened species and communities (sections 18 & 18A)	Approved

conditions of approval

This approval is subject to the conditions specified below.

expiry date of approval

This approval has effect until 31 December 2064.

Decision-maker

name and position	Dr. Simon Banks Assistant Secretary West Assessment Branch
signature	Simon Banks
date of decision	06 May 2014

Conditions attached to the approval

Conditions attached to the approval

1. The person taking the **action** must not **clear** more than 1.8 hectares of the ecological community *Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* within Mining Lease 6345 (refer to Maps at Schedule 1 and Schedule 2).

2. The person taking the **action** must not **clear** more than 3.4 hectares of the ecological community *Iron-grass Natural Temperate Grassland of South Australia* within Mining Lease 6345 (refer to Map at refer to Maps at Schedule 1 and Schedule 2).

3. To assist in mitigating the impacts of the proposal on *Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* and *Iron-grass Natural Temperate Grassland of South Australia*, the person taking the action must prepare and submit a Kanmantoo Copper Mines Native Vegetation Management Plan (NVMP) for the Minister's written approval prior to commencement of the action. The NVMP must be in accordance with the National Recovery Plan for the Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia 2012 and the National Recovery Plan for the Iron-grass Natural Temperate Grassland of South Australia 2012. The NVMP must include;

    a. Management actions designed to improve the ecological quality of *Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* and *Iron-grass Natural Temperate Grassland of South Australia* within Mining Lease 6345 and offset lands (refer to Maps at Schedule 1 and Schedule 2) and protect it from degradation for the duration of the **action**.

    b. Regeneration and revegetation strategies *for Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* and *Iron-grass Natural Temperate Grassland of South Australia* within the proposed ***'SEB-Offset Areas'*** (refer to Map at Schedule 2) to improve the ecological quality of these areas.

    c. An ecological monitoring program to monitor the success of the management actions in the NVMP and define measurable targets of management actions, performance indicators, and an adaptive management framework for the duration of the **action's** impact on *Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* and *Iron-grass Natural Temperate Grassland of South Australia.*

    The **action** must not commence until the NVMP is approved by the **Minister**. The approved NVMP must be implemented.

4. To compensate for the loss of up to 1.8 hectares of the ecological community *Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia* and up to 3.4 hectares of the ecological community *Iron-grass Natural Temperate Grassland of South Australia* the person taking the **action** must secure the lands identified as the ***'SEB-Offset Areas'*** in the Map at Schedule 2 of this notice as a conservation offset.

5. The person taking the **action** must provide written evidence to the **Department** of their compliance with Condition 4, along with **offset attributes**, **shapefiles** and textual

descriptions and maps to clearly define the location and boundaries of the offset sites, prior to the **commencement of the action**.

6. Within 30 days after the **commencement of the action**, the person taking the **action** must advise the **Department** in writing of the actual date of commencement.

7. The person taking the **action** must maintain accurate records substantiating all activities associated with or relevant to these conditions of approval, including measures taken to implement the offset and NVMP, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.

8. Within three months of every 12 month anniversary of the **commencement of the action**, the person taking the **action** must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of the NVMP as specified in the conditions. Documentary evidence providing proof of the date of publication must be provided to the **Department** at the same time as the compliance report is published. Non-compliance with any of the conditions of this approval must be reported to the **Department** within 2 business days of becoming aware of the non-compliance.

9. Upon the direction of the **Minister**, the person taking the **action** must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the commencement of the audit. Audit criteria must be agreed to by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.

10. If the person taking the **action** wishes to carry out any activity otherwise than in accordance with the NVMP as specified in the conditions, the person taking the **action** must submit to the **Department** for the **Minister's** written approval a revised version of that NVMP. The varied activity shall not commence until the **Minister** has approved the varied NVMP in writing. The **Minister** will not approve a varied NVMP unless the revised NVMP would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised NVMP, that NVMP must be implemented in place of the NVMP originally approved.

11. If the **Minister** believes that it is necessary or convenient for the better protection of listed threatened species and ecological communities to do so, the **Minister** may request that the person taking the **action** make specified revisions to the NVMP specified in the conditions and submit the revised NVMP for the **Minister's** written approval. The person taking the **action** must comply with any such request. The revised approved NVMP must be implemented. Unless the **Minister** has approved the revised NVMP then the person taking the **action** must continue to implement the NVMP originally approved.

12. If, at any time after 5 years from the date of this approval, the person taking the **action** has not substantially commenced the **action**, then the person taking the **action** must not substantially commence the **action** without the written agreement of the **Minister**.

13. Unless otherwise agreed to in writing by the **Minister**, the person taking the **action** must publish the NVMP referred to in these conditions of approval on their website. The NVMP must be published on the website within 1 month of being approved. The NVMP must remain on their website for the life of the **action**.

Definitions

a) **Action**, is the proposed expansion of copper mining operations at Kanmantoo Copper Mine within Mining Lease 6345.

b) **Clear/Clearing**, is defined as the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning of native vegetation.

c) **Commencement of the action**, means any preparatory works required to be undertaken including clearing vegetation, the erection of any onsite temporary structures, tunnel enhancement works and the use of heavy duty equipment for demolition or other purposes relating to the action, including the breaking of ground.

d) **Department**, the Australian Government Department administering the *Environment Protection and Biodiversity Conservation Act 1999*.

e) **Minister**, the Minister administering the *Environment Protection and Biodiversity Conservation Act 1999* and includes a delegate of the Minister.

f) **Offset attributes**, means an '.xls' file capturing relevant attributes of the Offset Area, including the EPBC reference ID number, the physical address of the offset site, coordinates of the boundary points in decimal degrees, the EPBC protected matters that the offset compensates for, any additional EPBC protected matters that are benefiting from the offset, and the size of the offset in hectares.

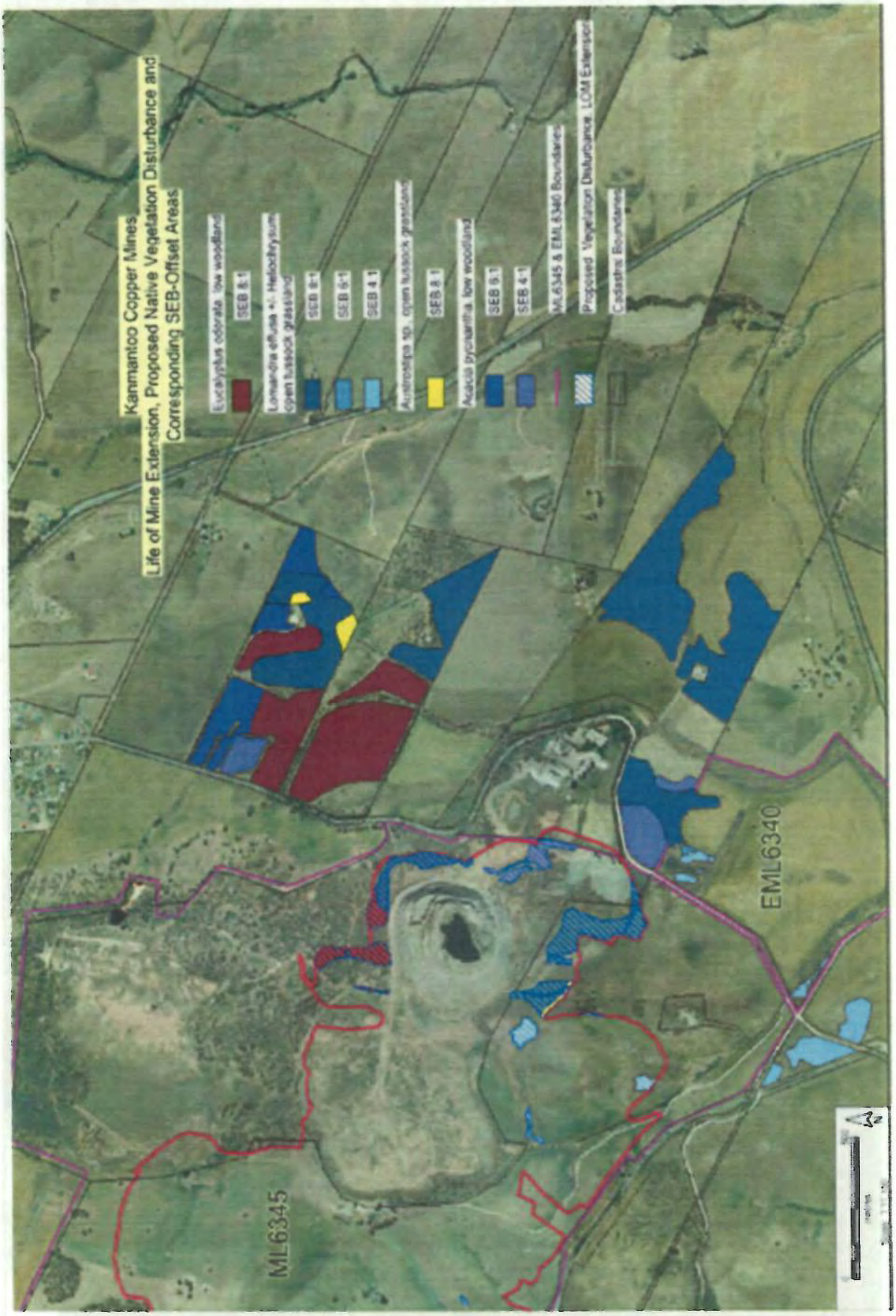
g) **SEB-Offset Areas**, Significant Environmental Benefit Offset Areas as depicted in Schedule 2, specifically Certificate of Title Reference: F160800 A61; F1636 A1; D80644 A21; D60948; D47967 A4 and D30934 Q1.

h) **Shapefiles**, means an ESRI Shapefile containing '.shp', '.shx' and '.dbf' files and other files capturing attributes of the Offset Area, including the shape, EPBC reference ID number and EPBC protected matters present at the relevant site. Attributes should also be captured in '.xls' format and in accordance with Departmental Requirements.

Schedule 1


Kanmantoo Copper Mines
Proposed LOM Extension
Native Vegetation Disturbance Areas
ML6345 & EML6340 Boundaries
Proposed 2014 LOM Disturbance Boundary
Proposed LOM Native Vegetation Disturbance
ML6345
EML6340

Schedule 2


Kanmantoo Copper Mines,
Life of Mine Extension, Proposed Native Vegetation Disturbance and
Corresponding SEB-Offset Areas
EML6340
ML6345

Appendix 2

Surface Water

Appendix 2A

Surface Water (Water Quality) Statistical Summary

Table 1 Dawesley Creek and Mount Barker Creek water quality – general parameters*

Site	**pH** **pH unit**	**TDS** **mg/L**	**EC at 25ºC** **µS/cm**	**SO_4** **mg/L**
LOD	0.1	1	1	1
Dawesley Creek (upstream of confluence with Mount Barker Creek)				
Average	*5.5*	1800	2820	**706**
Count	5	5	5	5
Minimum	*5.2*	1800	2800	**630**
Maximum	*6.3*	1800	2900	**800**
1st Quartile	*5.3*	1800	2800	**650**
Median	*5.4*	1800	2800	**690**
3rd Quartile	*5.5*	1800	2800	**760**
Mount Barker Creek (upstream of confluence with Dawesley Creek)				
Average	7.2	1068	2000	79
Count	5	5	5	5
Minimum	6.8	940	1900	64
Maximum	7.5	1100	2100	92
1st Quartile	7.2	1100	1900	71
Median	7.3	1100	2000	81
3rd Quartile	7.3	1100	2100	89
Mount Barker Creek (downstream of confluence with Dawesley Creek)				
Average	7.5	1309	2268	154
Count	22	22	22	22
Minimum	6.8	1200	2100	90
Maximum	8.2	1500	2500	310
1st Quartile	7.3	1225	2200	94
Median	7.6	1300	2300	96
3rd Quartile	7.7	1400	2300	270
ANZECC/ARMCANZ[A1]	6.5–9	–	100-5000	–
State water quality criteria[B1]				
Freshwater aquatic	6.5–9	[B2]	[B2]	–
Potable water	6.5–8.5	–	–	500
Irrigation	4.5–9	–	–	–
Livestock	–	–	–	1000

*Source:Burtt and Gum, 2000a.

[A1] ANZECC/ARMCANZ (2000). Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (for slightly-moderately disturbed aquatic ecosystems and 95% species protection).

[B1] EPA (2003). Environmental Protection (Water Quality) Policy (Schedule 2).

[B2] 10% variation.

Values in exceedence of ANZECC/ARMCANZ water quality criteria for freshwater ecosystem protection are shown in italics.

Values in exceedence of state water quality criteria are shown in bold.

Table 2 DawesleyCreek and Mount Barker Creek water quality – metals

Site	Al mg/L	As mg/L	Ba mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Zn mg/L
						Filtered metals (0.45 μm)							
LOD	0.002	0.01	0.001	0.0001	0.001	0.001	0.001	0.05	0.001	0.001	0.001	0.001	0.002
Dawesley Creek (upstream of confluence with Mount Barker Creek)													
Average	*0.633*	0.0025	0.028	*0.010*	–	*0.088*	*0.011*	–	*3.50*	0.001	*0.10*	0.01	*1.25*
Count	5	5	5	5	–	5	5	–	5	1	5	4	5
Minimum	*0.46*	0.0025	0.027	*0.009*	–	*0.079*	*0.008*	–	*3.43*	0.001	*0.087*	0.004	*1.17*
Maximum	*0.93*	0.0025	0.028	*0.012*	–	*0.1*	*0.013*	–	*3.55*	0.001	*0.114*	*0.02*	*1.32*
1st Quartile	*0.47*	0.0025	0.027	*0.01*	–	*0.081*	*0.011*	–	*3.49*	0.001	*0.09*	0.012	*1.22*
Median	*0.61*	0.0025	0.028	*0.01*	–	*0.083*	*0.011*	–	*3.51*	0.001	*0.095*	*0.017*	*1.25*
3rd Quartile	*0.7*	0.0025	0.028	*0.011*	–	*0.095*	*0.012*	–	*3.54*	0.001	*0.111*	*0.02*	*1.27*
Mount Barker Creek (upstream of confluence with Dawesley Creek)													
Average	0.0088	0.0025	0.061	–	0.0025	–	0.002	–	0.0058	0.002	0.003	–	0.004
Count	5	5	5	–	5	–	5	–	5	5	5	–	5
Minimum	0.004	0.0025	0.059	–	0.0025	–	0.002	–	0.003	0.002	0.003	–	0.003
Maximum	0.014	0.0025	0.063	–	0.0025	–	0.002	–	0.009	0.002	0.003	–	0.004
1st Quartile	0.005	0.0025	0.061	–	0.0025	–	0.002	–	0.004	0.002	0.003	–	0.003
Median	0.008	0.0025	0.062	–	0.0025	–	0.002	–	0.005	0.002	0.003	–	0.004
3rd Quartile	0.013	0.0025	0.062	–	0.0025	–	0.002	–	0.008	0.002	0.003	–	0.004
Mount Barker Creek (downstream of confluence with Dawesley Creek)													
Average	0.050	0.0025	0.0545	0.0004	0.0025	0.0018	0.0025	0.06	0.044	0.0012	0.007	0.001	0.015
Count	22	22	22	17	22	6	22	1	22	20	22	1	22
Minimum	0.022	0.0025	0.049	*0*	0.0025	0.001	0.002	0.06	0.004	0.001	0.006	0.001	0.004
Maximum	*0.090*	0.0025	0.059	*0.001*	0.0025	*0.004*	*0.005*	0.06	0.18	0.002	0.012	0.001	*0.065*
1st Quartile	0.035	0.0025	0.053	0	0.0025	0.001	0.002	0.06	0.019	0.001	0.006	0.001	0.007
Median	0.047	0.0025	0.055	0	0.0025	0.001	0.002	0.06	0.031	0.001	0.006	0.001	0.01
3rd Quartile	0.060	0.0025	0.056	*0.001*	0.0025	0.0025	0.003	0.06	0.059	0.001	0.007	0.001	0.015

Table 2 DawesleyCreek and Mount Barker Creek water quality – metals (cont.)

Site	Al mg/L	As mg/L	Ba mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Zn mg/L
LOD	0.02	0.01	0.005	0.0005	0.005	0.005	0.005	0.05	0.005	0.005	0.005	0.002	0.01
Total metals													
Dawesley Creek (upstream of confluence with Mount Barker Creek)													
Average	**0.74**	0.0025	–	**0.011**	–	**0.09**	**0.013**	0.05	**3.7**	–	**0.108**	**0.016**	**1.4**
Count	5	5	–	5	–	5	5	1	5	–	5	4	5
Minimum	**0.56**	0.0025	–	**0.009**	–	**0.09**	**0.011**	0.05	**3.6**	–	**0.097**	0.005	**1.3**
Maximum	**1.07**	0.0025	–	**0.012**	–	**0.11**	**0.014**	0.05	**4.0**	–	**0.12**	0.022	**1.5**
1st Quartile	**0.64**	0.0025	–	**0.011**	–	**0.09**	**0.012**	0.05	**3.6**	–	**0.1**	0.013	**1.3**
Median	**0.65**	0.0025	–	**0.011**	–	**0.09**	**0.013**	0.05	**3.7**	–	**0.10**	0.019	**1.3**
3rd Quartile	**0.77**	0.0025	–	**0.011**	–	**0.10**	**0.014**	0.05	**3.8**	–	**0.12**	0.022	**1.4**
Mount Barker Creek (upstream of confluence with Dawesley Creek)													
Average	**0.28**	0.0045	–	–	–	–	–	0.512	0.078	–	–	0.004	0.01
Count	5	5	–	–	–	–	–	5	5	–	–	5	1
Minimum	**0.16**	0.0025	–	–	–	–	–	0.32	0.066	–	–	0.003	0.01
Maximum	**0.37**	0.005	–	–	–	–	–	0.79	0.094	–	–	**0.007**	0.01
1st Quartile	**0.22**	0.005	–	–	–	–	–	0.35	0.072	–	–	0.003	0.01
Median	**0.29**	0.005	–	–	–	–	–	0.55	0.073	–	–	0.003	0.01
3rd Quartile	**0.34**	0.005	–	–	–	–	–	0.55	0.084	–	–	0.005	0.01
Mount Barker Creek (downstream of confluence with Dawesley Creek)													
Average	**0.55**	0.004	–	0.0013	–	0.012	0.006	0.361	**0.56**	–	0.013	**0.005**	**0.095**
Count	22	22	–	18	–	8	6	22	22	–	22	13	22
Minimum	**0.13**	0.0025	–	0.0005	–	0.006	0.005	0.12	0.18	–	0.008	0.002	0.02
Maximum	**1.19**	0.01	–	**0.0028**	–	0.02	0.008	0.91	**1.35**	–	**0.026**	**0.009**	**0.3**
1st Quartile	**0.36**	0.0025	–	0.0005	–	0.008	0.005	0.23	0.33	–	0.009	0.003	0.04
Median	**0.46**	0.0025	–	0.001	–	0.01	0.006	0.36	**0.52**	–	0.01	**0.005**	**0.06**
3rd Quartile	**0.68**	0.005	–	0.0018	–	0.017	0.007	0.45	**0.66**	–	0.016	**0.006**	**0.13**
ANZECC/ARMCANZ[A1]	0.055 [A2]	0.024[A3]; 0.012[A4]	–	0.00058[A5]	0.001	0.0039[A5]	0.0039[A5]	–	1.9	–	0.031[A5]	0.0157[A5]	0.022[A5]
State water quality criteria[B1]													
Freshwater aquatic	0.1[B2]	0.05	–	0.002	[B3]	–	0.01	1	–	–	0.15	0.005	0.05
Potable water	–	0.007	0.7	0.002	[B3]	–	2	–	0.5	0.05	0.02	0.01	0.05
Irrigation	1	–	–	0.01	1	0.05	0.2	1	2	0.01	0.2	0.2	2
Livestock	5	–	–	0.01	1	–	0.5	–	–	0.01	1	0.1	20

[A1] ANZECC/ARMCANZ (2000). Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (for slightly-moderately disturbed aquatic ecosystems and 95% species protection).

[A3] As(III).

[A4] As(V).

[A2] If pH>6.5 insufficient data exists to establish a trigger value for waters with pH<6.5.

[A5] Calculated for a water hardness of 100 mg $CaCO_3$/L.

[B1] EPA (2003). Environmental Protection (Water Quality) Policy (Schedule 2).

[B2] Applies to soluble form, filterable through a 0.1 µm filter.

[B3] Cr(VI). Insufficient data exists to establish a trigger value for Cr(III).

South Australian water quality criteria apply to total metal concentrations, whereas ANZECC/ARMCANZ values apply to filterable metal concentrations.

Exceedences of ANZECC (2000) guidelines are shown in italics.

Exceedences of state water quality criteria are shown in bold.

Table 3 Bremer River (near Hartley site GS426533) water quality summary statistics - general parameters**

	Conductivity* µs/cm	TDS[a] mg/L	pH pH units	Temperature ºC	DO mg/L	Turbidity NTU	oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
Highest LOD	–	–	–	–	–	>400	<0.01	<0.05	–	<0.005	–	–	–
Average	3188.4	1720.9	7.8	15.1	8.2	*16.9*	***0.83***	1.17	*2.0*	0.017	*0.1*	9.3	482.4
Count	200	112	163	178	116	141	112	112	112	112	113	103	104
Count < DL	–	–	–	–	–	–	30	1	–	54	–	–	–
Min	635	348.9	***6.3***	0	3.4	0.6	0.0025	0.025	0.516	0.0025	0.018	0.7	96.8
Max	*9580*	5450	8.9	28.5	14.2	***440***	***6.45***	4.6	***7.65***	**0.178**	**1.11**	**21.3**	1040
1st Quartile	2246	1281.5	7.7	12	6.6	3.8	0.003	0.85	*1.1*	0.0025	*0.043*	7.6	384.8
Median	3005	1627.3	7.81	14	8.3	*6.0*	0.20	1.07	*1.4*	0.0058	*0.07*	9.1	458.5
3rd Quartile	3940.3	2007.4	8.0	18.0	9.5	*9.9*	***1.3***	1.3	*2.6*	0.0173	*0.1*	10.7	565.4
ANZECC/ARMCANZ [B1]	100-5000	–	6.5-9	–	90%	1-50	0.1	–	1	–	0.04	–	–
State water quality criteria[#]													
Freshwater aquatic	º	º	6.5–9	–	–	20	0.5	–	5	0.1	0.5	15	–
Potable water	–	–	6.5–8.5	–	–	5	–	–	–	–	–	–	–
Irrigation	–	–	4.5–9	–	–	–	–	–	–	–	–	–	–
Livestock	–	–	–	–	–	–	–	–	–	–	–	–	–

**Source: EPA, 2006b.

* Measurement at 25ºC.

[a] Measured by electrical conductivity.

[#] Criteria described in Schedule 2 of the Environment Protection (Water Quality Policy) 2003.

º 10% variation.

Table 4 Bremer River (near Hartley site GS426533) water quality summary statistics - total metals**

	Cd mg/L	Cu mg/L	Hg mg/L	Ni mg/L	Pb mg/L	Zn mg/L
Highest LOD	<0.001	<0.03	<0.0005	<0.01	<0.005	<0.01
Average	*0.0006*	*0.0078*	0.0002	0.0066	0.0012	***0.0844***
Count	26	106	22	26	106	106
Count < DL	22	40	22	5	76	4
Minimum	0.00025	0.0005	0.0001	0.00025	0.00025	0.003
Maximum	*0.005*	*0.063*	0.00025	0.04	*0.026*	***0.496***
1st Quartile	0.00025	0.0025	0.00015	0.0026	0.0005	0.02
Median	0.00025	*0.0049*	0.00015	0.0049	0.0005	***0.0598***
3rd Quartile	0.0005	*0.0139*	0.00015	0.0076	0.0011	***0.1218***
ANZECC/ARMCANZ [B1]	0.00058[B11]	0.0039[B11]	0.0006[B9]	0.031[B1]	0.0157[B11]	0.022[B11]
State water quality criteria[#]						
Freshwater aquatic	0.002	0.01	0.0001	0.15	0.005	0.05
Potable water	0.002	2	0.001	0.02	0.01	0.05
Irrigation	0.01	0.2	0.002	0.2	0.2	2
Livestock	0.01	0.5	0.002	1	0.1	20

**Source: EPA, 2006b.

[B1] ANZECC/ARMCANZ (2000). Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (for slightly-moderately disturbed aquatic ecosystems and 95% species protection). Australian and New Zealand Environment and Conservation Council and the Agricultural and Resource Management Council of Australia and New Zealand. October 2000.

[B11] Calculated for a water hardness of 100 mg $CaCO_3$/L.

[#] Criteria described in Schedule 2 of the Environment Protection (Water Quality) Policy 2003.

Exceedences of ANZECC/ARMCANZ (2000) guidelines are shown in italics.

Exceedences of state water quality criteria (Schedule 2) guidelines are shown in bold.

Table 5 Lake Alexandrina water quality statistical summary – general parameters**

Date	Conductivity[#] µs/cm	TDS* mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg N/L	P (sol) mg P/L	Total P mg P/L	Organic carbon mg/L	chlorophyll (a) µg/L	Enterococci per 100mL
Poltalloch plains														
Average	1004	553	8.4	16.2	10.1	51.7	0.0037	1.4	1.4	0.0047	0.1	–	35.2	125.2
Count	90	90	24	24	15	90	90	90	90	90	24	–	88	24
Minimum	384	211	7.9	9	6.8	13.7	0.0025	0.63	0.6	0.0025	0.04	–	9.27	0
Maximum	1664	918	8.8	22	11.8	185	0.0230	4.99	5	0.0721	0.62	–	121.7	800
1st quartile	783	430	8.3	13	9.2	26.6	0.0025	1.03	1.0	0.0025	0.08	–	23.1	9
Median	1100	605	8.4	16	10.3	44.8	0.0025	1.2	1.2	0.0025	0.12	–	31.1	43
3rd Quartile	1241	684	8.6	19.3	11.2	69.5	0.0025	1.4	1.4	0.0025	0.16	–	43.1	61
Milang (GS426524)														
Average	746	406	8.3	16.4	9.5	77.0	0.027	1.3	1.3	0.026	0.2	7.3	30.9	119.0
Count	1077	1025	1026	792	667	894	412	450	388	440	399	123	93	23
Minimum	269	148	7	9	0	0.31	0.0025	0.03	0.04	0.0025	0.005	2.8	6.5	1
Maximum	1750	820	10	27	81	390	0.59	2.77	2.99	0.336	0.713	15	244.2	550
1st Quartile	541	297	8.1	13	8.5	33	0.008	0.96	0.98	0.0025	0.097	6	17.1	25
Median	683	375	8.3	16	9.6	58	0.01	1.19	1.2	0.007	0.148	7	24	49
3rd Quartile	913	497	8.5	20	10.4	103	0.02	1.5	1.5	0.033	0.223	8	32.3	120
Goolwa Barrage														
Average	2213	1228	8.6	16.3	9.0	18.6	0.006	1.1	1.1	0.0034	0.1	–	22.9	9.4
Count	87	87	23	24	15	87	87	87	87	87	23	–	85	23
Minimum	448	246	8.3	10	6.8	2.5	0.0	0.7	0.69	0.0025	0.04	–	3.3	0
Maximum	8460	4792	8.9	23	10.8	91.5	0.15	2.3	2.29	0.024	0.11	–	56.3	32
1st Quartile	1386	763	8.48	13.8	8.5	12.0	0.0025	0.9	0.89	0.0025	0.05	–	16.4	3.5
Median	1828	1009	8.6	16.3	9.1	15.6	0.0025	1.1	1.06	0.0025	0.06	–	22.6	8
3rd Quartile	2574	1425	8.7	18.3	9.7	20	0.0025	1.2	1.2	0.0025	0.08	–	26.2	10
1)	300-1000	–	6.5-9	–	90%	1-100	0.1	–	1	0.01	0.025	–	–	–
2)	–	–	8-8.5	–	–	0.5-10	0.05	–	1	0.01	0.1	–	–	–
State water quality criteria[a]														
Freshwater aquatic	º	º	6.5–9	–	–	20	0.5	–	5	0.1	0.5	15	–	–
Potable water	–	–	6.5–8.5	–	–	5	–	–	–	–	–	–	–	–
Irrigation	–	–	4.5–9	–	–	–	–	–	–	–	–	–	–	–
Livestock	–	–	–	–	–	–	–	–	–	–	–	–	–	–

**Source: EPA, 2006b.

[#] At 25 ºC.

* By EC.

[a] Criteria described in Schedules 2 of the Environment Protection (Water Quality Policy) 2003.

º No greater than 10% variation.

1) ANZECC/ARMCANZ (2000) default trigger values for freshwater lakes and reservoirs in South Central Australia (for slightly-moderately disturbed aquatic ecosystems and 95% species protection).

2) ANZECC/ARMCANZ (2000) default trigger values for marine ecosystems in South Central Australia (for slightly-moderately disturbed aquatic ecosystems and 95% species protection).

Table 6 Bremer catchment bed sediment statistical summary – pH, EC and metals*

	pH pH unit	EC µS/cm	Ag mg/kg	As mg/kg	Au mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Sb mg/kg	Sn mg/kg	Zn mg/kg
DL	0.01	1	0.1	0.5	0.001	20	0.5	0.1	0.1	0.2	20	0.5	50	0.1	2	0.5	0.5	10	0.5
Dawesley/Mount Barker Creek																			
Range	3.5–10.2	66–2100	<DL–400	0.5–**2350**	<DL–1.13	90–4650	0.2–9.5	<DL–2.7	<DL–**54**	0.90–360	<DL–270	2–**700**	100-5600	0.03–11	2–**320**	2–**42400**	<DL–2350	<DL–140	5–**5850**
Average	7.4	641	2.0	21.58	0.007	465	2.5	0.43	4.3	25.5	69.6	36.3	600	9.2	34.4	216.8	10.9	1.5	**590.2**
Median	7.4	568	0.3	10	0.002	460	2	0.4	1.95	13.5	70	27.5	5000	0.7	24	35	1	<DL	33
Langhorne Creek																			
Range	5.9–10.3	121–1500	<DL–0.8	1.0–19.5	<DL–0.006	280–700	<DL–5.5	<DL–1.8	<DL–2.1	2.2–27.5	<DL–130	6.5–130	2000–8000	0.2–1.2	6–**58**	7.5–9.5	<DL–1.5	<DL–25	18–400
Average	7.7	335	0.23	5.4	0.0016	426	1.7	0.43	0.22	8.41	41.7	33.6	3000	0.56	19.13	37.67	0.21	0.921	79.0
Median	7.6	276	0.2	3.5	0.001	390	1.5	0.3	0.2	7	40	20.5	300	0.5	15.5	16.5	<DL	<DL	49.8
Kanmantoo mine																			
Range	3.9–9.3	138–5000	0.1–2.2	4.0–14.5	0.005–0.14	190–600	1–4.5	3.5–100	<DL–0.3	11–100	90–180	140–**13500**	700–2700	0.7–2.2	16–**105**	14.5–89	<DL–0.5	<DL	40–185
Average	7.4	1667	0.6	7.2	0.0274	374	2.33	28	0.2	32.5	147	**2131**	1100	1.3	40	38.5	0.5	–	103
Median	7.9	679	0.4	5.5	0.011	310	2.5	18.5	0.2	21.5	150	**310**	900	1.2	26	27	0.5	–	78
ISQG-High**			–	70	–	–	–	–	10	–	370	270	–	–	52	220	–	–	410
ISQG-Low**			–	20	–	–	–	–	1.5	–	80	65	–	–	21	20	–	–	200
Average crustal abundance[a]			0.07	1.5	–	500	2.6	–	0.11	20	100	50	950	1.5	80	14	0.2	2.2	75
Shallow water sediment[a]			0.11	5	–	460	3	–	–	13	60	56	850	1	35	–	–	2	92

*Source: Burtt and Gum, 2000b.
[a] Salomons and Forstner, 1984.
** Interim Sediment Quality Guideline, ANZECC/ARMCANZ, 2000.
Exceedences of ISQG-High guidelines are shown in bold.

Table 7 Kanmantoo project area stream bed sediment results – pH, CN and metals*

Site	Date	pH	CN	As	Cd	Cr	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Se	Zn
		pH unit	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
PB01	4-Apr-06	7.1	1.9	4.0	<2.0	47	13	75	28,000	12	370	0.02	<2.0	25	<2.0	52
Kan01	May-00	3.86	–	12	0.2	150	100	**2200**	96400	47	650	–	2.2	**105**	1.0	160
PB02	4-Apr-06	4.90	<0.1	2.5	<2.0	40	16	360	21,000	8.6	240	0.02	<2.0	29	<2.0	40
Kan02	May-00	8.30	–	4	<0.1	180	15	260	50,900	25	1300	–	0.7	23	<0.5	78
PB03	4-Apr-06	7.10	<0.1	5.7	<2.0	87	54	**1,200**	62,000	38	520	0.06	<2.0	**68**	2.2	120
Kan03	May-00	7.70	–	8.5	0.2	160	41	**2,000**	90,500	89	800	–	1.2	**68**	<0.5	180
PB04	4-Apr-06	8.20	<0.1	4.9	<2.0	100	54	**1,200**	65,000	61	700	0.08	<2.0	**68**	<2.0	120
Kan04	May-00	5.50	–	5.0	0.1	180	51	**13,500**	106,000	66	2650	–	2	31	6	185
PB05	4-Apr-06	5.80	<0.1	2.2	<2.0	29	32	**5,800**	38,000	28	180	0.07	<2.0	18	6.3	40
Kan05	May-00	8.30	–	5.5	<0.1	90	22	240	42,800	22	900	–	0.8	26	<0.5	58
PB06	4-Apr-06	7.30	<0.1	3.1	<2.0	43	13	190	31,000	10	360	<0.01	<2.0	19	<2.0	26
Kan06	May-00	8.40	–	5.0	<0.1	180	12	**310**	41,800	21	1200	–	1.0	16	<0.5	66
PB07	4-Apr-06	7.90	<0.1	3.0	<2.0	33	10	120	23,000	13	280	<0.01	<2.0	15	<2.0	28
Kan07	May-00	9.30	–	4.0	<0.1	140	11	140	36,500	15	850	–	1.4	22	<0.5	40
PB08	4-Apr-06	8.40	<0.1	8.2	<2.0	100	29	250	61,000	29	640	0.08	<2.0	**58**	<2.0	100
Kan09	May-00	6.90	–	6.5	0.3	100	22.5	**380**	48,300	27	850	–	1.10	25	<0.5	59
PB10	4-Apr-06	8.30	<0.1	4.1	<2.0	42	12	92	25,000	8.5	390	<0.01	<2.0	21	<2.0	37
ISQG-High**				70	10	370	–	270	–	220	–	1	–	52	–	410
ISQG-Low				20	1.5	80	–	65	–	20	–	0.15	–	21	–	200
Average crustal abundance[a]				1.5	0.11	100	20	50	41,000	14	950	0.05	1.5	80	–	75
Shallow water sediment[a]				5	–	60	13	56	65,000	–	850	–	1	35	–	92

*Source: PB, 2006b.

** Interim Sediment Quality Guideline, ANZECC/ARMCANZ, 2000

[a] Salomons and Forstner, 1984.

Exceedences of ISQG-High guidelines are shown in bold.

Appendix 2B

Surface Water Quality Data

Table 8 DawesleyCreek and Mount Barker Creek water quality – general parameters*

Site	pH pH unit	TDS mg/L	EC at 25ºC µS/cm	SO_4 mg/L
LOD	0.1	1	1	1
Dawesley Creek (upstream of confluence with Mount Barker Creek)				
B47-1	5.4	1800	2800	650
B48-3	5.2	1800	2800	800
B49-3	5.5	1800	2800	690
B50-1	5.3	1800	2800	760
B55-1	6.3	1800	2900	630
Mount Barker Creek (upstream of confluence with Dawesley Creek)				
B26-3	7.3	1100	1900	64
B51-1	6.8	940	1900	71
B52-1	7.2	1100	2000	81
B53-1	7.3	1100	2100	89
B54-1	7.5	1100	2100	92
Mount Barker Creek (downstream of confluence with Dawesley Creek)				
B25-3	7.3	1400	2400	290
B56-1	6.8	1300	2300	270
B57-1	7	1400	2400	310
B58-1	7	1400	2300	290
B59-1	7.7	1400	2400	280
B60-1	7.1	1500	2500	270
B61-1	7.1	1300	2300	270
B62-1	7.5	1200	2200	91
B63-1	7.4	1200	2100	90
B64-1	7.5	1300	2200	91
B65-1	7.6	1200	2200	92
B66-1	7.9	1200	2200	92
B67-1	8.2	1200	2100	97
B68-1	7.7	1200	2200	94
B69-1	7.6	1300	2200	97
B70-1	7.6	1400	2200	96
B71-1	7.4	1300	2200	96
B72-1	8.1	1300	2300	97
B73-1	7.9	1300	2300	96
B74-1	7.6	1300	2300	95
B75-1	8.1	1400	2300	96
B76-1	7.6	1300	2300	95

*Siource: Burtt and Gum, 2000a.

Table 9 DawesleyCreek and Mount Barker Creek water quality – metals*

Site	Al mg/L	As mg/L	Ba mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Zn mg/L
Filtered metals (0.45 µm)													
LOD	0.002	0.01	0.001	0.0001	0.001	0.001	0.001	0.05	0.001	0.001	0.001	0.001	0.002
Dawesley Creek (upstream of confluence with Mount Barker Creek)													
B47-1	0.93	<0.005	0.028	0.009	–	0.095	0.013	–	3.43	–	0.114	–	1.25
B48-3	0.7	<0.005	0.028	0.01	–	0.1	0.012	–	3.54	–	0.111	0.004	1.32
B49-3	0.458	<0.005	0.028	0.012	–	0.083	0.011	–	3.55	–	0.095	0.02	1.27
B50-1	0.613	<0.005	0.027	0.011	–	0.081	0.011	–	3.51	0.001	0.09	0.02	1.22
B55-1	0.466	<0.005	0.027	0.01	–	0.079	0.008	–	3.49	–	0.087	0.014	1.17
Mount Barker Creek (upstream of confluence with Dawesley Creek)													
B26-3	0.008	<0.005	0.061	–	<0.005	–	0.002	–	0.003	0.002	0.003	–	0.004
B51-1	0.005	<0.005	0.059	–	<0.005	–	0.002	–	0.004	0.002	0.003	–	0.003
B52-1	0.004	<0.005	0.062	–	<0.005	–	0.002	–	0.005	0.002	0.003	–	0.004
B53-1	0.014	<0.005	0.062	–	<0.005	–	0.002	–	0.009	0.002	0.003	–	0.004
B54-1	0.013	<0.005	0.063	–	<0.005	–	0.002	–	0.008	0.002	0.003	–	0.003
Mount Barker Creek (downstream of confluence with Dawesley Creek)													
B25-3	0.048	<0.005	0.053	0.001	<0.005	0.001	0.005	–	0.051	–	0.007	–	0.017
B56-1	0.034	<0.005	0.049	0.001	<0.005	0.004	0.004	–	0.131	0.001	0.012	–	0.065
B57-1	0.072	<0.005	0.051	0.001	<0.005	0.003	0.003	0.06	0.18	–	0.009	0.001	0.058
B58-1	0.04	<0.005	0.053	0.001	<0.005	–	0.003	–	0.025	0.001	0.007	–	0.027
B59-1	0.034	<0.005	0.052	0.001	<0.005	–	0.003	–	0.019	0.001	0.007	–	0.015
B60-1	0.055	<0.005	0.053	0.001	<0.005	0.001	0.004	–	0.023	0.001	0.008	–	0.015
B61-1	0.039	<0.005	0.054	0.001	<0.005	–	0.004	–	0.021	0.001	0.007	–	0.026
B62-1	0.09	<0.005	0.059	0	<0.005	0.001	0.002	–	0.054	0.001	0.007	–	0.012
B63-1	0.047	<0.005	0.057	0	<0.005	–	0.002	–	0.005	0.001	0.006	–	0.01
B64-1	0.059	<0.005	0.057	0	<0.005	–	0.002	–	0.007	0.001	0.006	–	0.006
B65-1	0.06	<0.005	0.056	0	<0.005	–	0.002	–	0.004	0.001	0.006	–	0.01
B66-1	0.074	<0.005	0.054	–	<0.005	–	0.002	–	0.007	0.001	0.006	–	0.004
B67-1	0.071	<0.005	0.056	–	<0.005	0.001	0.002	–	0.042	0.001	0.007	–	0.005
B68-1	0.047	<0.005	0.056	0	<0.005	–	0.002	–	0.037	0.001	0.006	–	0.005
B69-1	0.03	<0.005	0.056	–	<0.005	–	0.002	–	0.02	0.001	0.006	–	0.008
B70-1	0.026	<0.005	0.057	–	<0.005	–	0.002	–	0.017	0.001	0.006	–	0.005
B71-1	0.022	<0.005	0.055	0	<0.005	–	0.002	–	0.024	0.001	0.006	–	0.008
B72-1	0.041	<0.005	0.055	–	<0.005	–	0.002	–	0.064	0.001	0.006	–	0.005
B73-1	0.055	<0.005	0.054	0	<0.005	–	0.002	–	0.061	0.002	0.006	–	0.008
B74-1	0.029	<0.005	0.054	0	<0.005	–	0.002	–	0.049	0.002	0.006	–	0.01
B75-1	0.078	<0.005	0.053	0	<0.005	–	0.002	–	0.06	0.001	0.006	–	0.009
B76-1	0.042	<0.005	0.055	0	<0.005	–	0.002	–	0.066	0.002	0.006	–	0.01

Table 9 DawesleyCreek and Mount Barker Creek water quality – metals (cont.)*

Site	Al mg/L	As mg/L	Ba mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Zn mg/L
Total metals													
LOD	0.02	0.01	0.005	0.0005	0.005	0.005	0.005	0.05	0.005	0.005	0.005	0.002	0.01
Dawesley Creek (upstream of confluence with Mount Barker Creek)													
B47-1	1.07	<0.005	0.028	0.0093	–	0.098	0.014	–	3.63	–	0.119	–	1.4
B48-3	0.77	<0.005	0.028	0.011	–	0.108	0.014	0.05	3.6	–	0.12	0.005	1.47
B49-3	0.56	<0.005	0.028	0.012	–	0.09	0.012	–	3.66	–	0.102	0.022	1.32
B50-1	0.64	<0.005	0.027	0.011	–	0.088	0.013	–	3.98	–	0.1	0.022	1.29
B55-1	0.65	<0.005	0.029	0.011	–	0.086	0.011	–	3.75	–	0.097	0.015	1.29
Mount Barker Creek (upstream of confluence with Dawesley Creek)													
B26-3	0.37	<0.01	0.071	–	–	–	–	0.79	0.084	–	–	0.007	0.01
B51-1	0.22	<0.005	0.065	–	–	–	–	0.35	0.066	–	–	0.005	–
B52-1	0.16	<0.01	0.069	–	–	–	–	0.32	0.073	–	–	0.003	–
B53-1	0.29	<0.01	0.073	–	–	–	–	0.55	0.094	–	–	0.003	–
B54-1	0.34	<0.01	0.073	–	–	–	–	0.55	0.072	–	–	0.003	–
Mount Barker Creek (downstream of confluence with Dawesley Creek)													
B25-3	0.69	<0.01	0.064	0.0026	–	0.016	0.008	0.46	1.35	–	0.023	0.009	0.19
B56-1	0.29	0.005	0.056	0.0026	–	0.019	0.005	0.25	0.9	–	0.026	0.005	0.3
B57-1	0.45	<0.01	0.061	0.0017	–	0.02	0.005	0.36	1.21	–	0.024	0.006	0.23
B58-1	1.17	<0.005	0.065	0.0028	–	0.011	0.007	0.56	0.893	–	0.019	0.008	0.2
B59-1	0.76	<0.005	0.063	0.0018	–	0.008	–	0.4	0.709	–	0.016	0.005	0.13
B60-1	0.87	<0.005	0.064	0.0018	–	0.007	0.005	0.39	0.639	–	0.015	0.005	0.12
B61-1	1.19	<0.01	0.064	0.0026	–	0.009	0.006	0.61	0.66	–	0.016	0.006	0.17
B62-1	0.4	<0.01	0.069	0.0005	–	–	–	0.23	0.278	–	0.009	0.002	0.05
B63-1	0.62	<0.01	0.068	0.001	–	–	–	0.36	0.323	–	0.01	0.003	0.08
B64-1	0.39	<0.01	0.065	0.0005	–	–	–	0.24	0.259	–	0.009	–	0.05
B65-1	0.65	<0.01	0.068	0.001	–	–	–	0.36	0.319	–	0.011	0.003	0.07
B66-1	0.21	<0.01	0.064	–	–	–	–	0.12	0.182	–	0.008	–	0.02
B67-1	0.35	0.005	0.065	0.0005	–	–	–	0.22	0.34	–	0.01	–	0.05
B68-1	0.43	<0.01	0.070	0.0005	–	–	–	0.26	0.501	–	0.01	–	0.04
B69-1	0.47	<0.005	0.069	0.001	–	–	–	0.33	0.54	–	0.01	0.002	0.06
B70-1	0.13	<0.005	0.064	–	–	–	–	0.13	0.218	–	0.009	–	0.02
B71-1	0.5	<0.005	0.067	0.0005	–	–	–	0.46	0.45	–	0.01	–	0.06
B72-1	0.23	<0.005	0.065	–	–	–	–	0.2	0.386	–	0.009	–	0.03
B73-1	0.57	<0.005	0.068	0.0005	–	–	–	0.48	0.567	–	0.01	0.002	0.06
B74-1	0.23	<0.005	0.064	–	–	–	–	0.22	0.377	–	0.008	–	0.02
B75-1	1.03	<0.005	0.069	0.0011	–	0.006	–	0.91	0.649	–	0.012	0.003	0.1
B76-1	0.44	<0.005	0.065	0.0005	–	–	–	0.39	0.578	–	0.011	–	0.04

*Source: Burtt and Gum, 2000b.

Table 10 Bremer River (near Hartley site GS426533) water quality - general parameters**

Date	Conductivity* us/cm	TDS[a] mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
Highest LOD	–	–	–	–	–	>400	<0.01	<0.05	–	<0.005	–	–	-
20-10-06	2240	1200	8.6	18.6	9.47	2.8	<0.005	0.59	0.595	0.006	0.034	7.7	385
29-09-06	1960	1100	7.7	13	7.7	5.1	1.63	1.23	2.86	<0.005	0.071	7.2	373
14-08-06	2680	1500	7.9	11	9.7	4.8	1.33	0.98	2.31	<0.005	0.028	7.9	430
17-07-06	1410	777	7.5	10	11.6	66	2.72	1.73	4.45	0.031	0.213	8.8	268
30-06-06	2390	1320	7.8	8	6.6	0.96	2.55	0.72	3.27	<0.005	0.018	6.6	447
19-05-06	1480	816	7.5	12	6.8	9.2	0.404	0.8	1.204	0.007	0.038	7.3	271
28-04-06	3320	1840	7.9	13	8.6	5.7	<0.005	1.03	1.035	0.009	0.067	11.3	530
21-03-06	4370	2440	8.0	17	4.6	6.3	<0.005	1.12	1.125	<0.005	0.144	12.9	770
20-02-06	3520	1960	7.9	19	3.7	5.4	<0.005	1.12	1.125	0.026	0.106	12.4	640
04-01-06	2130	1180	7.7	20	9.01	5	<0.005	1.1	1.105	<0.005	0.106	9.9	384
07-12-05	2090	1150	8.5	21	12.7	5.7	0.304	2.46	2.764	0.016	0.098	10.8	342
09-11-05	1260	–	7.4	19	4.7	17.1	0.013	2.01	2.023	0.08	0.164	21.3	188
05-10-05	2308	1280	7.7	16	7.6	5.22	0.301	1.24	1.541	<0.005	0.043	10.2	396
09-09-05	1661	916	7.8	15	8.2	15.3	0.592	<0.05	0.642	0.018	0.076	14.5	264
03-08-05	3436	1910	8.0	13	9.2	3.61	1.317	0.97	2.287	<0.005	0.024	8.9	547
06-07-05	3133	1740	7.6	10	9.4	9.89	2.801	1.12	3.921	0.018	0.051	9.2	502
08-06-05	4570	2550	8.0	12	5.8	4.09	0.006	0.51	0.516	0.018	0.072	8.5	752
04-05-05	8170	4620	8.2	16	6.9	11.3	<0.005	1.71	1.715	<0.005	0.106	11.5	1040
15-04-05	9580	5450	8.6	16	9.1	21.8	<0.005	1.87	1.875	<0.005	0.175	12.7	1020
16-03-05	4700	2620	8.1	18	3.4	9.3	0.005	0.93	0.935	0.026	0.091	9.8	800
09-02-05	4320	2410	8.0	–	–	10.1	<0.005	1.11	1.115	0.019	0.126	11.2	689
05-01-05	4280	2390	8.1	18.6	5.64	13.9	<0.005	1.41	1.415	<0.005	0.118	11.9	622
07-12-04	2365	1300	7.7	20.2	5.59	8.44	0.013	1.01	1.023	<0.005	0.103	9.3	392.8
03-11-04	3032	1700	7.9	17	6.45	5.45	0.012	1.14	1.152	<0.005	0.035	9.1	539.1
15-10-04	2854	1581.9	7.9	17	7.9	5.85	0.034	0.94	0.974	<0.005	0.036	10.4	492.6
08-09-04	2944	1632.3	8.0	12	9.8	4.42	0.306	1.08	1.386	<0.005	0.035	10.9	493.7
25-08-04	2293	1268.1	7.7	12	11	5.21	1.13	1.03	2.16	<0.005	0.034	12.7	372.2
07-07-04	1875	1035.2	7.5	–	–	14	2.1	1.13	3.23	0.022	0.071	–	376.1
23-06-04	997	548.5	7.4	10.6	7.7	110	1.22	1.13	2.35	0.039	0.168	8.9	199.2
05-05-04	3481	1934.2	7.7	16	8	6.17	<0.005	1.42	1.425	<0.005	0.088	12.4	590.2
03-03-04	3650	2029.4	7.7	24	4.6	5.04	<0.005	1.22	1.225	0.01	0.059	12	558.5
04-02-04	3920	2181.8	7.9	20	5.1	5.98	0.008	1.26	1.268	0.016	0.08	10.8	676
14-01-04	3082	1709.8	8.1	25	6.2	8.27	<0.005	1.1	1.105	0.006	0.06	–	512.7
27-11-03	2930	1624.5	7.7	21.3	6.7	5.34	<0.005	1.05	1.055	<0.01	0.036	9.8	468.1
22-10-03	2625	1453.6	8.0	16	10.2	6.09	0.11	1.11	1.22	0.008	0.05	10	461.8
10-09-03	2103	1162.2	7.9	13	8.2	6.81	0.68	0.94	1.62	0.011	0.049	11.7	356.5
13-08-03	2564	1419.5	7.7	13	8.4	17	1.43	1.09	2.52	0.029	0.085	10.2	435.9
23-07-03	8380	4745.5	8.1	10	7.4	2.2	0.005	1.04	1.045	0.033	0.068	11.3	777.1
12-06-03	1398	770.4	7.5	11	6.1	38.15	1.14	1.15	2.29	0.042	0.141	8.4	244.9
14-05-03	3956	2202.2	7.9	16	6.66	8.71	<0.005	1.21	1.215	0.008	0.119	7.5	683
08-01-03	2900	1607.7	8.1	23	8.4	15.9	<0.005	1.14	1.145	0.007	0.11	9.8	512.2
04-12-02	2675	1481.6	7.8	19	6.8	9.01	<0.005	1.24	1.245	<0.005	0.074	12	449
16-10-02	2363	1307.2	8.0	18	7.9	6.3	<0.005	0.84	0.845	<0.005	0.042	7.6	410.3
11-09-02	2138	1181.7	8.1	14	9.5	5.58	<0.005	0.79	0.795	<0.005	0.026	7.5	419.4
14-08-02	2322	1284.3	8.5	12	12.3	9.815	0.133	1.88	2.013	0.0055	0.135	8.4	412.4

Table 10 Bremer River (near Hartley site GS426533) water quality - general parameters (cont.)**

Date	Conductivity* us/cm	TDS[a] mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
10-07-02	1419	782	7.4	10	9	54.3	1.701	1.27	2.971	0.0237	0.116	7.9	281.5
12-06-02	2735	1515.2	7.8	–	–	5.61	0.0054	0.95	0.9554	<0.005	0.064	8.7	457.8
16-05-02	4310	2402.6	8.0	16	8.2	8.44	<0.005	0.9	0.905	0.0118	0.08	10.5	690.1
13-02-02	2940	1630.1	7.7	17	4.5	4.7	<0.005	0.72	0.725	<0.005	0.027	8.1	344.5
24-10-01	2193	1212.3	7.9	17	8.4	5.48	0.122	0.87	0.992	0.005	0.045	10	420.8
19-09-01	1916	1058	7.7	16	8.5	9.28	0.964	1.55	2.514	0.009	0.069	11.9	309.2
15-08-01	3935	2190.3	7.9	12	9.5	5.74	2.12	0.85	2.97	<0.005	0.032	6.4	586
18-07-01	2318	1282.1	7.6	–	–	3.15	0.811	0.67	1.481	<0.005	0.022	6.7	507.6
07-06-01	1841	1016.3	7.7	12.1	9.8	6.74	0.4831	0.78	1.2631	0.0055	0.057	6.9	350.1
30-05-01	1917	1058.6	7.6	12	6.5	6.84	0.5539	0.82	1.3739	0.022	0.094	6.9	373.1
17-01-01	4150	2311.9	8.3	22	–	10.2	0.0054	0.98	0.9854	<0.005	0.08	10.2	697
06-12-00	3110	1725.5	8.0	25	4.4	8.06	0.0273	1.36	1.3873	<0.005	0.059	8.1	543.3
06-11-00	2690	1490	7.9	0	6.1	8.5	0.0094	0.76	0.7694	<0.005	0.045	0.7	447.2
11-10-00	2780	1540.4	8.1	15	6.3	6.96	0.0067	1.1	1.1067	0.0085	0.068	8.7	455.5
06-09-00	1381	761	7.7	13	8.9	19.5	0.5148	1.39	1.9048	0.0392	0.15	14	219.3
07-08-00	2330	1288.8	7.8	10	9.4	6.03	0.777	0.92	1.697	0.0067	0.047	9	382.6
03-07-00	3210	1781.7	7.8	11	8.3	44.8	1.18	1.1	2.28	0.041	0.171	7.4	417
06-06-00	2186	1208.4	7.6	11	10.1	3.77	2.62	0.75	3.37	<0.005	0.036	4.1	388.1
01-05-00	3180	1764.8	7.9	16	9	5.51	<0.005	0.85	0.855	<0.005	0.043	8.4	495.6
03-04-00	3690	2052	7.7	17	6	14.2	0.009	1.09	1.099	<0.005	0.072	11.1	599.1
15-03-00	3550	1973	7.4	18	–	10.8	0.023	0.65	0.673	0.007	0.116	11.7	521.9
22-12-99	2686	1487.8	7.8	19	3.8	6.69	0.031	1.71	1.741	0.01	0.122	9.2	480.3
15-11-99	2950	1635.7	7.6	–	–	12.4	0.121	0.85	0.971	0.005	0.065	7.6	429.9
20-10-99	2700	1495.6	7.8	17	5.9	63.2	0.539	2.02	2.559	0.015	0.126	9.8	387.6
04-10-99	2920	1618.9	7.8	17	7.7	9.04	0.265	1.06	1.325	<0.005	0.052	9.1	438.5
02-08-99	2870	1590.8	7.6	13	7.3	12.2	1.94	0.98	2.92	<0.005	0.072	5.9	540.6
07-07-99	2140	1182.8	7.7	13	–	9.53	3.78	0.85	4.63	0.012	0.054	6.4	342.1
13-05-99	–	–	–	15	5.6	–	–	–	–	–	–	–	–
19-11-98	3180	1764.8	7.9	19	4.9	3.67	0.006	0.72	0.726	<0.005	0.032	7.6	500.3
24-09-98	2620	1450.8	7.9	16	10.6	2.7	2.92	1.28	4.2	<0.005	0.07	7.9	445.4
13-08-98	2890	1602	7.7	13	6.1	8.79	1.89	1.1	2.99	<0.005	0.04	8.8	443.8
23-07-98	3430	1905.4	8.0	10	11.9	6	2.52	0.67	3.19	<0.005	0.028	5.5	494.4
25-06-98	2470	1400	7.8	10	8.3	4.9	2.13	0.45	2.58	0.019	0.048	5.7	438
06-05-98	2580	1400	7.7	13	6.8	5.8	0.43	0.7	1.13	<0.005	0.223	6.9	374
29-04-98	2960	1600	8.4	14	7.9	7.4	2.12	2.02	4.14	<0.005	0.097	9.9	440
17-12-97	4070	2300	7.9	22	7.4	9.4	0.006	1.22	1.226	0.012	0.084	10.5	601
20-11-97	3100	1719.9	7.8	19	7	6.1	0.007	0.95	0.957	<0.005	0.054	11.5	463.4
23-10-97	4010	2200	7.7	–	–	5.6	0.026	1.35	1.376	0.009	0.099	9.9	605
17-09-97	3490	1900	7.8	13	12.7	6.5	1.88	0.99	2.87	<0.005	0.051	7.2	497
11-08-97	2150	1200	7.5	11	9.2	24	4.73	2.92	7.65	0.082	0.203	6.7	320
24-07-97	3480	1900	7.9	11	11.4	2.5	6.45	0.98	7.43	0.015	0.059	7.2	493
16-06-97	3730	2100	8.0	12	8.2	3	3.32	1.61	4.93	<0.005	0.105	8.9	505
22-05-97	5900	3300	8.0	13	6.4	3.8	0.013	1.19	1.203	<0.005	0.062	12.3	810
12-02-97	4630	2600	7.8	24	5.4	4	0.01	1.28	1.29	0.015	0.094	9.8	742
12-12-96	3880	2200	7.9	23	6	2.5	<0.005	0.86	0.865	0.009	0.033	9.8	604
07-11-96	3560	2000	8.1	15	7.2	3.1	<0.005	0.9	0.905	<0.005	0.043	9.1	503

Table 10 Bremer River (near Hartley site GS426533) water quality - general parameters (cont.)**

Date	Conductivity* us/cm	TDS[a] mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
24-10-96	2890	1600	8.2	–	6.8	6.7	0.024	1.54	1.564	<0.005	0.093	9.4	453
12-09-96	2700	1500	8.2	13	8.4	5	1.14	1.04	2.18	0.033	0.085	9.6	456
22-08-96	1360	750	7.8	11	9.9	31	0.6	1.49	2.09	0.034	0.191	11.8	210
11-07-96	3160	1800	7.6	–	9	11	2.7	1.24	3.94	0.046	0.106	6.4	476
27-06-96	1150	630	7.4	10	8.4	440	2.07	4.6	6.67	0.103	1.11	7.1	–
23-05-96	3700	2100	8.0	–	8.2	4.1	<0.01	0.64	0.65	<0.005	0.025	9.1	–
07-12-95	3840	2100	7.4	–	4.2	2.3	0.01	1.17	1.18	<0.005	0.086	8.4	–
16-11-95	3380	1900	7.8	–	9.2	3.2	<0.01	1.45	1.46	0.178	0.297	8.4	–
19-10-95	3620	2000	8.4	19	5.7	4.6	0.03	0.88	0.91	<0.005	0.102	7.3	–
07-09-95	3470	1900	8.2	–	11.3	4	0.31	0.77	1.08	<0.005	0.026	6.5	–
31-08-95	3190	1800	8.2	13	10.6	5	2.06	0.79	2.85	<0.005	0.038	8.1	–
22-06-95	–	–	–	–	9.4	5	–	–	–	–	–	–	–
01-06-95	3380	1900	7.9	11	–	1.5	0.45	0.83	1.28	0.166	0.242	8.4	–
26-07-94	4020	–	8.2	12	–	2.8	–	–	–	–	–	–	–
09-11-93	3470	–	6.6	15	–	0.7	–	–	–	–	–	–	–
01-07-93	4030	–	7.8	12	–	5.3	–	–	–	–	–	–	–
18-03-93	5480	–	–	–	–	6	–	–	–	–	–	–	–
15-12-92	2430	–	7.5	18	–	2	–	–	–	–	–	–	–
04-09-92	768	–	6.6	12	–	59	–	–	–	–	–	–	–
05-06-92	3300	–	7.6	10	–	0.8	–	–	–	–	–	–	–
28-08-91	1087	–	6.8	12	–	240	–	–	–	–	–	–	–
11-12-90	4970	–	8.1	22	–	6.5	–	–	–	–	–	–	–
20-07-90	3030	–	8.0	13	–	3.2	–	–	–	–	–	–	–
13-12-89	2860	–	7.7	–	–	3.1	–	–	–	–	–	–	–
13-09-89	1059	–	7.3	15	–	34	–	–	–	–	–	–	–
02-06-89	3560	–	8.9	12	–	4.1	–	–	–	–	–	–	–
12-12-88	4190	–	8.1	23	–	0.6	–	–	–	–	–	–	–
08-09-88	2430	–	8.5	15	–	2.5	–	–	–	–	–	–	–
22-06-88	2190	–	7.6	12.5	–	7.7	–	–	–	–	–	–	–
24-05-88	850	–	7.1	13	–	>400	–	–	–	–	–	–	–
30-11-87	3750	–	8.3	28	–	2.1	–	–	–	–	–	–	–
04-09-87	2200	–	–	12.5	11.7	–	–	–	–	–	–	–	–
03-09-87	2160	–	8.3	12	–	1.3	–	–	–	–	–	–	–
03-07-87	2340	–	7.5	11	–	3.3	–	–	–	–	–	–	–
24-06-87	808	444.2	6.8	–	–	–	1.34	2.66	4	0.032	0.574	8.9	124.9
16-12-86	1795	–	8.2	18	–	0.8	–	–	–	–	–	–	–
22-09-86	1695	–	7.8	15.5	–	4.9	–	–	–	–	–	–	–
04-07-86	3000	1663.7	7.6	–	–	–	3.26	1.71	4.97	0.144	0.335	–	–
13-06-86	5400	–	8.0	13.5	–	2.6	–	–	–	–	–	–	–
17-12-85	5560	–	8.1	19.5	8.2	–	–	–	–	–	–	–	–
11-09-85	1550	–	7.1	12.4	9.6	29	–	–	–	–	–	–	–
20-08-85	2610	–	7.4	10.2	8.8	14	–	–	–	–	–	–	–
09-08-85	1810	–	7.3	10.6	10	46	–	–	–	–	–	–	–
05-06-85	4080	–	7.8	11.8	9.5	2.5	–	–	–	–	–	–	–
03-06-85	4320	2408.3	7.6	9	–	1.1	<0.01	0.73	0.74	<0.005	0.023	7.7	673.9

Table 10 Bremer River (near Hartley site GS426533) water quality - general parameters (cont.)**

Date	Conductivity* us/cm	TDS[a] mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
27-03-85	7205	–	8.1	23.8	7	7	–	–	–	–	–	–	–
15-10-84	3230	–	7.7	18	6.4	4	–	–	–	–	–	–	–
14-08-84	2500	1383.7	7.6	11	9.3	10	0.5	0.98	1.48	0.017	0.04	–	392.0
27-06-84	4170	–	7.8	11	10.2	–	–	–	–	–	–	–	–
13-01-84	3700	–	7.7	25	8.8	–	–	–	–	–	–	–	–
16-11-83	3502	–	8.5	17	9.2	–	–	–	–	–	–	–	–
07-09-83	1104	611	7.5	14	8.6	37	0.3	2.36	2.66	0.05	0.333	16.5	176.2
13-07-83	4305	2425.3	8.0	9	11.4	1	0.93	0.99	1.92	0.011	0.036	–	655.7
02-06-83	3583	–	8.1	11	12.2	–	–	–	–	–	–	–	–
07-10-82	5126	–	8.1	18	–	–	–	–	–	–	–	–	–
24-08-82	5210	2914.5	7.9	–	–	1.9	0.84	0.89	1.73	<0.005	0.021	–	777.5
08-06-82	4687	2510.4	7.9	5.5	11.2	1.3	<0.01	0.67	0.68	<0.005	0.025	–	722.1
16-06-81	4166	2450.2	8.1	10.5	14.2	0.64	2.4	2.37	4.77	<0.005	0.045	–	620.8
20-11-80	4000	–	8.7	24	14.2	–	–	–	–	–	–	–	–
22-10-80	2397	–	8.7	20.6	13.5	–	–	–	–	–	–	–	–
16-09-80	4186	–	8.0	16.8	9.2	–	–	–	–	–	–	–	–
30-07-80	3453	–	7.9	11	10.8	–	–	–	–	–	–	–	–
25-06-80	4736	–	8.1	12.8	–	–	–	–	–	–	–	–	–
19-12-79	4456	–	8.3	21	8.3	–	–	–	–	–	–	–	–
20-11-79	3673	–	8.2	24	–	–	–	–	–	–	–	–	–
04-10-79	–	–	7.6	15.5	–	–	–	–	–	–	–	–	–
23-08-79	3010	1669.4	8.1	–	–	3	4.1	0.4	4.5	0.011	0.053	–	459.1
19-07-79	5428	–	8.2	9.5	–	–	–	–	–	–	–	–	–
11-06-79	5291	–	7.7	11.5	–	–	–	–	–	–	–	–	–
14-12-78	6756	–	7.8	19	–	–	–	–	–	–	–	–	–
21-11-78	4888	–	–	19.5	–	–	–	–	–	–	–	–	–
24-10-78	4105	–	8.0	22	–	–	–	–	–	–	–	–	–
28-09-78	1890	–	7.8	16.5	–	–	–	–	–	–	–	–	–
22-08-78	1856	–	6.7	12.5	–	–	–	–	–	–	–	–	–
17-07-78	3194	–	7.5	10.7	–	–	–	–	–	–	–	–	–
03-07-78	3513	–	–	11	–	–	–	–	–	–	–	–	–
25-05-78	5597	–	7.6	15	–	–	–	–	–	–	–	–	–
14-12-77	6415	–	–	28.5	–	–	–	–	–	–	–	–	–
12-10-77	4687	–	–	21	–	–	–	–	–	–	–	–	–
04-08-77	3684	–	–	11.8	–	–	–	–	–	–	–	–	–
17-05-77	7582	–	–	15.2	–	–	–	–	–	–	–	–	–
06-12-76	5294	–	–	24	–	–	–	–	–	–	–	–	–
25-10-76	2965	–	–	17.5	–	–	–	–	–	–	–	–	–
15-09-76	5060	–	–	15.8	–	–	–	–	–	–	–	–	–
26-08-76	3974	–	–	13.5	–	–	–	–	–	–	–	–	–
28-07-76	5223	–	–	12.8	–	–	–	–	–	–	–	–	–
15-07-76	4605	–	–	11	–	–	–	–	–	–	–	–	–
17-06-76	2250	–	–	13	–	–	–	–	–	–	–	–	–
25-10-75	825	–	–	14	–	–	–	–	–	–	–	–	–
24-10-75	635	348.9	6.3	–	–	93	–	–	–	–	0.228	–	96.8

Table 10 Bremer River (near Hartley site GS426533) water quality - general parameters (cont.)**

Date	Conductivity* us/cm	TDS[a] mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol as P) mg/L	Total P mg P/L	Organic C mg/L	Hardness mg $CaCO_3$/L
06-10-75	3207	–	–	17.8	–	–	–	–	–	–	–	–	–
05-09-75	2641	–	–	12.5	–	–	–	–	–	–	–	–	–
07-08-75	2375	–	–	12.8	–	–	–	–	–	–	–	–	–
10-07-75	4922	–	–	11.8	–	–	–	–	–	–	–	–	–
11-06-75	3717	–	–	11	–	–	–	–	–	–	–	–	–
04-11-74	2141	–	–	17	–	–	–	–	–	–	–	–	–
08-10-74	1440	–	–	16.4	–	–	–	–	–	–	–	–	–
11-09-74	2400	–	–	15.2	–	–	–	–	–	–	–	–	–
15-08-74	1833	–	–	13	–	–	–	–	–	–	–	–	–
01-08-74	985	–	–	11.5	–	–	–	–	–	–	–	–	–
25-07-74	1576	–	–	12	–	–	–	–	–	–	–	–	–
02-07-74	2248	–	–	10.8	–	–	–	–	–	–	–	–	–
04-06-74	2692	–	–	12.6	–	–	–	–	–	–	–	–	–
29-03-74	2040	–	–	–	–	–	–	–	–	–	–	–	–
01-02-74	3655	–	–	22	–	–	–	–	–	–	–	–	–
02-01-74	2500	–	–	21	–	–	–	–	–	–	–	–	–
31-10-73	2075	–	–	23.5	–	–	–	–	–	–	–	–	–
24-10-73	637	–	–	13.5	–	–	–	–	–	–	–	–	–
17-09-73	1267	–	–	–	–	–	–	–	–	–	–	–	–
01-08-73	2276	–	–	–	–	–	–	–	–	–	–	–	–
04-07-73	2428	–	–	–	–	–	–	–	–	–	–	–	–
24-05-73	3827	–	–	–	–	–	–	–	–	–	–	–	–

**Source: EPA, 2006b.
Note that "–" indicates that an analytical result could not be obtained on that occasion.
* Measurement at 25ºC.
[a] Measured by electrical conductivity.

Table 11 Bremer River (near Hartley GS426533) water quality - total metals**

Date	Cd mg/L	Cu mg/L	Hg mg/L	Ni mg/L	Pb mg/L	Zn mg/L
Highest LOD	<0.001	<0.03	<0.0005	<0.01	<0.005	<0.01
Ω	0.00058[a]	0.0039[a]	0.0006	0.031[a]	0.0157[a]	0.022[a]
20/10/06	<0.0005	<0.001	<0.0003	0.0021	<0.0005	0.006
29/09/06	<0.0005	0.0019	<0.0003	0.0048	<0.0005	0.015
14/08/06	<0.0005	0.0017	<0.0005	0.003	<0.0005	0.022
17/07/06	0.0014	0.0068	<0.0005	0.0066	0.005	0.114
30/06/06	<0.0005	<0.001	<0.0005	0.0042	<0.0005	0.013
19/05/06	<0.0005	0.0017	<0.0003	0.0025	0.0006	0.016
28/04/06	<0.0005	0.0021	<0.0003	0.0083	<0.0005	0.032
21/03/06	<0.0005	<0.001	<0.0003	0.0021	<0.0005	0.006
20/02/06	<0.0005	<0.001	<0.0003	0.0021	<0.0005	<0.003
04/01/06	<0.0005	0.001	<0.0003	<0.0005	<0.0005	0.012
07/12/05	<0.0005	0.002	<0.0003	0.0039	<0.0005	0.017
09/11/05	<0.0005	0.0066	<0.0003	0.0076	0.0015	0.01
05/10/05	<0.0005	0.0035	<0.0003	0.0061	<0.0005	0.0231
09/09/05	<0.0005	0.0049	<0.0003	0.0074	0.0011	0.0434
03/08/05	<0.0005	0.0027	<0.0003	0.0038	<0.0005	0.03
06/07/05	0.0017	0.0039	<0.0003	0.0098	<0.0005	0.1888
08/06/05	<0.0005	0.0015	<0.0003	<0.0005	<0.0005	0.0066
04/05/05	<0.0005	0.0041	<0.0003	0.0011	<0.0005	0.0135
15/04/05	<0.0005	0.0069	<0.0003	0.0032	0.0014	0.0253
16/03/05	<0.0005	0.0018	<0.0003	0.0138	<0.0005	0.0097
09/02/05	0.0011	0.0016	<0.0003	0.0084	<0.0005	0.0084
05/01/05	–	0.0034	–	–	0.0012	0.0201
07/12/04	–	0.003	–	–	<0.0005	0.0133
03/11/04	–	0.005	–	–	0.001	0.0165
15/10/04	–	0.0052	–	–	0.0009	0.0292
08/09/04	–	0.0032	–	–	<0.0005	0.0425
25/08/04	–	0.0048	–	–	0.0007	0.1027
23/06/04	–	0.0085	–	–	0.0034	0.047
05/05/04	–	0.0127	–	–	0.0011	0.0183
03/03/04	–	0.0047	–	–	0.0007	0.0087
04/02/04	–	0.0049	–	–	0.0031	0.0249
27/11/03	–	0.0024	–	–	<0.0005	0.0106
22/10/03	–	0.0022	–	–	0.0006	0.0266
10/09/03	–	0.0035	–	–	0.0011	0.1061
13/08/03	–	0.0021	–	–	0.001	0.145
23/07/03	–	0.004	–	–	<0.0005	0.0064
12/06/03	–	0.0047	–	–	0.0027	0.0509
14/05/03	–	<0.001	–	–	0.0005	0.0107
08/01/03	–	0.0046	–	–	0.001	0.0241
04/12/02	–	0.013	–	–	0.0016	0.0422
16/10/02	–	0.0042	–	–	<0.0005	0.0296
11/09/02	–	0.0012	–	–	0.001	0.0199
14/08/02	–	0.0051	–	–	<0.0005	0.0625
10/07/02	–	0.0045	–	–	0.0025	0.121
12/06/02	–	0.0017	–	–	<0.0005	0.0335
16/05/02	–	0.0031	–	–	<0.0005	0.0165
13/02/02	–	0.0051	–	–	0.0011	0.0104
24/10/01	–	0.004	–	–	0.001	0.0554
19/09/01	–	0.0142	–	–	0.0016	0.167
15/08/01	–	0.0065	–	–	0.0007	0.286
18/07/01	–	0.0054	–	–	0.0019	0.496
07/06/01	–	0.0182	–	–	0.0017	0.113
30/05/01	–	0.0119	–	–	0.002	0.296
17/01/01	–	<0.03	–	–	0.0011	0.1522
06/12/00	–	<0.03	–	–	0.001	0.1462
06/11/00	–	<0.03	–	–	0.0009	0.0963
11/10/00	–	<0.03	–	–	<0.001	0.077
06/09/00	–	<0.03	–	–	0.002	0.138
07/08/00	–	<0.03	–	–	0.001	0.1983

Table 11 Bremer River (near Hartley GS426533) water quality - total metals (cont.)**

Date	Cd mg/L	Cu mg/L	Hg mg/L	Ni mg/L	Pb mg/L	Zn mg/L
03/07/00	–	<0.03	–	–	<0.001	0.1239
06/06/00	–	<0.03	–	–	<0.001	0.1195
01/05/00	–	<0.03	–	–	<0.001	0.0277
03/04/00	–	<0.03	–	–	<0.001	<0.01
15/03/00	–	<0.03	–	–	<0.001	0.0968
22/12/99	–	<0.03	–	–	<0.001	0.0424
15/11/99	–	<0.03	–	–	<0.001	0.0509
20/10/99	–	<0.03	–	–	<0.001	<0.01
04/10/99	–	<0.03	–	–	<0.001	0.0105
02/08/99	–	<0.03	–	–	<0.001	<0.01
07/07/99	–	<0.03	–	–	<0.001	0.063
13/05/99	–	<0.03	–	–	<0.001	0.1056
19/11/98	–	<0.005	–	–	<0.001	0.1
24/09/98	–	<0.005	–	–	<0.001	0.157
13/08/98	–	0.005	–	–	<0.001	0.246
23/07/98	–	<0.005	–	–	<0.001	0.247
25/06/98	–	0.006	–	–	<0.001	0.131
06/05/98	–	<0.005	–	–	<0.001	0.104
29/04/98	–	0.01	–	–	0.003	0.122
17/12/97	–	0.006	–	–	<0.001	0.081
20/11/97	–	<0.005	–	–	<0.001	0.086
23/10/97	–	0.016	–	–	<0.001	0.125
17/09/97	–	<0.005	–	–	<0.001	0.163
11/08/97	–	0.009	–	–	0.002	0.164
24/07/97	–	<0.005	–	–	<0.001	0.141
16/06/97	–	0.007	–	–	<0.001	0.112
22/05/97	–	<0.005	–	–	<0.001	0.122
12/02/97	–	0.005	–	–	<0.001	0.057
12/12/96	–	<0.005	–	–	<0.001	0.043
07/11/96	–	<0.005	–	–	<0.001	0.041
24/10/96	–	<0.005	–	–	<0.001	0.037
12/09/96	–	0.063	–	–	<0.001	0.154
22/08/96	–	0.01	–	–	0.004	0.122
11/07/96	–	<0.005	–	–	<0.001	0.299
27/06/96	–	0.018	–	–	0.015	0.23
23/05/96	–	<0.005	–	–	0.001	0.071
07/12/95	–	0.012	–	–	<0.001	0.064
16/11/95	–	0.02	–	–	<0.001	0.076
19/10/95	–	0.01	–	–	<0.001	0.077
07/09/95	–	0.011	–	–	<0.001	0.179
31/08/95	–	0.017	–	–	<0.001	0.108
01/06/95	–	0.01	–	–	<0.001	0.074
03/06/85	0.005	0.006	<0.0001	<0.01	0.026	0.075
07/09/83	<0.001	0.009	–	0.014	<0.005	0.12
14/10/81	<0.001	0.024	–	0.01	<0.005	0.04
19/08/81	<0.001	0.015	–	0.04	<0.005	0.33
23/08/79	<0.001	0.009	–	<0.01	<0.005	0.12

**Source: EPA, 2006b.
[Ω] ANZECC/ARMCANZ (2000)
[a]Values calculated using a hardness of 100 mg $CaCO_3$/L.
Note that "–" indicates that an analytical result could not be obtained on that occasion.

Table 12 Lake Alexandrina (Poltalloch plains) water quality – general parameters**

Date	Conductivity[a] µs/cm	DO* mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol) mg P/L	Total P mg P/L	chlorophyll a ug/L	Enterococci per 100mL
17-01-07	1530	840.0	8.6	22	6.8	50	0.007	1.33	1.337	<0.005	0.125	50.0	280
20-12-06	1430	790.0	8	21	9	16	<0.005	1.22	1.225	<0.005	0.104	14.2	10
15-11-06	1300	720.0	8.5	16	9.4	99	<0.005	1.74	1.745	<0.005	0.19	63.1	34
18-10-06	1120	620.0	8.2	16	8.8	55	0.006	1.28	1.286	<0.005	0.146	23.0	64
27-09-06	1160	640.0	8.4	13	11.6	54	<0.005	1.16	1.165	<0.005	0.124	35.3	46
16-08-06	907	500.0	8.3	11	10.1	120	<0.005	2.4	2.405	<0.005	0.348	46.6	44
20-07-06	1230	677.0	8.3	9	10.8	15	<0.005	0.73	0.735	<0.005	0.05	19.2	12
23-06-06	1070	589.0	7.9	11	–	53	0.007	1.41	1.417	<0.005	0.123	23.8	60
17-05-06	1140	628.0	8.3	14	–	13.7	<0.005	0.75	0.755	0.005	0.04	16.3	6
27-04-06	1130	622.0	8.4	13	–	33.3	<0.005	1.69	1.695	0.006	0.092	22.9	42
22-03-06	1120	617.0	8.4	19	–	18.1	0.008	1.35	1.358	<0.005	0.055	16.3	32
16-02-06	1110	611.0	8.3	20	–	19.7	<0.005	1.33	1.335	0.008	0.063	20.4	60
03-01-06	1190	655.0	8.4	20	–	35.5	<0.005	0.92	0.925	<0.005	0.095	30.1	3
07-12-05	1090	600.0	8	22	–	105	<0.005	1.83	1.835	<0.005	0.242	51.9	800
09-11-05	1260	694.0	8.3	–	–	55.1	<0.005	1.85	1.855	<0.005	0.166	39.1	46
05-10-05	1376	758.0	8.68	17	8.4	41.1	<0.005	1.28	1.285	<0.005	0.126	41.9	58
14-09-05	1243	685.0	8.72	16	10.3	54.6	0.006	4.99	4.996	<0.005	0.619	52.9	440
10-08-05	1664	918.0	8.38	11	11.3	79.2	<0.005	1.8	1.805	<0.005	0.16	48.0	720
13-07-05	1139	627.0	8.41	10	11.8	43.7	<0.005	1.05	1.055	<0.005	0.132	37.0	39
22-06-05	1134	624.0	8.26	13	11.1	102	<0.005	1.81	1.815	<0.005	0.208	56.0	200
11-05-05	1487	820.0	8.6	16	11.1	16.8	<0.005	0.87	0.875	<0.005	0.059	19.7	4
13-04-05	1109	610.0	8.78	21	11.7	18.1	<0.005	0.63	0.635	<0.005	0.055	25.1	0
23-03-05	1322	728.0	8.55	19	–	19	<0.005	1.07	1.075	<0.005	0.08	30.2	1
16-02-05	1376	758.0	8.8	19	9.5	23.1	<0.005	1.07	1.075	<0.005	0.083	44.9	3
12-01-05	1297	714.0	–	–	–	48.9	<0.005	1.17	1.175	<0.005	–	41.2	–
15-12-04	1309	720.0	–	–	–	24.6	<0.005	0.96	0.965	<0.005	–	18.0	–
10-11-04	1161	640.0	–	–	–	29.2	<0.005	1.28	1.285	0.014	–	38.0	–
20-10-04	1150	633.1	–	–	–	42.7	<0.005	1.06	1.065	0.005	–	25.0	–
22-09-04	1288	709.5	–	–	–	16.2	<0.005	1.09	1.095	<0.005	–	34.0	–
11-08-04	1380	760.4	–	–	–	48	<0.005	1.69	1.695	<0.005	–	32.0	–
21-07-04	1365	752.1	–	–	–	40.3	<0.005	1.33	1.335	<0.005	–	29.8	–
16-06-04	1248	687.3	–	–	–	51.9	<0.005	1.37	1.375	<0.005	–	45.0	–
12-05-04	1190	655.2	–	–	–	26	<0.005	1.19	1.195	<0.005	–	22.8	–
14-04-04	1249	687.9	–	–	–	36.8	<0.005	1.37	1.375	<0.005	–	49.8	–
10-03-04	1270	699.5	–	–	–	19.6	<0.005	0.91	0.915	<0.005	–	32.0	–
14-01-04	1235	680.1	–	–	–	26.4	<0.005	1.21	1.215	<0.005	–	24.0	–
12-11-03	1160	638.6	–	–	–	29.6	<0.005	1.08	1.085	0.015	–	22.8	–
15-10-03	1212	667.4	–	–	–	47.6	0.023	1.47	1.493	<0.005	–	34.2	–
17-09-03	1340	738.3	–	–	–	19	<0.005	2.76	2.765	<0.005	–	53.3	–
13-08-03	1174	646.4	–	–	–	34.6	<0.005	1.01	1.015	<0.005	–	21.4	–

Table 12 Lake Alexandrina (Poltalloch plains) water quality – general parameters (cont.)****

Date	Conductivity[a]	DO*	pH	Temp	DO	Turbidity	Oxidised N	TKN	Total N	P (sol)	Total P	chlorophyll a	Enterococci
	µs/cm	mg/L	pH units	ºC	mg/L	NTU	mg N/L	mg N/L	mg/L	mg P/L	mg P/L	ug/L	per 100mL
16-07-03	1196	658.6	–	–	–	32.6	<0.005	1.13	1.135	<0.005	–	27.6	–
11-06-03	1280	705.0	–	–	–	62.8	<0.005	1.42	1.425	<0.005	–	42.6	–
14-05-03	1028	565.7	–	–	–	23.5	<0.005	1.13	1.135	<0.005	–	29.2	–
16-04-03	1371	755.4	–	–	–	27.1	0.016	1.46	1.476	<0.005	–	32.7	–
12-03-03	1331	733.3	–	–	–	15.5	<0.005	1.15	1.155	<0.005	–	25.7	–
12-02-03	1269	699.0	–	–	–	23.7	<0.005	1.046	1.051	<0.005	–	22.9	–
15-01-03	1152	634.2	–	–	–	34.4	<0.005	1.26	1.265	<0.005	–	37.0	–
11-12-02	1213	668.0	–	–	–	55.8	0.015	1.71	1.725	<0.005	–	39.0	–
13-11-02	1109	610.4	–	–	–	84.4	<0.005	2.23	2.235	<0.005	–	60.0	–
16-10-02	1017	559.6	–	–	–	61.8	<0.005	1.42	1.425	<0.005	–	63.6	–
17-09-02	1062	584.5	–	–	–	114	<0.005	2.85	2.855	0.0058	–	121.7	–
14-08-02	918	504.9	–	–	–	33.7	0.0168	1.06	1.0768	<0.005	–	44.7	–
10-07-02	1003	551.9	–	–	–	61.4	<0.005	1.46	1.465	<0.005	–	52.0	–
13-06-02	891	490.0	–	–	–	103	<0.005	1.96	1.965	<0.005	–	65.5	–
15-05-02	865	475.7	–	–	–	90.9	<0.005	2.66	2.665	<0.005	–	70.5	–
10-04-02	865	475.7	–	–	–	17.2	<0.005	0.79	0.795	<0.005	–	23.1	–
12-03-02	884	486.1	–	–	–	27.1	<0.005	1.02	1.025	<0.005	–	29.4	–
13-02-02	810	445.3	–	–	–	24.3	<0.005	1.02	1.025	<0.005	–	24.0	–
16-01-02	841	462.4	–	–	–	38.3	<0.005	1.14	1.145	<0.005	–	27.1	–
12-12-01	667	366.5	–	–	–	30.35	<0.005	1.35	1.355	0.0721	–	15.2	–
14-11-01	678	372.6	–	–	–	19.5	<0.005	0.7	0.705	<0.005	–	9.3	–
10-10-01	661	363.2	–	–	–	137	<0.005	2.26	2.265	<0.005	–	81.1	–
14-09-01	856	470.7	–	–	–	78.3	<0.005	1.37	1.375	<0.005	–	33.0	–
15-08-01	540	296.6	–	–	–	82.2	<0.005	1.19	1.195	<0.005	–	38.9	–
11-07-01	556	305.4	–	–	–	67.5	<0.005	1.24	1.245	0.011	–	37.7	–
13-06-01	537	294.9	–	–	–	89.3	0.0073	1.34	1.3473	0.0087	–	37.3	–
22-05-01	601	330.1	–	–	–	46	<0.005	0.85	0.855	<0.005	–	14.4	–
11-04-01	603	331.2	–	19	–	88.3	<0.005	1.41	1.415	0.016	–	28.6	–
14-03-01	547	300.4	–	–	–	38.1	<0.005	0.89	0.895	<0.005	–	13.0	–
14-02-01	510	280.1	–	–	–	45.8	<0.005	1.15	1.155	<0.005	–	21.8	–
10-01-01	384	210.8	–	–	–	73.6	<0.005	1.12	1.125	0.0063	–	17.6	–
13-12-00	424	232.7	–	–	–	75.9	<0.005	1.05	1.055	<0.005	–	24.2	–
15-11-00	429	235.5	–	–	–	72.2	<0.005	0.84	0.845	<0.005	–	17.7	–
12-10-00	715	392.9	–	–	–	70.1	<0.005	1.02	1.025	<0.005	–	28.8	–
13-09-00	807	443.7	–	–	–	57.3	<0.005	1.23	1.235	<0.005	–	35.3	–
16-08-00	848	466.3	–	–	–	47.9	<0.005	1.16	1.165	<0.005	–	29.3	–
12-07-00	789	433.7	–	–	–	47.7	0.006	1.03	1.036	<0.005	–	24.6	–
14-06-00	888	488.4	–	–	–	47.4	<0.005	1.64	1.645	<0.005	–	35.9	–
10-05-00	857	471.3	–	–	–	27.6	<0.005	0.96	0.965	<0.005	–	23.6	–
12-04-00	799	439.3	–	–	–	40.3	<0.005	1.03	1.035	<0.005	–	36.1	–

Table 12 Lake Alexandrina (Poltalloch plains) water quality – general parameters (cont.)**

Date	Conductivity[a] µs/cm	DO* mg/L	pH pH units	Temp ºC	DO mg/L	Turbidity NTU	Oxidised N mg N/L	TKN mg N/L	Total N mg/L	P (sol) mg P/L	Total P mg P/L	chlorophyll a ug/L	Enterococci per 100mL
15-03-00	779	428.2	–	–	–	16.8	<0.005	0.79	0.795	<0.005	–	24.8	–
16-02-00	858	471.8	–	–	–	19	0.014	0.8	0.814	<0.005	–	23.4	–
12-01-00	781	429.3	–	–	–	120	0.005	2.48	2.485	<0.005	–	70.1	–
15-12-99	722	396.8	–	–	–	94.5	<0.005	1.45	1.455	<0.005	–	47.0	–
10-11-99	683	375.3	–	–	–	37.4	<0.005	0.88	0.885	0.011	–	14.0	–
14-10-99	609	334.5	–	–	–	40	<0.005	0.75	0.755	<0.005	–	15.4	–
16-09-99	698	383.6	–	–	–	185	0.007	2.27	2.277	0.049	–	76.0	–
12-08-99	626	343.9	–	–	–	105	<0.005	1.08	1.085	<0.005	–	–	–
15-07-99	527	289.4	–	–	–	48	<0.005	0.74	0.745	0.007	–	–	–
01-07-99	653	358.8	–	–	–	94	<0.005	1.38	1.385	0.005	–	37.1	–

**Source: EPA, 2006b.

[a] At 25 ºC.

* By EC.

Appendix 2C

Surface Water (Management)

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Memo

To:	Marty Adams	**Company:**	Hillgrove Resources
From:	Glenn Passfield / Matt Driver	**Job No:**	A48/B2
Date:	08/08/07	**Doc No:**	026

Subject: **Kanmantoo Preliminary Stormwater Management Conceptual Design**

Following our letter dated 26 June 2007, and the teleconference held on 24 July 2007, Aquaterra is pleased to present the conceptual stormwater management plan for Kanmantoo Copper Gold Project MLA.

1 SITE VISIT

Glenn Passfield and Matthew Driver from the Aquaterra Adelaide office visited the Kanmantoo site on 30 July 2007. The weather was fine and dry during the visit. The Aquaterra personnel were accompanied by Marty Adams, project manager from Hillgrove Resources.

The purpose of the visit was to inspect the existing and proposed site of the Kanmantoo Copper-Gold project to confirm on-ground surface water management principles.

2 POTENTIAL IMPACTS OF THE PROPOSED MINING WORKS

Potential impacts relating to surface water runoff are outlined below, with management measures outlined in Section 7:

- Soil erosion due to increases in flow velocities around the infrastructure footprint
- Changes to flow volumes and the interruption of the ephemeral streams by the mining infrastructure footprint
- Potential contamination from sediments and chemicals

2.1 Soil Erosion

Surface water runoff in the development area is predominately by gully discharge in defined drainage paths.

Additional surface runoff and the diversion of runoff from its normal flow path may result in a localised increase in flow velocities as the flood waters are concentrated in constructed diversion channels, or along side flood bunds or raised pads.

Diversion channels will be designed to compensate for the increase in flow velocities due to elevated nature of the site and the increase in flow concentrations. Hence the potential impact from soil erosion from the development can be managed with appropriately designed flow diversions.

2.2 Changes in Flow Volumes

Flow diversions often result in a decrease of natural flow patterns downstream of a proposed development due to the re-diversion of water into alternative waterways or storages. For the proposed Kanmantoo development, all up-gradient runoff will be diverted around the infrastructure and back into the existing drainage path. This will minimise the potential to disturb downstream aquatic ecosystems due to decreased natural flow regimes.

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2.3 Contamination

Both the Tailings Storage Facility (TSF) outer banks and the Waste Rock Storage (WRS) have the potential to discharge sediment laden water into the natural environment. In addition, the Run of Mine (ROM) pad and associated stockpiles, the process plant, laydown areas, and other mining related infrastructure, all have the potential to contaminate stormwater with chemicals, including hydrocarbons.

Section 7 proposes water management measures to mitigate the potential impacts on downstream runoff water quality.

3 STORMWATER DEFINITIONS

Definitions of runoff sources for the Kanmantoo Copper-Gold Project are outlined below:

- *Clean Runoff*: Runoff generated from undisturbed areas, typical of baseline water quality.
- *Sediment Runoff*: runoff generated from disturbed areas but not containing any process or waste rock runoff, i.e. haul roads, vehicle tracks, borrow pits, with a higher sediment load than baseline water quality.
- *Waste Rock Runoff*: runoff generated from the WRS and outer embankment of the TSF, with a higher than baseline quality sediment loads and the potential for acid and metalliferous drainage (AMD) to develop from the interaction of reactive waste rock (PAF) with air and/or water.
- *Process Runoff*: runoff and water generated from the processing plant areas, ROM pad, associated stockpiles, mine lay-down areas, and workshop areas with high sediment loads and elevated chemical concentrations when compared to baseline water quality samples.

TSF decant and underdrainage water, any water from the existing open-pit are dealt with separately to this report.

4 STORMWATER MANAGEMENT PRINCIPLES

The plan is based on the following principles:

- Capture of ‘clean runoff’ and diversion water around disturbed mining areas using channels or bunds.
- Capture of ‘sediment runoff’ from haul roads, vehicle tracks, borrow pits, rehabilitated areas etc. for sediment load reduction before discharging off-site or re-use.
- Capture of ‘waste rock runoff’ from the outer batters of the TSF and the unrehabilitated WRS, to enable sediment load reduction before diversion to the decant water storage or process water storage for re-use in the mine processing plant, or to constructed wetlands for treatment and disposal.
- Capture and treatment of ‘process runoff’ from the processing plant areas, ROM pad, associated stockpiles, mine lay-down areas, and workshop areas for treatment and management near the source.

5 FEATURES OF ON-SITE SURFACE WATER MANAGEMENT

The main features of the on-site surface water management plan as indicated in Figure 2 and explained in more detail in Section 7 are:

- The use of bunding and diversion channels around the toe of the WRS and TSF to prevent the ‘clean runoff’ coming into contact with either the ‘waste rock runoff’ and/or the ‘process runoff’.
- Diversion of ‘clean runoff’ entering from the creek line to the west of the site around the TSF.
- The use of sediment basins, wetlands and silt traps to maximise the capture and treatment of ‘sediment runoff’ and ‘waste rock runoff’ prior to reuse in processing plant or discharge.
- Management and treatment of runoff from disturbed areas at the source through the use of contour banks, bunding and progressive rehabilitation.
- Management of ‘process runoff’ through the use of bunding and diversions.

6 DESIGN STORMS

The daily rainfall record and intensity frequency-duration (IFD) data for Kanmantoo weather station was used to calculate the runoff volumes for the Kanmantoo Copper-Gold Project. Rainfall for events of 24 hours and 72 hours duration, for 5 to 100 year Average Recurrence Interval (ARI) is presented in Table 1.

Table 1:
Kanmantoo Station Rainfall for Selected Storms (mm), (BOM, 1987)

Duration	Average Recurrence Interval (ARI)			
	5 Year	20 Year	50 Year	100 Year
24 hours	57.8	77.5	94.1	107.5
72 hours	72.0	95.0	113.8	129.6

7 CONCEPTUAL STORMWATER MANAGEMENT STRATEGY

The conceptual stormwater management strategies outlined below are designed to address the above potential impacts. Figure 1 presents the breakdown of each infrastructure area into average recurrence interval (ARI) runoff volumes, assuming no initial loss and no continuing loss for the purposes of conceptual design (conservative).

7.1 Proposed Runoff Storages

7.1.1 Decant Water Storage

A storage will be constructed on the tributary of the Dawesley/Nairne Creek up-gradient of the railway embankment culvert. The storage will be sized to TSF decant water, process water and the 1 in 100 year ARI design storm runoff volume collected in the southern drainage channels from the slopes of the WRS and TSF. The runoff volume is estimated to be 23.5ML The storage will be lined for the purposes of containing potentially contaminated decant water from the TSF (refer elsewhere for further details of the proposed lining system). There is also capacity for storage of water from the pre-existing open pit.

7.1.2 Process Area Sediment Basin

A sediment basin will be installed on the drainage line adjacent to the processing plant. This basin will have the capacity to contain runoff from the ROM pad, process plant area and the south-eastern batter of the WRS. It is estimated that basin will need to contain approximately 19.5 ML of runoff during a 1 in 100 year ARI 72 hour design storm. This basin would need to be emptied within 14 days of a storm event with the water used in the process plant.

7.1.3 Northern Sediment Basin/Wetland

A series of sedimentation basins will be installed near the north eastern toe of the TSF to treat runoff from the northern banks of the WRS and outer TSF banks. The sedimentation basins will be designed to remove sediment down to a particles size of 0.01 mm for a 1 in 5 year, 24 hour design storm. This basin will be designed to operate wet, i.e. it does not need to be emptied between storm events. The sedimentation basins will also have a higher level capacity to cope with the excess runoff from a 1 in 100 year 72 hour design storm which is estimated to be 32ML.

Overflow from this basin will then be discharged into the existing evaporation pond for disposal.

7.2 Infrastructure Stormwater Management

7.2.1 Tailings Storage Facility Outer Batters

The proposed TSF will produce increased runoff from its outer batters. This runoff has the potential to contain elevated sediment loads from the outer TSF batters.

To calculate total runoff potential from the TSF during a 1 in 100 year ARI 72 hr storm event, the TSF was divided into two areas based on potential runoff paths as per Figure 1. Runoff from Area G will head towards the Northern Sediment Basin/Wetland, whilst runoff from Area F will drain towards the Decant Water Storage where it will be collected.

Estimated runoff volumes for these two areas are shown in Table 2.

Table 2:
Runoff Volumes for the outer batters of the TSF

Area	Area Identifier	Area Runoff Coefficient	Area (ha)	Total Discharge (ML) 1: 100yr ARI 72hr Design Storm
Tailings Disposal Facility Batters	F	1	12	16
	G	1	10	13

The proposed TSF footprint will intercept a tributary of the Dawesley/Nairne Creek. A diversion channel will be constructed to enable 'clean runoff' to flow around the toe of the TSF, bypassing the Decant Water Storage to reunite with the Dawesley/Nairne Creek tributary immediately up-gradient of the railway culvert on the southern boundary of the site.

A diversion bund will be located at the base of the TSF outer toe to separate 'sediment runoff' from the 'clean runoff' diversion channel. The channel behind the bund will be sized so that runoff will be channelled at non-scouring velocities to the Decant Water Storage or the Northern Sediment Basin/Wetland. To reduce the sediment load in this runoff, contour banks will be located on the batter of the TSF.

7.2.2 Waste Rock Storage

The former WRS from past mining activity at Kanmantoo is located on top of the ridgeline central to the site, and little in the way of runoff is intercepted by the storage. Surface runoff from the trafficked waste rock storage surface currently spills to the side of the waste rock storage.

The current mining proposal includes increasing the height and footprint of the existing waste rock storage, extending to the south-west towards existing drainage lines.

Prior to and during rehabilitation, runoff from the WRS will contain sediment. Runoff will be collected in a series of contour banks around the batters of the WRS to reduce sediment load. Runoff volume calculations from the exposed surface of the WRS have been estimated as presented in Figure 1.

Table 3
Potential 1 in 100 year ARI runoff from the Waste Rock Storage

Area	Area Identifier	Area Runoff Coefficient	Area (ha)	Total Discharge (ML) 1: 100yr ARI 72hr Design Storm
Waste Rock Storage	A	0.45	11	6
	B	0.45	17	10
	C	0.45	13	8
	D	0.45	14	8
	E	0.45	5	3

As for the TSF batters, a diversion bund will be located at the base of the WRS outer toe to separate 'sediment runoff' from the 'clean runoff' diversion channel. The channel behind the bund will be sized so that runoff will be channelled at non-scouring velocities to the Decant Water Storage, Process Area Sediment Basin or the Northern Sediment Basin/Wetland. Around the process areas, runoff will be directed towards these channels so that both 'process runoff' and 'waste rock' runoff are separated from any 'clean' water.

Progressive rehabilitation of the exposed waste rock storage slopes will reduce the surface area exposed to rainfall and production of acid drainage (refer elsewhere for further information on management of PAF material). Rehabilitation will reduce the total volume of 'waste rock' runoff but may increase the volume of 'sediment runoff' due to the increased slope lengths caused by the flattening of these slopes in the rehabilitation process.

7.2.3 ROM Pad

Similar to the WRS, the ROM pad will produce sediment laden surface water runoff. This runoff may also contain trace elements from the ore stock piles. Bunding and small scale sediment traps will be used to treat the stormwater at the ROM pad. Overflow will be directed into the Process Area Sediment Basin located on the drainage line southeast of the main processing plant as shown conceptually on Figure 2. The eastern end of the ROM pad will be raised to minimise surface water runoff from upgradient entering the ROM pad.

Calculated runoff from the ROM pad from a 1 in 100 year ARI design storm is approximately 4 ML.

7.2.4 Processing Plant and Mining Services

The processing plant and mining services area includes all areas which have the potential to create contaminated runoff. The majority of these areas are situated upstream of the identifiable drainage lines, minimising the requirement to divert up-gradient surface flow. Surface runoff generated from these areas will be directed to the Decant Water Storage for re-use in the process plant or the Process Area Sediment Basin.

To protect the downstream environment from potential contamination, bunding and chemical containment/treatment will be included (where required) as close as possible to the source of the potentially contaminating activity. Diversion drains will also be incorporated around the processing plant and mining services to minimise the entry of 'clean water' into these areas. Raising haul roads and service roads around the processing plant will enable water streams to be kept separate, reducing the risk of cross contamination and benefit access around the site during wet periods.

The runoff volume estimated for the processing plant is 4 ML from a 1 in 100 year ARI design storm whilst runoff from the mining services area is estimated to be 3 ML. It is proposed that at least 1.5 ML of this runoff will be directed towards the Decant Water Storage and the remaining 5.5 ML will be directed towards the Process Area Sediment Basin.

Where possible, roofed areas will be connected to rainwater tanks for use in garden beds etc.

7.2.5 Haul Roads and Access Tracks

Runoff from haul roads and access tracks will contain high sediment loads. It is proposed that a series of interconnecting drains and culverts will enable this water to be directed to a number of small sediment traps located around the site. These sediment traps will be designed to remove particles down to 0.01 mm for the 1 in 5 year ARI 24hr storm discharge. Roads across identifiable drainage lines will have culverts installed to allow through flow of surface water, limiting the need for remediation work after rainfall events.

Once the sediment load in this runoff is reduced the clean water will be discharged into the pre-existing drainage paths.

7.3 Flood Defence

As the current planned location of pits are situated in elevated locations, the ability of a 1 in 100 year ARI flood to pose a risk to pit operations is limited, but may require further investigation.

Considering the layout of the site and the orientation of the mining associated infrastructure, the consequences of a flood will be limited to the localised disruption of mining services. The installation of diversion banks around the site, to limit the contamination of the different runoff streams, should ensure protection from a 1 in 100 year ARI flood. All bunding installed should be designed to limit the extent of flooding. Designing this bunding with a free board of approximately 0.5m would suitably control the potential for flooding and minimise the risk to life and property.

8 MINE CLOSURE

Mine closure will involve extensive reshaping and rehabilitation of disturbed areas to a natural condition. The implementation of leading practice techniques will enhance the long term sustainability of the rehabilitation works.

At closure, the TSF and WRS will be shaped for natural surface drainage and erosion rates similar to those of natural landforms in the area. Most of the preparatory work required to protect the environment is being undertaken as part of the Mining and Rehabilitation Plan (MARP) and will be implemented throughout the operations phase.

The closure phase will consist largely of the last stages of decommissioning, including demolition of infrastructure, final land-forming, revegetation and commencement of a post-closure monitoring program.

Rock filled gullies on the outer slopes of the waste rock storage should be constructed to handle excessive rainfall runoff as other drainage lines in the region show signs of significant erosion. Concave slope profiles, which mimic natural slopes, limit the loss of sediment from the slope. The Decant Water Storage liner will be removed and existing storages modified to operate as permanent sediment basins. Natural drainage paths will be reinstated, where possible.

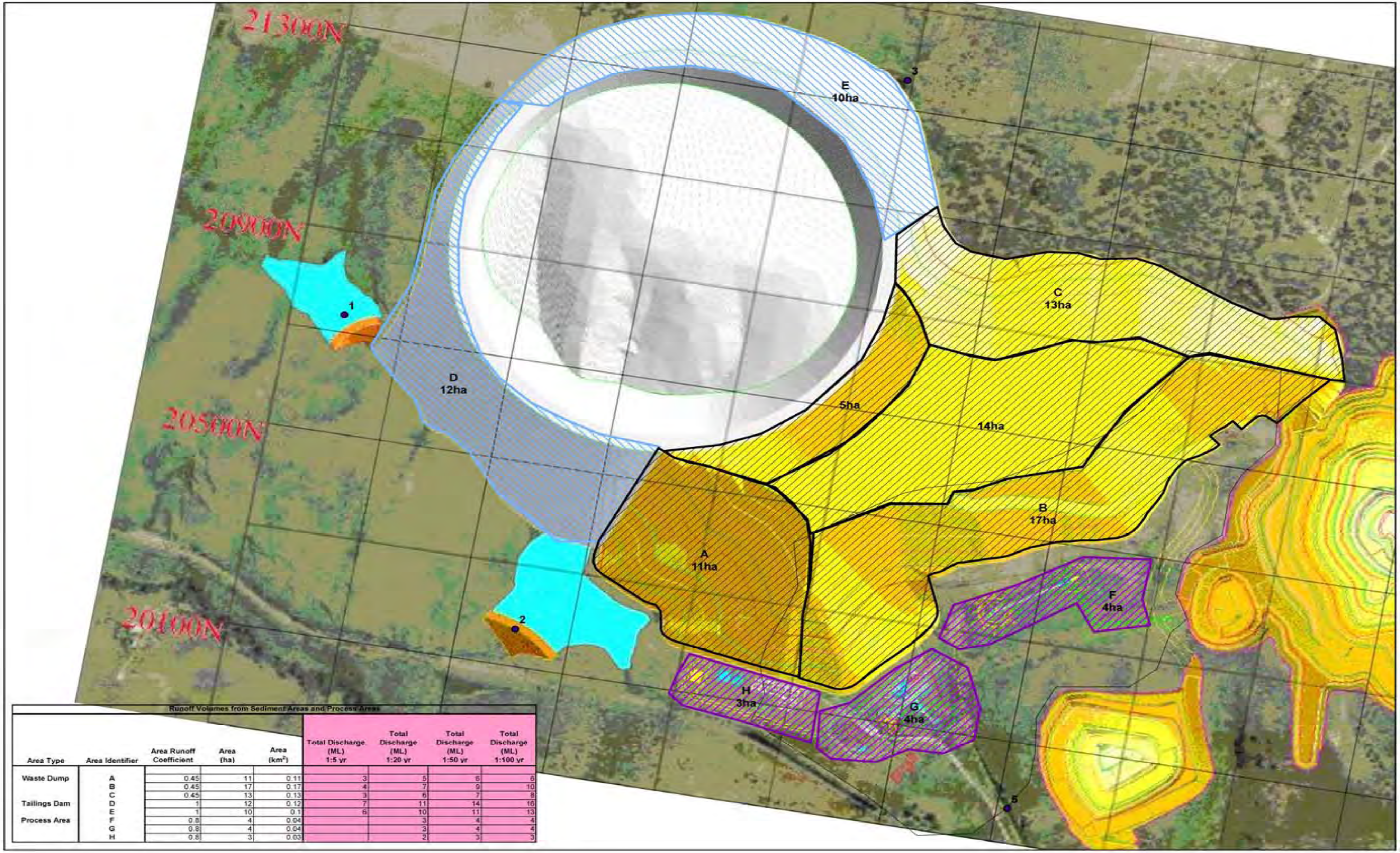
9 CONCLUSIONS AND RECOMMENDATIONS

The conceptual surface water management plan for the Kanmantoo Copper Gold Project is to:

- Maintain discharge from site of *clean runoff*
- Capture *sediment runoff* for treatment in silt traps prior to discharge
- Capture *waste rock runoff* and reuse the water in the processing circuit or treatment in sediment basins/wetlands
- Capture and treat *process runoff* at the source, diversion to sediment basin for treatment prior to discharge or storage in lined storage facilities and reuse in the processing circuit.

Regards,
Aquaterra

Matt Driver	Glenn Passfield
Water Resources Engineer	Senior Water Resources Engineer



Runoff Volumes from Sediment Areas and Process Areas

Area Type	Area Identifier	Area Runoff Coefficient	Area (ha)	Area (km^2)	Total Discharge (ML) 1:5 yr	Total Discharge (ML) 1:20 yr	Total Discharge (ML) 1:50 yr	Total Discharge (ML) 1:100 yr
Waste Dump	A	0.45	11	0.11	3	5	6	6
	B	0.45	17	0.17	4	7	9	10
	C	0.45	13	0.13	3	6	7	8
Tailings Dam	D	1	12	0.12	7	11	14	16
	E	1	10	0.1	6	10	11	13
Process Area	F	0.8	4	0.04		3	4	4
	G	0.8	4	0.04		3	4	4
	H	0.8	3	0.03		2	3	3

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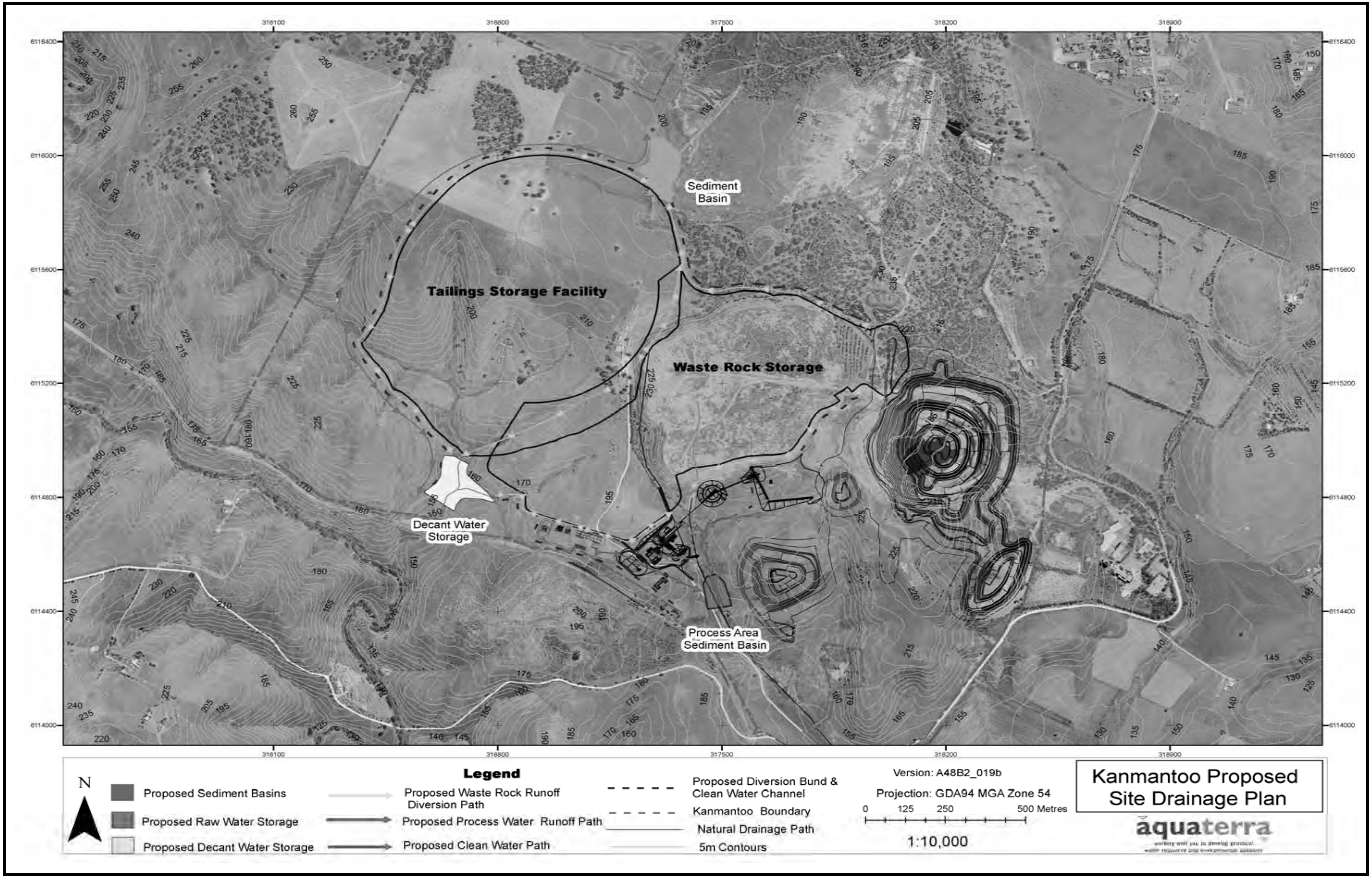
Calculated runoff from Kanmantoo Copper-Gold Project for various ARI design storms

Figure 1



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Kanmantoo proposed site drainage plan
Figure 2

Appendix 2D

Surface Water Management Plan

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Memo

To:	Victoria Alivanoglou	**Company:**	Coffey Natural Systems
From:	Glenn Passfield	**Job No:**	A48
Date:	15/04/2008	**Doc No:**	008c

Subject: **Kanmantoo Copper Ore Project – Topsoil Stockpile and Road Surface Water Management**

Victoria,

We refer to our recent proposal regarding the provision of further surface water information relating to the Kanmantoo Copper Project Mining Lease Proposal. This memo presents and discusses the results of our investigations.

1. Background

In July 2007, Aquaterra was commissioned by Hillgrove Resources to provide a preliminary stormwater management conceptual design for input to the Kanmantoo Copper Project Mining Lease Proposal. This design was presented to Hillgrove resources in August 2007 (Doc. Ref. 026, 08/08/2007).

At that time, the location of haul roads and topsoil stockpiles was not known. This information is now available, and Aquaterra have now been commissioned to provide further detail with regard to the design and location of silt traps pertaining to the haul roads and topsoil stockpiles. These nominal design arrangements are presented in the section below.

2. Topsoil Stockpile Silt Traps

It is proposed that each of the individual topsoil stockpiles (6 No.) will have an associated silt trap. The primary purpose of these silt traps is to:

a) Reduce the sediment load arriving at the larger sediment ponds and reduce the maintenance requirements on these sediment ponds; or
b) In the case that the stockpile drains directly into an existing watercourse, to reduce the sediment load arriving at the watercourses to an acceptable level.

Effective sediment removal is largely a function of surface area, and as the proportion of sediment required to be removed increases, the required surface area increases also. The proposed level of sediment removal for this project is 100% of 0.01mm size particles for a 1 in 5 year, 24 hour rainfall event. It should be noted that this will also remove approximately 25% of 0.005mm size particles.

The required surface area for the above design is approximately 16,000 m^2 per m^3/s of inflow. The inflow rates (and hence the size of each trap) will vary depending on the surface area of the proposed stockpiles.

The estimated total rainfall for the 1 in 5 year, 24 hour rainfall event is 57.8mm (average 2.5 mm/hr), as presented in the above mentioned Aquaterra Report. Assuming a runoff coefficient of 60% (conservative) the following table (Table 1) summarises the required silt trap dimensions. It is generally recommended that the length to width ratio of the trap should be at least 3:1. Our calculations below assume a length to width ratio of 4:1. It should also be noted that the dimensions below include the additional space required for the inner batter, crest and outer batter, which adds an approximate 20m to both the length and the width of the

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silt trap (assuming inner and outer slope batters of 1:3, and a crest width of 3m, for an internal height of 1.1m). It should also be noted that the above assumes a relatively level ground surface – the dimensions are likely to increase in steep locations.

Table 1: Kanmantoo Topsoil Stockpile Silt Trap Dimensions

Topsoil Stockpile	Surface Area (km^2)	Estimated Runoff (m^3/s)	Silt Trap Dimensions (m x m)
1a	0.0118	0.0049	37.8 x 24.5
1b	0.0393	0.0164	52.4 x 28.1
2	0.0244	0.0102	26.4 x 45.5
3	0.0031	0.0013	22.3 x 29.1
4	0.0068	0.0028	23.4 x 33.3
5	0.0137	0.0057	24.8 x 39.0
6	0.0179	0.0074	25.5 x 41.8

It should be noted that Stockpile No.1 straddles a catchment divide, and all runoff cannot be brought to a single silt trap. As such, two silt traps will be required for this stockpile.

The attached figure (Figure 2 revised from previous Aquaterra report) details the locations of the stockpiles and associated silt traps, and also indicates the proposed flow paths upon leaving the silt trap.

All the silt traps will have a rock lined overflow weir which will allow water to escape the trap in the event of rainfall events larger than a 1 in 5 year, 24 hour event.

The attached figure (A48-SK-001) show typical designs and details for typical drain cross sections, entrance and exit details and location of rip rap around overflow/inlet weirs.

3. Haul Road/Access Road Stormwater Management

Typically, the management of stormwater from haul roads and access roads would form part of the road design, and would normally involve the construction of 'turn-offs' – a cutting into the side of the road at certain intervals which diverts surface water runoff away from the road and into the adjacent bushland areas, whereby the velocities are suddenly decreased, and the majority of the sediment load drops out of the runoff in very close proximity to the source, i.e. the road. The intervals at which these turn-offs are constructed is largely dependent on the gradient of the road, i.e. steeper sections would require the turn-offs at closer intervals than for less steep roads. Generally, sedimentation ponds and silt traps would not be used in haul road stormwater management.

At this stage, it is not possible to show the locations of the 'turn-offs', however, as described above, it is anticipated that rainfall runoff arising from the haul roads would be contained within the general haul road corridors.

We trust this design memo is sufficient for your needs, but should you have any queries, please do not hesitate to contact the undersigned to discuss.

Regards,
Aquaterra

Daragh

Daragh Monaghan
Senior Water Resources Engineer

Glenn

Glenn Passfield
Senior Water Resources Engineer

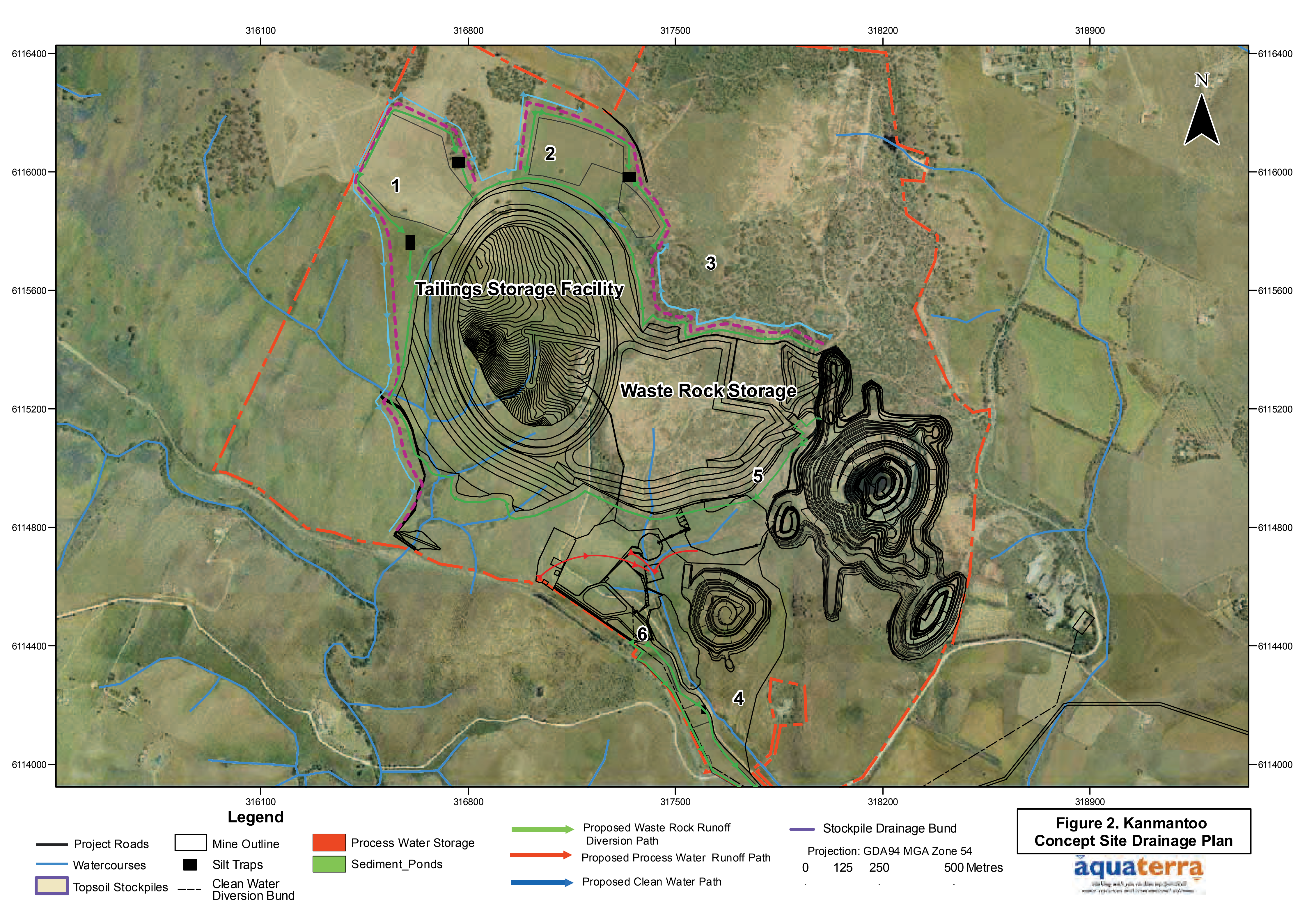
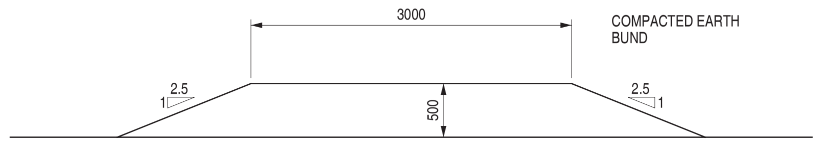


Figure 2. Kanmantoo Concept Site Drainage Plan

aquaterra



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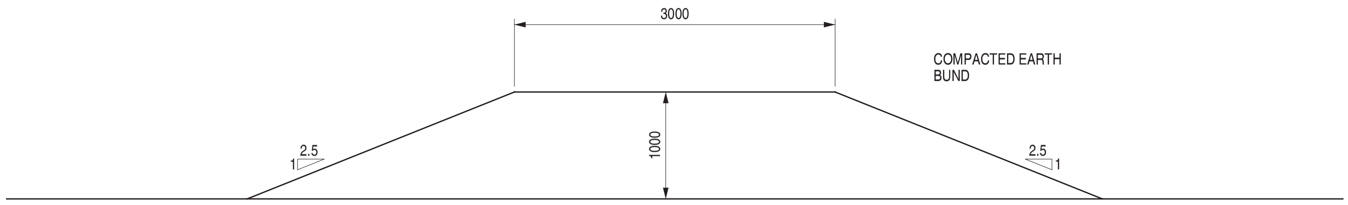

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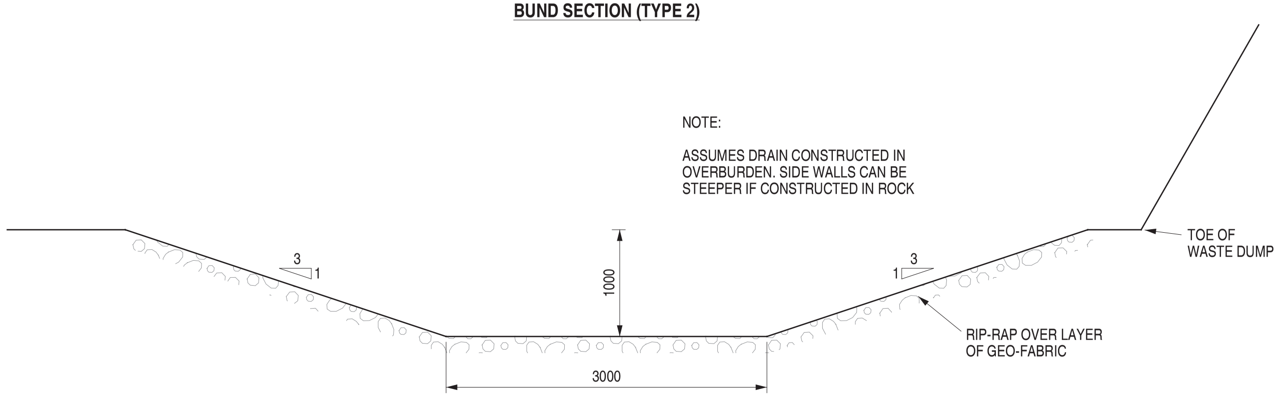
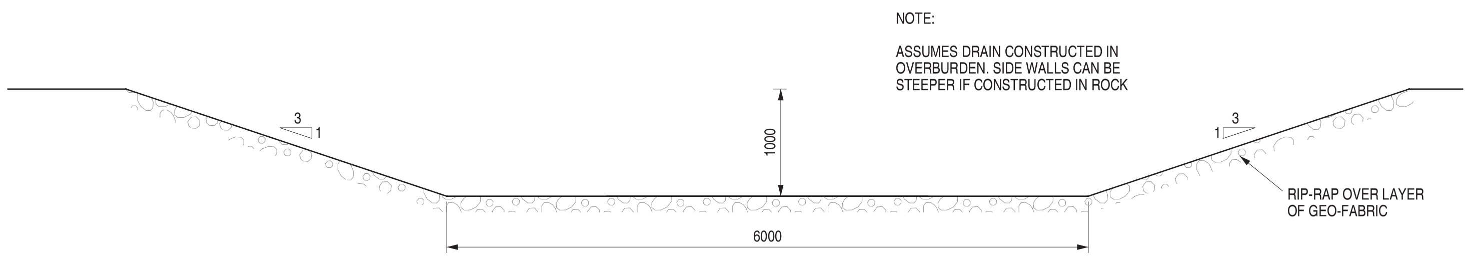


DRAIN DETAIL 1



DRAIN DETAIL 2

REVN	DATE	AMENDMENT	DRN	APPROVED
A	08-02-2008	DRAFT	CR	DM

DESIGNED: D. MONAGHAN
DRAWN: ENVIRONMENTAL DRAFTING
CHECKED: I. REA
APPROVED: --
CAD FILE:
SCALE: 1 : 50

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HILLGROVE RESOURCES

KANMANTOO COPPER PROJECT
TYPICAL WASTE DUMP DESIGN -
DRAIN AND BUND DETAILS

DWG SIZE	PROJECT No	DRAWING No	REVN
A3	A48	A48-SK-001	A

Appendix 2E

Surface Water Management Plan, 2010

Kanmantoo Copper Project		
Surface Water Management Plan		
HILLGROVE RESOURCES	**Issue:** Version 4	**Date:** 9 July 2010
	Authorised by:	**Signature:**

1. Background

The rivers and catchments of South Australia are governed by its largely semi-arid climate, resulting in some of the most variable rainfall and surface water flows (runoff) in the world. Annual rainfall in the area averages 424 mm, most of which falls in the winter months. Local drainage systems in the region of the mining lease are ephemeral, flowing only after large rainfall events.

Drainage in the ML area is ephemeral, with streams only flowing after high rainfall events. The annual average flow rate of the ML area (based on a catchment area of 4.4 km^2) is estimated to be 4.7 L/s . Drainage from the ML area reports eventually to the Bremer River, either via Dawesley Creek and Mount Barker Creek or via an unnamed ephemeral stream (Figure 1). The Bremer River has distinct annual high (winter and spring) and low (summer) flows, and runs south for about 40 km through Hartley and Langhorne Creek before discharging to Lake Alexandrina. Lake Alexandrina forms part of the Ramsar-listed Coorong, Lake Alexandrina and Lake Albert Wetland (see Figures 1 and 2).

1.1 Uses and Environmental Values

The *Natural Resources Management Act 2004* requires that regional Natural Resource Management Boards prepare a water allocation plan for each of the prescribed water resource regions. The mining lease is located within the Eastern Mount Lofty Ranges prescribed water resource region. A Water Allocation Plan is in the process of being prepared and will be a statutory instrument that will be used to guide the granting of licenses to take water, as well as the process for transferring of water licences and/or water allocations as well as providing environmental flows.

Generally, surface waters in South Australia are protected to provide maintenance of aquatic systems, recreational and aesthetic values, potable water uses, and agricultural and industrial uses. Specifically, the environmental values for the Bremer River include the maintenance of ecosystems, potable water, livestock drinking water and irrigation.

1.2 Water Quality

The major water quality concerns in the Mount Lofty Ranges watershed are generally the result of a number of small influences (diffuse pollution) combining to produce a major effect on water quality. The major pollutants include faeces, parasites (*Cryptosporidium* and *Giardia*), nutrients, sediment and pesticides. Specifically, water quality problems in the Bremer River catchment are most likely to include elevated turbidity, heavy metal, and nutrient levels are the most likely water quality problems. Within the mining lease, stored water in the old pit and old tailings dam are known to be acidic, have high electrical conductivity and a chemical composition typical of mine-related acid rock drainage.

The mining lease and surrounds contains mineralisation and hence the soil, rock and stream sediments contain high concentrations of some metals.

2. Relevant Legislation

A Water Allocation Plan for the region is in the process of being prepared in accordance with the *Natural Resources Management Act 2004* and will be a statutory instrument that will be used to guide the granting of licenses to take water, as well as the process for transferring of water licences and/or water allocations.

Relevant legislation includes:

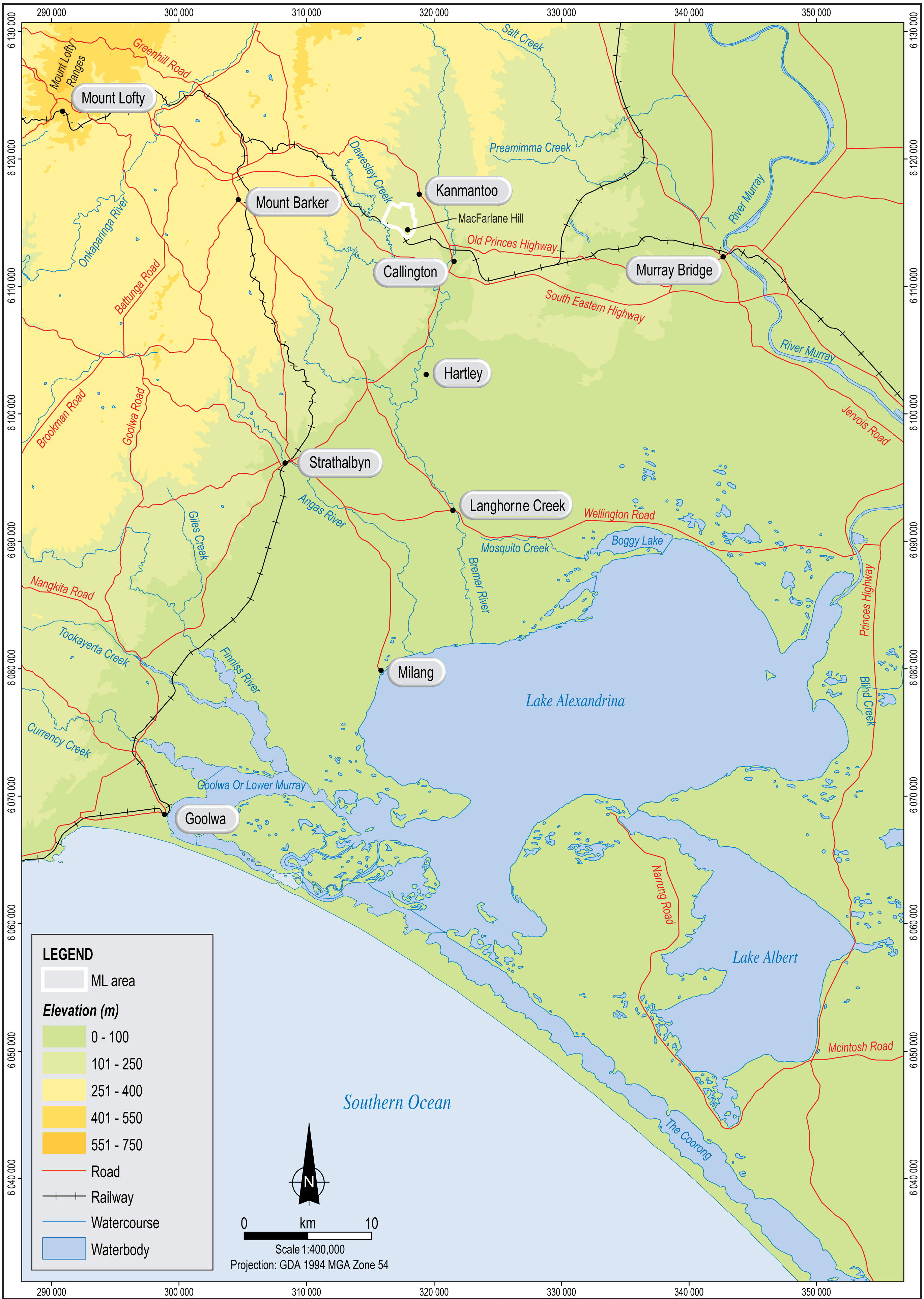
State:

- *Environment Protection Act 1993.*
  - Environment Protection (Water Quality) Policy 2003.
- *Water Resources Act 1997.*
- *Natural Resources Management Act 2004.*
- *River Murray Act 2003.*
- *Mining Act 1971.*

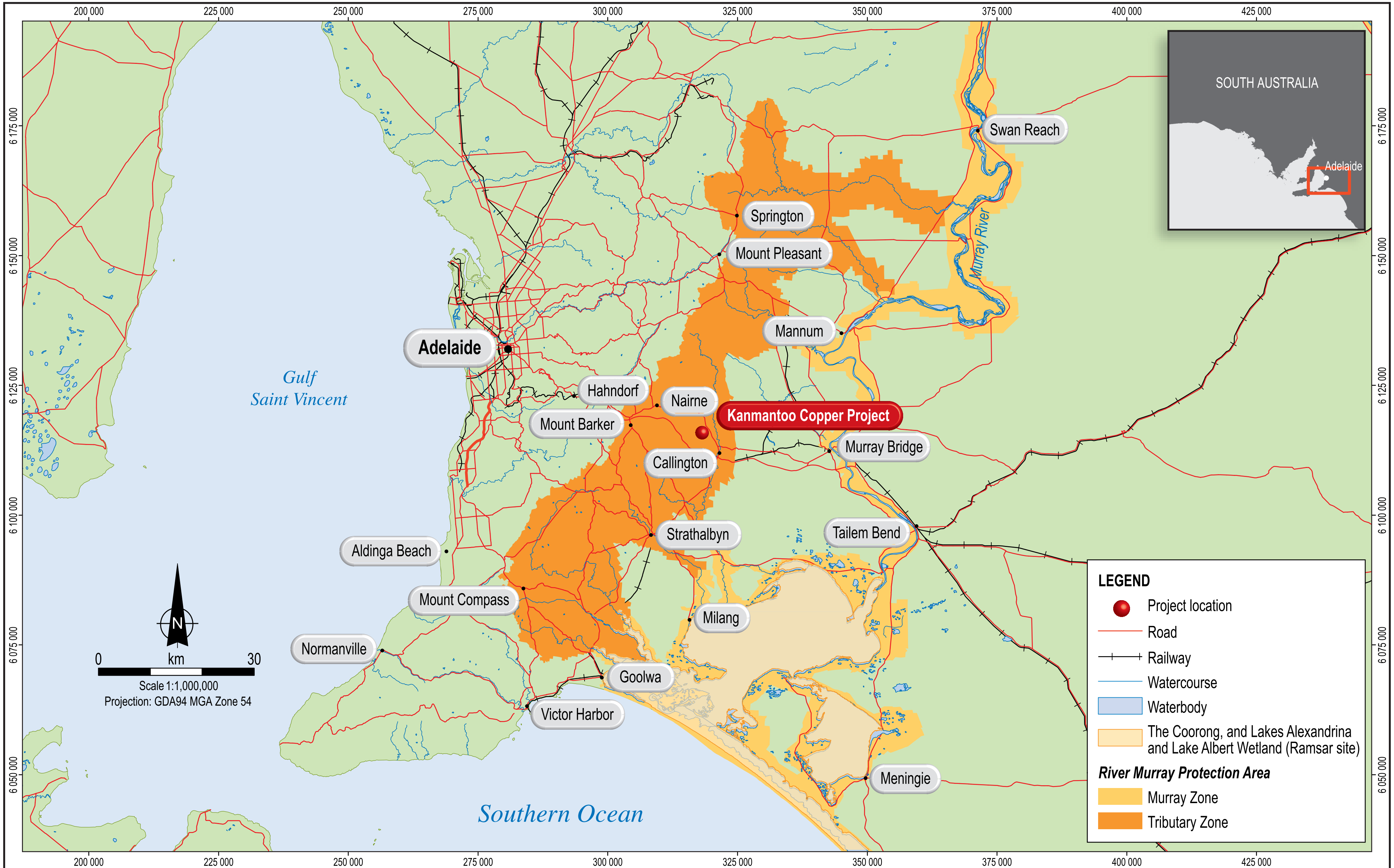
Commonwealth:

- None.

Surface water resources are protected at the State level however, the National Water Initiative to which the Commonwealth and South Australian governments are signatories, provides a platform for water reform in Australia. The National Water Initiative contains a number of performance indicators for surface water management.



coffey environments	Date: 20.06.2008 MXD: HillgroveResources_KanmantooGIS File Name: 5000_07_SW_F001_GIS_AI / Rev: 1	Hillgrove Copper Pty Ltd Kanmantoo Copper Project	HILLGROVE RESOURCES	Regional topography and watercourses	Figure No: 1



Source:
Place names, roads, rail and drainage from GEODATA TOPO 250K (optimum scale 1:250,000)
Prescribed water resource areas and River Murray protected area from DWLBC

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Date: 20.06.2008	
MXD: HillgroveResources_KanmantooGIS	
File Name: 5000_07_SW_F002_GIS_AI	Rev: 1

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Kanmantoo Copper Project

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River Murray Protection Area and Ramsar-listed wetland

Figure No: 2

3. Statutory Responsibilities

3.1 Mining Lease Conditions

A mining lease for operations at the Kanmantoo Copper Project has been issued (ML 6345), subject to conditions, under the Mining Act. These conditions must be complied with during all phases of the mining operation. Specifically, the following conditions must be adhered to in relation to surface water management:

- Condition 17: If the Lessee must in constructing and operating the Lease ensure that there is no adverse impact to the quality and quantity of surface or groundwater caused by mining operations to water dependent ecosystems or existing users unless adequate alternate supplies are provided in accordance with Condition 18 (below).
- Condition 18: If the Lessee adversely affects the ability of other persons to take water from any watercourse, well or dam, the lessee must replace or deepen existing wells if they are substantially affected by dewatering activities, or provide alternative water sources for the affected users regardless of cessation of mining operations whereby:
  - A ‘substantial affect’ is determined by the movement of physical or chemical parameters of the water in the subject well beyond normal seasonal variation. This is to be determined by the relevant authority, and;
  - An ‘alternative water source’ includes the potential to lower pumps, deepened weeks, extend supply form one of the Lessee’s well, or connection to the SA Water mains. In the case of any dispute, the final decision on an alternative water source is to be determined by PIRSA in consultation with the affected landholder and the Lessee.
- Condition 20: The Lessee must in constructing and operating the Lease ensure no stormwater contaminated as a result of mining operations is to leave the Lease area or result in contamination of soil at closure within the Lease area.
- Condition 21: The Lessee must in constructing and operating the Lease ensure no water runoff from the Lease results in flooding of adjacent areas, to an extent greater than that could reasonably be expected to occur prior to mining operations being established on the Lease.
- Condition 22: The Lessee must in constructing and operating the Lease ensure that no contamination and/or pollution of natural water drainage systems, streams and rivers, groundwater, land and soils occurs either on or off site is caused by waste products (other than mine waste and tailings) and hazardous materials used in mine operations.
- Condition 25: The Lessee must in constructing and operating the Lease ensure that no contamination of natural drainage systems, streams and creeks, and no contamination beyond approved EPA limits for groundwater, land and soils occurs either on or off the site resulting from permanent or temporary storage of the mine waste and tailings.
- Condition 27.4: No compromise of the quality and quantity of surface water to existing users and water dependent ecosystems.

3.2 MARP Commitments

A Mining and Rehabilitation Program (MARP) for the Kanmantoo Copper Project has been approved under the Mining Act for use during all phases of the mining operation. The MARP includes detailed and specific information on environmental control measures and establishes outcome-based performance criteria for the mining operation, presented in the table below. This management plan incorporates commitments made in the MARP that relate to surface water management.

Table 1 Control measures and performance criteria for surface water management

Outcome	Leading Indicator Criteria/ Assessment Criteria	Summary of Control Measures
No adverse impact to the quality and quantity of surface water caused by mining operations to water dependant ecosystems or existing users unless adequate alternate supplies are provided in accordance with Condition 18 of the lease conditions.	**Leading Indicator Criteria:** Photo monitoring of selected surface water management structures (see Figure 3) shows no erosion issues, structures are maintained as per design and operating as per design during/after rainfall. Monitoring will be conducted opportunistically during/after significant rainfall or quarterly if no rain. **Assessment Criteria:** Opportunistic water quality monitoring (i.e., after rainfall events which generate streamflow) of the two drainage lines downstream of the mine at or near the lease boundary (SW1 and SW2)[#]. Samples to be analysed for pH, turbidity, conductivity, hydrocarbons and water level taken, results not to exceed the ANZECC/ARMCANZ (2000) guidelines for mining (pH 6.5 to 9; turbidity 50 NTU; hydrocarbons 0 mg/L and EC not to exceed range[a] (100 to 5,000 µS/cm). [(1)]	Construction, and regular inspection, of surface water drainage/diversion system and sediment controls. Diversion of clean up-gradient runoff around infrastructure and back into the existing drainage path using channels and bunds. No off-site discharge of mine-contaminated water. Re-use or treatment of contaminated water. Integrated waste landform designed and constructed to avoid formation of ARD from waste rock (by encapsulating PAF material and implementing a cover on closure). HDPE liner on TSF floor and underdrainage system to collect seepage. Ensuring areas to be disturbed are minimised and clearing complies with relevant requirements. Progressively rehabilitating cleared land. Maintenance of freeboards on water storage facility.

Outcome	Leading Indicator Criteria/ Assessment Criteria	Summary of Control Measures
No stormwater contaminated as a result of mining operations is to leave the lease area or result in contamination of soil at closure within the lease area.	**Leading Indicator Criteria:** Photo monitoring of surface water management structures shows no erosion issues, structures are maintained as per design and operating effectively as per design during/after rainfall. Monitoring will be conducted opportunistically after a significant rainfall event or quarterly if no significant rain. Water quality monitoring of selected sediment traps (containing stormwater) for pH, conductivity and turbidity. Monitoring will be conducted opportunistically during/after a significant rainfall event. Selected samples (average two per year for each sediment trap also analysed for metals, major ions, nutrients and hydrocarbons). **Assessment Criteria:** Opportunistic water quality monitoring (i.e., after rainfall events which generate streamflow) of the two drainage lines downstream of the mine at or near the lease boundary (SW1 and SW2)[#].	Construction, and regular inspection, of surface water drainage/diversion system and sediment controls. Diversion of clean up-gradient runoff around infrastructure and back into the existing drainage path using channels and bunds.

4. Issues

The Environment Protection (Water Quality) Policy 2003 aims to protect a range of environmental values. The maintenance of aquatic ecosystems generally requires the most stringent water quality of all protected environmental values. Kanmantoo Copper Project will aim to ensure that all construction and operational mining activities do not negatively impact on aquatic ecosystems in the region.

Key issues of concern to surface water are:

- Changes in water quality (due to increased concentrations of total suspended solids and associated contaminants) and physical effects on aquatic fauna.
- Physical alteration of stream habitat (in-stream deposition).
- Chemical contamination of watercourses.
- Altered flow regimes.

5. Objectives

The objective of this management plan is:

- No long-term adverse effects on aquatic fauna and habitats due to the generation of fugitive sediment, chemical contamination or altered flow regime.

6. Associated Plans

- Waste Management Plan.
- Groundwater Management Plan.
- Potentially Acid Forming Rock Management Plan.
- Mine Closure and Rehabilitation Plan.

7. Standard Operating Procedures

- Surface Water and Stream Sampling.
- Spill Response.

8. Forms

- Post-rainfall Event Inspection Checklist.

9. Responsibilities

9.1 General Manager

The general manager will:

- Provide resources to implement the surface water management plan.

9.2 Environmental Coordinator

The environmental coordinator will:

- Implement the surface water management plan.
- Coordinate monitoring activities.
- Report monitoring results to government agencies.
- Review monitoring results, assess management action efficiency against results and either revise this management plan or implement corrective actions as applicable.
- Train and induct all employees on the requirements of the surface water management plan.

9.3 Department Managers

The department managers will:

- Support and promote the importance of minimisation impact on the environment.
- Ensure that personnel implement requirements of the surface water management plan.

9.4 All Personnel

All personnel will:

- Comply with requirements of the surface water management plan.
- Undertake an environmental induction.

10. Surface Water Quality Management

General surface water quality management procedures are covered in the Surface Water Quality Management Standard Operating Procedure and include:

10.1 Sediment

- Implementation and operation of the surface water management structures as designed to ensure that no significant sediment from disturbed areas is transported off-site.
- Installation of a diversion channel to ensure a Dawesley Creek ephemeral tributary is not hindered by the interception of the integrated waste landform. The diversion channel will allow water to flow around the toe of the integrated waste landform, and join with the creek on the southern boundary of the site (Figure 3).
- Construction of diversion bunds at the base of the integrated waste landform to separate sediment runoff form the clean runoff diversion channel. The diversion bund will direct sediment-laden runoff to either the TSF return water storage or to the northern sediment diversion and pond (Figure 3).
- Installation of a series of silt traps associated with each individual topsoil stockpile to reduce the sediment load arriving at the larger sediment ponds and at the watercourses (Figure 3).
- Placement of bunding and small scale sediment traps around the ROM stockpile. Overflow will be directed to the run-off collection pond. Clean water will be directed to the clean run-off collection pond adjacent to the processing plant (Figure 3).
- Construction of drains and culverts along haul roads and access track to direct runoff to a number of small sediment traps (Figure 3).
- The quality of water in sediment basins will be routinely monitored.
- Sediment accumulated in sediment basins will be removed periodically and disposed of to the active section of the integrated waste landform.

10.2 Chemical Contamination

- Miscellaneous chemicals will be purchased in small volumes and stored in accordance with Australian Standards and EPA guidelines.
- Installation of hyrdrocarbon interceptors and chemical containment areas (where required) to protect the downstream environment from potential contamination.
- If a chemical spill occurs Hillgrove’s Spill Response SOP will be followed to ensure contamination is minimised and spills are cleaned up properly.
- The Laratinga wastewater will be treated to at least Class A guidelines and approved by the Department of Health for use on the site.

11. Monitoring Procedures

Ongoing surface water monitoring will be conducted to allow identification of any impacts of mine construction and operations on surface water. Monitoring will be conducted at stream gauging stations, including sites upstream and downstream of the mining lease on Dawesley Creek, Mount Barker Creek and the Bremer River (Figure 3). Opportunistic sampling in the ephemeral creeks surrounding the mining lease will occur during high rainfall events. Potential sources of mine water discharge to the surrounding environment will also be monitored.

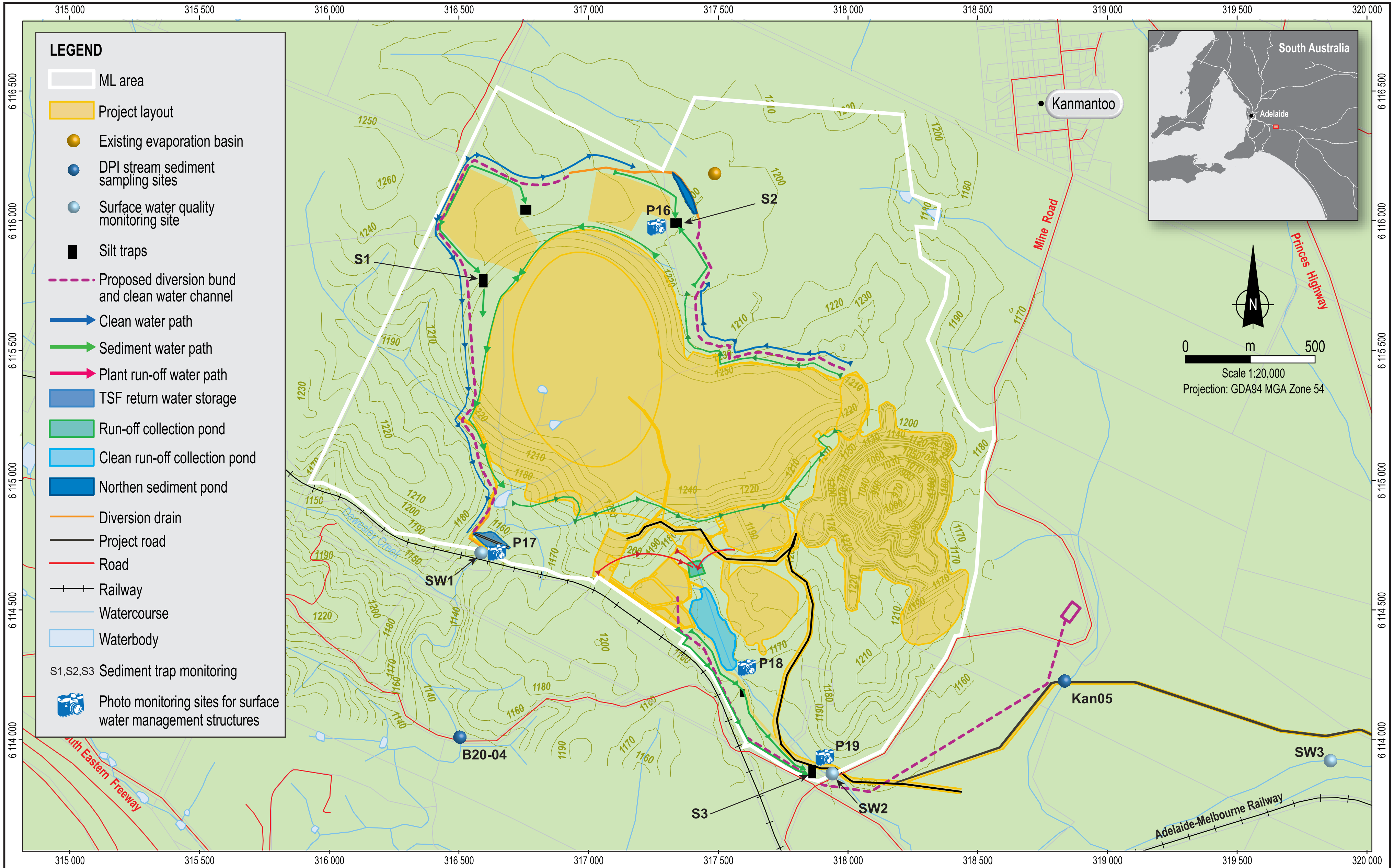
11.1 Parameters and Frequency

Monitoring stations have been installed within and adjacent to the mining lease (Figure 3). These stations will be monitored in accordance with the following table.

Table 2 Surface Water Monitoring Schedule and Parameters

Aspect	Method	Location	Frequency
Sediment	Photo monitoring of selected surface water management structures	P16 - P19 (Figure 3)	Opportunistically during/after significant rainfall or quarterly if no rain.
Stormwater contamination of soil	Soil sampling and analysis: • Metals - Al, As, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Pb, Zn. • Nutrients. • Hydrocarbons. Analysis will be conducted by an external/independent laboratory and the results will be accurate to standard detection limits.	Sites down gradient of major mine infrastructure and sediment traps (exact sites to be determined by contamination consultant)	At mine closure (baseline taken prior to disturbance of particular area)
Water quality	Water sampling and analysis: • pH, conductivity, TSS. • Hydrocarbons. Analysis will be conducted by an external/independent laboratory and the results will be accurate to standard detection limits. Water level will also be recorded.	SW1 and SW2 (Figure 3)	Opportunistically during/after a significant rainfall event.
	Water sampling and analysis: • pH, conductivity, turbidity, TSS. • Metals: Al, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Hg, Ni, Se, Zn (filtered and unfiltered) (selected samples). • Major ions: Ca, Mg, SO_4 (selected samples). • Alkalinity, DOC, nutrients (selected samples). • Nutrients and hydrocarbons (selected samples).	Selected sediment traps (containing stormwater) (S1-S3, Figure 3).	Opportunistically during/after a significant rainfall event.

Aspect	Method	Location	Frequency
	• Water depth. Two selected samples per year for each sediment trap will have the full analysis.		
	Water sampling and analysis: • pH, conductivity, turbidity, TSS. • Metals: Al, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Hg, Ni, Se, Zn (filtered and unfiltered). • Major ions: Ca, Mg, SO_4. • Alkalinity, DOC, nutrients (selected samples). • Water level. Analysis will be conducted by an external/independent laboratory and the results will be accurate to standard detection limits.	Surface water monitoring sites (Figure 3): • Drainage lines near ML boundary (SW1 and SW2). • Dawesely River upstream of SW1 at B24-05. • Dawesely River downstream of SW1 at B20-04. • Unnamed drainage line upstream of SW2 discharge at Kan 05. • Unnamed drainage line downstream of SW2 at SW3.	Opportunistically during/after rainfall events that generate stream flow on average every six months.
Flooding	Visual inspection – freeboard.	Water storage facilities	Weekly
TSF decant	Water sampling and analysis: • pH, conductivity, TDS. • Decant rate.	TSF decant structure.	Monthly
	Water sampling and analysis: • Metals: Al, As, Be, Ba, Cd, Co, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, V, Zn. • Major ions: Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3.	TSF decant structure.	Quarterly
TSF seepage	Water sampling and analysis: • pH, conductivity, TDS. • Seepage rate.	Water sampling and analysis: • Metals: Al, As, Be, Ba, Cd, Co, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, V, Zn. • Major ions: Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3.	Monthly.
	Water sampling and analysis: • Metals: Al, As, Be, Ba, Cd, Co, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, V, Zn. • Major ions: Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3.	Water sampling and analysis: • Metals: Al, As, Be, Ba, Cd, Co, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, V, Zn. • Major ions: Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3.	Quarterly



Source:
Place names, cadastre, roads, rail and drainage from DEH (optimum scale 1:50,000).
Closure contours from Snowden.
Project layout from Hillgrove Resources.

coffey environments

Date: 22.09.2008	
MXD: HillgroveResources_KanmantooGIS	
File Name: 5000_07_SW_F003_GIS_AI	Rev: 1

Hillgrove Copper Pty Ltd

Kanmantoo Copper Project

HILLGROVE RESOURCES

Location of surface water management features and monitoring sites

Figure No: 3

12. Compliance Criteria

Monitoring demonstrates:

- No project-specific changes in the health of remnant native riparian vegetation, where present, in Dawesley and Mount Barker creeks (as determined by vegetation survey carried out as part of vegetation monitoring).
- Photo monitoring of selected surface water management structures shows no erosion issues, structures are maintained as per design and operating effectively as per design during/after rainfall.
- Water quality samples to be analysed for pH, turbidity, conductivity, hydrocarbons and water level taken, results not to exceed the ANZECC/ARMCANZ (2000) guidelines for mining (pH 6.5 to 9; turbidity 50 NTU; hydrocarbons 0 mg/L and EC not to exceed range (100 to 5,000 µS/cm).
- At mine closure, soil sampling of stockpiles will be conducted to ensure no contamination as defined by Natural Environmental Protection Measures (NEPM) Standard Residential Health and Interim Urban Ecological investigation levels or a statistically significant difference in soil quality from baseline (which will be taken prior to disturbance on particular area). The number of soil samples will be consistent with the number of baseline soil samples taken. Soil will be analysed for metals (Al, As, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Pb, Zn), nutrients and hydrocarbons.

13. Review and Reporting

The surface water monitoring results will be reviewed regularly, with the results assessed against management action efficiency. Depending on the results of this review, the management plan will either be revised or corrective actions will be implemented as applicable.

Additionally, the surface water management structures will be regularly inspected for competency and to ensure they are operating efficiently. Their design and operation will be adapted as required where these inspections identify inefficiencies.

Reporting requirements include as a minimum:

- Hillgrove must provide to the Director Mines an annual Mining and Rehabilitation Compliance Report (MARCR) on operations carried out on the Lease and compliance with the approved MARP.
- Hillgrove must report any non-compliance with the Act, Lease Conditions and approved MARP to the Director of Mines. A verbal notification must be provided within 24 hours, after Hillgrove becomes aware of the non-compliance. A written report must be provided within 3 days of such time period as approved by the Director of Mines.
- Hillgrove must report to the Environment Protection Authority (EPA) (on EPA emergency phone number 1800 100 833) all incidents causing or threatening serious or material environmental harm (as defined in section 5 of the Environment Protection Act), upon becoming aware of the incident, in accordance with section 83 of the EP Act.

Appendix 3

Groundwater

Appendix 3A

Groundwater Monitoring and Management Plan

Kanmantoo Copper Mine

HILLGROVE RESOURCES

Groundwater Monitoring and Management Plan

Revision 8

16 May 2014

JACOBS SKM

Kanmantoo Copper Mine

Project no:	VE23832
Document title:	Groundwater Monitoring and Management Plan
Document no:	VE23832_GMMP_Rev8
Revision:	8
Date:	16 May 2014
Client name:	Hillgrove Resources
Client no:	
Project manager:	Michael Cowin
Author:	Jennifer Whelan / Michael Cowin
File name:	I:\VESA\Projects\VE23832\Deliverables\Reports\GMMP Update\Kanmantoo Copper Mine GMMP 2013_Revision 8_FINAL.docx

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Document history and status

Revision	Date	Description	By	Review	Approved
6B	30/07/2009	2009 revision for review	E. Picken	D McCarthy	D McCarthy
7A	08/02/2013	2013 revision for review	J. Whelan / M.Cowin	J Robinson	J Robinson
7B	17/06/2013	Updated 2013 revision	J. Whelan / M.Cowin	P Howe	P Howe
7	18/06/2013	Final (2013)	J. Whelan / M.Cowin	P Howe	M Cowin
8	16/06/2014	Updated 2014 revision to address issues raised by DEWNR	J. Whelan / M.Cowin	P. Howe	P. Howe

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Important note about your report

The sole purpose of this report and the associated services performed by Jacobs SKM is to provide a groundwater monitoring and management plan for the Kanmantoo Copper Mine in accordance with the scope of services set out in the contract between Jacobs SKM and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs SKM has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs SKM has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs SKM derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs SKM has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs SKM for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs SKM's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs SKM and the Client. Jacobs SKM accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 Preamble

Hillgrove Resources Ltd (Hillgrove) is currently updating the Life of Mine Program for Environment Protection and Rehabilitation (LOM PEPR) document for the Kanmantoo Copper Mine. This document describes the mining activities and associated environmental protection and rehabilitation objectives that have been developed for the mining operations. The document is being updated to cover the proposed extension and deepening of the main pit, and increased capacity of the tailings storage facility (TSF). This document will supersede the current approved Mining and Rehabilitation Program (MARP, now referred to as the PEPR) prepared by Coffey Natural Systems Pty Ltd (Coffey) in 2011 (Coffey, 2011). The LOM PEPR is due to be finalised in mid-2014.

During an agency meeting held on 19 March 2014 to discuss the updated LOM PEPR, the South Australian Department of Environment, Water and Natural Resources (DEWNR) raised a number of hydrogeological issues relating to the Kanmantoo Copper Mine project. These issues were discussed further during two subsequent meetings between Hillgrove, DEWNR and Jacobs SKM on 27 March and 14 April 2014. Jacobs SKM provided a response to DEWNRs issues in a letter report dated 14 May 2014 (Jacobs SKM, 2014).

This revised Groundwater Monitoring and Management Plan (GMMP) has been prepared by Jacobs SKM in response to the recommendations made to DEWNR. Once approved this GMMP will supersede the GMMP prepared by SKM in 2013 (SKM, 2013).

1.2 Scope

This Groundwater Monitoring and Management Plan (GMMP) describes the activities and commitments that Hillgrove will undertake to monitor and manage potential groundwater impacts associated with the Kanmantoo Copper Mine project. The GMMP forms part of Hillgrove's updated LOM PEPR.

The GMMP provides:

- A brief Site description and summary of the hydrogeological investigations undertaken to date
- A summary of potential groundwater impacts and issues identified
- An explanation of groundwater management objectives and approaches
- A detailed groundwater monitoring plan, inclusive of monitoring methodologies, threshold criteria and monitoring frequencies
- Contingency measures for any exceedances to threshold criteria measured during the monitoring
- An outline of the proposed process for future reviews of the GMMP and submission of monitoring reviews to regulatory agencies

A summary of all current and historical groundwater monitoring infrastructure that has been installed and monitored at the site and in the surrounding area is included as Appendix A. The summary table provides the rationale for installation of the infrastructure and serves to provide a record of all operational, decommissioned, and replacement monitoring wells. It is intended that this table be updated throughout the life of the site GMMP.

1.3 Site description and mining operations

The Kanmantoo Copper Mine is located about 40 km southeast of Adelaide in the Eastern Mount Lofty Ranges and is surrounded by cleared land which is used for agriculture and pastoral activities (Figure 1). The nearest towns are Kanmantoo (about 2 km to the north-northeast of the main pit) and Callington (about 4 km to the south-east).

Mining and ore processing has previously been undertaken on-site, with small-scale mining and ore crushing having commenced as early as 1846. From 1971 to 1976, open-pit mining and ore processing (to produce a sulphide ore concentrate for further processing off-site) was undertaken by a joint venture company formed by North and South Broken Hill Metals. During this period the mine produced a total of 4.05 million tonnes of ore grading 1.1% copper. Figure 1 shows the disturbed site areas from previous mining activities.

Hillgrove undertook resource drilling of the Kanmantoo copper ore-body between 2004 and 2011, and on the back of encouraging results, concluded a Definitive Feasibility Study (DFS) and Mining Lease Proposal (MLP) for an open-pit mining and 250 tonne/hr processing operation. The projected mine life is currently estimated at 10 years and includes lateral and vertical extension of the existing open pit (to approximately 300m below ground surface) and mining of multiple satellite pits. The approximate locations and extent of the open pit operations are depicted on Figure 2. Mining operations commenced at the Site in late 2011.

In terms of project water supply, Hillgrove have approval from Mount Barker Council to obtain treated effluent water for ore processing water and dust suppression requirements, which form the majority of the project water supplies.

Future mine operation involves a proposed expansion and deepening of the Cavanagh Pit.

The project site is identified as Mining Lease (ML) 6345 with respect to the site's PEPR.

1.4 Summary of hydrogeology investigations completed

During the course of the DFS and MLP studies, Hillgrove commissioned several hydrogeological investigations to better understand the groundwater resources of the Site and surrounding area and the potential impacts upon them from the (at the time of the investigations) proposed operations. These contributions resulted in an improved understanding of:

- groundwater quality and levels of usage (primarily for stock purposes) in surrounding landholdings
- impacts upon the local groundwater system from previous mining activities in the 1970s
- baseline groundwater conditions across the project site prior to the commencement of mining activities
- mine dewatering and post-mining water balances for mine voids
- the potential for on-site groundwater resources to contribute to process water supply demand
- the potential impact upon existing groundwater users and beneficial uses of surrounding water resources from proposed operations, notably from mine dewatering and potential seepage from the proposed Tailings Storage Facility (TSF)

These investigations are documented in several stand-alone reports that have been incorporated within, and appended to, the issued MLP (Enesar, 2007) and MARP (Coffey, 2010) documents:

- Parsons Brinckerhoff, 2006. *Kanmantoo Mine – Background Groundwater Quality Investigation.* Report prepared for Hillgrove Resources. July 2006
- REM. 2006. *Initial Groundwater Assessment of Old Kanmantoo Mine, Callington, South Australia*. 22 December 2006. Report prepared for Hillgrove Resources Limited
- REM. 2007a. *Kanmantoo Copper Project – Water Resources Investigation*. 5 June 2007. Report prepared for Hillgrove Resources Limited
- REM. 2007b. *Background Groundwater Quality Investigation of Regional Bores – Kanmantoo Copper Project, South Australia*. 29 June 2007. Report prepared for Hillgrove Resources Limited
- REM. 2007c. *Kanmantoo Copper Project – Groundwater Impact Assessment*. 31 August 2007. Report prepared for Hillgrove Resources Limited
- REM. 2008. *Kanmantoo Copper Project – Groundwater Impacts of Potential Seepage from Tailings Storage Facility.* 25 February 2008. Report prepared for Hillgrove Resources Limited

- SKM. 2008a. *Addendum to Final Report – Groundwater Impacts of Potential Seepage from Tailings Storage Facility (dated 25 February 2008)*. Prepared 5 August 2008
- SKM. 2008b. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 5 September 2008
- SKM. 2008c. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 9 September 2008
- SKM. 2008d. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 15 September 2008
- SKM. 2008e. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 16 September 2008
- SKM. 2008f. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 18 September 2008
- SKM. 2008g. *Letter Response to the EPA Comments for Exemption Application by Hillgrove Copper Pty Ltd*. Prepared 23 September 2008
- SKM. 2008h. Letter Report – Baseline Assessment of Landholders Bores (October 2008), Kanmantoo Copper Project. Prepared 6 November 2008
- SKM. 2009. Letter Report – Summary of Tailings Storage Facility Redesign and Review of Groundwater Monitoring and Management Requirements, Kanmantoo Copper Project. 20 March 2009

In accordance with the Site GMMP groundwater monitoring was undertaken to establish baseline conditions prior to the commencement of mining operations. These investigations are documented in several stand-alone reports as follows:

- SKM. 2010. Pre-Mining Assessment of Landholders Bores (October 2010) Kanmantoo Copper Project. November 2010
- SKM. 2010. Groundwater Monitoring Program, Kanmantoo Copper Project, October 2010. December 2010
- SKM. 2011. Groundwater Monitoring Program – January 2011, Kanmantoo Copper Project. March 2011
- SKM. 2011. Pre-Mining Assessment of Landholders Bores (May 2011) Kanmantoo Copper Project. June 2011
- SKM. 2011a. Groundwater Monitoring Event Summary – May 2011. September 2011
- SKM. 2012. Groundwater Monitoring Event Compliance Summary – August 2011. March 2012
- SKM. 2012a. Final Groundwater Monitoring Program – November 2011, Kanmantoo Cooper Project. March 2012
- SKM. 2012b. Pre-Mining Assessment of Landholder Bores (November 2011), Kanmantoo Copper Project. December 2011

1.5 Existing groundwater conditions

A total of 26 groundwater investigation and monitoring wells (KMB001 – KMB026) have been installed by Hillgrove within and adjacent to the site. The locations of these wells are shown on Figure 2. As shown on Figure 2, only 15 of the 26 monitoring wells are currently (as of January 2013) operational. Only one monitoring well is believed to have been installed on-site during or since the previous mining operations (well unit number 6627-07954) prior to Hillgrove's studies.

Figure 2 also shows surrounding landholders bores that have been identified and sampled as current (ie operational) and former (ie not in use) groundwater supply bores. Groundwater quality data from these bores has been used to assist in determining background groundwater concentrations of potential contaminants of concern.

Most of the Hillgrove monitoring wells have been sampled several times and detailed hydrochemical analyses completed. Combined with other aquifer testing, site visits and desk-based analyses, a conceptual hydrogeological model has been developed for the site and surrounding area. Key aspects of the conceptual model in relation to the GMMP include:

- Brackish to saline groundwater (typically about 1,000 to 10,000 mg/L Total Dissolved Solids [TDS]) occurs within fracture zones of weathered and fresh bedrock
- Groundwater levels indicate that groundwater flow paths across the site are typically to the south-east with potential recharge zones in elevated areas (north-west parts of the site) and possible discharge to deeply incised drainage lines such as Dawesley Creek. Figure 3 presents the inferred groundwater contours and flow direction from the November 2011 groundwater monitoring event (GME). Locally, groundwater flow paths are likely to be strongly controlled by fracture zone intensity and orientation. However, on a larger scale, there is probably a tendency for fracture zones to be somewhat interconnected and for the fractured rock aquifer to show some characteristics of a semi-isotropic and homogenous aquifer system.
- Groundwater levels around the existing open-pit show that it acts as a groundwater sink (refer Figure 3), and has probably acted this way for the most of the period since open-pit mining commenced in 1971. The groundwater sink conditions provide hydraulic containment of the contaminated water currently present within and immediately adjacent to the open-pit.
- Groundwater use from surrounding supply wells (equipped as windmills or with small electric-submersible pumps) is relatively sparse, but does form an important water supply for stock, domestic and irrigation purposes. Groundwater salinity in these surrounding wells is typically brackish (about 1,200 – 8,000 mg/L TDS).
- Groundwater sampled from some surrounding landholders supply wells has concentrations of several metals and ions that exceed SA Environment Protection Authority (EPA) water quality criteria for various beneficial uses. Cadmium, cobalt, copper, iron, nickel, selenium, and zinc were found to be above freshwater aquatic ecosystem criteria in several wells. Cobalt, iron, and zinc were also found to be above irrigation water criteria in one or more wells. The elevated metal levels are considered to be naturally occurring and reflect the relatively high levels of sulphide minerals present in the rocks of the region. Whilst metal levels were typically below livestock criteria, fluoride concentrations in groundwater from most wells sampled exceeded the livestock criteria.
- Previous mining activities have had an impact on local groundwater resources. Elevated trace metal concentrations have historically been observed in groundwater sampled from several wells close to previous infrastructure. Metal concentrations above all SA EPA (2003) water quality criteria were identified in wells close (and down gradient) to the old tailings dam (KMB011), waste rock dump (KMB004) and pit (KMB001 and 002). However, groundwater quality further down-gradient of these monitoring sites was typically of higher quality and typically below SA EPA (2003) criteria for freshwater ecosystem, irrigation and livestock purposes.
- Detailed assessments of the hydrogeology undertaken as part of the water resource study (REM, 2007a) found that very few significant groundwater intersections have been made during RC drilling for copper resource definition in the vicinity of the then proposed TSF. Mr John Treloar (previous Mine Manager) confirmed the dry nature of previous mining, with very minor rates of dewatering required from sumps at the base of the active pit floor. Significant volumes were only pumped in response to high rainfall events. No dewatering records from past mining were available for review.
- Six groundwater supply investigation wells have been drilled at the Site in locations where faults / shears and lithological contacts have been identified following the review of past geological and hydrogeological studies and investigation drilling undertaken by Hillgrove Resources. Figure 2 details these geological structures. The following information was obtained from the installation of these six groundwater supply wells:
    - groundwater typically occurs within fracture zone intervals at relatively deep levels below the limit of any bedrock weathering
    - conversely, little or no groundwater occurs in the weathered and relatively thin bedrock zone or shallow sequence of alluvial/colluvial sediments present along drainage lines

- the individual fracture zones appear to be relatively narrow
- the predominantly quartz-biotite schists between fracture zones appears to be highly impermeable and of limited porosity
- the nature of these groundwater occurrences suggest that individual aquifer zones, if pumped for water supply or dewatering purposes, will respond as confined aquifers (and probably as bounded or strip aquifers) that have a strongly heterogeneous pattern of drawdown

It should be noted that elevated trace metal concentrations have been observed in surface water sampled from several monitoring stations in nearby reaches of Dawesley Creek (Figure 2). Levels of aluminium, cadmium, chromium, copper, iron and zinc have occasionally exceeded criteria for most beneficial uses. This contamination is believed to be largely a result of Acid Rock Drainage associated with the abandoned Brukunga pyrite mine, which is located about 11 km to the north-west of the Kanmantoo site.

1.5.1 Background groundwater quality

For the purposes of baseline assessment several groundwater monitoring wells have been selected which are considered to represent background groundwater quality conditions pre-mining. The selected background wells are:

- KMB006, KMB016, KMB017, KMB018 and KMB020 – located adjacent to the up hydraulic gradient boundary of the mine
- KMB024 and KMB025 – located at a distance from the mine site which is considered not to have been affected by pre-mining or historical mining activities
- All landholders bores

Elevated concentrations of metals above the SA EPA (2003) water quality criteria in background groundwater are likely to be natural, due to the mineralised nature of the geology.

Elevated nutrient concentrations have been recorded in bores across the area. It is considered that the range of nitrate concentrations indicates a naturally (background) high nitrate level due to regional land use (broad acre agricultural practises) with potentially some localised impact (eg KMB021 and KMB026) from the fertiliser factory adjacent to the eastern site boundary.

As nutrients appear to be reasonably consistent with background and ambient (fertiliser factory) conditions, they are not considered to be present as a direct result of contamination associated with practises at the Site. Note wells that may have potentially been impacted from any influence of the fertiliser factory have not been included in the assessment of background water quality.

1.6 Groundwater impacts and management issues

1.6.1 Overview

The hydrogeological studies undertaken to date, in consultation with the local community and regulatory agencies, have identified that the key potential groundwater impacts associated with the proposed mining operation comprise the following:

- Reduced groundwater levels in surrounding areas as a result of open-pit dewatering and minor (backup) supply well abstraction may impact existing groundwater users in terms of groundwater levels and available yields from supply wells
- Reduced groundwater levels and an associated reduction in potential groundwater discharge to Dawesley Creek
- Potential for groundwater contamination (in the form of elevated trace metal concentrations) to enter the local aquifer system from potential seepage through the floor of the TSF and subsequent migration off-site

with potential deterioration of groundwater quality for various beneficial uses (freshwater aquatic ecosystems [Dawesley Creek] and livestock or irrigation uses [surrounding groundwater supply wells])

In addition to the impacts identified above, there is the potential that impacts to groundwater quality may occur within the deeper portions of the Kanmantoo Group Aquifer associated with the proposed deepening of the existing main pit to approximately 300m below the surrounding ground surface elevation[1] [which is in the order of 160 m to 170 m relative to the Australian Height Datum (AHD)] post mine closure (ie when pit dewatering ceases).

An understanding of groundwater contamination from previous mining activities has been achieved in order to understand the true site baseline conditions with respect to the potential impacts of new mining operations undertaken by Hillgrove. The elevated metal concentrations in groundwater near the historic open-pit and waste rock dump (refer Appendix B) occur within the footprint of new mining and waste rock storage activities. Consequently, the monitoring and management of groundwater in these site areas by Hillgrove will effectively consider the effects of past mining along with any impacts of current and future mining.

Any groundwater contamination associated with the historic tailings dam (Figure 1) has not been targeted as a direct component of this GMMP given our understanding that Hillgrove are not responsible for this issue. However, groundwater monitoring of wells near the existing tailings dam is proposed as part of the assessment of the potential impacts from pit dewatering or seepage from the new TSF.

1.6.2 Potential risks associated with the tailings storage facility (TSF)

Part of the DFS and MLP for the re-establishment of mining and ore-processing at the site included the design of the new TSF to store the process tailings once copper has been extracted from the ore. The TSF has been designed by Coffey to be encapsulated within the waste rock storage which together form an Integrated Waste Landform (IWL).

Both the Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE – formerly Primary Industries and Resources SA (PIRSA)) and the EPA have given consideration to the management and mitigation measures that are to be committed by Hillgrove in order to satisfy the requirement for net positive benefits from the mining operation.

The management and mitigation measures in relation to groundwater are detailed in this GMMP document and will be incorporated into any updates to the PEPR document which forms a set of binding operating and post-closure conditions for Hillgrove as part of their approval to undertake mining and processing at the site.

Potential impacts associated with seepage from the new TSF include:

- Groundwater level rises (mounding) beneath the TSF and changes to the groundwater flow regime
- Potential seepage of leachate with elevated concentrations of heavy metals and / or nutrients (associated with use of effluent water for processing) to migrate through the TSF liner and into the underlying groundwater system beneath and down hydraulic gradient of the site

It should be noted that the TSF has been designed with a full HDPE liner (of double-thickness in parts) with seepage modelling undertaken by Coffey (February 2009) predicting zero seepage. Coffey noted that the absence of any seepage cannot be practically achieved even with HDPE liners, however based on current technologies HDPE liners provide the best option for minimising seepage to the underlying groundwater system.

The ongoing monitoring of water levels in the vicinity of the TSF will identify any significant variations in a timely manner. It is expected that an almost simultaneous water level response in nearby wells will be observed if leakage of the TSF occurs.

[1] Information supplied by Hillgrove's Environment Manager, Catherine Davis, via email correspondence dated 30 May 2013 and 6 June 2013.

An assessment made by Jacobs SKM (2014) predicts that it is reasonable to expect that the future mine operation (which involves a proposed extension and deepening of the Cavanagh Pit) and mine closure could alter the flowpaths beneath the TSF such that they become controlled by the mine pit, due to dewatering during mining and evaporative losses post-mining.

1.6.3 Potential contaminants of concern

Based on the assessments of existing site conditions and the potential impacts associated with the current and future mining operations including the TSF, the principal contaminants of concern for the GMMP comprise:

- Aluminium
- Cadmium
- Copper
- Cobalt
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Zinc
- Nutrients (ammonia as N, total nitrogen as N, nitrite+nitrate as N (NOx) and phosphorus)

Historical water analyses completed to date both on-site and on surrounding landholdings are summarised in the tables provided in Appendix B.

1.6.4 Summary

Beneath the proposed TSF, preferential groundwater flow paths may occur along (1) discrete north-south structure zones associated with a main fault / shear identified from the desktop geological study in which groundwater wells KMB020 and KMB023 were installed and (2) the major structural features running north-east to south-west in which existing monitoring wells KMB005b, KMB008b and KMB010 are located.

To assess groundwater level rise and seepage of potentially contaminating leachate from the TSF, two groundwater monitoring wells (KMB020 and KMB023) were installed on major lithological contacts up and down hydraulic gradient of the TSF to detect any potential risks to the beneficial use of groundwater beneath and down hydraulic gradient. A third well (KMB022) was installed immediately down topographic gradient of the southern TSF wall where an almost simultaneous water level response would be expected if leakage of the TSF occurs. Groundwater wells KMB005b, KMB008b and KMB010 will also assist in detecting any potential impacts emanating from the TSF along this other preferential flow path.

Monitoring wells KMB020 and KMB023 have been installed 150 m north and 200 m south respectively, of the current (Stage 1) and proposed (Stage 2) TSF. Based on the estimated average linear groundwater velocity (~16.4 m/yr) these wells, in addition to monitoring well KMB022, have been positioned to identify any potential anticipated response associated with seepage and subsequent watertable rise, change in groundwater flow conditions, and / or migration of contaminants through the TSF liner and into the underlying groundwater system. The ultimate flowpath post-closure may be toward the pit but it is not presently and so it is considered the siting of these wells is appropriate for the current mine operation. However, it is reasonable to expect that the future mine operation (which involves a proposed expansion and deepening of the Cavanagh Pit) and mine closure could alter the flowpaths beneath the TSF such that they become controlled by the mine pit, due to dewatering during mining and evaporative losses post-mining. A groundwater monitoring well will be sited between the TSF and Cavanagh pit to assist with ongoing evaluation of groundwater flow paths during operation, and to provide data to assist in assessing mine closure strategies. Hillgrove has identified a small number of mineral exploration drill holes located on the northwest wall of Cavanagh pit that may be suitable for conversion to a monitoring well. A nominal location of this 'Upstream' monitoring well is presented on Figure 2.

The current proposed extension and deepening of the main pit may have implications for groundwater quality within the deeper portions of the Kanmantoo Group Aquifer, particularly post mine closure when dewatering activities cease and a pit lake may form. In order to assess the potential for groundwater quality impact following closure, it is considered necessary to undertake baseline monitoring of groundwater gradients and groundwater quality near to the main pit by constructing a monitoring well with screen interval set at or around the proposed future depth of the pit (approximately 300 m below the surrounding ground surface or -130 m to -140 m AHD). The collection of groundwater quality data at depth will provide a baseline for comparison post mine closure, and groundwater potentiometric data can be used to assess the potential for movement of water away from the pit after closure and possible pit lake recovery. The existing groundwater monitoring infrastructure is not sufficient to allow monitoring at this depth. A suitable location for construction of a deep monitoring well is shown on Figure 2.

Furthermore, given that the lateral extension of the pit will likely result in the decommissioning (or inadequacy) of current monitoring infrastructure on the eastern site boundary (located between existing pit operations and down pre-mining hydraulic gradient landholders bores), a sentinel well will be installed off site and down pre-mining hydraulic gradient of the southern portion of the proposed main pit extension. A suitable location for the sentinel well is shown on Figure 2.

Monitoring well KMB009 is to be replaced as this well will be decommissioned during the proposed extension of O'Neil pit to the east. Furthermore, an additional monitoring well is to be installed to the southeast of the Emily Star pit to address an existing gap in the groundwater monitoring infrastructure. Proposed locations for the replacement monitoring well and Emily Star monitoring well are shown on Figure 2.

The timing for the installation of the additional monitoring wells is subject to the timing of mining operations and pit extension activities. The wells will be installed prior to the deepening of the existing main pit, and prior to the southern extension of pit operations that will render adjacent monitoring well infrastructure inadequate. It is envisaged (based on current mining activity) that the wells will be installed before the end of 2014, at which time baseline data will be collected and the wells will be included in the monitoring program outlined in Section 3. A summary of the proposed construction of the wells is provided in Table 4.1

Table 1.1 : Additional groundwater monitoring wells to be installed

Well ID	Rationale	Estimated Depth (m bgl)
KMB027	Deep Well - located immediately down-gradient of the Cavanagh pit and will essentially be paired with the existing shallower KMB026 monitoring well. To assist in assessing fractured rock aquifer permeability at the final depth of Cavanagh pit and vertical hydraulic gradients	300
KMB028	Replacement for KMB009 which will likely go out of service due to the proposed extension of O'Neils pit to the east	70
KMB029	Sentinel Well - located off site and down-gradient of O'Neils and Cavanagh pits, and is planned as a shallow completion (intersecting the top 20 m or so of the fractured rock aquifer).	50
KMB030	Monitoring for Emily Star pit to address an existing gap in monitoring infrastructure	100
KMB031	'Upstream' well to be sited between the TSF and Cavanagh pit to assist with ongoing evaluation of groundwater flow paths during operation, and to provide data to assist in assessing mine closure strategies	100

2. Groundwater management objectives and approach

2.1 Groundwater management objectives

The groundwater management objectives for the Kanmantoo Copper Mine are summarised in Table 2-1. The basis of these objectives is to protect the surrounding water resources and existing groundwater users by:

- Ensuring that groundwater discharging across the site boundary meets the SA EPA water quality criteria for freshwater aquatic ecosystems or existing baseline conditions, whichever is higher
- Maintaining the supply capacity of existing groundwater wells in surrounding areas that may be adversely affected by pit dewatering or well abstraction for process water supplies

It should be noted that 'supply capacity' of existing supply wells is not readily known and that such capacity may be reduced at a future time by other external influences besides the Hillgrove mining operations, such as a potentially reduced allocation when a finalised Western Mount Lofty Water Allocation Plan (WAP) is introduced, or reduced groundwater levels due to natural groundwater recharge variation.

Management objectives for groundwater quality are to be applied to groundwater monitoring wells located on and adjacent to the southern and eastern site boundaries as these wells are located down hydraulic gradient (and pre-mining hydraulic gradient) of mining activities and will indicate if impacted groundwater is discharging across the Site boundary. Management objectives should be applied to the following groundwater monitoring wells[2]:

- KMB003
- KMB005b
- KMB008b
- KMB010
- KMB021
- KMB022
- KMB023
- KMB024
- KMB025
- KMB026
- Any new wells installed down gradient of mining operations

[2] Note groundwater monitoring well KMB009 located on the eastern site boundary has not been included as the construction of this well is not considered suitable for reliable measurements of groundwater quality at discrete aquifer intervals. This well has a drill rod and hammer present beneath the piezometer that was lost in the base of the bore following collapse during drilling (refer REM, 2007a). The well is however considered suitable for groundwater level monitoring.

Table 2.1 : Groundwater management objectives

Category	Contaminants of Concern	Aquatic Ecosystems Fresh Waters Criteria (mg/L)	Background Groundwater Quality (mg/L)		Adopted Groundwater Quality Objectives (mg/L)
			Min	Max	
Groundwater Quality	Aluminium	0.1	<0.01	0.13	**0.13**
	Cadmium	0.002	<0.001	0.009	**0.009**
	Cobalt	-	<0.001	0.14	**0.14**
	Copper	0.01	0.001	0.031	**0.031**
	Iron	1	<0.01	11	**11**
	Lead	0.005	<0.001	0.03	**0.03**
	Manganese	-	0.002	3.7	**3.7**
	Mercury	0.0001	<0.0001	0.0003	**0.0003**
	Nickel	0.15	<0.001	0.1	**0.1**
	Selenium	0.005	<0.01	0.1	**0.1**
	Zinc	0.05	<0.05	0.94	**0.94**
	Ammonia as N	0.5	<0.01	0.53	**0.53**
	Nitrite + Nitrate as N (NOx)	0.5	<0.01	20.7	**20.7**
	Total Nitrogen as N	5	<0.1	21.8	**21.8**
	Phosphorous	0.5	<0.01	3.82	**3.82**
	pH	Between 6.5– 9.0	6.03	8.17	**Between 6.0–8.5**
Groundwater Supplies	To not adversely affect the sustainability or capacity of existing groundwater supply wells on surrounding landholdings as a result of the proposed operations				

The adoption of water quality objectives that are in excess of SA EPA aquatic ecosystems criteria is based on an assessment of water quality measured in surrounding monitoring wells and groundwater supply wells that are considered to be representative of natural background hydrogeological conditions (and not from any possible impacts of previous mining activities at Kanmantoo). Appendix B provides a summary of the baseline groundwater quality analyses completed to November 2011.

While concentrations below the management objective can be considered to be within the background range, the groundwater monitoring data should be assessed for any changes (ie any apparent increasing trend) which may indicate that groundwater quality is being impacted.

Leachate collection (and laboratory analysis) from the tailings dam has previously been undertaken by SKM and Hillgrove and will be used in conjunction with ongoing groundwater monitoring to assist in assessing the potential impact and ongoing risks to groundwater. In addition, ongoing monitoring of the surface water and groundwater discharged through the French drains installed beneath the TSF liners will be undertaken to assist in the assessment of any potential breach of the TSF liners.

2.2 Groundwater management approach

Groundwater management requirements for the Kanmantoo Copper Mine will be achieved by adopting the following approach:

- Frequent monitoring of groundwater levels, quality and abstraction
- Implementing appropriate contingency measures (if required)

- Regular provision of monitoring data and analyses to regulatory agencies
- Undertaking annual management reviews of the GMMP, including a review of the frequency of monitoring, analytical program and number of wells included in the monitoring program

2.3 Responsible parties

The party responsible for implementation of, and adherence to, the GMMP will be Hillgrove Resources Ltd or their appointed representatives.

Regular monitoring data reviews and management reviews of the GMMP will be forwarded to DMITRE, and also the Department of Environment, Water and Natural Resources (DEWNR) if such a requirement accompanies any authorisation to extract groundwater during the project.

2.4 Environmental, health and safety protocols

All groundwater monitoring fieldwork conducted as part of the GMMP will be completed in accordance with a site-specific Environmental, Health and Safety (EHS) Plan. The purpose of the EHS Plan is to establish personal protection standards and mandatory safe working practises to minimise health and safety risks to employees and the general public during groundwater monitoring activities.

3. Groundwater monitoring

3.1 Monitoring schedule

Table 3-1 depicts the types and frequency of groundwater monitoring for the active-mining phase and post mine closure phase of the project.

The frequency of the monitoring program presented in Table 3-1 is by no means limiting and annual reviews will be undertaken during mining to assess whether this frequency needs to be increased or decreased and the wells included in the monitoring program increased or decreased.

Table 3.1 : Groundwater monitoring schedule

Well Category	Monitoring Category	Monitoring Parameters	Frequency	Targeted Wells
During Mining				
Hillgrove Monitoring	Level	Groundwater level (as m AHD)	Monthly	All operational wells
	Quality	Field EC, pH	Monthly	KMB020 – 026
	Level	Water level (as m AHD)	Annual	Pit void water bodies
	Quality	Laboratory EC, pH, metals suite1, nutrients[2], major ions[3]	Annual	All operational wells plus each pit void water body
Hillgrove production	Usage	Volume pumped and from individual sources	Monthly	Back up supply wells KMB005b, KMB008b
	Quality	EC, pH, metals suite[1], nutrients[2], major ions[3]	Annual	
Landholders	Level	Groundwater level (as m TOC)	6-monthly	6727-02909, 6272-00673, 6727-00670, 6727-03091, 6727-03038, 6727-00736, 6727-02459 and Mitchell's Bore.
	Quality	EC, pH	6-monthly	
	Quality	EC, pH, metals suite1, nutrients[2], major ions[3]	Annual	
	Usage	Estimated volume pumped	6-monthly	
Post Closure of Mine				
Hillgrove Monitoring	Level	Groundwater level (as m AHD)	6-monthly	All operational wells plus pit void water bodies
	Quality	EC, pH, metals suite[1], nutrients [2], major ions [3]	Annual	All operational wells plus each pit void water body

Note 1: Metals suite comprises aluminium, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, zinc

Note 2: Nutrients: Ammonia as N, total nitrogen as N, nitrite + nitrate as N (NOx), and total phosphorous

Note 3: Major Ions: sodium, magnesium, potassium, calcium, chloride, sulphate, bicarbonate, and carbonate

In addition to the monitoring schedule outlined above the five new monitoring wells should be sampled for the full suite of analytes a minimum of one week following installation.

3.2 Groundwater monitoring methodology

Key aspects of the methodologies that will be adopted as part of the groundwater monitoring program are summarised below.

3.2.1 Groundwater levels

The following principles and quality assurance procedures will be adhered to when measuring groundwater levels:

- Groundwater levels will be recorded as depths to groundwater (metres below reference point (m BRP) and in reduced terms relative to the Australian height Datum (m AHD). Existing Hillgrove monitoring wells are surveyed to m AHD.
- The reference point from which groundwater levels are measured shall be noted
- Groundwater levels will be measured using either calibrated pressure transducers (data loggers) and / or manually with a calibrated water level probe with an accuracy level of not less than +/- 0.02 m
- Groundwater levels will be measured as close as practicable to the nominated frequencies. Six monthly measurements should be recorded in the months of November and May to capture the likely maximum seasonal variation and be consistent with previous monitoring events. Once a year levels should be measured in November.
- Where possible, groundwater levels measured in either Hillgrove or adjacent landholder supply wells should only be recorded after the well has been inactive for a minimum of 12 hours, preferably 24 hours. A note should be made regarding the pumping status of the well at the time of water level measurement.
- Where possible and practical to do so, pit void water levels should be measured to within +/- 0.1 m accuracy

Fifteen landholders bores (including 6727-02909, 6272-00673, 6727-00672, 6727-00671, 6727-00670, 6727-03091, 6727-03038, 6727-00736, 6727-00737, 6727-00738, 6727-00739, 6727-00792, 6727-03043, 6727-02459 and 6627-05849) were previously identified by the former Department of Water Land Biodiversity Conservation (DWLBC, now DEWNR) Senior Hydrogeologist (Martin Stokes) that had the potential to be impacted by drawdown effects from pit dewatering or well abstraction for process water supplies. The well locations are presented in Figure 2.

The status of these monitoring wells was investigated in October 2008 (SKM, 2008h) to establish background groundwater quality prior to the recommencement of mining by Hillgrove at the Kanmantoo Copper Mine. An additional landholder bore was identified by SKM during the field investigation program and is referred to as Mitchell’s Bore.

Of the sixteen identified bores, six were found to have been destroyed, five were not in use and five were found to be operational and used for either irrigation, domestic and/or stock purposes (SKM, 6 November 2008). Of the five identified as not in use, only three were able to have a water level obtained. The landholder bores identified to be operational and to be present but not currently in use will be targeted for ongoing monitoring during mining (refer Table 3-1).

3.2.2 Groundwater usage

The following principles and quality assurance procedures will be adhered to when measuring groundwater usage:

- Groundwater abstractions from Hillgrove supply wells or dewatering pumps will be measured with suitably calibrated usage meters. Usage meters will be fitted to each individual abstraction source (ie each production / dewatering well and each open-pit)
- Usage information from surrounding landholder supply wells will be sought at each groundwater level monitoring event. However, this information may not be recorded or provided by landholders

3.2.3 Groundwater quality

The following principles and quality assurance procedures will be adhered to when sampling groundwater wells and analysing water samples:

- ***Well Purging and Sampling Proces***s - All groundwater monitoring wells will be purged using the low flow sampling technique (micro purge bladder pump), dedicated disposable bailer or stainless steel submersible pump (full purge), consistent with previous monitoring events. Measurement of field hydrochemical

4. Proposed changes to groundwater monitoring schedule

This section outlines the proposed changes to the groundwater monitoring schedule following an indication from DEWNR (during discussions with Hillgrove and Jacobs SKM in early 2014) that the current monitoring schedule could be reassessed given that sufficient baseline hydrogeological data, and during mining hydrogeological data, has been obtained.

4.1 Monitoring frequency

Monthly monitoring of groundwater levels in all operational monitoring wells and sampling for field EC and pH in selected wells is currently undertaken monthly. The results of the monthly monitoring since commencement of mining in 2011 have generally been consistent and have indicated no adverse impacts to groundwater quality during the mining phase. If the monitoring results for the remainder of 2014 continue to show no significant change in groundwater quality it is recommended that the frequency of monthly monitoring can be reduced to quarterly following the 2014 annual monitoring event (scheduled for November 2014). Quarterly events would be undertaken in February, May, August and November of each year during mining.

4.2 Targeted monitoring wells

Monitoring well KMB009 is to be removed from the monitoring schedule as this well is likely to be abandoned during the proposed extension of O'Neil pit and will be replaced by KMB028.

Monitoring well KMB003 is to be removed from the monitoring schedule. Due to effects of dewatering the most recent monitoring events have recorded a minimal volume of water in this well and therefore it is unlikely that there will be sufficient groundwater for sampling during future monitoring events. A replacement well for KMB003 is not considered necessary due to the proximity of monitoring well KMB026.

Monitoring wells KMB011 and KMB012 are located down gradient of the old TSF and groundwater is known to be impacted in this area from previous mining operations. The monitoring results for the two wells have been generally consistent during recent groundwater monitoring events and groundwater in this area is considered unlikely to be impacted by current mining activities. Therefore it is recommended that KMB011 and KMB012 are no longer included in the monitoring schedule.

Monitoring well KMB030 will be included in the quarterly sampling of field EC and pH. The remaining four new wells, KMB027, KMB028, KMB029 and KMB031 will be sampled during the annual monitoring events only.

The new monitoring wells KMB027 to KMB031 will be included in the schedule of targeted wells.

4.3 Analytical suite

A review of baseline groundwater analytical data and monitoring results from the 2012 and 2013 annual GMEs has indicated that concentrations of lead, mercury and selenium in groundwater are consistently below the laboratory LOR and / or the adopted groundwater management objectives in groundwater sampled from all monitoring wells. It is proposed that these metals be removed from the analytical suite for the annual monitoring events.

4.4 Summary of proposed changes to monitoring schedule

Table 4-1 depicts the proposed changes to the frequency of groundwater monitoring for the active-mining phase and post mine closure phase of the project.

The frequency of the monitoring program presented in Table 4-1 is by no means limiting and annual reviews will be undertaken during mining to assess whether this frequency needs to be increased or decreased and the wells included in the monitoring program increased or decreased.

Table 4.1 : Proposed groundwater monitoring schedule

Well Category	Monitoring Category	Monitoring Parameters	Frequency	Targeted Wells
During Mining				
Hillgrove Monitoring	Level	Groundwater level (as m AHD)	Quarterly	KMB010, KMB020 - 031
	Quality	Field EC, pH	Quarterly	KMB020 – 026, KMB030
	Level	Water level (as m AHD)	Annual	Pit void water bodies
	Quality	Laboratory EC, pH, metals suite[1], nutrients[2], major ions[3]	Annual	KMB010, KMB020 - 031 plus each pit void water body
Hillgrove production	Usage	Volume pumped and from individual sources	Quarterly	Back up supply wells KMB005b, KMB008b
	Quality	EC, pH, metals suite[1], nutrients[2], major ions[3]	Annual	
Landholders	Level	Groundwater level (as m TOC)	6-monthly	6727-02909, 6272-00673, 6727-00670, 6727-03091, 6727-03038, 6727-00736, 6727-02459 and Mitchell's Bore.
	Quality	EC, pH	6-monthly	
	Quality	EC, pH, metals suite[1], nutrients[2], major ions[3]	Annual	
	Usage	Estimated volume pumped	6-monthly	
Post Closure of Mine				
Hillgrove Monitoring	Level	Groundwater level (as m AHD)	6-monthly	All operational wells plus pit void water bodies
	Quality	EC, pH, metals suite[1], nutrients [2], major ions [3]	Annual	All operational wells plus each pit void water body

Note 1: Metals suite comprises aluminium, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, nickel, vanadium, zinc

Note 2: Nutrients: Ammonia as N, total nitrogen as N, nitrite + nitrate as N (NOx), and total phosphorous

Note 3: Major Ions: sodium, magnesium, potassium, calcium, chloride, sulphate, bicarbonate, and carbonate

5. Contingency measures

Table 5-1 summarises possible events and contingency measures that are to be implemented if the adopted groundwater management objectives for the Kanmantoo Copper Mine are exceeded or breached.

Table 5.1 : Groundwater management objectives

Event	Action
Groundwater level drawdown (near the project boundaries) due to mine dewatering and / or supply well abstraction significantly decline in excess of those predicted.	1. All Hillgrove monitoring wells will be monitored at 2 weekly intervals for a period of 8 weeks to provide additional information for discerning the influence of mining activities versus possible non-mining influences. 2. If the drawdown trends are confirmed as largely being a result of mining, then re-modelling of predicted drawdown and impacts will be undertaken within a 3 month period.
Groundwater levels in neighbouring landholders supply wells considered adversely impacted.	1. Initiate weekly monitoring of groundwater levels in affected wells (and relevant Hillgrove monitoring wells), as well as detailed monitoring of abstraction rates and timing from affected supply wells. 2. If apparent (from an independent hydrogeological assessment of monitoring data) that the supply capacity of landholders well has been adversely impacted by mining activities, then the landholders water supply will be made good by: • Lowering the pump within the affected well • Deepening or replacing the well • Supplying an alternative water supply of similar quality to affected well
Groundwater quality objectives exceeded in monitoring wells KMB003, 005b, 008b, 010, 021, 022, 023, 024, 025, 026, and / or any wells installed down pre-mining hydraulic gradient of current mining operations (until the destruction or mining through of such a well).	1. Undertake a confirmatory round of groundwater sampling and analyses within four weeks of the event that recorded the exceedance(s). 2. If the exceedance(s) is confirmed, then: • undertake more frequent sampling and analyses • consider installation of additional monitoring wells • confirm actual threshold criteria and beneficial uses in the area of concern • model the predicted fate of contaminants of concern focusing on protection of environmental values at down hydraulic gradient receptors 3. If step 2 shows that impacts are unacceptable in terms of EPA water quality criteria, then remedial options will be considered and submitted to DMITRE and the EPA for comment and approval. Such options are likely to include: • Natural attenuation (and associated monitoring) • Pump and treat

<table>
<tr><th>Event</th><th>Action</th></tr>
<tr><td>Breach of the TSF clay liner occurs and nutrients or heavy metal concentrations are identified above the adopted Groundwater Quality Objectives in monitoring wells strategically placed down hydraulic gradient of the TSF.</td><td>1. Undertake a confirmatory round of groundwater sampling and analyses within four weeks of the event that recorded the exceedance(s).
2. If the exceedance(s) is confirmed, then:
• undertake more frequent sampling and analyses
• consider installation of additional monitoring wells
• confirm actual threshold criteria and beneficial uses in the area of concern
• undertake a water balance assessment of water usage in mine operations including what's been placed in the TSF to assess the potential volume of leachate being lost to the underlying fractured rock system
3. If step 2 shows that impacts are unacceptable in terms of EPA water quality criteria, then remedial options will be considered and submitted to DMITRE and the EPA for comment and approval. The remedial option is likely to include pump and treat, with extracted water retained on-site and used in processing.
Monitoring wells down hydraulic gradient of the TSF have been strategically placed along potential preferential flow paths including (1) the north-south structural zone associated with the main fault / shear and (2) the major structural features running northeast to southwest in which existing monitoring wells KMB005b, KMB008b and KMB010 are located.</td></tr>
</table>

6. Plan review and monitoring review submissions

Every two years an independent review of the requirements of the GMMP should be undertaken by an experienced and suitably qualified groundwater practitioner. This review should include an assessment of whether modifications to the monitoring program, including a change in the frequency of sampling and number of monitoring wells can occur whilst still achieving the objectives of the GMMP.

7. References

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Figures

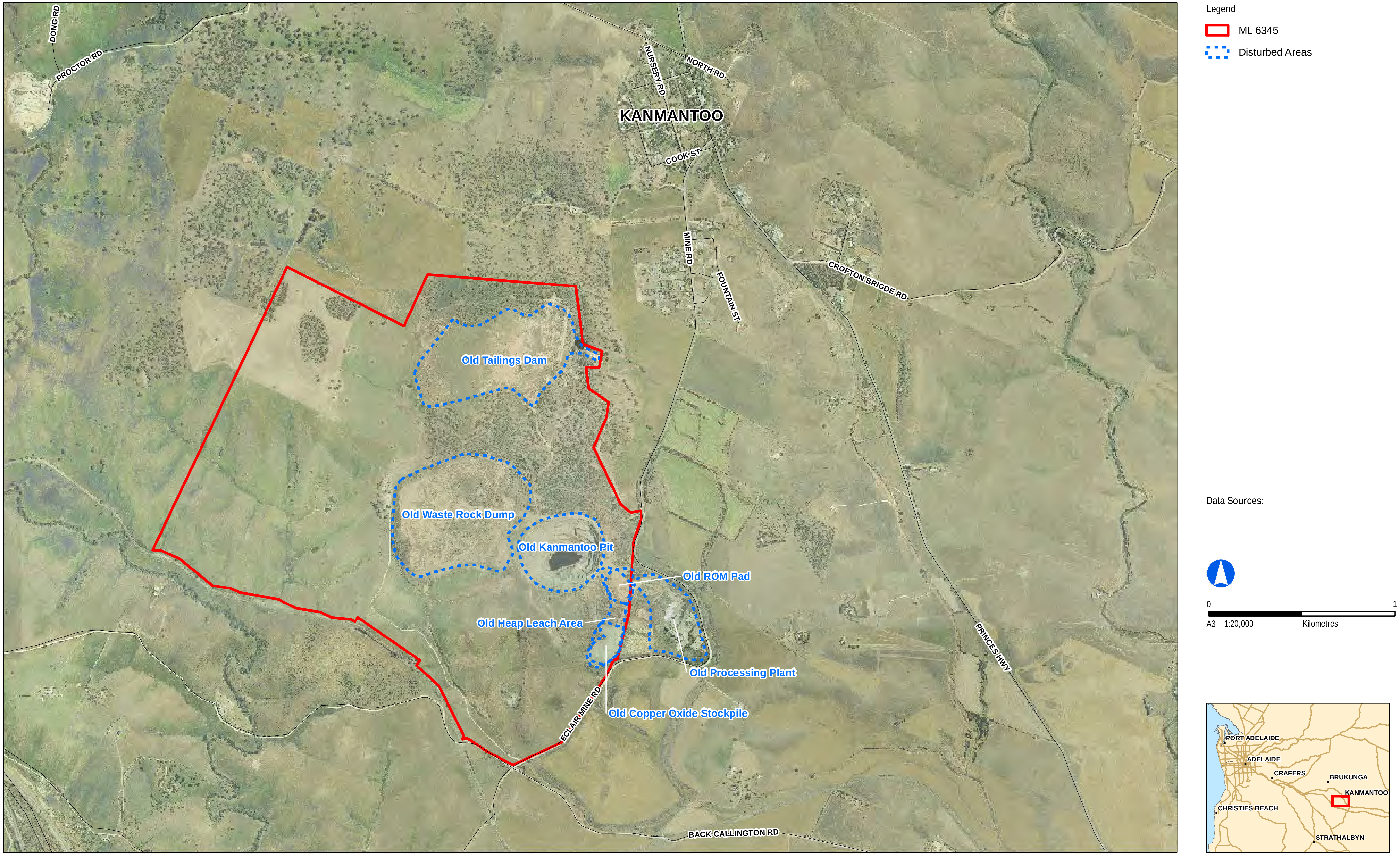

Figure 1. Site Location and Disturbed Areas from Previous Mining

Hillgrove Resources

V1 - May 2014

UTM GDA 94, Zone 54H

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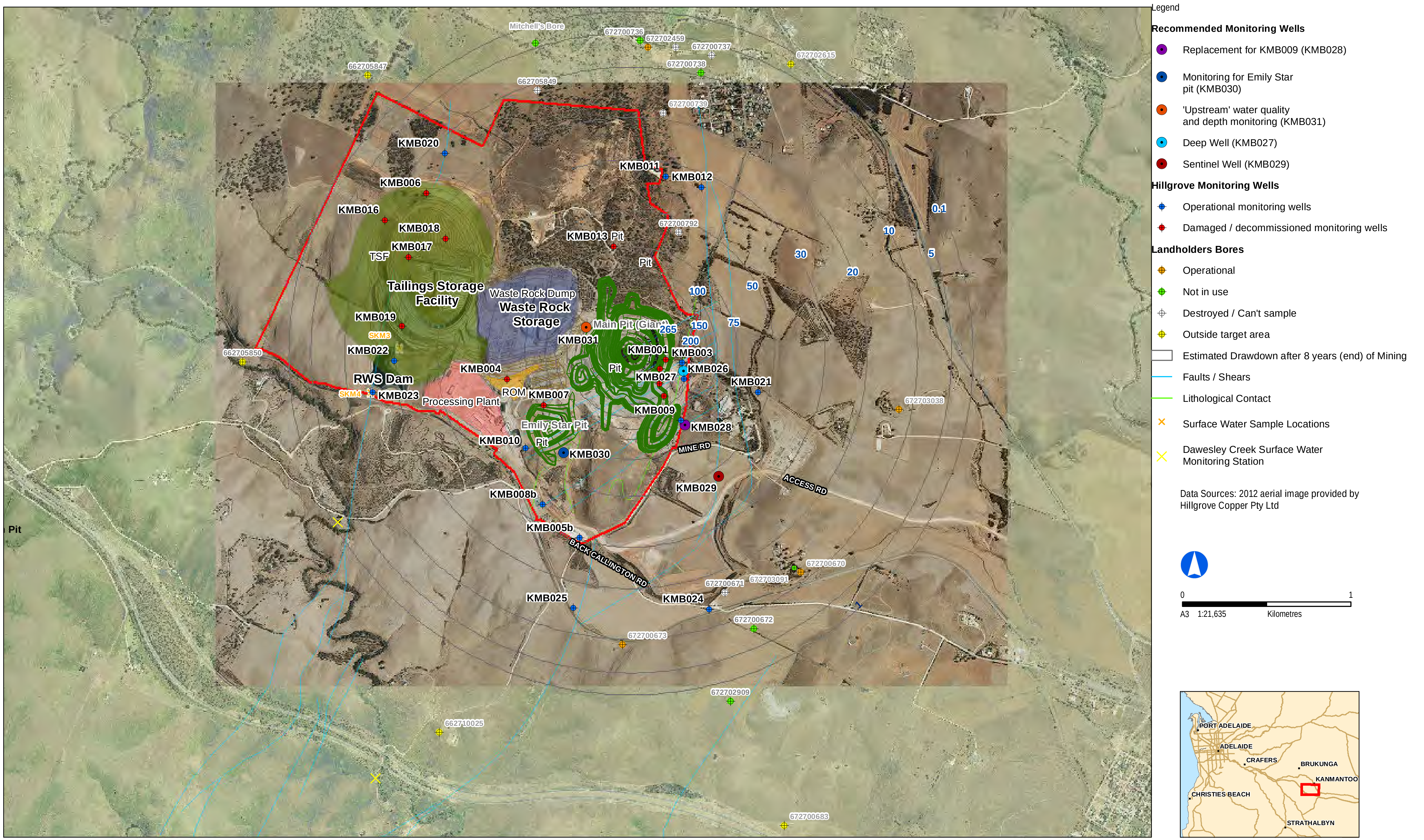

Figure 2. Groundwater Well Location Plan and Proposed Pit Extents

Hillgrove Resources

V3 - May 2014

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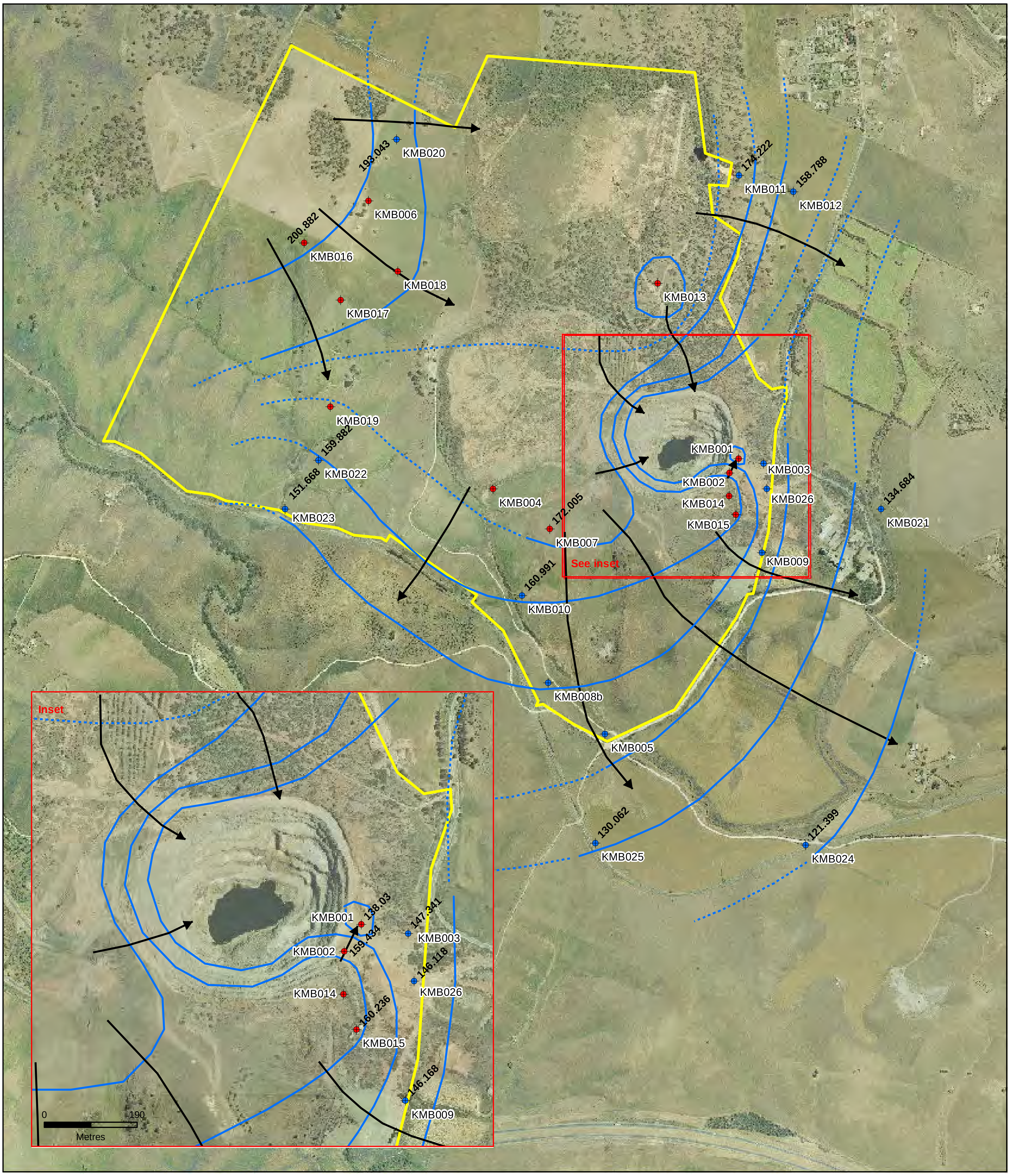

- Operating monitoring wells
- Damaged / decommissioned monitoring wells
- Interpreted Groundwater Elevation (mAHD)
- Inferred Groundwater Elevation (mAHD)
- Groundwater Flow Direction
- Site area

Jacobs SKM does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

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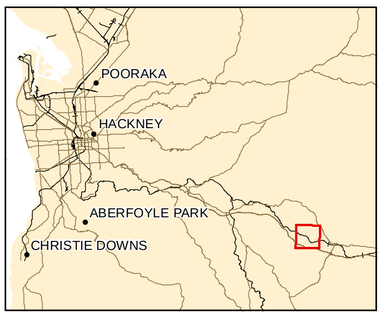

Figure 2. Inferred Groundwater Contours (mAHD) and Flow Direction - November 2011

GDA 1994, MGA Zone 54

JACOBS SKM

Hillgrove Resources - Kanmantoo Copper Project V1

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Appendix A. Summary of all current and historical groundwater monitoring infrastructure

Appendix A. Summary of all current and historical groundwater monitoring infrastructure
Hillgrove Resources - Kanmantoo Copper Project

Well	Purpose	Rationale for Installation	Date Installed	Depth of Well (m bgl)	First Water Cut (m bgl)	Depth of Casing (m bgl)	Screen Interval (m bgl)	Eastings	Northings	Reduced Level m AHD (top of PVC)	Current Status	Notes
KMB001	Monitoring Well	To provide an initial baseline assessment of the groundwater flow conditions and any groundwater quality impacts from historical mining activities	9/11/2006	57	55	-	47 to 57	318378.334	6114920.623	170.324	Destroyed	Identified as destroyed during the July 2012 monthly groundwater monitoring round
KMB002	Monitoring Well	To provide an initial baseline assessment of the groundwater flow conditions and any groundwater quality impacts from historical mining activities	8/11/2006	33.8	17	-	23.8 to 33.8	318343.319	6114865.801	169.667	Destroyed	Identified as destroyed during the January 2012 monthly groundwater monitoring round
KMB003	Monitoring Well	To provide an initial baseline assessment of the groundwater flow conditions and any groundwater quality impacts from historical mining activities	8/11/2006	30	23	-	20 to 30	318473.823	6114903.458	167.054	Operational	
KMB004	Monitoring Well	To provide an initial baseline assessment of the groundwater flow conditions and any groundwater quality impacts from historical mining activities	10/11/2006	15.8	8	-	5.8 to 15.8	317435.026	6114805.44	177.715	Destroyed	Identified as destroyed during the October 2010 GME
KMB005	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply	8/03/2007	120	8	18	Open hole	317865.277	6113863.304	151.748	Collapsed / damaged	Originally proposed for completion as a production well but could not accommodate suitable submersible pump
KMB005b	Water Supply	Replacement production well for KMB005		175	6	48		317862	6113860	-	Operational	
KMB006	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply. This well was also positioned to allow assessment of background groundwater quality.	10/03/2007	96	15	6.5	Open hole	316957.307	6115911.231	211.33	Decommissioned	Decommissioned in September 2011 to accommodate future TSF construction
KMB007	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply. This well was also positioned to allow assessment of background groundwater quality.	14/03/2007	138	54	6.5	Open hole	317653.206	6114651.134	189.981	Destroyed	Identified as destroyed during the May 2012 monthly groundwater monitoring round
KMB008	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply. This well was also positioned to allow assessment of background groundwater quality.	15/03/2007	120	60	10	Open hole	317647.21	6114060.999	159.985	Collapsed / damaged	Originally proposed for completion as a production well but could not accommodate suitable submersible pump
KMB008b	Water Supply	Replacement production well for KMB008		169	4	51.5		317640	6114059	-	Operational	
KMB009	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply	22/03/2007	66	-	53.5	47.5 to 53.5	318467.979	6114559.949	167.215	Operational	Suitable for groundwater level monitoring only due to construction
KMB010	Water Supply	To explore and measure fractured rock aquifer groundwater yields and quality, and provide potential well for water supply	27/03/2007	126	21	6	Open hole	317547.619	6114400.684	166.795	Operational	
KMB011	Monitoring Well	To assess potential impacts to groundwater quality down hydraulic gradient (east) of the old tailings dam	14/05/2007	11	6	-	5 to 11	318379.084	6116010.55	179.347	Operational	
KMB012	Monitoring Well	To assess potential impacts to groundwater quality down hydraulic gradient (east) of the old tailings dam	14/05/2007	17.6	16	-	5.6 to 17.6	318591.965	6115937.616	174.508	Operational	
KMB013	Monitoring Well	To assess potential impacts to groundwater quality down hydraulic gradient (southeast) of the old tailings dam and to assist in the assessment of groundwater flow patterns	15/05/2007	33	31	-	21 to 33	318068.488	6115581.485	231.039	Operational	Well is typically dry. Steel standpipe and PVC standpipe are damaged, well is capped level with surrounding ground surface now.
KMB014	Monitoring Well	To assist in delination of heavy metal impacts from historical mining activities	16/05/2007	24	18	-	15 to 24	318335.971	6114790.554	177.921	Destroyed	Identified as destroyed during the November 2011 GME
KMB015	Monitoring Well	To assist in delination of heavy metal impacts from historical mining activities	17/05/2007	27	24	-	15 to 27	318367.306	6114708.151	173.272	Destroyed	Identified as destroyed during the January 2012 monthly groundwater monitoring round
KMB016*	RC Holes	Installed in the proposed footprint (as of 2007) of the TSF and waste rock storage facility and utilised to provide properties for input into analytical groundwater flow and contaminant fate and transport modelling	June 2007	60	-	-	Open hole	316718	6115752	223.75	Destroyed	Identified as destroyed during the November 2013 GME
KMB017*	RC Holes	Installed in the proposed footprint (as of 2007) of the TSF and waste rock storage facility and utilised to provide properties for input into analytical groundwater flow and contaminant fate and transport modelling	June 2007	60	-	-	Open hole	316864	6115540	220.25	Decommissioned	Decommissioned in September 2011 to accommodate future TSF construction
KMB018*	RC Holes	Installed in the proposed footprint (as of 2007) of the TSF and waste rock storage facility and utilised to provide properties for input into analytical groundwater flow and contaminant fate and transport modelling	June 2007	60	-	-	Open hole	317074	6115639	213.4	Decommissioned	Decommissioned in September 2011 to accommodate future TSF construction
KMB019*	RC Holes	Installed in the proposed footprint (as of 2007) of the TSF and waste rock storage facility and utilised to provide properties for input into analytical groundwater flow and contaminant fate and transport modelling	June 2007	50	-	-	Open hole	-	-	180.13	Destroyed	Identified as destroyed during the May 2011 GME
KMB020	Monitoring Well	To assess potential groundwater level rise and seepage of potentially contaminating leachate resulting from any potential future breach of the TSF liners	3/08/2011	31	22	-	16 to 31	317064.524	6116147.653	212.477	Operational	

Appendix A. Summary of all current and historical groundwater monitoring infrastructure
Hillgrove Resources - Kanmantoo Copper Project

Well	Purpose	Rationale for Installation	Date Installed	Depth of Well (m bgl)	First Water Cut (m bgl)	Depth of Casing (m bgl)	Screen Interval (m bgl)	Eastings	Northings	Reduced Level m AHD (top of PVC)	Current Status	Notes
KMB021	Monitoring Well	To assess any impatcs to groundwater quality down pre-mining hydraulic gradient of the main pit (off site) and to provide data relating to groundwater level drawdown from future pit dewatering activities	2/09/2011	36	29.5	-	18 to 36	318901.469	6114747.793	150.926	Operational	
KMB022	Monitoring Well	To assess potential groundwater level rise and seepage of potentially contaminating leachate resulting from any potential future breach of the TSF liners	4/08/2011	26	17	-	11 to 26	316765.625	6114914.231	168.474	Operational	
KMB023	Monitoring Well	To assess potential groundwater level rise and seepage of potentially contaminating leachate resulting from any potential future breach of the TSF liners	2/09/2011	15	9.5	-	6 to 15	316630.598	6114723.114	157.048	Operational	
KMB024	Monitoring Well	To assess any impatcs to groundwater quality down hydraulic gradient of mining activities (off site), and to provide data relating to groundwater level drawdown from future pit dewatering activities and production well water use	2/09/2011	30	23.5	-	15 to 30	318618.796	6113430.466	138.756	Operational	
KMB025	Monitoring Well	To assess any impatcs to groundwater quality down hydraulic gradient of mining activities (off site), and to provide data relating to groundwater level drawdown from future pit dewatering activities and production well water use	1/09/2011	36	30	-	21 to 36	317817.984	6113458.283	154.486	Operational	
KMB026	Monitoring Well	To provide further information regarding the extent of groundwater quality impacts associated with former heap leach operations (SAMR area) undertaken at the site, and to provide data for use in a Detailed Risk Assessment undertaken to assess the potential risks associated with a localised area of groundwater impacts	2/08/2011	51	34	-	27 to 47	318499.663	6114814.23	170.739	Operational	Collapse in bore from 47m to 51m bgl

Note:
* RC wells installed in June 2007 by Hillgrove Resources

Appendix B. Groundwater quality analytical results

Table 1. Monitoring Well Construction Details and Groundwater Elevation Data
Hillgrove Resources - Kanmantoo Copper Project

Well	Purpose	Eastings	Northings	Depth of Well (m PVC)	Watertable Intersected (m bgl)	Depth of Casing (m bgl)	Reduced Level m AHD (top of PVC)	Water Levels (m PVC) 20 Nov 2006	Reduced Water Levels (m AHD)	Water Levels (m PVC) 21 Nov 2006	Reduced Water Levels (m AHD)	Water Levels (m PVC) 14 Dec 2006	Reduced Water Levels (m AHD)	Water Levels (m PVC) 30 Mar 2007	Reduced Water Levels (m AHD)	Water Levels (m PVC) 18 May 2007	Reduced Water Levels (m AHD)	Water Levels (m PVC) 5 June 2007	Reduced Water Levels (m AHD)
KMB001	Monitoring Well	318378.334	6114920.623	57.73	55	-	170.324	55.177	115.147	54.831	115.493	51.203	119.121	39.970	130.354	38.558	131.766	37.325	132.999
KMB002	Monitoring Well	318343.319	6114865.801	34.43	17	-	169.667	17.224	152.443	17.099	152.568	17.312	152.355	17.330	152.337	5.742	163.925	6.630	163.037
KMB003	Monitoring Well	318473.823	6114903.458	30.83	23	-	167.054	23.564	143.490	23.556	143.498	23.567	143.487	23.705	143.349	23.774	143.280	23.815	143.239
KMB004	Monitoring Well	317435.026	6114805.44	16.52	8	-	177.715	8.423	169.292	8.421	169.294	8.526	169.189	9.320	168.395	-	-	9.240	168.475
KMB005	Water Supply	317865.277	6113863.304	120	8	18	151.748	-	-	-	-	-	-	5.390	146.358	-	-	-	-
KMB005b	Water Supply	317862	6113860	175	6	48	-	-	-	-	-	-	-	-	-	-	-	-	-
KMB006	Water Supply	316957.307	6115911.231	96	15	6	211.33	-	-	-	-	-	-	12.435	198.895	-	-	-	-
KMB007*	Water Supply	317653.206	6114651.134	138	54	6	189.981	-	-	-	-	-	-	19.010	170.971	-	-	20.153	169.828
KMB008*	Water Supply	317647.21	6114060.999	120	60	10	159.985	-	-	-	-	-	-	5.885	154.100	-	-	-	-
KMB008b	Water Supply	317640	6114059	169	4	51.5	-	-	-	-	-	-	-	-	-	-	-	-	-
KMB009	Water Supply	318467.979	6114559.949	66	-	54	167.215	-	-	-	-	-	-	23.315	143.900	-	-	23.290	143.925
KMB010	Water Supply	317546 - GPS	6114396 - GPS	120	21	6	166.795	-	-	-	-	-	-	4.970	161.825	-	-	3.745	163.050
KMB011**	Monitoring Well	318388	6116001	11.04	6	-	179.347	-	-	-	-	-	-	-	-	5.712	173.635	5.640	173.707
KMB012**	Monitoring Well	318589	6115955	17.6	16	-	174.508	-	-	-	-	-	-	-	-	16.179	158.329	16.220	158.288
KMB013**	Monitoring Well	318071	3115583	33.92	31	-	231.039	-	-	-	-	-	-	-	-	30.452	200.587	30.600	200.439
KMB014**	Monitoring Well	318330	6114792	24.93	18	-	177.921	-	-	-	-	-	-	-	-	18.324	159.597	18.330	159.591
KMB015**	Monitoring Well	318367	6114710	27.92	24	-	173.272	-	-	-	-	-	-	-	-	24.013	149.259	21.565	151.707
KMB016***	RC Holes	316718	6115752	60	-	-	223.75	-	-	-	-	-	-	-	-	-	-	25.395	198.355
KMB017***	RC Holes	316864	6115540	60	-	-	220.25	-	-	-	-	-	-	-	-	-	-	-	-
KMB018***	RC Holes	317074	6115639	60	-	-	213.4	-	-	-	-	-	-	-	-	-	-	21.396	192.004
KMB019***	RC Holes	-	-	50	-	-	180.13	-	-	-	-	-	-	-	-	-	-	15.100	165.030
KMB020	Monitoring Well	317064.524	6116147.653	31.76	22	-	212.477	-	-	-	-	-	-	-	-	-	-	-	-
KMB021	Monitoring Well	318901.469	6114747.793	35.58	29.5	-	150.926	-	-	-	-	-	-	-	-	-	-	-	-
KMB022	Monitoring Well	316765.625	6114914.231	26	17	-	168.474	-	-	-	-	-	-	-	-	-	-	-	-
KMB023	Monitoring Well	316630.598	6114723.114	15.76	9.5	-	157.048	-	-	-	-	-	-	-	-	-	-	-	-
KMB024	Monitoring Well	318618.796	6113430.466	30.78	23.5	-	138.756	-	-	-	-	-	-	-	-	-	-	-	-
KMB025	Monitoring Well	317817.984	6113458.283	36.61	30	-	154.486	-	-	-	-	-	-	-	-	-	-	-	-
KMB026	Monitoring Well	318499.663	6114814.23	51	34	-	170.739	-	-	-	-	-	-	-	-	-	-	-	-

Note:

Water level in pit was approximately 105 m AHD on the 6 December 2006 (data provided to REM by Hillgrove Resources).

* Only water supply wells which have not been cased over the watertable.

** Wells drilled in May 2007 by REM

***RC wells installed in June 2007 by Hillgrove Resources

† Water levels gauged on 14 September 2011

Table 1. Monitoring Well Construction Details and Groundwater Elevation Data
Hillgrove Resources - Kanmantoo Copper Project

Well	Purpose	Eastings	Northings	Depth of Well (m PVC)	Watertable Intersected (m bgl)	Depth of Casing (m bgl)	Reduced Level m AHD (top of PVC)	Water Levels (m PVC) 7 July 2007	Reduced Water Levels (m AHD)	Water Levels (m PVC) 11 October 2010	Reduced Water Levels (m AHD)	Water Levels (m PVC) 21 January 2011	Reduced Water Levels (m AHD)	Water Levels (m PVC) 16 May 2011	Reduced Water Levels (m AHD)	Water Levels (m PVC) 15 August 2011	Reduced Water Levels (m AHD)	Water Levels (m PVC) 7 November 2011	Reduced Water Levels (m AHD)
KMB001	Monitoring Well	318378.334	6114920.623	57.73	55	-	170.324	35.470	134.854	31.886	138.438	32.369	137.955	33.493	136.831	31.845	138.479	32.294	138.030
KMB002	Monitoring Well	318343.319	6114865.801	34.43	17	-	169.667	4.608	165.059	5.678	163.989	7.367	162.300	11.628	158.039	5.902	163.765	10.233	159.434
KMB003	Monitoring Well	318473.823	6114903.458	30.83	23	-	167.054	23.824	143.230	20.975	146.079	19.895	147.159	19.609	147.445	19.102	147.952	19.713	147.341
KMB004	Monitoring Well	317435.026	6114805.44	16.52	8	-	177.715	9.401	168.314	DESTROYED		DESTROYED		DESTROYED		DESTROYED		DESTROYED	
KMB005	Water Supply	317865.277	6113863.304	120	8	18	151.748	5.374	146.374	14.463	137.285	21.835	129.913	22.271	129.477	7.713	144.035	-	-
KMB005b	Water Supply	317862	6113860	175	6	48	-	-	-	-	-	-	-	-	-	-	-	-	-
KMB006	Water Supply	316957.307	6115911.231	96	15	6	211.33	12.978	198.352	15.595	195.735	11.859	199.471	11.801	199.529	11.609	199.721	-	-
KMB007*	Water Supply	317653.206	6114651.134	138	54	6	189.981	20.211	169.770	17.704	172.277	17.186	172.795	17.321	172.660	17.625	172.356	17.976	172.005
KMB008*	Water Supply	317647.21	6114060.999	120	60	10	159.985	3.786	156.199	9.835	150.150	4.360	155.625	8.070	151.915	-	-	-	-
KMB008b	Water Supply	317640	6114059	169	4	51.5	-	-	-	-	-	-	-	-	-	-	-	-	-
KMB009	Water Supply	318467.979	6114559.949	66	-	54	167.215	23.522	143.693	22.826	144.389	20.780	146.435	20.727	146.488	20.817	146.398	21.047	146.168
KMB010	Water Supply	317546 - GPS	6114396 - GPS	120	21	6	166.795	3.754	163.041	3.659	163.136	4.134	162.661	4.124	162.671	4.290	162.505	5.804	160.991
KMB011**	Monitoring Well	318388	6116001	11.04	6	-	179.347	5.407	173.940	4.891	174.456	4.865	174.482	5.195	174.152	4.933	174.414	5.125	174.222
KMB012**	Monitoring Well	318589	6115955	17.6	16	-	174.508	16.201	158.307	16.279	158.229	16.101	158.407	15.950	158.558	15.800	158.708	15.720	158.788
KMB013**	Monitoring Well	318071	3115583	33.92	31	-	231.039	30.690	200.349	33.564	197.475	33.792	197.247	33.818	197.221	33.940	197.099	-	-
KMB014**	Monitoring Well	318330	6114792	24.93	18	-	177.921	17.972	159.949	17.814	160.107	14.158	163.763	13.622	164.299	14.811	163.110	-	-
KMB015**	Monitoring Well	318367	6114710	27.92	24	-	173.272	20.958	152.314	7.684	165.588	8.035	165.237	9.112	164.160	9.645	163.627	13.036	160.236
KMB016***	RC Holes	316718	6115752	60	-	-	223.75	25.442	198.308	21.044	202.706	21.560	202.190	22.228	201.522	22.614	201.136	22.868	200.882
KMB017***	RC Holes	316864	6115540	60	-	-	220.25	27.146	193.104	24.367	195.883	24.825	195.425	26.930	193.320	-	-	-	-
KMB018***	RC Holes	317074	6115639	60	-	-	213.4	21.473	191.927	20.086	193.314	19.609	193.791	19.714	193.686	19.634	193.766	-	-
KMB019***	RC Holes	-	-	50	-	-	180.13	15.640	164.490	10.882	169.248	13.719	166.411	DESTROYED		DESTROYED		DESTROYED	
KMB020	Monitoring Well	317064.524	6116147.653	31.76	22	-	212.477	-	-	-	-	-	-	-	-	19.389	193.088	19.434	193.043
KMB021	Monitoring Well	318901.469	6114747.793	35.58	29.5	-	150.926	-	-	-	-	-	-	-	-	16.24†	134.686	16.242	134.684
KMB022	Monitoring Well	316765.625	6114914.231	26	17	-	168.474	-	-	-	-	-	-	-	-	8.311	160.163	8.592	159.882
KMB023	Monitoring Well	316630.598	6114723.114	15.76	9.5	-	157.048	-	-	-	-	-	-	-	-	5.522†	151.526	5.380	151.668
KMB024	Monitoring Well	318618.796	6113430.466	30.78	23.5	-	138.756	-	-	-	-	-	-	-	-	17.42†	121.336	17.357	121.399
KMB025	Monitoring Well	317817.984	6113458.283	36.61	30	-	154.486	-	-	-	-	-	-	-	-	24.35†	130.136	24.424	130.062
KMB026	Monitoring Well	318499.663	6114814.23	51	34	-	170.739	-	-	-	-	-	-	-	-	24.334	146.405	24.621	146.118

Note:
Water level in pit was approximately 105 m AHD on the 6 December 2006 (data provided to REM by Hillgrove Resources).
* Only water supply wells which have not been cased over the watertable.
** Wells drilled in May 2007 by REM
***RC wells installed in June 2007 by Hillgrove Resources
† Water levels gauged on 14 September 2011

Table 2. Summary of Groundwater and Surface Water Field Parameters
Hillgrove Resources - Kanmantoo Copper Project

Well	Sampling Depth (2007) (m bPVC)	Sampling Depth (2010) (m bPVC)	Sampling Depth (Jan 2011) (m bPVC)	Sampling Depth (May 2011) (m bPVC)	Sampling Depth (Aug / Sept 2011) (m bPVC)	pH								Electrical Conductivity (mS/cm)								Total Dissolved Solids (mg/L)							
						Nov-2006	Apr-2007	Jun-2007	Oct-2010	Jan-2011	May-2011	Aug / Sept 2011	Nov-2011	Nov-2006	Apr-2007	Jun-2007	Oct-2010	Jan-2011	May-2011	Aug / Sept 2011	Nov-2011	Nov-2006	Apr-2007	Jun-2007	Oct-2010	Jan-2011	May-2011	Aug / Sept 2011	Nov-2011
KMB001	40	watertable	watertable	watertable	watertable	4.94	5.15	-	6.67	5.03	5.07	4.50	3.25	5.96	5.98	-	4.25	5.61	5.22	5.41	1.86	3,874	3,887	-	2,763	3,647	3,393	3,517	1,210
KMB002	24	watertable - 26	26	26	26	3.94	4.17	-	4.08	3.57	3.88	3.49	3.30	3.98	1.98	-	7.00	2.86	2.73	19.73	17.93	2,587	1,287	-	4,550	1,859	1,775	12,825	11,655
KMB003	24	watertable - 24	24	24	24	6.71	7.51	-	6.76	6.90	6.60	6.50	6.37	3.61	3.35	-	3.48	3.78	3.78	4.12	4.15	2,347	2,178	-	2,262	2,457	2,457	2,678	2,698
KMB004	10	Destroyed	Destroyed	Destroyed	Destroyed	6.8	7.97	-	Destroyed					5.92	6.11	-	Destroyed					3,848	3,972	-	Destroyed				
KMB005	54	-	-	-	-	-	7.35	-	-	-	-	-	-	-	5.39	-	-	-	-	-	-	-	3,504	-	-	-	-	-	-
KMB005b	-	unknown*	unknown*	unknown*	unknown*	-	-	-	7.13	7.14	6.83	7.07	6.49	-	-	-	5.50	5.91	5.63	6.16	5.89	-	-	-	3,575	3,842	3,660	4,004	3,829
KMB006 - watertable	13	-	-	-	-	-	7.55	-	-	-	-	-	-	-	12.94	-	-	-	-	-	-	-	8,411	-	-	-	-	-	-
KMB006 - at depth	48	48	48	36	36	-	7.89	-	6.73	7.37	6.65	6.65	-	-	13.05	-	12.23	13.23	13.34	13.43	-	-	8,483	-	7,950	8,600	8,671	8,730	-
KMB007 - watertable	20	54	-	-	-	-	7.96	-	-	-	-	-	-	-	2.74	-	-	-	-	-	-	-	1,781	-	-	-	-	-	-
KMB007 - at depth	54	54	54	54	54	-	7.57	-	6.62	6.49	6.53	6.40	6.38	-	4.23	-	4.09	4.97	5.66	5.59	5.41	-	2,750	-	2,659	3,231	3,679	3,634	3,517
KMB008	60	-	-	-	-	-	7.12	-	-	-	-	-	-	-	5.83	-	-	-	-	-	-	-	3,790	-	-	-	-	-	-
KMB008b	-	unknown*	unknown*	unknown*	unknown*	-	-	-	6.67	7.04	6.49	6.78	6.72	-	-	-	6.09	5.90	5.96	6.86	45.00	-	-	-	3,959	3,835	3,874	4,459	29,250
KMB009	-	watertable	watertable	watertable	watertable	-	-	-	6.07	6.89	6.90	6.46	7.09	-	-	-	5.22	5.24	5.25	5.61	1.80	-	-	-	3,393	3,406	3,413	3,647	1,167
KMB010	-	34.5	34.5	35.0	34.5	-	-	-	6.82	6.79	6.75	6.73	6.52	-	-	-	5.96	2.91	7.09	3.91	3.49	-	-	-	3,874	1,892	4,609	2,542	2,269
KMB011	7	watertable	watertable	watertable	watertable	-	-	6.34	5.21	5.63	4.12**	5.45	5.58	-	-	9.27	9.60	9.92	9.30	10.10	9.34	-	-	6,026	6,240	6,448	6,045	6,565	6,071
KMB012	17	watertable	watertable	watertable	watertable	-	-	8.32	7.51	7.50	5.83**	7.53	7.20	-	-	7.69	6.72	7.19	6.72	7.05	6.67	-	-	4,999	4,368	4,674	4,368	4,583	4,336
KMB013	32	watertable	-	-	-	-	-	7.87	6.58	-	-	-	-	-	-	24.86	24.90	-	-	-	-	-	-	16,159	16,185	-	-	-	-
KMB014	20	watertable	watertable	watertable	watertable	-	-	6.99	5.70	5.09	6.03	5.49	-	-	-	2.27	3.36	3.73	3.71	3.60	-	-	-	1,473	2,184	2,425	2,412	2,340	-
KMB015	23	watertable	watertable	watertable	watertable	-	-	6.87	3.84	4.16	3.94	3.92	4.08	-	-	3.12	3.34	3.55	4.04	3.24	2.57	-	-	2,028	2,168	2,308	2,626	2,106	1,671
KMB016	27	watertable - 23	23	24	24	-	-	7.81	7.03	7.83	6.92	6.95	6.84	-	-	6.69	1.41	1.56	1.47	1.42	1.68	-	-	4,349	917	1,011	956	923	1,090
KMB017	28	watertable - 27	27	-	-	-	-	7.63	7.00	7.56	-	-	-	-	-	16.39	5.19	5.34	-	-	-	-	-	10,654	3,374	3,471	-	-	-
KMB018	23	watertable - 22	22	22	22	-	-	7.78	7.20	7.64	6.90	6.88	-	-	-	10.64	8.25	9.12	9.16	8.77	-	-	-	6,916	5,363	5,928	5,954	5,701	-
KMB019	16	watertable - 13	16	Destroyed	Destroyed	-	-	7.35	6.82	7.82	Destroyed			-	-	9.46	2.41	2.57	Destroyed			-	-	6,149	1,567	1,671	Destroyed		
KMB020	-	-	-	-	23	-	-	-	-	-	-	7.31	7.08	-	-	-	-	-	-	6.92	6.72	-	-	-	-	-	-	4,498	4,368
KMB021	-	-	-	-	30.5	-	-	-	-	-	-	6.85	6.51	-	-	-	-	-	-	5.45	5.38	-	-	-	-	-	-	3,543	3,497
KMB022	-	-	-	-	18	-	-	-	-	-	-	7.03	6.68	-	-	-	-	-	-	11.24	12.00	-	-	-	-	-	-	7,306	7,800
KMB023	-	-	-	-	10.5	-	-	-	-	-	-	6.81	6.76	-	-	-	-	-	-	6.66	5.72	-	-	-	-	-	-	4,329	3,718
KMB024	-	-	-	-	27	-	-	-	-	-	-	7.30	6.98	-	-	-	-	-	-	2.55	2.51	-	-	-	-	-	-	1,658	1,632
KMB025	-	-	-	-	31.5	-	-	-	-	-	-	6.60	6.03	-	-	-	-	-	-	10.23	9.42	-	-	-	-	-	-	6,650	6,123
KMB026	-	-	-	-	35	-	-	-	-	-	-	6.52	6.44	-	-	-	-	-	-	5.32	4.94	-	-	-	-	-	-	3,458	3,211
Pit Void	-	-	-	-	-	-	-	-	2.85	-	2.74	2.45	2.52	-	-	-	9.61	-	12.18	14.54	8.24	-	-	-	6,247	-	7,917	9,451	5,356
Spring 1 (SW1)	-	-	-	-	-	-	-	-	7.88	-	8.21	-	-	-	-	-	15.56	-	9.75	-	-	-	-	-	10,114	-	6,338	-	-
Spring 2 (SW2)	-	-	-	-	-	-	-	-	-	-	8.07	-	-	-	-	-	-	-	8.51	-	-	-	-	-	-	-	5,532	-	-
SW3 (spring)	-	-	-	-	-	-	-	-	-	-	-	7.86	8.40	-	-	-	-	-	-	9.45	2.93	-	-	-	-	-	-	6,143	1,905
SW4 (surface water)	-	-	-	-	-	-	-	-	-	-	-	7.88	7.35	-	-	-	-	-	-	0.30	0.48	-	-	-	-	-	-	193	314

Note:

TDS calculated by multiplying EC by a factor of 650

* These wells were equipped with an electric well pump by a contractor.

** These pH values recorded in the May 2011 sampling event are believed to be spurious. The pH probe was found to be faulty shortly after sampling these wells.

Table 1: Summary of Lanholder Bore Details and Status

Client: Hillgrove Resources

Project Name: November 2011 Groundwater Monitoring Event

Project Number: VE23468

Well ID	Property Owner	Parcel Details	Phone	Well Status	Purpose	Easting	Northing	Drill Date	Drill Permit	Depth (m)	SWL (m TOC) May 2011	SWL (m TOC) Nov 2011	Pump Depth (m)	Yield (L/sec)	Comments/Sampling Details	Sampled 20/10/08	Sampled 30/10/08	Sampled October 2010	Sampled May 2011	Sampled November 2011
672702909	George Fule	D60948 A29	0409 520 990	Not in use		0318785	6112840	17/04/2002[2]	58111[2]	91[2]	28.515	28.175	83[1]	2.25[2]	Need generator to sample (silenced 2kva is sufficient).	No	Yes	Yes	Yes	Yes
672700673	Geoff & Sue Aubert	D47967 A3	Geoff 0438 400 096 08 8388 6822	Operational	Stock	0318119	6113235			43[1]	23.76	23.305	30[1]	0.5[1]	Windmill driven pump, take grab sample from adjacent concrete water tank (can't sample from poly-pipe)	Yes	No	Yes	Yes	Yes
672700672	Bill & Sarah Filmer	D60948 A25	0439 464 473	Not in use		0318982[2]	6113334[2]			~ 60	34.145	-	-	-	Not on Filmer's property, AJ & RM Phillips? Old windmill, out of service, bore drilled inside old large diameter well, cannot get bailer down to sample	No	No	No	No	No
672700671	Bill & Sarah Filmer	D60948 Q26, Q27	0439 464 473	Destroyed		0318729[2]	6113539[2]			9.1[2]		-	-	-	Destroyed	No	No	No	No	No
672700670	Bill & Sarah Filmer	D60948 Q26, Q27	0439 464 473	Not in use	Irrigation	0319196	6113655	Pre 1950's[1]		15.91	11.115	10.895	≈ 15[1]	0.5[2]	Old bore, not used . Pump has seized and cannot be sampled.	No	Yes	No	No	Yes
672703091	Bill & Sarah Filmer	D60948 Q26, Q27	0439 464 473	Not in Use	Domestic & Irrigation	0319131	6113699	21/11/2005[2]	107260[2]	133[1]	13.68	13.41	72[1]	0.75[2]	Bore pump has broken down, to be replaced by property owner by end of 2011.	No	Yes	No	No	Yes
672703038	Keith & Barbara Wilkinson	F1636 A3	08 8538 5339 Call after 6pm	Operational	Domestic & Stock	0319767	6114639	≈ 1980[1]		40[1]	18.26	17.8	≈ 30[1]	1.25[1]	Has electric pump to sample.	Yes	No	Yes	Yes	Yes
672700736	Alex Wells	F16808 A69	08 8538 5001 0407 600 438	Not in use		0318226	6116815	1952[1]		72[1]	16.23	14.115	-	-	Old bore not in use, sample by bailer.	No	Yes	Yes	Yes	Yes
672700737	Steve & Wendy Kurtis	F212360 A107	Steve 0400 565 731, 8538 5586	Destroyed		0318650[2]	6116729[2]			12.2[2]		-	-	-	Destroyed	No	No	No	No	No
672700738	Steve & Wendy Kurtis	F212360 A107	Wendy 0400 565 732	Not in use		0318585[2]	6116626[2]			8.595	Dry	-	-	-	Windmill driven pump, not in use, well has been capped. Property owner potentially looking to reinstate well.	No	No	No	No	No
672700739	Alex Wells	D20509 A60	08 8538 5001 0407 600 438	Destroyed		0318361[2]	6116388[2]			64[2]		-	-	1.8[2]	Destroyed	No	No	No	No	No
672700792	Alex Wells	D20509 A60	08 8538 5001 0407 600 438	Destroyed		0318455[2]	6115679[2]			Unknown		-	-	-	Destroyed	No	No	No	No	No
672703043	Alex Wells	F16808 A69	08 8538 5001 0407 600 438	Destroyed		0318436[2]	6116778[2]	13/04/1994[2]		187.2[2]		-	-	-	Destroyed	No	No	No	No	No
672702459	Alex Wells	F16808 A69	08 8538 5001 0407 600 438	Operational	Domestic & Stock	0318242	6116800	22/04/1994[2]	31701[2]	104[1]	14.825	12.5	≈ 92[1]	1.25[1]	Has electric pump to sample	Yes	No	Yes	Yes	Yes
662705849	Alex Wells	D20509 A60	08 8538 5001 0407 600 438	Destroyed		0317614[2]	6116522[2]	28/11/1973[2]		71.1[2]		-	-	-	Destroyed	No	No	No	No	No
Mitchell's Bore	Alex Wells	F16808 A69	08 8538 5001 0407 600 438	Not in use		0317600	6116792	Pre 1950's[1]		72[1]	28.69	28.65	-	-	Old bore not in use, sample by bailer.	No	Yes	Yes	Yes	Yes

Note:

[1] Information provided by Landholder

[2] Information sourced from DWLBC Drillhole Enquiry System

[3] Electronic Dip Meter used to gauge standing water level (SWL)

Can't be sampled

Table 2. Monitoring Well Construction Details and Groundwater Elevation Data
Hillgrove Resources - Kanmantoo Copper Project

Well	Purpose	Eastings	Northings	Depth of Well (m PVC)	Water Levels (m PVC) May 2011	Water Levels (m PVC) Nov 2011
672702909		0318785	6112840	91[2]	28.515	28.175
672700673	Stock	0318119	6113235	43[1]	23.760	23.305
672700672		0318982[2]	6113334[2]	~ 60	34.145	-
672700671		0318729[2]	6113539[2]	9.1[2]	-	-
672700670	Irrigation	0319196	6113655	15.91	11.115	10.895
672703091	Domestic & Irrigation	0319131	6113699	133[1]	13.680	13.410
672703038	Domestic & Stock	0319767	6114639	40[1]	18.260	17.800
672700736		0318226	6116815	72[1]	16.230	14.115
672700737		0318650[2]	6116729[2]	12.2[2]	-	-
672700738		0318585[2]	61166262	8.595	Dry	-
672700739		0318361[2]	6116388[2]	64[2]	-	-
672700792		0318455[2]	6115679[2]	Unknown	-	-
672703043		0318436[2]	6116778[2]	187.2[2]	-	-
672702459	Domestic & Stock	0318242	6116800	104[1]	14.825	12.500
662705849		0317614[2]	6116522[2]	71.1[2]	-	-
Mitchell's Bore		0317600	6116792	72[1]	28.690	28.650

Note:

Water level in pit was approximately 105 m AHD on the 6 December 2006 (data provided to REM by Hillgrove Resources).

* Only water supply wells which have not been cased over the watertable.

** Wells drilled in May 2007 by REM

***RC wells installed in June 2007 by Hillgrove Resources

† Water levels gauged on 14 September 2011

Table 3. Summary of Groundwater and Surface Water Field Parameters
Hillgrove Resources - Kanmantoo Copper Project

Well	Sampling Depth (May 2011) (m bPVC)	Sampling Depth (Nov 2011) (m bPVC)	pH		Electrical Conductivity (mS/cm)		Total Dissolved Solids (mg/L)		Redox (mV)		Temperature (ºC)	
			May-2011	Nov-2011	May-2011	Nov-2011	May-2011	Nov-2011	May-2011	Nov-2011	May-2011	Nov-2011
672702909			7.80	8.17	3.90	3.57	2,535	2,321	5.9	47.2	20.6	19.5
672700673			7.04	7.53	6.40	6.56	4,160	4,264	230.6	167.9	14.5	17.5
672700672			-	-	-	-	-	-	-	-	-	-
672700671			-	-	-	-	-	-	-	-	-	-
672700670			-	7.67	-	3.94	-	2,561	-	159.9	-	16.9
672703091			-	7.15	-	5.23	-	3,400	-	133.4	-	18.0
672703038			6.85	7.34	4.21	3.67	2,737	2,386	36.8	65.8	18.8	19.5
672700736			6.54	6.87	8.15	6.55	5,298	4,258	9.2	-16.7	18.1	17.3
672700737			-	-	-	-	-	-	-	-	-	-
672700738			-	-	-	-	-	-	-	-	-	-
672700739			-	-	-	-	-	-	-	-	-	-
672700792			-	-	-	-	-	-	-	-	-	-
672703043			-	-	-	-	-	-	-	-	-	-
672702459			6.53	6.72	8.58	7.59	5,577	4,934	9.3	22.7	19.3	17.8
662705849			-	-	-	-	-	-	-	-	-	-
Mitchell's Bore			6.73	7.08	9.59	8.63	6,234	5,610	-44.1	-75.4	16.7	17.0

Note:

TDS calculated by multiplying EC by a factor of 650

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals and Nutrient Analysis
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units							
			Location	KMB001	KMB001	KMB001	KMB001	KMB001	KMB001	KMB001
			Sampled	21/11/2006	3/04/2007	18/10/2010	24/01/2011	19/05/2011	16/08/2011	7/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	MGT	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	-	5.96	6.00	5.12	4.45	4.15
Electrical Conductivity	1	10	µS/cm	-	-	5430	2360	5430	5270	6750
MAJOR IONS										
Calcium	1	0.5	mg/L	520	487	323	351	325	246	226
Magnesium	1	0.5	mg/L	410	445	374	475	411	359	386
Potassium	1	0.5	mg/L	140	75	64	86	89	57	32
Sodium	1	0.5	mg/L	420	403	361	402	368	328	213
Chloride	1	1	mg/L	220	376	356	801	300	316	343
Sulphate as SO4 2-	1	5	mg/L	1300	3910	2650	2360	3200	2600	3770
Hydroxide Alkalinity as CaCO3	1		mg/L	-	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	<0.5	<1	308	77	2	<1	<1
Carbonate Alkalinity as CaCO3	1	10	mg/L	<0.5	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	-	<1	308	77	2	<1	<1
Total Cyanide	0.005	0.01	mg/L	<0.01	0.014	-	-	-	-	-
Total Anions	0.01		meq/L	-	92	71.3	73.3	75.1	63	88.2
Total Cations	0.01		meq/L	-	80.4	64.2	76.3	68.3	57.6	53.1
Ionic Balance	0.01		%	-	6.77	5.25	1.98	4.78	4.57	-
HEAVY METALS (Dissolved)										
Aluminium	0.01	0.005	mg/L	15	-	0.12	10.9	21	41	178
Arsenic	0.001	0.001	mg/L	0.041	0.004	0.012	0.003	0.037	0.011	0.008
Beryllium	0.001	0.001	mg/L	-	0.056	0.002	0.04	0.084	0.091	0.237
Barium	0.001	0.02	mg/L	-	0.036	0.062	0.032	0.025	0.02	0.02
Cadmium	0.0001	0.0002	mg/L	0.051	0.126	0.0003	0.001	0.0086	0.0042	0.0553
Chromium	0.001	0.001	mg/L	<0.001	0.001	<0.001	0.002	<0.001	0.004	0.017
Cobalt	0.001	0.001	mg/L	9.4	14.7	0.074	1.52	6.58	5.75	15.4
Copper	0.001	0.001	mg/L	14	14.8	0.001	0.007	0.014	0.033	10.2
Iron	0.01	0.05	mg/L	120	-	5.55	114	120	277	379
Lead	0.001	0.001	mg/L	0.06	0.449	<0.001	0.006	0.026	0.007	0.092
Manganese	0.001	0.005	mg/L	21	25.8	22.1	94.2	102	78.6	115
Mercury	0.0001	0.0001	mg/L	0.0003	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	3	4.94	0.037	0.324	1.88	1.53	4.64
Selenium	0.01	0.001	mg/L	0.24	-	<0.01	<0.01	<0.01	<0.01	0.02
Vanadium	0.01	0.005	mg/L	-	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Zinc	0.005	0.001	mg/L	8.1	16.4	0.01	0.461	4.17	3.12	13.2
NUTRIENTS										
Ammonia as N	0.01	0.01	mg/L	-	-	0.37	<0.01	<0.01	<0.01	0.29
Nitrite as N	0.01		mg/L	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	0.2	<0.010	0.02	0.41	0.11	0.15	0.1
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	-	0.02	0.41	0.11	0.15	0.1
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	-	0.9	<0.1	2.5	1.2	1.5
Total Nitrogen as N	0.1	0.2	mg/L	-	-	0.9	0.4	2.6	1.4	1.6
Total Phosphorus as P	0.01	0.05	mg/L	-	-	0.07	0.13	0.61	0.17	0.23

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

			Location	KMB002	KMB002	KMB002	KMB002	KMB002	KMB002	KMB002
			Sampled	21/11/2006	3/04/2007	14/10/2010	25/01/2011	19/05/2011	17/08/2011	9/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	MGT	ALS	ALS	ALS	ALS	ALS	ALS
Chemical	**ALS LOR**	**MGT LOR**	**Units**							
pH	0.01	0.1	pH unit	-	-	3.87	3.67	3.89	3.82	3.7
Electrical Conductivity	1	10	µS/cm	-	-	6810	3150	3030	24000	17500
MAJOR IONS										
Calcium	1	0.5	mg/L	240	188	233	198	155	346	280
Magnesium	1	0.5	mg/L	230	168	294	147	133	1500	1140
Potassium	1	0.5	mg/L	52	34	41	36	30	27	14
Sodium	1	0.5	mg/L	280	143	102	70	62	111	72
Chloride	1	1	mg/L	150	285	155	82	86	204	192
Sulphate as SO4 2-	1	5	mg/L	870	1750	5400	1050	1000	26500	14400
Hydroxide Alkalinity as CaCO3	1		mg/L	-	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	<0.5	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	1	10	mg/L	<0.5	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	-	<1	<1	<1	<1	<1	<1
Total Cyanide	0.005	0.01	mg/L	<0.01	<0.005	-	-	-	-	-
Total Anions	0.01		meq/L	-	44.4	117	24.2	23.2	557	305
Total Cations	0.01		meq/L	-	35.5	126	26.0	22.2	146	111
Ionic Balance	0.01		%	-	11.2	3.83	3.58	2.35	58.4	-
HEAVY METALS (Dissolved)										
Aluminium	0.01	0.005	mg/L	91	-	391	98.9	122	1320	1150
Arsenic	0.001	0.001	mg/L	0.006	0.003	0.015	0.003	0.003	<0.100	0.027
Beryllium	0.001	0.001	mg/L	-	0.051	0.176	0.042	0.056	0.256	0.232
Barium	0.001	0.02	mg/L	-	0.016	0.016	0.017	0.021	<0.100	0.024
Cadmium	0.0001	0.0002	mg/L	0.024	4.16	0.0321	0.0161	0.0215	0.0417	0.0462
Chromium	0.001	0.001	mg/L	<0.001	0.004	0.036	0.008	0.008	0.4	0.304
Cobalt	0.001	0.001	mg/L	3.6	4.4	42.1	6.27	8.39	58.2	59
Copper	0.001	0.001	mg/L	10	118	495	128	146	581	526
Iron	0.01	0.05	mg/L	1.2	-	108	0.54	0.56	5860	4730
Lead	0.001	0.001	mg/L	0.23	0.045	0.027	0.016	0.059	<0.100	0.006
Manganese	0.001	0.005	mg/L	17	20.5	263	37.5	42.7	490	451
Mercury	0.0001	0.0001	mg/L	<0.0005	<0.0001	<0.0001	<0.0001	0.0013	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	2.5	1.91	7.21	3.03	6.37	18	16
Selenium	0.01	0.001	mg/L	0.039	-	0.04	0.01	0.01	<1.00	0.1
Vanadium	0.01	0.005	mg/L	-	<0.01	<0.01	<0.01	<0.01	<1.00	0.3
Zinc	0.005	0.001	mg/L	1.3	1.8	26.2	4.13	5.84	116	111
NUTRIENTS										
Ammonia as N	0.01	0.01	mg/L	-	-	0.08	0.17	<0.01	4.22	<0.01
Nitrite as N	0.01		mg/L	-	-	0.02	-	<0.01	0.02	0.04
Nitrate as N	0.01	0.02	mg/L	9.6	14.4	7.19	-	9.74	<0.01	0.62
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	-	7.21	8.69	9.74	<0.01	0.66
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	-	0.5	<0.1	0.5	4.4	3.6
Total Nitrogen as N	0.1	0.2	mg/L	-	-	7.7	8.7	10.2	4.4	4.3
Total Phosphorus as P	0.01	0.05	mg/L	-	-	0.36	0.25	0.55	9.05	4.78

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units									
			Location	KMB003	KMB003	KMB003	KMB003	KMB003	KMB003	KMB003	KMB004	KMB004
			Sampled	21/11/2006	3/04/2007	14/10/2010	24/01/2011	19/05/2011	16/08/2011	8/11/2011	21/11/2006	2/04/2007
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	MGT	ALS	ALS	ALS	ALS	ALS	ALS	MGT	ALS
pH	0.01	0.1	pH unit	-	-	7.01	6.08	6.84	7.68	6.78	-	-
Electrical Conductivity	1	10	µS/cm	-	-	3690	4010	3780	3960	4010	-	-
MAJOR IONS												
Calcium	1	0.5	mg/L	150	139	148	137	141	165	160	400	395
Magnesium	1	0.5	mg/L	140	144	140	157	145	172	169	430	417
Potassium	1	0.5	mg/L	48	38	45	42	41	42	30	66	50
Sodium	1	0.5	mg/L	470	492	501	544	516	555	532	740	768
Chloride	1	1	mg/L	590	712	628	750	550	528	577	310	441
Sulphate as SO4 2-	1	5	mg/L	340	948	1060	823	980	1200	1090	1100	3090
Hydroxide Alkalinity as CaCO3	1		mg/L	-	<1	<1	<1	<1	<1	<1	-	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	240	226	165	163	142	154	160	430	374
Carbonate Alkalinity as CaCO3	1	10	mg/L	<0.5	<1	<1	<1	<1	<1	<1	<0.5	<1
Total Alkalinity as CaCO3	1	20	mg/L	-	226	165	163	142	154	160	-	374
Total Cyanide	0.005	0.01	mg/L	<0.01	<0.005	-	-	-	-	-	<0.01	0.017
Total Anions	0.01		meq/L	-	44.3	43.2	41.6	38.8	43	-	-	84.2
Total Cations	0.01		meq/L	-	41.2	41.8	44.5	42.5	47.6	-	-	88.7
Ionic Balance	0.01		%	-	3.65	1.6	3.37	4.59	5.12	-	-	2.59
HEAVY METALS (Dissolved)												
Aluminium	0.01	0.005	mg/L	<0.005	-	0.02	<0.01	<0.01	<0.01	<0.01	<0.005	-
Arsenic	0.001	0.001	mg/L	0.009	0.01	<0.001	0.001	<0.001	<0.001	<0.001	0.008	0.003
Beryllium	0.001	0.001	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.001
Barium	0.001	0.02	mg/L	-	0.039	0.012	0.014	0.013	0.013	0.014	-	0.039
Cadmium	0.0001	0.0002	mg/L	<0.0002	0.0003	0.0004	0.0003	0.0003	0.0003	0.0003	0.0057	0.0058
Chromium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.096	0.011	0.004	0.001	0.002	0.002	0.001	0.29	0.101
Copper	0.001	0.001	mg/L	0.09	0.01	0.037	0.006	0.014	0.006	0.008	0.14	0.039
Iron	0.01	0.05	mg/L	1.7	-	<0.05	<0.05	<0.05	<0.05	<0.05	3.8	-
Lead	0.001	0.001	mg/L	<0.001	<0.001	0.001	0.002	<0.001	0.001	0.002	<0.001	0.002
Manganese	0.001	0.005	mg/L	0.71	0.219	0.022	0.036	0.004	0.003	0.003	1.8	1.01
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.023	0.026	0.019	0.014	0.009	0.011	0.01	0.27	0.158
Selenium	0.01	0.001	mg/L	0.063	-	0.01	0.02	0.02	0.01	0.01	0.074	-
Vanadium	0.01	0.005	mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01
Zinc	0.005	0.001	mg/L	0.013	0.009	0.045	0.045	0.036	0.056	0.056	0.066	0.053
NUTRIENTS												
Ammonia as N	0.01	0.01	mg/L	-	-	0.02	0.03	<0.01	<0.01	0.02	-	-
Nitrite as N	0.01		mg/L	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Nitrate as N	0.01	0.02	mg/L	2.4	10.2	11.8	14.5	14.4	10.9	11.2	6.3	5.82
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	-	11.8	14.5	14.4	10.9	11.2	-	-
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	-	<0.1	<0.1	0.3	<0.1	0.3	-	-
Total Nitrogen as N	0.1	0.2	mg/L	-	-	11.8	14.5	14.7	10.9	11.5	-	-
Total Phosphorus as P	0.01	0.05	mg/L	-	-	0.05	0.25	0.14	0.1	0.41	-	-

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units					
			Location	KMB005b	KMB005b	KMB005b	KMB005b	KMB005b
			Sampled	13/10/2010	21/01/2011	17/05/2011	17/08/2011	9/11/2011
			Depth	-	-	-	-	-
			y	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	7.37	7.22	7.2	7.82	7.08
Electrical Conductivity	1	10	µS/cm	6130	6300	6380	6420	5790
MAJOR IONS								
Calcium	1	0.5	mg/L	52	56	52	61	52
Magnesium	1	0.5	mg/L	93	120	116	119	101
Potassium	1	0.5	mg/L	62	78	65	60	41
Sodium	1	0.5	mg/L	1060	1120	1260	1040	870
Chloride	1	1	mg/L	1530	1610	1650	1320	1440
Sulphate as SO4 2-	1	5	mg/L	430	687	573	715	443
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	351	337	331	341	322
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	351	337	331	341	322
Total Cyanide	0.005	0.01	mg/L	-	-	-	-	-
Total Anions	0.01		meq/L	59.2	66.4	65.1	58.9	56.3
Total Cations	0.01		meq/L	59.2	63.4	68.6	59.6	49.8
Ionic Balance	0.01		%	0.08	2.34	2.57	0.55	6.13
HEAVY METALS (Dissolved)								
Aluminium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	0.01
Arsenic	0.001	0.001	mg/L	0.001	0.001	<0.001	0.001	<0.001
Beryllium	0.001	0.001	mg/L	0.003	0.003	0.002	<0.001	0.004
Barium	0.001	0.02	mg/L	0.016	0.018	0.018	0.016	0.021
Cadmium	0.0001	0.0002	mg/L	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	0.003	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.01	0.007	0.005	0.002	0.003
Copper	0.001	0.001	mg/L	0.008	0.02	0.003	0.003	0.013
Iron	0.01	0.05	mg/L	1.45	1.38	1.3	0.08	1.38
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.338	0.233	0.277	0.181	0.187
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.002	0.004	0.001	<0.001	0.001
Selenium	0.01	0.001	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.019	0.032	0.021	0.006	0.025
NUTRIENTS								
Ammonia as N	0.01	0.01	mg/L	0.09	0.07	0.06	0.05	0.07
Nitrite as N	0.01		mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	0.02	0.04	0.04	<0.01	0.04
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	0.02	0.04	0.04	<0.01	0.04
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	<0.1	<0.1	0.5	0.3	<0.1
Total Nitrogen as N	0.1	0.2	mg/L	<0.1	<0.1	0.5	0.3	<0.1
Total Phosphorus as P	0.01	0.05	mg/L	<0.01	0.64	0.04	0.23	0.13

LOR - Limits of Reporting

Table 2. Summary of Groundwater and Surface Water Field Parameters
Hillgrove Resources - Kanmantoo Copper Project

Well	Sampling Depth (2007) (m bPVC)	Sampling Depth (2010) (m bPVC)	Sampling Depth (Jan 2011) (m bPVC)	Sampling Depth (May 2011) (m bPVC)	Sampling Depth (Aug / Sept 2011) (m bPVC)	Redox (mV)								Temperature (ºC)							
						Nov-2006	Apr-2007	Jun-2007	Oct-2010	Jan-2011	May-2011	Aug / Sept 2011	Nov-2011	Nov-06	Apr-07	Jun-07	Oct-2010	Jan-2011	May-2011	Aug / Sept 2011	Nov-2011
KMB001	40	watertable	watertable	watertable	watertable	193	188	-	188	110.0	125.4	159.0	293.0	14.0	18.5	-	22.1	20.7	21.1	17.0	29.8
KMB002	24	watertable - 26	26	26	26	396	252	-	283	472.4	395.8	239.0	277.0	17.1	21.3	-	20.7	22.0	21.6	15.9	26.0
KMB003	24	watertable - 24	24	24	24	42	18	-	183	48.7	101.6	194.0	164.0	13.7	21.3	-	20.7	22.0	20.9	17.5	24.4
KMB004	10	Destroyed	Destroyed	Destroyed	Destroyed	86	15	-	Destroyed					13.7	19.1	-	Destroyed				
KMB005	54	-	-	-	-	-	-24	-	-	-	-	-	-	-	22.0	-	-	-	-	-	-
KMB005b	-	unknown*	unknown*	unknown*	unknown*	-	-	-	32.70	-0.6	-5.4	-25.0	135.0	-	-	-	20.8	22.9	19.7	18.5	25.9
KMB006 - watertable	13	-	-	-	-	-	50	-	-	-	-	-	-	-	19.3	-	-	-	-	-	-
KMB006 - at depth	48	48	48	36	36	-	-41	-	248	74.2	8.7	22.0	-	-	19.8	-	19.2	25.7	20.1	18.4	-
KMB007 - watertable	20	54	-	-	-	-	37	-	-	-	-	-	-	-	21.6	-	-	-	-	-	-
KMB007 - at depth	54	54	54	54	54	-	14	-	249	92.1	25.4	27.0	67.0	-	19.3	-	20.2	21.0	20.3	17.8	23.2
KMB008	60	-	-	-	-	-	-55	-	-	-	-	-	-	-	21.6	-	-	-	-	-	-
KMB008b	-	unknown*	unknown*	unknown*	unknown*	-	-	-	48	11.9	-27.2	-20.0	6.5	-	-	-	20.8	23.5	19.4	19.1	23.6
KMB009	-	watertable	watertable	watertable	watertable	-	-	-	350.00	31.1	-93.7	-25.0	50.0	-	-	-	20.2	22.6	20.7	17.6	27.0
KMB010	-	34.5	34.5	35.0	34.5	-	-	-	243.00	148.7	126.9	109.0	126.0	-	-	-	19.7	23.8	20.3	17.9	25.0
KMB011	7	watertable	watertable	watertable	watertable	-	-	14	77	75.3	68.8	69.0	99.6	-	-	15.7	18.9	22.4	18.7	16.2	17.2
KMB012	17	watertable	watertable	watertable	watertable	-	-	131	111	234.7	98.6	171.0	142.7	-	-	15.7	19.4	22.7	18.3	17.2	18.9
KMB013	32	watertable	-	-	-	-	-	-64	291	-	-	-	-	-	-	15.9	20.2	-	-	-	-
KMB014	20	watertable	watertable	watertable	watertable	-	-	52	269	219.1	226.1	214.0	-	-	-	15.7	18.9	19.6	20.5	17.1	-
KMB015	23	watertable	watertable	watertable	watertable	-	-	115	304	278.9	303.8	265.0	296.4	-	-	15.6	19.6	19.6	21.0	16.8	16.7
KMB016	27	watertable - 23	23	24	24	-	-	56	236	118.3	176.0	138.0	44.0	-	-	15.2	19.4	22.1	19.9	16.5	31.6
KMB017	28	watertable - 27	27	-	-	-	-	144	255	152.2	-	-	-	-	-	14.4	19.3	22.2	-	-	-
KMB018	23	watertable - 22	22	22	22	-	-	20	246	166.8	184.4	18.0	-	-	-	14.6	19.3	21.4	19.8	16.7	-
KMB019	16	watertable - 13	16	Destroyed	Destroyed	-	-	73	184	143.0	Destroyed			-	-	16.0	20.0	20.9	Destroyed		
KMB020	-	-	-	-	23	-	-	-	-	-	-	-55.00	-182.00	-	-	-	-	-	-	17.70	23.50
KMB021	-	-	-	-	30.5	-	-	-	-	-	-	63.80	-126.00	-	-	-	-	-	-	19.10	24.40
KMB022	-	-	-	-	18	-	-	-	-	-	-	80.00	-32.00	-	-	-	-	-	-	16.70	27.80
KMB023	-	-	-	-	10.5	-	-	-	-	-	-	35.80	110.00	-	-	-	-	-	-	20.00	21.20
KMB024	-	-	-	-	27	-	-	-	-	-	-	46.30	-144.00	-	-	-	-	-	-	20.30	23.80
KMB025	-	-	-	-	31.5	-	-	-	-	-	-	89.10	105.00	-	-	-	-	-	-	21.40	25.00
KMB026	-	-	-	-	35	-	-	-	-	-	-	142.00	204.00	-	-	-	-	-	-	17.10	24.20
Pit Void	-	-	-	-	-	-	-	-	496.30	-	498.0	420.0	512.0	-	-	-	15.5	-	17.2	14.4	28.3
Spring 1 (SW1)	-	-	-	-	-	-	-	-	216.00	-	182.9	-	-	-	-	-	18.3	-	18.2	-	-
Spring 2 (SW2)	-	-	-	-	-	-	-	-	-	-	170.0	-	-	-	-	-	-	-	18.9	-	-
SW3 (spring)	-	-	-	-	-	-	-	-	-	-	-	118.0	15.0	-	-	-	-	-	-	12.5	33.2
SW4 (surface water)	-	-	-	-	-	-	-	-	-	-	-	93.0	64.0	-	-	-	-	-	-	12.3	26.5

Note:

TDS calculated by multiplying EC by a factor of 650

* These wells were equipped with an electric well pump by a contractor.

** These pH values recorded in the May 2011 sampling event are believed to be spurious. The pH probe was found to be faulty shortly after sampling the

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units	KMB006S	KMB006D	KMB006	KMB006	KMB006	KMB006
			Location	KMB006S	KMB006D	KMB006	KMB006	KMB006	KMB006
			Sampled	2/04/2007	2/04/2007	18/10/2010	25/01/2011	19/05/2011	18/08/2011
			Depth	Watertable	48 m bgl	48 m bgl	48 m bgl	36 m bgl	36 m bgl
			y	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	-	-	6.93	6.84	7.09
Electrical Conductivity	1	10	µS/cm	-	-	-	13700	13400	15200
MAJOR IONS									
Calcium	1	0.5	mg/L	142	143	-	168	147	138
Magnesium	1	0.5	mg/L	355	360	-	382	340	330
Potassium	1	0.5	mg/L	134	135	-	168	140	114
Sodium	1	0.5	mg/L	2430	2440	-	530	2660	2290
Chloride	1	1	mg/L	4010	3850	-	4400	4230	4320
Sulphate as SO4 2-	1	5	mg/L	612	624	527	530	516	631
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	717	732	846	791	734	844
Carbonate Alkalinity as CaCO3	1	10	mg/L	6	4	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	723	736	846	791	734	844
Total Cyanide	0.005	0.01	mg/L	<0.005	0.006	-	-	-	-
Total Anions	0.01		meq/L	140	136	143	151	145	152
Total Cations	0.01		meq/L	146	147	124	166	155	136
Ionic Balance	0.01		%	1.87	3.69	7.02	4.7	3.35	5.32
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	-	-	0.01	0.02	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.005	0.005	<0.001	<0.001	0.002	0.003
Beryllium	0.001	0.001	mg/L	0.003	0.004	<0.001	0.004	0.005	0.001
Barium	0.001	0.02	mg/L	0.042	0.044	0.049	0.038	0.036	0.03
Cadmium	0.0001	0.0002	mg/L	0.0014	0.0014	0.0003	0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.014	0.008	0.002	0.002	0.001	<0.001
Copper	0.001	0.001	mg/L	0.186	0.02	0.021	0.018	0.004	0.003
Iron	0.01	0.05	mg/L	-	-	<0.05	1.72	1.2	<0.05
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.21	0.208	0.301	0.239	0.2	0.166
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.049	0.02	0.022	0.005	0.019	0.004
Selenium	0.01	0.001	mg/L	-	-	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.014	0.021	0.493	0.028	0.013	0.01
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	-	-	<0.01	0.05	0.06	0.03
Nitrite as N	0.01		mg/L	-	-	0.06	-	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	<0.010	<0.010	0.65	-	0.06	<0.01
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	-	0.72	0.04	0.06	<0.01
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	-	0.2	<0.1	0.2	<0.1
Total Nitrogen as N	0.1	0.2	mg/L	-	-	0.9	<0.1	0.3	<0.1
Total Phosphorus as P	0.01	0.05	mg/L	-	-	0.04	0.03	0.26	0.37

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units							
			Location	KMB007S	KMB007D	KMB007	KMB007	KMB007	KMB007	KMB007
			Sampled	3/04/2007	3/04/2007	18/10/2010	27/01/2011	17/05/2011	18/08/2011	10/11/2011
			Depth	Watertable	54 m bgl	54 m bgl	54 m bgl	54 m bgl	54 m bgl	54 m bgl
			y	ALS	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	-	6.74	6.88	6.71	6.96	6.61
Electrical Conductivity	1	10	µS/cm	-	-	4350	5160	5900	5820	5670
MAJOR IONS										
Calcium	1	0.5	mg/L	35	45	58	70	69	72	72
Magnesium	1	0.5	mg/L	68	99	108	145	158	150	153
Potassium	1	0.5	mg/L	45	52	56	76	82	62	61
Sodium	1	0.5	mg/L	441	679	679	926	1020	895	895
Chloride	1	1	mg/L	690	1170	1000	1250	1450	1210	1360
Sulphate as SO4 2-	1	5	mg/L	315	403	450	539	552	663	625
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	239	301	280	284	314	313	289
Carbonate Alkalinity as CaCO3	1	10	mg/L	24	35	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	262	336	280	284	314	313	289
Total Cyanide	0.005	0.01	mg/L	0.008	<0.005	-	-	-	-	-
Total Anions	0.01		meq/L	31.3	48.1	43.2	52.2	58.7	54.2	57.2
Total Cations	0.01		meq/L	27.6	41.2	42.8	57.6	62.7	56.4	56.7
Ionic Balance	0.01		%	6.2	7.67	0.5	4.95	3.3	2.03	0.43
HEAVY METALS (Dissolved)										
Aluminium	0.01	0.005	mg/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	<0.001	0.005	<0.001	0.002	0.004	<0.001	0.003
Beryllium	0.001	0.001	mg/L	<0.001	0.003	0.002	0.003	0.004	0.001	0.004
Barium	0.001	0.02	mg/L	0.033	0.044	0.038	0.05	0.058	0.048	0.059
Cadmium	0.0001	0.0002	mg/L	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.005	0.013	0.004	0.005	0.007	0.005	0.007
Copper	0.001	0.001	mg/L	0.002	<0.001	0.003	0.006	0.002	0.002	0.004
Iron	0.01	0.05	mg/L	-	-	<0.05	1.35	1.75	<0.05	1.61
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.654	0.312	0.292	0.335	0.465	0.359	0.436
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.012	0.036	0.012	0.004	0.014	0.017	0.016
Selenium	0.01	0.001	mg/L	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.011	0.018	0.011	0.009	0.026	0.013	0.047
NUTRIENTS										
Ammonia as N	0.01	0.01	mg/L	-	-	<0.01	0.08	<0.01	0.03	0.04
Nitrite as N	0.01		mg/L	-	-	0.05	-	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	5.36	<0.010	0.42	-	0.01	<0.01	0.02
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	-	0.48	0.01	0.01	<0.01	0.02
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	-	0.3	<0.1	0.4	<0.1	0.1
Total Nitrogen as N	0.1	0.2	mg/L	-	-	0.8	<0.1	0.4	<0.1	0.1
Total Phosphorus as P	0.01	0.05	mg/L	-	-	0.86	0.29	0.39	1	0.32

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units						
			Location	KMB008	KMB008b	KMB008b	KMB008b	KMB008b	KMB008b
			Sampled	2/04/2007	13/10/2010	21/01/2011	17/05/2011	17/08/2011	10/11/2011
			Depth	60 m bgl	-	-	-	-	-
			y	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	7.27	7.06	6.97	7.18	7.07
Electrical Conductivity	1	10	µS/cm	-	6760	6400	6750	6860	6880
MAJOR IONS									
Calcium	1	0.5	mg/L	56	80	62	68	81	81
Magnesium	1	0.5	mg/L	115	125	122	146	156	153
Potassium	1	0.5	mg/L	50	60	59	68	59	62
Sodium	1	0.5	mg/L	1020	1140	1030	1270	1190	1300
Chloride	1	1	mg/L	1890	1680	1550	1700	1520	1950
Sulphate as SO4 2-	1	5	mg/L	299	435	158	504	674	286
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	371	412	357	396	427	378
Carbonate Alkalinity as CaCO3	1	10	mg/L	52	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	423	412	357	396	427	378
Total Cyanide	0.005	0.01	mg/L	0.009	-	-	-	-	-
Total Anions	0.01		meq/L	68.1	64.8	54.2	66.4	65.4	68.5
Total Cations	0.01		meq/L	58	61.8	59.3	72.4	70.2	74.8
Ionic Balance	0.01		%	8	2.35	4.46	4.31	3.45	4.35
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.002	<0.001	<0.001	<0.001	<0.001	0.001
Beryllium	0.001	0.001	mg/L	0.003	0.004	0.003	0.004	<0.001	0.004
Barium	0.001	0.02	mg/L	0.042	0.038	0.038	0.038	0.033	0.044
Cadmium	0.0001	0.0002	mg/L	0.0003	0.0001	0.0002	<0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.007	0.007	0.008	0.004	0.002	0.005
Copper	0.001	0.001	mg/L	0.001	0.002	0.002	0.003	0.002	0.005
Iron	0.01	0.05	mg/L	-	1.7	1.24	2.71	<0.05	2.78
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.119	0.163	0.17	0.167	0.108	0.161
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.011	0.003	0.003	0.003	0.001	0.002
Selenium	0.01	0.001	mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.022	0.015	0.012	0.016	<0.005	0.037
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	-	0.09	0.04	0.05	0.05	0.06
Nitrite as N	0.01		mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	<0.010	<0.01	0.12	0.04	<0.01	<0.01
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	<0.01	0.12	0.04	<0.01	<0.01
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	<0.1	<0.1	0.3	<0.1	<0.1
Total Nitrogen as N	0.1	0.2	mg/L	-	<0.1	0.1	0.3	<0.1	<0.1
Total Phosphorus as P	0.01	0.05	mg/L	-	<0.01	0.08	0.12	0.11	0.09

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units	KMB009	KMB009	KMB009	KMB009	KMB009
			Location	KMB009	KMB009	KMB009	KMB009	KMB009
			Sampled	18/10/2010	24/01/2011	19/05/2011	16/08/2011	9/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	6.75	6.16	6.82	6.49	6.63
Electrical Conductivity	1	10	µS/cm	5290	5510	5240	5360	5110
MAJOR IONS								
Calcium	1	0.5	mg/L	71	60	64	54	65
Magnesium	1	0.5	mg/L	67	65	84	88	70
Potassium	1	0.5	mg/L	64	50	92	65	44
Sodium	1	0.5	mg/L	899	700	1170	983	715
Chloride	1	1	mg/L	1130	1100	1500	1130	1100
Sulphate as SO4 2-	1	5	mg/L	683	352	538	582	524
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	294	208	235	206	207
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	294	208	235	206	207
Total Cyanide	0.005	0.01	mg/L	-	-	-	-	-
Total Anions	0.01		meq/L	52	42.5	58.2	48.1	46.1
Total Cations	0.01		meq/L	49.8	40.1	63.3	54.4	41.2
Ionic Balance	0.01		%	2.11	2.94	4.15	6.08	5.56
HEAVY METALS (Dissolved)								
Aluminium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	0.02	0.08
Arsenic	0.001	0.001	mg/L	0.021	0.026	0.022	0.024	0.013
Beryllium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	0.001	0.02	mg/L	0.042	0.045	0.041	0.041	0.05
Cadmium	0.0001	0.0002	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.013	0.014	0.008	0.012	0.024
Copper	0.001	0.001	mg/L	<0.001	0.002	0.002	0.002	0.034
Iron	0.01	0.05	mg/L	23	30.7	27.7	33.4	20
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	1.47	1.48	1.24	1.26	1.64
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.004	0.005	0.002	0.004	0.02
Selenium	0.01	0.001	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.012	0.006	<0.005	0.02	0.034
NUTRIENTS								
Ammonia as N	0.01	0.01	mg/L	0.08	0.03	0.12	0.02	<0.01
Nitrite as N	0.01		mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	0.02	0.1	0.01	0.01	0.15
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	0.02	0.1	0.01	0.01	0.15
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	0.3	<0.1	0.2	<0.1	5.2
Total Nitrogen as N	0.1	0.2	mg/L	0.3	0.1	0.2	<0.1	5.4
Total Phosphorus as P	0.01	0.05	mg/L	0.24	0.64	0.32	0.32	9.16

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units	KMB010	KMB010	KMB010	KMB010	KMB010
			Location	KMB010	KMB010	KMB010	KMB010	KMB010
			Sampled	18/10/2010	27/01/2011	17/05/2011	18/08/2011	10/11/2011
			Depth	34.5 m bgl	34.5 m bgl	34.5m bgl	34.5m bgl	34.5m bgl
			y	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	7.23	7.15	6.84	7.08	6.81
Electrical Conductivity	1	10	µS/cm	6250	5900	7340	4000	3920
MAJOR IONS								
Calcium	1	0.5	mg/L	47	51	54	36	35
Magnesium	1	0.5	mg/L	101	121	141	73	65
Potassium	1	0.5	mg/L	52	73	73	37	30
Sodium	1	0.5	mg/L	1130	1120	1520	677	595
Chloride	1	1	mg/L	1620	1350	1950	904	985
Sulphate as SO4 2-	1	5	mg/L	389	705	518	345	228
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	382	354	432	269	236
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	382	354	432	269	236
Total Cyanide	0.005	0.01	mg/L	-	-	-	-	-
Total Anions	0.01		meq/L	61.4	59.9	74.4	38.1	37.2
Total Cations	0.01		meq/L	61	63.2	82.4	38.2	33.7
Ionic Balance	0.01		%	0.35	2.65	5.09	0.16	4.95
HEAVY METALS (Dissolved)								
Aluminium	0.01	0.005	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	0.001	0.02	mg/L	0.021	0.018	0.022	0.004	0.004
Cadmium	0.0001	0.0002	mg/L	0.0011	0.0011	0.0021	<0.0001	0.0002
Chromium	0.001	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.009	0.012	0.013	<0.001	<0.001
Copper	0.001	0.001	mg/L	0.006	0.012	0.015	0.005	0.023
Iron	0.01	0.05	mg/L	0.37	<0.05	<0.05	<0.05	<0.05
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.195	0.214	0.28	0.002	0.004
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.007	0.007	0.009	0.003	0.002
Selenium	0.01	0.001	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.03	0.025	0.053	0.008	0.034
NUTRIENTS								
Ammonia as N	0.01	0.01	mg/L	0.03	0.06	<0.01	<0.01	<0.01
Nitrite as N	0.01		mg/L	<0.01	-	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	0.02	-	0.05	3.49	3.75
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	0.02	1.02	0.05	3.49	3.75
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	<0.1	0.2	0.3	<0.1	<0.1
Total Nitrogen as N	0.1	0.2	mg/L	<0.1	1.2	0.4	3.5	3.8
Total Phosphorus as P	0.01	0.05	mg/L	1.14	0.11	0.15	0.25	0.22

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units						
			Location	KMB011	KMB011	KMB011	KMB011	KMB011	KMB011
			Sampled	4/06/2007	13/10/2010	21/01/2011	17/05/2011	16/08/2011	7/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	4.96	4.86	4.87	5.05	4.3
Electrical Conductivity	1	10	µS/cm	-	11000	10800	10800	10800	11200
MAJOR IONS									
Calcium	1	0.5	mg/L	440	516	411	443	457	467
Magnesium	1	0.5	mg/L	1080	1200	1130	1220	1310	1340
Potassium	1	0.5	mg/L	114	130	146	119	136	85
Sodium	1	0.5	mg/L	707	600	538	533	622	440
Chloride	1	1	mg/L	602	568	565	558	543	567
Sulphate as SO4 2-	1	5	mg/L	7050	8540	6710	8800	9110	7680
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	71	4	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	71	4	<1	<1	<1	<1
Total Cyanide	0.005	0.01	mg/L	0.0263	-	-	-	-	-
Total Anions	0.01		meq/L	165	194	156	199	205	-
Total Cations	0.01		meq/L	165	216	141	179	393	-
Ionic Balance	0.01		%	0.07	5.43	4.92	5.37	4.72	-
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	0.12	0.46	0.23	0.31	0.54	0.53
Arsenic	0.001	0.001	mg/L	0.002	0.006	0.005	0.006	0.005	0.005
Beryllium	0.001	0.001	mg/L	-	0.002	<0.001	<0.001	0.002	0.001
Barium	0.001	0.02	mg/L	-	0.021	0.022	0.02	0.021	0.02
Cadmium	0.0001	0.0002	mg/L	0.0036	0.0092	0.009	0.0078	0.0102	0.0086
Chromium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	7.49	23.4	23.9	22.9	20.6	24.2
Copper	0.001	0.001	mg/L	0.016	0.89	0.602	0.762	1.41	1.29
Iron	0.01	0.05	mg/L	149	937	799	706	752	805
Lead	0.001	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	171	135	117	130	109	136
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	1.5	4.98	4.82	4.57	5.57	4.18
Selenium	0.01	0.001	mg/L	<0.010	0.01	<0.01	0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.312	1.59	1.49	1.23	1.58	1.24
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	-	0.5	2.18	2.79	2.6	<0.01
Nitrite as N	0.01		mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	-	<0.01	<0.01	<0.01	<0.01	0.02
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	<0.01	<0.01	<0.01	<0.01	0.02
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	3.7	2.9	4.6	2.7	5.4
Total Nitrogen as N	0.1	0.2	mg/L	-	3.7	2.9	4.6	2.7	5.4
Total Phosphorus as P	0.01	0.05	mg/L	-	0.03	0.13	0.26	<0.10	0.25

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units	KMB012	KMB012	KMB012	KMB012	KMB012	KMB012
			Sampled	4/06/2007	12/10/2010	21/01/2011	17/05/2011	16/08/2011	7/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	7.55	6.12	7.22	7.6	7.19
Electrical Conductivity	1	10	µS/cm	-	7,570	7,660	7,760	7350	7260
MAJOR IONS									
Calcium	1	0.5	mg/L	93	140	143	109	136	122
Magnesium	1	0.5	mg/L	99	120	158	132	145	132
Potassium	1	0.5	mg/L	44	43	55	44	50	30
Sodium	1	0.5	mg/L	1440	1500	1560	1830	1690	1850
Chloride	1	1	mg/L	682	688	1400	672	632	1200
Sulphate as SO4 2-	1	5	mg/L	2520	2960	1620	2640	2830	2340
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	475	472	432	461	457	440
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	475	472	432	461	457	440
Total Cyanide	0.005	0.01	mg/L	0.0064	-	-	-	-	-
Total Anions	0.01		meq/L	81.1	90.6	81.8	83.1	85.9	91.4
Total Cations	0.01		meq/L	76.6	84.8	89.4	97	93.5	98.2
Ionic Balance	0.01		%	2.92	3.33	4.45	7.64	4.22	3.57
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.002	0.002	0.002	0.002	<0.001	0.001
Beryllium	0.001	0.001	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	0.001	0.02	mg/L	-	0.028	0.009	0.008	0.012	0.016
Cadmium	0.0001	0.0002	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.003	0.003	0.009	0.032	0.004	0.002
Copper	0.001	0.001	mg/L	0.006	0.004	0.006	0.01	0.007	0.008
Iron	0.01	0.05	mg/L	0.08	0.06	0.29	0.97	0.07	<0.05
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.291	0.077	0.067	0.215	0.035	0.024
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.002	0.006	0.002	0.006	<0.001	0.001
Selenium	0.01	0.001	mg/L	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.011	0.02	0.006	0.018	0.02	0.024
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	-	0.03	0.02	<0.01	<0.01	0.02
Nitrite as N	0.01		mg/L	-	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	0.01	0.02	mg/L	-	1.37	1.41	1.8	1.34	1.06
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	1.37	1.41	1.8	1.34	1.06
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	0.4	<0.1	0.4	0.2	0.2
Total Nitrogen as N	0.1	0.2	mg/L	-	1.8	1.4	2.2	1.5	1.3
Total Phosphorus as P	0.01	0.05	mg/L	-	0.25	0.16	0.15	0.33	0.22

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

			Location	KMB013	KMB013	KMB013	KMB013	KMB014	KMB014	KMB014	KMB014	KMB014
			Sampled	4/06/2007	18/10/2010	21/01/2011	16/05/2011	4/06/2007	18/10/2010	24/01/2011	19/05/2011	16/08/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS
Chemical	**ALS LOR**	**MGT LOR**	**Units**									
pH	0.01	0.1	pH unit	-	6.87	-	-	-	6.04	6.3	6.14	6.08
Electrical Conductivity	1	10	µS/cm	-	27800	-	-	-	3400	3880	3730	3850
MAJOR IONS												
Calcium	1	0.5	mg/L	120	183	-	-	71	92	94	108	110
Magnesium	1	0.5	mg/L	448	476	-	-	48	113	136	134	137
Potassium	1	0.5	mg/L	211	216	-	-	41	46	37	54	49
Sodium	1	0.5	mg/L	5350	5880	-	-	286	527	478	622	606
Chloride	1	1	mg/L	8560	9420	-	-	367	592	487	704	651
Sulphate as SO4 2-	1	5	mg/L	1960	845	-	-	380	983	988	1030	1070
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	-	-	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	253	594	-	-	162	<1	55	30	64
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	-	-	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	253	594	-	-	162	<1	55	30	64
Total Cyanide	0.005	0.01	mg/L	0.0051	-	-	-	<0.0050	-	-	-	-
Total Anions	0.01		meq/L	287	295	-	-	21.5	37.2	35.4	42	41.9
Total Cations	0.01		meq/L	281	310	-	-	20.9	38	37.5	44.8	44.4
Ionic Balance	0.01		%	1.11	2.41	-	-	1.33	1.14	2.9	3.28	2.83
HEAVY METALS (Dissolved)												
Aluminium	0.01	0.005	mg/L	0.01	0.01	<0.01	<0.01	0.02	0.55	0.1	0.09	0.08
Arsenic	0.001	0.001	mg/L	0.004	0.006	<0.001	0.006	0.003	<0.001	<0.001	<0.001	<0.001
Beryllium	0.001	0.001	mg/L	-	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001
Barium	0.001	0.02	mg/L	-	0.259	0.25	0.254	-	0.01	0.01	0.009	0.008
Cadmium	0.0001	0.0002	mg/L	0.0441	0.0003	<0.0001	<0.0001	0.0001	0.0056	0.0005	0.0005	0.0004
Chromium	0.001	0.001	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.005	<0.001	0.001	<0.001	0.015	0.183	0.026	0.027	0.022
Copper	0.001	0.001	mg/L	0.01	0.001	0.003	0.002	0.004	0.561	0.968	0.759	0.494
Iron	0.01	0.05	mg/L	5.65	11.8	19,6	12.6	6.27	0.11	0.1	<0.05	<0.05
Lead	0.001	0.001	mg/L	0.004	<0.001	<0.001	<0.001	0.008	<0.001	0.001	0.002	<0.001
Manganese	0.001	0.005	mg/L	2.54	2.74	3.41	3.32	0.625	0.574	0.099	0.086	0.097
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0006	0.0004	0.0005
Nickel	0.001	0.001	mg/L	0.009	<0.001	<0.001	0.001	0.013	0.147	0.033	0.03	0.021
Selenium	0.01	0.001	mg/L	<0.010	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.014	0.009	0.013	0.008	0.01	0.085	0.033	0.029	0.054
NUTRIENTS												
Ammonia as N	0.01	0.01	mg/L	-	0.35	-	-	-	0.02	0.05	0.02	0.03
Nitrite as N	0.01		mg/L	-	<0.01	-	-	-	0.06	0.05	0.09	0.08
Nitrate as N	0.01	0.02	mg/L	-	0.02	-	-	-	9.14	12.8	26	24.3
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	0.02	-	-	-	9.2	12.8	26.1	24.4
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	7.2	-	-	-	0.5	<0.1	0.5	0.2
Total Nitrogen as N	0.1	0.2	mg/L	-	7.2	-	-	-	9.7	12.8	26.6	24.6
Total Phosphorus as P	0.01	0.05	mg/L	-	23.6	-	-	-	1.47	0.16	0.05	<0.01

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

			Location	KMB015	KMB015	KMB015	KMB015	KMB015	KMB015
			Sampled	4/06/2007	18/10/2010	24/01/2011	19/05/2011	16/08/2011	7/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS
Chemical	**ALS LOR**	**MGT LOR**	**Units**						
pH	0.01	0.1	pH unit	-	3.87	4.62	3.88	4.09	3.99
Electrical Conductivity	1	10	µS/cm	-	3700	3760	4110	3410	2820
MAJOR IONS									
Calcium	1	0.5	mg/L	196	89	154	249	202	141
Magnesium	1	0.5	mg/L	134	138	163	199	157	109
Potassium	1	0.5	mg/L	67	19	19	30	26	14
Sodium	1	0.5	mg/L	297	214	212	214	198	158
Chloride	1	1	mg/L	361	312	721	266	258	254
Sulphate as SO4 2-	1	5	mg/L	1120	851	370	1700	1350	1190
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	150	46	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	150	46	<1	<1	<1	<1
Total Cyanide	0.005	0.01	mg/L	<0.0050	-	-	-	-	-
Total Anions	0.01		meq/L	36.5	27.4	28	42.9	35.4	-
Total Cations	0.01		meq/L	35.4	25.7	30.8	38.9	32.3	-
Ionic Balance	0.01		%	1.42	3.34	4.71	4.9	4.59	-
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	0.18	45	31	33.2	24.1	14.9
Arsenic	0.001	0.001	mg/L	0.002	0.003	0.002	0.002	0.002	0.001
Beryllium	0.001	0.001	mg/L	-	0.012	0.01	0.016	0.009	0.007
Barium	0.001	0.02	mg/L	-	0.013	0.016	0.012	0.01	0.012
Cadmium	0.0001	0.0002	mg/L	0.0114	0.0072	0.0088	0.0146	0.0105	0.0087
Chromium	0.001	0.001	mg/L	<0.001	0.001	0.001	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	2.31	4.45	3.78	6.69	5.31	3.14
Copper	0.001	0.001	mg/L	9.95	219	200	374	243	1.56
Iron	0.01	0.05	mg/L	0.24	162	37.5	15.1	6.71	2.77
Lead	0.001	0.001	mg/L	0.025	0.009	0.008	0.008	0.002	0.012
Manganese	0.001	0.005	mg/L	10.1	34	19.5	17.8	14.9	9.68
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	0.0004	<0.0001	0.0004	0.0002
Nickel	0.001	0.001	mg/L	0.69	1.38	0.974	1.42	1.07	0.681
Selenium	0.01	0.001	mg/L	<0.010	0.02	0.02	0.03	0.02	0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	1.63	6.83	2.92	3.41	2.37	1.59
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	-	<0.01	0.11	0.44	0.46	<0.01
Nitrite as N	0.01		mg/L	-	0.02	0.02	0.02	0.02	0.05
Nitrate as N	0.01	0.02	mg/L	-	11.3	14	10.2	5.25	4.59
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	11.3	14	10.2	5.27	4.64
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	1.0	<0.1	1.1	0.7	0.7
Total Nitrogen as N	0.1	0.2	mg/L	-	12.3	14	11.3	6	5.3
Total Phosphorus as P	0.01	0.05	mg/L	-	2.21	<0.01	<0.01	<0.01	0.59

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units									
			Location	KMB016	KMB016	KMB016	KMB016	KMB016	KMB016	KMB017	KMB017	KMB017
			Sampled	7/06/2007	19/10/2010	25/01/2011	19/05/2011	17/08/2011	8/11/2011	7/06/2007	19/10/2010	25/01/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	6.62	7.29	7.09	7.28	7.12	-	7.15	7.11
Electrical Conductivity	1	10	µS/cm	-	1500	1550	1470	1480	1540	-	5450	5460
MAJOR IONS												
Calcium	1	0.5	mg/L	52	37	38	36	30	19	98	67	91
Magnesium	1	0.5	mg/L	97	21	26	27	24	21	321	94	113
Potassium	1	0.5	mg/L	70	15	19	23	16	16	159	63	80
Sodium	1	0.5	mg/L	1130	238	281	301	226	277	3250	897	930
Chloride	1	1	mg/L	1360	285	351	350	258	269	4910	1440	1450
Sulphate as SO4 2-	1	5	mg/L	286	127	60	72	88	63	703	210	233
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	668	180	271	244	296	291	569	304	317
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	668	180	271	244	296	291	569	304	317
Total Cyanide	0.005	0.01	mg/L	0.0144	-	-	-	-	-	0.007	-	-
Total Anions	0.01		meq/L	57.6	14.3	16.5	16.2	15	-	164	51.2	52.1
Total Cations	0.01		meq/L	61.4	14.3	16.7	17.7	13.7	-	177	51.7	56.4
Ionic Balance	0.01		%	3.15	0.03	0.51	4.29	4.59	-	3.59	0.54	3.94
HEAVY METALS (Dissolved)												
Aluminium	0.01	0.005	mg/L	0.02	0.11	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.002	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.001
Beryllium	0.001	0.001	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Barium	0.001	0.02	mg/L	-	0.013	0.011	0.01	0.007	0.008	-	0.026	0.071
Cadmium	0.0001	0.0002	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0088	0.0016	0.0002
Chromium	0.001	0.001	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Cobalt	0.001	0.001	mg/L	0.004	<0.001	<0.001	<0.001	<0.001	0.001	0.013	0.007	0.005
Copper	0.001	0.001	mg/L	0.001	0.011	0.005	0.006	0.002	0.005	0.003	0.031	0.028
Iron	0.01	0.05	mg/L	0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	<0.05
Lead	0.001	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.105	0.005	0.002	0.014	0.006	0.025	0.8	0.233	0.148
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.019	0.002	0.002	0.003	0.011	0.003	0.02	0.014	0.008
Selenium	0.01	0.001	mg/L	0.038	0.02	0.02	0.01	0.01	0.01	<0.010	0.01	0.02
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.008	0.04	<0.005	0.014	0.006	0.034	0.091	0.027	<0.005
NUTRIENTS												
Ammonia as N	0.01	0.01	mg/L	-	<0.01	0.02	<0.01	0.07	0.04	-	<0.01	0.15
Nitrite as N	0.01		mg/L	-	<0.01	-	0.02	<0.01	<0.01	-	<0.01	-
Nitrate as N	0.01	0.02	mg/L	-	8.8	-	10.4	7.73	8.61	-	12.2	-
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	8.8	11.6	10.4	7.73	8.61	-	12.2	20.7
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	0.5	0.2	0.7	<0.1	0.2	-	1.9	1.1
Total Nitrogen as N	0.1	0.2	mg/L	-	9.3	11.8	11.1	7.7	8.8	-	14.1	21.8
Total Phosphorus as P	0.01	0.05	mg/L	-	1.24	<0.01	0.06	0.16	0.16	-	0.73	0.03

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units								
			Location	KMB018	KMB018	KMB018	KMB018	KMB018	KMB019	KMB019	KMB019
			Sampled	7/06/2007	19/10/2010	25/01/2011	19/05/2011	17/08/2011	7/06/2007	14/10/2010	25/01/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	-	7.2	7.27	7.35	7.65	-	7.34	7.17
Electrical Conductivity	1	10	µS/cm	-	8800	9150	9120	9400	-	2410	2610
MAJOR IONS											
Calcium	1	0.5	mg/L	61	71	73	57	64	129	37	41
Magnesium	1	0.5	mg/L	176	136	170	143	159	214	32	37
Potassium	1	0.5	mg/L	92	88	133	103	91	75	20	18
Sodium	1	0.5	mg/L	2030	1490	1670	2170	1760	1510	476	497
Chloride	1	1	mg/L	2680	2530	2560	2850	2030	2510	659	750
Sulphate as SO4 2-	1	5	mg/L	438	332	587	333	439	419	139	82
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	746	841	804	743	827	524	189	165
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	746	841	804	743	827	524	189	165
Total Cyanide	0.005	0.01	mg/L	0.0086	-	-	-	-	0.0098	-	-
Total Anions	0.01		meq/L	99.5	95.1	100	102	82.9	89.9	25.3	26.2
Total Cations	0.01		meq/L	108	81.9	93.7	112	95.2	91.7	25.7	27.2
Ionic Balance	0.01		%	4.08	7.45	3.52	4.51	6.84	1.01	0.78	1.84
HEAVY METALS (Dissolved)											
Aluminium	0.01	0.005	mg/L	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	0.001	0.004	0.002	0.004	0.004	<0.001	<0.001	<0.001
Beryllium	0.001	0.001	mg/L	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Barium	0.001	0.02	mg/L	-	0.048	0.041	0.032	0.025	-	0.022	0.018
Cadmium	0.0001	0.0002	mg/L	0.0004	0.0002	<0.0001	<0.0001	<0.0001	0.0021	<0.0001	<0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.002
Cobalt	0.001	0.001	mg/L	0.005	0.004	0.002	0.003	0.001	0.008	0.001	<0.001
Copper	0.001	0.001	mg/L	0.004	0.007	0.008	0.006	0.01	0.024	0.049	0.048
Iron	0.01	0.05	mg/L	0.02	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	<0.05
Lead	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	0.507	0.142	0.068	0.06	0.032	0.17	0.003	<0.001
Mercury	0.0001	0.0001	mg/L	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	0.001	mg/L	0.008	0.002	0.002	0.005	0.021	0.008	0.004	0.003
Selenium	0.01	0.001	mg/L	0.011	<0.01	0.01	0.01	0.02	<0.010	<0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.005	0.015	<0.005	0.01	0.016	0.034	0.026	<0.005
NUTRIENTS											
Ammonia as N	0.01	0.01	mg/L	-	0.14	0.02	<0.01	<0.01	-	0.05	<0.01
Nitrite as N	0.01		mg/L	-	0.05	-	0.01	<0.01	-	<0.01	-
Nitrate as N	0.01	0.02	mg/L	-	2.11	-	4.64	4.19	-	4.26	-
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	-	2.16	5.04	4.66	4.19	-	4.26	5.71
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	-	1.0	0.1	0.6	<0.1	-	0.4	0.6
Total Nitrogen as N	0.1	0.2	mg/L	-	3.2	5.1	5.3	4.2	-	4.7	6.3
Total Phosphorus as P	0.01	0.05	mg/L	-	1.24	<0.01	<0.01	0.07	-	<0.01	<0.01

LOR - Limits of Reporting

Summary of Groundwater Analytical Results, Major Ion, Heavy Metals
Hillgrove Resources - Kanmantoo Copper Project

Chemical	ALS LOR	MGT LOR	Units	KMB020	KMB020	KMB021	KMB021	KMB022	KMB022
			Sampled	18/08/2011	8/11/2011	14/09/2011	10/11/2011	17/08/2011	8/11/2011
			Depth	Watertable	Watertable	Watertable	Watertable	Watertable	Watertable
			y	ALS	ALS	ALS	ALS	ALS	ALS
pH	0.01	0.1	pH unit	7.45	7.31	7.06	6.88	7.45	7.33
Electrical Conductivity	1	10	µS/cm	7200	7150	5450	5640	12200	11800
MAJOR IONS									
Calcium	1	0.5	mg/L	50	44	120	107	184	20
Magnesium	1	0.5	mg/L	92	93	122	114	308	36
Potassium	1	0.5	mg/L	45	33	36	28	92	8
Sodium	1	0.5	mg/L	1360	1380	827	839	1890	222
Chloride	1	1	mg/L	1460	1660	1350	1460	3790	3960
Sulphate as SO4 2-	1	5	mg/L	384	151	536	236	568	449
Hydroxide Alkalinity as CaCO3	1		mg/L	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	1	20	mg/L	768	872	406	429	671	636
Carbonate Alkalinity as CaCO3	1	10	mg/L	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO3	1	20	mg/L	768	872	406	429	671	636
Total Cyanide	0.005	0.01	mg/L	-	-	-	-	-	-
Total Anions	0.01		meq/L	64.5	-	57.4	54.7	132	-
Total Cations	0.01		meq/L	70.4	-	52.9	51.9	119	-
Ionic Balance	0.01		%	4.31	-	4.03	2.58	5.21	-
HEAVY METALS (Dissolved)									
Aluminium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	0.001	0.001	mg/L	<0.001	0.013	<0.001	0.008	0.002	0.002
Beryllium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	0.001	0.02	mg/L	0.059	0.094	0.088	0.04	0.062	0.066
Cadmium	0.0001	0.0002	mg/L	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0001
Chromium	0.001	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001	0.001	mg/L	0.006	0.001	0.003	0.002	0.002	0.002
Copper	0.001	0.001	mg/L	0.001	0.007	0.002	0.003	0.002	0.006
Iron	0.01	0.05	mg/L	0.34	0.34	<0.05	1.7	<0.05	0.17
Lead	0.001	0.001	mg/L	<0.001	<0.001	0.007	<0.001	<0.001	<0.001
Manganese	0.001	0.005	mg/L	1.21	3.69	0.904	1.26	0.035	0.031
Mercury	0.0001	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004
Nickel	0.001	0.001	mg/L	0.002	0.005	0.008	0.026	0.019	0.009
Selenium	0.01	0.001	mg/L	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Vanadium	0.01	0.005	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.005	0.001	mg/L	0.006	0.016	0.012	0.02	<0.005	0.035
NUTRIENTS									
Ammonia as N	0.01	0.01	mg/L	0.02	0.1	0.18	0.1	0.02	0.05
Nitrite as N	0.01		mg/L	<0.01	0.03	-	<0.01	0.03	0.14
Nitrate as N	0.01	0.02	mg/L	<0.01	0.05	-	0.07	<0.01	0.02
NOx (Nitrite + Nitrate as N)	0.01	0.05	mg/L	<0.01	0.08	<0.01	0.07	0.02	0.16
Total Kjeldahl Nitrogen (TKN)	0.1	0.2	mg/L	<0.1	0.6	1.6	2	0.2	0.3
Total Nitrogen as N	0.1	0.2	mg/L	<0.1	0.7	1.6	2.1	0.2	0.5
Total Phosphorus as P	0.01	0.05	mg/L	0.31	0.47	5.98	5.27	0.93	0.19

LOR - Limits of Reporting

Appendix 3B

Responses to DEWNR

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Catherine Davis
Hillgrove Resourses
Éclair Mine Rd (cnr Back Callington Rd),
Kanmantoo
SA 5252

30 April 2014 VE23758.500

Dear Catherine,

Kanmantoo Copper Mine – Response to DEWNR issues regarding re: groundwater management

1. Background

Hillgrove Resources Limited (Hillgrove) has engaged Jacobs SKM to provide a response to hydrogeological issues raised by the South Australian Department of Environment, Water and Natural Recourses (DEWNR). Attachment 1 presents the issues as raised by DEWNR on the 19th of March 2014.

The following presents discussion (including data analysis and mapping, and advice in regards to monitoring infrastructure) in response to the hydrogeological issues raised by DEWNR.

2. Response to DEWNR issues

Issue 1 Additional groundwater monitoring infrastructure down-hydraulic gradient of the TSF

Analysis

Refer to Comment No. 1 (attachment 1) for details of DEWNR's issue.

Existing monitoring wells KMB020, 022 and 023 are located along an inferred groundwater flowpath from beneath the tailings storage facility (TSF), as shown on Figure 1. The ultimate flowpath post-closure may be toward the pit but it is not presently and so it is considered the siting of these wells is appropriate for the current mine operation.

However, it is reasonable to expect that the future mine operation (which involves a proposed expansion and deepening of the Cavanagh Pit) and mine closure could alter the flowpaths beneath the TSF such that they become controlled by the mine pit, due to dewatering during mining and evaporative losses post-mining.

Recommendations

- It is recommended that a groundwater monitoring well be sited between the TSF and Cavanagh pit to assist with ongoing evaluation of groundwater flow paths during operation, and to provide data to assist in assessing mine closure strategies. Hillgrove has identified a small number of mineral exploration drill holes located on the northwest wall of Cavanagh pit that may be suitable for conversion to a monitoring well. A nominal location of a single monitoring well is presented on Figure 1.

Issue 2 Proposed deep and sentinel wells

Analysis

Refer to Comment No. 2 (attachment 1) for details of DEWNR's issue.

The proposed 'deep' well (see Figure 1) is located immediately down-gradient of the Cavanagh pit and will essentially be paired with the existing shallower KMB026 monitoring well. The purpose of the 'deep well' is to assist in assessing fractured rock aquifer permeability at the final depth of Cavanagh pit and vertical hydraulic gradients. It is considered that the identified position of the 'deep' well is appropriate for this purpose.

The proposed 'sentinel' well (also shown on Figure 1) is located off site and down-gradient of O'Neils and Cavanagh pits, and is planned as a shallow completion (intersecting the top 20 m or so of the fractured rock aquifer). In addition, KMB009 will likely go out of service due to the proposed extension of O'Neils pit to the east and will possibly need to be replaced by another well of suitable depth completion (based on existing and predicted future depth to water table).

There is an existing gap in monitoring infrastructure coverage to the southeast of Emily Star pit.

Recommendations

- It is recommended that a replacement monitoring well for KMB009 be located to the southeast of KMB009. Figure 1 presents a nominal location for this new well.
- It is recommended that a new monitoring well be drilled and constructed to the southeast of Emily Star pit. Figure 1 presents a nominal location for this new well.

Issue 3 Updating the mine *Groundwater monitoring and management plan*

Analysis

Refer to Comment No. 3 (attachment 1) for details of DEWNR's issue.

New monitoring infrastructure will provide additional water quality and level data that will provide greater understanding of mine site groundwater conditions, and will assist in informing the development of mine closure management strategies.

Recommendations

- It is recommended that the mine GMMP be updated with all new information arising from installation of new groundwater monitoring infrastructure.

- It is recommended that the existing groundwater monitoring and analytical commitments outlined in the GMMP be reviewed and, where appropriate, optimised and agreed with DEWNR (eg. in the situation where a good baseline has been established there may be opportunity to reduce the number of monitoring events required and reduce the suite of parameters measured / analysed).

Issue 4 Final mine pit influence on fractured rock groundwater system

Analysis

Refer to Comment No. 4 (attachment 1) for details of DEWNR's issue.

The proposed deepening and extension of the mine pit(s) has the potential to alter groundwater flow paths beneath the mine site and off the mine site. Hillgrove proposes backfilling of the Emily Star and O'Neils pits (refer Figure 1) once mining of the ore in those pits is completed, which will reduce the evaporative losses of water from mine site groundwater system after closure and the zone of influence the mine pit(s) have on the regional groundwater system.

The results of modeling post-mine pit water body recovery at Kanmantoo (REM, 2007) indicates the pit water body in Cavanagh pit is likely to recover to around 50 m below the pre-mine water table elevation. Factors controlling pit water body recovery include groundwater inflow and incident rainfall (inputs) and evaporation (output).

Analytical modeling has been undertaken to calculate the zone of influence of the closed pit(s) on regional water table elevations, and to predict the drawdown surface away from the pit. Analytical solutions used in the analyses have been sourced from Armstrong (1996), and Marinelli and Nicocoli (2000) – see Attachment 2:

- Marinelli and Niccoli (2000) allows calculation of the steady state zone of influence of the closed mine pit
- Armstrong (1996) allows calculation of the drawdown surface

The analytical model assumes that the fractured rock aquifer is both isotropic and homogeneous. Refer to Attachment 2 for the values of various parameters used in the analysis.

Water table elevation contours for the pre-mine condition were inferred from available groundwater level data and a digital elevation model of the mine site and surrounding area. Figure 2 presents the inferred pre-mine water table elevation contours.

The inferred pre-mine water table elevation contours were digitised and converted to a potentiometric surface, from which the predicted post mine drawdown surface was subtracted to provide an inferred post-mine water table surface. Figure 3 presents the predicted water table elevation contours for the mine post-closure in steady state, and Figures 4 and 5 show the water table surface (in profile) along each of the cross-sections shown on Figure 1 (Emily Star - southwest to northeast; O'Neil's – northwest to southeast, respectively).

The following conclusions are drawn from the analysis:

- The Cavanagh mine pit will act as a permanent groundwater sink following mine closure
- Some of the seepage from the back-filled Emily Star and O'Neils pits will likely be captured by the Cavanagh open pit, but some may move down-gradient and off-site
- The extent to which Cavanagh pit will capture seepage emanating from the backfilled Emily Star and O'Neils pits is very much determined by the level to which the Cavanagh pit water body recovers following mine closure – the lower the elevation of the pit water body the greater the potential for the pit to capture seepage from the other backfilled pits and vice versa.
- The implications for a case where seepage from the backfilled pits moves off-site will be reliant on the quality of the seepage water, i.e. if the seepage is not impacted by acidic metalliferous drainage (AMD) the implications are unlikely to have adverse outcomes, whereas AMD impacted seepage has the potential to have some adverse effects.

Recommendations

- As the predicted pit water body recovery analysis is based on preliminary-level water balance modeling it is recommended that a more detailed assessment be undertaken.
- The complexity and, indeed, the need for the assessment should be predicated by the risk posed to potential environmental and third party groundwater users.

Issue 5 Pre-existing contaminated groundwater

Analysis

Refer to Comment No. 5 (attachment 1) for details of DEWNR's issue.

Metal contaminated groundwater has been sampled from wells KMB001 and KMB002 historically (now decommissioned due to mining activities, but were located southeast of Cavanagh pit,). The source of the contamination has been identified as the former heap leach operation at the Kanmantoo mine (prior to Hillgrove's involvement), which used pit water as supply. The heap leach operation has since been decommissioned.

Recommendations

- None.

3. References

Armstrong, D. 1996. Mine dewatering. Unpublished.

Marinelli, F. and Niccoli, W.L. 2000. Simple analytical equation for estimating ground water inflow to a mine pit. Ground Water. Vol. 38, No. 2.

REM. 2007. Kanmantoo Copper Project groundwater impact assessment. Prepared for Hillgrove Resources Limited by Resource & Environmental Management Pty Limited. August 2007.

We trust the information presented in this letter report meets your expectations. Please do not hesitate to call if you have any questions.

Yours sincerely

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Principal Hydrogeologist
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FIGURES

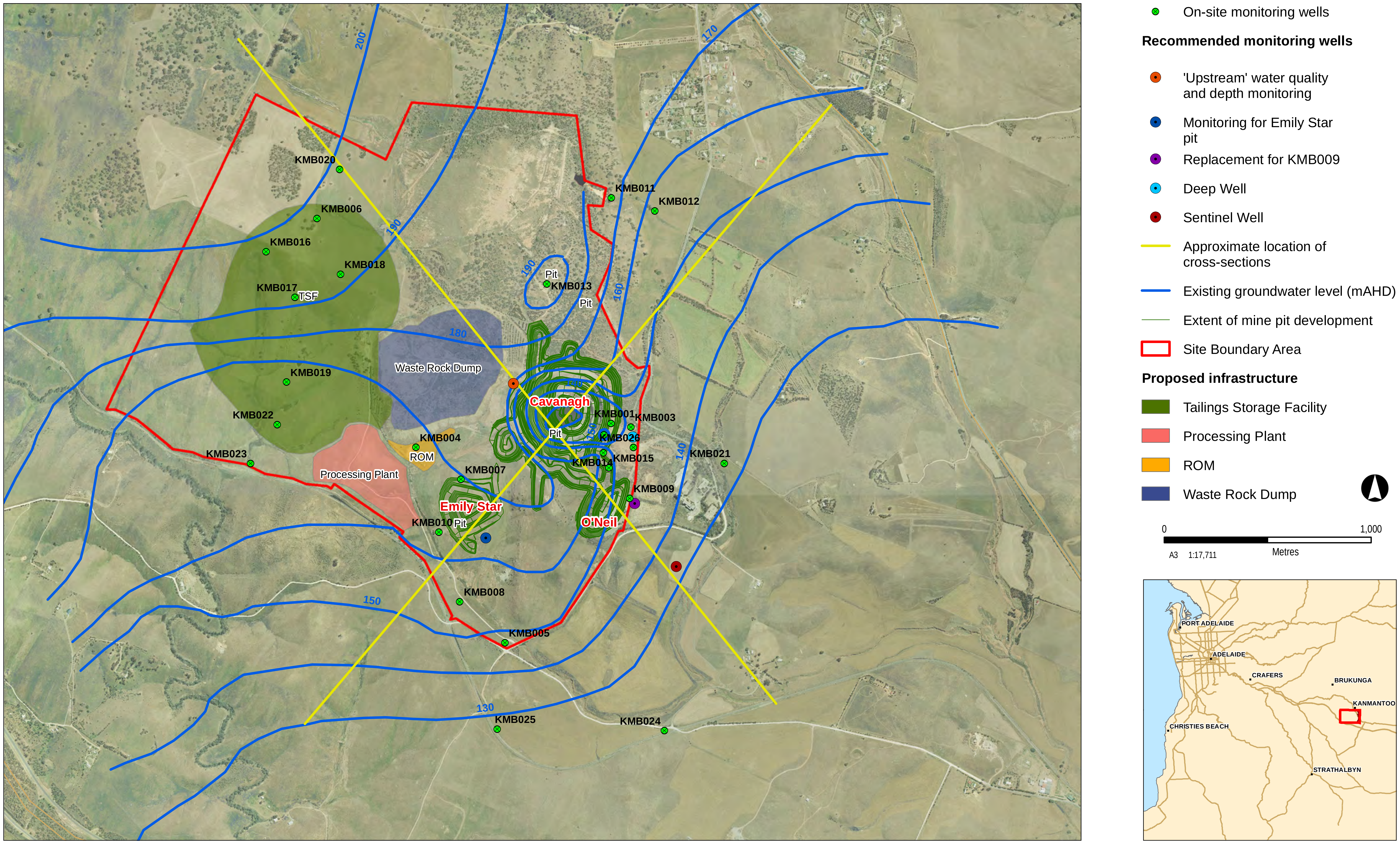

Figure 1: Exisiting groundwater conditions

UTM GDA 94, Zone 54H

JACOBS SKM

Hillgrove Resources

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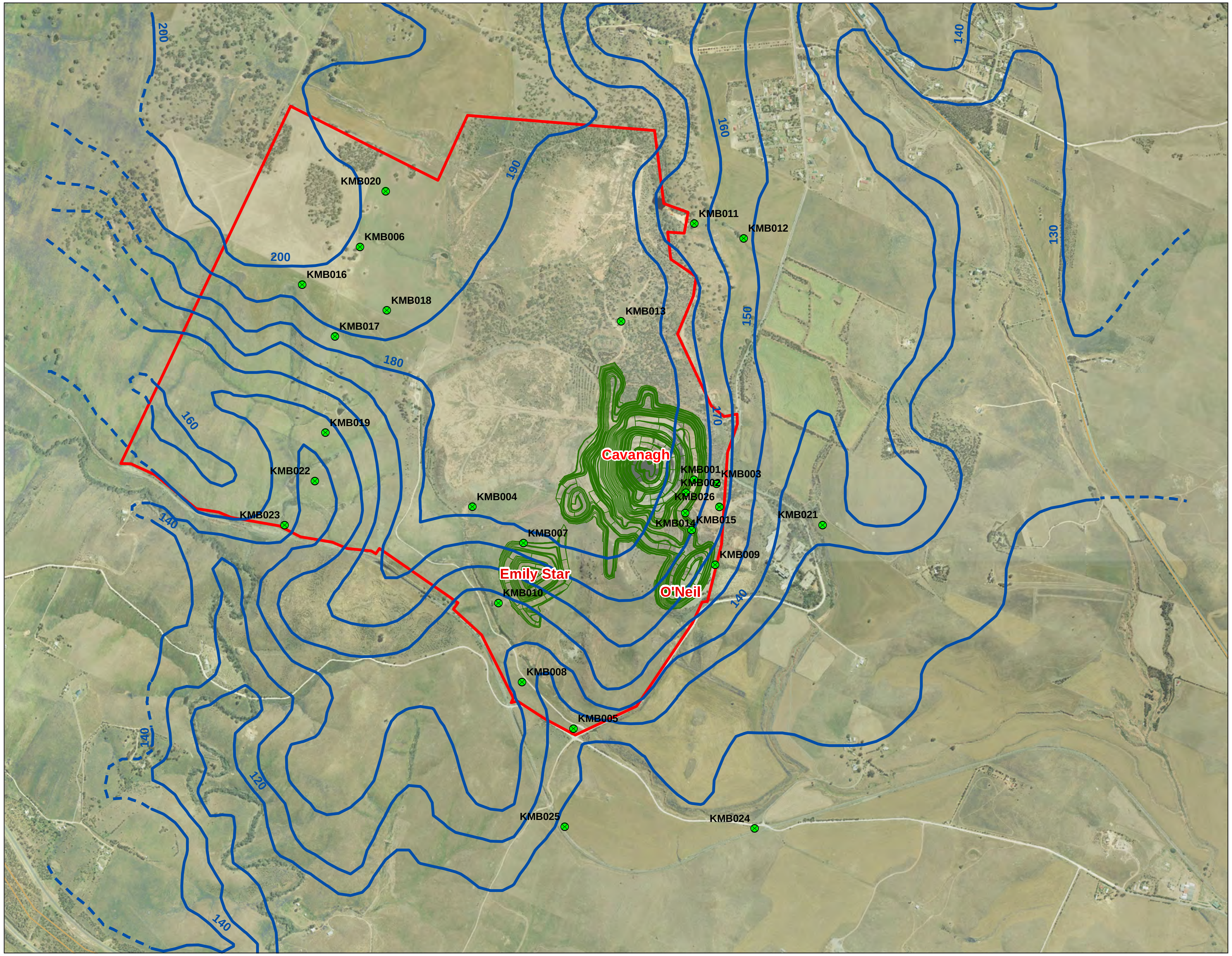
I:\VESA\Projects\VE23758\Technical\Spatial_Data\ArcGIS\2014 gw model\Figures for letter\Figure 1 - exisiting gw contours.mxd



On-site monitoring wells

Pre-mining groundwater contours (mAHD)

Inferred pre-mining contours

Extent of mine pit development

Site Boundary Area

Figure 2: Pre-mining groundwater contours

UTM GDA 94, Zone 54H

Hillgrove Resources

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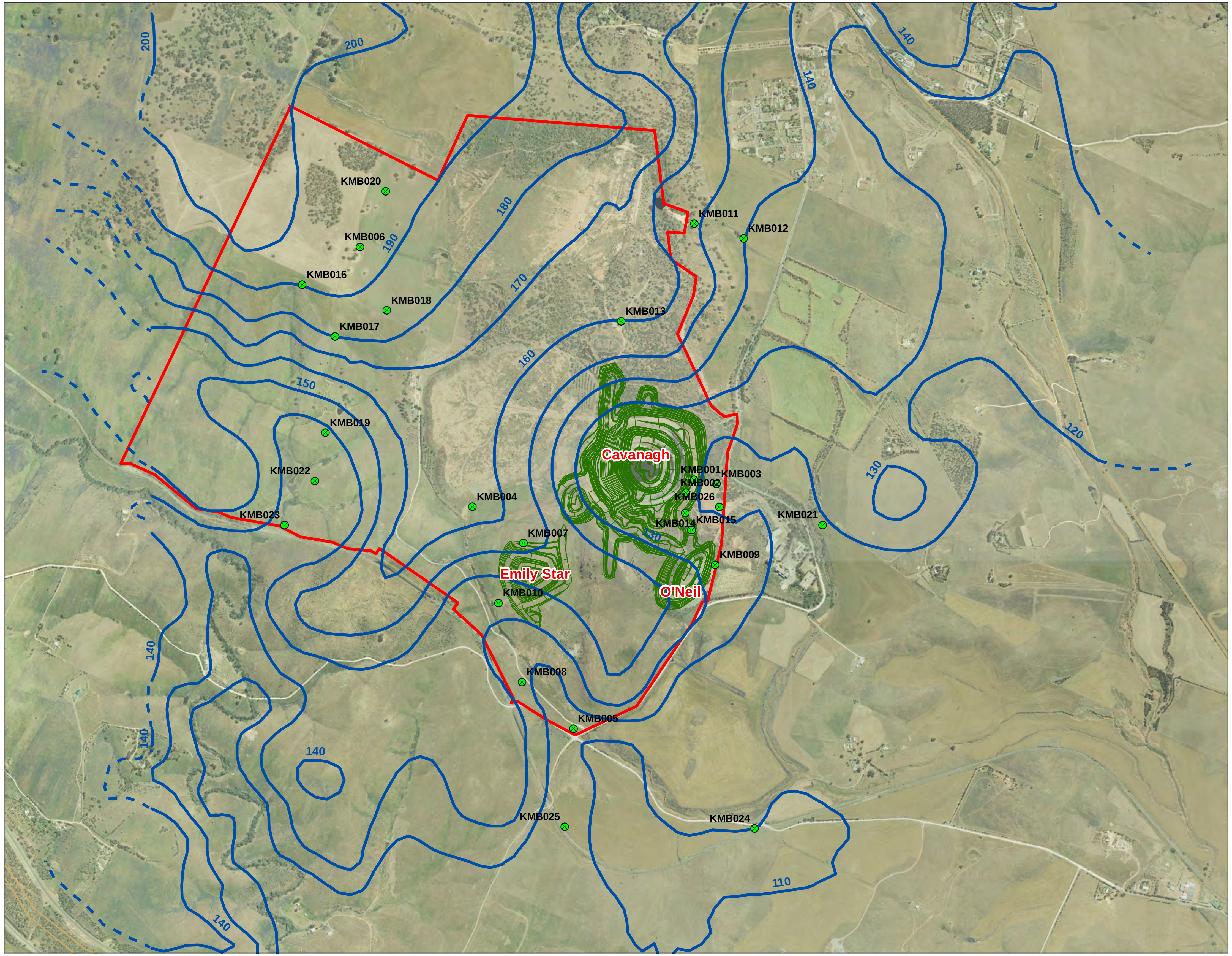

UTM GDA 94, Zone 54H

Figure 3: Post-mining groundwater contours

Hillgrove Resources

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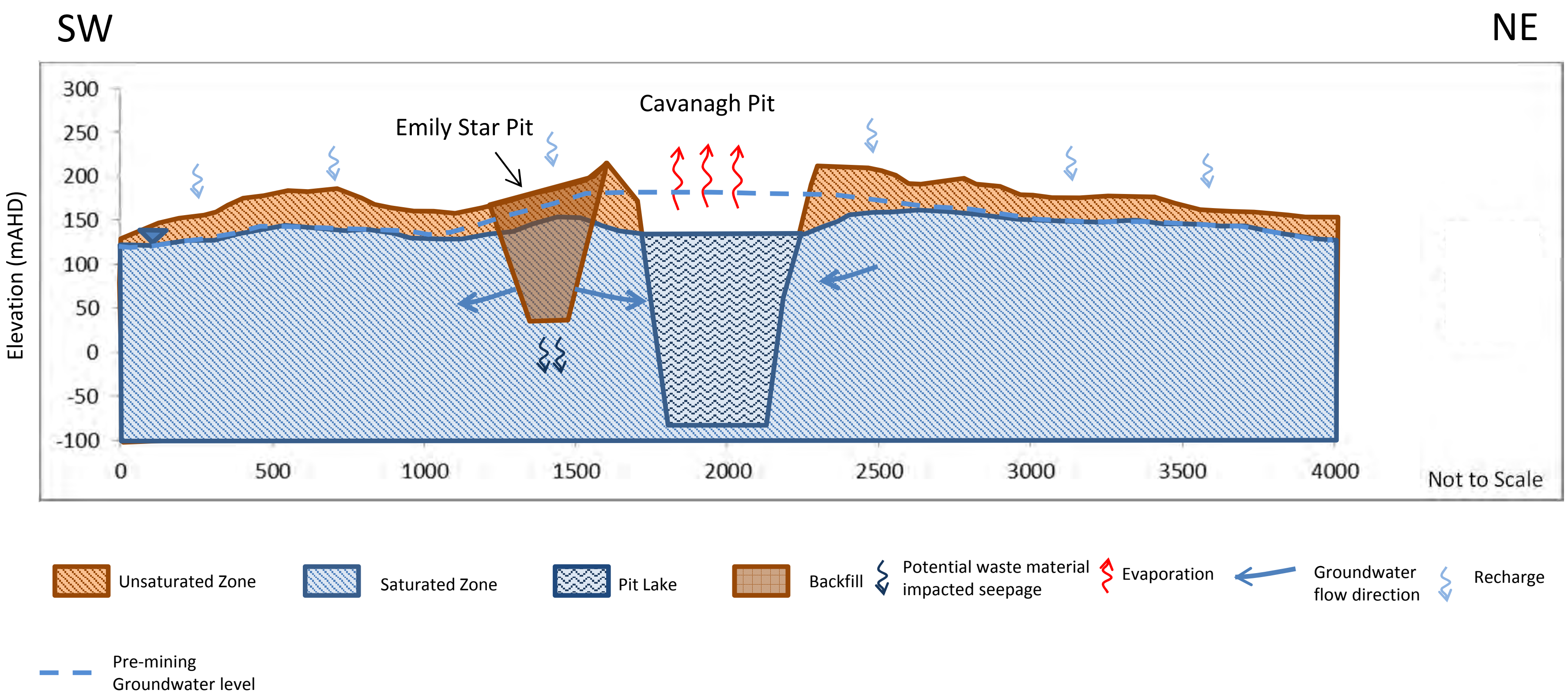


Figure 4: SW-NE cross-section with predicted drawdown post mining

JACOBS SKM

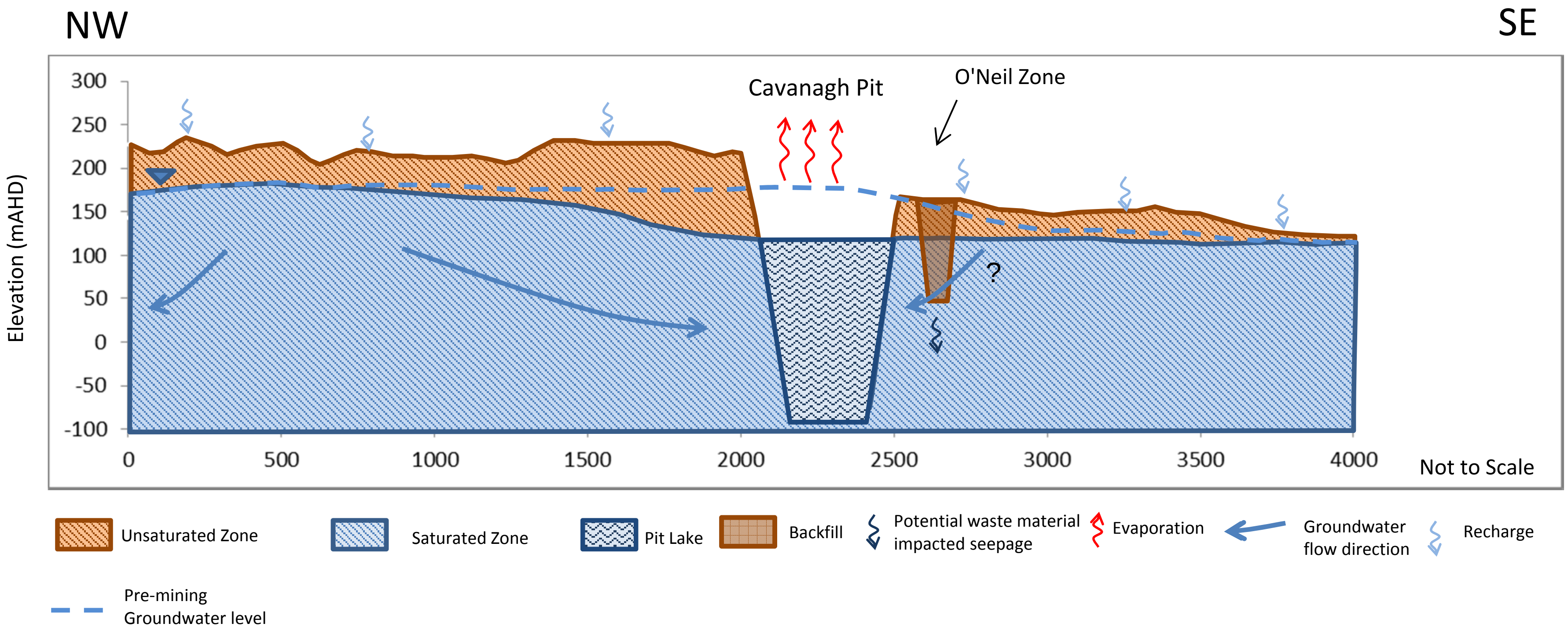


Figure 5: NW-SE cross-section with predicted drawdown post mining

JACOBS SKM

ATTACHMENT 1
Tabulation of DEWNR hydrogeological issues

Comment No	DEWNR Comment (to identify relevant section / paragraph and consider required actions)
1	SKM 2013 - Pg 9: Monitoring wells KMB020, 022 and 023 were installed to monitor the TSF, but both are located perpendicular to the flow direction which is towards the main pit. A well located close and downgradient of the TSF, in a similar location to former wells KMB 004 and KMB 007, is recommended for effective for monitoring.
2	SKM 2013 - Figure 2: The proposed Deep and Sentinel wells will be useful additions to the monitoring network. However, there is a general lack of monitoring wells located close to the pits on their downgradient side. Wells located downgradient with screen depths corresponding to the maximum pit depth and the zone of fluctuating water level following backfilling for each of the Emily Star and O'Neil Zone pits are requested. Particular attention should be given to the potential for any contaminated water from the backfilled O'Neil Zone to move beyond the boundary of the mining lease, as the hydraulic gradient in Figure 3 indicates that groundwater flowing into these backfilled smaller pits may flow south or south-east. See also point 7 below.
3	SKM 2013 - Pg 14: Table 3-1: Hillgrove Monitoring during mining: The new wells 'Deep Well' and 'Sentinel Well', plus any other new wells, should be added to the water quality sampling list.
4	SKM 2013/Coffey 2013: There is no indication of any increased drawdown impacts resulting from the pit extension. What is the area of the increased drawdown compared to the existing drawdown extent? This would be easiest for us to interpret if presented as a topographic figure and cross-section.
5	SKM 2013/Coffey 2013: Contaminated pit water was found in KMB001 and KMB002.Was the source of this contamination identified? What was it?

ATTACHMENT 2
Analytical models

Mine pit zone

$h_0 = \{h_p^2 + WK_{h1}^{-1}[r_0^2 \ln(r_0 r_p^{-1}) - (r_0^2 - r_p^2)2^{-1}]\}^{0.5}$ m

$Q_1 = W\pi(r_0^2 - r_p^2)$ m³/day

where:

		Baseline	Stage 1	
$Q =$	groundwater inflow to pit (m³/day)		959	(11 L/sec)
$W =$	rainfall recharge rate (m³/day)	8.2E-05		
$R =$	rainfall (m³/day)	1.0E-03		
$E =$	evaporation (m³/day)	3.3E-03		
$r_0 =$	radius of influence (m)	1950		
$r_p =$	equivalent pit radius (m)	300		
$r_g =$	equivalent pit radius at surface (m) - for evap. potential	550		
$K_{h1} =$	hydraulic conductivity (m/day)	0.03	bulk	
$d =$	depth of mine pit water bodyaquifer thickness (m)	173		

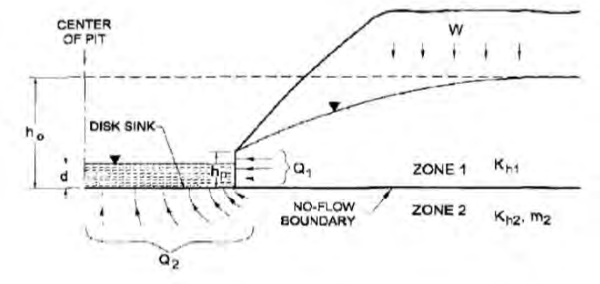
Below mine pit zone

$Q_2 = [4r\pi K_{h2} m_2^{-1}(h_0 - d)]2$ m³/day

$m_2 = (K_{h2} \cdot K_{v2}^{-1})^{0.5}$

where:

		Baseline	Stage 1
$Q =$	groundwater inflow to pit (m³/day)		44
$h_0 =$	saturated thickness of aquifer (m)	173	
$h_p =$	height of aquifer seepage face in the mine pit (m)	123	
$r_p =$	equivalent pit radius (m)	300	
$K_{h2} =$	hydraulic conductivity for aquifer (m/day)	0.01	
$K_{v2} =$	vertical hydraulic conductivity for aquifer (m/day)	0.01	
$d =$	depth of water in base of pit (m)	1	
$m_2 =$	anisotropy parameter	1.0	



Total predicted pit inflow (m³/day)	1,002.62	(12 L/sec)
Total predicted pit inflow (ML/day)	1.00	
Total predicted pit inflow (GL/yr)	0.37	

$h_0 = \{h_p^2 + W/K_{h1}[r_0^2 \ln(r_0/r_p) - (r_0^2 - r_p^2)/2]\}^{0.5}$

173 ⟺ 172

check

Description:
1. Dry pit - actual condition)
2. Recharge balanced by evaporative discharge
3. Evaporation assumed 1,000 mm/yr) from entire pit

Instructions:
- User entered data
- User adjusted parameter to equilibrate with user entered aquifer thickness (D); cell M7 => check provided in cell H23
- Analytical model calculates these parameters

I -

ESTIMATING DRAWDOWN OUTSIDE THE PIT - circular pit

Reference: Armstrong, D. 1996. Mine dewatering. Unpublished

This sheet can be used to assess various pit dimensions (eg. pit floor area or depths), or a series of pits in an area

$$s_r = h_0 - \{h_0^2[(\ln r/r_{pit}) / (\ln r_0/r_{pit})]\}^{0.5}$$

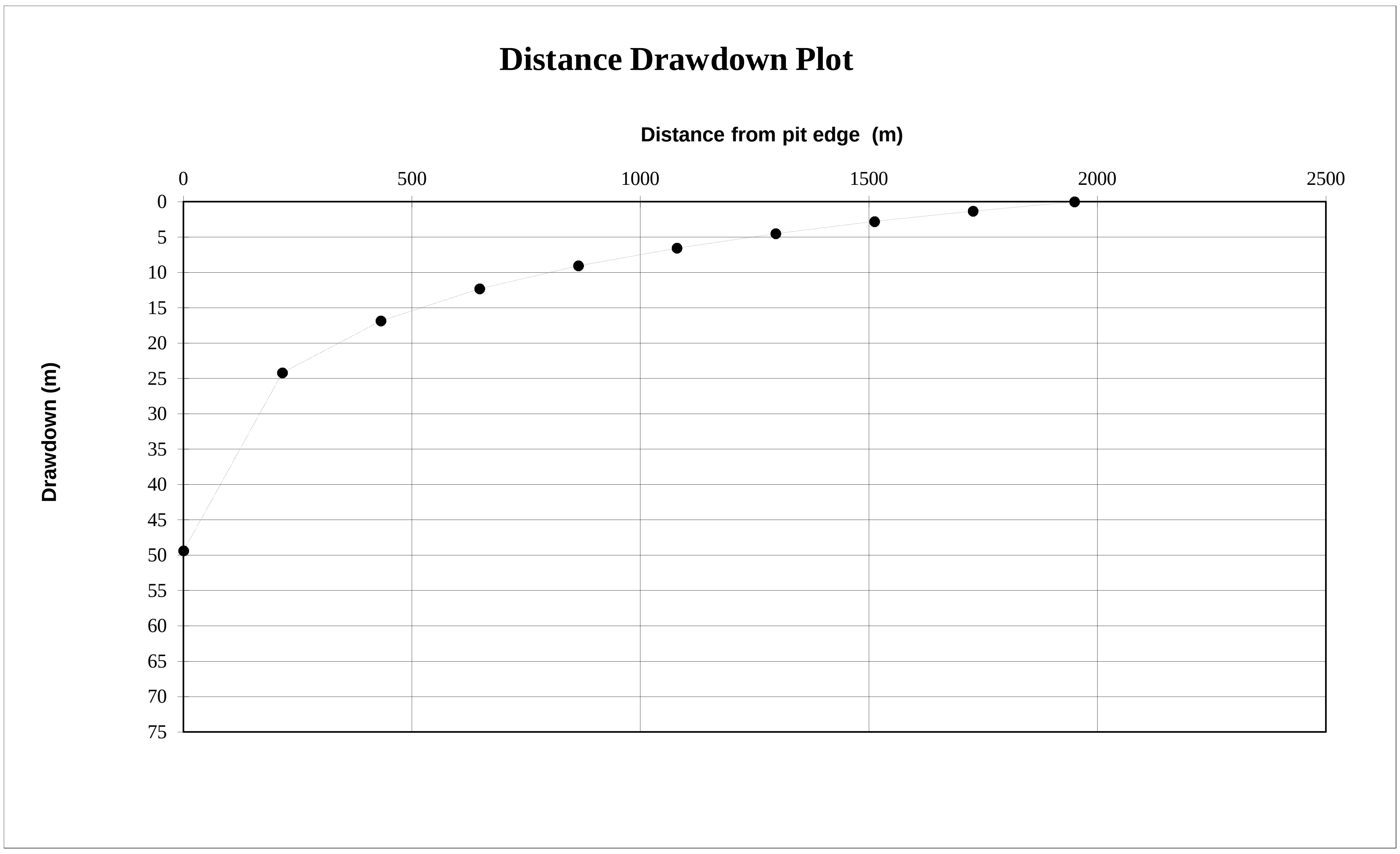
where:
- r = distance from pit
- r_0 = extent of drawdown for time elapsed
- r_{pit} = radius pit
- h_0 = difference b/n water table and pit lake elevation(m)

Description Scenario 1: Low K

[refer worksheet "circular pit (r and Q)" for values r_0, r_{pit}, h_0]

r_0 =	1950
r_{pit} =	310
h_0 =	50
h_0^2 =	2500
$\ln(r_0/r_{pit})$ =	1.986604

		Dist. from pit edge	$\ln(r/r_{pit})$	$[(\ln r/r_{pit}) / (\ln r_0/r_{pit})]$	s_r
$r_{(i)}$ =	310.1	0.1	0.00032255	0.0	**49.3629**
$r_{(ii)}$ =	526.1	216.1	0.52894564	0.3	**24.2000**
$r_{(iii)}$ =	742.1	432.1	0.872949455	0.4	**16.8557**
$r_{(iv)}$ =	958.1	648.1	1.128423711	0.6	**12.3166**
$r_{(v)}$ =	1174.1	864.1	1.331732589	0.7	**9.0624**
$r_{(vi)}$ =	1390.1	1080.1	1.500609039	0.8	**6.5442**
$r_{(vii)}$ =	1606.1	1296.1	1.645044176	0.8	**4.5009**
$r_{(viii)}$ =	1822.1	1512.1	1.771226462	0.9	**2.7881**
$r_{(ix)}$ =	2038.1	1728.1	1.88325595	0.9	**1.3179**
$r_{(x)}$ =	2260	1950.0	1.98660373	1.0	**0.0000**



Appendix 4

Flora

Appendix 4A

Flora Survey

Final Report
Kanmantoo Copper Project
Flora Assessment

Coffey Natural Systems Pty Ltd

Level 1, 2-3 Greenhill Rd
Wayville SA 5034

May 2007

ECOLOGICAL ASSOCIATES DE005-C

Contents

Figures, Tables and Appendices

Figures

Tables

Appendices

Executive Summary

Scope of Work

Ecological Associates was engaged by Coffey Natural Systems on behalf of Hillgrove Resources Ltd to:

- survey the flora of the Kanmantoo Copper Project Area and the road between the site and Callington;
- assess potential impacts to flora associated with the project;
- identify opportunities to avoid, minimise or mitigate impacts;
- establish a foundation for ongoing monitoring; and
- recommend further investigations, if required.

Methods

A review was conducted of reports and surveys describing the plant species and vegetation associations of the study area and the region.

A survey of the project area, based on the methods of the Biological Survey of South Australia, was conducted in February 2007. The survey involved four quadrats in the main vegetation types, descriptions of all vegetation types, assessments of scattered trees and assessment of roadside vegetation.

Findings

A total of 113 ha of native vegetation was identified in the study area. Eight vegetation communities were identified with vegetation condition ranging from "very good" to "poor".

Eucalyptus odorata Low woodland is the most extensive vegetation community and occupies 54.1 ha. This vegetation community is listed as a critically endangered ecological community under the *EPBC Act 1999*. It is also of conservation significance at the state level (Neagle 1995) and at the regional level (Kahrimanis *et al.* 2001). At the local level, the remnants on the site include some of the best preserved examples in the western slopes of the Southern Mount Lofty Ranges (Ecological Associates 2007).

Lomandra effusa ± Heliochrysum leucopsideum Open tussock grassland occupies 23.3 ha of the study area. This vegetation community is also listed as a critically endangered ecological community under the *EPBC Act 1999*. It is of conservation significance at the state level (Neagle 1995), and at the regional level (Kahrimanis *et al.* 2001). At the local level, the remnants on the site include some of the best preserved examples in the western slopes of the Southern Mount Lofty Ranges (Ecological Associates 2007).

Remnant patches of *Austrostipa* sp. Open tussock grassland occupies 17 ha. This community is of regional conservation significance (Kahrimanis *et al.* 2001).

Other plant associations observed on the site were:

- *Acacia pycnantha* Low woodland (11.2 ha)

- *Eucalyptus gracilis* ± *E. oleosa* Open mallee (4 ha)
- *Allocasuarina verticillata* ± *Callitris gracilis* ± *Lomandra effusa* Low woodland (1.8 ha)
- *Eucalyptus leucoxylon* ssp. *leucoxylon* ± *Lomandra effusa* Open woodland (1.3 ha)
- *Callitris gracilis* Low woodland (0.2 ha).

The highest level of conservation significance for plant species recorded during the survey was regional. Four species listed as rare in the Murray botanical region were recorded:

- *Eucalyptus leucoxylon* ssp. *leucoxylon;*
- *Elymus scaber var. scaber;*
- *Aristida contorta;* and
- *Aristida behriana.*

However, from previous investigations it is known that the site also supports two species of conservation significance at the state level:

- *Diuris behrii* (Behr's cowslip orchid) – rare; and
- *Ptilotus erubescens* (hairy tails) – rare;

and a further 19 species of regional conservation significance.

Fifty six scattered trees were documented in the area defined by the proposed project footprint. Fifty five of these trees were *Eucalyptus odorata* and one was *Allocasuarina verticillata*.

Roadside vegetation between the project area and Callington was assessed. The vegetation is predominantly degraded *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland.

Potential Impacts

The condition of native vegetation, and the proportion impacted by the proposed project footprint is presented in the table below. Coffey Natural Systems provided calculations of areas to be cleared.

Vegetation Community	Condition	Area (ha) to be cleared	Area (ha) within project area	% of project area to be cleared
Eucalyptus odorata Low woodland	Very good	1.23	14.90	8.28%
	Good	2.02	9.70	20.85%
	Moderate	0.32	28.50	1.12%
	Poor	0.34	1.00	35.45%
Lomandra effusa ± *Heliochrysum leucopsideum* Open	Very good	9.59	17.80	53.90%
	Good	0.00	2.05	0.00%

Vegetation Community	Condition	Area (ha) to be cleared	Area (ha) within project area	% of project area to be cleared
tussock grassland	Moderate	2.54	3.50	72.44%
Austrostipa sp. Open tussock grassland	Very good	0.21	11.60	1.80%
	Good	0.00	4.70	0.00%
	Moderate	0.61	0.70	86.67%
Eucalyptus gracilis ± *E. oleosa* Open mallee	Very good	2.79	4.00	69.76%
Acacia pycnantha Low woodland	Good	4.26	7.70	55.29%
	Moderate	2.57	3.50	73.34%
Scattered Trees		56 trees		

The project footprint impacts on some of the known individuals of *Diuris behrii* but not on known individuals of *Ptilotus erubescens*.

In addition to vegetation clearance, the project potentially impacts upon flora and vegetation by:

- habitat fragmentation;
- an increased risk of pest plant invasion due to increased soil disturbance and the importation of weed propagules on vehicles and machinery;
- acid leachate;
- reduced vegetation health arising from altered surface- and groundwater hydrology; and
- impacts arising from the accumulation of dust from mining operations upon vegetation and the soil surface.

Measures to Mitigate and Minimise Risks

Measures to minimise these risks a proposed. In particular, measures to minimise and mitigate the impacts of vegetation clearance include enhancement of vegetation on the site by connecting remnants with revegetation, improving the quality of remnant vegetation and contributing to regional programs that restore or enhance remnant vegetation.

Limitations of this Study

The survey was conducted in autumn following a 12 month period of particularly low rainfall. Under these dry conditions, and at this time of year, it is likely that many plant species were absent or dormant as seeds or propagules and could not be observed. Similarly, condition would be more accurately assessed in spring when annual weeds are present.

It is recommended that the survey is repeated in spring.

1.1 Introduction

Ecological Associates Pty Ltd was engaged by Coffey Natural Systems Pty Ltd on behalf of Hillgrove Resources Limited (HRL) to assess the potential impacts of the proposed redevelopment and expansion of the Kanmantoo Copper Mine (‘the project’) on vegetation and plant species in the project area. For the purposes of this report, the study area corresponds to the project area.

1.2 Scope of Work

The overall objective of this project was to survey and report on the potential impacts of the proposed project on vegetation and plant species. The scope of work was to:

- provide a comprehensive list of all flora species and vegetation communities;
- report the conservation significance or pest status of all species and vegetation communities present;
- report data in accordance with the Draft Guidelines for a Native Vegetation Significant Environmental Benefit Policy for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry;
- establish a foundation for ongoing monitoring;
- describe the potential impacts of the proposed development on plant species and vegetation communities;
- identify opportunities to avoid, minimise or mitigate impacts;
- describe potential residual impacts of the project following implementation of mitigation measures; and
- report uncertainties associated with the assessment.

1.3 Background to the Project

The Kanmantoo Copper Project is located between the townships of Kanmantoo (1.5 km to the north east) and Callington (1.5 km to the south east), 44 km east of Adelaide in South Australia (Figure 1). The project area comprises approximately of 439 ha, including the property on which the mine is to be developed. Options for the transport of concentrate are currently being investigated, however the option via the Back Callington Road between the site and Callington was investigated as this may involve impacts to flora.

The project area has been subject to intermittent mining operations from the mid 1800s to the 1970s (Hibbird 2004). The original Kanmantoo mine was first worked in 1848 and activities continued, with several breaks, over the next century. An open pit resource was defined in 1969 and Kanmantoo Mines Pty Ltd worked this from 1971 to 1976. The site now contains a decommissioned open cut, tailings dam and waste rock dump. The granted mining lease ML5776 covers the Kanmantoo Mine and copper-gold resource. The areas to the immediate south and north of ML5776 are covered by EL application no. 736/2004. A prefeasibility study for this project was completed in June 2006.

Figure 1. Location of proposed Kanmantoo Copper Project.

Some of the vegetation remnants and plant species in the study area are considered a high priority for conservation; these areas are generally located close to the existing mine pit (Playfair 2004; Ecological Associates 2007). To the west of the existing mine pit, on the 'Paringa' property, the land is currently utilized for grazing and has largely been cleared of native vegetation, although some scattered trees and small remnants exist.

2.1 Landform

The study area is located in the catchment of the Bremer River (a tributary of the River Murray) on the eastern slopes of the Mount Lofty Block. A north – south trending range, reaching a height of approximately 120 m above the surrounding terrain, dominates the immediate physical environment of the study area. The slopes of these hills are steep and dissected by several gullies but the area on the top of the hills is gently undulating (Hibbird 2004).

All watercourses in the area of the mine are first order streams and flow intermittently. They contain salt tolerant vegetation, particularly the introduced sedge *Juncus acutus* (Sharp Rush), suggesting they receive saline groundwater discharge.

2.2 Known Vegetation Values

The study area falls within the region covered by the Biodiversity Plan for the South Australian Murray-Darling Basin and, more specifically, is within the Eastern Mount Lofty Ranges Regional Ecological Area (REA) (Kahrimanis *et al.* 2001). The clearance of native vegetation within the Eastern Mount Lofty Ranges REA has been extensive, with only 6% of the original vegetation cover remaining (Kahrimanis *et al.* 2001).

Two ecological communities listed as critically endangered under the *EPBC Act 1999* occur within the study area; Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia. Both listings are effective from 21 June 2007. DEH vegetation mapping of the region that includes the study area refers to these two ecological communities as *Eucalyptus odorata* woodland and *Lomandra effusa* +/- *L. multiflora* ssp. *dura* (open) tussock grassland respectively.

An index of conservation prioritisation for plant associations has been devised for South Australia. (Neagle 1995). This prioritisation provides the widely accepted list of vegetation communities of conservation significance. Under this index, *Lomandra effusa* +/- *L. multiflora* ssp. *dura* (open) tussock grassland has a Priority 1 conservation rating (very rare and endangered in SA), the highest conservation significance possible for a vegetation community in the state. This vegetation community occurs to the immediate south of the existing mine pit on the summit and slopes of a feature known as MacFarlane Hill (Playfair 2004; Ecological Associates 2007). Although MacFarlane Hill has reportedly been grazed by stock (Hibbird 2004; Playfair 2004; Parsons Brinckerhoff 2006), approximately 5.8 ha of this remnant is of high quality (Ecological Associates 2007). This 5.8 ha area represents a small proportion (approximately 0.4%) of the high quality remnants of the vegetation community in the eastern slopes of the Southern Mount Lofty Ranges (Ecological Associates 2007).

An area of *Eucalyptus odorata* woodland occurs to the north of the existing pit (Playfair 2004; Ecological Associates 2007). This vegetation has a conservation rating of Priority 3 (Neagle 1995), being poorly conserved in South Australia with most remnants being small and/or degraded and/or atypical. Within the study area a long history of grazing has depleted the understorey of some of this vegetation. However the area closest to the mine pit and extending along the eastern boundary of the property is in better condition than elsewhere (Playfair 2004) and has an intact understorey of native grasses and shrubs (Ecological Associates 2007). The *E. odorata* woodland within the study area is one of the largest remnants in the eastern slopes of the Southern Mount Lofty Ranges and includes approximately one third of the high quality vegetation of this type in the region (Ecological Associates 2007).

A waste-rock dump from past open pit mining operations is located immediately west of the mine pit. It consists of approximately 25 million tonnes of rock and covers an area of approximately 0.36 km^2 (Hibbird 2004). This feature has very steep sides and a level upper surface on to which soil has been placed. A revegetation area has been established on the eastern side and Golden Wattle, (*Acacia pycnantha*) and grass species are present. Bare ground is typical elsewhere.

To the north of the waste-rock dump is the old tailings retention area, covering approximately 0.35 km^2 (Hibbird 2004). This area has also been capped with soil and partially revegetated. It features grassy areas and unvegetated areas. In a gully to the east of the tailings retention area are two dams retaining acid leachate from the tailings. A small area of *Eucalyptus leucoxylon* ssp. *leucoxylon* woodland is located adjacent to these dams. A sedgeland dominated by introduced Sharp Rush (*Juncus acutus*) has formed to the west of the tailings area.

2.3 Mine Proposal

Hillgrove propose to redevelop and expand the existing Kanmantoo mine to extract copper ore and process the ore on site. The proposal involves extending the existing pit to the north and south and excavating additional satellite pits to the north, south and south-west (Figure 2). An integrated waste landform will be constructed involving an extension to the existing waste rock stockpile and construction of a new tailings storage facility to the west. An area for plant and equipment will also be required (Figure 2). The project 'footprint' is the sum of these features. In addition to the project footprint, vehicle tracks throughout the area will be utilised.

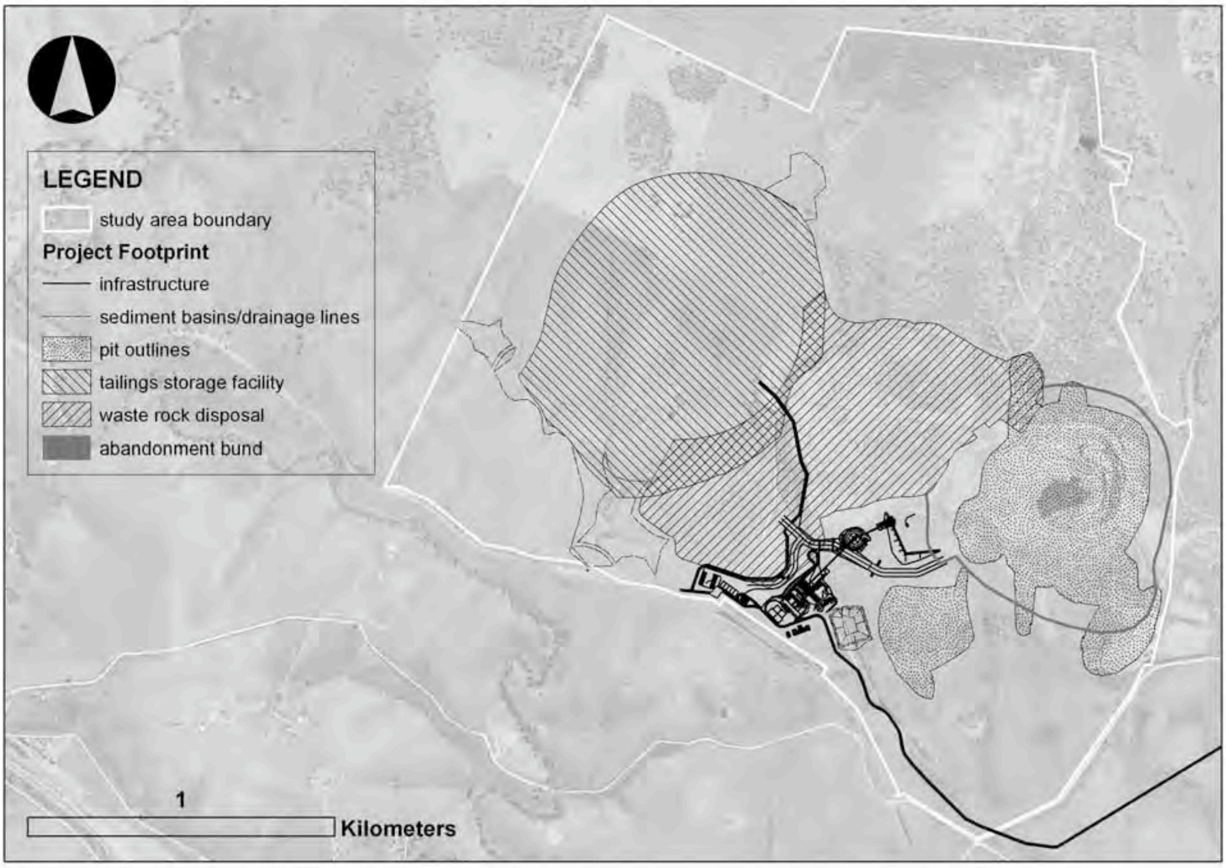


Figure 2. Proposed project footprint of Kanmantoo Copper Project.

2.4 Legislative Framework

Environment Protection and Biodiversity Conservation Act 1999

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*) an action requires approval from the Commonwealth Minister for the Environment and Water Resources if it is likely to have a significant impact on a matter of national conservation significance. Matters of national environmental significance relevant to this project are threatened species and ecological communities, migratory species and Wetlands of International Importance (Ramsar sites) listed under the *EPBC Act 1999*.

Assessment of the study area requires consideration of whether the site supports, or is likely to support, any matters of national environmental significance and risks to those matters. Where the proposal poses a significant risk, it is recommended that the matter be referred to the Minister for Environment and Water Resources. The project was referred on 26 February 2007, and the DEWR determined on 30 March 2007 that the project was not a controlled action. No further assessment under the EPBC Act is therefore required for the project.

Native Vegetation Act 1991

The *Native Vegetation Act 1991* regulates the clearance of native vegetation in South Australia. Under the Act, native vegetation includes vegetation that has never been cleared or has been cleared but has regenerated naturally. Planted vegetation is not considered native vegetation unless it's planting was undertaken in compliance with a condition imposed by the Native Vegetation Council.

The Native Vegetation Council has delegated Primary Industries and Resources South Australia (PIRSA) to administer the *Native Vegetation Act 1991* as it applies to mining. PIRSA applies the policies of the Native Vegetation Council on clearance and revegetation through the use of Mining and Rehabilitation Programs (MARPs) under Regulation 42 of the Mining Act.

In seeking approval to clear native vegetation it is necessary for a MARP to demonstrate that:

- the work cannot be established without the clearance of some native vegetation and that native vegetation is avoided or impacts minimised wherever possible;
- the site chosen contains the least significant native vegetation, provided that works can occur at that site; and
- intact strata of native vegetation are avoided.

It is also necessary for the MARP to demonstrate that in clearing native vegetation, a Significant Environmental Benefit (SEB) will be achieved elsewhere. Works to revegetate, restore, regenerate or enhance native vegetation may achieve SEB.

So that SEB can be calculated, MARPs must report the nature and extent of impacts on native vegetation. This involves a detailed assessment of the plant species and plant communities present, their conservation significance and habitat value for fauna.

National Parks and Wildlife (NPW) Act 1972

The *NPW Act 1972* provides for the protection of flora and fauna species listed under the Schedules of the Act. There are penalties for taking these protected species without a permit issued by the Department for Environment and Heritage (DEH). For plants, 'taking' includes removal of the plant or part of the plant from where it is growing, or damaging the plant.

Development Act 1993

The District Council of Mount Barker has prepared a development plan as per the requirements of the *Development Act 1993*. This plan contains rules, policies and objectives to guide development on land within the council area. Of particular relevance to exploration activities is an area designated as 'Policy Area 16' in the Development Plan. This is an area of remnant vegetation to the north of the mining lease. The objectives of the plan for this area are to protect and enhance all native species and revegetate degraded vegetation.

2.5 Existing Information

The most comprehensive existing information on the flora and vegetation of the study area is provided by Playfair (2004). Playfair's report, commissioned by Hillgrove, presents information from a survey of a part of the study area (Mining Lease 5776) in July 2004 and also a collation of pre-existing information. Playfair lists 91 native and 12 introduced plant species including one species listed as threatened in South Australia (*Diuris behrii*, Behr's cowslip orchid) and an additional nine species considered rare or threatened in the region. Playfair mapped part of the *Eucalyptus odorata* woodland, describing the area extending north of the open pit along the eastern boundary of the property as in better condition and less invaded by introduced species than areas to the north-west and along the northern boundary of the property. Part of the *Lomandra effusa* grassland was also mapped.

In 2006 Hillgrove commissioned Ecological Associates to investigate the extent and condition of remnants of *Eucalyptus odorata* woodland and *Lomandra effusa* grassland in the Kanmantoo area (Ecological Associates 2007). The purpose of this investigation was to enable a more accurate assessment of the significance of any potential development by Hillgrove on the two plant associations, both of which have been nominated for listing as threatened ecological communities under the *EPBC Act 1999.* The investigation found that the area of *Eucalyptus odorata* woodland within the study area comprises approximately one third of the high quality remnant vegetation of this type in the eastern slopes of the Southern Mount Lofty Ranges and is one of the largest remnants. *Lomandra effusa* grassland of 5.8 ha within the study area was also considered high quality, however this represented only 0.4% of the high quality remnants in the eastern slopes of the Southern Mount Lofty Ranges.

The Department for Environment and Heritage (DEH) manages the Biological Database of South Australia (BDBSA). An extract from the BDBSA revealed three locations within the study area for which flora records were available. These records consisted of a total of 75 native plant species, including one species listed as threatened in South Australia, *Ptilotus erubescens* (Hairy-tails). Records of 21 introduced species were also present. For this study, the BDBSA extract was extended to a 6 km radius from the study area boundary. This provided additional records of two species listed as threatened under the *EPBC Act 1991*; *Acacia menzelii* (Menzel's wattle) and *Olearia pannosa* ssp. *pannosa* (silver daisy-bush). Additionally, eight species listed as threatened within South Australia occur within this extended area. These ten species have not been recorded within the study area, however their presence within the vicinity of the study area suggests they may be present but have not yet been detected.

In 2006 the Kanmantoo-Callington Landcare Group, with support from Hillgrove, undertook a study of the significant vegetation within the study area. This work reported plant species not previously recorded for the area. Management recommendations were made for particular patches of vegetation within the study area. Referring to the area of *Eucalyptus odorata* woodland immediately north of the existing pit, the authors concluded "It is the least disturbed or weed invaded area of this … vegetation association known to exist in SA …" (Simon and Seager 2006).

The Kanmantoo-Callington Landcare Group, again in 2006 and with support from Hillgrove, prepared an Interim Weed Control Strategy for the Kanmantoo mine site (Seager 2006). This report addressed the highest priority weed issues in the area. Weed species not previously recorded for the study area were identified in this report.

In spring 2006 Ecological Associates undertook a targeted survey within the study area for the two plant species listed as threatened in South Australia known to occur within the study area; *Diuris behrii* (Behr's cowslip orchid) and *Ptilotus erubescens* (Hairy-tails) (Ecological Associates 2006). This survey recorded *Diuris behrii* at two locations within *Eucalyptus odorata* woodland. *Ptilotus erubescens* was not detected.

Native vegetation within the study area has been mapped by DEH (Kahrimanis *et al.* 2001). This mapping indicates 53 ha of native vegetation within the study area. It should be noted that this mapping was undertaken at a relatively coarse scale by interpretation of 1:40 000 aerial photography and has not been ground-truthed.

A summary of plant species and vegetation communities of conservation significance previously reported for the area is provided in Table 1.

Table 1. Conservation significance of previously reported species and vegetation communities.

Species or Vegetation Community	Level of Significance		
	National[1]	State[2]	Regional[3]
Eucalyptus odorata woodland	✓	✓	✓
Lomandra effusa grassland	✓	✓	✓
Ptilotis erubescens (Hairy-tails)		✓	✓
Diuris behrii (Behr's cowslip orchid)		✓	✓
11 additional species			✓

1. Listed as threatened under the *EPBC Act 1999*.

2. Listed as rare or threatened in Neagle (1995) (vegetation communities) or under the *NPW Act 1972* (species).

3. Listed as threatened in the SA Murray-Darling Basin in Kahrimanis *et al.* (2001).

3.1 Method

Vegetation Community Mapping

On 12, 13 and 27 February and 8 March 2007 the entire study area was surveyed by vehicle and on foot. Native vegetation remnants were located and the vegetation communities comprising them were identified. ArcMap© was used to map all remnants based on the field survey and extrapolation of orthorectified aerial photography. Terminology follows the regional floristic mapping for the western Murray flats (Kahrimanis *et al.* 2001).

A list of all plant species observed was compiled for each vegetation community, except two communities that comprised a very minor component of the vegetation within the study area.

Vegetation Condition Mapping

Vegetation condition was also mapped. The condition of native vegetation remnants was assessed using the methodology outlined in *Draft Guidelines for Native Vegetation Significant Environmental Benefit Under the Native Vegetation Act 1991 and Regulations 2003 for the Mineral and Petroleum Resources Industry* (DWLBC 2005). Using this methodology, vegetation condition was reported as a significant environmental benefit (SEB) ratio. These ratios represent the area to be offset in compensation for impacted areas of native vegetation. The SEB ratios that can be assigned are 10:1 (highest quality vegetation), 8:1, 6:1, 4:1 and 2:1 (lowest quality vegetation).

Quadrat Survey

The vegetation survey method outlined in the *Guide to a native vegetation survey using the Biological Survey of South Australia* (Heard and Channon 1997) was used to prepare detailed quadrat descriptions of the four major vegetation associations present in the study area. One quadrat was surveyed within each of the following vegetation associations:

- *Austrostipa* sp. Open tussock grassland;
- *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland;
- *Eucalyptus odorata* Low woodland; and
- *Eucalyptus gracilis* ± *Eucalyptus oleosa* Open mallee.

Scattered Tree Assessment

Scattered trees within the study area that are located within the project footprint were assessed using a datasheet provided by PIRSA based on the methodology outlined in *Scattered Tree Habitat Value Ready Reckoner* (Cutten and Hodder 2002). This methodology requires a photograph of each tree and a record of its location, species, height, trunk diameter at breast height, proportion of canopy dieback, canopy diameter, proportion of canopy mistletoe, number of individual mistletoe infections and number of small (<5 cm), medium (5 – 15 cm) and large (>15 cm) diameter hollows. Subsequently, suitability as habitat for threatened fauna, density of scattered trees in the vicinity and proximity to remnant native vegetation was scored for each tree using a scoring system provided by PIRSA based on the principles outlined by Cutten and Hodder (2002). Spatial data for scattered tree density and proximity to remnant native vegetation were obtained using ArcMap©. The total SEB for all scattered trees within the proposed project footprint was calculated using the NV_Points19.xls spreadsheet provided by the Native Vegetation Group within DWLBC.

Roadside Vegetation Assessment

An assessment of the roadside vegetation of Back Callington Road between Mine Road and the township of Callington was made. The road was divided into four sections, each with relatively homogeneous vegetation on both sides (north and south). For each section, both sides of the road were surveyed at several locations and a plant species list was compiled for each side. The flora survey was not comprehensive but recorded dominant and notable species. Planted trees were not assessed but there presence was noted. The vegetation community comprising the roadside vegetation was identified and its condition was scored using the approach described above for vegetation within the study area. Based on the information obtained, the side of Back Callington Road (north or south) of lower conservation significance was identified, providing guidance for potential clearance of roadside vegetation for road widening.

3.2 Results

Vegetation Communities

A total of 113 ha of native vegetation was identified and mapped within the study area. Eight vegetation communities were identified with vegetation condition ranging from SEB 8:1 to SEB 2:1 (Figure 4).

Eucalyptus odorata Low woodland is the most extensive vegetation community within the study area, occupying 54.1 ha. This vegetation community has been nominated for listing as a threatened ecological community (as Peppermint Box (*E. odorata*) Grassy Woodland) under the *EPBC Act 1999*. It is also of significance at the state level, listed as Priority 3 for conservation in Neagle (1995), and at the regional level, listed as threatened within the South Australian Murray-Darling Basin (Kahrimanis *et al.* 2001). A complete list of the plant species recorded for this vegetation community within the study area is provided in Appendix A. Quadrat survey data are provided in Appendix B. The best examples of this vegetation occurred to the north and north-west of the existing open pit (Figure 4) and had a condition of SEB 8:1. These areas have all vegetation strata intact, low cover of weeds, evidence of recent regeneration of overstorey trees and some old, hollow bearing trees (Figure 3). Areas with condition of SEB 6:1 are located immediately north of the open pit and a short distance further north (Figure 4). These areas have an intact overstorey and some evidence of regeneration of overstorey trees but an understorey with considerable weed infestation. Considerable physical disturbance, mainly vehicular tracks, is apparent at some locations within this area. Adjacent to the above areas, the northern boundary of the study area and the north-west corner of the study area are areas where condition was SEB 4:1 (Figure 4). The understorey of these areas is either very heavily invaded by weeds or largely absent with bare ground apparent (Figure 5). An intact overstorey is present but recent regeneration of overstorey trees is not apparent. These areas appear to have been subjected to extended periods of stock grazing. Two small areas, both of which fall within the footprint of the proposed tailings storage facility, have a condition of SEB 2:1 with the understorey completely absent and considerable soil disturbance and trampling from intensive stock grazing (Figure 6).

Figure 3. *Eucalyptus odorata* Low woodland with condition score of SEB 8:1.

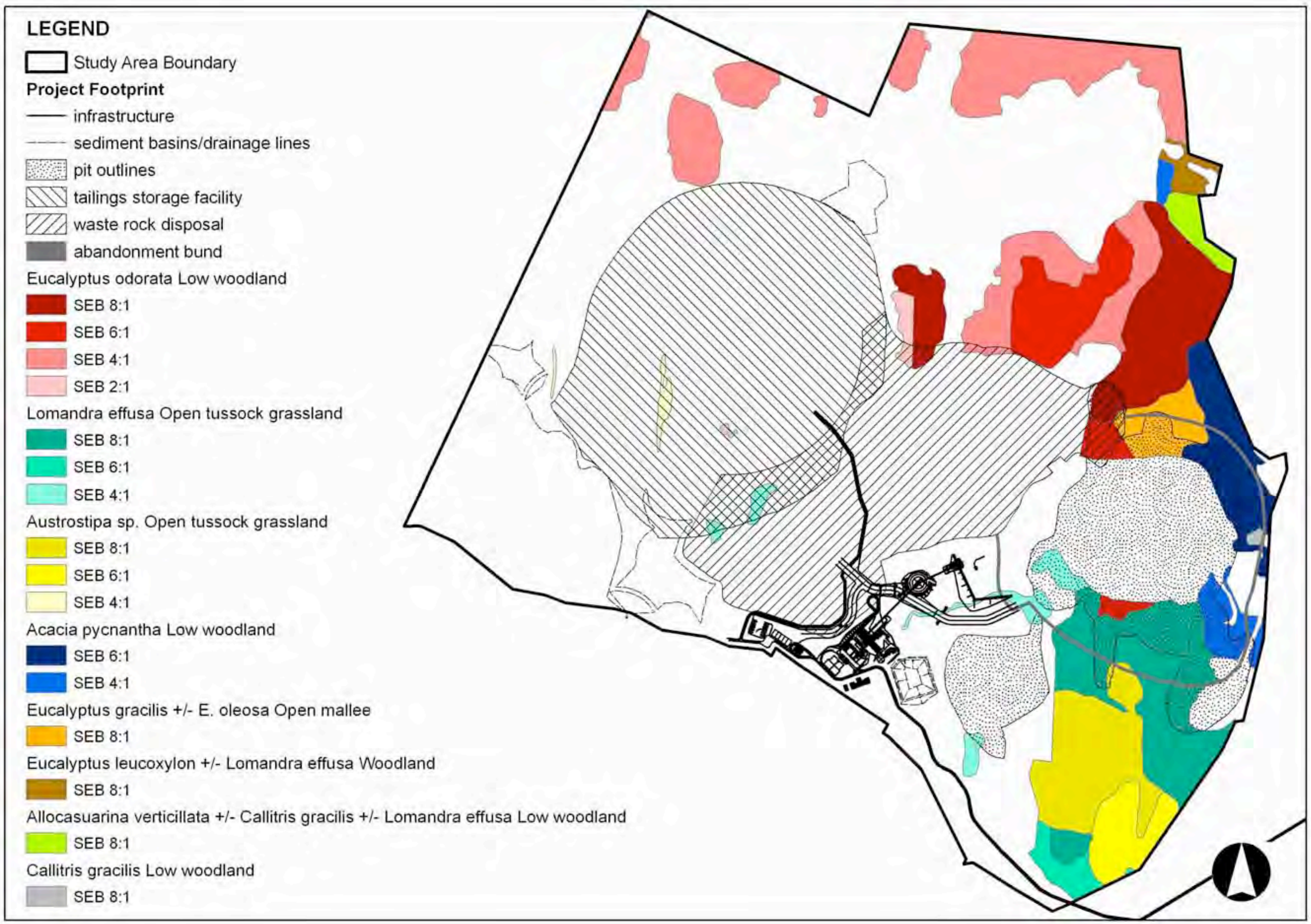


Figure 4. Vegetation map of the study area with proposed project footprint overlaid.

Figure 5. ***Eucalyptus odorata*** **Low woodland with condition score of SEB 4:1.**

Figure 6. ***Eucalyptus odorata*** **Low woodland with condition score of SEB 2:1 (right of fence).**

Lomandra effusa ± Heliochrysum leucopsideum Open tussock grassland occupies 23.3 ha of the study area. This vegetation community has been nominated for listing as a threatened ecological community (as Iron Grass (*L. effusa – L. multiflora* ssp. *dura*) Tussock Grassland) under the *EPBC Act 1999*. It is significant at the state level, listed as Priority 1 for conservation in South Australia (Neagle 1995), and at the regional level, listed as threatened within the SA Murray-Darling Basin (Kahrimanis *et al.* 2001). The community occurs predominantly to the south of the existing open pit on the crest and slopes of MacFarlane Hill. A list of the plant species recorded within the study area for this vegetation community is provided in Appendix A. The quadrat survey data are provided in Appendix B. The best examples featured an intact structure of dense *L. effusa* interspersed with native grasses and few weeds (Figure 7). These areas have been assigned a condition score of SEB 8:1. Emergent trees, typically *Allocasuarina verticillata*, are present in some areas. At the extreme south of the study area is a remnant patch with intact structure and featuring dense *L. effusa*, but with considerable weed invasion, predominantly the grass *Avena barbata* (Bearded Oat). This area has been assigned a condition score of SEB 6:1. Smaller remnants are present immediately south-west of the open pit and further west. These areas are more degraded, with sparse *L. effusa*, few native grasses and considerable soil disturbance, and have been assigned a condition score of SEB 4:1 (Figure 8).

Figure 7. *Lomandra effusa +/- Heliochrysum leucopsideum* Open tussock grassland with condition score of SEB 8:1.

Figure 8. *Lomandra effusa +/- Heliochrysum leucopsideum* Open tussock grassland with condition score of SEB 4:1.

Remnant patches of *Austrostipa* sp. Open tussock grassland occupies 17 ha. This community is of regional conservation significance, listed as threatened within the SA Murray-Darling Basin (Kahrimanis *et al*. 2001). The community is floristically quite similar to *Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland, however *L. effusa* is absent and the dominant species is the native grass *Austrostipa* sp. (the species was not able to be identified due to the absence of flowers or seed). A complete species list for this community within the study area is provided in Appendix A. Quadrat survey data are provided in Appendix B. *Austrostipa* sp. Open tussock grassland occurs predominantly on the southern crest and slopes of MacFarlane Hill. Small remnants also occur amongst outcropping ridgelines on the former 'Paringa' grazing property (Figure 4). The best example occurs on the western slope of MacFarlane Hill. In this area the vegetation has a low cover and diversity of weeds and a relatively high diversity of native grasses and herbs, a relatively high density of grass tussocks, and has been assigned a condition score of SEB 8:1 (Figure 9). On the southern slope of MacFarlane Hill the vegetation is intact but with a greater proportion of weeds (Figure 10) and has been assigned a condition score of SEB 6:1. The small remnants on the former 'Paringa' property have been subject to extended grazing and feature stock tracks, bare ground and considerable weed invasion. These areas have been assigned a condition score of SEB 4:1.

Figure 9. ***Austrostipa*** **sp. Open tussock grassland with condition score of SEB 8:1.**

Figure 10. ***Austrostipa*** **sp. Open tussock grassland with condition score of SEB 6:1.**

To the immediate east and north-east of the existing pit, divided by the work area for the existing mine, is an area of 11.2 ha of *Acacia pycnantha* Low woodland (Figure 4). This vegetation community was not mapped by DEH for the Western Murray Flats vegetation mapping project (Kahrimanis *et al.* 2001). Anecdotal reports and the absence of overstorey *Eucalyptus* species suggest that this community has been subject to past disturbance or clearance and has regenerated naturally. It is likely that, if left undisturbed, this community would in time develop into one of the adjoining vegetation communities, i.e. either *Eucalyptus odorata* Low woodland, *Eucalyptus gracilis ± E. oleosa* Open mallee or a combination of both. To the north east of the existing pit this vegetation community is dominated by an overstorey of low *Acacia pycnantha*, has an intact understorey dominated by native grasses, particularly *Austrostipa* sp., and low shrubs and has a low cover of weeds (Figure 11). The condition of the vegetation in this vicinity was scored as SEB 6:1. Further to the south, at the base of the eastern side of MacFarlane Hill, the vegetation appears to have been more recently disturbed and partially cleared. At this location a condition score of SEB 4:1 was assigned. Another small patch of this community, in the same condition, is located south of the tailings retention dam in the north-east of the study area. A complete species list for *Acacia pycnantha* Low woodland is provided in Appendix A.

Figure 11. *Acacia pycnantha* Low woodland with condition score of SEB 6:1.

A small area (4 hectares) of *Eucalyptus gracilis ± E. oleosa* Open mallee is located to the immediate north of the existing open pit. There is evidence of past timber gathering in this area, however the vegetation is relatively intact with a diverse native understorey and low weed cover (Figure 12). This vegetation was assigned a condition score of SEB 8:1. A list of the plant species identified for this community is provided in Appendix A. Quadrat survey data are provided in Appendix B.

Figure 12. ***Eucalyptus gracilis* ± *E. oleosa* Open mallee with condition score of SEB 8:1.**

A 1.8 ha remnant of *Allocasuarina verticillata* ± *Callitris gracilis* ± *Lomandra effusa* Low woodland is located in steep, rocky terrain to the south of the tailings retention dam in the north-east of the study area (Figure 13). The vegetation structure is intact in this area, with overstorey trees and understorey shrubs, grasses and herbs all present at apparently natural densities. Some weedy grass species are present but weed cover is low. A condition score of SEB 8:1 was assigned to this vegetation. Appendix A lists the plant species present.

Figure 13. ***Allocasuarina verticillata* ± *Callitris gracilis* ± *Lomandra effusa* Low woodland with condition score SEB 8:1.**

To the immediate south of the tailings retention dam near the north-east corner of the study area is a remnant patch of *Eucalyptus leucoxylon* ssp. *leucoxylon* ± *Lomandra effusa* Open woodland of 1.3 ha. The vegetation appears to be in good condition with all strata intact and was assigned a condition score of SEB 8:1. The remnant is small and located a considerable distance from the proposed project footprint, therefore a plant species list was not compiled. This community is of conservation significance at the regional level, listed as threatened within the SA Murray-Darling Basin (Kahrimanis *et al.* 2001).

A very small (0.2 ha) area of *Callitris gracilis* Low woodland is located east of the existing open pit adjacent to the mine entrance gate. The vegetation at this location appears relatively intact with overstorey trees and understorey shrubs, grasses and herbs all present and weed cover low. A condition score of SEB 8:1 has been assigned. Due to its small size a species list was not compiled, however plant species likely to be present are those listed for the adjacent *Acacia pycnantha* Low woodland (Appendix A), with the addition of *Callitris gracilis*. This community is of conservation significance at the regional level, listed as threatened within the SA Murray-Darling Basin (Kahrimanis *et al.* 2001).

A summary of the vegetation communities identified and mapped, their condition, area and conservation significance is provided (Table 2).

Table 2. Area and conservation significance of surveyed vegetation communities.

Vegetation Community	SEB Ratio	Area (ha)	Conservation Significance		
			National	State	Regional
Eucalyptus odorata Low woodland	8:1	14.9	✓	✓	✓
	6:1	9.7			
	4:1	28.5			
	2:1	1.0			
Lomandra effusa ± *Heliochrysum leucopsideum* Open tussock grassland	8:1	17.8	✓	✓	✓
	6:1	2.1			
	4:1	3.5			
Austrostipa sp. Open tussock grassland	8:1	11.6			✓
	6:1	4.7			
	4:1	0.7			
Acacia pycnantha Low woodland	6:1	7.7			
	4:1	3.5			
Eucalyptus gracilis ± *E. oleosa* Open mallee	8:1	4.0			
Allocasuarina verticillata ± *Callitris gracilis* ± *Lomandra effusa* Low woodland	6:1	1.8			
Eucalyptus leucoxylon ssp. *leucoxylon* ± *Lomandra effusa* Open woodland	6:1	1.3			✓
Callitris gracilis Low woodland	8:1	0.2			✓

Overlaying the proposed project footprint upon the mapped vegetation reveals the location and extent of vegetation that will require clearance under the proposal (Figure 4). Four vegetation communities, with condition ranging from SEB 8:1 to SEB 2:1, will be partially cleared. Table 3 provides a summary of the vegetation clearance and the offset areas required for each community to achieve significant environmental benefit.

Table 3. Vegetation requiring clearance and SEB offset calculation. Coffey Natural Systems provided calculations of areas to be cleared.

Vegetation Community	Area (ha) of each condition level (SEB ratio) to be cleared				Total area to be cleared (ha)	SEB offset required (ha)
	8:1	6:1	4:1	2:1		
Eucalyptus odorata Low woodland	1.23	2.02	0.32	0.34	3.92	23.92
Lomandra effusa ± Heliochrysum leucopsideum Open tussock grassland	9.59		2.54		12.13	86.88
Austrostipa sp. Open tussock grassland	0.21		0.61		0.82	4.12
Eucalyptus gracilis ± E. oleosa Open mallee	2.79				2.79	22.32
Acacia pycnantha Low woodland		4.26	2.57		6.82	35.84
Scattered Trees	56 trees (see below)					17.8
TOTAL						190.88

Species of Conservation Significance

The highest level of conservation significance for plant species recorded during the survey was regional. Four species listed as rare in the Murray botanical region were recorded (Table 4).

Table 4. Surveyed species of conservation significance.

Species	Common Name	Conservation Significance		
		National	State	Regional
Eucalyptus leucoxylon ssp. leucoxylon	South Australian Blue Gum			R[1]
Elymus scaber var. scaber	Native Wheat-grass			R
Aristida contorta	Curly Wire-grass			R
Aristida behriana	Brush Wire-grass			R

1. R = Rare; having a low overall frequency, confined to a restricted range or scattered sparsely over a wider area.

The shrub *Acacia iteaphylla*, listed as rare in SA, was also recorded within the study area. However, this species was growing outside of its natural range and can be considered introduced. The species is commonly planted for revegetation projects.

Although relatively few species of conservation significance were recorded for the current survey, an additional two species of state significance and 19 species of regional significance have been recorded in the study area by previous surveys. A complete list of plant species, both native and introduced, recorded for the study area by this and previous surveys is provided in Appendix C.

The two species of conservation significance at the state level that have been recorded previously within the study area are *Diuris behrii* (Behr's cowslip orchid), which is listed as vulnerable, and *Ptilotus erubescens* (hairy tails), listed as rare. The known locations of *Diuris behrii* were recorded by Ecological Associates (2006) and by the Kanmantoo-Callington Landcare Group (KCLG) in the significant vegetation study in 2006. The single location of *Ptilotus erubescens* was obtained from the BDBSA extract provided by DEH. An additional 53 species are also listed at the same location, indicating that the BDBSA record location may represent an amalgamation of records for a wider area. Thus the spatial confidence of the BDBSA *Ptilotus erubescens* record is lower than that for the *Diuris behrii* records.

The known locations of species of conservation significance at the state level within the study area are shown in Figure 14. This figure indicates that some of the known *Diuris behrii* sites fall within the proposed project footprint.

Scattered Trees

Fifty-six scattered trees were documented within the area defined by the proposed project footprint plus a ten metre buffer to allow for small scale spatial error. Fifty–five of these trees were *Eucalyptus odorata* and there was one *Allocasuarina verticillata*. Twenty-four trees had hollows. Tree height ranged from 4 to 13 metres and canopy diameter from 2 to 17 metres. Diameter at breast height ranged from 8 to 120 cm. Mistletoe was not noted on any tree. Dieback ranged from 0 to 90%. All scattered trees scored one point (the lowest score) for suitability for threatened fauna species. All scattered trees were located a considerable distance from vegetation of high quality and there were no threatened fauna species observations or previous records in the immediate vicinity of the trees. Data for all fifty-six scattered trees assessed is provided in Appendix D.

The total offset required to achieve SEB for the clearance of the fifty-six scattered trees within the project footprint (plus ten metre buffer) is 17.8 hectares.

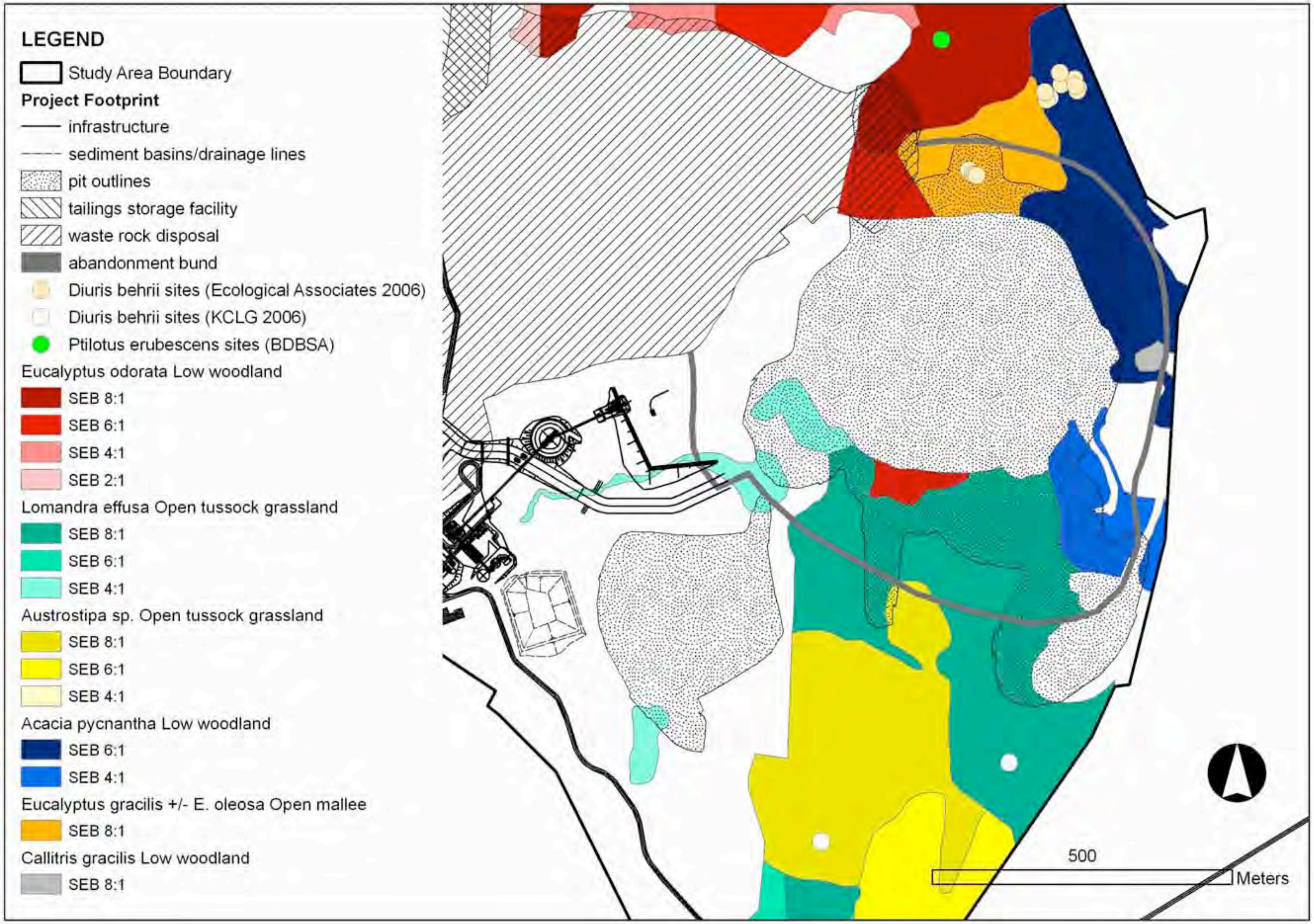


Figure 14. Location of threatened species (source indicated) within study area.

Roadside Vegetation

For the purpose of assessment, Back Callington Road was divided into four sections of approximately equal length within which the roadside vegetation was relatively homogeneous (Figure 15). The roadside reserve varies in width from approximately 1 to 5 m.

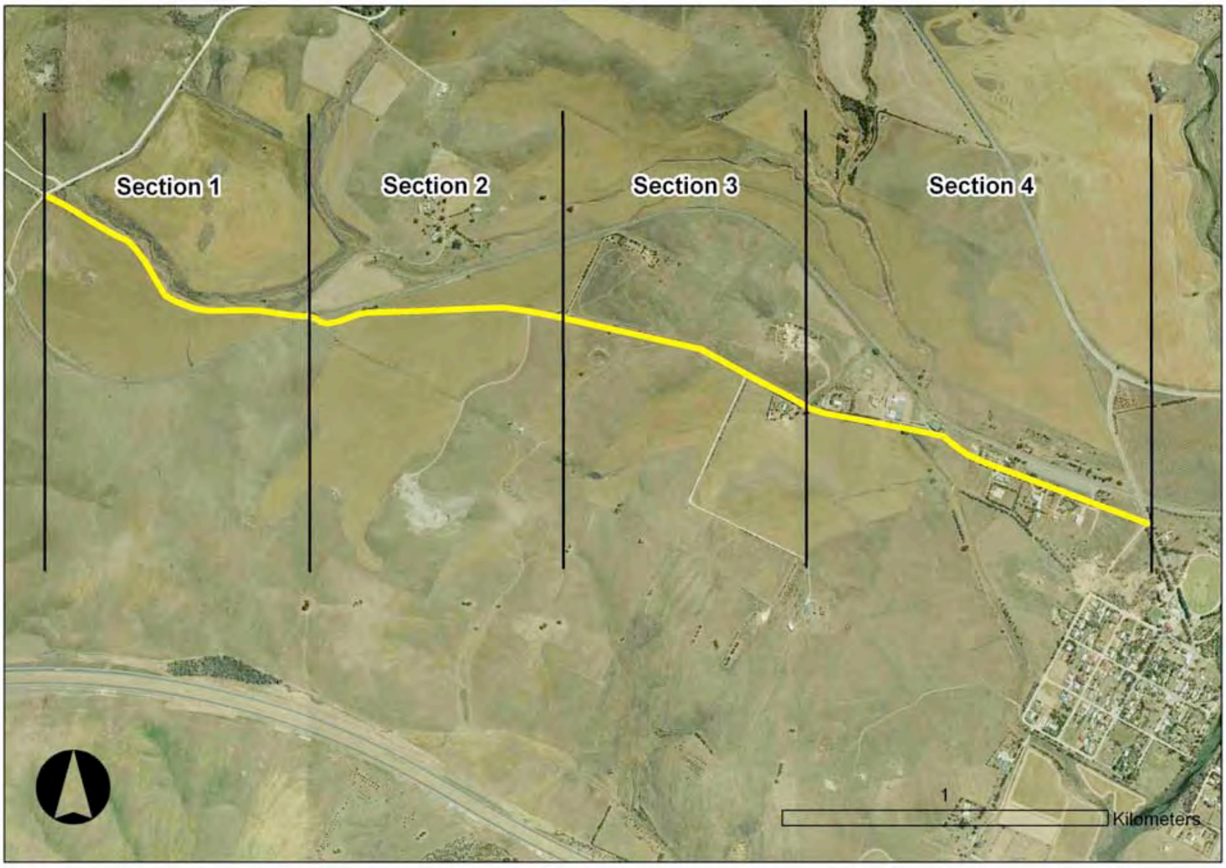


Figure 15. Sections of Back Callington Road (yellow line) assessed for conservation significance.

Vegetation on both sides of Section 1 is classified as *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland. However, because the tussocks are typically sparse and the vegetation is dominated by weeds, a condition score of SEB 2:1 was assigned to both sides. One species of conservation significance was observed on both side of the road, the regionally rare grass *Aristida contorta*. Some of the trees (e.g. *Acacia pycnantha*) appear to have been planted and therefore do not constitute native vegetation. The overall conservation significance of the vegetation is very similar on both sides of the road. However the northern side is, in some areas, contiguous with native vegetation immediately north of the roadside reserve. In contrast, the southern side borders cropped paddock with no native vegetation. Given this difference, the southern side of Back Callington Road in Section 1 is considered to have lower conservation significance than the northern side.

Figure 16. Example of roadside vegetation, Back Callington Road; southern side within Section 1.

Section 2 also features *Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland on both sides. The *Lomandra effusa* tussocks are very sparse in places and the vegetation is dominated by weeds, with a condition score of SEB 2:1. There is very little difference in conservation significance of the vegetation on either side of the road. On both sides the roadside reserve adjoins cropped land. Trees have been planted on the northern side. These trees are not native vegetation as such but may provide habitat for fauna. Given the presence of planted trees on the northern side and the absence of any other differences between the north and south side, the southern side of Back Callington Road in Section 2 is considered to have lower conservation significance than the northern side.

In Section 3 both sides of the road again feature *Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland. The vegetation is typically weed dominated, with a condition score of SEB 2:1 on both sides. However, on the northern side there are some small patches of *L. effusa* of greater density. The northern side also features some planted trees, that may have value as discussed above. Therefore, the southern side of Back Callington Road is considered to have lower conservation significance than the northern side in Section 3.

Section 4 was not surveyed for flora because native vegetation appears to be absent from this section. The roadside vegetation consists exclusively of weeds and planted trees. The road passes through a residential area in Section 4. The conservation significance of the roadside vegetation in this section appears to be very low on both sides of the road. Both sides have been planted with a similar number of trees. Neither side appears to have a higher conservation significance than the other.

Table 5. Summary of data collected for each section of Back Callington Road.

Section	Length (m)	Vegetation Community	Conservation Significance			Side of Road	
			Nat.	State	Reg.	north	south
1	960	*Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland	✓	✓	✓	✓	✓
		Vegetation Condition (SEB ratio)				2:1	2:1
		Lower Significance (preference for clearance)					✓
2	770	*Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland	✓	✓	✓	✓	✓
		Vegetation Condition (SEB ratio)				2:1	2:1
		Lower Significance (preference for clearance)					✓
3	800	*Lomandra effusa ± Heliochrysum leucopsideum* Open tussock grassland	✓	✓	✓	✓	✓
		Vegetation Condition (SEB ratio)				2:1	2:1
		Lower Significance (preference for clearance)					✓
4	1100	No native vegetation – planted trees				✓	✓
		Vegetation Condition (SEB ratio)				n.a.	n.a.
		Lower Significance (preference for clearance)				No recommendation	

3.3 Pest Plants

Twenty-four introduced plant species were recorded for the survey (Appendix A). The total number of introduced species documented for the study area by all known surveys is 47 (Appendix C). The pest status of introduced species, i.e. the capacity to cause ecological degradation, varies between species.

Grasses

Several introduced grasses are present within the study area but Wild Oats (*Avena barbata*) is the most abundant. This species is very common throughout the agricultural regions of South Australia. Within the study area it was most abundant within the *Austrostipa* sp. open tussock grassland and *Lomandra effusa ± Heliochrysum leucopsideum* open tussock grassland. Native grassland vegetation may benefit from intermittent controlled grazing, which may assist in the control of introduced grasses such as wild oats. Burning is another management tool used to promote native grasses and disadvantage introduced grasses.

Herbs

Bridal creeper (*Asparagus asparagoides*) has been recorded within the *Eucalyptus odorata* Low woodland vegetation community, particularly beneath the canopies of old, large trees (Ecological Associates 2006). The species is proclaimed in South Australia. The spread of Bridal Creeper is facilitated by physical disturbance.

Disa bracteata (South African Weed Orchid) has been recorded within *Eucalyptus gracilis ± E. oleosa* Open mallee and *Acacia pycnantha* Low woodland vegetation communities within the study area (Ecological Associates 2006). It may also be present in other communities. Although it is not a proclaimed species it has the potential to degrade understorey vegetation and displace native orchid species.

Artichoke Thistle (*Cynara cardunculus ssp. flavescens*) was recorded within the *Austrostipa* sp. open tussock grassland, although it is probably not restricted to this vegetation community. This species has the potential to degrade native grassland communities and should be controlled.

Salvation Jane (*Echium plantagineum*) does not currently appear to be abundant within the study area. However, this species has great potential to spread and degrade native vegetation, particularly grassland communities.

Shrubs

Red-head Cotton-bush *(Asclepias curassavica)* was recorded within the *Austrostipa* sp. open tussock grassland and *Lomandra effusa ± Heliochrysum leucopsideum* open tussock grassland. Flinders Ranges Wattle (*Acacia iteaphylla*) was recorded within the *Eucalyptus gracilis ± E. oleosa* Open mallee and *Acacia pycnantha* Low woodland vegetation communities, where it may have been intentionally planted. Western Coastal Wattle (*Acacia cyclops*) and Boneseed (*Chrysanthemoides monilifera ssp. monilifera*) have also been recorded within the study area. All of these species are a high priority for control.

Woody Weeds

Woody weeds recorded within the study area include Olive (*Olea europaea ssp. europaea*), Aleppo Pine (*Pinus halepensis*) and African Boxthorn (*Lycium ferocissimum*). All of these species are a priority for control.

4.1 Clearance of Native Vegetation

The proposed development involves structures and excavations which require the clearance of native vegetation. The composition, area and quality of vegetation to be impacted is presented in Table 6.

Table 6. Summary of unavoidable vegetation clearance impacts. Coffey Natural Systems provided calculations of areas to be cleared.

Vegetation Community	Condition (SEB ratio)	Condition Description	Area (ha) to be cleared	Area (ha) within project area	% of project area to be cleared
Eucalyptus odorata Low woodland	8:1	Very good condition: little disturbance, all strata present, evidence of overstorey recruitment, large old trees present, high understorey diversity, low weed cover, litter and woody debris cover high.	1.23	14.9	8.26%
	6:1	Good condition: some disturbance (grazing, weed invasion, tracks, timber getting), at least strata depleted in cover, limited overstorey recruitment, large old trees present, high to moderate understorey diversity, low to moderate weed cover, litter and woody debris cover high to moderate.	2.02	9.7	20.82%
	4:1	Moderate condition: considerable disturbance (extended grazing), at least one strata absent, no evidence of overstorey recruitment, moderate to low understorey diversity, moderate to high weed cover, litter and woody debris cover moderate to low.	0.32	28.5	1.12%
	2:1	Poor condition: high disturbance (extended grazing), at least one strata absent, no evidence of overstorey recruitment, very low understorey diversity, high weed cover, litter and woody debris cover low to absent.	0.34	1.0	34%
Lomandra effusa ± Heliochrysum leucopsideum Open tussock grassland	8:1	Very good condition: little disturbance, all strata present, native diversity high, weed cover low, litter cover high.	9.59	17.8	53.88%
	4:1	Moderate condition: considerable disturbance (extended grazing, tracks, weed invasion), one strata depleted, native diversity moderate to low, weed cover moderate to high, litter cover moderate to low.	2.54	3.5	72.57%
Austrostipa sp. Open tussock grassland	8:1	Very good condition: little disturbance, all strata intact, high density of tussocks, native diversity high, weed cover low, litter cover high to moderate.	0.21	11.6	1.81%

Vegetation Community	Condition (SEB ratio)	Condition Description	Area (ha) to be cleared	Area (ha) within project area	% of project area to be cleared
	4:1	Moderate condition: considerable disturbance (extended grazing, weed invasion), all strata present but depleted in cover, moderate to low density of tussocks, native diversity moderate to low, weed cover moderate to high, litter cover moderate to low.	0.61	0.7	87.14%
Eucalyptus gracilis ± E. oleosa Open mallee	8:1	Very good condition: little disturbance, all strata intact, evidence of overstorey recruitment, high understorey diversity, weed cover low, litter and woody debris cover high.	2.79	4.0	69.75%
Acacia pycnantha Low woodland	6:1	Good condition: some disturbance (past clearance, weed invasion, tracks), overstorey depleted, high understorey diversity, weed cover low to moderate, litter and woody debris cover high to moderate.	4.26	7.7	55.32%
	4:1	Moderate condition: considerable disturbance (past clearance, weed invasion, tracks), overstorey depleted, moderate understorey diversity, weed cover moderate to high, litter and woody debris moderate to low.	2.57	3.5	73.43%
Scattered Trees	n/a	See Appendix D	56 trees	not assessed	

Under the Native Vegetation Act, the Native Vegetation Council has developed a framework to calculate the significance of vegetation clearance and the mitigation required to compensate for them. The mitigation requirements are based entirely on the quality of the vegetation and are presented in Table 6.

Based on this framework, impacts are most effectively reduced by minimising the area of high quality vegetation to be cleared.

The framework does not take into account the conservation significance of different vegetation types. This survey has determined that the plant communities with the highest conservation significance at a state or regional level are:

- *Eucalyptus odorata* Low woodland;
- *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland; and
- *Austrostipa* sp. open tussock grassland

Impacts on the conservation values of the site will be best be minimised by minimising the clearance of these plant associations.

Impacts on roadside vegetation can be minimised by limiting clearance to the southern side of the Back Callington Road.

4.2 Incidental Impacts on Native Vegetation

The project has the potential to impact on vegetation through the normal operation of the site. These impacts may result from track construction, vehicle movement and earthmoving.

These activities potentially impact on native vegetation in the following ways.

- Track construction can fragment native vegetation, increasing the perimeter to area ratio and making vegetation remnants more vulnerable to weed invasion. Pruning involved in track construction can also expose trees to disease such as Mundulla Yellows.
- Stockpiling earth can smother native vegetation and spread weed propagules.
- Earth and debris on vehicles can spread weed propagules.

These risks can be minimised by:

- locating tracks outside vegetation remnants where possible;
- minimising the length and number of tracks in vegetation remnants;
- maintaining proper hygiene procedures when pruning or removing vegetation;
- identifying stockpile sites for earth where they will not contaminate native vegetation; and
- establishing standards for these risk minimisation measures and assessing performance against them.

These risk minimisation measures can be incorporated in an Environmental Management Plan. This may involve clearly delimiting protected vegetation on the ground with fencing or flagging tape, clearly identifying roads and access-ways, developing procedures for vehicle traffic and clearly identifying areas not considered as native vegetation where vehicle movements, ground disturbance, equipment laydown or other disturbances are acceptable.

The highest priorities for protection are sites in the best condition and vegetation communities with conservation significance at the state or regional level, namely:

- *Eucalyptus odorata* Low woodland;
- *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland; and
- *Austrostipa* sp. open tussock grassland.

4.3 Dust

Dust generated by mine operations is a potential risk to native vegetation. Dust may affect vegetation chemically, through the minerals they contain, or physically by deposits on leaves and flowers. Activities that create dust include vehicle movement, quarrying and crushing of rock, conveyance of ore and waste rock and stockpiles.

Dust particles form a crust on leaves, stems and flowers. This may eventually block stomata inhibiting gas exchange or reduce the light available for photosynthesis (Murray 2005). Reductions in photosynthesis and respiration may result in poor growth and flowering. Plants with leaf hairs may be affected to a greater extent as the leaf hairs trap dust on the leaf surface. Reactive dust particles include alkaline and acidic particles. These particles may have more severe impacts and symptoms include yellow spots on leaves, leaf curling and interveinal necrosis (Murray 2005). In severe cases there may be abscission of leaves, reduced seed or fruit set or plant death.

The risks to vegetation associated with dust are uncertain. The risk would be better defined if the composition and load of dust were known.

Nevertheless, the risk of dust to vegetation can be minimised by:

- controlling dust generation in blasting, excavations, earthmoving and ore treatment;
- maintaining roads to reduce potential for dust generation; and
- minimising vehicle movements.

4.4 Acid Mine Leachate

The mine has the potential to generate acidic leachates which can impact on native vegetation. Acid leachates form where minerals rich in reduced sulphur are oxidised and may therefore be associated with the mine pit and waste rock storage. If they escape to the environment they may degrade native vegetation, particularly in watercourses.

It is understood that the management of acid leachate is being considered in detail in other components of the mine development project. Risks to native vegetation will be minimised by preventing acid leachate from affecting to the soil or soil water in which native vegetation occurs.

4.5 Altered Groundwater and Surface Water Hydrology

The mine proposal involves the development of waste-rock stockpiles and excavations which may alter the runoff and drainage characteristics of the site. Vegetation condition is potentially affected by these works if they result in changes in the soil water regime, such as through waterlogging or the diversion of runoff. These activities may promote weed invasion, reduce tree health and may degrade the habitat for existing native plants.

Any impacts on the soil water regime of remnant vegetation or the flow regime in watercourses should be avoided.

The risk of altered groundwater and surface water hydrology to native vegetation can be minimised by:

- locating fill and excavations away from drainage lines;
- planning fill and excavations to avoid detaining or diverting runoff; and
- minimising drawdown on aquifers that discharge to wetlands and watercourses.

5.1 Options to Mitigate the Impacts of Vegetation Clearance

Introduction

The Significant Environmental Benefit required to mitigate the impacts on vegetation communities and scattered tree removal can be achieved in a number of ways. The offsets should be determined when the footprint of the mine development is finalised and offset strategies are negotiated with PIRSA. The costs and SEB return of each offset strategy will vary and must be planned to provide the most appropriate outcome for the project. However, the following strategies have been identified for consideration by Hillgrove for the Kanmantoo Copper Mine project.

These strategies may be undertaken on the Kanmantoo Coper Mine site or in the local area in cooperation with natural resource management agencies, research organizations, community groups, local government or government conservation agencies. Research recently by State Flora commissioned by Hillgrove Resources into propagation of *Lomandra effusa* may be considered as a contribution to SEB requirements.

Habitat Rehabilitation

Vegetation may be rehabilitated by controlling stock access. Grazing is currently mainly associated with SEB 2:1 and SEB 4:1 areas, but also with some SEB 6:1 and 8:1 areas. Grazing by stock can degrade native vegetation in a variety of ways including reducing plant biodiversity (by preferentially grazing more palatable species), preventing plant recruitment (by grazing seedlings), reducing habitat value by reducing overall plant cover, contributing to soil erosion by damaging soil crusts and promoting weeds by increased soil disturbance and reduced competition from native plants. Stock should be excluded from the project area to promote understorey vegetation diversity, overstorey species recruitment, reduce erosion risks and control weed risks.

Vegetation may also be rehabilitated by controlling weeds in vegetation remnants across the project area. The site supports a range of weed species such as exotic grasses (Wild Oats), herbaceous weeds (Bridal Creeper), shrubby weeds (Boneseed), woody weeds (African Boxthorn) and exotic trees (Olive and Aleppo Pine). These weeds are located within and adjacent to vegetation remnants. Control of these weeds will promote native species diversity and will promote the recruitment of overstorey vegetation.

Vegetation may be rehabilitated by controlling pest animals which degrade native vegetation and reduce habitat value for native fauna. Pest fauna known to, or likely to, occur at the site include Cat, Rabbit, European Hare and Fox. Pest fauna control would involve a program of baiting, burrow ripping and monitoring.

Habitat Consolidation

Revegetation can be used to consolidate isolated remnants and increase their overall habitat value. The property includes a number of vegetation patches which are potentially linked by revegetation to provide fewer, larger remnants with greater overall habitat diversity and reduced edge effects. Linkages can be highly effective in enhancing the resilience of populations of native flora and fauna because they facilitate the migration of biota across the landscape. This can help overcome genetic isolation (leading to problems such as inbreeding) and boost overall population numbers.

Habitat Protection

Significant Environmental Benefit can be achieved by preserving, in perpetuity, vegetation remnants under Heritage Agreements. Heritage Agreements formally dedicate an area of high-quality remnant vegetation exclusively for the purpose of conservation. The agreement is identified on the title of the property and persists when the property changes hands.

High value remnants on the property (SEB 8:1), protected from clearing during the project and nominated for Heritage Agreements, would be inspected by staff from the Department for Environment and Heritage. The department would provide species lists and access to grants for ongoing management (e.g. weed control and fencing) of the area to ensure a Significant Environmental Benefit.

Hillgrove could also identify and purchase high value remnants elsewhere in the district and place them under Heritage Agreements to further ensure the project results in a Significant Environmental Benefit, should other methods listed above not be feasible.

Payment to Native Vegetation Fund

The impacts associated with the project may be offset by payment to the Native Vegetation Fund. Determination of the amount to be paid to ensure Significant Environmental Benefit is as follows (DWLBC 2005):

a) Determine area to be cleared (in hectares);

b) Determine offset required (in hectares);

c) Determine land value ($/hectare – based on Valuer General determination for equivalent land purchase within region);

d) Native Vegetation Fund payment = [(a) x $800] + [(b) x (c)]

5.2 Limitations of this Study

The timing of this flora survey, in late summer following an extended dry period, was not optimal. Some annual and ephemeral herbaceous species are likely to be present only as below-ground seeds or tubers at this time. Some species lacked flowers or fruits and could not able to be identified.

Previous vegetation investigations (listed in Section 2.5) provide some information about the site at other times of year. However, the scope of this study was to provide a comprehensive assessment of the potential impacts of the proposal across the site, which the previous studies do not address.

5.3 Recommendations for Further Investigations

Spring Survey

Due to the limitations of the survey timing, it is recommended that elements of this survey are repeated in spring 2007. The following tasks should be repeated:

- survey of the quadrats; and
- species lists of the major vegetation communities.

Native Vegetation Management Plan

A Native Vegetation Management Plan should be prepared providing detailed information on the nature of vegetation rehabilitation and restoration works to be undertaken at the site. The plan would specify:

- the location and nature of revegetation, and a schedule for establishment maintenance tasks;
- the location and nature of pest plant control, and a schedule for maintenance tasks;
- a schedule for pest animal control activities and monitoring; and
- grazing management and a monitoring schedule.

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Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Acacia acinacea	Wreath Wattle								✓	
Acacia ligulata	Umbrella Bush								✓	
Acacia microcarpa	Manna Wattle								✓	
Acacia pycnantha	Golden Wattle				✓	✓	✓		✓	✓
Allocasuarina verticillata	Drooping Sheoak				✓		✓		✓	✓
Amphipogon sp.	Grey-beard Grass							✓	✓	
Amyema miquelii	Box Mistletoe								✓	
Aristida behriana	Brush Wire-grass			R			✓			
Aristida contorta	Curly Wire-grass			R	✓	✓	✓	✓	✓	✓
Atriplex semibaccata	Berry Saltbush								✓	
Austrodanthonia sp.					✓		✓	✓	✓	✓
Austrostipa elegantissima	Feather Spear-grass				✓				✓	
Austrostipa sp.	Spear-grass				✓	✓	✓	✓	✓	✓
Bromus sp.	Brome									
Bursaria spinosa ssp. lasiophylla	Downy Bursaria									✓
Callitris gracilis	Southern Cypress Pine									✓
Calostemma purpureum	Pink Garland-lily									
Chamaesyce drummondii										
Chenopodium desertorum ssp. microphyllum	Small-leaf Goosefoot								✓	
Convolvulus sp.	Bindweed				✓	✓		✓		

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Dianella revoluta var. revoluta	Black-anther Flax-lily				✓				✓	✓
Dodonaea viscosa ssp. cuneata	Wedge-leaf Hop-bush				✓	✓	✓			✓
Einadia nutans ssp. nutans	Climbing Saltbush								✓	
Elymus scaber var. scaber	Native Wheat-grass			R	✓		✓	✓	✓	
Enchylaena tomentosa var. tomentosa	Ruby Saltbush				✓	✓	✓		✓	✓
Enneapogon nigricans	Black-head Grass							✓		
Enneapogon sp.	Bottle-washers/Nineawn						✓	✓		✓
Epilobium billardierianum	Robust Willow-herb									
Eucalyptus gracilis	Yorrell				✓	✓			✓	
Eucalyptus leucoxylon ssp. leucoxylon	South Australian Blue Gum			R					✓	
Eucalyptus odorata	Peppermint Box								✓	
Eutaxia microphylla	Common Eutaxia				✓	✓			✓	✓
Gonocarpus tetragynus	Small-leaf Raspwort				✓	✓				✓
Goodenia robusta	Woolly Goodenia				✓					✓
Gramineae sp.	Grass Family						✓	✓		
Hardenbergia violacea	Native Lilac					✓				
Juncus pallidus	Pale Rush									
Juncus subsecundus	Finger Rush									
Kennedia prostrata	Scarlet Runner				✓	✓				
Lepidosperma viscidum	Sticky Sword-sedge						✓		✓	
Lomandra effusa	Scented Mat-rush				✓	✓	✓	✓	✓	

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Lomandra micrantha ssp. micrantha	Small-flower Mat-rush						✓		✓	
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe						✓			
Maireana brevifolia	Short-leaf Bluebush								✓	
Maireana enchylaenoides	Wingless Fissure-plant						✓	✓		
Maireana georgei	Satiny Bluebush						✓			
Maireana sp.	Bluebush/Fissure-plant									
Olearia axillaris	Coast Daisy-bush				✓	✓				
Oxalis perennans	Native Sorrel							✓		
Persicaria prostrata	Creeping Knotweed									
Plantago sp.	Plantain								✓	
Rhamnaceae sp.									✓	
Salsola kali	Buckbush									
Scaevola albida	Pale Fanflower				✓	✓				
Scaevola sp.	Fanflower				✓	✓	✓			
Senecio sp.	Groundsel				✓				✓	
Themeda triandra	Kangaroo Grass						✓			
Thysanotus patersonii	Twining Fringe-lily				✓					
Velleia sp.	Velleia				✓	✓				
Vittadinia blackii	Narrow-leaf New Holland Daisy								✓	
Vittadinia cuneata	Fuzzy New Holland Daisy					✓	✓	✓	✓	
Vittadinia sp.	New Holland Daisy				✓	✓		✓	✓	

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Wahlenbergia luteola	Yellow-wash Bluebell						✓	✓		
**Acacia iteaphylla*	Flinders Ranges Wattle		R		✓	✓				
**Aira sp.*	Hair-grass				✓					
**Asclepias curassavica*	Red-head Cotton-bush						✓	✓		
**Avena barbata*	Bearded Oat						✓	✓	✓	✓
**Briza maxima*	Large Quaking-grass				✓	✓	✓	✓	✓	✓
**Chenopodium album*	Fat Hen									
**Chondrilla juncea*	Skeleton Weed							✓		
**Cynara cardunculus ssp. flavescens*	Artichoke Thistle							✓		
**Cynodon dactylon var. dactylon*	Couch									
**Hirschfeldia incana*	Hoary Mustard									
**Juncus acutus*	Sharp Rush									
**Lycium ferocissimum*	African Boxthorn								✓	
**Marrubium vulgare*	Horehound							✓		
**Nicotiana glauca*	Tree Tobacco									
**Panicum hillmanii*	Witch-grass							✓		
**Polypogon monspeliensis*	Annual Beard-grass									
**Romulea rosea var. australis*	Common Onion-grass							✓		
**Salvia verbenaca form*	Wild Sage							✓		
**Scabiosa atropurpurea*	Pincushion									
**Senecio pterophorus*	African Daisy								✓	

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
**Solanum nigrum*	Black Nightshade							✓		
**Trifolium arvense var. arvense*	Hare's-foot Clover								✓	
**Trifolium sp.*	Clover									
**Vulpia myuros*	Fescue							✓		

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Austrostipa* sp. Open tussock grassland

SITE DESCRIPTION

Quadrat: Quadrat 1	Easting: 31802 8
Date: 13/2/07	Northing: 611441 0
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 10
Landform Element: Hill slope	Site Aspect: 225°
Outcrop Cover: <10%	Outcrop Lithology: Not identifie d
Surface Strew Size:	Surface Strew Cover:
Surface Strew Lithology:	
Fire Scars: No	Plant Litter: 65%
Bare Earth: 3%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): None

VERTEBRATE PRESENCE

Animals Present	Evidence Type
Rabbit	Dung
Sheep	Dung

Comments: Although evidence of sheep is present the area appears to have been stock free for a considerable time.

SOILS

Surface Soil Texture Class: silty loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION

Quadrat Size: 30x30m — Climatic Conditions: Dry

Species	AD	LF	CA	LS
Austrostipa sp.	dominant overstorey	grass <0.5m	2	dead/dormant
Moss		mosses	2	dead/dormant
Austrodanthonia sp.		grass <0.5m	1	dead/dormant
*Avena barbata**		grass <0.5m	1	dead/dormant
Gramineae sp.		grass <0.5m	1	dead/dormant
Elymus scaber		grass <0.5m	T	dead/dormant
*Romulea rosea**		herbaceous	T	dead/dormant
Vittadinia cuneata		herbaceous	T	flowering
Aristeda behriana		grass <0.5m	N	vegetative
Convolvulus sp.		herbaceous	N	vegetative
Maireana enchylaenoides		herbaceous	N	flowering
Wahlenbergia luteola		herbaceous	N	flowering

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Grass <0.5m	sparse

Structural Description: Open (tussock) grassland

Upper Stratum Age Classes Present: n/a

OVERSTOREY MEASUREMENTS

Canopy Type: n/a

Overstorey Height (m): n/a

Canopy Depth (m): n/a

Canopy Diameter (m): n/a

Gap (m): n/a

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland

SITE DESCRIPTION

Quadrat: Quadrat 2	Easting: 31813 9
Date: 13/2/07	Northing: 611455 0
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 15°
Landform Element: Hill slope	Site Aspect: 90°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 40%
Bare Earth: 5%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks, gully erosion

VERTEBRATE PRESENCE

Animals Present	Evidence Type
rabbit	dung

Comments:

SOILS

Surface Soil Texture Class: silty loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION

Quadrat Size: 30x30m

Climatic Conditions: Dry

Species	AD	LF	CA	LS
Lomandra effusa	Dominant overstorey	Sedge <0.5m	3	vegetative
Austrodanthonia sp.		Grass <0.5m	1	Dead/dormant
Austrostipa sp.		Grass <0.5m	1	Dead/dormant
*Avena barbata**		Grass <0.5m	1	Dead/dormant
*Briza maxima**		Grass <0.5m	T	Dead/dormant
Elymus scaber		Grass <0.5m	T	Dead/dormant
Enchyleana tomentosa		Shrub <0.5m	T	vegetative
Enneapogon sp.		Grass <0.5m	T	Dead/dormant
Gramineae sp.		Grass >0.5m	T	Dead/dormant
Themeda triandra		Grass >0.5m	T	Dead/dormant
Acacia pycnantha	emergent	Tree <0.5m	N	vegetative
Aristida behriana		Grass <0.5m	N	Dead/dormant
Dodonea viscosa ssp. cuneata		Shrub >2m	N	vegetative
Lepidosperma viscidum		Sedge <0.5m	N	vegetative
Maireana enchylaenoides		Shrub <0.5m	N	immature fruits
Maireana georgei		shrub 0.5-1.0m	N	Mature fruits

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Sedges <0.5m	mid dense

Structural Description: Sedgeland

Upper Stratum Age Classes Present: n/a

OVERSTOREY MEASUREMENTS

Canopy Type: n/a

Overstorey Height (m): n/a

Canopy Depth (m): n/a

Canopy Diameter (m): n/a

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Eucalyptus gracilis* ± *E. oleosa* Open mallee

SITE DESCRIPTION

Quadrat: Quadrat 3	Easting: 318152
Date: 13/2/07	Northing: 6115240
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 5°
Landform Element: Hill slope	Site Aspect: 180°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 35%
Bare Earth: 10%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks, borrow/quarry pit, coppice regrowth, fence lines

VERTEBRATE PRESENCE

Animals Present	Evidence Type

Comments:

SOILS

Surface Soil Texture Class: loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION				
Quadrat Size: 30x30m	Climatic Conditions: Dry			
Species	AD	LF	CA	LS
Eucalyptus gracilis	Overstorey species	mallee	3	Mature fruits
Acacia pycnantha	Understorey species	Tree <0.5m	1	vegetative
Eucalyptus leucoxylon ssp. leucoxylon		Tree 5-15m	N	vegetative
Allocasuarina verticillata		Tree 5-15m	N	vegetative
Briza maxima		Grass <0.5m	1	Dead/dormant
Gonocarpus tetragynus	Understorey species	Shrub <0.5m	1	Dead/dormant
Senecio sp.		herbaceous	1	Dead/dormant
Austrodanthonia sp.		Grass <0.5m	1	Dead/dormant
Lomandra effusa		Sedge <0.5m	T	vegetative
Dianella revoluta var. revoluta		Sedge >0.5m	N	vegetative
Moss		moss	2	Dead/dormant
Austrostipa sp.		Grass >0.5m	T	Dead/dormant
Aira sp.		Grass <0.5m	T	Dead/dormant
Olearia axillaris		Shrub <0.5m	T	Dead/dormant
Austrostipa elegantissima		Grass >0.5m	T	vegetative
Thysanotus patersonii		vine	T	Dead/dormant
Romulea rosa		herbaceous	1	Dead/dormant
Goodenia robusta		herbaceous	T	Dead/dormant
Austrostipa sp.	Understorey species	Grass <0.5m	1	Dead/dormant
Enchyleana tomentosa		Shrub <0.5m	N	vegetative

VEGETATION ASSOCIATION DESCRIPTION	
Life Form/Height Class	Canopy Cover
Mallee >3m	mid dense
Sedges <0.5m	very sparse
Trees 5-15m	very sparse
Grass <0.5m	sparse
Herbaceous spp	very sparse

Structural Description: Mallee
Upper Stratum Age Classes Present: mature, hollows

OVERSTOREY MEASUREMENTS

Canopy Type: 50%
Overstorey Height (m): 4, 3, 8, 9, 5, 10, 8, 9, 7, 5
Canopy Depth (m): 1, 0.5, 2, 1, 0.5, 1, 1.5, 0.5, 0.5, 1
Canopy Diameter (m): 1.5, 5, 4, 7, 1, 6, 2, 3, 6, 2
Gap (m): 0, 10, 2, 1, 8, 6, 0, 0, 2, 5

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Eucalyptus odorata* Low woodland

SITE DESCRIPTION

Quadrat: Quadrat 4	Easting: 31810 6
Date: 13/2/07	Northing: 611552 3
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the south-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 15°
Landform Element: Hill slope	Site Aspect: 360°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 40%
Bare Earth: 1%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks

VERTEBRATE PRESENCE

Animals Present	Evidence Type
macropod	Dung, sightings

Comments:

SOILS

Surface Soil Texture Class: loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION

Quadrat size: 30x30 m — Climatic Conditions: Dry

Species	AD	LF	CA	LS
Eucalyptus odorata	Overstorey species	Tree 5-15m	4	
Enchylaena tomentosa	Understorey species	Shrub <0.5m	2	
Austrodanthonia sp.		Grass <0.5m	1	
Acacia pycnantha		Tree <0.5m	N	
Amyema miquelii		mistletoe	N	
Asclepias curassavica		Shrub 0-0.5m	T	
Austrostipa elegantissima		Grass <0.5m	T	
Austrostipa sp.		Grass <0.5m	T	
Avena barbata		Grass <0.5m	T	
Chenopodium desertorum ssp. microphyllum		Shrub <0.5m	N	
Einadia nutans ssp. nutans		Shrub <0.5m	N	
Lomandra effusa		Sedge <0.5m	N	
Lomandra micrantha		Sedge <0.5m	N	
Lycium ferrocissimum		Shrub 0.5-1m	N	
Maireana brevifolia		Shrub <0.5m	N	
Moss		moss	T	
Senecio pterophorus		Shrub 0.5-1m	T	
Vittadinia blackii		Shrub <0.5m	T	
Vittadinia sp.		Shrub <0.5m	N	

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Trees 5-15m	sparse
Shrubs 0-0.5m	sparse
Grass <0.5m	mid dense

Structural Description: Low Woodland

Upper Stratum Age Classes Present: sapling, mature, senescent, hollows, dead trees

OVERSTOREY MEASUREMENTS

Canopy Type: 45%
Overstorey Height (m): 10, 10, 8, 14, 6, 10
Canopy Depth (m): 1, 5, 3, 4, 2, 3, 2, 4, 5
Canopy Diameter (m): 18, 4, 10, 6, 4, 10, 3, 6, 8, 3
Gap (m): 1, 0, 0, 0, 5, 3, 4, 0, 0

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Acacia acinacea	Wreath Wattle				1
Acacia halliana	Hall's Wattle				2
Acacia ligulata	Umbrella Bush				4
Acacia microcarpa	Manna Wattle				4
Acacia pycnantha	Golden Wattle				1
Acaena echinata	Sheep's Burr				5
Allocasuarina verticillata	Drooping Sheoak				1
Amphipogon caricinus var. caricinus	Long Grey-beard Grass				1
Amphipogon sp.	Grey-beard Grass				4
Amyema miquelii	Box Mistletoe				4
Aristida behriana	Brush Wire-grass			R	1
Aristida contorta	Curly Wire-grass			R	4
Arthropodium fimbriatum	Nodding Vanilla-lily				1
Arthropodium strictum	Common Vanilla-lily				1
Asperula conferta	Common Woodruff				1
Astroloma humifusum	Cranberry Heath				2
Atriplex semibaccata	Berry Saltbush				1
Austrodanthonia caespitosa	Common Wallaby-grass				5
Austrodanthonia pilosa	Velvet Wallaby-grass			K	5
Austrodanthonia setacea	Small-flower Wallaby-grass				5
Austrodanthonia sp.					1
Austrostipa blackii	Crested Spear-grass			T	5
Austrostipa elegantissima	Feather Spear-grass				1
Austrostipa eremophila	Rusty Spear-grass				5
Austrostipa scabra group	Falcate-awn Spear-grass				5
Austrostipa sp.	Spear-grass				1
Blennospora drummondii	Dwarf Button-flower				5
Bromus sp.	Brome				4
Bulbine bulbosa	Bulbine-lily			R	1
Bursaria spinosa	Bursaria				1
Bursaria spinosa ssp. lasiophylla	Downy Bursaria				4

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Caesia calliantha	Blue Grass-lily			R	2
Callitris gracilis	Southern Cypress Pine				1
Calostemma purpureum	Pink Garland-lily				1
Centrolepis aristata	Pointed Centrolepis			K	5
Chamaesyce drummondii					4
Cheilanthes austrotenuifolia	Annual Rock-fern				1
Chenopodium desertorum	Desert Goosefoot				1
Chenopodium desertorum ssp. microphyllum	Small-leaf Goosefoot				4
Chrysocephalum apiculatum	Common Everlasting				2
Chrysocephalum baxteri	White Everlasting				2
Chrysocephalum semipapposum	Clustered Everlasting				1
Convolvulus erubescens complex					1
Convolvulus sp.	Bindweed				4
Crassula colorata	Dense Crassula				1
Crassula sieberiana complex	Australian Stonecrop				1
Cryptandra sp.	Cryptandra				1
Cullen australasicum	Tall Scurf-pea				5
Cynoglossum suaveolens	Sweet Hound's-tongue			R	1
Daucus glochidiatus	Native Carrot				5
Dianella revoluta var. revoluta	Black-anther Flax-lily				1
Dichondra repens	Kidney Weed				1
Diuris behrii	Behr's Cowslip Orchid		V	V	1
Diuris sp.	Donkey Orchid				1
Dodonaea viscosa ssp. cuneata	Wedge-leaf Hop-bush				4
Dodonaea viscosa ssp. spatulata	Sticky Hop-bush				1
Drosera macrantha ssp. planchonii	Climbing Sundew				2
Einadia nutans ssp. nutans	Climbing Saltbush				1
Elymus scaber var. scaber	Native Wheat-grass			R	1
Enchylaena tomentosa var. tomentosa	Ruby Saltbush				1
Enneapogon nigricans	Black-head Grass				1
Enneapogon sp.	Bottle-washers/Nineawn				4

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Epilobium billardierianum	Robust Willow-herb				4
Eucalyptus calycogona ssp. calycogona	Square-fruit Mallee				1
Eucalyptus gracilis	Yorrell				4
Eucalyptus leucoxylon ssp. leucoxylon	South Australian Blue Gum			R	1
Eucalyptus odorata	Peppermint Box				1
Eucalyptus oleosa ssp. oleosa	Red Mallee				1
Eucalyptus phenax ssp. phenax	White Mallee				1
Eucalyptus porosa	Mallee Box				1
Eucalyptus rugosa	Coastal White Mallee				2
Eucalyptus socialis					1
Eutaxia microphylla	Common Eutaxia				1
Glycine rubiginosa	Twining Glycine				1
Gonocarpus elatus	Hill Raspwort				1
Gonocarpus tetragynus	Small-leaf Raspwort				4
Goodenia pinnatifida	Cut-leaf Goodenia				1
Goodenia pusilliflora	Small-flower Goodenia				1
Goodenia robusta	Woolly Goodenia				1
Gramineae sp.	Grass Family				1
Halgania cyanea	Rough Blue-flower				1
Hardenbergia violacea	Native Lilac				1
Helichrysum leucopsideum	Satin Everlasting				1
Hibbertia crinita				Q	5
Hydrocotyle callicarpa	Tiny Pennywort				5
Hypoxis glabella var. glabella	Tiny Star				1
Juncus bufonius	Toad Rush				5
Juncus pallidus	Pale Rush				4
Juncus subsecundus	Finger Rush				4
Kennedia prostrata	Scarlet Runner				1
Lagenophora huegelii	Coarse Bottle-daisy				1
Lepidosperma viscidum	Sticky Sword-sedge				1
Leptorhynchos squamatus ssp. squamatus	Scaly Buttons			R	1

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Levenhookia dubia	Hairy Stylewort			R	1
Lomandra densiflora	Soft Tussock Mat-rush				1
Lomandra effusa	Scented Mat-rush				1
Lomandra micrantha ssp. micrantha	Small-flower Mat-rush				4
Lomandra multiflora ssp. dura	Hard Mat-rush				1
Lomandra nana	Small Mat-rush			R	2
Lotus australis	Austral Trefoil				5
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe				4
Maireana brevifolia	Short-leaf Bluebush				1
Maireana enchylaenoides	Wingless Fissure-plant				1
Maireana georgei	Satiny Bluebush				4
Maireana sp.	Bluebush/Fissure-plant				4
Microtis unifolia complex	Onion-orchid				1
Millotia myosotidifolia	Broad-leaf Millotia				1
Neurachne alopecuroidea	Fox-tail Mulga-grass				1
Olearia axillaris	Coast Daisy-bush				4
Olearia ramulosa	Twiggy Daisy-bush			R	1
Oxalis perennans	Native Sorrel				1
Panicum effusum var. effusum	Hairy Panic				5
Persicaria prostrata	Creeping Knotweed				4
Pheladenia deformis	Bluebeard Orchid				1
Phyllangium divergens	Wiry Mitrewort				5
Pimelea curviflora var. gracilis	Curved Riceflower				1
Pimelea micrantha	Silky Riceflower				5
Plantago gaudichaudii	Narrow-leaf Plantain			T	1
Plantago sp.	Plantain				4
Plantago varia	Variable Plantain				5
Pogonolepis muelleriana	Stiff Cup-flower				1
Pomaderris paniculosa ssp. paniculosa	Mallee Pomaderris				2
Poranthera microphylla	Small Poranthera				5
Pteridium esculentum	Bracken Fern			R	4

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Pterostylis sp.	Greenhood				1
Ptilotus erubescens	Hairy-tails		R	R	5
Ptilotus spathulatus f. spathulatus	Pussy-tails				1
Rhamnaceae sp.					4
Salsola kali	Buckbush				4
Scaevola albida	Pale Fanflower				1
Scaevola sp.	Fanflower				4
Sebaea ovata	Yellow Sebaea				5
Senecio picridioides	Purple-leaf Groundsel			R	5
Senecio pinnatifolius	Variable Groundsel				1
Senecio quadridentatus	Cotton Groundsel				1
Senecio sp.	Groundsel				4
Senna artemisioides	Desert Senna				1
Solenogyne dominii	Smooth Solenogyne			R	1
Stackhousia monogyna	Creamy Candles				1
Swainsona sp.	Swainson-pea				1
Themeda triandra	Kangaroo Grass				4
Thysanotus patersonii	Twining Fringe-lily				1
Tricoryne elatior	Yellow Rush-lily				5
Triptilodiscus pygmaeus	Small Yellow-heads				1
Velleia arguta	Toothed Velleia				1
Velleia paradoxa	Spur Velleia				5
Velleia sp.	Velleia				4
Vittadinia blackii	Narrow-leaf New Holland Daisy				4
Vittadinia cervicularis var. cervicularis	Waisted New Holland Daisy				5
Vittadinia cuneata var. cuneata f. cuneata	Fuzzy New Holland Daisy				1
Vittadinia gracilis	Woolly New Holland Daisy				1
Vittadinia megacephala	Giant New Holland Daisy				1
Vittadinia sp.	New Holland Daisy				4
Wahlenbergia luteola	Yellow-wash Bluebell				1
Wahlenbergia stricta ssp. stricta	Tall Bluebell				1

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
Wurmbea sp.	Nancy				2
**Acacia cyclops*	Western Coastal Wattle				1
**Acacia iteaphylla*	Flinders Ranges Wattle		R		4
**Aira elegantissima*	Delicate Hair-grass				5
**Aira sp.*	Hair-grass				4
**Anagallis arvensis*	Pimpernel				5
**Asclepias curassavica*	Red-head Cotton-bush				4
**Asparagus asparagoides*	Bridal Creeper				3
**Asphodelus fistulosus*	Onion Weed				1
**Avena barbata*	Bearded Oat				1
**Briza maxima*	Large Quaking-grass				4
**Briza minor*	Lesser Quaking-grass				1
**Bromus hordeaceus ssp. hordeaceus*	Soft Brome				5
**Carduus pycnocephalus*	Shore Thistle				5
**Centaurea melitensis*	Malta Thistle				5
**Centaurium erythraea*	Common Centaury				5
**Chenopodium album*	Fat Hen				4
**Chondrilla juncea*	Skeleton Weed				4
**Chrysanthemoides monilifera ssp. monilifera*	Boneseed				3
**Cynara cardunculus ssp. flavescens*	Artichoke Thistle				1
**Disa brachteata*	South African Weed Orchid				6
**Echium plantagineum*	Salvation Jane				1
**Galium murale*	Small Bedstraw				5
**Gomphocarpus cancellatus*	Broad-leaf Cotton-bush				1
**Juncus acutus*	Sharp Rush				4
**Lycium ferocissimum*	African Boxthorn				4
**Marrubium vulgare*	Horehound				1
**Nicotiana glauca*	Tree Tobacco				5
**Olea europaea ssp. europaea*	Olive				3
**Oxalis pes-caprae*	Soursob				1
**Panicum hillmanii*	Witch-grass				4

Appendix C
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		National	State	Regional	
**Parentucellia latifolia*	Red Bartsia				1
**Pentaschistis pallida*	Pussy Tail				5
**Petrorhagia dubia*	Velvet Pink				5
**Pinus halepensis*	Aleppo Pine				3
**Polypogon monspeliensis*	Annual Beard-grass				4
**Romulea minutiflora*	Small-flower Onion-grass				5
**Romulea rosea var. australis*	Common Onion-grass				4
**Salvia verbenaca form*	Wild Sage				1
**Scabiosa atropurpurea*	Pincushion				1
**Senecio pterophorus*	African Daisy				1
**Silene gallica var. gallica*	French Catchfly				5
**Solanum nigrum*	Black Nightshade				4
**Spergularia sp.*	Sand-spurrey				1
**Tolpis barbata*	Yellow Hawkweed				5
**Trifolium angustifolium*	Narrow-leaf Clover				1
**Trifolium arvense var. arvense*	Hare's-foot Clover				4
**Trifolium sp.*	Clover				4
**Vulpia ciliata*	Fringed Fescue				5
**Vulpia myuros*	Fescue				4

*Introduced species
[a]Conservation Significance Codes:
V = Vulnerable; rare and at risk from potential threats in the long term
T = Threatened; rare and likely to become either endangered or vulnerable
R = Rare; having a low overall frequency, confined to a restricted range or scattered sparsely over a wide area
K = Uncertain; either threatened or rare but insufficient data for a more precise assessment
[b]Sources:
1 = Playfair (2004)
2 = not 1 but Kanmantoo-Callington Landcare Group Significant Vegetation Study (2006)
3 = not 1 or 2 but Kanmantoo-Callington Landcare Group Interim Weed Control Strategy (2006)
4 = not 1, 2 or 3 but the survey undertaken for this report
5 = not 1, 2, 3 or 4 but Biological Database of South Australia (DEH)
6 = not 1, 2, 3, 4 or 5 but Ecological Associates (2006)

Appendix D
Data for Scattered Trees within Proposed Project Footprint

Tree #	Longitude	Latitude	Species	Height (m)	DBH (cm)	Canopy Radius (m)	Canopy Area (m^2)	% Dieback	hollows			Threatened Species Score	Density Score	Proximity Score	Tree Score	SEBMF	Photo File (DSCN)
									small	medium	large						
10	138.98798044800	-35.08341939190	*Eucalyptus odorata*	9	75	6	113.1	10		3	3	1	1	1	43.84	8	2461
11	138.99052921700	-35.08267491120	*Eucalyptus odorata*	12	65	6	113.1	0	1	1	1	1	2	2	69.06	10	2462
12	138.99081621300	-35.08295863870	*Eucalyptus odorata*	11	60	5	78.5	5			2	1	2	2	66.45	10	2462
13	138.99075376800	-35.08301999420	*Eucalyptus odorata*	8	60	5.5	95.0	5		1		1	2	2	39.13	6	2462
14	138.99153563200	-35.08289845660	*Eucalyptus odorata*	12	75	6	113.1	10				1	2	2	33.94	6	2463
15	138.99153563200	-35.08289845660	*Eucalyptus odorata*	11	40	7	153.9	0				1	2	2	37.35	6	2463
16	138.99123799100	-35.08317589760	*Eucalyptus odorata*	9	50	6	113.1	0	2			1	2	2	40.97	8	2464
17	138.99127545800	-35.08324747910	*Eucalyptus odorata*	6	40	4	50.3	20		1		1	2	2	33.94	6	2464
18	138.99160453100	-35.08340639990	*Eucalyptus odorata*	9	50	4	50.3	0				1	2	2	28.86	6	2465
19	138.99160453100	-35.08340639990	*Eucalyptus odorata*	9	45	3	28.3	0			1	1	2	2	56.07	8	2465
20	138.99188021200	-35.08302669970	*Eucalyptus odorata*	11	90	8.5	227.0	0			1	1	2	2	69.06	10	2466
21	138.99197107200	-35.08324529980	*Eucalyptus odorata*	9	50	6.5	132.7	0				1	2	2	28.86	6	2467
22	138.99201432200	-35.08332828060	*Eucalyptus odorata*	10	40	6.5	132.7	0	1			1	2	2	51.59	8	2467

Appendix D
Data for Scattered Trees within Proposed Project Footprint

Tree #	Longitude	Latitude	Species	Height (m)	DBH (cm)	Canopy Radius (m)	Canopy Area (m^2)	% Dieback	hollows			Threatened Species Score	Density Score	Proximity Score	Tree Score	SEBMF	Photo File (DSCN)
									small	medium	large						
23	138.99183947600	-35.08337941020	*Eucalyptus odorata*	13	60	6	113.1	0		1	1	1	2	2	69.06	10	2467
24	138.99179345900	-35.08342953400	*Eucalyptus odorata*	11	45	7.5	176.7	5		1		1	2	2	49.44	8	2467
25	138.99165096700	-35.08392104880	*Eucalyptus odorata*	8	85	6	113.1	0		1		1	1	1	34.35	6	2468
26	138.99244297300	-35.08401073520	*Eucalyptus odorata*	10	40	5.5	95.0	0				1	1	1	31.14	6	2469
27	138.99447499800	-35.08505076170	*Eucalyptus odorata*	12	80	7.5	176.7	0	1	2		1	2	1	47.87	8	2470
28	138.99451682300	-35.08520448580	*Eucalyptus odorata*	11	40	7.5	176.7	0				1	2	1	34.35	6	2470
29	138.99522174100	-35.08630167690	*Eucalyptus odorata*	9	55	5	78.5	10				1	1	1	21.16	6	2471
30	138.99502367700	-35.08629815650	*Eucalyptus odorata*	12	55	4.5	63.6	5				1	1	1	29.60	6	2472
31	138.99391299100	-35.08221415800	*Eucalyptus odorata*	11	120	7	153.9	5				1	1	1	29.60	6	2473
32	138.99231791500	-35.08158417420	*Eucalyptus odorata*	9	80	6	113.1	0	1	1		1	2	1	37.79	6	2474
33	138.99257188700	-35.08160043510	*Eucalyptus odorata*	7	55	5	78.5	20		1	1	1	2	1	43.84	8	2475
41	138.99410963100	-35.08801644670	*Eucalyptus odorata*	12	60	3.5	38.5	50	2			1	1	1	27.05	6	2485
42	138.99416713000	-35.08812909950	*Eucalyptus odorata*	9	40	3.5	38.5	5				1	1	1	22.38	6	2486

Appendix D
Data for Scattered Trees within Proposed Project Footprint

Tree #	Longitude	Latitude	Species	Height (m)	DBH (cm)	Canopy Radius (m)	Canopy Area (m^2)	% Dieback	hollows			Threatened Species Score	Density Score	Proximity Score	Tree Score	SEBMF	Photo File (DSCN)
									small	medium	large						
43	138.99359833400	-35.08796364070	*Eucalyptus odorata*	6	25	2.5	19.6	30			1	1	3	1	43.84	8	2488
44	138.99359833400	-35.08796364070	*Eucalyptus odorata*	11	50	5	78.5	20				1	3	1	31.14	6	2488
45	138.99359833400	-35.08796364070	*Eucalyptus odorata*	4	20	2	12.6	5	1			1	3	1	30.75	6	2488
46	138.99288126300	-35.08845331150	*Eucalyptus odorata*	10	40	3.5	38.5	5			1	1	1	2	61.42	10	2489
47	138.99118250200	-35.08825868370	*Eucalyptus odorata*	10	35	5	78.5	20				1	1	3	30.36	6	2492
48	138.99106356300	-35.08893879130	*Eucalyptus odorata*	9	40	4	50.3	5				1	1	3	27.05	6	2493
49	138.99106356300	-35.08893879130	*Eucalyptus odorata*	5	45	3.5	38.5	5	1			1	1	3	38.68	6	2493
50	138.99122181300	-35.08781109010	*Eucalyptus odorata*	7	20	2	12.6	30				1	3	2	23.33	6	2494
51	138.99122181300	-35.08781109010	*Eucalyptus odorata*	8	45	4	50.3	70				1	3	2	14.49	4	2494
52	138.99122181300	-35.08781109010	*Eucalyptus odorata*	5	20	2	12.6	10				1	3	2	28.86	6	2494
53	138.99122181300	-35.08781109010	*Eucalyptus odorata*	6	30	2	12.6	20				1	3	2	26.00	6	2494
54	138.99122181300	-35.08781109010	*Eucalyptus odorata*	7	40	3	28.3	5				1	3	2	30.36	6	2494
55	138.99098093800	-35.08720165960	*Eucalyptus odorata*	8	35	3.5	38.5	20	1			1	1	2	30.75	6	2495

Appendix D
Data for Scattered Trees within Proposed Project Footprint

Tree #	Longitude	Latitude	Species	Height (m)	DBH (cm)	Canopy Radius (m)	Canopy Area (m^2)	% Dieback	hollows			Threatened Species Score	Density Score	Proximity Score	Tree Score	SEBMF	Photo File (DSCN)
									small	medium	large						
56	138.99122264900	-35.08765319900	*Eucalyptus odorata*	5	50	3.5	38.5	10				1	2	2	26.00	6	2496
57	138.99054464000	-35.08737405760	*Eucalyptus odorata*	7	25	3	28.3	90				1	2	2	9.58	4	2497
58	138.99021456000	-35.08743088690	*Eucalyptus odorata*	7	45	3.5	38.5	20				1	2	2	23.33	6	2498
59	138.99027801100	-35.08779784660	*Eucalyptus odorata*	6	25	2.5	19.6	60				1	2	2	14.49	4	2499
60	138.99013526700	-35.08856881410	*Eucalyptus odorata*	10	50	5	78.5	20	1			1	2	2	43.35	8	2500
61	138.98985983800	-35.08888598530	*Eucalyptus odorata*	9	35	2.5	19.6	10				1	2	2	26.00	6	2501
62	138.98985883200	-35.08908547460	*Eucalyptus odorata*	7	40	4.5	63.6	5				1	2	2	27.40	6	2502
63	138.98985883200	-35.08908547460	*Eucalyptus odorata*	4	8	1	3.1	0				1	2	2	21.76	6	2502
64	138.98913790500	-35.08945796640	*Eucalyptus odorata*	11	80	5	78.5	0				1	2	3	40.51	8	2503
65	138.98913790500	-35.08945796640	*Eucalyptus odorata*	7	30	1.5	7.1	80				1	2	3	12.49	4	2504
66	138.98905442100	-35.08889369670	*Eucalyptus odorata*	8	30	4.5	63.6	5				1	2	3	29.98	6	2505
67	138.98911703400	-35.08863721040	*Eucalyptus odorata*	8	35	4.5	63.6	20				1	2	3	25.65	6	2506
68	138.98896683000	-35.08814636620	*Eucalyptus odorata*	9	70	3.5	38.5	20		1		1	2	3	36.91	6	2508

Appendix D
Data for Scattered Trees within Proposed Project Footprint

Tree #	Longitude	Latitude	Species	Height (m)	DBH (cm)	Canopy Radius (m)	Canopy Area (m^2)	% Dieback	hollows			Threatened Species Score	Density Score	Proximity Score	Tree Score	SEBMF	Photo File (DSCN)
									small	medium	large						
69	138.98932985000	-35.08794771510	*Allocasuarina verticillata*	8	30	3	28.3	0				1	2	3	40.51	8	2509
73	138.99037438000	-35.09059616730	*Eucalyptus odorata*	10	40	2.5	19.6	10		1	1	1	2	2	63.90	10	2533
74	138.99356257900	-35.09166660920	*Eucalyptus odorata*	7	25	2	12.6	40				1	2	2	18.56	4	2536
75	138.99356257900	-35.09166660920	*Eucalyptus odorata*	7	45	4	50.3	30				1	1	2	18.56	4	2536

Appendix 4B

Spring Flora Survey

Final Report
Kanmantoo Copper Project
Spring Flora Assessment

Coffey Natural Systems Pty Ltd

Level 1, 2-3 Greenhill Rd
Wayville SA 5034

November 2007

ECOLOGICAL ASSOCIATES DE008-B

Contents

Figures, Tables and Appendices

Figures

Appendices

1.1 Introduction

Ecological Associates (2007) conducted a review of existing floristic information and a field investigation of the vegetation of the Kanmantoo Copper Project area (the study area) in February 2007. The outcome of that study was comprehensive vegetation mapping, plants species lists and scattered tree mapping for the study area. However, a limitation of the study was the likelihood that ephemeral and herbaceous plant species present in the study area had not been recorded due to the timing of the field investigation, in late summer following a particularly dry period. Therefore, a second flora survey was undertaken in spring 2007.

1.2 Scope of Work

The scope of work for this project was to:

- resurvey the four vegetation survey quadrats established in February 2007;
- search all remnant vegetation on the property for flora species not previously recorded; and
- flag the locations of threatened orchids potentially impacted by the project to enable their subsequent translocation if necessary.

2.1 Quadrat Survey

The four vegetation survey quadrats that were established and surveyed in February 2007 (Ecological Associates 2007) were re-surveyed on 13-14 September 2007.

As per the February 2007 survey, the method outlined in the *Guide to a native vegetation survey using the Biological Survey of South Australia* (Heard and Channon 1997) was used to prepare detailed quadrat descriptions. Quadrats were located within each of the following vegetation associations:

- *Austrostipa* sp. Open tussock grassland;
- *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland;
- *Eucalyptus gracilis* ± *Eucalyptus oleosa* Open mallee; and
- *Eucalyptus odorata* Low woodland.

Cumulative species richness was determined for each survey quadrat for February and September. Cumulative species richness is the total number of species that have been recorded in the quadrat, taking into account both surveys.

2.2 Vegetation Community Assessment

In addition to the survey quadrats, all vegetation associations present in the study area were searched for additional species not previously recorded. A GPS was used to note the locations of species or features of interest, enabling them to be assigned to one of the previously mapped vegetation associations.

2.3 Orchid Flagging

The locations of individual *Diuris behrii* plants potentially impacted by the project were flagged. This species is listed as threatened in South Australia. Flagged orchids occur in the vicinity of waypoints 028 and 029 (Figure 3). Flagging consisted of the placement of a 70 cm bamboo stake into the ground 10 cm due north of individual *D. behrii* plants. A length of pink flagging tape was attached near the top of each stake. Approximately 80 individual *D. behrii* plants were flagged.

A second orchid species, *Microtis parviflora*, was recorded in the vicinity of waypoints 028 and 029. This species has regional conservation significance. This species occurs in distinct clumps of several plants growing in 1m^2 of each other. Four to five bamboo stakes were placed around the perimeter of each clump. Pink flagging tape was attached near the top of all stakes around each clump in the manner of a fence.

3.1 Summary

A total of 14 native and 22 introduced species were recorded during the survey that had not been previously recorded for the study area. These species are highlighted with shading in Appendix D, which provides a plant species list for the study area using the combined records of all known surveys. The complete plant list for the study area consists of 243 species, of which 172 (71%) are native and 71 (29%) are introduced.

3.2 Quadrat Survey

The complete data for all resurveyed quadrats is provided in Appendix B and photographs of each quadrat are provided in Appendix C. In all four survey quadrats, native and introduced plant species that were not observed in February 2007 were observed in September 2007. A small number of species recorded in February 2007 were absent in September 2007. The cumulative species richness in each quadrat at the two survey times is illustrated in Figure 1.

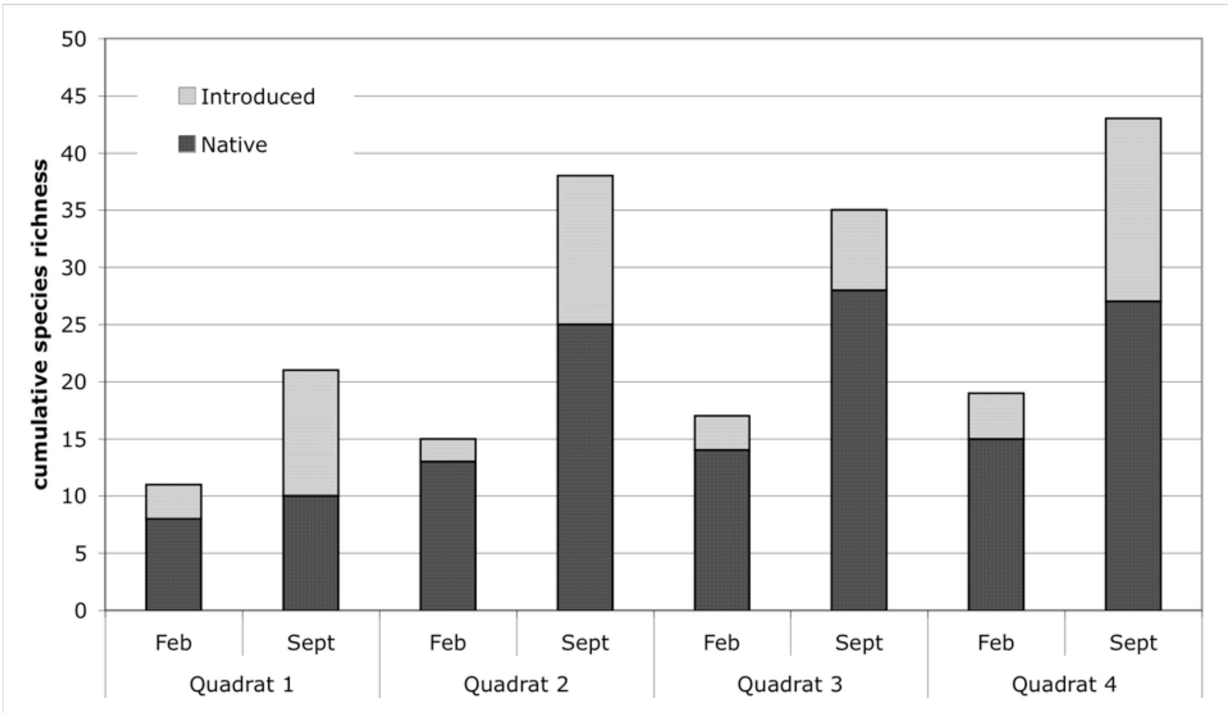

Figure 1. Cumulative species richness for the four survey quadrats in February and September 2007.

The total species richness was markedly higher for all quadrats in September. Species richness increased by 45% in quadrat 1, by 113% in quadrat 2, by 63% in quadrat 3 and 122% in quadrat 4 between February and September. The species richness of native species was also markedly higher in quadrats 2, 3 and 4 in September than in February. Much greater numbers of species were observable and identifiable in September than in February.

The highest cumulative native species richness (28 species) was recorded in quadrat 3, located in the *Eucalyptus gracilis* ± *Eucalyptus oleosa* Open mallee vegetation. Quadrat 4 (*Eucalyptus odorata* Low woodland) had 27 native species, quadrat 2 (*Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland) 25 native species and quadrat 1 (*Austrostipa blackii* Open tussock grassland) 10 native species.

Cumulative introduced species richness was lowest in quadrat 3 (7 species). Quadrat 1 had 11 introduced species, quadrat 2 had 13 introduced species and quadrat 4 had 16 introduced species.

3.3 Vegetation Community Assessment

A number of species not previously recorded for the study area were recorded in September 2007. Additionally, species that were known to occur in the study area but had not been assigned to a particular vegetation community were located, identified and assigned to vegetation communities during the spring survey. The revised list of species occurring in each vegetation community is provided in Appendix A. Many native species were in flower during the survey (Figure 2).

Figure 2. *Bulbine bolbosa* (yellow flowers) in *Eucalyptus odorata* low woodland (left) and *Scaevola albida* (white flowers, foreground) and *Goodenia robusta* (yellow flowers, mid-ground) in *Acacia pycnantha* low woodland.

3.4 Threatened Species

Previous surveys of the study area have recorded two plant species of state conservation significance; *Ptilotus erubescens* (Hairy Tails, state rare) and *Diuris behrii* (Behr's Cowslip Orchid, state vulnerable). No additional species of state conservation significance were recorded in September 2007. The locations of *Diuris behrii* plants were accurately mapped. The majority of *Diuris behrii* plants (approximately 80 plants) were located in the vicinity of waypoints 028 and 029 (Figure 3), corresponding with *D. behrii* locations recorded in a previous survey (Ecological Associates 2006). Single *D. behrii* plants were recorded at waypoints 031 and 049 (Figure 3).

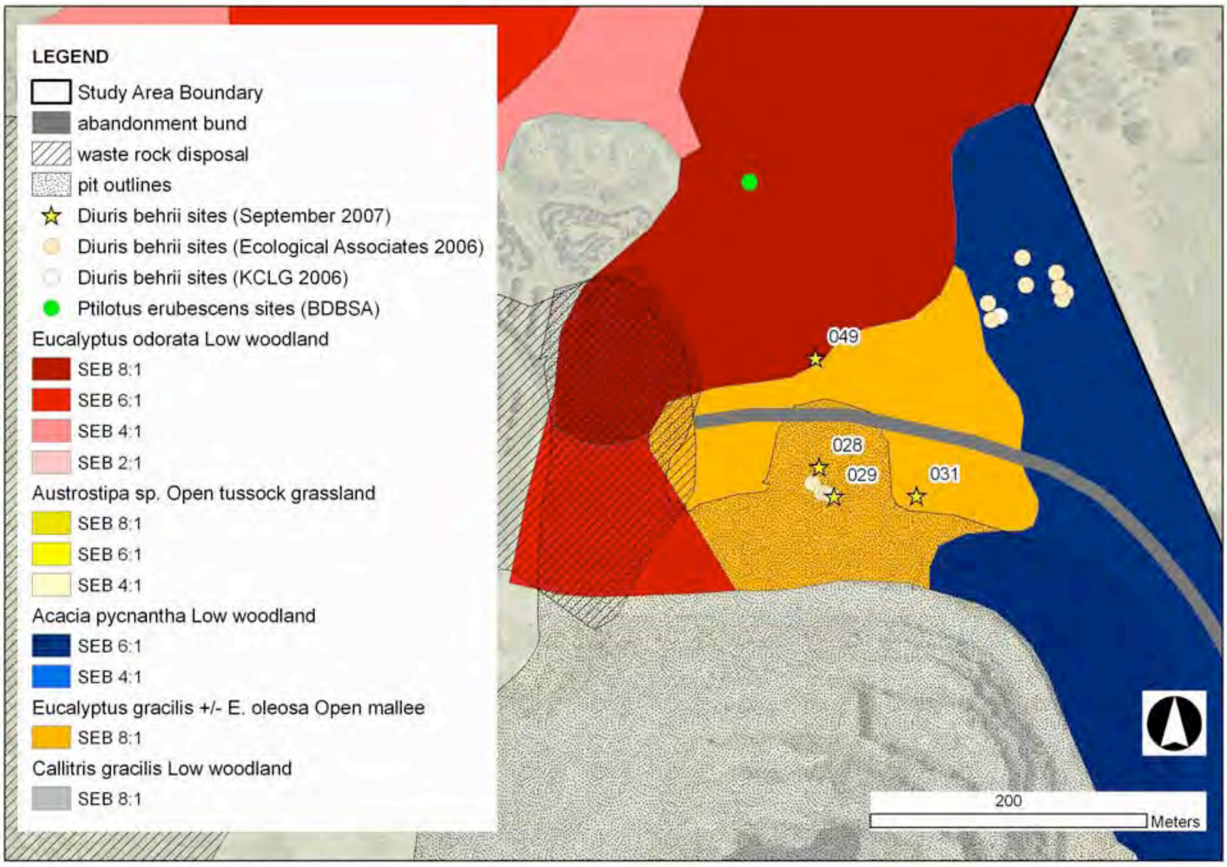

Figure 3. Known locations of plant species of state conservation significance in the study area.

The *D. behrii* plants recorded in spring 2006 (Ecological Associates 2006) in the *Acacia pycnantha* woodland (Figure 3) were not recorded in September 2007. No *Ptilotus erubescens* plants were recorded in September 2007.

Figure 4. *Diuris behrii* plants in the vicinity of waypoint 028, 13 September 2007.

Of the 14 native species recorded in the study area for the first time in September 2007, two have regional conservation significance; *Austrodanthonia auriculata* (Lobed Wallaby Grass, regionally uncommmon) and *Microtis parviflora* (Slender Onion-orchid, status uncertain but likely to be rare or threatened).

Conclusions

The results of this spring survey do not affect the conclusions of the previous vegetation assessment.

This survey confirms the importance of conducting vegetation surveys in spring when plants are most readily observed and identified.

References

Ecological Associates (2006). *Targeted survey for threatened species and weed species at Kanmantoo Mine*. (Ecological Associates Pty Ltd: Adelaide, South Australia).

Ecological Associates (2007). *Final Report - Kanmantoo Copper Project Flora Assessment*. (Ecological Associates: Adelaide, South Australia).

Heard, L. and Channon, B. (1997). *Guide to a native vegetation survey using the Biological Survey of South Australia*. (Geographic Analysis and Research Unit, Information and Data Analysis Branch, Department of Housing and Urban Development: Adelaide, Australia).

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Acacia acinacea	Wreath Wattle								✓	
Acacia ligulata	Umbrella Bush								✓	
Acacia microcarpa	Manna Wattle								✓	
Acacia paradoxa	Kangaroo Thorn				✓				✓	
Acacia pycnantha	Golden Wattle				✓	✓	✓		✓	✓
Acaena echinata	Sheep's Burr							✓		
Ajuga australis f. A (A.G.Spooner 9058)	Australian Bugle			N	✓				✓	
Allocasuarina verticillata	Drooping Sheoak				✓		✓		✓	✓
Amphipogon sp.	Grey-beard Grass							✓	✓	
Amyema miquelii	Box Mistletoe								✓	
Aristida behriana	Brush Wire-grass			R			✓			✓
Aristida contorta	Curly Wire-grass			R	✓	✓	✓	✓	✓	✓
Arthropodium fimbriatum	Nodding Vanilla-lily								✓	
Arthropodium strictum	Common Vanilla-lily				✓					
Asperula conferta	Common Woodruff								✓	
Atriplex semibaccata	Berry Saltbush								✓	
Austrodanthonia auriculata	Lobed Wallaby-grass			U				✓		
Austrodanthonia caespitosa	Common Wallaby-grass					✓		✓	✓	
Austrodanthonia sp.	Wallaby-grass				✓		✓	✓	✓	✓
Austrostipa blackii	Crested Spear-grass			T			✓	✓		
Austrostipa elegantissima	Feather Spear-grass				✓				✓	
Austrostipa nodosa	Tall Spear-grass						✓		✓	
Austrostipa scabra ssp. scabra	Rough Spear-grass				✓	✓			✓	
Austrostipa sp.	Spear-grass				✓	✓	✓	✓	✓	✓

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Blennospora drummondii	Dwarf Button-flower								✓	
Bulbine bulbosa	Bulbine-lily			R	✓				✓	
Bursaria spinosa ssp. lasiophylla	Downy Bursaria						✓			✓
Calandrinia eremaea	Dryland Purslane						✓		✓	
Callitris gracilis	Southern Cypress Pine				✓					✓
Calostemma purpureum	Pink Garland-lily								✓	
Cheilanthes austrotenuifolia	Annual Rock-fern				✓			✓		✓
Chenopodium desertorum ssp. microphyllum	Small-leaf Goosefoot						✓		✓	
Clematis micrphylla var. microphylla	Old Man's Beard				✓					✓
Convolvulus angustissimus					✓		✓		✓	
Convolvulus sp.	Bindweed				✓	✓		✓		
Crassula sp.								✓	✓	
Cryptandra tomentosa	Heath Cryptandra								✓	
Cynoglossum suaveolens	Sweet Hound's-tongue			R	✓					
Dampiera rosmarinifolia	Rosemary Dampiera						✓			
Dianella revoluta var. revoluta	Black-anther Flax-lily				✓		✓		✓	✓
Dichondra repens	Kidney Weed							✓	✓	
Diuris behrii	Behr's Cowslip Orchid		V	V	✓				✓	
Dodonaea viscosa ssp. cuneata	Wedge-leaf Hop-bush				✓	✓	✓			✓
Einadia nutans ssp. nutans	Climbing Saltbush				✓				✓	
Elymus scaber var. scaber	Native Wheat-grass			R	✓		✓	✓	✓	
Enchylaena tomentosa var. tomentosa	Ruby Saltbush				✓	✓	✓		✓	✓
Enneapogon nigricans	Black-head Grass					✓		✓		

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Enneapogon polyphyllus	Leafy Bottle-washers								✓	✓
Enneapogon sp.	Bottle-washers/Nineawn						✓	✓		✓
Eucalyptus calycogona ssp. calycogona	Square-fruit Mallee								✓	
Eucalyptus gracilis	Yorrell				✓	✓			✓	
Eucalyptus leucoxylon ssp. leucoxylon	South Australian Blue Gum			R	✓				✓	
Eucalyptus odorata	Peppermint Box				✓				✓	
Eucalyptus phenax ssp. phenax	White Mallee								✓	
Eutaxia microphylla	Common Eutaxia				✓	✓			✓	✓
Glycine rubiginosa	Twining Glycine				✓					
Gonocarpus elatus	Hill Raspwort				✓		✓	✓		✓
Gonocarpus tetragynus	Small-leaf Raspwort				✓	✓				✓
Goodenia pinnatifida	Cut-leaf Goodenia								✓	
Goodenia pusilliflora	Small-flower Goodenia						✓		✓	
Goodenia robusta	Woolly Goodenia				✓	✓				✓
Gramineae sp.	Grass Family						✓	✓		
Hardenbergia violacea	Native Lilac				✓	✓				
Kennedia prostrata	Scarlet Runner				✓	✓		✓		✓
Lepidosperma viscidum	Sticky Sword-sedge						✓		✓	
Leptorhynchos squamatus ssp. squamatus	Scaly Buttons			R					✓	
Lomandra effusa	Scented Mat-rush				✓	✓	✓	✓	✓	
Lomandra densiflora	Soft Tussock Mat-rush						✓		✓	✓
Lomandra micrantha ssp. micrantha	Small-flower Mat-rush						✓		✓	
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe						✓			

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Maireana brevifolia	Short-leaf Bluebush								✓	
Maireana enchylaenoides	Wingless Fissure-plant						✓	✓	✓	
Maireana georgei	Satiny Bluebush						✓			
Millotia myosotidifolia	Broad-leaf Millotia				✓		✓			✓
Neurachne alopecuroidea	Fox-tail Mulga-grass								✓	
Olearia axillaris	Coast Daisy-bush				✓	✓				
Oxalis perennans	Native Sorrel				✓		✓	✓		✓
Pimelea curviflora var. gracilis	Curved Riceflower						✓			
Plantago gaudichaudii	Narrow-leaf Plantain			T					✓	
Plantago sp.	Plantain								✓	
Podolepis tepperi	Delicate Copper-wire Daisy						✓			
Pogonolepis muelleriana	Stiff Cup-flower						✓			
Pomaderris paniculosa ssp. paniculosa	Mallee Pomaderris						✓			
Ptilotus spathulatus f. spathulatus	Pussy-tails					✓	✓	✓	✓	✓
Rhamnaceae sp.								✓	✓	
Rhodanthe microglossa	Clustered Everlasting								✓	
Salsola kali	Buckbush					✓				
Scaevola albida	Pale Fanflower				✓	✓	✓			
Scaevola sp.	Fanflower				✓	✓	✓			
Senecio quadridentatus	Cotton Groundsel								✓	
Senecio sp.	Groundsel				✓				✓	
Senecio spanomerus					✓				✓	
Stackhousia monogyna	Creamy Candles				✓			✓	✓	
Themeda triandra	Kangaroo Grass						✓			

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
Thysanotus patersonii	Twining Fringe-lily				✓					
Velleia paradoxa	Spur Velleia			Q	✓					
Velleia sp.	Velleia				✓	✓				
Vittadinia blackii	Narrow-leaf New Holland Daisy								✓	
Vittadinia cervicularis var. cervicularis	Waisted New Holland Daisy								✓	
Vittadinia cuneata	Fuzzy New Holland Daisy					✓	✓	✓	✓	
Vittadinia gracilis	Woolly New Holland Daisy							✓		✓
Vittadinia sp.	New Holland Daisy				✓	✓		✓	✓	
Wahlenbergia luteola	Yellow-wash Bluebell				✓		✓	✓		
Wurmbea dioica	Early Nancy				✓					
**Acacia iteaphylla*	Flinders Ranges Wattle		R		✓	✓				
**Aira caryophyllea*	Silvery Hair-grass						✓		✓	
**Aira sp.*	Hair-grass				✓					
**Anagallis arvensis*	Pimpernel				✓				✓	✓
**Arctotheca calendula*	Cape Weed				✓		✓	✓	✓	✓
**Asclepias curassavica*	Red-head Cotton-bush						✓	✓	✓	
**Asparagus asparagoides*	Bridal Creeper									✓
**Asphodelus fistulosus*	Onion Weed						✓		✓	
**Avena barbata*	Bearded Oat						✓	✓	✓	✓
**Brassica tournefortii*	Wild Turnip								✓	
**Briza maxima*	Large Quaking-grass				✓	✓	✓	✓	✓	✓
**Briza minor*	Lesser Quaking-grass						✓			
**Bromus madritensis*	Compact Brome				✓					
**Bromus rubens*	Red Brome						✓	✓	✓	

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
**Chondrilla juncea*	Skeleton Weed							✓		
**Cynara cardunculus ssp. flavescens*	Artichoke Thistle							✓		
**Echium plantagineum*	Salvation Jane							✓	✓	
**Ehrharta longiflora*	Annual Veldt Grass								✓	
**Erodium brachycarpum*	Short-fruit Heron's-bill						✓	✓	✓	✓
**Freesia cultivar*	Freesia								✓	
**Fumaria officinalis ssp. officinalis*	Common Fumitory				✓		✓			✓
**Hordeum hystrix*								✓		✓
**Hypochaeris glabra*	Smooth Cat's Ear					✓				✓
**Lolium rigidum*	Wimmera Ryegrass						✓			
**Lycium ferocissimum*	African Boxthorn								✓	
**Marrubium vulgare*	Horehound							✓		
**Moraea setifolia*	Thread Iris				✓					
**Oxalis pes-caprae*	Soursob								✓	
**Panicum hillmanii*	Witch-grass							✓		
**Parentucellia latifolia*	Red Bartsia				✓		✓			
**Petrorhagia dubia*	Velvet Pink							✓	✓	
**Plantago bellardii*	Hairy Plantain						✓	✓		
**Poa bulbosa*	Bulbous Meadow-grass				✓					
**Romulea rosea var. australis*	Common Onion-grass				✓		✓	✓	✓	✓
**Rumex sp.*	Dock							✓		
**Salvia verbenaca form*	Wild Sage							✓		
**Senecio pterophorus*	African Daisy								✓	
**Silene gallica var. gallica*	French Catchfly							✓		

Appendix A
Surveyed Flora and Location

Species	Common Name	Conservation Significance			Vegetation Community					
		Nat.	State	Reg.	Mallee	*A. pycnantha* woodland	*L. effusa* grassland	*Austrostipa* grassland	*E. odorata* woodland	*A. verticillata* woodland
**Silene sp.*									✓	
**Solanum nigrum*	Black Nightshade							✓		
**Sonchus oleraceus*	Common Sow-thistle				✓		✓		✓	
**Trifolium arvense var. arvense*	Hare's-foot Clover				✓		✓		✓	
**Trifolium campestre*	Hop Clover						✓	✓	✓	
**Trifolium subterraneum*	Subterranean Clover							✓		
**Vicia sativa ssp. nigra*	Narrow-leaf Vetch				✓					
**Vulpia myuros*	Fescue				✓			✓		
**Zaluzianskya divaricata*	Spreading Night-phlox				✓				✓	

*Introduced species

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Austrostipa blackii* Open tussock grassland	
SITE DESCRIPTION	
Quadrat: Quadrat 1	Easting: 318028
Date: 13/9/07	Northing: 6114410
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat. It is marked with a star dropper with a metal tag that reads "10050 N, 9650 E".
PHYSICAL DESCRIPTION	
Landform Pattern: Hill	Site Slope: 10
Landform Element: Hill slope	Site Aspect: 225°
Outcrop Cover: <10%	Outcrop Lithology: Not identified
Surface Strew Size:	Surface Strew Cover:
Surface Strew Lithology:	
Fire Scars: No	Plant Litter: 2%
Bare Earth: 3%	Salt Crystals: 0%
DISTURBANCE	
Disturbance Impacts (within 30m radius of quadrat): None	
VERTEBRATE PRESENCE	
Animals Present	Evidence Type
Rabbit	Dung
Sheep	Dung
Comments: Although evidence of sheep is present the area appears to have been stock free for a considerable time.	
SOILS	
Surface Soil Texture Class: silty loam	

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION

Quadrat Size: 30x30m — Climatic Conditions: Wet

Species	AD	LF	CA	LS
Austrostipa blackii	dominant overstorey	grass <0.5m	3	flowering
*Romulea rosea**	dominant overstorey	herbaceous	3	budding
*Arctotheca calendula**	dominant understorey	herbaceous	2	flowering
Moss		mosses	2	vegetative
*Trifolium campestre**	dominant understorey	herbaceous	2	budding
*Avena barbata**		grass <0.5m	1	flowering
*Erodium brachycarpum**		herbaceous	1	flowering
*Bromus rubens**		grass <0.5m	T	flowering
Convolvulus sp.		herbaceous	T	vegetative
Crassula sp.		herbaceous	T	budding
*Hordeum hystrix**		grass <0.5m	T	flowering
*Plantago bellardii**		herbaceous	T	flowering
*Trifolium subterraneum**		herbaceous	T	vegetative
Acaena echinata		herbaceous	N	budding
Austrodanthonia auriculata		grass <0.5m	N	budding
*Echium plantagineum**		herbaceous	N	vegetative
Ptilotus spathulatus		herbaceous	N	flowering

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Grass <0.5m	sparse

Structural Description: Open (tussock) grassland

Upper Stratum Age Classes Present: n/a

OVERSTOREY MEASUREMENTS

Canopy Type: n/a
Overstorey Height (m): n/a
Canopy Depth (m): n/a
Canopy Diameter (m): n/a
Gap (m): n/a

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland

SITE DESCRIPTION

Quadrat: Quadrat 2	Easting: 31813 9
Date: 13/9/07	Northing: 611455 0
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 15°
Landform Element: Hill slope	Site Aspect: 90°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 15%
Bare Earth: 5%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks, gully erosion

VERTEBRATE PRESENCE

Animals Present	Evidence Type
rabbit	dung

Comments:

SOILS

Surface Soil Texture Class: silty loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION				
Quadrat Size: 30x30m	Climatic Conditions: Wet			
Species	AD	LF	CA	LS
Lomandra effusa	Dominant overstorey	Sedge <0.5m	3	vegetative
Austrostipa blackii	Dominant overstorey	Grass <0.5m	2	vegetative
*Romulea rosa**	Dominant understorey	herbaceous	2	flowering
*Avena barbata**		Grass <0.5m	1	flowering
Calandrinia eremaea		herbaceous	1	flowering
Convolvulus angustissimus		herbaceous	1	flowering
*Erodium brachycarpum**		herbaceous	1	flowering
*Fumaria officinalis ssp. officinalis**		herbaceous	1	flowering
Gonocarpus elatus		herbaceous	1	budding
Goodenia pusilliflora		herbaceous	1	flowering
Lichen		lichens	1	
Maireana enchylaenoides		Shrub <0.5m	1	immature fruits
Moss		mosses	1	
*Aira caryophyllea**		Grass <0.5m	T	flowering
*Arctotheca calendula**		herbaceous	T	flowering
Aristida behriana		Grass <0.5m	T	flowering
*Briza maxima**		Grass <0.5m	T	flowering
*Bromus rubens**		Grass <0.5m	T	flowering
Chenopodium desertorum		herbaceous	T	vegetative
Enchyleana tomentosa		Shrub <0.5m	T	immature fruits
Millotia myosotidifolia		herbaceous	T	flowering
Oxalis perennans		herbaceous	T	flowering
*Parentucellia latifolia**		herbaceous	T	flowering
Pimelea curviflora var. gracilis		herbaceous	T	vegetative
*Plantago bellardii**		herbaceous	T	flowering
Pogonolepis muelleriana		herbaceous	T	vegetative
Ptilotus spathulatus		herbaceous	T	flowering

*Sonchus oleraceus**		herbaceous	T	flowering
Themeda triandra		Grass >0.5m	T	flowering
*Trifolium campestre**		herbaceous	T	flowering
Wahlenbergia luteola		herbaceous	T	budding
Acacia pycnantha	emergent	Tree <0.5m	N	vegetative
*Briza minor**		Grass <0.5m	N	flowering
Dodonea viscosa ssp. cuneata		Shrub >2m	N	recently shed
Lomandra densiflora		Sedge <0.5m	N	vegetative
Maireana georgei		shrub 0.5-1.0m	N	vegetative

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Sedges <0.5m	mid dense

Structural Description: Sedgeland
Upper Stratum Age Classes Present: n/a

OVERSTOREY MEASUREMENTS

Canopy Type: n/a
Overstorey Height (m): n/a
Canopy Depth (m): n/a
Canopy Diameter (m): n/a
Gap (m): n/a

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Eucalyptus gracilis* ± *E. oleosa* Open mallee

SITE DESCRIPTION

Quadrat: Quadrat 3	Easting: 31815 2
Date: 13/9/07	Northing: 611524 0
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the north-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 5°
Landform Element: Hill slope	Site Aspect: 180°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 20%
Bare Earth: 5%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks, borrow/quarry pit, coppice regrowth, fence lines

VERTEBRATE PRESENCE

Animals Present	Evidence Type

Comments:

SOILS

Surface Soil Texture Class: loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION				
Quadrat Size: 30x30m	Climatic Conditions: Wet			
Species	AD	LF	CA	LS
Eucalyptus gracilis	Overstorey species	mallee	3	Mature fruits
Austrostipa scabra ssp. scabra		Grass <0.5m	2	recently shed
Millotia myosotidifolia		herbaceous	2	flowering
Moss		moss	2	
Acacia pycnantha	Understorey species	Tree <0.5m	1	vegetative
Arthropodium strictum		herbaceous	1	flowering
Gonocarpus tetragynus	Understorey species	Shrub <0.5m	1	budding
Lichen		lichens	1	
*Romulea rosa**		herbaceous	1	budding
Scaevola albida		herbaceous	1	flowering
*Vulpia myuros**		Grass <0.5m	1	budding
Wurmbea dioica		herbaceous	1	flowering
*Arctotheca calendula**		herbaceous	T	flowering
*Briza maxima**		Grass <0.5m	T	flowering
Bulbine bulbosa		herbaceous	T	flowering
Calandrinia eremaea		herbaceous	T	budding
Cheilanthes austrotenuifolia		ferns	T	vegetative
Convolvulus angustissimus		herbaceous	T	vegetative
Diuris behrii		herbaceous	T	flowering
Einadia nutans ssp. nutans		Shrub <0.5m	T	budding
*Fumaria officinalis ssp. officinalis**		herbaceous	T	flowering
Oxalis perennans		herbaceous	T	flowering
*Sonchus oleraceus**		herbaceous	T	flowering
Stackhousia monogyna		herbaceous	T	flowering
Thysanotus patersonii		vine	T	flowering
Ajuga australis		herbaceous	N	vegetative
Allocasuarina verticillata		Tree 5-15m	N	recently shed

Austrostipa elegantissima	Grass >0.5m	N	budding
Cynoglossum suaveolens	herbaceous	N	flowering
Enchyleana tomentosa	Shrub <0.5m	N	immature fruits
Eucalyptus leucoxylon ssp. leucoxylon	Tree 5-15m	N	vegetative
Goodenia robusta	herbaceous	N	budding
Senecio spanomerus	Shrub <0.5m	N	flowering

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Mallee >3m	mid dense
Sedges <0.5m	very sparse
Trees 5-15m	very sparse
Grass <0.5m	sparse
Herbaceous spp	very sparse

Structural Description: Mallee
Upper Stratum Age Classes Present: mature, hollows

OVERSTOREY MEASUREMENTS

Canopy Type: 50%
Overstorey Height (m): 4, 3, 8, 9, 5, 10, 8, 9, 7, 5
Canopy Depth (m): 1, 0.5, 2, 1, 0.5, 1, 1.5, 0.5, 0.5, 1
Canopy Diameter (m): 1.5, 5, 4, 7, 1, 6, 2, 3, 6, 2
Gap (m): 0, 10, 2, 1, 8, 6, 0, 0, 2, 5

Appendix B
Biological Survey Quadrat Data

Biological Survey Quadrat – *Eucalyptus odorata* Low woodland

SITE DESCRIPTION

Quadrat: Quadrat 4	Easting: 31810 6
Date: 13/9/07	Northing: 611552 3
Observer: Ben Taylor	MGA Zone: 54
	Note: This position is the south-west corner of the quadrat.

PHYSICAL DESCRIPTION

Landform Pattern: Hill	Site Slope: 15°
Landform Element: Hill slope	Site Aspect: 360°
Outcrop Cover: nil	Outcrop Lithology: n/a
Surface Strew Size: cobble (51-250mm)	Surface Strew Cover: <10%
Surface Strew Lithology: Not identified	
Fire Scars: No	Plant Litter: 25%
Bare Earth: 1%	Salt Crystals: 0%

DISTURBANCE

Disturbance Impacts (within 30m radius of quadrat): Access tracks

VERTEBRATE PRESENCE

Animals Present	Evidence Type
macropod	Dung, sightings

Comments:

SOILS

Surface Soil Texture Class: loam

Appendix B
Biological Survey Quadrat Data

VEGETATION DESCRIPTION

Quadrat size: 30x30 m   Climatic Conditions: Wet

Species	AD	LF	CA	LS
Eucalyptus odorata	Overstorey species	Tree 5-15m	4	recently shed
Austrostipa scabra ssp. scabra		Grass <0.5m	3	vegetative
*Ehrharta longiflora**		Grass <0.5m	2	flowering
Enchylaena tomentosa	Understorey species	Shrub <0.5m	2	mature fruits
*Romulea rosa**		herbaceous	2	vegetative
*Arctotheca calendula**		herbaceous	1	flowering
*Brassica tournefortii**		herbaceous	1	Mature fruits
Chenopodium desertorum		Shrub <0.5m	1	vegetative
*Echium plantagineum**		herbaceous	1	seedling
Goodenia pusilliflora		herbaceous	1	flowering
Moss		moss	1	
*Trifolium campestre**		herbaceous	1	vegetative
Vittadinia cervicularis		Shrub <0.5m	1	flowering
*Asclepias curassavica**		Shrub <0.5m	T	flowering
Austrostipa elegantissima		Grass <0.5m	T	vegetative
*Avena barbata**		Grass <0.5m	T	immature fruits
*Bromus rubens**		Grass <0.5m	T	Immature fruits
Convolvulus angustissimus		herbaceous	T	vegetative
Crassula sp.		herbaceous	T	budding
Dichondra repens		Mat plants	T	vegetative
Einadia nutans ssp. nutans		Shrub <0.5m	T	budding
*Erodium brachycarpum**		herbaceous	T	budding
Maireana brevifolia		Shrub <0.5m	T	vegetative
Maireana enchylaenoides		herbaceous	T	immature fruits
Ptilotus spathulatus f. spathulatus		herbaceous	T	flowering
Rhodanthe microglossa		herbaceous	T	flowering
*Senecio pterophorus**		Shrub 0.5-1m	T	vegetative

*Silene sp.**	herbaceous	T	budding
*Sonchus oleraceus**	herbaceous	T	flowering
*Zaluzianskya divaricata**	herbaceous	T	seedling
Acacia pycnantha	Tree <0.5m	N	vegetative
*Aira caryophyllea**	Grass <0.5m	N	flowering
Ajuga australis	herbaceous	N	vegetative
Amyema miquelii	mistletoe	N	recently shed
Arthropodium fimbriatum	herbaceous	N	mature fruits
*Asphodelus fistulosus**	herbaceous	N	flowering
Austrostipa nodosa	Grass <0.5m	N	flowering
Goodenia pinnatifida	herbaceous	N	vegetative
Lomandra effusa	Sedge <0.5m	N	vegetative
Lomandra micrantha ssp. micrantha	Sedge <0.5m	N	vegetative
Senecio spanomerus	herbaceous	N	flowering

VEGETATION ASSOCIATION DESCRIPTION

Life Form/Height Class	Canopy Cover
Trees 5-15m	sparse
Shrubs 0-0.5m	sparse
Grass <0.5m	mid dense

Structural Description: Low Woodland

Upper Stratum Age Classes Present: sapling, mature, senescent, hollows, dead trees

OVERSTOREY MEASUREMENTS

Canopy Type: 45%

Overstorey Height (m): 10, 10, 8, 14, 6, 10

Canopy Depth (m): 1, 5, 3, 4, 2, 3, 2, 4, 5

Canopy Diameter (m): 18, 4, 10, 6, 4, 10, 3, 6, 8, 3

Gap (m): 1, 0, 0, 0, 5, 3, 4, 0, 0

Appendix C
Biological Survey Quadrat Photographs

Quadrat 1, *Austrostipa blackii* Open tussock grassland, 13 September 2007.

Quadrat 2, *Lomandra effusa* ± *Heliochrysum leucopsideum* Open tussock grassland, 13 September 2007.

Quadrat 3, *Eucalyptus gracilis* ± *Eucalyptus oleosa* Open mallee, 14 September 2007.

Quadrat 4, *Eucalyptus odorata* Low woodland, 13 September 2007.

Appendix D
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		Nat.	State	Reg.	
Acacia acinacea	Wreath Wattle				1
Acacia halliana	Hall's Wattle				2
Acacia ligulata	Umbrella Bush				4
Acacia microcarpa	Manna Wattle				4
Acacia paradoxa	Kangaroo Thorn				7
Acacia pycnantha	Golden Wattle				1
Acaena echinata	Sheep's Burr				5
Ajuga australis f. A (A.G.Spooner 9058)	Australian Bugle				7
Allocasuarina verticillata	Drooping Sheoak				1
Amphipogon caricinus var. caricinus	Long Grey-beard Grass				1
Amphipogon sp.	Grey-beard Grass				4
Amyema miquelii	Box Mistletoe				4
Aristida behriana	Brush Wire-grass			R	1
Aristida contorta	Curly Wire-grass			R	4
Arthropodium fimbriatum	Nodding Vanilla-lily				1
Arthropodium strictum	Common Vanilla-lily				1
Asperula conferta	Common Woodruff				1
Astroloma humifusum	Cranberry Heath				2
Atriplex semibaccata	Berry Saltbush				1
Austrodanthonia auriculata	Lobed Wallaby-grass			U	7
Austrodanthonia caespitosa	Common Wallaby-grass				5
Austrodanthonia pilosa	Velvet Wallaby-grass			K	5
Austrodanthonia setacea	Small-flower Wallaby-grass				5
Austrodanthonia sp.					1
Austrostipa blackii	Crested Spear-grass			T	5
Austrostipa elegantissima	Feather Spear-grass				1
Austrostipa eremophila	Rusty Spear-grass				5
Austrostipa nodosa	Tall Spear-grass				7
Austrostipa scabra group	Falcate-awn Spear-grass				5
Austrostipa scabra ssp. scabra	Rough Spear-grass				7
Austrostipa sp.	Spear-grass				1
Blennospora drummondii	Dwarf Button-flower				5
Bromus sp.	Brome				4
Bulbine bulbosa	Bulbine-lily			R	1
Bursaria spinosa	Bursaria				1
Bursaria spinosa ssp. lasiophylla	Downy Bursaria				4
Caesia calliantha	Blue Grass-lily			R	2
Calandrinia eremaea	Dryland Purslane				7
Callitris gracilis	Southern Cypress Pine				1
Calostemma purpureum	Pink Garland-lily				1
Centrolepis aristata	Pointed Centrolepis			K	5
Chamaesyce drummondii					4
Cheilanthes austrotenuifolia	Annual Rock-fern				1
Chenopodium desertorum	Desert Goosefoot				1
Chenopodium desertorum ssp. microphyllum	Small-leaf Goosefoot				4
Chrysocephalum apiculatum	Common Everlasting				2
Chrysocephalum baxteri	White Everlasting				2
Chrysocephalum semipapposum	Clustered Everlasting				1
Clematis micrphylla var. microphylla	Old Man's Beard				7

Appendix D
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		Nat.	State	Reg.	
Convolvulus angustissimus					7
Convolvulus erubescens complex					1
Convolvulus sp.	Bindweed				4
Crassula colorata	Dense Crassula				1
Crassula sieberiana complex	Australian Stonecrop				1
Cryptandra sp.	Cryptandra				1
Cryptandra tomentosa	Heath Cryptandra				7
Cullen australasicum	Tall Scurf-pea				5
Cynoglossum suaveolens	Sweet Hound's-tongue			R	1
Dampiera rosmarinifolia	Rosemary Dampiera				7
Daucus glochidiatus	Native Carrot				5
Dianella revoluta var. revoluta	Black-anther Flax-lily				1
Dichondra repens	Kidney Weed				1
Diuris behrii	Behr's Cowslip Orchid		V	V	1
Diuris sp.	Donkey Orchid				1
Dodonaea viscosa ssp. cuneata	Wedge-leaf Hop-bush				4
Dodonaea viscosa ssp. spatulata	Sticky Hop-bush				1
Drosera macrantha ssp. planchonii	Climbing Sundew				2
Einadia nutans ssp. nutans	Climbing Saltbush				1
Elymus scaber var. scaber	Native Wheat-grass			R	1
Enchylaena tomentosa var. tomentosa	Ruby Saltbush				1
Enneapogon nigricans	Black-head Grass				1
Enneapogon polyphyllus	Leafy Bottle-washers				7
Enneapogon sp.	Bottle-washers/Nineawn				4
Epilobium billardierianum	Robust Willow-herb				4
Eucalyptus calycogona ssp. calycogona	Square-fruit Mallee				1
Eucalyptus gracilis	Yorrell				4
Eucalyptus leucoxylon ssp. leucoxylon	South Australian Blue Gum			R	1
Eucalyptus odorata	Peppermint Box				1
Eucalyptus oleosa ssp. oleosa	Red Mallee				1
Eucalyptus phenax ssp. phenax	White Mallee				1
Eucalyptus porosa	Mallee Box				1
Eucalyptus rugosa	Coastal White Mallee				2
Eucalyptus socialis					1
Eutaxia microphylla	Common Eutaxia				1
Glycine rubiginosa	Twining Glycine				1
Gonocarpus elatus	Hill Raspwort				1
Gonocarpus tetragynus	Small-leaf Raspwort				4
Goodenia pinnatifida	Cut-leaf Goodenia				1
Goodenia pusilliflora	Small-flower Goodenia				1
Goodenia robusta	Woolly Goodenia				1
Gramineae sp.	Grass Family				1
Halgania cyanea	Rough Blue-flower				1
Hardenbergia violacea	Native Lilac				1
Helichrysum leucopsideum	Satin Everlasting				1
Hibbertia crinita				Q	5
Hydrocotyle callicarpa	Tiny Pennywort				5
Hypoxis glabella var. glabella	Tiny Star				1
Juncus bufonius	Toad Rush				5
Juncus pallidus	Pale Rush				4
Juncus subsecundus	Finger Rush				4
Kennedia prostrata	Scarlet Runner				1

Appendix D
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		Nat.	State	Reg.	
Lagenophora huegelii	Coarse Bottle-daisy				1
Lepidosperma viscidum	Sticky Sword-sedge				1
Leptorhynchos squamatus ssp. squamatus	Scaly Buttons			R	1
Levenhookia dubia	Hairy Stylewort			R	1
Lomandra densiflora	Soft Tussock Mat-rush				1
Lomandra effusa	Scented Mat-rush				1
Lomandra micrantha ssp. micrantha	Small-flower Mat-rush				4
Lomandra multiflora ssp. dura	Hard Mat-rush				1
Lomandra nana	Small Mat-rush			R	2
Lotus australis	Austral Trefoil				5
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe				4
Maireana brevifolia	Short-leaf Bluebush				1
Maireana enchylaenoides	Wingless Fissure-plant				1
Maireana georgei	Satiny Bluebush				4
Maireana sp.	Bluebush/Fissure-plant				4
Microtis parviflora	Slender Onion-orchid			K	7
Microtis unifolia complex	Onion-orchid				1
Millotia myosotidifolia	Broad-leaf Millotia				1
Neurachne alopecuroidea	Fox-tail Mulga-grass				1
Olearia axillaris	Coast Daisy-bush				4
Olearia ramulosa	Twiggy Daisy-bush			R	1
Oxalis perennans	Native Sorrel				1
Panicum effusum var. effusum	Hairy Panic				5
Persicaria prostrata	Creeping Knotweed				4
Pheladenia deformis	Bluebeard Orchid				1
Phyllangium divergens	Wiry Mitrewort				5
Pimelea curviflora var. gracilis	Curved Riceflower				1
Pimelea micrantha	Silky Riceflower				5
Plantago gaudichaudii	Narrow-leaf Plantain			T	1
Plantago sp.	Plantain				4
Plantago varia	Variable Plantain				5
Podolepis tepperi	Delicate Copper-wire Daisy				7
Pogonolepis muelleriana	Stiff Cup-flower				1
Pomaderris paniculosa ssp. paniculosa	Mallee Pomaderris				2
Poranthera microphylla	Small Poranthera				5
Pteridium esculentum	Bracken Fern			R	4
Pterostylis sp.	Greenhood				1
Ptilotus erubescens	Hairy-tails		R	R	5
Ptilotus spathulatus f. spathulatus	Pussy-tails				1
Rhamnaceae sp.					4
Rhodanthe microglossa	Clustered Everlasting				7
Salsola kali	Buckbush				4
Scaevola albida	Pale Fanflower				1
Scaevola sp.	Fanflower				4
Sebaea ovata	Yellow Sebaea				5
Senecio picridioides	Purple-leaf Groundsel			R	5
Senecio pinnatifolius	Variable Groundsel				1
Senecio quadridentatus	Cotton Groundsel				1
Senecio sp.	Groundsel				4
Senecio spanomerus					7
Senna artemisioides	Desert Senna				1

Appendix D
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		Nat.	State	Reg.	
Solenogyne dominii	Smooth Solenogyne			R	1
Stackhousia monogyna	Creamy Candles				1
Swainsona sp.	Swainson-pea				1
Themeda triandra	Kangaroo Grass				4
Thysanotus patersonii	Twining Fringe-lily				1
Tricoryne elatior	Yellow Rush-lily				5
Triptilodiscus pygmaeus	Small Yellow-heads				1
Velleia arguta	Toothed Velleia				1
Velleia paradoxa	Spur Velleia			Q	5
Velleia sp.	Velleia				4
Vittadinia blackii	Narrow-leaf New Holland Daisy				4
Vittadinia cervicularis var. cervicularis	Waisted New Holland Daisy				5
Vittadinia cuneata var. cuneata f. cuneata	Fuzzy New Holland Daisy				1
Vittadinia gracilis	Woolly New Holland Daisy				1
Vittadinia megacephala	Giant New Holland Daisy				1
Vittadinia sp.	New Holland Daisy				4
Wahlenbergia luteola	Yellow-wash Bluebell				1
Wahlenbergia stricta ssp. stricta	Tall Bluebell				1
Wurmbea dioica	Early Nancy				7
Wurmbea sp.	Nancy				2
**Acacia cyclops*	Western Coastal Wattle				1
**Acacia iteaphylla*	Flinders Ranges Wattle		R		4
**Aira caryophyllea*	Silvery Hair-grass				7
**Aira elegantissima*	Delicate Hair-grass				5
**Aira sp.*	Hair-grass				4
**Anagallis arvensis*	Pimpernel				5
**Arctotheca calendula*	Cape Weed				7
**Asclepias curassavica*	Red-head Cotton-bush				4
**Asparagus asparagoides*	Bridal Creeper				3
**Asphodelus fistulosus*	Onion Weed				1
**Avena barbata*	Bearded Oat				1
**Brassica tournefortii*	Wild Turnip				7
**Briza maxima*	Large Quaking-grass				4
**Briza minor*	Lesser Quaking-grass				1
**Bromus hordeaceus ssp. hordeaceus*	Soft Brome				5
**Bromus madritensis*	Compact Brome				7
**Bromus rubens*	Red Brome				7
**Carduus pycnocephalus*	Shore Thistle				5
**Centaurea melitensis*	Malta Thistle				5
**Centaurium erythraea*	Common Centaury				5
**Chenopodium album*	Fat Hen				4
**Chondrilla juncea*	Skeleton Weed				4
**Chrysanthemoides monilifera ssp. monilifera*	Boneseed				3
**Cynara cardunculus ssp. flavescens*	Artichoke Thistle				1
**Disa brachteata*	South African Weed Orchid				6
**Echium plantagineum*	Salvation Jane				1
**Ehrharta longiflora*	Annual Veldt Grass				7
**Erodium brachycarpum*	Short-fruit Heron's-bill				7
**Freesia cultivar*	Freesia				7
**Fumaria officinalis ssp. officinalis*	Common Fumitory				7

Appendix D
Combined Species List for all Surveys

Species	Common Name	Conservation Significance[a]			Source[b]
		Nat.	State	Reg.	
**Galium murale*	Small Bedstraw				5
**Gomphocarpus cancellatus*	Broad-leaf Cotton-bush				1
**Hordeum hystrix*					7
**Hypochaeris glabra*	Smooth Cat's Ear				7
**Juncus acutus*	Sharp Rush				4
**Lolium rigidum*	Wimmera Ryegrass				7
**Lycium ferocissimum*	African Boxthorn				4
**Marrubium vulgare*	Horehound				1
**Medicago minima var. minima*	Little Medic				7
**Moraea setifolia*	Thread Iris				7
**Nicotiana glauca*	Tree Tobacco				5
**Olea europaea ssp. europaea*	Olive				3
**Oxalis pes-caprae*	Soursob				1
**Panicum hillmanii*	Witch-grass				4
**Parentucellia latifolia*	Red Bartsia				1
**Pentaschistis pallida*	Pussy Tail				5
**Petrorhagia dubia*	Velvet Pink				5
**Pinus halepensis*	Aleppo Pine				3
**Plantago bellardii*	Hairy Plantain				7
**Poa bulbosa*	Bulbous Meadow-grass				7
**Polypogon monspeliensis*	Annual Beard-grass				4
**Romulea minutiflora*	Small-flower Onion-grass				5
**Romulea rosea var. australis*	Common Onion-grass				4
**Rumex sp.*	Dock				7
**Salvia verbenaca form*	Wild Sage				1
**Scabiosa atropurpurea*	Pincushion				1
**Senecio pterophorus*	African Daisy				1
**Silene gallica var. gallica*	French Catchfly				5
**Solanum nigrum*	Black Nightshade				4
**Sonchus oleraceus*	Common Sow-thistle				7
**Spergularia sp.*	Sand-spurrey				1
**Tolpis barbata*	Yellow Hawkweed				5
**Trifolium angustifolium*	Narrow-leaf Clover				1
**Trifolium arvense var. arvense*	Hare's-foot Clover				4
**Trifolium campestre*	Hop Clover				7
**Trifolium sp.*	Clover				4
**Trifolium subterraneum*	Subterranean Clover				7
**Vicia sativa ssp. nigra*	Narrow-leaf Vetch				7
**Vulpia ciliata*	Fringed Fescue				5
**Vulpia myuros*	Fescue				4
**Zaluzianskya divaricata*	Spreading Night-phlox				7

*Introduced species
[a]Conservation Significance Codes:
V = Vulnerable; rare and at risk from potential threats in the long term
T = Threatened; rare and likely to become either endangered or vulnerable
R = Rare; having a low overall frequency, confined to a restricted range or scattered sparsely over a wide area
U = Uncommon; less common species but not rare
K = Uncertain; either threatened or rare but insufficient data for a more precise assessment
Q = Not yet assessed but flagged as being of possible significance
[b]Sources:
1 = Playfair (2004)
2 = not 1 but Kanmantoo-Callington Landcare Group Significant Vegetation Study (2006)

3 = not 1 or 2 but Kanmantoo-Callington Landcare Group Interim Weed Control Strategy (2006)
4 = not 1, 2 or 3 but Ecological Associates (2007)
5 = not 1, 2, 3 or 4 but Biological Database of South Australia (DEH)
6 = not 1, 2, 3, 4 or 5 but Ecological Associates (2006)
7 = not 1, 2, 3, 4, 5 or 6 but the survey undertaken for this report

Shaded species were new records in September 2007.

Appendix 4C

EPBC Act Vegetation Survey

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Monday, 5 August 2013

Re: Vegetation Survey of Peppermint Box and Irongrass communities at Kanmantoo Copper Mine

Hillgrove Resources engaged EBS Ecology to undertake an assessment of the Peppermint Box Woodland and Irongrass Tussock Grassland communities mapped within the Hillgrove Resources Kanmantoo mining lease. Primarily this was to determine whether these remnant patches meet the criteria of the nationally threatened ecological communities (TEC), set out in the DEWHA document 'EPBC Act Policy Statement 3.7 Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia' (2007). A particular focus was placed on the relevant communities located within the proposed Life of Mine (LOM) disturbance increase area and these were assessed against the policy statement criteria.

Methodology

Field Survey

The field survey was undertaken by EBS Ecology staff on the 25th June, 2013.

Floristic Mapping

Previous floristic mapping was provided prior to the survey. The vegetation associations and boundaries were checked and corrected where necessary.

Extent of communities

The extent of *Lomandra* grassland patches and Peppermint Box Woodland were recorded using hand held Garmin GPS (Accuracy +/- 15m) units which are carried around the extent of the communities present. The track log was saved with the relevant patch number and entered into Arc GIS software to enable the total area to be calculated.

Species diversity

Species diversity totals were obtained from a 50 x 50m quadrat for each representative area. All species observed within the quadrats were recorded with totals compared against benchmark criteria outlined in the *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South* Australia (Table 1) (TSSC 2007) and the Commonwealth Listing Advice on Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia (Table 1) (TSSC 2007).

Table 1. Condition classes for Iron-Grass Natural Temperate Grassland of South Australia.

Condition Class	Minimum Size	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in addition to identified disturbance resistant species[2]	No. of Perennial Grass Species[1]	Tussock Count[3]
Listed ecological community					
A	0.1 ha	> 30	+10	≥5	1/m
B	0.25 ha	> 15	+3	>4	1/m
Degraded patches amenable to rehabilitation					
C		> 5	No minimum	≥1	No minimum

[1] As measured in a 50m X 50m quadrat;

[2] The following species are identified as disturbance resistant species: *Ptilotus spathulatus* forma *spathulatus; Sida corrugata; Oxalis perennans; Convolvulus erubescens; Euphorbia drummondii;* and, *Maireana enchylaenoides;* and,

[3] As measured along a 50m transect.

Table 2. Condition classes for Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia.

Condition Class	Minimum Size	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in addition to identified disturbance resistant species[2]	No. of Perennial Grass Species[1]
Listed ecological community				
A	0.1 ha	> 30	+10	≥5
B	1 ha	> 15	+3	≥2
Degraded patches amenable to rehabilitation				
C		> 5	No minimum	≥1

[1] As measured in a 50m X 50m quadrat;

[2] The following species are identified as disturbance resistant species: *Ptilotus spathulatus* forma *spathulatus; Sida corrugata; Oxalis perennans; Convolvulus erubescens; Euphorbia drummondii;* and, *Maireana enchylaenoides*

Tussock Density

Tussock density was calculated by using a 50m transect through the centre of the 50m x 50m quadrat. This is used to quickly and accurately establish whether the density of tussocks meets the minimum criteria for the TEC which is $1/m^2$. Tussocks bases or aerial parts of the plants need to be intersected by the tape to be recorded.

Survey Limitations

The survey was undertaken at a time of year which did not allow for the highest potential species diversity, which coincides with the emergence of annual herbaceous species and bulbous species from families such as Liliaceae (*Bulbine bulbosa, Wurmbea dioica,* and *Arthropodium* spp.), Stackhousiaceae (*Stackhousia monogyna*) and Orchidaceae.

Results

Thirteen sites were assessed in the Peppermint Box (*Eucalyptus odorata*) Woodland remnants across the mine site, whilst four sites were assessed in the Irongrass (*Lomandra* spp.) Grassland remnants. Seven Peppermint Box (*Eucalyptus odorata*) Woodland sites qualified as the TEC condition class B, whilst four qualified as condition class C which are regarded as degraded patches amenable to rehabilitation. *Eucalyptus odorata* patch 11, which falls within the proposed impact area, was not assessed due the low quality woodland community present. This patch had a very low density of Peppermint Box trees in the overstorey with an understorey dominated by *Austrostipa scabra,* forming a dense climax community with low diversity of indigenous herbaceous and grass species. This does not subsequently form part of the Threatened Ecological Community.

Of the four Irongrass (*Lomandra* spp.) Grassland sites assessed, two qualified as the TEC condition class B, and two qualified as condition class C which are regarded as degraded patches amenable to rehabilitation. Table 3 shows the species recorded for each of the sites. Table 4 and 5 displays the results of the assessment against the EPBC listing criteria for each site. Figure 1 shows locations of each site and condition rating assigned as assessed against the EPBC listing criteria. In addition, the mapping also displays the amendments to the vegetation mapping across the mine site.

Table 2. Species lists for Peppermint Box (*Eucalyptus odorata*) Woodland sites and Irongrass (*Lomandra* spp.) Grassland sites.

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
G	*Lomandra effusa*	Scented Mat-rush			✓	✓		✓	✓			✓						✓	✓	✓	✓
H	*Enchylaena tomentosa var.*	Ruby Saltbush			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		
	Acacia pycnantha	Golden Wattle			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓				✓	✓	
G	*Austrostipa scabra ssp. scabra*	Rough Spear-grass			✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
G	*Austrostipa sp. 2*	Spear-grass												✓	✓				✓		
G	*Austrostipa sp. 3*	Spear-grass							✓		✓						✓	✓			
H	*Vittadinia cuneata var. cuneata f. cuneata*	Fuzzy New Holland Daisy			✓	✓	✓	✓	✓	✓				✓				✓	✓		✓
H	*Maireana enchylaenoides*	Wingless Fissure-plant			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			
H	*Liliaceae sp.*	Lily Family			✓	✓	✓	✓	✓	✓				✓							✓
G	*Austrodanthonia setacea*	Small-flower Wallaby-grass			✓	✓	✓	✓	✓	✓											
G	*Austrodanthonia caespitosa*	Common Wallaby-grass												✓				✓	✓		✓
G	*Austrodanthonia sp.*	Wallaby-grass									✓										
G	*Elymus scaber var. scaber*	Native Wheat-grass			✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
H	*Oxalis perennans*	Native Sorrel			✓	✓												✓	✓	✓	✓
H	*Gonocarpus tetragynus*	Small-leaf Raspwort			✓	✓	✓		✓	✓				✓					✓		✓
H	*Thysanotus patersonii*	Twining Fringe-lily			✓	✓	✓			✓				✓					✓		
H	*Einadia nutans ssp.*	Climbing Saltbush			✓		✓		✓	✓	✓	✓	✓								
H	*Senecio spanomerus*				✓	✓	✓		✓	✓		✓									✓
	Atriplex semibaccata	Berry Saltbush									✓	✓									
	Allocasuarina verticillata	Drooping Sheoak			✓	✓			✓					✓	✓						
H	*Cheilanthes austrotenuifolia*	Annual Rock-fern				✓	✓			✓		✓		✓					✓		✓
H	*Dianella revoluta var. revoluta*	Black-anther Flax-lily				✓													✓		
	Senecio quadridentatus	Cotton Groundsel					✓														
	Eutaxia microphylla	Common Eutaxia				✓	✓		✓	✓				✓							✓
H	*Dichondra repens*	Kidney Weed					✓	✓		✓											

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
H	*Plantago drummondii*	Dark Plantain					✓											✓			
	Acacia microcarpa	Manna Wattle					✓			✓	✓										
H	*Vittadinia blackii*	Narrow-leaf New Holland Daisy					✓		✓									✓			
H	*Chenopodium desertorum* ssp.	Desert Goosefoot							✓		✓							✓			
	Maireana brevifolia	Short-leaf Bluebush							✓		✓	✓				✓					
	Rhagodia candolleana ssp. *candolleana*	Sea-berry Saltbush																			
H	*Lepidosperma viscidum*	Sticky Sword-sedge								✓				✓							
	Pittosporum angustifolium	Native Apricot							✓												
G	*Lomandra multiflora* ssp. *dura*	Hard Mat-rush							✓	✓		✓		✓					✓		
G	*Lomandra densiflora*	Soft Tussock Mat-rush								✓				✓					✓		
G	*Lomandra micrantha* ssp. *micrantha*	Small-flower Mat-rush																			
H	*Goodenia robusta*	Woolly Goodenia							✓										✓		
G	*Austrostipa elegantissima*	Feather Spear-grass								✓											
H	*Burchardia umbellata*	Milkmaids								✓											
H	*Goodenia pinnatifida*	Cut-leaf Goodenia								✓									✓		
H	*Prasophyllum* sp.	Leek-orchid																			
H	*Lagenophora* sp.	Bottle-daisy								✓											
H	*Compositae* sp.	Daisy Family								✓											
G	*Austrodanthonia* sp.																				
H	*Wahlenbergia stricta* ssp. *stricta*	Tall Bluebell										✓	✓					✓			✓
	Dodonaea viscosa ssp. *spatulata*	Sticky Hop-bush										✓		✓					✓		
H	*Calostemma purpureum*	Pink Garland-lily								✓		✓									
	Cryptandra amara var.	Cryptandra												✓					✓		
H	*Erodium* sp.	Heron's-bill/Crowfoot																✓			✓
H	*Acaena echinata*	Sheep's Burr																	✓	✓	✓
G	*Themeda triandra*	Kangaroo Grass																	✓		✓

TYPE	Scientific Name	Common Name	Comm. Status	SA Status	OD1	OD2	OD3	OD4	OD5	OD6	OD7	OD8	OD9	OD10	OD11	OD12	OD13	LOM1	LOM2	LOM3	LOM4
	Pomaderris paniculosa ssp.																		✓		✓
H	*Haloragis aspera*	Rough Raspwort																	✓		
G	*Amphipogon strictus*	Spreading Grey-beard Grass																	✓		✓
	Scaevola aemula	Fairy Fanflower																	✓		
	Bursaria spinosa ssp.	Bursaria																	✓		
H	*Asperula sp.*	Woodruff																	✓		
G	*Enneapogon nigricans*	Black-head Grass																			✓
H	*Diuris behrii*	Behr's Cowslip Orchid		V	✓					✓											
H	*Ptilotus erubescens*	Hairy-tails		R			✓														
H	*Stackhousia monogyna*	Creamy Candles			✓																
H	*Wurmbea dioica* ssp.				✓																
H	*Arthropodium strictum*	Common Vanilla-lily			✓							✓									
H	*Cynoglossum suaveolens*	Sweet Hound's-tongue			✓					✓											
H	*Ptilotus spathulatus*	Pussy-tails						✓													

Vegetation type, G = Grass, H = Broadleaf Herbaceous species (count excludes disturbance resistance species listed in Tables 1 & 2.)

Table 3. EPBC assessment against the criteria results.

Peppermint Box sites								
Site	**Easting**	**Northing**	**Size**	**Native species**	**Herbaceous species additional to disturbance resistant**	**Grass species**	**TEC? (ABC)**	**Patch**
A			**0.1ha**	**>30**	**10**	**≥5**		
B			**1ha**	**>15**	**3**	**≥2**		
C				**>5**	**no minimum**	**≥1**		
OD1	318098	6115279	17.454	20	12	4	B	10
OD2	318020	6115236	17.454	16	8	3	B	10
OD3	318060	6115367	17.454	20	12	3	B	10
OD4	318142	6115473	17.454	11	4	4	C	10
OD5	318025	6115659	7.657	21	9	6	B	12
OD6	318246	6115323	17.454	27	17	6	B	10
OD7	317505	6115534	2.83	11	3	3	C	14
OD8	317882	6115668	7.657	16	7	4	B	12
OD9	317710	6115563	5.331	6	3	2	C	13
OD10	318226	6115846	17.454	17	7	5	B	10
OD11	317954	6116352	11.137	7	1	3	C	6
OD12	316597	6116330	1.22	3	0	2	NO	1
OD13	316816	6116033	3.541	4	1	3	NO	2

Table 4. EPBC assessment against the criteria results.

Irongrass Grassland sites									
Site	**Easting**	**Northing**	**Size**	**Native species**	**Herbaceous species additional to disturbance resistant**	**Grass species**	**TEC? (ABC)**	**Patch**	**Tussocks per m²**
A			**0.1ha**	**>30**	**10**	**≥5**			**>1**
B			**1ha**	**>15**	**3**	**>4**			**>1**
C				**>5**	**no minimum**	**≥1**			**>1**
LOM1	318155	6114317	14.542	14	7	5	C	22	>1
LOM2	317930	6114029	0.98	27	10	9	B	28	>1
LOM3	317919	6114045	0.98	5	1	2	C	28	>1
LOM4	317932	6114303	0.337	17	8	6	B	30	>1

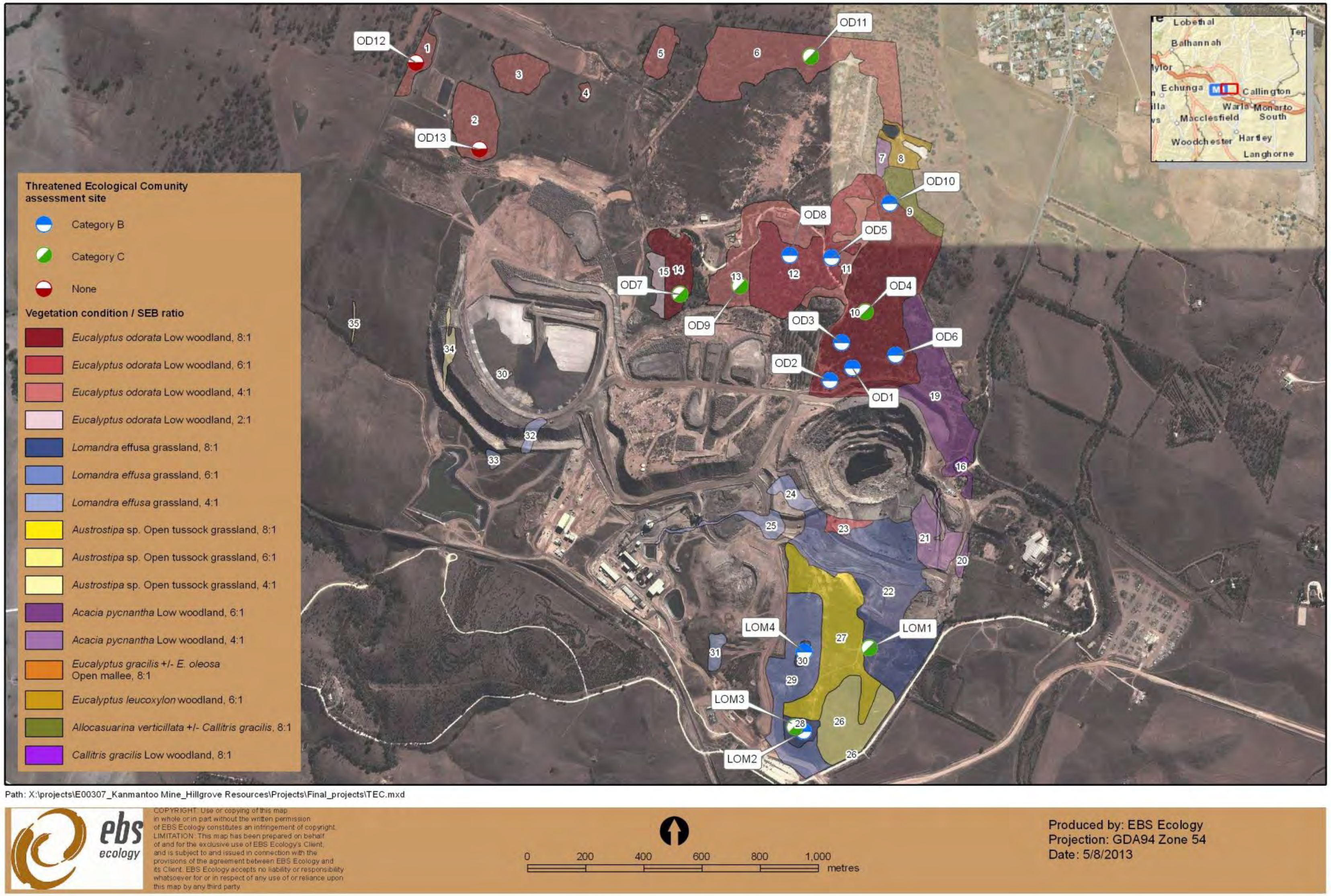

Figure 1. Vegetation mapping and EPBC assessment sites.

References

Department of the Environment and Water Resources (2007) *EPBC Act Policy Statement 3.7 Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia'*

Threatened Species Scientific Committee (2007) *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South Australia* [Listing Advice].

Threatened Species Scientific Committee (TSSC) (2007) *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South Australia* [Listing Advice].

Appendix 4D

Vegetation Assessment

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January 10, 2014

Catherine Davis
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RE: Vegetation Assessment

Dear Catherine,

Following on from our meeting this morning, I subsequently had a look over the buffer area highlighted as being potentially required for clearance. I have attached a map which shows the tracks and clearance buffer assessed. The following is a summary of what I observed.

General Observations; The entire site assessed is highly disturbed from its original state. This site has had changes in land use from mining to pastoral and agricultural. Soils are not consistent with surrounding areas with no evidence of clay loams present within the clearance buffer.
Boundary areas have been planted with amenity species in some areas (*Eucalyptus torquata*, *Acacia iteaphylla*) and other sections have volunteer weeds (*Acacia cyclops*) and exotic species (See below for a full species list). The open sections of the buffer have been used for agricultural purposes however currently consist entirely of exotic herbaceous and grass species.
There were signs of pest animal activity in the area with active rabbit burrows present in the southern extent of the buffer.
There were high numbers of New Holland and White-plumed Honey-eaters present foraging on the Eucalypts observed at the time of the survey. It is possible that some fauna species of conservation significance may use this area periodically for some habitat resources. These are expected however, to be transient visits only, due to the level of fragmentation. Such species may include Brush-tailed Possum, Diamond Fire-tail, Elegant parrot, White-winged Chough, Jacky winter and Hooded Robin.

Native vegetation; Very little native vegetation was present in the area. Small patches of regenerated *Austrostipa* sp. (Spear Grass), *Themeda triandra* (Kangaroo Grass), *Aristida behriana* (Brush Wire-grass) *Enchylaena tomentosa* (Ruby Saltbush) and *Enneapogon nigricans* (Black heads) were observed along the fence lines where disturbance was lowest. Individual *Dodonaea viscosa* ssp. *spathulata* (Sticky Hop-bush), *Lomandra effusa* (Scented Mat-rush) and *Acacia pycnantha* (Golden Wattle) were also sparsely present. The individual occurrences are not at a density that constitutes native vegetation and a clearance application and subsequent offset requirement is not necessary in this instance. No species of conservation significance were recorded other than *Acacia iteaphylla* (Flinders Ranges Wattle, Rare SA), which has been planted as an amenity species and therefore discounted.

A list of the weed species recorded onsite is provided below. It is a requirement of the landowner under the *Natural Resources Management Act 2004* to control outbreaks of declared species.

Family	Species	Common	Declared
LEGUMINOSAE	*Acacia cyclops*	Western Coastal Wattle	
LILIACEAE	*Asphodelus fistulosus*	Onion Weed	✓
GRAMINEAE	*Avena barbata*	Bearded Oat	
CHENOPODIACEAE	*Chenopodium album*	Fat Hen	
CUCURBITACEAE	*Citrullus lanatus*	Bitter Melon	
COMPOSITAE	*Cynara cardunculus ssp. flavescens*	Artichoke Thistle	
GRAMINEAE	*Cynodon dactylon var. dactylon*	Couch	
BORAGINACEAE	*Echium plantagineum*	Salvation Jane	✓
AIZOACEAE	*Galenia sp.*	Galenia	
ASCLEPIADACEAE	*Gomphocarpus cancellatus*	Broad-leaf Cotton-bush	
BORAGINACEAE	*Heliotropium europaeum*	Common Heliotrope	
LABIATAE	*Marrubium vulgare*	Horehound	✓
POLYGONACEAE	*Polygonum aviculare*	Wireweed	
DIPSACACEAE	*Scabiosa atropurpurea*	Pincushion	
GRAMINEAE	*Vulpia myuros*	Fescue	

Yours sincerely,

Andrew Sinel

Ecologist

EBS Ecology

Appendix 4E

LFA Monitoring

Kanmantoo Mine

LFA Monitoring – Autumn 2012

Kanmantoo Mine LFA Monitoring – Autumn 2012

20 July 2012

Version 1

Prepared by EBS Ecology for Hillgrove Resources

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	25/07/2012	T. Brown	A. Sinel	25/07/2012	Draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	25/07/2012	Electronic	J. Crocker, Hillgrove Resources

CITATION: EBS Ecology (2011) *Kanmantoo Mine LFA Monitoring – Autumn 2012.* Report to Hillgrove Resources. EBS Ecology, Adelaide.

Front cover photo: Typical *Eucalyptus odorata* (Peppermint Box) Woodland in good condition.

GLOSSARY AND ABBREVIATION OF TERMS

EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
LFA	Landscape Function Analysis
MARP	Mining and Rehabilitation Program
SSA	Soil Surface Assessment
TPC	Threshold of Potential Concern

EXECUTIVE SUMMARY

A Landscape Function Analysis (LFA) monitoring program has been implemented into the ongoing environmental management, restoration and SEB offset program components of the Kanmantoo Mine.

2012 is the second year of monitoring the three vegetation communities, which include two nationally threatened ecological communities listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act); *Eucalyptus odorata* (Peppermint Box) Open Woodland and *Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland. The third vegetation association is *Austrostipa scabra* (Spear grass) Tussock Grassland.

Analysis of the data has demonstrated that the analogue sites are in very good condition and are consistent with the previous year's datasets. They are still yielding the higher end of the target values, due to exceptional seasonal condition over the past three years and it will be important to monitor the analogue sites annually for several more years to capture the lower end of a 'target range' of values.

The rehabilitation sites established in *Eucalyptus odorata* (Peppermint Box) Open Woodland areas are generally in poor condition, however there are small variations in the data which indicate that the removal of grazing and the favourable seasonal conditions are benefiting the vegetation community. It is anticipated that the LFA indices values will begin to improve further, once active restoration of the sites is commence.

Rehabilitation sites for the other two vegetation types will need to be established as soon as they are identified and restorative activities have been initiated.

Contents

List of Tables

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1 INTRODUCTION

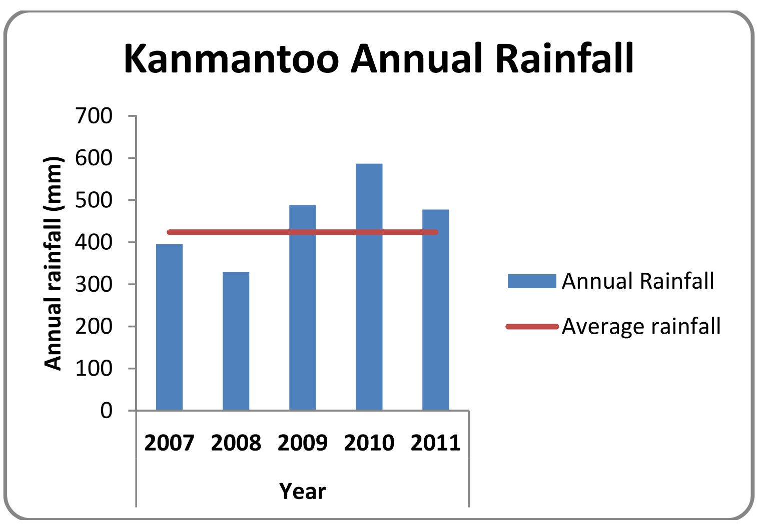
For Hillgrove Resources to meet its objectives and obligations under the MARP, the nominated offset areas will require annual monitoring to determine the overall success of the ongoing restoration programs. EBS Ecology has been commissioned by Hillgrove Resources to undertake a Landscape Function Analysis (LFA) (Tongway and Hindley, 2005) land condition monitoring program across the Kanmantoo Copper Mine project site. Details of the monitoring program and associated methodologies are detailed in *Kanmantoo Mine Vegetation Monitoring – Landscape Function Analysis. (*EBS Ecology, 2011). It is the intent that data collection be repeated over time to achieve a time series trajectory for the different land types across the mine site, enabling critical indicators to be identified, their values analysed and used to adapt future management activities if required.

This primary aims of this report are to:

- provide the second year of LFA monitoring data for the existing sites across the Kanmantoo Mine site
- provide discussion and analysis of data for relevant critical indicators
- provide recommendations for future LFA monitoring.

1.1 Seasonal conditions

The long-term average annual rainfall for the district is 424 mm. 2011 was another above average rainfall season contributing to the 'pulse' event (Figure 1). It is important to note that a natural decline may be experienced in the data index values following this period of above average precipitation. It is necessary that during and after this period, to collect a series of 'target values' for the analogue sites which will become the 'target range' the rehabilitation sites are aiming for.



Data source: Commonwealth of Australia/Bureau of Metrology (2012)

Figure 1. Kanmantoo annual rainfall 2007-2011.

2 RESULTS

Data was collected at the analogue sites for a second year during May 2012 and will be used in association with one or two additional datasets to determine what the 'target range' of values are for each vegetation association.

Vegetation communities have responded well to above average seasonal conditions over the past few years, with good cover of native perennial and annual species. Some juvenile grass and other native herb recruitment is evident mainly throughout *Eucalyptus odorata* Open Woodland and *Lomandra effusa* / *Lomandra multiflora* spp. *dura* Grassland associations. Mosses and lichens have also responded well and appear to be much more prevalent than in 2011. Local disturbance to the soil surface brought about by high mouse numbers in 2011, appear to have declined significantly and the subsequent damage is recovering.

Site photos for 2012 are displayed in Figures 2 – 5.

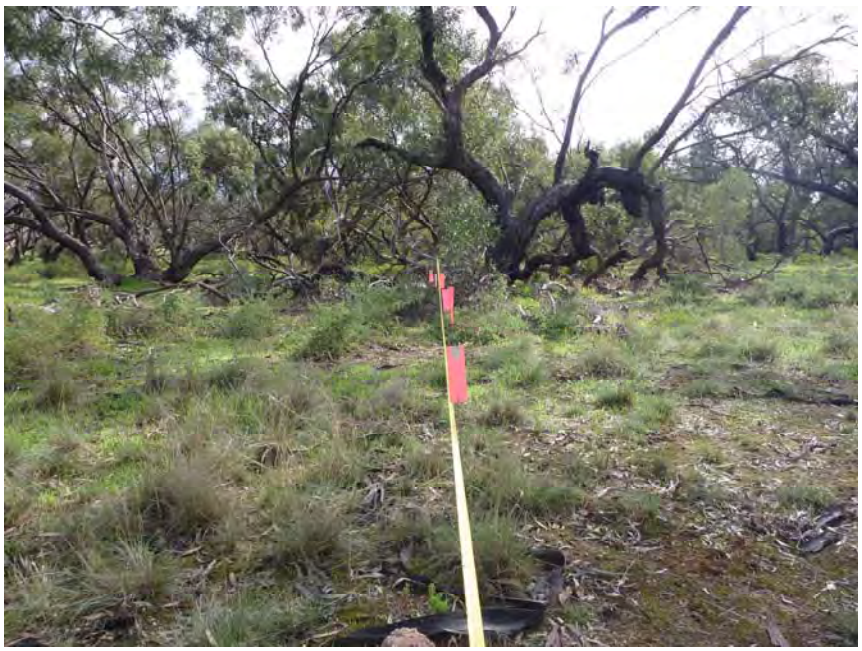


Figure 2. Analogue site - *Eucalyptus odorata* (Peppermint Box) Open Woodland 2012.

Figure 3. Analogue site - *Lomandra effusa* (Scented Scented Mat-rush) +/- *Lomandra multiflora* ssp. dura (Hard Mat-rush) Grassland, 2012.

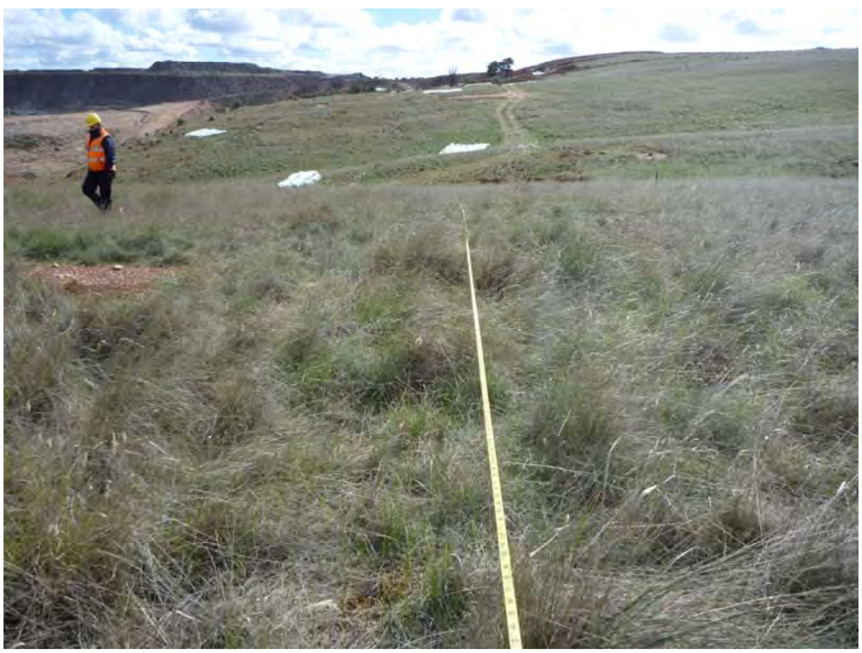


Figure 4. Analogue site - *Austrostipa* spp. (Spear Grass) Grassland, 2012.

Figure 5. Rehabilitation site - *Eucalyptus odorata* (Peppermint Box) Open Woodland 2012.

2.1 LFA

Results for Soil Surface Assessments for individual zones and contribution to whole of site values are provided in Table 1. Data from each of the three replicate sites within the same vegetation associations have been combined to obtain average values. For example KANODO 1, 2 and 3 have a single set of values for each indices.

Year 2 results (2012) have been added to the table, with subsequent years also to be included following each monitoring event. As new rehabilitation sites are established, more datasets will be included within the annual reports.

Table 1. SSA results.

Site name		Zones	Stability (%) 2011 (baseline)	Stability (%) 2012 (Year 2)	Infiltration (%) 2011 (baseline)	Infiltration (%) 2012 (Year 2)	Nutrients (%) 2011 (baseline)	Nutrients (%) 2012 (Year 2)
KANODO Analogue site (8:1)		**Whole of landscape**	**61.26**	**60.56**	**37.4**	**44.3**	**26.6**	**31.76**
	Individual zones	Bare Ground	60.2	57.7	28.36	30.3	20.8	19.36
		Grass Sward	64.6	62	34.46	39.4	27.7	26.9
		Tree Patch	61.2	62.46	45.8	57.96	31.46	44.4
		Shrub Patch	62.45	62.5	36.7	49.53	24.5	35.26
KANODO Rehabilitation site (4:1)		**Whole of landscape**	**69.66**	**61.3**	**54.4**	**54.8**	**47.3**	**40.9**
	Individual zones	Bare Ground	-	61.3	-	51.6	-	34.05
		Exotic Grass Sward	70.1	62.3	48.26	53.9	41.36	38.1
		Tree Patch	69.6	60.4	59.93	56.1	52.7	44.16
KANLOM Analogue site (8:1)		**Whole of landscape**	**62.5**	**61.5**	**27.1**	**30.03**	**21.6**	**21.9**
	Individual zones	Grass Sward	64.1	63.4	29.2	32.5	23.6	25.2
		Bare Stony Ground	56.3	58.6	20.1	25.6	14.8	15.9
		Shrub Patch	69.4	68.1	31.1	51.5	27.7	50
KANSTI Analogue site (8:1)		**Whole of landscape**	**64.9**	**60.6**	**36**	**39.3**	**29.5**	**25.2**
	Individual zones	Grass Sward	66.4	63	37.43	42.3	30.9	27.8
		Bare Ground	55.1	56.36	20.5	34.26	14.9	20.6

A number of graphs display data for each of the vegetation associations. Data has only been compared between *Eucalyptus odorata* analogue and rehabilitation sites where sites were both assessed (see Figures 6 - 10). *Lomandra* and *Austrostipa* Grassland sites have data displayed only for analogue sites as the rehabilitation sites are yet to be established. Site comparison will become possible for these associations as further sites are selected for restoration.

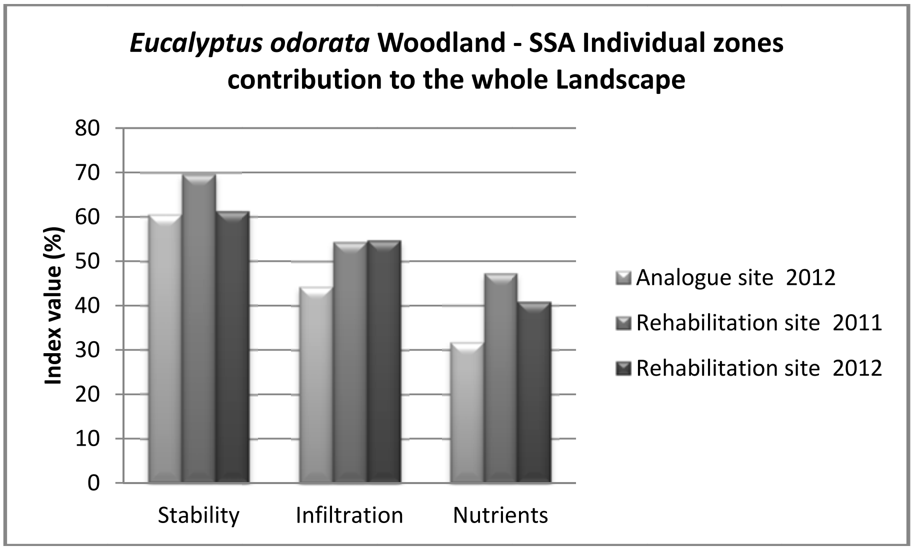


Figure 6. ***Eucalyptus odorata*** **Woodland SSA individual zones contribution to the whole of the landscape site comparison**

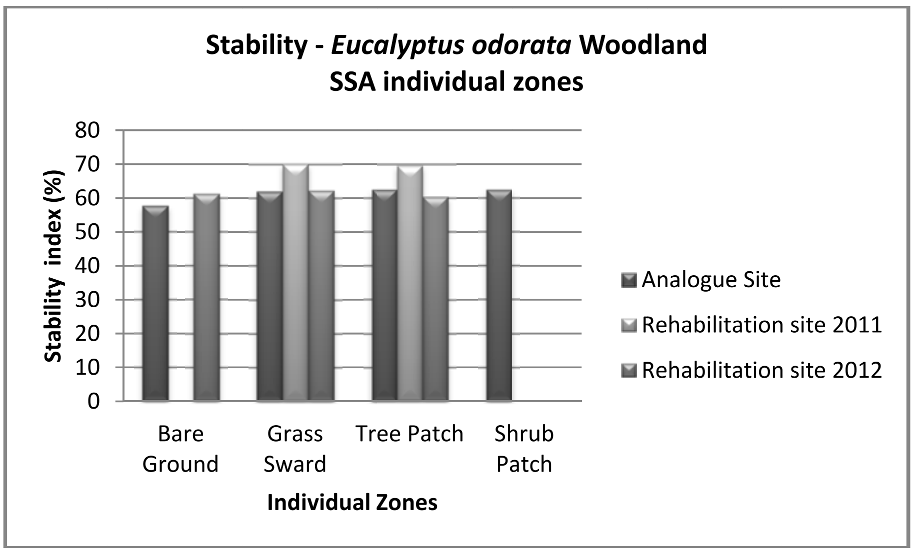


Figure 7. ***Eucalyptus odorata*** **Woodland SSA individual zones contribution to Stability**

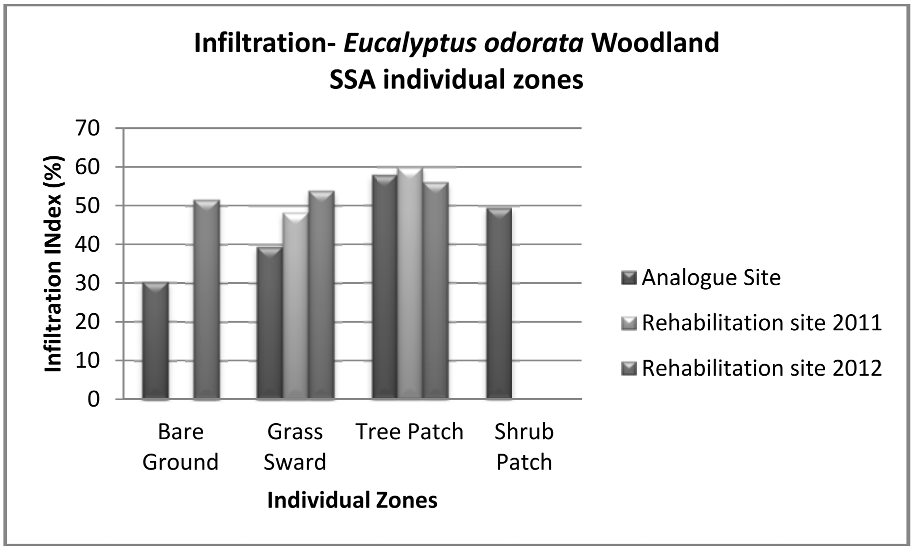


Figure 8. ***Eucalyptus odorata*** **Woodland SSA individual zones contribution to Infiltration.**

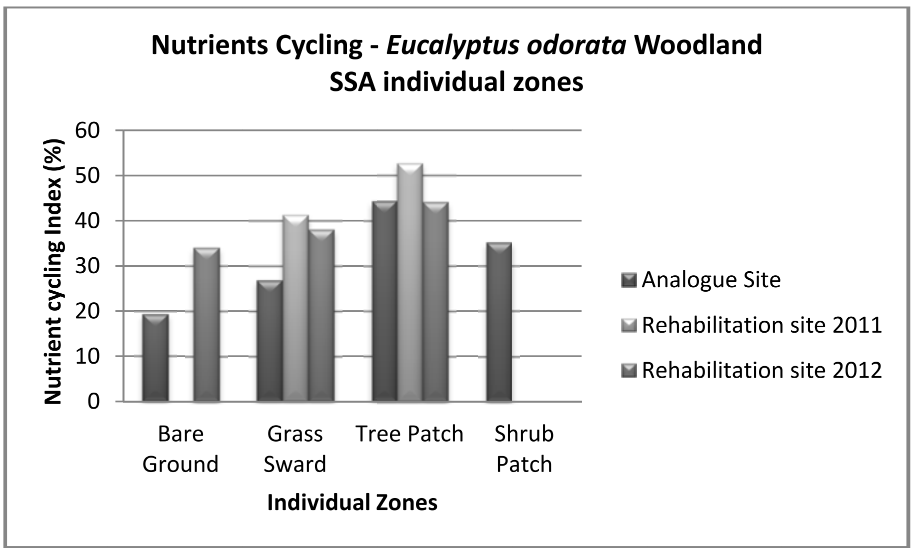


Figure 9. ***Eucalyptus odorata*** **Woodland SSA individual zones contribution to Nutrient Cycling.**

A summary of the landscape organization data is provided in Table 5. This includes the averaged values between the three replicate sites for number of landscape patches per 10 m, Total patch area (m^2), average inter-patch length and Landscape Organisational Index. The landscape organization index is the proportion of the length of patch to the total length of the transect i.e. a totally bare transect would have an index of zero or if it was all patch (e.g. a sward) the index would be 1. These values can be compared from year to year to measure changes in the landscape. For example, patch sizes and/or number of patches are increasing and by extension, inter-patch lengths are decreasing.

Table 2. Summary of the landscape organisation data for KANODO analogue and rehabilitation sites.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011	2.6	242.4	1.94	0.59
Analogue 2012	2.9	327.5	1.6	0.75
Rehabilitation 2011	0.96	520.46	0	1
Rehabilitation 2012	1.16	476.2	1.2	0.97

*length of patches/length of transect

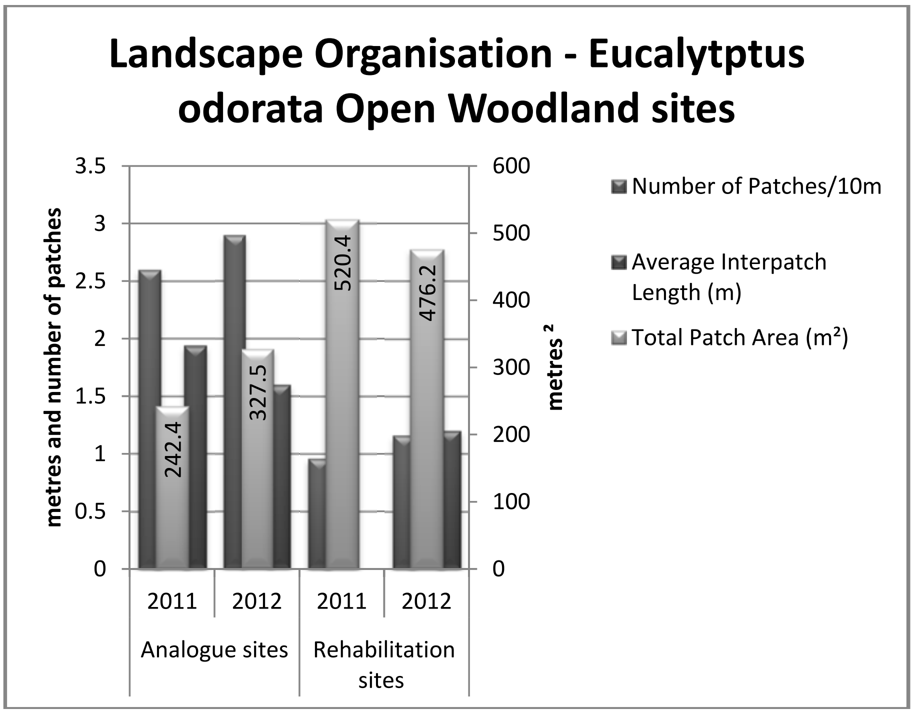


Figure 101. ***Eucalyptus odorata*** **Woodland Landscape organisation data**

Collated data for Lomandra ssp. Grassland sites is presented in Figures 11 and 12. Note that only two replicates of the shrub patch type were recorded when five are required for statistical reliability. This may increase over time if shrub cover increases within the transect monitoring zones. The existing data is probably not overly robust with only two replicates.

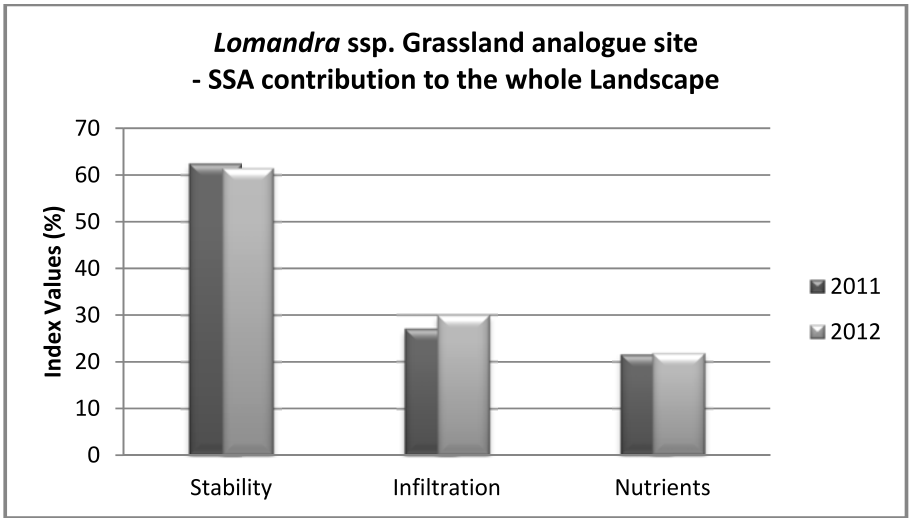


Figure11. Lomandra ssp. Grassland analogue site - SSA contribution to the whole of the landscape.

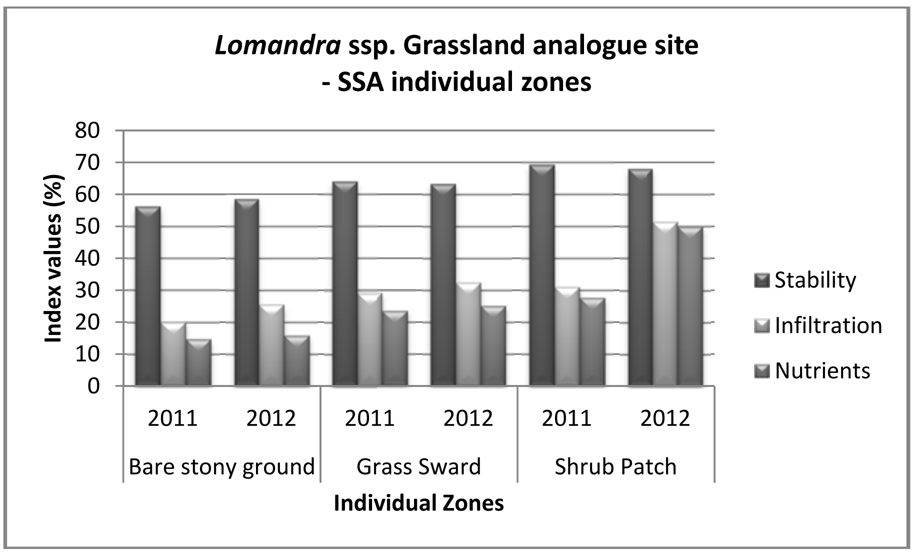


Figure 12. Lomandra ssp. Grassland SSA individual zones.

A summary of the landscape organization data is provided in Table 6.

Table 3. Summary of the landscape organisation data for KANLOM analogue sites.

Site type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisation al Index*
Analogue 2011	4.4	92.9	0.76	0.64
Analogue 2012	5.4	95.1	0.71	0.56

*length of patches/length of transect

Collated data for *Austrostipa* ssp. Grassland sites is presented in Figures 13 and 14.

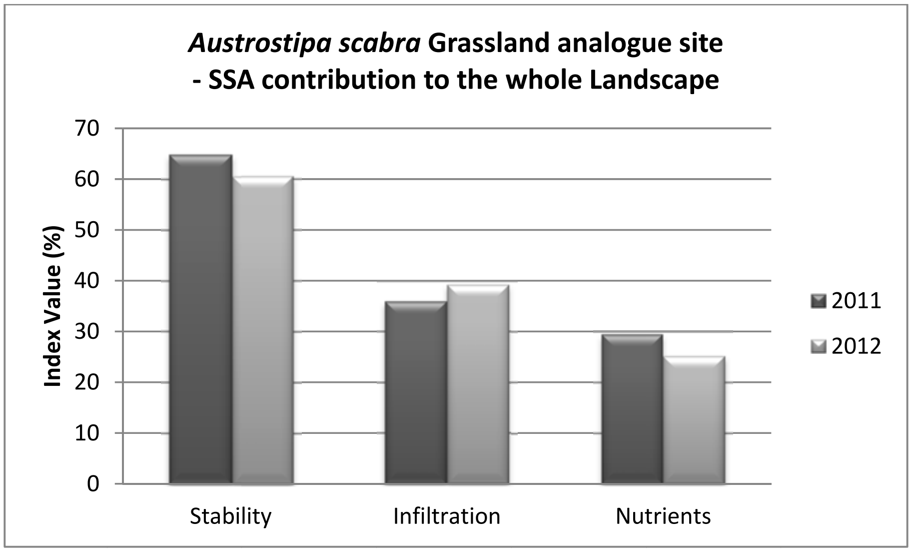


Figure 13. ***Austrostipa*** **spp. (Spear Grass) Grassland analogue site - SSA contribution to the whole of the landscape.**

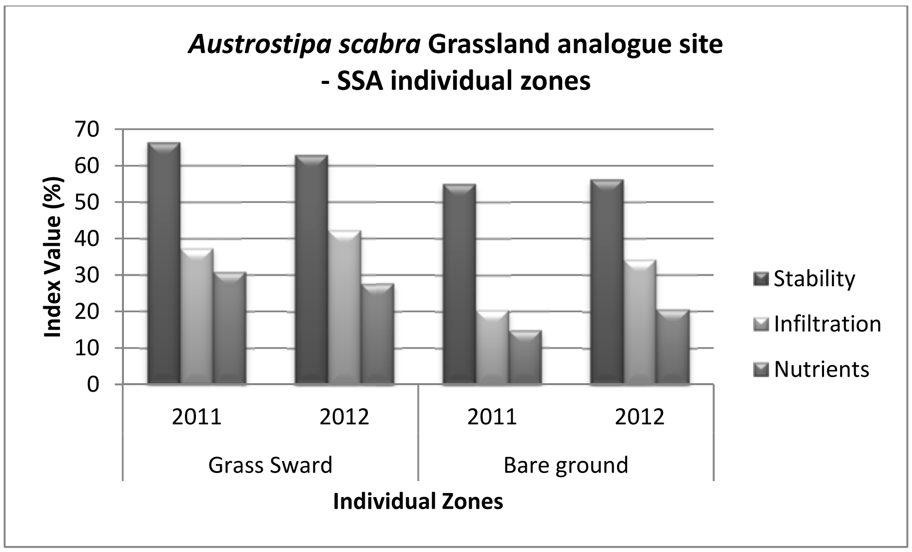


Figure 14. ***Austrostipa*** **spp. (Spear Grass) Grassland analogue site SSA individual zones.**

A summary of the landscape organization data is provided in Table 4.

Table 4. Summary of the landscape organisation data for KANSTI analogue sites.

Site Type	No. of patch zones per 10 m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011	2.5	215.5	20.18	0.85
Analogue 2012	6.9	122	0.58	0.61

*length of patches/length of transect

3 DISCUSSION

Eucalyptus odorata (Peppermint Box) Open Woodland

As expected the indices values obtained from the analogue sites are consistent with those collected in 2011, indicating that the community is in a highly functional and stable state. Another year of above average rainfall has again inflated the values somewhat and it will be important in the following few years to collect annual data from the analogue sites to obtain more realistic values and the development of a 'target range' of values in which the rehabilitation sites can aspire to.

The whole of landscape values obtained from the rehabilitation sites are higher than the analogue sites for infiltration and nutrient cycling, primarily due to the exceptional season and the continuous dense cover of annual grasses. This has led to the retention of soil moisture, enhanced infiltration due to high volumes of below-ground biomass, and nutrients in the soil from the breakdown of the annual biomass in the previous two years. Stability has stabilised and in 2012 is more in line with the analogue sites (Figure 6) and is probably also due to the high cover of grasses and exotic herbs. The values of the individual zones show that there is significant variation in the indices between analogue and rehabilitation sites within the bare ground and areas dominated by grass, whereas the tree patches yield very similar values for stability, infiltration and nutrient levels. The influence of the trees appears to have a consistent effect upon the soil function. An important feature of the woodland landscapes are that they tend to be more resilient to degradation through weed invasion because the trees groves are scarcely impacted and continue to cycle nutrients in spite of bare patches between the tree groves (in summer months), which tend to be prey to wind and water erosion when their surfaces are disturbed. Future analysis aimed at detecting genuine degradation of a site, will need to focus on the data between tree patches in the inter-patch areas, and use any of the bare soil inter-patch values as indicators of soil degradation, augmented by the inter-patch length, rather than the whole of site indices, which will always be buffered by good tree patch values. These may not be available until the continuous annual grass cover has died off.

Some of the general observations made during the 2012 monitoring survey included a higher incidence of mosses and cryptograms, higher levels of litter and softer ground due to the exceptional high rainfall in May. Infiltration rates in particular appear to have been influenced by these factors and exhibit elevated levels, particularly within the analogue sites. Increases in moss cover appear to be influencing native grass recruitment within the *Eucalyptus odorata* (Peppermint Box) Open Woodland rehabilitation sites. Despite only occurring in small localised areas, it is suggesting the early stages of recovery following the removal of grazing and favourable seasonal conditions.

Once future targeted management activities are initiated (outlined in *Kanmantoo Mine Vegetation Monitoring – Landscape Function Analysis* (EBS Ecology, 2011)), it is anticipated that the LFA indices values will gradually begin to improve, that is, infiltration and nutrient cycling levels will begin reducing and stability remaining consistent with the Analogue site value..

The landscape organisational data shows that the rehabilitation sites are behaving very differently in terms of patch/interpatch variation. Much of the community is dominated by grassy exotics forming a 'continuous' homogenous patch in the understorey. Some small areas of bare ground were evident during the 2012 survey, as well as small areas dominated by the moss / native grass combination. This may be the emergence of a more heterogeneous landscape structure now that the primary degrading factor has been removed (grazing), coupled with good seasonal conditions. The proposed management activities (understorey restoration) will aim to accelerate this process by mimicking landscape patch arrangement observed in the analogue sites.

Lomandra effusa (Scented Scented Mat-rush) +/- Lomandra multiflora ssp. dura (Hard Mat-rush) Grassland

The overall condition of the analogue sites from a biodiversity perspective is excellent. There are very few weeds, a high cover of native vegetation and high species diversity for the vegetation community. The LFA values obtained from the indices demonstrate that the sites are highly functional and in a stable state, however they are likely to be higher than normal for the same reason that the woodland sites have inflated values. Very little has changed overall since 2011. Some small increases in infiltration and nutrient cycling were noted within the patch and interpatch zones, and may be attributed to the increase in cryptograms, particularly within the interpatch zones. The soils were also relatively moist given the above average rainfall in the months of March and May 2012. It is recommended that additional datasets are collected in the next few years to obtain more realistic target values.

Austrostipa spp. (Spear Grass) Grassland

The overall condition of the *Austrostipa* spp. analogue sites is very good and LFA values have remained fairly consistent with 2011. There are few weeds and a high cover of native grasses, however many of the plants are old and some senescing, with elevated levels of surface litter, mainly made up of native grass thatch. The LFA values obtained from the sites demonstrate that the sites are highly functional and in a stable state.

Landscape organisational data has yielded significant variation from 2011 data, where the patchiness has increased due to an overall decrease in surface litter. The litter appeared in 2011 to be creating 'land bridges' between the tussocks and led to larger areas being measured as grass swards. The decrease in dry grass litter levels may be a result of the widespread disturbance to soil surface due to mouse activity throughout 2011, subsequently breaking up the thick thatch layer.

For the same reasons as the other land types, the SSA values obtained are likely to be higher than would normally be expected due to exceptional seasonal conditions. It is therefore recommended that additional datasets are collected in the next few years to obtain more realistic target values.

4 REFERENCES

EBS Ecology (2011) *Kanmantoo Mine Vegetation Monitoring – Landscape Function Analysis.* Report to Hillgrove Resources. EBS Ecology, Adelaide.

Commonwealth of Australia (2012) *Bureau of Meteorology – Climate data, Kanmantoo*.

Tongway, D.J., and Hindley, N.L. (2005) *Landscape Function Analysis: Procedures for monitoring and assessing landscapes. With special reference to Minesites and Rangelands.* CSIRO Sustainable Ecosystems, Canberra.

Tongway, D.J (2005) *Landscape Function Analysis: Field Procedures* CSIRO Sustainable Ecosystems, Canberra.

5 APPENDICES

Appendix 1. Potential question for repeat visits

Landscape Organisation

- Is Landscape Organisation due to biological or physical/engineering features? If a mixture of biological and physical, what is the balance between them?
- Has physical patchiness declined since the last monitoring period? If so, is there cause for concern? Specify threatening processes (e.g. sedimentation, rill or gully initiation).
- Is biological patchiness increasing; is the rate significant?
- Has patch width increased or decreased since the previous monitoring? If decreasing, can the cause be identified (e.g. banks cut by rills, vegetation patches no longer linked by "litter bridges"). If increasing, what is the cause? (e.g. plant litter build-up between adjacent grass plants?)
- Are patches increasing or decreasing in length (ie. up and down slope)?
- Is the patch area increasing or decreasing?
- Has biological patch quality compensated for loss of physical patchiness, or not? Note that 'whole transect' LFA indices (bottom line in last table on Summary page) are comprised of both 'quality' and 'proportion' values. Comment should be made on the make-up of the final number.
- Does patchiness change with season? E.g. massive annual plant growth that 'hays off" in the non-growing season?
- Is a stony surface a significant inter-patch type? Is the stone embedded or resting on the surface?
- Is stone cover of such significance that a soil crust has not formed between stones?
- If patches are due to applied mulch, is the density and spacing of mulch having an effect on runoff and erosion/sedimentation processes? Can check rill density to confirm. Look also for sediment trapped in upslope edges of mulch. Comment on whether too much or too little mulch appears to have been used, giving reasons.
- What are the major differences between the analogue site and the rehabilitation sites? (E.g. patch type and size).
- Are any of the assessed sites approaching the Landscape Organisation of the analogue sites?
- Is a rill assessment necessary? If so, observe the nature of the rill floor and note if it is rock or is unstable (loose alluvium, slaking soil)
- Are rills increasing or decreasing in number or cross-section; are live plant or litter obstructions becoming established?
- Is sediment noticeably being captured in developing patches? If so, watch these areas in future for plant germination. If no sediment is being trapped, consider an intervention to supply more

resource flow "obstructions"

- Are patch/inter-patch types changing in character; are new names necessary? The need to do so should be explained, as both beneficial and detrimental changes can occur: explain in terms of resource regulation (patches may now be more complex: grass-shrub clumps forming? shrubs colonising? troughs growing plants? troughs becoming flats? Banks becoming slopes?)

Soil Surface Assessment

- Is rainsplash protection due to physical or biological factors? Is the protection threatened by disturbance? If so, specify and discuss. Is rainsplash protection likely to increase over time (vegetation growth) or remain the same (rock)
- Is litter accumulating noticeably? Is decomposition becoming a more conspicuous process? What is the balance between litter derived from perennial vs. annual plants?
- Is annual litter robust enough to be considered perennial (e.g. from biennial plants)? Is litter decomposition being reflected in soil darkening (look at the boundary between the litter and the mineral soil colour)?
- Is the surface crust becoming more or less pronounced? Is the sub-crust soil coherent (hard or weakly aggregated or single-grain) Are there any bio-aggregates (e.g. worm pellets, termite carton) present?
- Is all the litter accumulated subject to consumption by fire? (some landscapes have highly discontinuous litter beds, reducing the potential for complete loss in fire; grasslands are likely to lose all litter in a fire)
- Is plant litter (or applied mulch) sufficiently dense as to effectively filter out all particulate matter during overland flow? Look for deposited materials (physical or biological) near the upslope edge of the litter or mulch patch.
- Does the architecture of plant foliage tend to trap or accumulate resources at ground level, or is there a "gap" between the soil surface and the plant canopy? Can this be used to infer litter accumulation potential? Consider deploying the full vegetation function procedure in EFA.
- Are there some indicators that do not alter across the function/dysfunction continuum? (e.g. soil texture, surface roughness) If so, comment on this and concentrate on the more informative dynamic indicators.
- What are the threatening processes for the patch types assessed? (e.g. trampling, weeds, vehicular traffic, erosion, burial under sediment, fire)
- Do the indicators of cryptogam cover, surface condition and slake test "match" each other, or can a mis-match be interpreted in functional terms?
- If evidence of current erosion is rarely observed, is this because potentially available material is held in a "safe" location in the landscape, or because there is no erodible material present, or remaining?

- Is alluvium frequently or infrequently encountered? If infrequent, is this due to its rapid outflow from the landscape, or is little soil available for transport: look for clues off the line transect for guidance. Look for alluvial fans at the foot of the slope to confirm.
- How strongly differentiated are the index values for patches and inter-patches? If differences are small, discuss the significance. If marked, discuss whether patches are vulnerable to disturbance or robust. Good discrimination implies that the L/O task has been done well.
- Are any indicators reaching their maximum score? If so, identify and comment on as having reached a significant 'milestone' in rehabilitation.

Interpretational Framework

- This step involves examining both the whole-of-site LFA values and the respective patch inter patch LFA values so as to effectively summarize the findings of successive monitoring episodes, looking for trend over time. A sigmoidal or 'S' shaped curve with time should be expected.
- Are LFA indices increasing, implying that rehabilitation is progressing satisfactorily?
- Is there a particular factor which is restraining improved function? Is additional management intervention necessary? What recommendations for action can be specified from the data? Is the increase expressed at the whole site level or just within a single patch type? Discuss.
- Has there been a significant increase in LFA values from the initial value?
- Can a critical threshold be discerned in the index values (ie. LFA values about midway between initial and reference site values)? Discuss in terms of consequences for management actions (no problem; monitor at infrequent intervals; potential problem close to critical threshold, monitor more frequently; current problem, design intervention actions based on LFA indices. Devise target values and rehabilitation success and failure criteria for future monitoring.
- Expect the stability index to reach its plateau value before the infiltration index does. The nutrient cycling index will be the slowest as, for its plateau value, a mature vegetation stand, providing substantial litter fall and decomposition is necessary. A site may be concluded to be self-sustaining well before this however, if the stability and infiltration indices have progressed well and the nutrient cycling index is on an upward plane.

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Appendix 5

Fauna

Appendix 5A

Fauna Survey

ecological
associates pty ltd

Final Report

Kanmantoo Copper Project:
Fauna Baseline Survey and Impact Assessment

Coffey Natural Systems

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Wayville SA 5034

August 2007

ECOLOGICAL ASSOCIATES REPORT DE006-C3

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Executive Summary

Scope of Work

Ecological Associates was engaged by Coffey Natural Systems on behalf of Hillgrove Resources to:

- survey the fauna of the Kanmantoo Copper Project Area
- identify potential impacts to fauna associated with the project; and
- identify opportunities to avoid, minimise or mitigate impacts;
- recommend further investigations, if required; and
- recommend a program to monitor the effects of mine on fauna in the future.

Methods

Records of fauna previously observed in the region were extracted from the Biological Survey of South Australia to assess the fauna likely to be present in the area.

A survey of the site, based on the methods of the Biological Survey of South Australia, was conducted over one week in February 2007. The survey involved trapping, bird searches, active searches for vertebrate fauna in litter, debris, hollows and bark, spotlighting and bat recordings. The survey assessed the fauna of the main habitat types of the site (*Eucalyptus odorata* woodland, *Lomandra effusa* tussock grassland and *Austrostipa* sp. grassland) and the general landscape.

Findings

The overall diversity of fauna found at the site was low in comparison to records of fauna previously observed in the area. The abundances of fauna were also low in comparison to values expected from surveys in similar habitats. The low diversity and abundances are believed to partly reflect the low rainfall experienced in the region in the 12 months prior to the survey and the timing of the survey in late summer, when many species may not be active.

The greatest diversity and abundance of fauna was found in the *E. odorata* woodland. This vegetation provided relatively complex habitat components such as hollows, understorey vegetation, logs and deep debris.

Species diversity and abundances were lower in the *L. effusa* tussock grassland. However, this habitat type supports specialist grassland species that are unlikely to be found in other vegetation types.

Two bird species of conservation significance listed under the South Australian National Parks and Wildlife Act 1972 were observed. Diamond Firetail *Stagonopleura guttata* is recognised as vulnerable. It was mainly associated with the *E. odorata* woodland. Peregrine Falcon *Falco peregrinus* is recognised as rare. A pair is resident at the site and nests annually in the cliff face of the existing open cut.

One migratory bird species that is protected under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) was observed. The Rainbow Bee-eater *Merops ornatus* is subject to the Japan Australia Migratory Bird Agreement (JAMBA) and is therefore protected under the EPBC Act.

The Brushtail Possum *Trichosurus vulpecula* was observed. This species has been proposed for listing as rare under the schedules of the National Parks and Wildlife Act (NPWC & DEH 2003). This species is dependent on tree hollows and was observed in the *E. odorata* woodland.

Potential Impacts

The proposed mine development potentially impacts on the fauna of the site. The potential impacts and measures to address these impacts are identified in Table ES-1.

Table ES-1. Potential Impacts and Impact Minimisation Measures

Potential Impact	Possible Minimisation Measures
Clearing vegetation and therefore reducing fauna habitat in *E. odorata* woodland, *L. effusa* tussock grassland, *Austrostipa* sp. grassland, mallee vegetation and scattered trees.	Reduce impacts by planning excavations, roadways and other infrastructure by avoiding remnant vegetation, where possible.
	Minimise impacts by avoiding high quality habitat, where possible.
Disturbing fauna from the noise of blasting, traffic, excavations, ore processing and other activities	Locate noisy activities as far as possible from high value habitat. Take measures to minimise noise generation.
Disturbing fauna from vibrations associated with blasting, traffic, excavations, ore processing and other activities	Locate disturbing activities as far as possible from high value habitat. Take measures to minimise vibration generation.
Degrading habitat quality by dust generated from the mine and roadways	Minimise dust creation in excavations, vehicle movement and ore processing. Maintain roads to minimise dust creation.
Degrading habitat quality by weed invasion associated with increased traffic	Control movement of weed-contaminated vehicles and soil and ensure vehicles remain free of soil and weeds. Implement a weed monitoring and control program.

Significance of Impacts

The mine development may significantly impact on Diamond Firetails, which have conservation significance at the state level. This species is closely associated with grassy woodlands such as the *E. odorata* woodland on the site. Their significant decline in South Australia is associated with habitat loss and predation. In order to clarify the significance of any impacts on this species, further investigations are required to assess the size of the population on the site and the distribution of the species in the region. It may be possible to mitigate the impacts of the mine by rehabilitating or protecting similar habitat elsewhere.

The potential impact on Rainbow Bee-eater is not expected to be significant at the national level. The regional and national population of this species is not threatened. Mitigation measures associated with the Significant Environmental Benefit for vegetation are likely to provide alternative habitat for this species.

The potential impact on Brushtail Possum may be significant at the local, regional and state level. This species depends on tree hollows and productive habitat associated with grassy woodlands. It may be possible to mitigate impacts on this species by protecting and rehabilitating other grassy woodland habitat elsewhere.

The potential impact on Peregrine Falcon is not expected to be significant at the local, regional, state or national level. The breeding pair may leave the site when the mine is redeveloped, but this is not likely to significantly affect the security of this species in the region.

Impacts on other fauna affected by the mine are expected to be mitigated by habitat rehabilitation under the Significant Environmental Benefit framework. They are not expected to be significant.

Recommendations

Further investigations are recommended to assess:

- Diamond Firetail distribution and numbers in grassy woodland remnants within the region; and
- the size and nature of the Diamond Firetail population on the site.

It is recommended that, where possible, activities involving vegetation clearance, excavations, traffic, noise and other disturbances be located to avoid remnant vegetation. In order of priority, protection should be given to: 1. *Eucalyptus odorata* woodland and mallee; 2. *Lomandra effusa* grassland; and 3. *Austrostipa* sp grassland.

Impact on fauna habitat can be mitigated to some extent by the preservation, restoration or creation of similar habitat elsewhere. Mitigation processes are not relevant to the Peregrine Falcons that presently use the site. Alternative habitat could be preserved or rehabilitated to mitigate expected impacts on Diamond Firetail, Rainbow Bee-eaters and Brushtail Possum.

1.1 Introduction

Coffey Natural Systems, on behalf of Hillgrove Resources Limited (HRL), engaged ecological Associates to carry out a fauna baseline survey to assess the potential impacts of the proposed redevelopment and expansion of the Kanmantoo Copper Mine ('the project') on local fauna, habitats, and associated ecological communities.

1.2 Objectives

The purpose of the survey and impact assessment was to provide information on fauna for the Kanmantoo Copper Project Mining Lease Proposal (MLP). The scope of work was as follows.

1. Baseline Survey

- Survey the study area to describe the fauna species (including introduced species) and habitat types with a particular focus on species and communities of conservation significance (ie local, regional, state or national).
- Place the species and habitats present in the study area in a regional context.

2. Impact Assessment

- Describe the potential impact of the project (including construction, operations, decommissioning, post-decommissioning) on species, communities and habitats of local, regional, state or national significance. Placing this within local, regional, state and national context as appropriate.
- Describe any impact of the project to introduced fauna species.
- Describe the ability of communities or individual species to recover from habitat disturbance associated with the project.
- Discuss ways in which impacts on species, communities and habitats can be minimised or mitigated, including possible methods for protecting areas that will not be disturbed.
- Discuss the regional context for fauna and habitats of conservation significance, and the relative importance of the study area within this context.
- Describe potential residual impacts of the project following implementation of mitigation measures and rehabilitation.
- Identify uncertainties with respect to the fauna impact assessment.

1.3 Background

The Kanmantoo Copper Project is located between the townships of Kanmantoo (1.5 km to the north east) and Callington (3.5 km to the south east), 44 km east of Adelaide in South Australia.

The project area has been subject to intermittent mining operations from the mid 1800's to the 1970's. The original Kanmantoo mine was first worked in 1848 and activities continued, with numerous breaks, over the next century. An open pit resource was defined in 1969 and Kanmantoo Mines Pty Ltd worked this from 1971 to 1976. The site now contains a decommissioned open cut, tailings storage and waste rock dump. The granted mining lease ML5776 covers the Kanmantoo Mine and copper-gold resource. The areas to the immediate south and north of ML5776 are covered by EL 3298 which is surrounded by the larger EL3277 which covers 498 km^2. A prefeasibility study for this project was completed in June 2006, which returned a positive result.

2.1 Site Description

The Kanmantoo Copper Mine Project is located in the Eastern Mount Lofty Ranges Ecological Area near the western boundary of the South Australian Murray Darling Basin (Kahrimanis et al. 2001). The project is to be developed within an area of 439 ha (Figure 1).

A north – south trending range, reaching a height of about 120 m above the surrounding area, dominates the immediate physical environment of the Kanmantoo Copper Mine area. The slopes of these hills are steep and dissected by several gullies but the area on the top of the hills is gently undulating.

All watercourses in the area of the mine are first order streams and flow intermittently. They contain salt tolerant vegetation (*[1]*Juncus acutus*) suggesting they receive saline groundwater discharge.

The existing open cut is about 470 m across at its widest point. It is roughly circular and about 120 m deep from the western, highest pit wall. The 1971-76 mine plant and administration buildings were all located to the southeast of the pit, in the area now occupied by Neutrog Australia, a fertilizer manufacturer. An acid leaching mineral extraction plant is presently operating directly to the east of the pit and MacFarlane Hill.

Much of western part of the project area has been cleared for grazing and was previously part of the Paringa Station. A waste-rock dump, from the previous open pit mining operations, is located immediately west of the open pit. It consists of approximately 25 million tonnes of rock and covers an area of approximately 0.36 km^2. This waste-rock dump has a level upper surface and very steep sides. Soil has been placed on the top of the waste dump and revegetated with a variety of local and non-local native trees species. High-density plantations are found on the eastern side. Most of the dump surface is covered by Golden Wattle (*Acacia pycnantha)* bare ground, and grass covers.

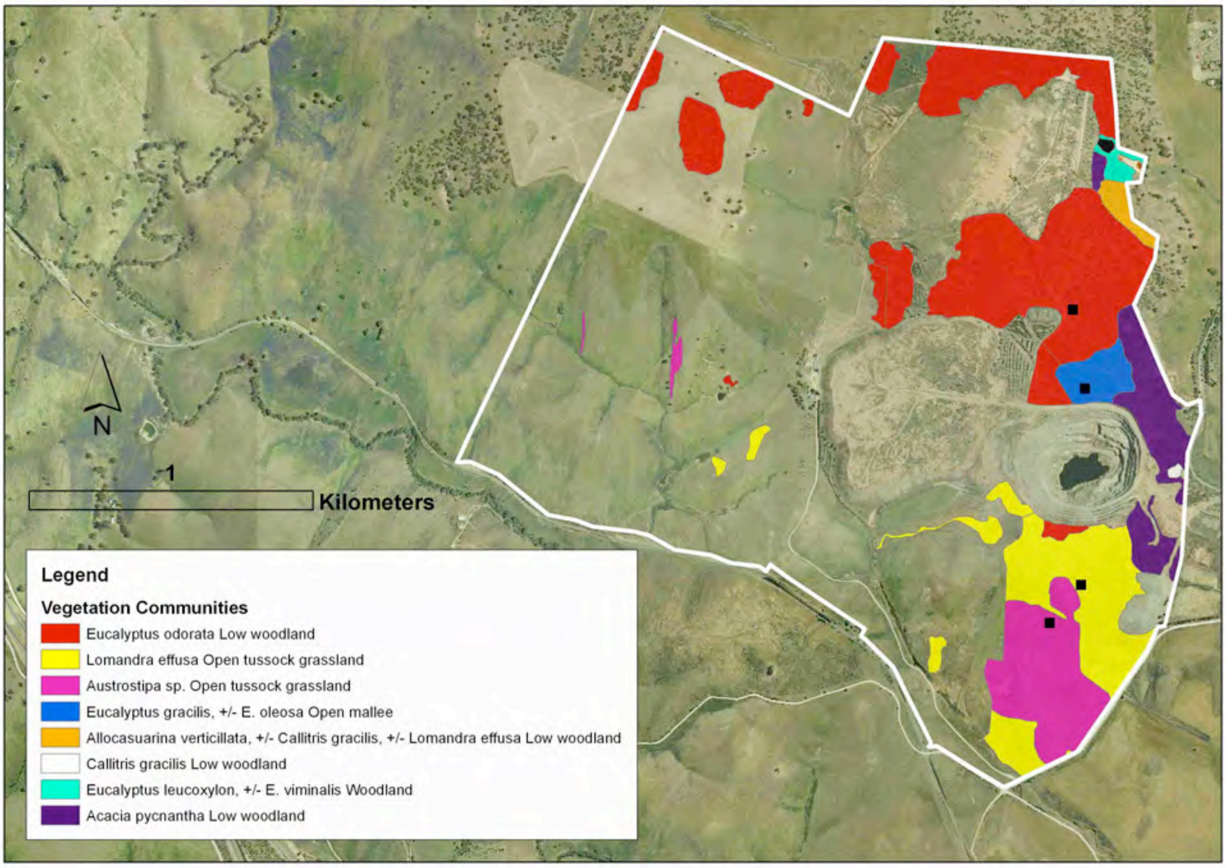
To the north of the waste-rock dump is located the old tailings retention area, covering about 0.35 km^2. This site has also been capped with soil and revegetated with a variety of tree species. It has extensive areas of bare ground and grass across it. In a gully to the east of this tailings area are two dams that retain acid leachate from the tailings. Remnant *Eucalyptus leucoxylon* woodland is found on the slopes around these dams. A **J. acutus* wetland has formed to the west of the tailings area.

A variety of remnant native vegetation communities are found across the eastern half of the site (Figure 1). These habitat types consist of *Eucalyptus odorata* woodlands, *Eucalyptus leucoxylon* woodlands, *Allocasuarina verticillata* woodlands, *Callitris gracilis* woodlands, and mallee woodlands, which extend from the north face of the open pit to the north and west. All habitat remnants vary in quality across the site (Figure 2). To the west between the waste rock dump and the old tailings storage area is a very healthy mature remnant of the *Eucalyptus odorata* woodland. The understorey of other nearby remnants has been heavily grazed and is in poorer condition. The *Eucalyptus odorata* woodland continues to the north of the old tailings storage area, on to a gently rising ridge and to the west of the Kanmantoo township. This area has been grazed and the understorey predominantly comprises introduced grass

[1] Designates introduced flora or fauna throughout the text.

species. The Peppermint Box (*Eucalyptus odorata*) Grassy Woodland is listed as a Critically Endangered Ecological Community under the EPBC Act. *Eucalyptus odorata* Woodland is also recognized as a plant association of high conservation significance in South Australia (Neagle 1995). This plant association occurs only in South Australia (DEH 2005b, a) and is listed as a critically endangered ecosystems of South Australia's agricultural region. The community is of significance in the Kanmantoo region as only 6% of native vegetation remains and only 8% of the Eastern Mount Lofty Ranges Regional Ecological Area is formally protected in NPWSA reserves and Heritage Agreements (Kahrimanis et al. 2001). The largest *Eucalyptus odorata* Woodland remnants occur in the Kanmantoo area between the Princes Highway and the Back Callington Road, west of Mine Road. This includes the remnants within the Kanmantoo mine lease. A third of the *E. odorata* woodlands of high quality within the study region occur within the mine lease (Ecological Associates 2007b).

Figure 1: Kanmantoo Copper Project study area (white line), native vegetation communities (coloured), and vegetation survey quadrats (black squares).



To the south of the open pit, the area is dominated by MacFarlane Hill. MacFarlane Hill extends about 800 m south from the southern rim of the open pit. The hill is quite flat on top but has very steep sides. It has been cleared of trees and shrubs, although Drooping Sheoaks (*Allocasuarina verticillata*) are scattered in places and a number of introduced eucalyptus trees have been planted near the summit. The area has been used for stock grazing. Over parts of this area, generally on the east slope of MacFarlane Hill, there is a community of *Lomandra effusa*, which forms dense tussocks. The Iron Grass (*Lomandra* *effusa*) Natural Temperate Grassland is listed as a Critically Endangered Ecological Community under the EPBC Act. The area of *Lomandra effusa* grassland within the site represents only a small proportion of the high quality *Lomandra* grasslands in the study region (Ecological Associates 2007b). It is of significance as it is one of the few patches that are not grazed. To the west of the saddle there is an *Austrostipa* grassland community.

2.2 Nature and Extent of Mine Project

The proposed works and the quality of vegetation are presented in Figure 2. The quality of vegetation is expressed as Significant Environmental Benefit (SEB) ratios, which represent the area of vegetation that is required to compensate any vegetation clearance. High SEB ratios (e.g. 8:1) reflect high quality vegetation.

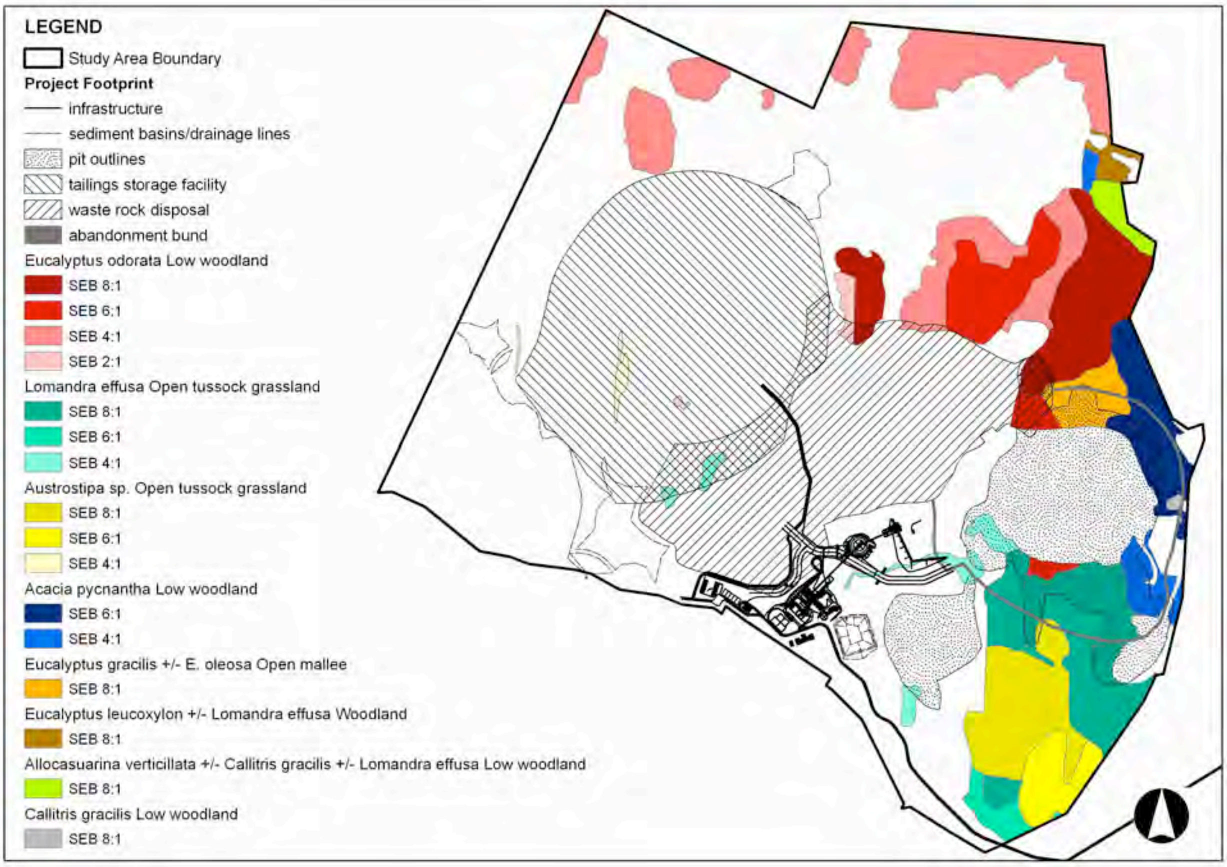


Figure 2: Kanmantoo Copper Project footprint (black-hatched or dappled areas), and Significant Environmental Benefit (SEB) assessment for each native vegetation community.

The project extends the existing open cut mainly to the south and slightly to the north. Two satellite pits may be developed to the north of the existing pit and two to the southwest. The existing waste rock dump will be extended and raised by 20 m and combined with a new tailings storage facility (approximately 1 km external diameter) to the west of the waste rock dump on the Paringa farmland. A new processing plant and equipment area (200 m x 200 m) will be constructed to the south of the existing rock dump on the Paringa farmland.

2.3 Legislative Framework

Primary Industries and Resources South Australia (PIRSA) will assess the Kanmantoo Copper Project (KCP) under the *Mining Act 1971*. The key assessment document under the Mining Act is the Mining Lease Proposal (MLP). The MLP will be placed on public exhibition and referred to relevant State Government agencies for comment. PIRSA will consider available information including the Mining Lease application, the MLP, and submissions on the MLP in making the decision to approve the project, and the establishment of appropriate mining lease conditions. The MLP must identify the potential impacts of a mine development on fauna and identify measures to avoid, minimise or mitigate impacts. The MLP must identify how impacts will be monitored and measures to rehabilitate the mine after closure.

Matters of National Environmental Significance (NES) are identified in the schedules of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Actions that will have, or are likely to have a significant impact on a matter of NES must be referred to the Commonwealth Minister for the Environment.

The South Australian National Parks and Wildlife Act 1972 (NP&W Act) prohibits the taking or disturbance of native animals. The Act provides particular protection to endangered, vulnerable and rare species, which are listed in the schedules of the Act. A permit may be sought from the Minister for the Environment through the Department of Environment and Heritage (DEH) for actions, which affect protected species. The Act does not specify the requirements of a permit, but it is necessary to inform the Department of the species to be affected, how they will be affected, what measures have been taken to avoid disturbance and what amelioration measures have been proposed.

A referral was lodged under the EPBC Act on 26 February 2007 and the DEWR determined on 30 March 2007 that the project is not a controlled action. No further assessment under the EPBC Act is therefore required for the project.

2.4 Existing Data

No fauna survey work has previously been conducted at the site.

Existing records of flora and fauna relevant to the site have previously been reviewed (Parsons Brinckerhoff 2006). This study involved a desktop assessment of potential impacts of the mine on species of state and national conservation significance.

Records of fauna previously observed in the region were extracted from the Biological Survey of South Australia in February 2007. Records for an area of 6 km radius from the site boundary were reviewed to assess the fauna likely to be present in the area. Bird data from this search are presented in Appendix A.

3.1 Introduction

This survey applied the methods of the Biological Survey of South Australia (National Parks and Wildlife SA 2000). The survey was carried out under:

- The Wildlife Ethics Committee Approval of a Project Involving Animals – Application Number 7/2007;
- Permit to Undertake Scientific Research – Permit Number W25407 1; and
- Licence to Use Animals for Teaching, Research or Experimental Purposes – Licence No 202.

3.2 Methods

Trap Lines

One set of traplines was installed within three of the existing flora survey quadrats (Ecological Associates 2007b) (Figure 3):

1. *Eucalyptus odorata* woodland (SW corner: GDA 94 54H 0318112E 6115517S),

2. *Lomandra effusa* grassland (NW corner: GDA 94 54H 0318140E 6114548S), and

3. *Austrostipa* Grassland (NW corner: GDA 94 54H 0318029E 6114414S) previously identified within the Kanmantoo Copper Project area.

Each trap-line consisted of a pit-line (six pitfalls 10 m apart), one Elliot trap-line (15 traps 10 m apart), and two Sherman traps at either end of the line. Traps were installed and opened on Monday 26 February 2007; they were finally cleared, closed and removed on Friday 02 March 2007. Traps were checked in the evening and morning each day.

Roaming Surveys

Two observers carried out roaming surveys for birds of at least two hours total duration each day over three days. Each of the key habitat types was surveyed each day. In addition walks were made through all other habitat types at least once.

Physical Search

Physical searches were conducted on each day with particular emphasis within the three key habitat types and during roaming surveys throughout the area. Physical searches involved the lifting of rocks and logs, looking under bark on tree trunks, digging up burrows and raking of leaf litter. Observations were made of animals active at the time, or for signs of animals, including tracks, scats, scratchings, burrows, and skulls. Active animals were, where possible, hand caught and identified.

Anabat Survey

Two Anabat bat detectors and recorders were installed at the site during the survey. Each recorded bat calls over 4 nights (detectors and recorders were switched off during the day). The first detector was placed for two nights on the saddle between the *Lomandra effusa* grassland and the *Austrostipa* Grassland (GDA 94 54H 0318147E 6114260S). It was then shifted to western edge of the *Austrostipa* Grassland along the rocky outcrop (GDA 94 54H 0317932E 6114338S) for the remaining two nights. A second detector was placed in a flyway within the *Eucalyptus odorata* woodland quadrat (GDA 94 54H 0318116E 6115497S) on all four nights.

Spotlighting

Spotlighting for nocturnal mammals, birds and reptiles was carried out on a warm humid evening (Wed 28/02) between 20:00 and 22:30. Using a portable spotlight, two observers walked a predetermined route along existing tracks. The route followed north from the pit past regrowth areas to the west, through *Eucalyptus odorata* and *Eucalyptus leucoxylon* woodlands, along the eastern edge of the site through *Allocasuarina verticillata* woodlands and *Callitris gracilis* woodlands, and west parallel to the pit through mallee woodlands (Figure 1). All sightings, audible movement and calls were investigated and identified.

Figure 3: Sites of trap-lines A. *Eucalyptus odorata* woodland B. *Austrostipa* grassland C. *Lomandra effusa* grassland.

3.3 Results

Weather

Surveys were carried out over five days (four nights) 26/02/2007 to 02/03/2007. Weather conditions during this period were warm to hot and dry, with overnight dew and fog on Monday 26 February and Wednesday 28 February (Table 1). All days were generally fine and sunny. All traps were checked and cleared each morning between 07:00 and 09:00 and late each afternoon between 17:00 and 19:00. On hot days traps were also checked and cleared in the early afternoon.

Mean annual rainfall at Murray Bridge is 342.4 mm (N = 122years - 1885-2007 BOM 2007). Total rainfall on site in the previous 11-month (23/04/06 – 15/03/07) period was 196 mm. Thus rainfall at the Kanmantoo Copper Mine site was significantly below average over the last year. In the three months prior to the baseline survey total rainfall was 49 mm, well below the rate of evaporative loss. As a consequence of this long, dry period the floral understorey across the survey area had very few annual plants or grasses growing or flowering. Limited flowering was observed in a mallee species and the Harlequin Mistletoe (*Lysiana exocarpi*) was flowering.

Table 1: Weather during survey period. Weather station located on Kanmantoo Project Area, MacFarlane Hill

Date	Daily Temperature (^oC)		Maximum Humidity (%)	Dew Point (^oC)
	Maximum	Minimum		
Monday 26/02/07	24.8	11.2	90	10.9
Tuesday 27/02/07	29.8	12.9	94	12.9
Wednesday 28/02/07	32.8	17.2	66	10.6
Thursday 01/03/07	28.9	15.5	90	13.8
Friday 02/03/07	37.9	17.7	79	11.9

Trap Lines

No native mammals were caught in the trap-lines (Table 2). The House Mouse (**Mus musculus*) was trapped throughout the study area, but was particularly associated with the *Lomandra effusa* grassland. Signs of active burrows beneath *Lomandra* tussocks were evident throughout the *Lomandra* habitat type. Five species of skink entered traps.

Table 2: Trapline Survey (Pitfall Traps, Elliot Traps, and Cage Traps)

Common Name	Scientific Name	Habitat Type: *Eucalyptus odorata* woodland	Habitat Type: *Lomandra effusa* grassland	Habitat Type: *Austrostipa* sp. grassland	Conservation Status: AUS	Conservation Status: SA
House Mouse	**Mus musculus*	1	9	3		
Eastern Spotted Ctenotus	*Ctenotus orientalis*		2			
Eastern Striped Skink	*Ctenotus robustus*	4				
Dwarf Skink	*Menetia greyii*	1	1			
Sleepy Lizard	*Tiliqua rugosa*			2		
Eastern Bluetongue	*Tiliqua scincoides*		1			

Roaming Survey

Two species of Kangaroo were observed across the project area (Table 3). The Western Grey Kangaroo (*Macropus fuliginosus*) was relatively common. Females were all observed with young at feet, but no pouch young were evident. The Euro (*Macropus robustus*) was observed in small numbers. Foxes (**Vulpes vulpes*) and European (Brown) Hares (**Lepus capensis*) were active throughout the day. Signs and observations suggest foxes are relatively common, but European Hares were in low numbers. A number of apparently active, large rabbit warrens were found in the *Austrostipa* grassland, but no rabbits were observed to be associated with these warrens.

Thirty-two bird species were recorded during the survey (Table 4). The highest species diversity was observed in the *Eucalyptus odorata* woodlands (69% of birds observed). This is most likely a product of the relative large area of the woodlands compared with other habitat types surveyed, and the relative high diversity of microhabitats present within this habitat type. The diversity of birds in all other habitat types was markedly lower (Table 4).

Only two introduced bird species were observed. Three separate large flocks (> 100 birds) of the Common Starling (**Sturnus vulgaris*) were associated with the feeding lot near the Paringa farm homestead. A small flock of European Goldfinch were observed foraging on the cones of *Allocasuarina verticillata*.

Table 3: Roaming Survey – Mammals.

Common Name	Scientific Name	Habitat Type									Conservation Status	
		***Eucalyptus odorata* woodland**	***Lomandra effusa* grassland**	***Austrostipa sp.* grassland**	**Mallee Woodland**	***Allocasuarina* Woodland**	**Golden wattle Woodland**	**Rock Outcrop**	**Riparian NE Gully**	**Regrowth**	**AUS**	**SA**
Western Grey Kangaroo	*Macropus fuliginosus*	5, >10								2		
Euro	*Macropus robustus*		1		2							
Fox	**Vulpes vulpes*	2,1			1							
Brown Hare	**Lepus capensis*	1							1	1		

Three of the observed bird species have a significant conservation status. Flocks of up to nine Rainbow Bee-eaters (*Merops ornatus*) were observed feeding and roosting in the *Eucalyptus odorata* woodlands throughout the survey period. These birds are listed as Marine Migratory species under the Japan Australia Migratory Bird Agreement (JAMBA) and are therefore protected under the EPBC Act. A pair of Peregrine Falcons (*Falco peregrinus*) is permanently resident in the area, and nest annually on the rock face of the open cut (pers. com: J. Popow, Hillgrove Resources Ltd. 12/02/2007). These birds are classified as rare species within South Australia under the NP&W Act. Diamond Firetail (*Stagonopleura guttata*. Shaw, 1796) was observed in at least one flock (probably more) on four occasions, feeding on the ground in the *Eucalyptus odorata* woodlands. These birds are classified as vulnerable threatened species within South Australia under the NP&W Act.

No snakes or amphibians were detected. The Eastern Brown Snake (*Pseudonaja textiles*) is reported to be common across the site, and one Red-bellied Black Snake (*Pseudechis porphyriacus*) has been observed within the last year (pers. com: Kanmantoo mine site employees, Hillgrove Resources Ltd. 02/03/2007).

Table 4: Roaming Survey – Birds

Common Name	Scientific Name	Habitat Type										Conservation Status	
		Eucalyptus odorata woodland	Farmland	*Lomandra effusa* grassland	*Austrostipa* sp. grassland	Mallee woodland	*Allocasuarina* woodland	Golden wattle woodland	Rock Outcrop	Riparian NE Gully	Regrowth	AUS	SA
Crested Pigeon	*Ocyphaps lophotes*				2			1			1	`	
Dusky Woodswallow	*Artamus cyanopterus*	4											
Australian Magpie	*Gymnorhina tibicen*	7, >10,5		4	2			5	3	3	4		
Little Raven	*Corvus mellori*	>20	>20					2	2				
White-winged Chough	*Corcorax melanorhamphos*	8, H						H					
Magpie-lark	*Grallina cyanoleuca*		1										
Willie Wagtail	*Rhipidura leucophrys*	1		1					2	1			
Welcome Swallow	*Hirundo neoxena*	2						2	1				
White-plumed Honeyeater	*Lichenostomus penicillatus*	1,1,2				2,1				1	1		
Singing Honeyeater	*Lichenostomus virescens*			2,2		1		3		2			
Noisy Miner	*Manorina melanocephala*									3			
Brown-headed Honeyeater	*Melithreptus brevirostris*	1,2									1		
New Holland Honeyeater	*Phylidonyris novaehollandiae*	2,1		1						2			
Rainbow Bee-eater	*Merops ornatus*	9,4				3						Marine Migratory	

Common Name	Scientific Name	Habitat Type										Conservation Status	
		Eucalyptus odorata woodland	Farmland	*Lomandra effusa* grassland	*Austrostipa* sp. grassland	Mallee woodland	*Allocasuarina* woodland	Golden wattle woodland	Rock Outcrop	Riparian NE Gully	Regrowth	AUS	SA
												(JAMBA)	
Grey Shrike-thrush	*Colluricincla harmonica*	2,			1	2							
Rufous Whistler	*Pachycephala rufiventris*						1						
Striated Pardalote	*Pardalotus striatus*	1,1,1											
Galah	*Cacatua roseicapilla*												
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	2											
Adelaide Rosella	*Platycercus elegans Race adelaide*	2,2,2, 2,2,2			2	1				4,2, 2			
Diamond Firetail	*Stagonopleura guttata*	2,2,7. 5											V
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	>10,5				>10					5		
Yellow Thornbill	*Acanthiza nana*	2				1							
Southern Whiteface	*Aphelocephala leucopsis*					1							
Weebill	*Smicrornis brevirostris*	>10,1 ,1				1,1					1		
European Goldfinch	**Carduelis carduelis*						5						
Common Starling	**Sturnus vulgaris*		>100 >100 >100										
Wedge-tailed Eagle	*Aquila audax*	2,2											

Common Name	Scientific Name	Habitat Type										Conservation Status	
		Eucalyptus odorata woodland	Farmland	*Lomandra effusa* grassland	*Austrostipa* sp. grassland	Mallee woodland	*Allocasuarina* woodland	Golden wattle woodland	Rock Outcrop	Riparian NE Gully	Regrowth	AUS	SA
Black-shouldered Kite	*Elanus axillaris*												
Nankeen Kestrel	*Falco cenchroides*	1									1		
Peregrine Falcon	*Falco peregrinus*	2											R
Australian Owlet-nightjar	*Aegotheles cristatus*	1											
Percentage of all observed species found in each habitat type		**69**	**9**	**13**	**13**	**28**	**6**	**19**	**13**	**22**	**22**		

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)
CE: Critically Endangered threatened species rating – species facing an extremely high risk of extinction in the wild in the immediate future.
E: Endangered threatened species rating – species not critically endangered but facing an extremely high risk of extinction in the wild in the immediate future.
R: South Australian Rare Species (Schedule 9). National Parks and Wildlife Act 1972.
V: Vulnerable threatened species rating; species not critically endangered or endangered but facing a high risk of extinction in the wild in the medium-term future.
Marine: Listed – over-fly marine area – EPBC Act
Migratory: Protected migratory species under the EPBC Act
H: Heard

Physical Search

Eight species of lizards were observed across the area during the physical searches (Table 5). No vertebrate species were located during the litter-raking, log rolling or under bark on trees. No amphibians were detected during the survey. Given the relatively warm and dry conditions this is not unexpected.

The Tawny Dragon (*Ctenophorus decressii*) was common and active, being found associated with rocks, rock falls and rock faces throughout the site.

The four species of skink found all appeared to be relatively common across the site. The Sleepy Lizards (*Tiliqua rugosa*) are generally inactive at this time of the year. Despite this many animals, including both young of the year and juveniles (individuals between 1 and 3 years) were observed. The Sleepy Lizards were in relatively high density in the grassland habitats. The Dwarf Skink (*Menetia greyii*) was relatively common and active throughout the study area. Adults and juveniles of both the Eastern Spotted Ctenotus (*Ctenotus orientalis*) and the Eastern Striped Skink (*Ctenotus robustus*) were observed. The Eastern Spotted Ctenotus was strongly associated with the *Lomandra effusa* Grassland. The Eastern Striped Skink was most frequently observed in the *Eucalyptus odorata* woodlands, but was found in other habitat types.

Table 5: Physical Search – Reptiles and Amphibians

		Habitat Type									Conservation Status	
Common Name	**Scientific Name**	***Eucalyptus odorata* woodland**	***Lomandra effusa* grassland**	***Austrostipa* sp. grassland**	**Mallee Woodland**	***Allocasuarina* Woodland**	**Golden wattle Woodland**	**Rock Outcrop**	**Riparian NE Gully**	**Regrowth**	**AUS**	**SA**
Tawny Dragon	*Ctenophorus decressii*	3				1	3	>5				
Eastern Spotted Ctenotus	*Ctenotus orientalis*		2									
Eastern Striped Skink	*Ctenotus robustus*	2	1									
Dwarf Skink	*Menetia greyii*	3		2								
Sleepy Lizard	*Tiliqua rugosa*	1		6					1			
Adelaide Snake-lizard	*Delma molleri?* (Possibly *D. inornata)*[1]			1								
Thick-tailed Gecko	*Nephrurus milii*		1				1					
Southern Rock Dtella	*Gehyra* sp. '2n=44'							2				

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)

The skin of a Pygoponid or legless lizard was found under a rock in the *Austrostipa* grassland. This animal was from the *Delma* genus (M. Hutchinson, Pers. Com. 02/03/07), and based on locality probably the Adelaide Snake Lizard (*Delma molleri*), but *D. inornata* could not be excluded.

Both the Thick-tailed Gecko (*Nephrurus milii*) and the Southern Rock Della (*Gehyra* sp. '2n=44') were widespread across the area.

Anabat

Anabat detectors recorded seven (possibly eight) bat species over the four nights surveyed (Table 6). Weather conditions during the survey were good for bat activity. Time versus frequency graphs of each of the seven species identified are included in this report under Australasian Bat Society Inc. reporting standards for insectivorous bat surveys using bat detectors (Appendix B). Species composition in the area was typical for the Mount Lofty Ranges, but overall the number of calls recorded per night was low for the region (pers. com. Terry Reardon SA Museum March 2007). None of the species recorded merit a conservation status, as all are common and widespread. The highest diversity of bat species, and largest number of each species recorded, were associated with the *Eucalyptus odorata* woodland. Species known to forage above tree canopies, or in the open (*Tadarida australis*, *Chalinolobus gouldii*, and *Nyctophilus geoffroyi*) were recorded above the *Lomandra effusa* and *Austrostipa* grasslands. Three species (*Chalinolobus morio*, *Vespadelus darlingtoni* and *V. regulus*) that forage in, around, or on tree foliage, or above the shrub layer were only associated with the *Eucalyptus odorata* woodlands. *Mormopterus planiceps* a species that forages high above tree canopies was also recorded in the *Eucalyptus odorata* woodlands. The Little Forest Bat (*Vespadelus vulturnus*) may also be in the area although the analysis was not definitive. All species recorded roost in tree hollows or under bark (Reardon and Bourne 2006).

Table 6: Bats identified from Anabat Recordings (27/02/06 – 02/03/07)

Common Name	Scientific Name	Habitat Type: *Eucalyptus odorata* woodland 27/02	*Eucalyptus odorata* woodland 28/02	*Eucalyptus odorata* woodland 01/03	Ridge between *Lomandra effusa* grassland and *Austrostipa* sp grassland 26/02	Ridge between *Lomandra effusa* grassland and *Austrostipa* sp grassland 27/02	Rock face west of *Austrostipa* sp grassland 28/02	Rock face west of *Austrostipa* sp grassland 01/03	Conservation Status: AUS	Conservation Status: SA
White-striped Freetail-bat	*Tadarida australis*	8	3	9	4	7	6	6		
Southern Freetail-bat	*Mormopterus planiceps*	2	6	1	-	-	1	-		
Gould's Wattled Bat	*Chalinolobus gouldii*	4	1	1	-	1	1	2		
	Mp or *Cg ?*	8	9	14	1	2	10	5		
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	2	5	1	-	1	3	1		
Chocolate Wattled Bat	*Chalinolobus morio*	2	2	1	-	-	-	-		
Large Forest Bat	*Vespadelus darlingtoni*	1	-	1	-	-	-	-		
Southern Forest Bat	*Vespadelus regulus*	?	-	-	-	-	1	-		
	Vd or *Vr*	1	-	-	-	-	-	-		
Little Forest Bat	*Vespadelus vulturnus* or *Vd*	-	-	1	-	-	-	-		
	Bat call not identifiable	1	3	3	-	-	4	3		
	Total calls per night	29	29	32	5	11	26	17		

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)

Spotlighting

On the evening when spotlighting was carried out, conditions for nocturnal animal activity were good, being warm and relatively humid. This needs to be placed in the background context of a dry autumn following a severe drought. Animal activity was relatively low and only four species were recorded (Table 7). No nocturnal birds were heard calling or observed. Some nocturnal lizards were active and heard moving through leaf litter. Two species were caught: the Thick-tailed Gecko and the Southern Rock Dtella. One Rabbit was observed, they were not common across the site. Three Brushtail Possums (*Trichosurus vulpecula*) were each observed foraging in different tree types in the Woodland area. These possums have no national conservation status. Within South Australia Brushtail Possums currently have no conservation rating but have been nominated for listing as rare under the National Parks and Wildlife Act (National Parks and Wildlife Council and Department of Environment and Heritage 2003).

Table 7: Spotlighting Survey

Common Name	Scientific Name	Habitat Type: *Eucalyptus odorata* woodland	Habitat Type: Mallee Woodland	Habitat Type: *Allocasuarina* Woodland	Habitat Type: Golden wattle Woodland	Conservation Status: AUS	Conservation Status: SA
Common Brushtail Possum	*Trichosurus vulpecula*	1	1	1			R*
Rabbit	**Oryctolagus cuniculus*	1					
Thick-tailed Gecko	*Nephrurus milii*			1	1		
Southern Rock Dtella	*Gehyra* sp. '2n=44'	1					

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)
CE: Critically Endangered threatened species rating – species facing an extremely high risk of extinction in the wild in the immediate future
E: Endangered threatened species rating – species not critically endangered but facing an extremely high risk of extinction in the wild in the immediate future
V: Vulnerable threatened species rating; species not critically endangered or endangered but facing a high risk of extinction in the wild in the medium-term future
R: South Australian Rare Species (Schedule 9). National Parks and Wildlife Act 1972.
*: considered potentially vulnerable in Australia (Foulkes and Gillen 2000) and endangered in the Murray Mallee/ Murray Plains Regional Ecological Area (Barratt et al. 1991).

4.1 Regional Perspective

Compared with existing records for the region, the survey reported low species diversity of mammals (15 species - Appendix C), birds (32 species - Appendix C), amphibians and reptiles (no amphibians, nine species of reptile - Appendix D), and low numbers for each species. This would partly reflect that this was a one-off survey, and that more species would be reported from longer-term monitoring. It probably also reflects the low availability of food (seeds, flowers, forage, prey) at the end of summer and the unusually dry period leading up to the survey. A survey in spring would likely report a broader range of fauna.

Neither can the existing DEH fauna records of reptiles, amphibians, and mammals (in particular) within 6 km of the study site be considered as a complete and representative fauna list. All 15 mammals recorded in this survey, excepting the House Mouse (*Mus musculus*), are new records for the area.

Of the mammals observed in this survey, four species were introduced (House Mouse, Fox, Brown Hare and Rabbit). Of these species only the House Mice were present in any significant numbers. Their numbers were moderately high in the *Lomandra effusa* grasslands. Bat species composition in the area was typical for the Mount Lofty Ranges, but overall the number of calls recorded per night was low for the region (pers. com. Terry Reardon, SA Museum, March 2007). One mammal of nominated conservation significance within South Australia – the Brushtail Possum *Trichosurus vulpecula* – was found during this survey.

Of the nine species of reptiles recorded during the survey, only two had been previously recorded in the area (*Ctenotus robustus* and *Gehyra* sp “2n=44”). Five species previously recorded and common to the area were not found (*Christinus marmoratus, Hemiergis decresiensis, Pogona barbarta, Pseudonaja textiles* and *Morethia boulengeri*). A rare species, the carpet python (*Morelia spilota*) is probably locally extinct and was not found. A number of regionally common skinks (eg *Lampropholis guichenoti* and *Lerista bougainvillii*) were not recorded in the area. For a habitat fragment of this size in the southern Mount Lofty Ranges the species count of reptiles in this survey was moderate (Sacchi 2003). Given the dry conditions it is not unexpected that no amphibians were found during this study; a survey during spring would be required to detect these species. No reptiles of conservation significance were found in the Kanmantoo Project Area during this survey.

A comparison between the DEH records of birds within 6 km of the Kanmantoo Project Area boundary and birds detected in this survey (Appendix 3) showed 31 species recorded in the survey out of 109 species previously recorded in the locality, with one new record for the area (Australian Owlet-nightjar, *Aegotheles cristatus*). Of the locally abundant species only 45% (ie 13 out of 29 species) were found on site in the survey (Table 8). Species not observed were mostly insectivorous (10 species), or nectivorous (4 species) in feeding habit. In late summer / autumn most nectivorous birds are highly nomadic, moving to habitats associated with highly productive soils in the Mount Lofty region (Paton et al. 2004).

The DEH database records 13 species of water birds locally. Water quality on site, in the two water bodies presently holding water was, due to low pH, not suitable for water birds. The dry swamp in the NW corner of the study area, and the ephemeral creeks on the farmland may provide suitable habitat for water birds during periods with higher rainfall in winter and spring. Of the locally uncommon species, 27% were observed in the study area.

Table 8: Bird species observed in survey compared with number in DEH records within a 7 km radius of the Kanmantoo Copper Mine.

DEH records	Bird Species	
	Observed in Survey	Not Observed in Survey
Locally "abundant" species (≥ 1% of records*)	13	16
Locally "uncommon" species (< 1% of records)	18	48
Not Recorded	1	Not Applicable
Water Birds	0	13

* Species recorded in ≥ 1% of 2202 records of bird species in DEH records.

The survey reported two birds of conservation significance at the state level:

- a population of Diamond Firetail.
- a breeding pair of Peregrine Falcon.

One species of national conservation significance was also reported: Rainbow Bee-eaters were present in significant numbers.

4.2 Species of Management Concern

*Diamond Firetail (*Stagonopleura guttata*) – Vulnerable in South Australia*

Reasons for listing as vulnerable in SA

The Diamond Firetail is classified as vulnerable because the best available evidence, based on direct observation, indicates there has been a reduction in population size of greater than 50% over the last 10 years or three generations (National Parks and Wildlife Council and Department of Environment and Heritage 2003). The species is therefore considered to be facing a high risk of extinction in the wild.

This species has declined over most of its historical range across south eastern and eastern Australia in both extent and density and is considered to be near-threatened nationally (Garnett and Crawley 2000). In South Australia, where it is classified as vulnerable under the NPW Act, a significant reduction in distribution was recorded between 1974-1975 and 1984-1985 (Paton et al. 1994). This decline has continued and Diamond Firetails are now rarely reported in the western, central and southern Mount Lofty Ranges (Paton et al. 2004). Declines have also been recorded in the Strathalbyn area on the eastern side of the ranges (Eckert 2000).

Factors implicated in the decline of Diamond Firetails include clearing of habitat, nest predation by birds (McGuire and Kleindorfer 2007), predation by cats (Read 1987), and trapping by man (Blakers et al.

1984). Foraging behaviour in general and the loss of native seed species is not considered to be a factor in the decline of Diamond Firetails in the Mount Lofty Ranges in South Australia (Read 1994, Antos and Bennett 2006). Diamond Firetails are sensitive to patch size and quality, with minimum threshold plains grassy woodland patch size being estimated at around 20 ha (Robinson and Howell 2003).

Relevant behavioural ecology

The Diamond Firetail is a type of finch. They live in a wide range of *Eucalyptus* dominated vegetation communities that have a grassy understorey, including woodland, forest and mallee (Antos and Bennett 2006, Higgins et al. 2006). Diamond Firetails are known to use large revegetation patches (eg the Monarto plantations) where they successfully breed and have achieved densities comparable to those using remnant native vegetation patches (Paton et al. 2004).

Diamond Firetails are mainly resident or sedentary throughout their range. Regular short-distance migratory movements are known in western Victoria (O'Gorman 1981) and in South Australia seasonal movements occur (O'Gorman 1981, Higgins et al. 2006). The longest recorded distance moved by an individual bird in the Mount Lofty ranges is 5 km (Paton et al. 2004). Movements away from breeding areas, to over-wintering sites, tend to occur in autumn. In non-breeding season they can form large flocks, usually of up to c. 40 individuals, with many juveniles in the groups (O'Gorman 1981, Higgins et al. 2006). These groups disperse in late winter and early spring, and birds appear singly or in pairs during the breeding season (Higgins et al. 2006).

The diet of Diamond Firetails in the Mount Lofty Ranges consists of predominantly grass seeds (up to 73% of crops, (Read 1994)), but the grass species seed composition changes with season. Diamond Firetails now forage extensively on the seeds of many introduced plants that have colonised much of the range of the finches, and potentially replaced much of the native seed plants (Read 1994). No arthropods were found in their crops. Foraging takes place exclusively on the ground and generally in flocks (Antos and Bennett 2006). Seeds are taken by gleaning from bare ground and foraging in grassy understorey and in ground litter (Antos and Bennett 2006).

Access to free standing water is very important to finches to aid digestion and prevent dehydration as a consequence of the low water content of many seeds. Consumption of green vegetation apparently allows survival for short periods without freestanding water (Read 1994, Higgins et al. 2006).

The monogamous Diamond Firetails breed in simple pairs. Home ranges for a pair vary in size from 2 to 20 ha (Paton et al. 2004). Nesting usually occurs in small loose colonies with multiple nests in one tree (Higgins et al. 2006). Nest site selection varies between areas (McGuire and Kleindorfer 2007), but in some areas a preference is shown for nesting in mistletoe (O'Gorman 1981, Cooney 2005, Cooney et al. 2006). Egg laying occurs between the months of October and November in South Australia (Higgins et al. 2006). Time from egg laying to fledging is approximately 47 days (Higgins et al. 2006).

*Peregrine Falcon (*Falco peregrinus*) – Rare in South Australia*

Reasons for listing

The Peregrine Falcon has a worldwide distribution. It has declined significantly in most countries other than Australia. In Australian the population is substantial, widespread and viable (Olsen and Olsen

1988b). In South Australia it is classified as rare because the resident population is small, with the total population estimated at less than 3000 mature individuals (National Parks and Wildlife Council and Department of Environment and Heritage 2003).

The Peregrine Falcon appears to be a species that has benefited from changes such as partial clearing of woodlands and forests and the building of farm dams (Olsen and Olsen 1988b). Nevertheless, in South Australia the level of pesticide contamination detected in the Peregrine Falcon and the consequent thinning of egg shells was considered sufficient to interfere with this species' reproduction (Olsen and Olsen 1979, Falkenberg et al. 1994).

Relevant behavioural ecology

The Peregrine Falcon uses a traditional nest site or territory, frequently one that has been used over several generations (Olsen and Olsen 1988a). The spacing between these traditional nests is often regular.

In general, for Peregrine Falcon to breed successfully, the minimum basic requirements of adequate prey and suitable nest sites must be present. Populations of most native birds on which the falcon preys have probably declined because of clearing. However this impact is compensated by the availability of suitable introduced bird species (Falkenberg et al. 1994). The main prey species of Peregrine Falcons are the Rock Dove (*Columba livia*), Common Starling (*Sturnus vulgaris*), Silver Gulls (*Larus novaehollandiae*) and Galah (*Cacatua roseicapilla*) (Falkenberg et al. 1994, Emison et al. 1997) which constitute50-75% of their diet.

In a long-term study in Victoria it was found that over half of Peregrine Falcon eyries are on cliffs (51%), 37% are in trees, and the rest (12%) are on human-made structures and quarry faces (Emison et al. 1997). Over half of the quarries with eyries were actively operated when birds were present, often forcing the Peregrine Falcons to select another site in the quarry when a previous eyrie was destroyed (Emison et al. 1997). This suggests that the bird tolerates a degree of noise, vibration and activity associated with quarrying.

*Rainbow Bee-eater (*Merops ornatus*) – EPBC migratory species JAMBA*

Reasons for listing

Rainbow Bee-eaters are listed under the Japan-Australia Migratory Bird Agreement (JAMBA) as they migrate over marine waters during their northern movements in autumn. Inclusion of a species under JAMBA automatically resulted in its listing under the EPBC Act. Despite this automatic listing, at present the Rainbow Bee-eater is not listed as a threatened species within Australia, nor is it considered rare or threatened within South Australia. There is evidence of a five-year decline in numbers in the wheat-sheep belt of New South Wales and Queensland (Olsen et al. 2003).

Impacts on EPBC migratory species are considered significant if they:

- Substantially modify, destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or

- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Relevant behavioural ecology

Rainbow Bee-eaters (*Merops ornatus*) are migratory both within Australia and overseas to islands north of Australia. In the autumn months the Bee-eaters depart southern Australia and are only found in the northern States in the winter months. They migrate annually between Australia and New Guinea (Blakers et al. 1984). During spring and summer they have an Australian wide distribution, but are predominantly found breeding in southern Australia between September and February (Barrett et al. 2003). They are burrow breeders, with nests generally located in vertical banks of soil.

*Brushtail Possum (*Trichosurus vulpecula*) – Nominated for Listing as Rare in South Australia*

Reasons for nomination for listing as rare in SA

The Brushtail Possum has the widest distribution of any Australian mammal, being found across southern, eastern, and northern Australia. Within this distribution it occurs in most areas where there are trees, especially open forests and woodlands (How 1983). Their abundance has declined dramatically throughout much of their range, and they are now considered rare in the arid zone, although in some localities they are very common (Kerle et al. 1992).

Within South Australia Brushtail Possums currently have no conservation rating under the National Parks and Wildlife Act 1972 (Schedule 9) but have been nominated for listing as rare (National Parks and Wildlife Council and Department of Environment and Heritage 2003). They are classified as endangered in the Murray Mallee/ Murray Plains Regional Ecological Area (Barratt et al. 1991). They have no national conservation status, but are considered potentially vulnerable in Australia (Foulkes and Gillen 2000).

Within South Australia they have disappeared from greater than 50% of their former area of occupancy and it is believed that further decline in area is continuing. The have also experienced a greater than 50% reduction in abundance and it is believed this decline is also continuing (NPWC & DEH 2003).

Population decline has been attributed to habitat loss (Kahrimanis et al. 2001), cycles of resource-poor seasons and predation (Kerle et al. 1992). It has been hypothesised that the decline in abundance and distribution arises as a consequence of disturbance of refuge habitat patches critical for the survival of the species. This occurred at the same time as areas of southern Australia experienced below average rainfall. Once the populations were reduced, they fell into a ‘predator-pit’ through depredation by dingoes and introduced predators (eg cats and foxes), and have been unable to increase in numbers even with the advent of improved conditions (Kerle et al. 1992).

Relevant behavioural ecology

Brushtail Possums are nocturnal arboreal marsupials. Home range size varies from 0.7 to 11.3 ha, with the extent of home range overlap being highly variable; some populations are apparently territorial, while others show no evidence of territoriality (Kerle 1998). Brushtail Possum density is typically in the range of 0.4 to 1.4 animals / ha (How 1983).

Brushtail Possums generally live up to 11 years (How 1983). Their major breeding period is in autumn, but they may also breed in spring. The young spend four to five months in the pouch and a further one to two months suckling and on their mother's back prior to dispersal. Dispersal occurs between six and 18 months of age, during which time there is high mortality, particularly in males (How 1983).

In the Mt Lofty Ranges Brushtail Possums prefer habitat dominated by smooth-barked eucalypts (Armstrong et al. 2003). They tend to live in habitat associated with more fertile soils, which produce a variety of more nutritious plant species, and the larger trees (Braithwaite et al. 1984) that provide the large hollows they require for shelter (How and Hillcox 2000, Harper 2005). This preference for woodland vegetation remnants based on more fertile soils, means they are associated with a much-reduced habitat type in the Mount Lofty Ranges (Armstrong et al. 2003).

Brushtail Possums feed mainly on *Eucalyptus* leaves (Dearing and Cork 1999). They can detoxify poisons in the leaves to some extent but cannot cope with an exclusively *Eucalyptus* diet. Compared to other possums the Brushtail Possum has higher nutritional needs, requiring a wider variety of plant species (How 1983). Ground vegetation particularly grasses comprises about 25% of their diet (Kerle 1984).

Brushtail Possums are susceptible to predation from foxes, cats and dingoes when they come to the ground to feed (Jones and Coman 1981, Kerle et al. 1992, Pickett et al. 2005). In areas with high fox density possums reduce the distance travelled on ground and change their foraging habits relative to areas with low fox density (Pickett et al. 2005). Predation of dispersing sub-adults appears to be a major threat (Kahrimanis et al. 2001).

5.1 Approach to Threat Assessment

The threats to fauna associated with the Project are considered in five main categories:

- vegetation clearance;
- noise and vibration;
- dust;
- traffic and activity;
- contaminated surface water storage;

The degree to which these threats do or do not affect the fauna values identified in this report is discussed. Opportunities to minimise these threats are identified.

5.2 Vegetation Clearance

The proposed project involves the clearance of areas of native vegetation in *Eucalyptus odorata* woodland and open mallee, *Lomandra effusa* grassland, *Austrostipa* sp. grassland, *Eucalyptus gracilis* +/- Open mallee and *Acacia pycnantha* Low woodland. The area of vegetation to be cleared on the site is presented in Table 9.

The fauna values of the site are most sensitive to clearance of woodland vegetation. Woodland vegetation supported the highest numbers of species and the highest numbers of individuals. Two species of conservation significance were associated with woodland habitat.

Woodland vegetation also supported the vulnerable (SA) Diamond Firetail. The value of woodland for this species was related to the size, integrity and quality of the habitat component (Table 9). This species depends on grassy woodland vegetation, and this site is one of the largest and best-preserved habitat remnants in the region (Ecological Associates 2007b). The species is vulnerable to a decline in woodland area; with 20 ha reported as the minimum required for species presence.

Brushtail Possum, nominated for listing under the NP&W Act as rare, depends on the diversity of species and habitat complexity in woodlands for sheltering hollows and for food in the form of leaves, flowers invertebrates and carrion. This site is one of the largest and best-preserved habitat remnants in a region where less than 8% of natural habitat remains. Many of the remaining habitat fragments in the region constitute poor habitat because of small size, isolation, shape and understorey grazing.

The project involves the clearance of approximately 13% of *Eucalyptus odorata* Low woodland in either 'very good' or 'good' condition (Table 9) and will reduce the area of good quality vegetation (or better) to 21.5 ha.

The project involves the clearance of 48% of the 'good' quality *Lomandra effusa* grassland habitat. No species of conservation significance were associated with grassland habitat. The cleared area would effectively divide the existing large remnant into two fragments to the east and west of the pit.

Vegetation clearance threatens the fauna values of the site by potentially:

- reducing the extent of good quality habitat below the threshold required to sustain the Diamond Firetail population at the site; and
- reducing the habitat available to Brushtail Possum.

Vegetation clearance will also reduce the availability of habitat for non-threatened fauna but these values are not specifically protected under legislation.

Table 9: Area and conservation significance of surveyed woodland vegetation communities in the Kanmantoo Copper Project. Vegetation condition was reported as a significant environmental benefit (SEB) ratio (DWLBC 2005). Higher SEB ratios indicate better quality habitat.

Vegetation Community	Condition (SEB ratio)	Condition Description	Area (ha) to be cleared*	Area (ha) within project area	% of project area to be cleared
Eucalyptus odorata Low woodland	8:1	Very good condition: little disturbance, all strata present, evidence of overstorey recruitment, large old trees present, high understorey diversity, low weed cover, litter and woody debris cover high.	1.2	14.9	8.3%
	6:1	Good condition: some disturbance (grazing, weed invasion, tracks, timber getting), at least strata depleted in cover, limited overstorey recruitment, large old trees present, high to moderate understorey diversity, low to moderate weed cover, litter and woody debris cover high to moderate.	2.0	9.7	20.9%
	4:1	Moderate condition: considerable disturbance (extended grazing), at least one strata absent, no evidence of overstorey recruitment, moderate to low understorey diversity, moderate to high weed cover, litter and woody debris cover moderate to low.	0.3	28.5	1.1%
	2:1	Poor condition: high disturbance (extended grazing), at least one strata absent, no evidence of overstorey recruitment, very low understorey diversity, high weed cover, litter and woody debris cover low to absent.	0.3	1.0	35.5%
Lomandra effusa ± Heliochrysum leucopsideum Open tussock grassland	8:1	Very good condition: little disturbance, all strata present, native diversity high, weed cover low, litter cover high.	9.6	17.8	53.9%
	6:1	Good condition: some disturbance (grazing, weed invasion), all strata present, high to moderate density of tussocks, native diversity high to moderate, weed cover moderate, litter cover variable.	0.0	2.1	0.0%

Vegetation Community	Condition (SEB ratio)	Condition Description	Area (ha) to be cleared*	Area (ha) within project area	% of project area to be cleared
	4:1	Moderate condition: considerable disturbance (extended grazing, tracks, weed invasion), one strata depleted, native diversity moderate to low, weed cover moderate to high, litter cover moderate to low.	2.5	3.5	72.4%
Austrostipa sp. Open tussock grassland	8:1	Very good condition: little disturbance, all strata intact, high density of tussocks, native diversity high, weed cover low, litter cover high to moderate.	0.2	11.6	1.8%
	6:1	Good condition: some disturbance (grazing, weed invasion), all strata present, high to moderate density of tussocks, native diversity high to moderate, weed cover moderate, litter cover variable.	0.0	4.7	0.0%
	4:1	Moderate condition: considerable disturbance (extended grazing, weed invasion), all strata present but depleted in cover, moderate to low density of tussocks, native diversity moderate to low, weed cover moderate to high, litter cover moderate to low.	0.6	0.7	86.7%
Eucalyptus gracilis ± E. oleosa Open mallee	8:1	Very good condition: little disturbance, all strata intact, evidence of overstorey recruitment, high understorey diversity, weed cover low, litter and woody debris cover high.	2.8	4.0	69.8%
Acacia pycnantha Low woodland	6:1	Good condition: some disturbance (past clearance, weed invasion, tracks), overstorey depleted, high understorey diversity, weed cover low to moderate, litter and woody debris cover high to moderate.	4.3	7.7	55.3%
	4:1	Moderate condition: considerable disturbance (past clearance, weed invasion, tracks), overstorey depleted, moderate understorey diversity, weed cover moderate to high, litter and woody debris moderate to low.	2.6	3.5	73.3%
Scattered Trees	n/a	See Appendix D	56 trees	not assessed	

* Calculations of areas to be cleared provided by Coffee Natural Systems

Threats associated with vegetation clearance may be minimised by:

- minimising where possible the extent of clearance in woodland vegetation, particularly in 'good' and 'very good' quality vegetation; and

- consolidating areas to be cleared so that large blocks, rather than small fragments, are preserved.

It may be possible to mitigate the impacts on fauna by providing or protecting alternative habitat elsewhere. This could include improving the quality of remnants in 'moderate' or 'poor' quality elsewhere on the site so that they are equivalent, or better, than the quality and extent of habitat that is cleared. This could involve:

- weed control;
- stock removal; and
- revegetation to enhance, extend and connect remnants.

However, it is possible that the habitat improvements associated with these measures will develop after the impacts of the project take place, so it is recommended that work of this type start as early as possible.

5.3 Noise and Vibration

Noise and vibrations generated by the project present a threat to fauna values on the site. Vehicle traffic, blasting and excavations, and ore processing may generate the noise and vibrations.

High noise levels are known to decrease species diversity, numbers, and breeding success in the vicinity of the noise, in both mammals and birds (Forman and Alexander 1998, Habib et al. 2007). The noise level at which population densities of all woodland birds begin to decline is around 42 decibels on average (Forman and Alexander 1998). Many possible reasons are proposed for the effects of traffic noise on birds. Likely hypotheses include hearing loss, increase in stress hormones, altered behaviours, interference with communication during breeding activities, differential sensitivity to different frequencies, deleterious effects on food supply or other habitat parameters (Forman and Alexander 1998), and predator avoidance communication during nesting and fledging phase (Forman et al. 2002). Birds with higher pitched songs are less susceptible to the effect of noise pollution than those with lower pitched songs (Rheindt 2003), suggesting that acoustic masking is one of the mechanisms by which noise negatively affects passerine density. The impact of vibrations and noise can be subtle to the extent that vibrations associated with traffic effect the emergence of earth worms from soil and in turn reduce the abundance of birds found feeding on them (Forman and Alexander 1998).

As noise levels within a habitat component increase above critical minimums, both the number of species and the population of each species present in the fragment will decrease. The louder the noise, and the longer the duration of the noise, the greater the impact on species present in the area. For a social species like the Diamond Firetail, which uses a variety of contact and predator avoidance calls, research indicates that the consequences of prolonged and loud noise (to the extent that it prevents effective communication among group members) are reduced breeding success and higher predation levels (Forman and Alexander 1998). Both of these outcomes would reduce population levels of the Diamond Firetail within the Project Area.

The threat associated with noise and vibration is therefore difficult to define without information on the noise and vibrations generated and the tolerance of species on the site. The literature suggests that the Diamond Firetail could be affected if noise interferes with their calls.

Measures to minimise this threat can be incorporated into the project design. These include:

- minimising noise levels within all high quality habitat;
- locating excavations as far from high-value habitat as possible;
- locating roadways as far from high-value habitat as possible;
- limiting the number and extent of roads constructed; and
- regulating traffic volume.

5.4 Dust

Excavations and traffic will potentially increase dust loads to native vegetation. Dust can contaminate forage and reduce rates of photosynthesis with negative consequences for productivity and biomass in the area affected.

Dust impacts can be minimised by:

- controlling dust production in the excavation works; and
- controlling dust during processing and transportation of material.

5.5 Traffic and Activity

Roads function as barriers for the movement and dispersal of many species, with roads as narrow as 2.5 m acting as barriers for insects and spiders (Forman and Alexander 1998). Roads and associated traffic impact on fauna through roadkill, vehicle disturbance and road avoidance, barrier effects and habitat fragmentation. For bird populations exposed to traffic, numbers may be lower, animal density may be lower, and the extent of breeding may be reduced (Forman et al. 2002). The effect increases with increased traffic volume (Forman et al. 2002). The barrier effect tends to create metapopulations, where large populations are split into smaller, partially isolated populations. Small populations fluctuate more widely over time and have a higher probability of extinction than do larger populations.

Raptor behaviour is impacted by traffic levels on roads (Bautista et al. 2004) with birds decreasing activity in the area of roads as traffic activity increases.

Depending on intensity, traffic and activity may disrupt fauna directly, indirectly or not at all. Direct impacts may occur where intense activity and noise disrupts feeding, calling and other activities and where fauna are discouraged from using otherwise suitable habitat. Indirect impacts may result from declining food availability. This threat potentially significantly affects fauna, particularly Diamond Firetail, and should be minimised.

The threat to fauna associated with roads and traffic can be minimised by:

- locating roads as far from high-value habitat as possible;
- minimising noise levels within all high quality habitat;
- limiting the extent of roads within the site; and

- monitoring and managing weed threats.

5.6 Attraction of Water Birds to Contaminated Water

The project potentially involves the storage of contaminated surface water on the site in a tailings storage facility. The expected chemical composition of the water is not known, but may present a threat to fauna if it has high concentrations of heavy metals, low or high pH or other contaminants. Waterbirds, which are attracted to open water, are particularly at risk.

Low or high pH can have immediate effects on the mucosal membranes, skin or feathers of the birds. Exposure to heavy metals such as copper can have short-term toxic effects on the individual animal or longer term effects on the individual and its progeny (Kertesz et al. 2006) resulting in premature mortality or teratogenicity.

The site is not an important waterbird habitat and the risk associated with this threat is expected to be low. However, the site is located near the Lower Lakes and Coorong Ramsar Site, which supports high numbers of waterbirds. Furthermore, many waterbirds visit waterbodies opportunistically and the possibility of exposure remains even in isolated sites. The level of risk also depends on the nature of the contamination and this is not known at this stage.

The threat associated with contaminated surface water can be minimised by:

- minimising the area of any uncovered contaminated water storage;
- minimising the concentration of hazardous chemicals in a contaminated water storage;
- placing passive deterrent devices (eg raptor silhouettes, plastic models of birds taking of) over or near to the water body; and
- periodic broadcast of taped alarm calls.

5.7 Summary of Threats to Species of Conservation Significance

Diamond Firetail

As a consequence of the dry conditions over the last year, the Diamond Firetail population has declined to low levels in the Mount Lofty Region (pers. com. Dr David Paton, The University of Adelaide, March 2007). Diamond Firetail presence, under such conditions, suggests the grassy woodlands at Kanmantoo Copper Project Area constitute a refuge for the species. This species depends on grassy woodlands, of which the *Eucalyptus odorata* at the site is one of the best-preserved remnants in the region (Ecological Associates 2007b). The proposed mining development may significantly impact on this population at the local and possibly regional level.

Peregrine Falcon

The Peregrine Falcon is naturally found in low densities throughout its distribution. The birds tolerance of mining activity, ability to shift to new prey species and the low number of individuals directly impacted on, suggests that it is unlikely that the mine development will significantly affect the size or population viability of this species nationally or at the state level. At the local level it may result in the pair relocating their nest site within the open cut or to a new locality.

Rainbow Bee-eater

Given the status of the population in South Australia, this project cannot be predicted to significantly affect the size or viability of the Rainbow Bee-eater population in South Australia or nationally. However, it may impact on species presence and habitat use at the local level. Rainbow Bee-eaters may breed in sandy banks in the area, and prior to their annual northerly migration, the local population may use the woodlands within the site as feeding grounds to build up fat reserves.

Brushtail Possum

Brushtail Possums prefer vegetation remnants based on more fertile soils. In the study area these fertile soils have been favoured and preferentially cleared by European settlers (Armstrong et al. 2003), and are associated with woodland, a much reduced habitat type in the Eastern Mount Lofty Ranges Ecological Area (Kahrimanis et al. 2001). In the Murray Darling Basin the loss of food trees, hollow trees and hollow branches is reducing the area of habitat available to this species and concomitantly increasing the competition among species that require similar habitat resources (Kahrimanis et al. 2001). This loss of habitat, in combination with high predation pressures, may be underlying the continuing decline of this species in South Australia.

The possible loss and degradation of Brushtail Possum habitat, in the context of a relatively large and species rich floral habitat fragment, may significantly impact on the Brushtail Possum population at the local level, and possibly contribute to the ongoing decline in population size at the regional level.

6.1 Diamond Firetail Investigations

This report identifies that the project may represent a significant threat to Diamond Firetail. Further investigations are required to better define this threat and to identify viable measures to minimise or mitigate impacts, if necessary.

Firstly, it is necessary to better assess the population in the Kanmantoo Project area in relation to other habitat in the region. It is recommended that other suitable habitat in the western slopes of the Southern Mount Lofty Ranges be surveyed to report the distribution of Diamond Firetail. This study would indicate whether the population at the mine site is a significant or insignificant proportion of the regional population.

Secondly, it is necessary to describe the status of the Diamond Firetail population in the Kanmantoo Copper Project area. In this study the size of the population and the size and number of flocks could not be determined. A reliable description of the population is recommended to quantify and monitor the magnitude of any impacts. A capture / mark / release program is recommended. Birds would be captured at focal points such as drinking sites or feeding areas using mist nets, banded to allow permanent identification, and then released. Birds would later be captured or observed and the proportion of banded birds caught would be used to estimate the population size.

On the completion of these studies, it is recommended that a detailed harm minimisation and mitigation plan is developed. This could involve operational guidelines for the mine or rehabilitation or protection of habitat elsewhere. Suitable alternative habitat would be identified from the proposed survey of habitat in the western Mount Lofty Ranges and from Ecological Associates (2007b). The plan would establish targets for the performance of the species and would set out how these targets would be monitored and reported.

The objectives and methodologies of these investigations should be established in consultation with representatives of the Department of Environment and Heritage.

6.2 Spring Survey

The results of this survey are likely to have been affected by the preceding dry conditions. This survey was conducted at the end of summer and after a 12-month period with below average rainfall. Under these conditions, food availability (including seeds, insects, flowers, nectar, forage) would have been particularly low and would have resulted in fewer species and individuals being observed than in more favourable conditions.

It is recommended that the survey be repeated in spring when a more representative sample of the site fauna will be evident.

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Appendix A
Bird Observations from the Biological Survey of SA

DEH records of birds within 6 km of the Kanmantoo Copper Mine area boundary

SPECIES	COMNAME	DEH Total Records	Percent of Observations	Ecol Assoc Survey
Corvus sp.		8	0.36	
Tachybaptus novaehollandiae	Australasian Grebe, (Little Grebe)	5	0.23	
Falco longipennis	Australian Hobby	2	0.09	
Gymnorhina tibicen	Australian Magpie	142	6.45	O
Aegotheles cristatus	Australian Owlet-nightjar	0	0.00	O
Corvus coronoides	Australian Raven	2	0.09	
Chenonetta jubata	Australian Wood Duck, (Maned Duck)	11	0.50	
Tyto alba	Barn Owl	2	0.09	
Falco subniger	Black Falcon	1	0.05	
Coracina novaehollandiae	Black-faced Cuckoo-shrike	29	1.32	
Elanus axillaris	Black-shouldered Kite	9	0.41	O
Falco berigora	Brown Falcon	3	0.14	
Accipiter fasciatus	Brown Goshawk	3	0.14	
Cincloramphus cruralis	Brown Songlark	1	0.05	
Climacteris picumnus	Brown Treecreeper	8	0.36	
Melithreptus brevirostris	Brown-headed Honeyeater	6	0.27	O
Melopsittacus undulatus	Budgerigar	1	0.05	
Acanthiza reguloides	Buff-rumped Thornbill	23	1.04	
Scythrops novaehollandiae	Channel-billed Cuckoo	1	0.05	
Acrocephalus stentoreus	Clamorous Reedwarbler	2	0.09	
Nymphicus hollandicus	Cockatiel	1	0.05	
Accipiter cirrhocephalus	Collared Sparrowhawk	1	0.05	
Phaps chalcoptera	Common Bronzewing	3	0.14	
Sturnus vulgaris	Common Starling	62	2.82	O
Phylidonyris pyrrhoptera	Crescent Honeyeater	4	0.18	
Oreoica gutturalis	Crested Bellbird	1	0.05	
Ocyphaps lophotes	Crested Pigeon	34	1.54	O
Platycercus elegans	Crimson Rosella	198	8.99	O
Stagonopleura guttata	Diamond Firetail	8	0.36	O
Gallinula tenebrosa	Dusky Moorhen	4	0.18	
Artamus cyanopterus	Dusky Woodswallow	13	0.59	O
Acanthorhynchus tenuirostris	Eastern Spinebill	19	0.86	
Turdus merula	Eurasian Blackbird	39	1.77	
Fulica atra	Eurasian Coot	5	0.23	
Alauda arvensis	Eurasian Skylark	2	0.09	
Carduelis carduelis	European Goldfinch	12	0.54	O
Petrochelidon ariel	Fairy Martin	3	0.14	
Cacomantis flabelliformis	Fan-tailed Cuckoo	2	0.09	
Cacatua roseicapilla	Galah	85	3.86	O
Pachycephala pectoralis	Golden Whistler	27	1.23	
Phalacrocorax carbo	Great Cormorant	2	0.09	
Strepera versicolor	Grey Currawong	28	1.27	
Rhipidura albiscapa	Grey Fantail	61	2.77	
Colluricincla harmonica	Grey Shrike-thrush	40	1.82	O
Aythya australis	Hardhead (White-eyed Duck)	1	0.05	
Poliocephalus poliocephalus	Hoary-headed Grebe	1	0.05	
Chrysococcyx basalis	Horsfield's Bronze-cuckoo	3	0.14	
Mirafra javanica	Horsfield's Bushlark	1	0.05	
Passer domesticus	House Sparrow	36	1.63	

Appendix A
Bird Observations from the Biological Survey of SA

SPECIES	COMNAME	DEH Total Records	Percent of Observations	Ecol Assoc Survey
Microeca fascinans	Jacky Winter	1	0.05	
Dacelo novaeguineae	Laughing Kookaburra	10	0.45	
Cacatua sanguinea	Little Corella	4	0.18	
Phalacrocorax melanoleucos	Little Pied Cormorant	2	0.09	
Corvus mellori	Little Raven	63	2.86	O
Anthochaera chrysoptera	Little Wattlebird	1	0.05	
Grallina cyanoleuca	Magpie-lark	27	1.23	O
Vanellus miles	Masked Lapwing	1	0.05	
Dicaeum hirundinaceum	Mistletoebird	2	0.09	
Glossopsitta concinna	Musk Lorikeet	42	1.91	
Falco cenchroides	Nankeen Kestrel	10	0.45	O
Phylidonyris novaehollandiae	New Holland Honeyeater	97	4.41	O
Manorina melanocephala	Noisy Miner	9	0.41	O
Anas superciliosa	Pacific Black Duck	4	0.18	
Geopelia placida	Peaceful Dove	4	0.18	
Falco peregrinus	Peregrine Falcon	4	0.18	O
Phalacrocorax varius	Pied Cormorant	1	0.05	
Porphyrio porphyrio	Purple Swamphen	1	0.05	
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	6	0.27	O
Merops ornatus	Rainbow Bee-eater	4	0.18	O
Trichoglossus haematodus	Rainbow Lorikeet	9	0.41	
Anthochaera carunculata	Red Wattlebird	81	3.68	
Neochmia temporalis	Red-browed Finch	20	0.91	
Petroica goodenovii	Red-capped Robin	1	0.05	
Psephotus haematonotus	Red-rumped Parrot	23	1.04	
Myiagra inquieta	Restless Flycatcher	2	0.09	
Anthus novaeseelandiae	Richard's Pipit	5	0.23	
Columba livia	Rock Dove	9	0.41	
Cincloramphus mathewsi	Rufous Songlark	3	0.14	
Pachycephala rufiventris	Rufous Whistler	5	0.23	O
Zosterops lateralis	Silvereye	6	0.27	
Lichenostomus virescens	Singing Honeyeater	13	0.59	O
Aphelocephala leucopsis	Southern Whiteface	3	0.14	O
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	2	0.09	
Circus assimilis	Spotted Harrier	1	0.05	
Pardalotus punctatus	Spotted Pardalote	3	0.14	
Streptopelia chinensis	Spotted Turtle-dove	4	0.18	
Pardalotus striatus	Striated Pardalote	116	5.27	O
Acanthiza lineata	Striated Thornbill	53	2.41	
Coturnix pectoralis	Stubble Quail	1	0.05	
Cacatua galerita	Sulphur-crested Cockatoo	23	1.04	
Malurus cyaneus	Superb Fairy-wren	133	6.04	
Petrochelidon nigricans	Tree Martin	41	1.86	
Daphoenositta chrysoptera	Varied Sittella	4	0.18	
Malurus lamberti	Variegated Fairy-wren	1	0.05	
Aquila audax	Wedge-tailed Eagle	4	0.18	O
Smicrornis brevirostris	Weebill	4	0.18	O
Hirundo neoxena	Welcome Swallow	28	1.27	O
Cheramoeca leucosternus	White-backed Swallow	1	0.05	
Pomatostomus superciliosus	White-browed Babbler	15	0.68	
Egretta novaehollandiae	White-faced Heron	5	0.23	
Epthianura albifrons	White-fronted Chat	1	0.05	

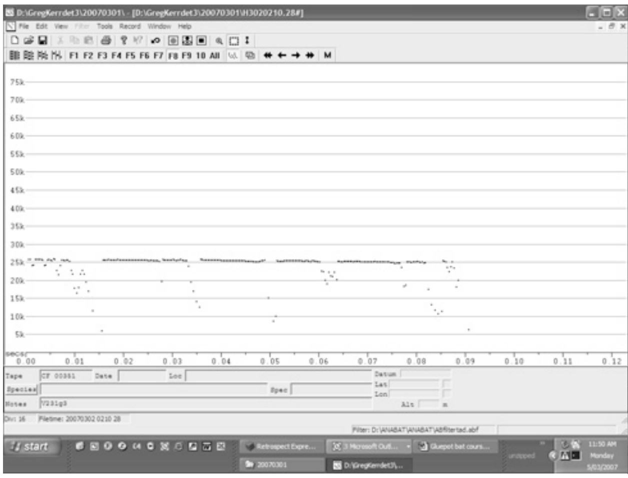
Appendix A
Bird Observations from the Biological Survey of SA

SPECIES	COMNAME	DEH Total Records	Percent of Observations	Ecol Assoc Survey
Melithreptus lunatus	White-naped Honeyeater	29	1.32	
Lichenostomus penicillatus	White-plumed Honeyeater	73	3.32	O
Cormobates leucophaeus	White-throated Treecreeper	2	0.09	
Corcorax melanorhamphos	White-winged Chough	6	0.27	O
Rhipidura leucophrys	Willie Wagtail	60	2.72	O
Acanthiza nana	Yellow Thornbill	17	0.77	O
Lichenostomus chrysops	Yellow-faced Honeyeater	101	4.59	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	45	2.04	O
Taeniopygia guttata	Zebra Finch	1	0.05	
Grand Total		2202	100.00	

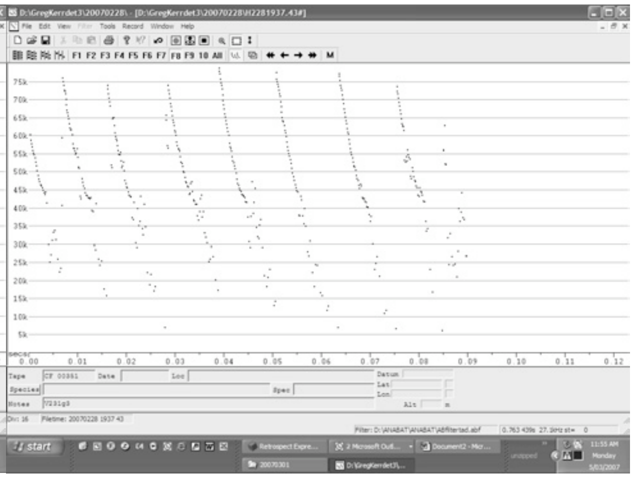
Appendix B
Bat species call identification graphs

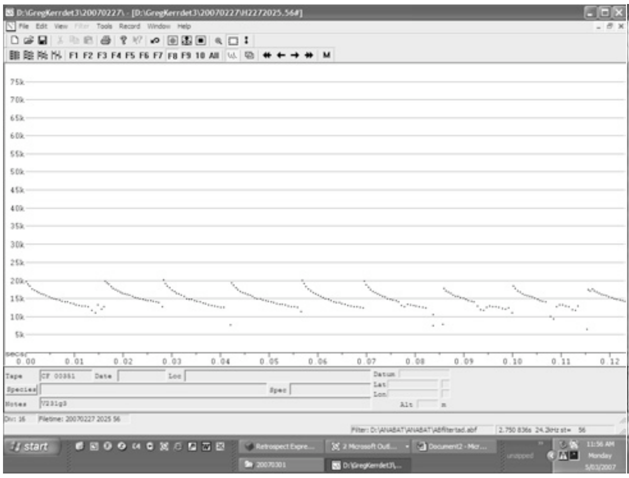
The Australasian Bat Society Inc. reporting standards for insectivorous bat surveys using bat detectors require a sample ‘time versus frequency’ graph of each species identified during the survey to be included in the final report. These graphs must be of bats recorded and identified during the survey. Graphs of each of the seven species identified are presented below:

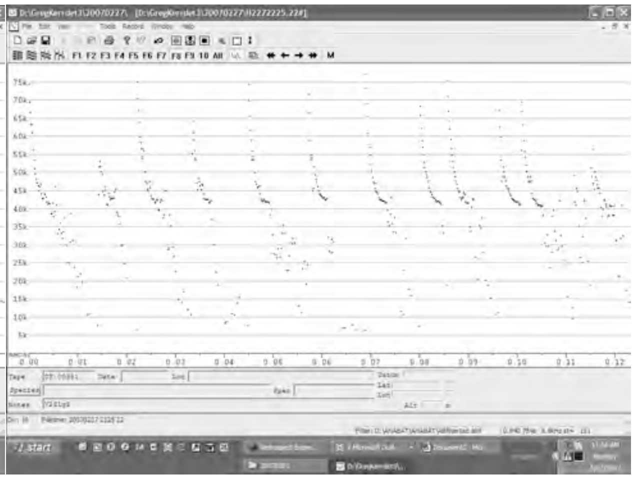
Mormopterus planiceps



Nyctophilus geoffroyi

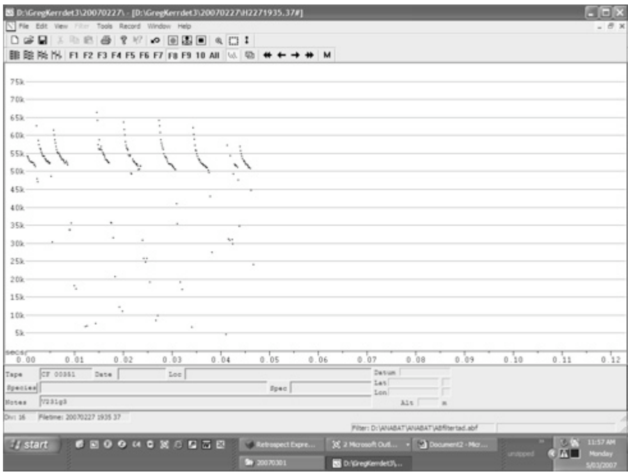




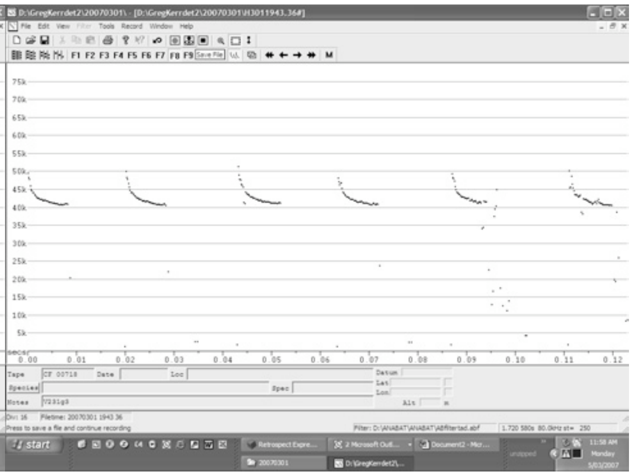


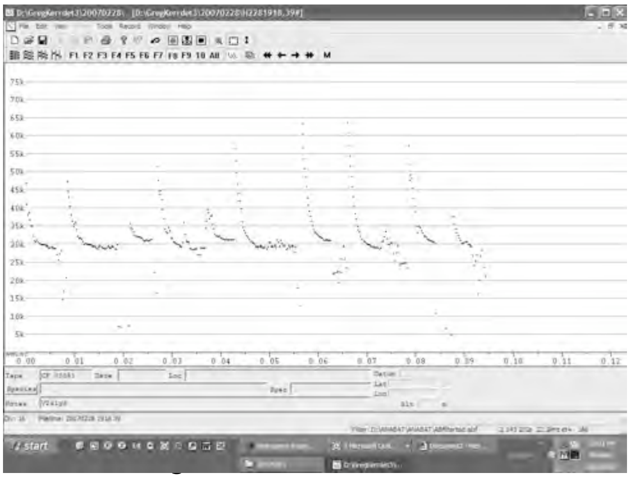
Appendix B
Bat species call identification graphs

Chalinolobus morio



Vespadelus darlingtoni





Appendix C
Mammals

Family	Common Name	Scientific Name	Habitat Type									Conservation Status	
			Eucalyptus odorata woodland	*Lomandra effusa* grassland	*Austrostipa* sp. grassland	Mallee Woodland	*Allocasuarina* Woodland	Golden wattle Woodland	Rock Outcrop	Riparian NE Gully	Regrowth	AUS	SA
MACROPODIDAE	Western Grey Kangaroo	*Macropus fuliginosus*	5, >10								2		
MACROPODIDAE	Euro	*Macropus robustus*		1		2							
PHALANGERIDAE	Common Brushtail Possum	*Trichosurus vulpecula*	2			1							
CANIDAE	Fox	**Vulpes vulpes*	2,1			1							
MURIDAE Murinae	House Mouse	**Mus musculus*	1	9	3								
LEPORIDAE	Rabbit	**Oryctolagus cuniculus*	1										
LEPORIDAE	Brown Hare	**Lepus capensis*	1							1	1		
MOLOSSIDAE	White-striped Freetail-bat	*Tadarida australis*	20	11	12								
MOLOSSIDAE	Southern Freetail-bat	*Mormopterus planiceps*	9		1								
VESPERTILIONIDAE Vespertilioninae	Gould's Wattled Bat	*Chalinolobus gouldii*	6	1	3								
VESPERTILIONIDAE Nyctophilinae	Lesser Long-eared Bat	*Nyctophilus geoffroyi*	8	1	4								
VESPERTILIONIDAE Vespertilioninae	Chocolate Wattled Bat	*Chalinolobus morio*	5										
VESPERTILIONIDAE Vespertilioninae	Large Forest Bat	*Vespadelus darlingtoni*	2										
VESPERTILIONIDAE Vespertilioninae	Southern Forest Bat	*Vespadelus regulus*			1								
VESPERTILIONIDAE Vespertilioninae	Little Forest Bat	*Vespadelus vulturnus or Vd*	1?										

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)
CE: Critically Endangered threatened species rating – species facing an extremely high risk of extinction in the wild in the immediate future
E: Endangered threatened species rating – species not critically endangered but facing an extremely high risk of extinction in the wild in the immediate future
V: Vulnerable threatened species rating; species not critically endangered or endangered but facing a high risk of extinction in the wild in the medium-term future

Appendix D
Reptile

Family	Common Name	Scientific Name	Habitat Type									Conservation Status	
			Eucalyptus odorata woodland	*Lomandra effusa* grassland	*Austrostipa* sp. grassland	Mallee Woodland	*Allocasuarina* Woodland	Golden wattle Woodland	Rock Outcrop	Riparian NE Gully	Regrowth	AUS	SA
AGAMIDAE	Tawny Dragon	*Ctenophorus decressii*	3					3	>5				
SCINCIDAE	Eastern Spotted Ctenotus	*Ctenotus orientalis*		2									
SCINCIDAE	Eastern Striped Skink	*Ctenotus robustus*	3	1									
SCINCIDAE	Dwarf Skink	*Menetia greyii*	3	1	2								
SCINCIDAE	Sleepy Lizard	*Tiliqua rugosa*	1		6				2	1			
SCINCIDAE	Eastern Bluetongue	*Tiliqua scincoides*	1										
GEKKONIDAE Pygopodinae	Adelaide Snake-lizard	*Delma molleri?* (Possibly *D. inornata*)[1]			1								
GEKKONIDAE Diplodactylinae	Thick-tailed Gecko	*Nephrurus milii*	2	1				1					
GEKKONIDAE Gekkoninae	Southern Rock Dtella	*Gehyra* sp. '2n=44'	1						2				

AUS: National Conservation rating (EPBC Act)
SA: State Conservation rating (NPW Act)
CE: Critically Endangered threatened species rating – species facing an extremely high risk of extinction in the wild in the immediate future
E: Endangered threatened species rating – species not critically endangered but facing an extremely high risk of extinction in the wild in the immediate future
V: Vulnerable threatened species rating; species not critically endangered or endangered but facing a high risk of extinction in the wild in the medium-term future
1: Identification made from skin cast. Based on location probably *Delma molleri*, but *Delma inornata* cannot be excluded

Appendix 5B

Spring Fauna Survey

Kanmantoo Copper Project:
Spring Fauna Survey
Final Report

Coffey Natural Systems

2-3 Greenhill Rd
Wayville SA 5034

November 2007

ECOLOGICAL ASSOCIATES REPORT DE009-B1

Contents

Figures, Tables & Appendices

Figures

Tables

Appendices

1.1 Introduction

Coffey Natural Systems, on behalf of Hillgrove Resources Limited (HRL), engaged Ecological Associates Pty Ltd to carry out a spring fauna survey during September 2007, to update the findings of the Baseline Fauna Survey in February 2007, conducted for the proposed redevelopment and expansion of the Kanmantoo Copper Mine (‘the project’).

1.2 Background

Ecological Associates undertook a Fauna Baseline Survey and Impact Assessment of the proposed redevelopment and expansion of the Kanmantoo Copper Mine in February 2007. This survey was conducted at the end of summer and after a 12-month period with below average rainfall. Under these conditions, food availability (including seeds, insects, flowers, nectar, forage) would have been particularly low and would have resulted in fewer species and individuals being observed than in more favourable conditions.

The Fauna Baseline Survey and Impact Assessment recommended that the survey be repeated in spring when a more representative sample of the site fauna would be evident (Ecological Associates, 2007).

1.3 Objectives

The purpose of the project was to survey the fauna for the Kanmantoo Copper Project Mining Lease Proposal (MLP) in spring 2007. The scope of work was as follows.

- Survey the study area to describe the fauna species (including introduced species) and habitat types with a particular focus on species and communities of conservation significance (ie local, regional, state or national).
- Place the species and habitats present in the study area in a regional context.

1.4 Study Area

The Kanmantoo Copper Mine Project is located in the Eastern Mount Lofty Ranges Ecological Area near the western boundary of the South Australian Murray Darling Basin (Kahrimanis et al. 2001). The project is to be developed within an area of 439 ha (Figure 1).

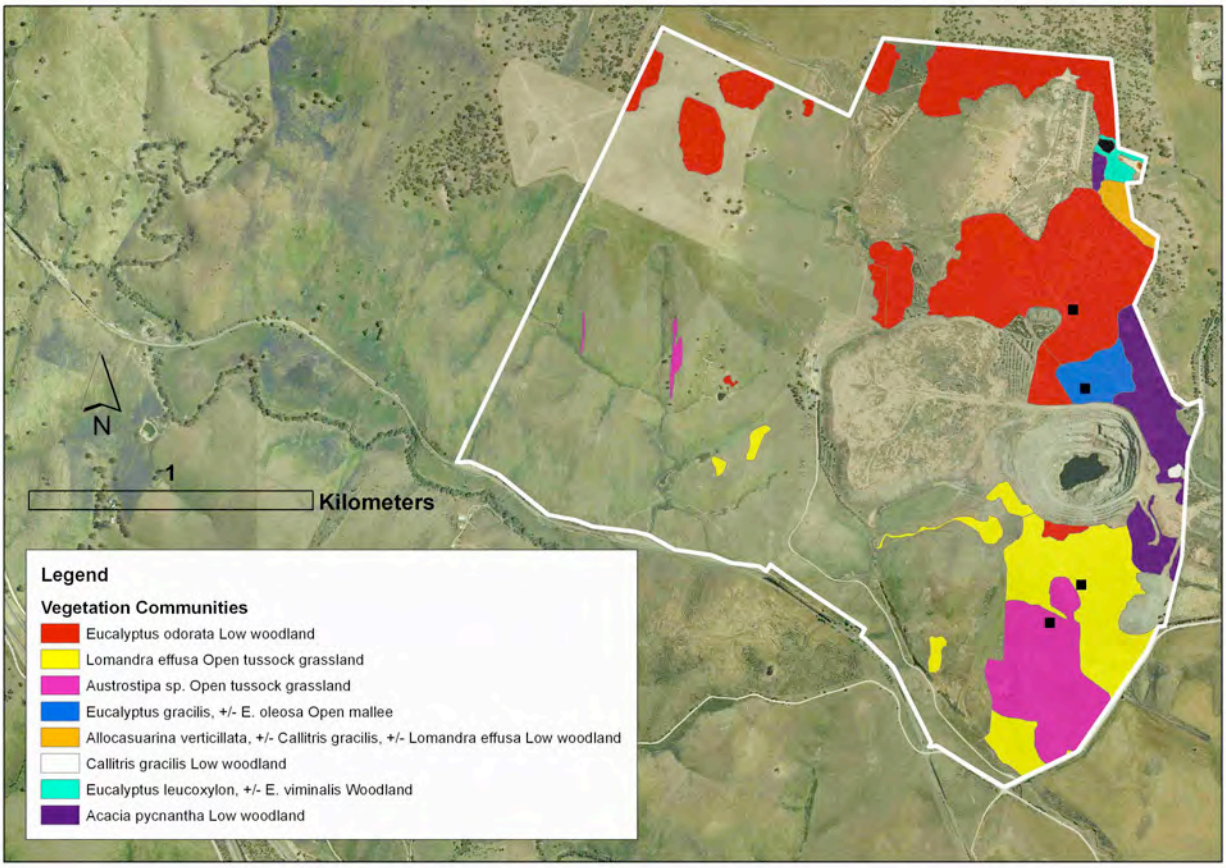


Figure 1: Kanmantoo Copper Project study area (white line), native vegetation communities (coloured), and vegetation survey quadrats (black squares).

2.1 Introduction

This survey applied the methods of the Biological Survey of South Australia (Owens 2000). The survey was carried out under:

- The Wildlife Ethics Committee Approval of a Project Involving Animals – Application Number 7/2007;
- Permit to Undertake Scientific Research – Permit Number W25407 1; and
- Licence to Use Animals for Teaching, Research or Experimental Purposes – Licence No 202.

The survey replicated the methods applied in the earlier Baseline Fauna Survey (Ecological Associates 2007), which are described below.

2.2 Methods

Trap Lines

One set of traplines was installed within three of the existing flora survey quadrats (Ecological Associates 2007):

1. *Eucalyptus odorata* woodland (SW corner: GDA 94 54H 0318112E 6115517S),

2. *Lomandra effusa* grassland (NW corner: GDA 94 54H 0318140E 6114548S), and

3. *Austrostipa* Grassland (NW corner: GDA 94 54H 0318029E 6114414S) previously identified within the Kanmantoo Copper Project area.

Each trap-line consisted of a pit-line (six pitfalls 10 m apart), one Elliot trap-line (15 traps 10 m apart), and two Sherman traps at either end of the line. Traps were installed and opened on Monday 24 September 2007; they were finally cleared, closed and removed on Friday 28 September 2007. Traps were checked in the evening and morning each day.

Roaming Surveys

Two observers carried out roaming surveys for birds of at least two hours total duration each day over three days. Each of the key habitat types was surveyed each day. In addition walks were made through all other habitat types at least once.

Physical Search

Physical searches were conducted on each day with particular emphasis within the three key habitat types and during roaming surveys throughout the area. Physical searches involved the lifting of rocks and logs, looking under bark on tree trunks, digging up burrows and raking of leaf litter. Observations were made of animals active at the time, or for signs of animals, including tracks, scats, scratchings, burrows, and skulls. Active animals were, where possible, hand caught and identified.

Spotlighting

Spotlighting for nocturnal mammals, birds and reptiles was carried out on a warm humid evening (Wed 26/09) between 20:00 and 22:30. Using a portable spotlight, two observers walked a predetermined route along existing tracks and then spotlighted via vehicle in areas to the south. The walked route followed east parallel to the pit through mallee woodlands, along the eastern edge of the site through *Allocasuarina verticillata* woodlands and *Callitris gracilis* woodlands, and south towards the pit through *Eucalyptus odorata* and *Eucalyptus leucoxylon* woodlands, and past regrowth areas to the west (Figure 1). The spotlight survey by car followed the tracks from site 1 around to the west of the existing pit up to the southern limits of the high country, around to the north of site 2 , back around the north of the pit and down to the eastern gate entrance. All sightings, audible movement and calls were investigated and identified.

2.3 Results

Weather

Surveys were carried out over five days (four nights) 24/09/2007 to 28/09/2007. Weather conditions during this period were mild to warm (Table 1). There were strong northerly winds on Tuesday 25 September and strong westerly winds Wednesday to Friday 26-28 September. There were light showers during the mornings of Wednesday and Thursday 26-27 September and during the middle of the day on Friday 28 September. All traps were checked and cleared each morning between 07:00 and 09:00 and late each afternoon between 15:00 and 17:00.

Mean annual rainfall at Murray Bridge is 342.4 mm (N = 122years - 1885-2007 BOM 2007). Total rainfall at Murray Bridge in the previous 4-month period (01/06/07 – 30/09/07) was 96.6 mm, being below the long-term average for this period (146.2 mm). At the Kanmantoo Mine Site weather station rainfall over the previous year (01/10/07 – 30/09/07) was 196.4 mm, and in the previous 4-month period was 62 mm. Winter and spring rainfall was below average but sufficient to provide for normal spring growth and flowering in annual and perennial plants.

Table 1: Weather during survey period. Weather station located on Kanmantoo Project Area, MacFarlane Hill

Date	Rainfall (mm)	Daily Temperature (°C) Maximum	Daily Temperature (°C) Minimum	Maximum Humidity (%)	Dew Point (°C)
Monday 24/09/07	0	21.5	6.5	83	4.2
Tuesday 25/09/07	0	27.2	7.4	75	3.3
Wednesday 26/09/07	4	24.2	10.8	84	9.1
Thursday 27/09/07	1.2	20.1	9.3	88	8.9
Friday 28/09/07	3	13.9	7.6	80	6.7

Eucalyptus odorata Low Woodland

Two species of native mammal (Euro, *Macropus robustus*; and Common Brushtail Possum, *Trichosurus vulpecula*) were recorded during the spring survey from *Eucalyptus odorata* Woodland (Table 2). One Common Brushtail Possum was caught in a trap and several others were observed spotlighting in this habitat. No Foxes (**Vulpes vulpes*)[1] or House Mice (**Mus musculus*) were recorded.

[1] * denotes an introduced species

A total of 19 species of bird were recorded from the *Eucalyptus odorata* Woodland (Table 3). The Diamond Firetail (*Stagonopleura guttata*) was recorded from this habitat and has a State Conservation Status of Vulnerable. Ten Diamond Firetails were observed in this survey, but the protocol adopted does not allow a population estimate to be made from these observations. Diamond Firetails were also recorded from this habitat during the February 2007 survey. Black Kite (*Milvus migrans*) and Southern Boobook (*Ninox novaeseelandie*) are new records for the State Biological Database from this general area. Four other species not recorded during the February 2007 survey were recorded during the spring survey (Little Corella, *Cacatua sanguinea*; Brown Treecreeper, *Climacteris picumnus*; Varied Sitella, *Daphoenositta chrysoptera*; and Red-rumped Parrot, *Psephotus haematonotus*). Two other species (Singing Honeyeater, *Lichenostomus virescens* and Common Starling, **Sturnus vulgaris*) were recorded during the February 2007 survey but not from *Eucalyptus odorata* Woodland.

A total of six species of reptile were recorded from the *Eucalyptus odorata* Woodland (Table 4). The Marbled Gecko (*Christinus marmoratus*) is the only species not recorded during the February 2007 survey.

Lomandra effusa Open Tussock Grassland

The only mammal recorded during the Spring Survey from the *Lomandra effusa* Open Tussock Grassland was the Euro, *Macropus robustus* (Table 2).

A total of five species of bird were recorded from this habitat, none of which have Conservation Status. Two species were not recorded during the February 2007 survey (Black-faced Cuckoo-shrike, *Coracina novaehollandiae*; and Fairy Martin, *Petrocheilidon ariel*). Fairy Martins are migratory, arriving in southern Australia in August prior to breeding (Frith 1979). In the previous Baseline Survey they may have already bred and moved out of the area.

Four species of reptile were recorded from the *Lomandra effusa* Open Tussock Grassland. The Olive Snake-lizard (*Delma inornata*) was recorded from this habitat and has a State Conservation Status of Rare. This and one other species (Little Whip Snake, *Suta flagellum*) were not recorded during the February 2007 survey.

Austrostipa blackii Open Tussock Grassland

No mammals were recorded during the Spring Survey from the *Austrostipa blackii* Open Tussock Grassland.

A total of five species of bird were recorded from this habitat (Table 3). The Peregrine Falcon (*Falco peregrinus*) was recorded from this habitat and has a State Conservation Status of Rare. Peregrine Falcons were also recorded during the February 2007 survey. Two species were not recorded during the February 2007 survey (Eurasian Skylark, *Alauda arvensis* and Brown Falcon, *Falco berigora*).

Four species of reptile were recorded from the *Austrostipa blackii* Open Tussock Grassland, none of which have Conservation Status. Two species were not recorded during the February 2007 survey (Bougainville’s Skink, *Lerista bougainvilli*; and Little Whip Snake, *Suta flagellum*).

Other habitats visited during the Spring Survey

A number of other habitats within the site were visited during the Spring Survey (*eg Eucalyptus leucoxylon* Woodland, *Allocasuarina* Woodland and Mallee) and these results are described below.

Two species of native mammal were recorded from these other habitats (Western Grey Kangaroo, *Macropus fuliginosus* and Euro, *Macropus robustus*) (Table 2). Exotic mammal species encountered were the Brown Hare (**Lepus capensis*) and the Rabbit (**Oryctolagus cuniculus*). Both species were in low abundance. A number of large warrens remain open on the site, but they are used by a number of native fauna species as refuge (eg the sleepy lizard).

A total of 21 species of bird were recorded from these habitats (Table 3). Two species with Conservation Status were recorded. The Rainbow Bee-eater (*Merops ornatus*), listed as a Marine Migratory species under the Japan Australia Migratory Bird Agreement (JAMBA) is therefore protected under the EPBC Act. It was recorded from *Eucalyptus leucoxylon* Woodland and *Allocasuarina* Woodland. During the February 2007 survey this species was recorded from *Eucalyptus odorata* Woodland and Mallee. The Diamond Firetail has a State Conservation Status of Vulnerable and was recorded from *Allocasuarina* Woodland and *Eucalyptus odorata* Woodland. During the February 2007 survey this species was recorded from *Eucalyptus odorata* Woodland. Black-faced Woodswallow (*Artamus cinereus*) is a new record for the State Biological Database from this general area. Eight species observed were not recorded during the February 2007 survey (Eurasian Skylark, **Alauda arvensis*; Richard's Pipit, *Anthus novaeseelandiae*; Horsfield's Bronze-cuckoo, *Chrysococcyx basalis*; Rock Dove, **Columba livia*; Black-faced Cuckoo-shrike, *Coracina novaehollandiae*; House Sparrow, **Passer domesticus*; Red-rumped Parrot, *Psephotus haematonotus*; and Grey Fantail, *Rhipidura albiscarpa*).

Three species of amphibians and four species of reptile were recorded from these habitats (Table 4), none of which have Conservation Status. The amphibians were all associated with a *Juncus acutus* Wetland. The amphibians and two species of reptile (Bougainville's Skink, *Lerista bougainvillii*; and Little Whip Snake, *Suta flagellum*) were not recorded during the February 2007 survey.

Table 2. Mammals recorded during Kanmantoo Spring Survey

			Habitat Type											Conservation Status	
	Common Name	**Scientific Name**	***Eucalyptus odorata* Low Woodland**	***Lomandra effusa* Open Tussock Grassland**	***Austrostipa blackii* Open Tussock Grassland**	**Eucalyptus leucoxylon Woodland**	***Eucalyptus leucoxylon, Allocasuarina, Acacia***	***Allocasuarina* Woodland**	**Mallee**	***Acacia pycnantha***	***Juncus acutus* Wetland**	**Grassland**	**Filled area with limited veg**	**AUS**	**SA**
	Western Grey Kangaroo	*Macropus fuliginosus*							6						
	Euro	*Macropus robustus*	2	2					1						
	Common Brushtail Possum	*Trichosurus vulpecula*	5												
*	Brown Hare	*Lepus capensis*	2			2			2						
*	Rabbit	*Oryctolagus cuniculus*	1									1			

(* = exotic)

Table 3. Birds recorded during Kanmantoo Spring Survey

	Common Name	Scientific Name	Habitat Type											Conservation Status	
			Eucalyptus odorata Low Woodland	*Lomandra effusa* Open Tussock Grassland	*Austrostipa blackii* Open Tussock Grassland	Eucalyptus leucoxylon Woodland	*Eucalyptus leucoxylon, Allocasuarina, Acacia*	*Allocasuarina* Woodland	Mallee	*Acacia pycnantha*	*Juncus acutus* Wetland	Grassland	Filled area with limited veg	AUS	SA
	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	1						2						
*	Eurasian Skylark	*Alauda arvensis*			2								2		
	Richard's Pipit	*Anthus novaeseelandiae*											1		
	Black-faced Woodswallow	*Artamus cinereus*					4								
	Dusky Woodswallow	*Artamus cyanopterus*	1			1									
	Galah	*Cacatua roseicapilla*	22												
	Little Corella	*Cacatua sanguinea*	1												
*	European Goldfinch	*Carduelis carduelis*										5			
	Horsfield's Bronze-cuckoo	*Chrysococcyx basalis*									1				
	Brown Treecreeper	*Climacteris picumnus*	4												
	Grey Shrike-thrush	*Colluricincla harmonica*							1						
*	Rock Dove	*Columba livia*										1			
	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		1									1		
	White-winged Chough	*Corcorax melanorhamphos*	4				8								
	Varied Sittella	*Daphoenositta chrysoptera*	2												
	Black-shouldered Kite	*Elanus axillaris*		1											
	Brown Falcon	*Falco berigora*			1										
	Nankeen Kestrel	*Falco cenchroides*		1									3		
	Peregrine Falcon	*Falco peregrinus*			2										R
	Australian Magpie	*Gymnorhina tibicen*			5										
	Welcome Swallow	*Hirundo neoxena*		5											
	White-plumed Honeyeater	*Lichenostomus penicillatus*	1			2									

			Habitat Type											Conservation Status	
	Common Name	**Scientific Name**	***Eucalyptus odorata*** **Low Woodland**	***Lomandra effusa*** **Open Tussock Grassland**	***Austrostipa blackii*** **Open Tussock Grassland**	**Eucalyptus leucoxylon Woodland**	***Eucalyptus leucoxylon, Allocasuarina, Acacia***	***Allocasuarina*** **Woodland**	**Mallee**	***Acacia pycnantha***	***Juncus acutus*** **Wetland**	**Grassland**	**Filled area with limited veg**	**AUS**	**SA**
	Singing Honeyeater	*Lichenostomus virescens*	1										1		
	Brown-headed Honeyeater	*Melithreptus brevirostris*	1						1						
	Rainbow Bee-eater	*Merops ornatus*				2		4						JAMBA	
	Black Kite	*Milvus migrans*	1												
	Southern Boobook	*Ninox novaeseelandiae*	X												
	Rufous Whistler	*Pachycephala rufiventris*	3												
	Striated Pardalote	*Pardalotus striatus*	2												
*	House Sparrow	*Passer domesticus*										1			
	Fairy Martin	*Petrochelidon ariel*		20											
	Adelaide Rosella	*Platycercus elegans*	6						2						
	Red-rumped Parrot	*Psephotus haematonotus*	3				1								
	Grey Fantail	*Rhipidura albiscapa*							1						
	Willie Wagtail	*Rhipidura leucophrys*			2										
	Weebill	*Smicrornis brevirostris*	4												
	Diamond Firetail	*Stagonopleura guttata*	5					4							V
*	Common Starling	*Sturnus vulgaris*	1												

AUS: National Conservation Rating (EPBC Act), JAMBA = Japan Australia Migratory Bird Agreement
SA: State Conservation rating (NPW Act), R = Rare, V = Vulnerable

Table 4. Amphibians and Reptiles recorded during Kanmantoo Spring Survey

			Habitat Type											Conservation Status	
	Common Name	**Scientific Name**	***Eucalyptus odorata* Low Woodland**	***Lomandra effusa* Open Tussock Grassland**	***Austrostipa blackii* Open Tussock Grassland**	**Eucalyptus leucoxylon Woodland**	***Eucalyptus leucoxylon, Allocasuarina, Acacia***	***Allocasuarina* Woodland**	**Mallee**	***Acacia pycnantha***	***Juncus acutus* Wetland**	**Grassland**	**Filled area with limited veg**	**AUS**	**SA**
	Eastern Sign Bearing Froglet	*Crinia parinsignifera*									X				
*	Common Froglet	*Crinia signifera*									X				
	Spotted Grass Frog	*Limnodynastes tasmaniensis*									X				
	Marbled Gecko	*Christinus marmoratus*	1												
	Tawny Dragon	*Ctenophorus decresii*	2				3			1					
	Eastern Striped Skink	*Ctenotus robustus*		1						1					
	Olive Snake-lizard	*Delma inornata*		2											R
*	Tree Dtella	*Gehyra* "2n=44"	1												
	Bougainville's Skink	*Lerista bougainvillii*			1				1						
	Dwarf Skink	*Menetia greyii*	3												
	Barking Gecko	*Nephrurus milii*			3										
*	Little Whip Snake	*Suta flagellum*		2	1					1					
	Sleepy Lizard	*Tiliqua rugosa*	1	7	3										
	Eastern Bluetongue	*Tiliqua scincoides*	1												

* = exotic, X = heard

SA: State Conservation rating (NPW Act), R = Rare

3.1 Overview

The Spring Survey provided information about additional fauna species known to occur in the project area and confirmed the continued presence of most species recorded during the previous survey in February 2007.

The Spring Survey recorded a total of five species of mammal, thirty-eight species of bird, three species of amphibian and eleven species of reptile. Very few Eucalypts were flowering at the time of the survey. When they are flowering, a higher diversity and abundance of birds could be expected, especially honeyeaters and insectivores. Although there was an abundance of grasses in seed, very few granivorous birds were observed.

One species of National Conservation Significance was recorded:

- Rainbow Bee-eater (*Merops ornatus*) (Listing under JAMBA and therefore EPBC). This species was also recorded during the February 2007 survey.

Three species of State Conservation Significance were recorded:

- Peregrine Falcon (*Falco peregrinus*), Rare in South Australia. This species was also recorded during the February 2007 survey and is resident at the site.
- Diamond Firetail (*Stagonopleura guttata*), Vulnerable in South Australia. Flocks of four and five birds were observed during the survey. This species was also recorded during the February 2007 survey.
- Olive Snake-lizard (*Delma inornata*), Rare in South Australia. Two specimens were collected in pitfalls in the *Lomandra effusa* Open Tussock Grassland (A sloughed skin of a *Delma* species was collected during the February 2007 survey in *Austrostipa* Open Tussock Grassland but there was insufficient material to identify it to species).

The continuing presence of the Peregrine Falcon and Diamond Firetail at the Kanmantoo Copper Mine site verifies that these species are permanent residents in the area. The presence of the Rainbow Bee-eaters as pairs in early spring also suggests that this species uses the site for breeding.

Multiple captures of species new to the area (eg Olive Snake-lizard *Delma inornata* and Little Whip Snake *Suta flagellum*), confirms the importance of repeat surveys in a year to capture animals during transient activity periods. The absence of the Eastern Spotted Ctenotus *Ctenotus orientalis* in the second survey, which was captured in the first survey, supports this need.

In this survey water was present in the creek flowing south out of the site, and the dam was full. Three different frog calls were evident in the reeds and along the edge of this dam: Eastern Sign Bearing Froglet *Crinia parinsignifera*, Common Froglet *Crinia signifera*, and Spotted Grass Frog *Limnodynastes tasmaniensis*. None of these species have significant conservation ratings.

As with the survey in February, five reptile species previously recorded and common to the area (BDBSA) were not found (*Christinus marmoratus, Hemiergis decresiensis, Pogona barbarta, Pseudonaja textiles* and *Morethia boulengeri*). Anecdotally (pers. com: J. Popow, Hillgrove Resources Ltd. 12/02/2007) the Eastern Brown Snake *Pseudonaja textiles* is known to occur in reasonable numbers across the site. Despite extensive searches both during this, and the previous survey this species was not observed. The regionally common skink *Lerista bougainvillii* was captured for the first time in the spring survey.

For a habitat fragment of this size in the southern Mount Lofty Ranges the species count of reptiles in this survey was relatively good (Sacchi 2003), suggesting the outcome of the combined surveys was sufficient to determine the presence of a majority of the reptile species in the area.

Following on from the survey in summer ten additional bird species were observed in spring (Appendix A). Three of these species were new records for the area: *Artamis cinereus* Black-faced Wood Swallow, *Milvus migrans* Black Kite, and *Ninox novaeseelandiae* Southern Boobook. Of the rest, two were exotics *Sturnus vulgaris* Common Starling and *Alauda arvensis* Eurasian Skylark. None of the new species have significant conservation ratings. Honeyeaters were again in low abundance during this survey and again no eucalypts or wattles were in flower. In a regional context, the role that this remnant patch plays for Honeyeaters during the flowering period is still not determined.

It is of note that, unlike the previous survey, no House Mice (**Mus musculus*) or Foxes (**Vulpes vulpes*) were recorded during the Spring Survey. Following a recommendation made in the February Fauna Survey report, Hillgrove Resources Pty Ltd commenced a fox-baiting program (Marty Adams, Pers Com. 06/06/2007), which appears to have significantly reduced the fox population in the area. House Mouse populations generally decline in cold weather over winter, when reproductive rates are low (Singleton et al. 2001).

3.2 Species of Management Concern

In the Fauna Baseline Survey and Impact Assessment of the Kanmantoo project (Ecological Associates, August 2007) management concerns for four species were documented:

- Diamond Firetail (*Stagonopleura guttata*), State Conservation Status, Vulnerable;
- Peregrine Falcon (*Falco peregrinus*), State Conservation Status, Rare;
- Rainbow Bee-eater (*Merops ornatus*), National Conservation Status, JAMBA; and
- Common Brushtail Possum (*Trichosurus vulpecula*), Nominated for listing as State Rare.

The significance of these species at the site is discussed in the Baseline Survey Report (Ecological Associates 2007).

The Spring Survey recorded the continued presence of each of these species at the site. One additional species of Conservation Status, the Olive Snake-lizard (*Delma inornata*) was collected during the Spring Survey from L*omandra effusa* Open Tussock Grassland and is a species of management concern.

Olive Snake-lizard (Delma inornata) – Rare in South Australia

Reasons for listing

The Olive Snake-lizards are widespread across eastern Australia between SE Queensland and SE South Australia. The animals at Kanmantoo are part of an isolated population in the Mount Lofty Ranges. The only other records for South Australia are to the south-east of Bordertown at the western edge of the main area of distribution in Victoria and New South Wales.

Within South Australia the Olive Snake-lizard currently has a Rare conservation rating under the National Parks and Wildlife Act 1972 (Schedule 9), but has been proposed for relisting as Near Threatened in a 2003 review of threatened species status (National Parks and Wildlife Council and Department of Environment and Heritage 2003). The Near Threatened classification means that: assessment against the criteria indicates that the taxon is close to qualifying as Critically Endangered, Endangered or Vulnerable (IUCN, 2001). Within South Australia the Olive Snake-lizard has a restricted distribution and this distribution does not lie within existing protected areas.

Relevant Behavioural Ecology

The Olive Snake-lizard (*Delma inornata*) is a species of legless lizard. Knowledge of the behavioural ecology of this secretive species is limited. They are active during the day in summer, but in winter the animal can shelter deep beneath the surface. The species occurs in grasslands, open forests and on rocky outcrops. It prefers structurally simple microhabitats and is more likely to be found at sites with no tree cover (Fischer et al. 2004). The species is known to withstand moderate levels of disturbance from grazing (ie introduction of some weeds, fertilizers and soil compaction) as long as a sufficient number of half-buried rocks and logs are available as a shelter site (Fischer et al. 2004). Consequently the species also occurs in farmlands and grazing lands. *Lomandra effusa* tussocks provide ideal microhabitat for this species. They are known to also shelter under metal, woody debris, and rocks.

The species is known to eat a variety of invertebrates. The predominant prey classes are spiders, cockroaches, grasshoppers, and lepidopteran adults.

Threat Assessment and Mitigation

Proposed clearance of high quality *Lomandra effusa* grassland at the Kanmantoo Copper Project site will directly impact on the existing population of the Olive Snake-lizards *Delma inornata*. The tendency of the species to be active in the summer months, and to enter into extended periods of inactivity in deep refuge at other times, reduces the range of options available to mitigate the impact of habitat clearance. Trapping over the summer period and subsequent translocation may be possible. It is unknown how successfully this species will respond to translocation.

The monitoring and relocation of the Olive Snake-lizards (*Delma inornata*), prior to clearance provides an excellent opportunity to collect further data on this species. It would be possible to collect detailed data on, for example population demographics, morphometrics, and habitat associations at Kanmantoo. Subsequently the captured individuals could be radio tracked upon release at a suitable site and their subsequent behaviour and survival monitored. Properly constructed such a study could constitute a valid Honours project within a tertiary Biodiversity and Conservation, or Environmental Studies program. The data collected would be an invaluable resource, providing the opportunity for publication of much needed information in this subject area.

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SPECIES	COMMON NAME	DEH Records	Autumn 2007 Ecol Assoc Survey	Spring 2007 Ecol Assoc Survey
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	X		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	X	X	X
Acanthiza lineata	Striated Thornbill	X		
Acanthiza nana	Yellow Thornbill	X	X	
Acanthiza reguloides	Buff-rumped Thornbill	X		
Acanthorhynchus tenuirostris	Eastern Spinebill	X		
Accipiter cirrhocephalus	Collared Sparrowhawk	X		
Accipiter fasciatus	Brown Goshawk	X		
Acrocephalus stentoreus	Clamorous Reedwarbler	X		
Aegotheles cristatus	Australian Owlet-nightjar		X	X
Alauda arvensis	Eurasian Skylark	X		X
Anas superciliosa	Pacific Black Duck	X		
Anthochaera carunculata	Red Wattlebird	X		
Anthochaera chrysoptera	Little Wattlebird	X		
Anthus novaeseelandiae	Richard's Pipit	X		X
Aphelocephala leucopsis	Southern Whiteface	X	X	
Aquila audax	Wedge-tailed Eagle	X	X	X
Artamis cinereus	Black-faced Wood Swallow			X
Artamus cyanopterus	Dusky Woodswallow	X	X	X
Aythya australis	Hardhead (White-eyed Duck)	X		
Cacatua galerita	Sulphur-crested Cockatoo	X		
Cacatua roseicapilla	Galah	X	X	X
Cacatua sanguinea	Little Corella	X		X
Cacomantis flabelliformis	Fan-tailed Cuckoo	X		
Carduelis carduelis	European Goldfinch	X	X	
Chenonetta jubata	Australian Wood Duck, (Maned Duck)	X		
Cheramoeca leucosternus	White-backed Swallow	X		
Chrysococcyx basalis	Horsfield's Bronze-cuckoo	X		X
Cincloramphus cruralis	Brown Songlark	X		
Cincloramphus mathewsi	Rufous Songlark	X		
Circus assimilis	Spotted Harrier	X		
Climacteris picumnus	Brown Treecreeper	X		X
Colluricincla harmonica	Grey Shrike-thrush	X	X	X
Columba livia	Rock Dove	X		X
Coracina novaehollandiae	Black-faced Cuckoo-shrike	X		X
Corcorax melanorhamphos	White-winged Chough	X	X	X
Cormobates leucophaeus	White-throated Treecreeper	X		
Corvus coronoides	Australian Raven	X		
Corvus mellori	Little Raven	X	X	
Corvus sp.		X		X
Coturnix pectoralis	Stubble Quail	X		
Dacelo novaeguineae	Laughing Kookaburra	X		
Daphoenositta chrysoptera	Varied Sittella	X		X
Dicaeum hirundinaceum	Mistletoebird	X		
Egretta novaehollandiae	White-faced Heron	X		
Elanus axillaris	Black-shouldered Kite	X	X	X
Epthianura albifrons	White-fronted Chat	X		
Falco berigora	Brown Falcon	X		X
Falco cenchroides	Nankeen Kestrel	X	X	X
Falco longipennis	Australian Hobby	X		
Falco peregrinus	Peregrine Falcon	X	X	X
Falco subniger	Black Falcon	X		
Fulica atra	Eurasian Coot	X		
Gallinula tenebrosa	Dusky Moorhen	X		
Geopelia placida	Peaceful Dove	X		
Glossopsitta concinna	Musk Lorikeet	X		
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	X	X	
Grallina cyanoleuca	Magpie-lark	X	X	
Gymnorhina tibicen	Australian Magpie	X	X	X
Hirundo neoxena	Welcome Swallow	X	X	X
Lichenostomus chrysops	Yellow-faced Honeyeater	X		
Lichenostomus penicillatus	White-plumed Honeyeater	X	X	X
Lichenostomus virescens	Singing Honeyeater	X	X	X
Malurus cyaneus	Superb Fairy-wren	X		
Malurus lamberti	Variegated Fairy-wren	X		
Manorina melanocephala	Noisy Miner	X	X	
Melithreptus brevirostris	Brown-headed Honeyeater	X	X	
Melithreptus lunatus	White-naped Honeyeater	X		
Melopsittacus undulatus	Budgerigar	X		
Merops ornatus	Rainbow Bee-eater	X	X	X
Microeca fascinans	Jacky Winter	X		
Milvus migrans	Black Kite			X
Mirafra javanica	Horsfield's Bushlark	X		
Myiagra inquieta	Restless Flycatcher	X		
Neochmia temporalis	Red-browed Finch	X		
Ninox novaeseelandiae	Southern Boobook			X
Nymphicus hollandicus	Cockatiel	X		
Ocyphaps lophotes	Crested Pigeon	X	X	
Oreoica gutturalis	Crested Bellbird	X		
Pachycephala pectoralis	Golden Whistler	X		
Pachycephala rufiventris	Rufous Whistler	X	X	X
Pardalotus punctatus	Spotted Pardalote	X		
Pardalotus striatus	Striated Pardalote	X	X	X
Passer domesticus	House Sparrow	X		X
Petrochelidon ariel	Fairy Martin	X		X
Petrochelidon nigricans	Tree Martin	X		
Petroica goodenovii	Red-capped Robin	X		
Phalacrocorax carbo	Great Cormorant	X		
Phalacrocorax melanoleucos	Little Pied Cormorant	X		
Phalacrocorax varius	Pied Cormorant	X		
Phaps chalcoptera	Common Bronzewing	X		
Phylidonyris novaehollandiae	New Holland Honeyeater	X	X	
Phylidonyris pyrrhoptera	Crescent Honeyeater	X		
Platycercus elegans	Crimson Rosella	X	X	X
Poliocephalus poliocephalus	Hoary-headed Grebe	X		
Pomatostomus superciliosus	White-browed Babbler	X		
Porphyrio porphyrio	Purple Swamphen	X		
Psephotus haematonotus	Red-rumped Parrot	X		X
Rhipidura albiscapa	Grey Fantail	X		X
Rhipidura leucophrys	Willie Wagtail	X	X	X
Scythrops novaehollandiae	Channel-billed Cuckoo	X		
Smicrornis brevirostris	Weebill	X	X	X
Stagonopleura guttata	Diamond Firetail	X	X	X
Strepera versicolor	Grey Currawong	X		
Streptopelia chinensis	Spotted Turtle-dove	X		
Sturnus vulgaris	Common Starling	X	X	X
Tachybaptus novaehollandiae	Australasian Grebe, (Little Grebe)	X		
Taeniopygia guttata	Zebra Finch	X		
Trichoglossus haematodus	Rainbow Lorikeet	X		
Turdus merula	Eurasian Blackbird	X		
Tyto alba	Barn Owl	X		
Vanellus miles	Masked Lapwing	X		
Zosterops lateralis	Silvereye	X		

SPECIES	COMMON NAME	DEH Total Records	Percent of Observations	Ecol Assoc February Survey	Ecol Assoc September Survey
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	2	0.09		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	45	2.04	O	O
Acanthiza lineata	Striated Thornbill	53	2.41		
Acanthiza nana	Yellow Thornbill	17	0.77	O	
Acanthiza reguloides	Buff-rumped Thornbill	23	1.04		
Acanthorhynchus tenuirostris	Eastern Spinebill	19	0.86		
Accipiter cirrhocephalus	Collared Sparrowhawk	1	0.05		
Accipiter fasciatus	Brown Goshawk	3	0.14		
Acrocephalus stentoreus	Clamorous Reedwarbler	2	0.09		
Aegotheles cristatus	Australian Owlet-nightjar	0	0	O	
Alauda arvensis	Eurasian Skylark	2	0.09		O
Anas superciliosa	Pacific Black Duck	4	0.18		
Anthochaera carunculata	Red Wattlebird	81	3.68		
Anthochaera chrysoptera	Little Wattlebird	1	0.05		
Anthus novaeseelandiae	Richard's Pipit	5	0.23		O
Aphelocephala leucopsis	Southern Whiteface	3	0.14	O	
Aquila audax	Wedge-tailed Eagle	4	0.18	O	
Artamus cinereus	Black-faced Woodswallow	0	0		O
Artamus cyanopterus	Dusky Woodswallow	13	0.59	O	O
Aythya australis	Hardhead (White-eyed Duck)	1	0.05		
Cacatua galerita	Sulphur-crested Cockatoo	23	1.04		
Cacatua roseicapilla	Galah	85	3.86	O	O
Cacatua sanguinea	Little Corella	4	0.18		O
Cacomantis flabelliformis	Fan-tailed Cuckoo	2	0.09		
Carduelis carduelis	European Goldfinch	12	0.54	O	O
Chenonetta jubata	Australian Wood Duck, (Maned Duck)	11	0.5		
Cheramoeca leucosternus	White-backed Swallow	1	0.05		
Chrysococcyx basalis	Horsfield's Bronze-cuckoo	3	0.14		O
Cincloramphus cruralis	Brown Songlark	1	0.05		
Cincloramphus mathewsi	Rufous Songlark	3	0.14		

Circus assimilis	Spotted Harrier	1	0.05		
Climacteris picumnus	Brown Treecreeper	8	0.36		O
Colluricincla harmonica	Grey Shrike-thrush	40	1.82	O	O
Columba livia	Rock Dove	9	0.41		O
Coracina novaehollandiae	Black-faced Cuckoo-shrike	29	1.32		O
Corcorax melanorhamphos	White-winged Chough	6	0.27	O	O
Cormobates leucophaeus	White-throated Treecreeper	2	0.09		
Corvus coronoides	Australian Raven	2	0.09		
Corvus mellori	Little Raven	63	2.86	O	O
Corvus sp.		8	0.36		O
Coturnix pectoralis	Stubble Quail	1	0.05		
Dacelo novaeguineae	Laughing Kookaburra	10	0.45		
Daphoenositta chrysoptera	Varied Sittella	4	0.18		O
Dicaeum hirundinaceum	Mistletoebird	2	0.09		
Egretta novaehollandiae	White-faced Heron	5	0.23		
Elanus axillaris	Black-shouldered Kite	9	0.41	O	O
Epthianura albifrons	White-fronted Chat	1	0.05		
Falco berigora	Brown Falcon	3	0.14		O
Falco cenchroides	Nankeen Kestrel	10	0.45	O	O
Falco longipennis	Australian Hobby	2	0.09		
Falco peregrinus	Peregrine Falcon	4	0.18	O	O
Falco subniger	Black Falcon	1	0.05		
Fulica atra	Eurasian Coot	5	0.23		
Gallinula tenebrosa	Dusky Moorhen	4	0.18		
Geopelia placida	Peaceful Dove	4	0.18		
Glossopsitta concinna	Musk Lorikeet	42	1.91		
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	6	0.27	O	
Grallina cyanoleuca	Magpie-lark	27	1.23	O	
Gymnorhina tibicen	Australian Magpie	142	6.45	O	O
Hirundo neoxena	Welcome Swallow	28	1.27	O	O
Lichenostomus chrysops	Yellow-faced Honeyeater	101	4.59		
Lichenostomus penicillatus	White-plumed Honeyeater	73	3.32	O	O
Lichenostomus virescens	Singing Honeyeater	13	0.59	O	
Malurus cyaneus	Superb Fairy-wren	133	6.04		

Malurus lamberti	Variegated Fairy-wren	1	0.05		
Manorina melanocephala	Noisy Miner	9	0.41	O	
Melithreptus brevirostris	Brown-headed Honeyeater	6	0.27	O	O
Melithreptus lunatus	White-naped Honeyeater	29	1.32		
Melopsittacus undulatus	Budgerigar	1	0.05		
Merops ornatus	Rainbow Bee-eater	4	0.18	O	O
Microeca fascinans	Jacky Winter	1	0.05		
Milvus migrans	Black Kite	0	0		O
Mirafra javanica	Horsfield's Bushlark	1	0.05		
Myiagra inquieta	Restless Flycatcher	2	0.09		
Neochmia temporalis	Red-browed Finch	20	0.91		
Ninox novaeseelandiae	Southern Boobook	0	0		O
Nymphicus hollandicus	Cockatiel	1	0.05		
Ocyphaps lophotes	Crested Pigeon	34	1.54	O	
Oreoica gutturalis	Crested Bellbird	1	0.05		
Pachycephala pectoralis	Golden Whistler	27	1.23		
Pachycephala rufiventris	Rufous Whistler	5	0.23	O	O
Pardalotus punctatus	Spotted Pardalote	3	0.14		
Pardalotus striatus	Striated Pardalote	116	5.27	O	
Passer domesticus	House Sparrow	36	1.63		O
Petrochelidon ariel	Fairy Martin	3	0.14		O
Petrochelidon nigricans	Tree Martin	41	1.86		
Petroica goodenovii	Red-capped Robin	1	0.05		
Phalacrocorax carbo	Great Cormorant	2	0.09		
Phalacrocorax melanoleucos	Little Pied Cormorant	2	0.09		
Phalacrocorax varius	Pied Cormorant	1	0.05		
Phaps chalcoptera	Common Bronzewing	3	0.14		
Phylidonyris novaehollandiae	New Holland Honeyeater	97	4.41	O	
Phylidonyris pyrrhoptera	Crescent Honeyeater	4	0.18		
Platycercus elegans adelaide	Crimson (Adelaide) Rosella	198	8.99	O	O
Poliocephalus poliocephalus	Hoary-headed Grebe	1	0.05		
Pomatostomus superciliosus	White-browed Babbler	15	0.68		
Porphyrio porphyrio	Purple Swamphen	1	0.05		
Psephotus haematonotus	Red-rumped Parrot	23	1.04		O

Rhipidura fuliginosa	Grey Fantail	61	2.77		O
Rhipidura leucophrys	Willie Wagtail	60	2.72		O
Scythrops novaehollandiae	Channel-billed Cuckoo	1	0.05		
Smicrornis brevirostris	Weebill	4	0.18	O	O
Stagonopleura guttata	Diamond Firetail	8	0.36	O	O
Strepera versicolor	Grey Currawong	28	1.27		
Streptopelia chinensis	Spotted Turtle-dove	4	0.18		
Sturnus vulgaris	Common Starling	62	2.82	O	O
Tachybaptus novaehollandiae	Australasian Grebe, (Little Grebe)	5	0.23		
Taeniopygia guttata	Zebra Finch	1	0.05		
Trichoglossus haematodus	Rainbow Lorikeet	9	0.41		
Turdus merula	Eurasian Blackbird	39	1.77		
Tyto alba	Barn Owl	2	0.09		
Vanellus miles	Masked Lapwing	1	0.05		
Zosterops lateralis	Silvereye	6	0.27		
Grand Total		2202	100	32	38

15 new species on top of last survey

3 new species for the locality

No new species of conservation significance

Family	Scientific Name	Common Name	Ecol Assoc February Survey	Ecol Assoc September Survey	Conservation Status AUS	Conservation Status SA
Reptiles						
AGAMIDAE	*Ctenophorus decressii*	Tawny Dragon	O	O		
SCINCIDAE	*Ctenotus orientalis*	Eastern Spotted Ctenotus	O			
SCINCIDAE	*Ctenotus robustus*	Eastern Striped Skink	O	O		
SCINCIDAE	*Lerista bougainvillii*	Bougainville's Skink		O		
SCINCIDAE	*Menetia greyii*	Dwarf Skink	O	O		
SCINCIDAE	*Tiliqua rugosa*	Sleepy Lizard	O	O		
SCINCIDAE	*Tiliqua scincoides*	Eastern Bluetongue	O	O		
GEKKONIDAE Pygopodinae	*Delma molleri*? (Possibly *D. inornata*)1	Adelaide Snake-lizard	O			
GEKKONIDAE Pygopodinae	*Delma inornata*	Olive Legless Lizard		O		Rare
GEKKONIDAE Diplodactylinae	*Nephrurus milii*	Thick-tailed Gecko	O	O		
GEKKONIDAE Gekkoninae	*Gehyra* sp. '2n=44'	Southern Rock Dtella	O	O		
GEKKONIDAE Gekkoninae	*Christinus marmoratus*	Marbled Gecko		O		
ELAPIDAE	*Suta flagellum*	Little Whip Snake		O		
Amphibians						
MYOBATRACHIDAE	*Limnodynastes tasmaniensis*	Spotted Grass Frog		H		
MYOBATRACHIDAE	*Crinia signifera*	Common Froglet		H		
MYOBATRACHIDAE	*Crinia parsignifera*	Eastern Sign Bearing Froglet		H		
		Total	9	14		

3 new species of lizard.
Delma inornata rare in SA. 1
new snake species 3
new frog species

16 species in total

Family	Scientific Name	Common Name	Ecol Assoc February Survey	Ecol Assoc September Survey	Conservation Status AUS	Conservation Status SA
MACROPODIDAE	*Macropus fuliginosus*	Western Grey Kangaroo	O	O		
MACROPODIDAE	*Macropus robustus*	Euro	O	O		
PHALANGERIDAE	*Trichosurus vulpecula*	Common Brushtail Possum	O	O		
CANIDAE	**Vulpes vulpes*	Fox	O			
MURIDAE Murinae	**Mus musculus*	House Mouse	O			
LEPORIDAE	**Oryctolagus cuniculus*	Rabbit	O	O		
LEPORIDAE	**Lepus capensis*	Brown Hare	O	O		
MOLOSSIDAE	*Tadarida australis*	White-striped Freetail-bat	O			
MOLOSSIDAE	*Mormopterus planiceps*	Southern Freetail-bat	O			
VESPERTILIONIDAE Vespertilioninae	*Chalinolobus gouldii*	Gould's Wattled Bat	O			
VESPERTILIONIDAE Nyctophilinae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	O			
VESPERTILIONIDAE Vespertilioninae	*Chalinolobus morio*	Chocolate Wattled Bat	O			
VESPERTILIONIDAE Vespertilioninae	*Vespadelus darlingtoni*	Large Forest Bat	O			
VESPERTILIONIDAE Vespertilioninae	*Vespadelus regulus*	Southern Forest Bat	O			
VESPERTILIONIDAE Vespertilioninae	*Vespadelus vulturnus* or *Vd*	Little Forest Bat	O			
		Total	15	5		

n.b. no anabat surveys in September
no new mammal species

Appendix 5C

Fauna Management Plan

Kanmantoo Copper Project		
Fauna Management Plan		
HILLGROVE RESOURCES	**Issue:** Version 4	**Date:** July 2010
	Authorised by:	**Signature:**

1. Background

1.1 Fauna Species

Where present, fauna species of conservation significance in the mining lease are classified as significant at the:

- National level, i.e., listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- State level, i.e., listed under the *National Parks and Wildlife Act 1972* (NPW Act).

The mining lease contains three major fauna habitats (Figure 1):

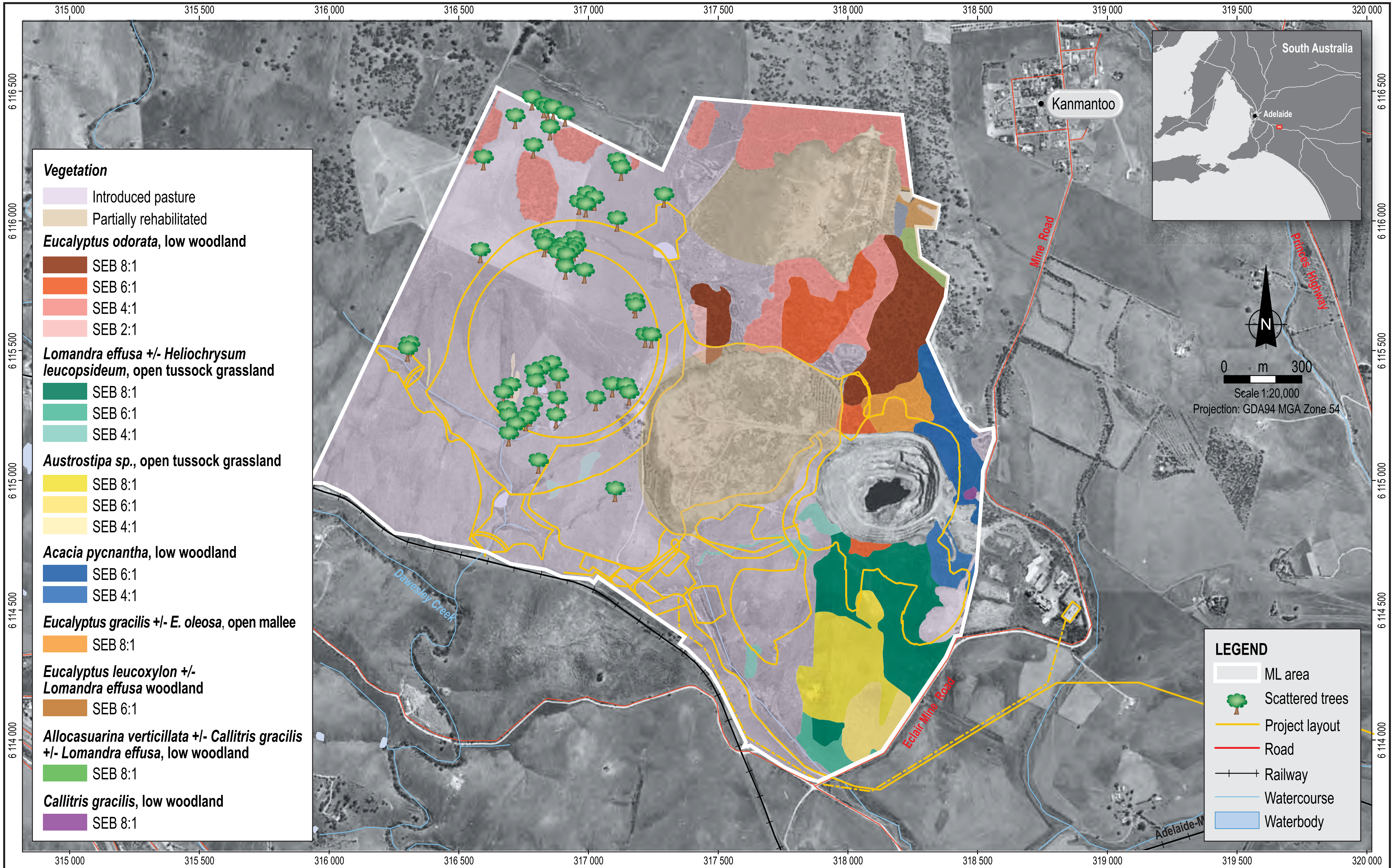
- *Eucalyptus odorata* woodland.
- *Lomandra effusa* grassland.
- *Austrostipa* spp. grassland.

At the national level, one migratory EPBC Act-listed species (the rainbow bee-eater, *Merops ornatus*) is a seasonal visitor to the mining lease. However, this species is not listed as a threatened species under the act. It is highly unlikely that the rainbow bee-eater will be impacted by mining activities.

At the state level, three NPW Act listed species are known to occur within the mining lease. These are the:

- Diamond firetail (*Stagonopleura guttata*) listed as vulnerable.
- Peregrine falcon (*Falco peregrinus*) listed as rare.
- Common brushtail possum (*Trichosurus vulpecula)* listed as rare.

Approximately 3.2 ha of high quality (classified as 'good' and 'very good' condition) vegetation will be cleared in the *E. odorata* woodland. This habitat currently supports populations of the NPW Act listed diamond firetail and the brushtail possum. As a result, reduced abundance of threatened species in the mining lease is likely to occur. Areas of *L. effusa* grassland will be cleared; however, this is not expected to result in significant impacts to threatened species.



Source:
Place names, roads, drainage and cadastre from DEH, SA (optimum scale 1:50,000)
Project layout from Hillgrove Resources
Vegetation survey from Ecological Associates

coffey environments

Date:	30.06.2008
MXD:	HillgroveResources_KanmantooGIS
File Name:	5000_07_Fa_F001_GIS_AI
Rev:	1

Hillgrove Copper Pty Ltd

Kanmantoo Copper Project

HILLGROVE RESOURCES

ML area vegetation

Figure No: 1

1.2 Introduced Species

Four introduced vertebrate species (other than sheep and cattle) are known to occur on the mining lease and surrounding region. These are the:

- European rabbit (*Oryctolagus cuniculus*).
- European (brown) hare (*Lepus capensis*).
- House mouse (*Mus domesticus*).
- Red fox (*Vulpes vulpes*).

2. Relevant Legislation

Fauna is protected at both the State and Federal level. The Australian Government's power and role in protection of fauna is restricted to protection of nationally threatened native species. Relevant legislation includes:

State:

- *Native Vegetation Act 1991.*
- *National Parks and Wildlife Act 1972.*
- *Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986.*
- *Mining Act 1971.*

Commonwealth:

- *Environmental Protection and Biodiversity Conservation Act 1999.*

3. Statutory Responsibilities

3.1 Mining Lease Conditions

A mining lease for operations at the Kanmantoo Copper Project has been issued (ML 6345), subject to conditions, under the Mining Act. These conditions must be complied with during all phases of the mining operation. Specifically, the following conditions must be adhered to in relation to fauna management:

- Condition 13: The Lessee must, in constructing and operating the Lease, ensure that there are no net adverse impacts from the site operations on the native fauna abundance or diversity in the Lease area and in adjacent areas.

- Condition 15: The Lessee must, in constructing and operating the Lease, ensure no introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weeds or pest species in the Lease area and adjacent areas caused by mining operations.

A number of mining lease conditions associated with mine closure and rehabilitation are also related to fauna management, however these are addressed in the project Mine Closure and Rehabilitation Plan and are not addressed in this management plan.

3.2 MARP Commitments

A Mining and Rehabilitation Program (MARP) for the Kanmantoo Copper Project has been approved under the Mining Act for use during all phases of the mining operation. The MARP includes detailed and specific information on environmental control measures and establishes outcome-based performance criteria for the mining operation, presented in the table below. This EMP incorporates commitments made in the MARP that relate to fauna management.

Table 1 Control measures and performance criteria for fauna management

Outcome	Assessment Criteria	Summary of Control Measures
No net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.	**Assessment Criteria:** Post-mining fauna survey within the ML and adjacent areas shows no net adverse impacts on native fauna abundance or diversity (as determined by flora and fauna consultant) compared to baseline (as shown in Appendix 5A and 5B of the MARP) that can be reasonably attributed to mining operations.	Establishment and ongoing management of SEB offset areas (including the implementation of a threatened species management plan). Project infrastructure located outside areas of very good quality *E. odorata* low woodland where possible. Clearly identifying and documenting areas to be protected and areas to be cleared. Minimising the area of direct land clearing. Progressively rehabilitating cleared land. Additional surveying of diamond firetail populations.
No introduction of new pests (including feral animals), nor increase in abundance of existing pest species in the lease area and adjacent areas caused by mining operations.	**Assessment Criteria:** Annual fauna surveys within the ML indicate no significant increase in abundance of pest (feral) species and no introduction of new pest species that can be reasonably attributed to mining operations (as determined by flora and fauna consultant) when compared to baseline (as shown in Appendix 5A and 5B of the MARP).	Prohibition of pets and feeding of animals. Controlled extermination of introduced fauna species. Internal and external auditing to assess housekeeping standards (in particular litter control). Implementation of Hillgrove's Feral Animal Control SOP.

4. Issues

Native bird, reptile and mammal species, including a number of EPBC Act and NPW Act listed species, may be affected by vegetation clearing and ground disturbance during construction of the project.

Key issues of concern to fauna are:

- Removal and/or disturbance of habitat.
- Reduced level of resources.
- Increased abundance of feral animals.

5. Objectives

The objectives of this management plan include:

- No significant adverse impact to the abundance and diversity of threatened or non-threatened native fauna species.

- No significant increase in introduced fauna species.

6. Associated Plans

- SEB Native Vegetation Management Plan.
- Flora Management Plan.
- Noise and Vibration Plan.
- Traffic Management Plan.
- Threatened Species Management Plan.

7. Standard Operating Procedures

- General Fauna Management.
- Excavation Inspection.
- Feral Animal Control.

8. Forms

- Trapped Animal Logsheet.
- Incident Report.

9. Responsibilities

9.1 General Manager

The general manager will:

- Provide resources to implement the fauna management plan.

9.2 Environmental Coordinator

The environmental coordinator will:

- Implement the fauna management plan.
- Manage the SEB offset area.
- Coordinate monitoring activities.
- Report monitoring results to government agencies.
- Review monitoring results, assess management action efficiency against results and either revise this management plan or implement corrective actions as applicable.
- Train and induct all employees on the requirements of the fauna management plan.

9.3 Department Managers

The department managers will:

- Support and promote the importance of minimising impact on the environment.
- Ensure that personnel implement requirements of the fauna management plan.

9.4 All Personnel

All personnel will:

- Comply with requirements of the fauna management plan.
- Undertake an environmental induction.

10. General Management Procedures

General fauna management procedures are covered in the General Fauna Management Standard Operating Procedure and include:

- Establishment and ongoing management of SEB offset areas (including the implementation of a threatened species management plan).
- Project infrastructure located outside areas of very good quality *E. odorata* low woodland where possible.
- Clearly identifying and documenting areas to be protected and areas to be cleared.
- Minimising the area of direct land clearing.
- Progressively rehabilitating cleared land.
- Additional surveying of diamond firetail populations.
- Prohibition of pets and feeding of animals.
- Controlled extermination of introduced fauna species.
- Internal and external auditing to assess housekeeping standards (in particular litter control). Implementation of Hillgrove's Feral Animal Control SOP.

11. Monitoring Procedures

Ongoing fauna monitoring will be conducted to allow identification of any impacts of mine construction and operations on native fauna. Monitoring will be conducted in the major habitat types present on the mining lease, which are areas of remnant *Eucalyptus odorata* low woodland and *Lomandra effusa* grassland and *Austrostipa* spp. grassland in areas remote from project activity (Figure 1).

11.1 Methods

Fauna monitoring will involve fauna surveys and targeted counts for threatened species at selected sites to allow assessment of:

- Changes in the abundance, composition or condition of fauna species, particularly threatened species.
- Ongoing impacts to fauna as a result of project-related activities.
- Success of rehabilitation and/or relocation activities for threatened species.
- Increases in the density and distribution of pest animal infestations.
- Introduction of new pest animal species.

- Diversity and health of waterbird populations at permanent waterbodies.

Survey methods will include visual observations, spotlighting, bird census transects, trapping and active searching.

11.2 Monitoring Sites and Frequency

Monitoring sites will be located within the three major fauna habitat areas (*Eucalyptus odorata* low woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland) within the mining lease. Inspection and monitoring is also to be conducted prior to, during and following disturbance. The number of sites to be sampled during monitoring will be calculated to allow for valid statistical comparisons between control and impact sites.

Fauna monitoring will be undertaken as follows:

- Annually during spring for selected sites within the three major fauna habitat areas (*Eucalyptus odorata* woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland) within the mining lease to specifically identify the presence of diamond firetail, brushtail possum and other selected species.
- Annually during spring for selected sites within the three major fauna habitat areas (*Eucalyptus odorata* woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland) within the mining lease for non-target species.
- Annually for pest animal presence and pest animal control success within the mining lease and surrounds.
- Weekly inspection of waterbodies located within the mining lease (including the TSF decant and process water dam) for all fauna species.
- Daily inspection of potential ‘fauna traps’ located within the mining lease (including temporary trenches and excavations).
- As required animal deaths as a result of project activities will be recorded.
- Post-closure fauna monitoring.

12. Compliance Criteria

Records will be retained to demonstrate:

- Native vegetation clearance to be in accordance with approved SEB Native Vegetation Management Plan.
- Regular surveying at selected sites to detect changes in abundance, composition or condition of fauna species from baseline shows no significant adverse impact.
- Regular checking of site water bodies to detect potential adverse impacts on migratory wetland bird species shows no adverse impacts to these species.
- SEB offset areas established and monitored to demonstrate objectives are being achieved.

13. Review and Reporting

The fauna monitoring results will be reviewed at least annually, the results assessed against management action efficiency. Depending on the results of this review, the management plan will either be revised or corrective actions will be implemented as applicable.

Reporting requirements include as a minimum:

- Hillgrove must provide to the Director Mines an annual Mining and Rehabilitation Compliance Report (MARCR) on operations carried out on the Lease and compliance with the approved MARP.
- Hillgrove must report any non-compliance with the Act, Lease Conditions and approved MARP to the Director of Mines. A verbal notification must be provided within 24 hours, after Hillgrove becomes aware of the non-compliance. A written report must be provided within 3 days of such time period as approved by the Director of Mines.
- Hillgrove must report to the Environment Protection Authority (EPA) (on EPA emergency phone number 1800 100 833) all incidents causing or threatening serious or material environmental harm (as defined in section 5 of the Environment Protection Act), upon becoming aware of the incident, in accordance with section 83 of the EP Act.

HILLGROVE RESOURCES	GENERAL FAUNA MANAGEMENT SOP
Date: July 2010	Version: 4
Relevant Plan	Fauna Management Plan

1. Background

This document addresses the general management of fauna during construction and operation of the mine. There is potential for interaction with fauna during construction and operation of the mine, this includes the potential for fauna to be involved in collisions with vehicles along the access road, trapped in project infrastructure and become habituated to people.

By following this procedure, the construction and operation of the project will minimise the potential for adverse affects to the general fauna of the area, be conducted in compliance with Hillgrove Resources' Environmental Management System.

2. Objectives

The objectives of this SOP are to:

- Minimise adverse impacts to fauna, in particular threatened species, during construction and operation of the project.
- Ensure the proper handling of injured or trapped fauna.

3. Relevant Forms

- Incident report.
- Trapped animal logsheet.

4. Procedures

4.1 Planning and Preparation

To ensure minimal impact upon fauna:

- A member of the Environment Department should be trained and/or experienced in the handling of wildlife to handle injured or trapped native fauna during construction and operation of the project.
- Regular information sessions should be conducted by Environment Department personnel to inform workers of procedures to follow should they encounter injured fauna.
- Ensure that incident reporting procedures are followed for any native fauna injured or trapped as a result of project activities.
- Appropriate wildlife handling equipment (e.g., gloves, sack and blanket) must be available at the Environment Department office.

- Hillgrove will consultant relevant experts including the Department of Environment and Heritage and Department of Water, Land and Biodiversity Conservation and if deemed appropriate, resident fauna species will be relocated (in agreed manner) to areas not subject to disturbance.

4.2 General Fauna Interaction

During construction and operation staff may encounter and interact with fauna during the course of their duties. If fauna is encountered:

- Personnel must not chase, harass, intimidate or otherwise interfere with native fauna in the project area. This includes shooting or trapping fauna.
- Personnel must not feed native fauna in the project area.
- In the event that native fauna becomes habituated to people, personnel must report this to Environment Department personnel for investigation.
- Should the habituation of fauna in the project area become a problem, the Environment Department should develop procedures to address this.

4.3 Vehicle Collisions

When personnel are driving vehicles:

- Personnel must follow all vehicle travel procedures outlined in the Traffic Management Plan.
- In the event that there is a collision between a vehicle and native fauna, personnel must:
  - Stop safely and assess whether the animal is injured or dead. If the animal is potentially dangerous (e.g., a snake), assess the condition of the animal from a distance and then inform the Environment Department.
  - If the animal is alive and not injured (as may happen in a low speed accident with a large animal), do not prevent the animal from escaping.
  - If the animal is injured, follow the procedures outlined in Section 4.4 below.
  - If the animal is dead, clear it from obstructing other vehicle traffic and submit an incident report to the Environment Department.

4.4 Rescuing Injured Wildlife

If personnel find injured wildlife (e.g., as a result of a collision with a vehicle or entrapment in project machinery) they must follow these steps:

- Ensure they are not at risk from either the injured animal or from other traffic or equipment.
- Assess whether the animal is suffering and beyond recovery. If this is the case, contact the Environment Department for advice as to how to euthanase the animal quickly and humanely.
- If the animal appears to be suffering from shock or is likely to recover from its injuries try to catch the animal with as little struggle as possible. If this is to be done:
  - If possible wear protective gloves.

  - Place a blanket, jacket or sack over the animal and wrap it up to prevent it from biting and scratching.
  - Once the animal is caught place it in a dark, quiet, warm (but not hot) place and deliver it to the Environment Department.
- If Environment Department personnel do not have comprehensive knowledge of what to feed the animal and how to manage the injured animal they must seek this information from a veterinarian, a local wildlife rescue group or regional Department of Environment and Heritage officers.
- If a rescue permit is required to care for the injured animal, this should be obtained by Environment Department personnel from regional Department of Environment and Heritage officers.

Appendix 5D

Threatened Species Management Plan

Kanmantoo Copper Project		
Threatened Species Management Plan		
HILLGROVE RESOURCES	**Issue:** Version 1	**Date:** November 2011
	Authorised by:	**Signature:**

1. Background

This plan provides for the management of the entire project area for the appropriate protection of threatened fauna and flora species and includes strategies for monitoring and maintaining the status of existing threatened fauna and flora populations.

1.1 Threatened Species

Where present, species of conservation significance in the mining lease are classified as significant at the:

- National level, i.e., listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- State level, i.e., listed under the *National Parks and Wildlife Act 1972* (NPW Act).

1.1.1 Threatened Fauna Species

At the National level, one migratory EPBC Act-listed species (the rainbow bee-eater, *Merops ornatus*) is a seasonal visitor to the mining lease. However, this species is not listed as a threatened species under the act. It is highly unlikely that the rainbow bee-eater will be impacted by mining activities as it is found in a range of habitats, is an aerial feeder and although nesting areas are often re-used, breeding pairs usually build a new nesting burrow each breeding season (DSEWPAC, 2011).

At the State level, four NPW Act listed species are known to occur within the mining lease. These are the:

- Diamond firetail (*Stagonopleura guttata*) listed as vulnerable.
- Peregrine falcon (*Falco peregrinus*) listed as rare.
- White-winged chough (*Corcorax melanorhamphos*) listed as rare.
- Common brushtail possum (*Trichosurus vulpecula)* listed as rare.

Refer to the threatened fauna profiles for more information on each species.

Common Name	Diamond firetail
Scientific Name	*Stagonopleura guttata*
Conservation Status	Vulnerable (NPW Act)
Description	Small finch-like bird. Crimson rump and black chest band (gray in females). Flanks are black, spotted white.

Habitat/Distribution	Endemic to south-eastern Australia, ranging from Carnarvon Ranges in Queensland to the Eyre Peninsula and Kangaroo Island in South Australia. Diamond firetails are found in open grassy woodland, heath and farmland or grassland with scattered trees (Birds Australia, 2006).
Distribution in Project Area	This species has been repeatedly recorded in the project area (Ecological Associates, 2006; DES, 2008; DES, 2009; DES 2010) with the majority of the sightings recorded in the *Allocasuarina verticillata* and adjacent *Eucalyptus odorata* woodlands located along the eastern edge of the mining lease (ML).
Threats	Habitat clearance. Grazing and disturbance by stock and rabbits. Inappropriate fire regimes. Predation by feral cats (Wilson and Bignall, 2009).
Recovery Plan	Regional recovery plan for threatened species and ecological communities of Adelaide and the Mount Lofty Ranges, South Australia (Wilson and Bignall, 2009)

Common Name	Peregrine Falcon
Scientific Name	*Falco peregrinus*
Conservation Status	Rare (NPW Act)
Description	Large bird of prey with a black “hood”, blue-black upperparts and creamy white chin, throat and underparts, which are finely barred from the breast to the tail. The eye ring is yellow and the beak is yellow, tipped black (Birds Australia, 2008a).
Habitat/Distribution	The peregrine falcon is found across Australia but is not common anywhere. It is found in most habitats, from rainforests to arid zones and at most altitudes from coast to alpine areas (Birds Australia, 2008a).
Distribution in Project Area	This species has been repeatedly recorded in the project area (Ecological Associates, 2006; DES, 2008; DES, 2009; DES 2010). A pair of falcons have previously been observed nesting within the walls of the open pit and have since been observed in the project area after expansion of the pit commenced.
Threats	Recreational activities and site disturbance (Wilson and Bignall, 2009).
Recovery Plan	Regional recovery plan for threatened species and ecological communities of Adelaide and the Mount Lofty Ranges, South Australia (Wilson and Bignall, 2009)

Common Name	White-winged chough
Scientific Name	*Corcorax melanorhamphos*
Conservation Status	Rare (NPW Act)
Description	Large bird, almost all black with the exception of a white wing patch, which can be observed when the bird is in flight. Has a curved beak and the adults have red eyes (Birds Australia, 2008b).
Habitat/Distribution	Found throughout most of eastern and southeastern mainland Australia. This species has been repeatedly recorded in the project area (Ecological Associates, 2006; DES, 2008; DES, 2009; DES 2010).
Distribution in Project Area	This species has been repeatedly recorded in the project area (Ecological Associates, 2006; DES, 2008; DES, 2009; DES 2010). Records were with the *Eucalyptus odorata* and *Acacia pycnantha* woodlands to the north of the pit.
Threats	Predation by feral cats and foxes. Weed invasion (Wilson and Bignall, 2009).
Recovery Plan	Regional recovery plan for threatened species and ecological communities of Adelaide and the Mount Lofty Ranges, South Australia (Wilson and Bignall, 2009)

Common Name	Common brushtail possum
Scientific Name	*Trichosurus vulpecula*
Conservation Status	Rare (NPW Act)
Description	Generally silver-grey fur, with a pale to white coloured underside and dark brown to black bush tail.
Habitat/Distribution	The common brushtail possum is found in most of eastern Australia, from far north Queensland right through New South Wales, all of Victoria, and into the southern half of South Australia, where suitable habitat exists.
Distribution in Project Area	This species has been repeatedly recorded in the project area (Ecological Associates, 2006; DES, 2008; DES, 2009; DES 2010) with the majority of the sightings recorded in the *Allocasuarina verticillata* and adjacent *Eucalyptus odorata* woodlands located north of the existing pit.
Threats	Habitat loss, habitat fragmentation, loss of tree hollows, fox predation, relocation by humans, competition for food, change in fire regimes
Recovery Plan	No recovery plan currently exists for this species

1.1.2 Threatened Flora Species

Management of the threatened vegetation communities that exist within the mining lease is addressed in the associated Native Vegetation Management Plan (Coffey Environments, 2010) and is not covered in this document.

No plant species of National (EPBC Act-listed) conservation significance have been recorded in the project area, and none are considered to be present.

Two flora species of State-listed (NPW Act-listed) have been recorded in the project area:

- *Diuris behrii* (Behr's cowslip orchid) listed as vulnerable.
- *Ptilotus erubescens* (hairy-tails) listed as rare.

Refer to the threatened flora profiles below for more information on these species.

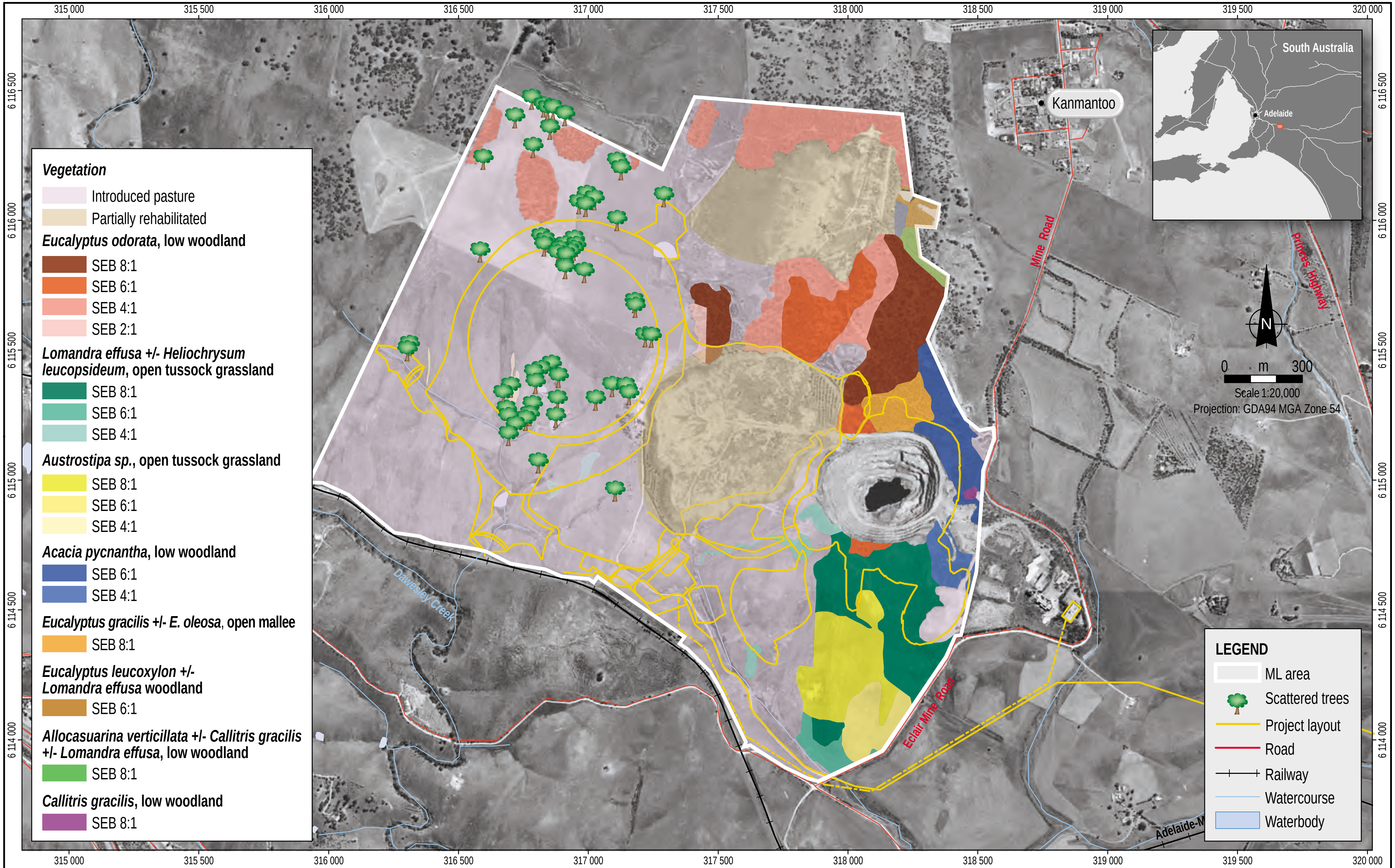
Common Name	Behr's cowslip orchid
Scientific Name	*Diuris behrii*
Conservation Status	Vulnerable (NPW Act)
Description	From the Family Orchidaceae, Behr's cowslip orchid is a perennial orchid that grows to a height of approximately 40 cm. The plant has three to six leaves, to about 20 cm in height, in a grass-like tussock. One to four yellow flowers appear from September to November and often have fine brownish striations inside (DEH, 2008).
Habitat/Distribution	Within the Adelaide Mount Lofty Ranges the preferred broad vegetation groups are grassy woodland and grassland. At the Hillgrove site the orchid has been observed within the *Eucalyptus odorata* woodland north of the existing pit.
Distribution in Project Area	The species was initially recorded to the north of the existing open pit during the spring 2007 survey (Ecological Associates 2007b). The locations of individual *D. behrii* plants that occur within the project footprint were flagged for future identification at this time. Approximately 80 plants were flagged. A number of plants have since been relocated to a nursery in Littlehampton where they will be handed over to the Native Orchid Society of SA for maintenance and propagation.
Threats	Grazing and disturbance by kangaroos and rabbits. Weed invasion. Residential and commercial development.

Recovery Plan	Regional recovery plan for threatened species and ecological communities of Adelaide and the Mount Lofty Ranges, South Australia (Wilson and Bignall, 2009)

Common Name	Hairy tails
Scientific Name	*Ptilotus erubescens*
Conservation Status	Rare (NPW Act)
Description	Small tufted herb. Has tufted, feathery flower heads. Inconspicuous when not in f lower , looks like a grass and grows about 0.5 m in height.
Habitat/Distribution	There is one historical record of *Ptilotus erubsecens* within the project area. This record is from the Biological Database of South Australia (managed by the Department of Environment and Natural Resources) and dates from 1994. Despite this historical record, no evidence of *P. erubescens* has been found in subsequent details surveys of the area specifically targeting threatened species (Ecological Associates, 2006, 2007a, 2007b).
Threats	Habitat loss, habitat fragmentation.
Recovery Plan	No recovery plan currently exists for this species.

A further 19 species of regional conservation significance (an unofficial regional conservation rating derived for regional conservation planning purposes) have been recorded within the mining lease. These are:

- South Australian blue gum (*Eucalyptus leucoxylon ssp. leucoxylon*).
- Native wheat-grass (*Elymus scaber var. scaber*).
- Curly wire-grass (*Aristida contorta*).
- Brush wire-grass (*Aristida behriana*).
- Small-flower wallaby-grass (*Austrodanthonia setacea*).
- Crested spear-grass (*Austrostipa blackii*).
- Bulbine lily (*Bulbine bulbosa*).
- Blue grass-lily (*Caesia calliantha*).
- Pointed centrolepis (*Centrolepis aristata*).
- Sweet hound’s tongue (*Cynoglossum suaveolens*).
- *Hibbertia crinite*.
- Scaly buttons (*Leptorhynchos squamatus ssp. squamatus*).
- Hairy stylewort (*Levenhookia dubia*).
- Small mat-rush (*Lomandra nana*).
- Twiggy daisy-bush (*Olearia ramulosa*).
- Narrow-leaf plantain (*Plantago gaudichaudii*).
- Brackern fern (*Pteridium esculentum*).
- Purple-leaf groundsel (*Senecio picridioides*).
- Smooth solenogyne (*Solenogyne dominii*).



Source:
Place names, roads, drainage and cadastre from DEH, SA (optimum scale 1:50,000)
Project layout from Hillgrove Resources
Vegetation survey from Ecological Associates

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Date: 30.06.2008
MXD: HillgroveResources_KanmantooGIS
Job No: 5000_07_FI_F001_GIS_AI

Hillgrove Copper Pty Ltd

Kanmantoo Copper Project

HILLGROVE RESOURCES

ML area vegetation

Figure No: 1

2. Relevant Legislation

Flora and fauna are protected at both the State and National level. Relevant legislation includes:

State:

- *Native Vegetation Act 1991.*
- *National Parks and Wildlife Act 1972.*
- *Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986.*
- *Mining Act 1971.*

Commonwealth:

- *Environmental Protection and Biodiversity Conservation Act 1999.*

3. Statutory Responsibilities

3.1 Mining Lease Conditions

A mining lease (ML) for operations at the Kanmantoo Copper Project has been issued (ML 6345), subject to conditions, under the Mining Act. These conditions must be complied with during all phases of the mining operation. Specifically, the following conditions must be adhered to in relation to threatened flora and fauna management:

- Condition 5: The Lessee must ensure that no uncontrolled fires caused by mining operations effect remnant vegetation on or off the mine site.

- Condition 13: The Lessee must, in constructing and operating the Lease, ensure that there are no net adverse impacts from the site operations on the native fauna abundance or diversity in the Lease area and in adjacent areas.

- Condition14: The lessee must, in constructing and operating the Lease, ensure that all clearance of native vegetation is authorised under appropriate legislation and ensure no permanent loss of abundance or diversity on or off the Lease.

- Condition 15: The Lessee must, in constructing and operating the Lease, ensure no introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weeds or pest species in the Lease area and adjacent areas caused by mining operations.

A number of mining lease conditions associated with mine closure and rehabilitation are also related to fauna management, however these are addressed in the project Mine Closure and Completion Plan (Coffey Natural Systems, 2009) and are not addressed in this management plan.

3.2 PEPR Commitments

A Program for Environmental Protection and Rehabilitation (PEPR) for the Kanmantoo Copper Project has been approved under the Mining Act for use during all phases of the mining operation (Coffey Environments, 2011). The PEPR includes detailed and specific information on environmental control measures and establishes outcome-based performance criteria for the mining operation, presented in the table below. This environmental management plan (EMP) incorporates commitments made in the PEPR that relate to flora and fauna management.

Table 1 Control measures and performance criteria for flora and fauna management

Outcome	Assessment Criteria	Summary of Control Measures
No net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.	Post-mining fauna survey within the ML and adjacent areas shows no net adverse impacts on native fauna abundance or diversity (as determined by flora and fauna consultant) compared to baseline (as shown in Appendix 5A and 5B of the PEPR (Coffey Environments, 2011)) that can be reasonably attributed to mining operations.	Establishment and ongoing management of significant environmental benefit (SEB) offset areas (including the implementation of a threatened species management plan). Project infrastructure located outside areas of very good quality *E. odorata* low woodland where possible. Clearly identifying and documenting areas to be protected and areas to be cleared. Minimising the area of direct land clearing. Progressively rehabilitating cleared land. Additional surveying of diamond firetail populations.
No introduction of new pests (including feral animals), nor increase in abundance of existing pest species in the lease area and adjacent areas caused by mining operations.	Annual fauna surveys within the ML indicate no significant increase in abundance of pest (feral) species and no introduction of new pest species that can be reasonably attributed to mining operations (as determined by flora and fauna consultant) when compared to baseline (as shown in Appendix 5A and 5B of the PEPR).	Prohibition of pets and feeding of animals. Controlled extermination of introduced fauna species. Internal and external auditing to assess housekeeping standards (in particular litter control). Implementation of Hillgrove's Feral Animal Control standard operating procedure (SOP).
All clearance of native vegetation is authorised under appropriate legislation and no permanent loss of abundance or diversity on or off the lease due to operations.	**Leading Indicator Criteria:** Annual flora surveys within the ML (including photographic monitoring) show no significant mine related change (as determined by flora and fauna consultant) in remnant vegetation (not cleared for mining) compared to baseline (as shown in Appendix 4A and 4B of the PEPR). **Assessment Criteria:** Review of site clearance records and maps of cleared areas to show clearance is in accordance with approved Native Vegetation Management Plan (Appendix 9 of the PEPR). At mine closure, flora survey to show onsite revegetation has been undertaken in accordance with the approved Native Vegetation Plan (see Appendix 9 of the PEPR).	Clear identification and documentation of areas to be protected and areas to be cleared. Ensuring areas to be disturbed are minimised and clearing complies with relevant requirements. Implementation of the Native Vegetation Management Plan and Flora Management Plan. Clearing to be undertaken in accordance with Hillgrove's Native Vegetation Management Plan and Ground Disturbance SOP . Establishment and ongoing management of SEB offset areas. Avoidance of threatened vegetation communities and flora species during the design phase where practicable. Progressive rehabilitation. 'No go zones' clearly defined.

Outcome	Assessment Criteria	Summary of Control Measures
No uncontrolled fires caused by mining operations effect remnant vegetation on or off the mine site.	Annual flora surveys within the ML (including photographic monitoring) show no significant fire related change (as determined by flora and fauna consultant) in remnant vegetation (not cleared for mining) compared to baseline (as shown in Appendices 4A and 4B of the PEPR) resulting from uncontrolled fires caused by mining operations.	Clear identification and documentation of areas to be protected and areas to be cleared. Installation of fire breaks. Control measure relating to fire hazards are summarised in Section 7.15 of the PEPR (Coffey Environments, 2011). All fires caused by mining operations are controlled.
No introduction of new weeds and plant pathogens, nor increase in abundance of existing weed species in the lease area and adjacent areas caused by mining operations.	Annual flora surveys within the ML (including photographic monitoring) show no significant increase in weeds or plant pathogens and no introduction of new declared weeds that can be reasonably attributed to mining operations (as determined by flora and fauna consultant) compared to baseline (as shown in Appendices 4A and 4B of the PEPR).	Inspection and wash down of vehicles and project equipment. Control of declared weed species. Regular monitoring for weed outbreaks and implementation of weed control measures. Minimisation of disturbance areas. Implementation of Hillgrove's Weed and Pathogen Management SOP.

4. Issues

Three major fauna habitat areas have been identified in the project area (*Eucalyptus odorata* low woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland), threatened flora and fauna species may be affected by clearance of these areas as a result of project activities. Key issues of concern to threatened flora and fauna are:

- Removal and/or disturbance of habitat.
- Reduced level of resources.
- Increased abundance of feral animals.
- Increased abundance of weed species.

5. Objectives

The objectives of this management plan include:

- No significant adverse impact to the abundance and diversity of threatened fauna species in the lease area and adjacent areas.
- No significant adverse impact to the abundance of threatened flora species in the lease area and adjacent areas.

6. Associated Plans

- Native Vegetation Management Plan.
- Flora Management Plan.
- Noise and Vibration Plan.
- Traffic Management Plan.

7. Standard Operating Procedures

- General Fauna Management.
- Excavation Inspection.
- Feral Animal Control.
- Weed and Pathogen Management.
- Ground Disturbance.

8. Forms

- Trapped Animal Logsheet.
- Incident Report.
- Ground Disturbance Certificate.
- Equipment Inspection Certificate.

9. Responsibilities

9.1 General Manager

The general manager will:

- Provide resources to implement the threatened species management plan.

9.2 Environmental Coordinator

The environmental coordinator will:

- Implement the threatened species management plan.
- Manage the SEB offset area.
- Coordinate monitoring activities.
- Report monitoring results to government agencies.
- Review monitoring results, assess management action efficiency against results and either revise this management plan or implement corrective actions as applicable.
- Train and induct all employees on the requirements of the threatened species management plan.

9.3 Department Managers

The department managers will:

- Support and promote the importance of minimising impact on the environment.
- Ensure that personnel implement requirements of the threatened species management plan.

9.4 All Personnel

All personnel will:

- Comply with requirements of the threatened species management plan.
- Undertake an environmental induction.

10. Management Procedures

10.1 General Management Procedures

General flora and fauna management procedures, which are also relevant to the management threatened flora and fauna, are covered in the General Fauna Management SOP and Ground Disturbance SOP and include:

- Establishment and ongoing management of SEB offset areas (including the implementation of a threatened species management plan).
- Project infrastructure located outside areas of very good quality *E. odorata* low woodland where possible.
- Avoidance of threatened vegetation communities and flora species during the design phase where practicable.
- Erecting an appropriate level of fencing, bunding or flagging tape to mark ‘no-go’ zones to ensure areas to be protected are clearly defined, identified and avoided.
- Clearly identifying and documenting areas to be protected and areas to be cleared.
- Minimising the area of direct land clearing.
- Installation of fire breaks.
- Progressively rehabilitating disturbed areas and avoiding unnecessary future disturbance of these areas.
- Prohibition of pets and feeding of animals.
- Control of all declared weed species.
- Inspection and wash down of all vehicles and project equipment.
- Controlled extermination of introduced fauna species.
- Internal and external auditing to assess housekeeping standards (in particular litter control). Implementation of Hillgrove’s Feral Animal Control SOP.

10.2 Management Procedures Specific to Threatened Species

Management procedures specific to the threatened species listed in Sections 1.1.1 and 1.1.2 include:

- Annual surveys to monitor the presence and distribution of threatened species within the project area.
- Translocation of threatened plant species identified during flora surveys prior to land clearance of designated mining areas. Collected plants are to be transported to a nursery facility managed by COOE Pty Ltd located at Littlehampton, the plants are then to be handed over to the Native Orchid Society of SA for maintenance and propagation.
- Avoid disturbance of identified nests during the breeding season i.e., diamond firetail, August to January; white-winged chough, August to December; peregrine falcon, August to December.

- Stockpiling of tree stumps and large trees containing hollows that have been removed during land clearance. The tree stumps and large trees will be relocated into revegetated areas to provide ready-made habitat for fauna that utilise hollows i.e., brushtail possums and peregrine falcons.
- Management of grasses (i.e., staged slashing program) to minimise impact to feeding by beautiful firetail.

11. Monitoring Procedures

Ongoing fauna and flora monitoring will be conducted to allow identification of any impacts of mine construction and operations on threatened native fauna and flora. Monitoring will be conducted in the major habitat types present on the mining lease, which are areas of remnant *Eucalyptus odorata* low woodland and *Lomandra effusa* grassland and *Austrostipa* spp. grassland in areas remote from project activity (see Figure 1).

11.1 Fauna

11.1.1 Method

Threatened fauna monitoring will be conducted as part of the annual spring fauna surveys and will involve targeted counts for threatened species at selected sites to allow assessment of:

- Changes in the abundance, composition or condition of threatened species.
- Ongoing impacts to fauna as a result of project-related activities.
- Success of rehabilitation and/or relocation activities for threatened species.
- Increases in the density and distribution of pest animal infestations.
- Introduction of new pest animal species.
- Diversity and health of waterbird populations at permanent waterbodies.

Survey methods will include visual observations, spotlighting, bird census transects, trapping and active searching.

11.1.2 Monitoring Sites and Frequency

Monitoring sites are located within the three major fauna habitat areas (*Eucalyptus odorata* low woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland) within the mining lease. Inspection and monitoring is also to be conducted prior to, during and following disturbance. The number of sites to be sampled during monitoring is calculated to allow for valid statistical comparisons between control and impact sites.

Fauna monitoring will be undertaken as follows:

- Annually during spring for selected sites within the three major fauna habitat areas (*Eucalyptus odorata* woodland, *Lomandra effusa* grassland and *Austrostipa* spp. grassland) within the mining lease to specifically identify the presence of diamond firetail, brushtail possum and other selected species in the mining lease.

- Annually for pest animal presence and pest animal control success within the mining lease and surrounds.
- Weekly inspection of waterbodies located within the mining lease (including the TSF decant and process water dam) for the presence of fauna species.
- Daily inspection of potential ‘fauna traps’ located within the mining lease (including temporary trenches and excavations).
- As required animal deaths as a result of project activities will be recorded through the incident reporting system.

11.2 Flora

11.2.1 Method

Monitoring sites are surveyed and photographed to allow assessment of:

- Changes in the abundance, composition or condition of vegetation communities, particularly threatened vegetation communities (*Eucalyptus odorata* low woodland and *Lomandra effusa* ± *Heliochrysum leucopsideum* open tussock grassland).
- Ongoing impacts to threatened flora as a result of project-related activities.
- Accumulation of litter.
- Landscape function analysis (LFA).

Transects and photo monitoring will be used to allow the comparison of quantitative data on threatened flora abundance in the different vegetation communities, and between near-mine and control sites.

Monitoring is to be conducted in the 24 established monitoring sites (Figure 2).

11.2.2 Monitoring Sites and Frequency

A minimum of three transects have been established within each of the following major vegetation associations:

- *Austrostipa* spp. open tussock grassland.
- *Lomandra effusa* ± *Heliochrysum leucopsideum* open tussock grassland.
- *Eucalyptus odorata* low woodland.

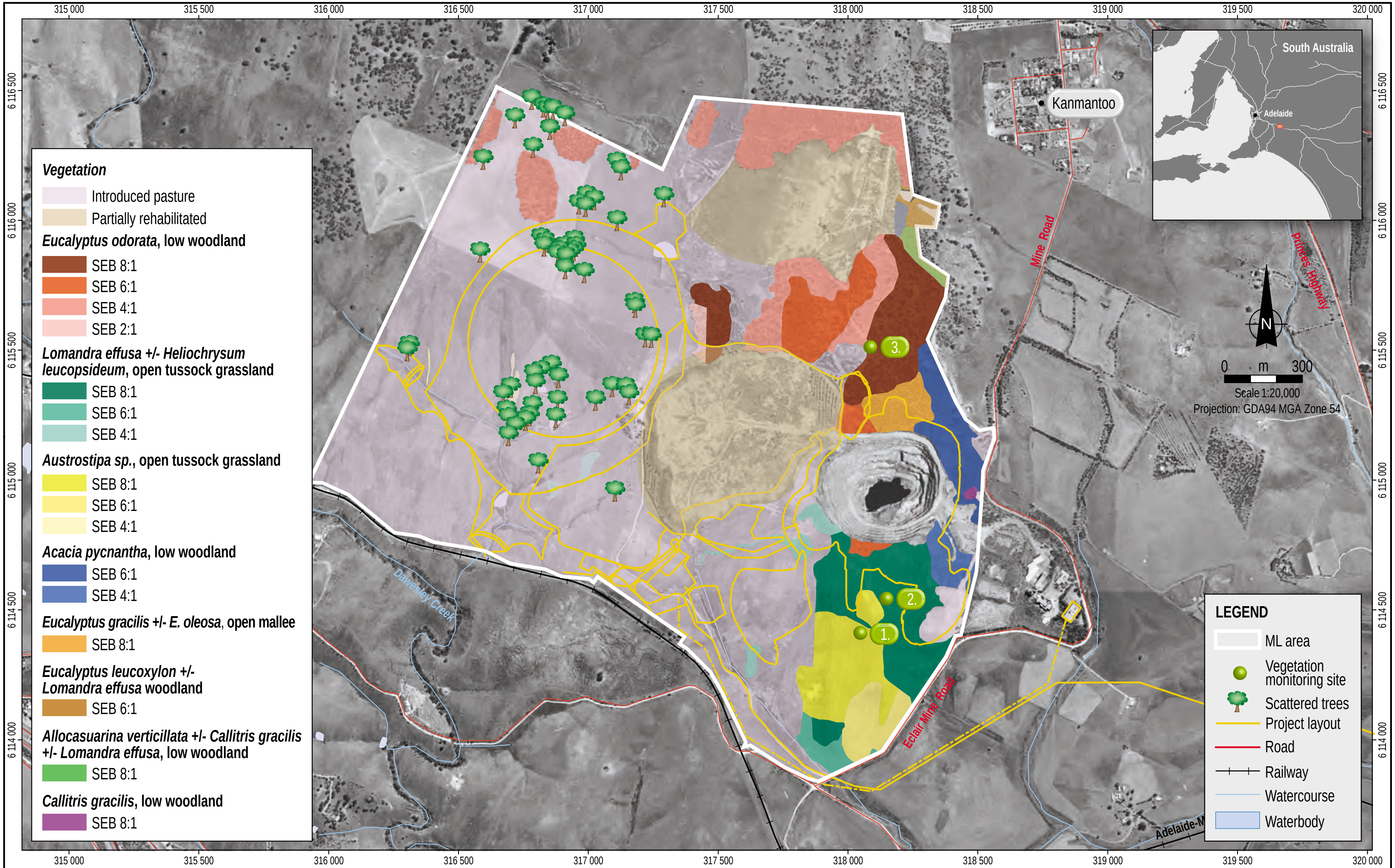
Transect locations and the permanent vegetation monitoring sites positions are listed in Table 2 and shown on Figure 2.

Vegetation monitoring will be undertaken as follows:

- Annually during spring of quadrats listed in Table 2 to identify the presence of *Diuris behrii* (Behr’s cowslip orchid) and *Ptilotus erubescens* (hairy tails).
- Threatened plants observed during the survey will be flagged for translocation to a nursery facility managed by COOE Pty Ltd located at Littlehampton, the plants are then to be handed over to the Native Orchid Society of SA (*Diurus behrii*) or local land care group (*Ptilotus erubescens*) for maintenance and propagation.

Table 2 Location and description of permanent vegetation monitoring sites

Site name	UTM (WGS84)		Transect position	Vegetation association	Condition (SEB ratio)
	Easting	Northing			
KANLOM 1	317961	6114064	Start	*Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland	8:1
KANLOM 1	317967	6114049	End		
KANLOM 2	317963	6114040	Start	*Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland	8:1
KANLOM 2	317964	6114024	End		
KANLOM 3	317931	6114051	Start	*Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland	8:1
KANLOM 3	317922	6114028	End		
KANODO 1	317515	6115604	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 1	317470	6115623	End		
KANODO 2	317528	6115551	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 2	317505	6115592	End		
KANODO 3	318229	6115760	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 3	318260	6115786	End		
KANODO 4	316754	6116204	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 4	316788	6116247	End		
KANODO 5	316751	6116127	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 5	316746	6116089	End		
KANODO 6	316537	6116233	Start	*Eucalyptus odorata* (Peppermint Box) Open Woodland	8:1
KANODO 6	316579	6116250	End		
KANSTI 1	318063	6114321	Start	*Austrostipa scabra* (Spear grass) Tussock Grassland	4:1
KANSTI 1	318038	6114335	End		
KANSTI 2	318008	6114283	Start	*Austrostipa scabra* (Spear grass) Tussock Grassland	4:1
KANSTI 2	318005	6114311	End		
KANSTI 3	318130	6115752	Start	*Austrostipa scabra* (Spear grass) Tussock Grassland	4:1
KANSTI 3	318131	6115768	End		



Source:
Place names, roads, drainage and cadastre from DEH, SA (optimum scale 1:50,000)
Project layout from Hillgrove Resources
Vegetation survey and monitoring sites from Ecological Associates

coffey natural systems

Date: 30.06.2008	Hillgrove Copper Pty Ltd	HILLGROVE RESOURCES	Established flora monitoring sites	Figure No: 2
MXD: HillgroveResources_KanmantooGIS				
Job No: 5000_07_FI_F002_GIS_AI	Kanmantoo Copper Project			

12. Review and Reporting

The fauna and flora monitoring results will be reviewed at least annually, the results assessed against management action efficiency. Depending on the results of this review, the management plan will either be revised or corrective actions will be implemented as applicable.

Reporting requirements include as a minimum:

- Hillgrove must provide to the Director of Mines an annual Mining and Rehabilitation Compliance Report (MARCR) on operations carried out on the mining lease and compliance with the approved PEPR.
- Hillgrove must report any non-compliance with the Act, Lease Conditions and approved PEPR to the Director of Mines. A verbal notification must be provided within 24 hours, after Hillgrove becomes aware of the non-compliance. A written report must be provided within 3 days of such time period as approved by the Director of Mines.
- Hillgrove must report to the Environment Protection Authority (EPA) (on EPA emergency phone number 1800 100 833) all incidents causing or threatening serious or material environmental harm (as defined in section 5 of the Environment Protection Act), upon becoming aware of the incident, in accordance with section 83 of the EP Act.

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Appendix 6

Socio-economic

Appendix 6A

Stakeholder and Community Engagement Plan

Prepared by:

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HILLGROVE RESOURCES LIMITED

Updated Stakeholder and Community Engagement Plan

April 2014

Contents

Version control code	Status	Date	Person supplied
v1 for review	DRAFT	9 April 2014	Steve McClare GM Kanmantoo Copper Mine

1. Statement of Commitment to Effective Stakeholder and Community Engagement

The Board and Executive Management of Hillgrove Resources Limited (the company) sees effective stakeholder and community engagement as a key to success for its Kanmantoo Copper Mine development. The company particularly recognises the unique challenges and opportunities for its Kanmantoo operation working in an environmentally sensitive area and in close proximity to two small regional townships with residents enjoying a rural lifestyle.

The company understands that it has obligations under the SA Mining Act to consult with the community and document issues of concern and steps taken to address these. Beyond this the company is committed to leading practice that seeks to involve the community with a view to:

- ensuring the local and regional community is kept fully informed about each stage of the mine's development through the provision of clear, accurate and unbiased information in appropriate formats and delivered through a variety of media
- building stakeholder and community awareness in, understanding of, and support for, the company and the Kanmantoo Copper Mine
- building the company's understanding of its stakeholders and the wider community with a focus on addressing priority issues of concern in a timely manner as well as opportunities as they arise
- identifying and realising opportunities for the company to participate as a member of the community and deliver real and measurable benefits to the community
- encouraging community input into topics and issues that help to inform and improve the company's decision making

The company recognises and supports the South Australian Government's policy for effective community engagement contained in its guideline document 'Better Together' (SA Government 2012) [1]. In line with these guidelines, the company is committed to:

- clearly understanding the purpose of effectively engaging with stakeholders and the wider community
- communicating clearly, in accurate and unbiased terms
- communicating in a timely fashion with stakeholders and the wider community with particular appreciation of the likely changes to priorities through various stages of the mine's development
- identifying and involving the full range of stakeholders and the wider community likely to be impacted by our operations
- understanding, appreciating and being sensitive to the nature of the community in which we are operating
- behaving in a genuine manner with a particular emphasis on 'doing what we say we will do'
- encouraging innovative and creative solutions to issues and realising opportunities by listening to and appreciating community input.

April 2014

[1] Better Together: principles of engagement - a foundation for engagement in the South Australian government (SA Government 2012)

2. About the Plan

The Stakeholder and Community Engagement Plan (SCEP) for the Kanmantoo Copper Mine project has been updated in April 2014 as part of Hillgrove Resources Limited's commitment to good practice and continual improvement.

The updated SCEP:

- recognises and acknowledges experience in the implementation of the current plan in the spirit of continual improvement
- recognises the performance orientated (risk based) formats sought by the mining regulator (DMITRE) in the SA Mining Act review 2011
- reflects policy developments of the SA Government and the South Australian Chamber of Mines and Energy (SACOME) in providing direction for effective community engagement
- reflects draft guidelines for Community Consultative Committees[2] currently being developed by South Australian Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE). The Kanmantoo Callington Community Consultative Committee (KCCCC) is an important community forum which is supported by the company

3. Guiding principles for Stakeholder and Community Engagement

Hillgrove Resources Limited sees effective community engagement as a key success factor in striving to be a leading practice metalliferous mining company with a working copper mine in the Adelaide Hills of South Australia.

The company recognises the unique challenges of operating a mine in a sensitive environmental precinct near regional populations. The Board and executive team of the company are committed to proactively working with all stakeholders and the wider community who may be impacted by our operation.

The company's approach to community engagement is based on the good practice principles of the South Australian Government's guidelines for effective community engagement contained in their policy document 'Better Together (2012)'. In line with Better Together principles, the company's approach is designed to lead to six important outcomes:

1. '[3]We know why we are engaging and we communicate this clearly
2. We know who to engage
3. We know the background and history
4. We begin early
5. We are genuine
6. We are creative, relevant and engaging'.

This approach also reflects the principles of the SACOME Code of Practice for Community and Stakeholder Engagement for the South Australian Resources Industry in recognising that effective community engagement features:

1. involving stakeholders and communities of interest in the decision-making processes of the company in order to '[4]promote more informed, better understood and sustainable decisions'

[2] ibid pp 8

[3] Better Together SA Government 2012 pp 12 source: http://saplan.org.au/better_together/principles/5-we-are-genuine

2. respectfully acknowledging the interests of stakeholders and the wider community and valuing their input in order to '[5]build trust and positive relationships with and between stakeholder' groups'.

The five key principles for effective community engagement under the SACOME Code are:

1. Inclusivity
2. Transparency and accountability
3. Clarity, accuracy and balance
4. Accessibility and timeliness
5. Meaningfulness and respect

The 'Better Together' and the SACOME Code principles can be mapped against one another:

Better Together	**SACOME Code of Practice**
We know why we are engaging and we communicate this clearly	Transparency and accountability Clarity, accuracy and balance Meaningfulness and respect
We know who to engage	Inclusivity
We know the background and history	Clarity, accuracy and balance Meaningfulness and respect
We begin early	Accessibility and timeliness
We are genuine	Transparency and accountability Meaningfulness and respect
We are creative, relevant and engaging	Clarity, accuracy and balance Meaningfulness and respect

[4] SAC OME Code of Practice for Stakeholder and Community Engagement (2010 reviewed 2013) source: http://www.sacome.org.au/

[5] ibid

4. Stage of the mining operation and its impact on the SCEP

The relationship with the community changes over time as the mining operation moves through stages including exploration, feasibility studies, approvals processes, construction, commissioning and operating and rehabilitation and mine closure.

Hillgrove Resources sought to effectively engage with the community at a very early stage in the development of the project (2005). This early relationship was based on keeping the community fully informed by providing accurate, complete and unbiased information about the project.

During the approvals process for the original mine lease application (2009) the relationship between the company and the community became more structured with the formation of the Kanmantoo Callington Community Consultative Committee (KCCCC). This group arose as a natural progression from broader public forums and shifted the focus from the company informing the community to the company and the community engaging in meaningful consultation to add value and improve decision making.

Now that the mine is fully operational, it is appropriate that the company updates its SCEP. Future decisions for the company may include continually improving day to day operations, further approvals and eventually rehabilitation and mine closure. The updated SCEP looks to involve the community in these next steps.

5. Project summary

The Kanmantoo Copper Project is located in the Adelaide Hills region of South Australia. The area has a long history of mining with over 39,000 tonnes of copper metal having been extracted by various operators over time. Despite this it remains one of the most under explored and prospective base metal provinces in Australia, showing outstanding potential for copper-gold and silver-lead-zinc mineralisation.

The project's location, 55 kilometres by road from Adelaide's CBD, brings significant inherent operating and capital cost advantages. The mine accesses low cost grid power and water. Ample water is available to operate the mine with the majority of its process water coming from treated waste water from the District Council of Mt Barker's Laratinga Water Treatment Plant. The water is piped about 15km form Mt Barker to Callington. Hillgrove assisted in building this infrastructure which now provides environmental and other benefits through sustainable water resources management.

The mine is situated three kilometres from the South Eastern Freeway which is the main dual carriageway leading to Adelaide and the export port of Port Adelaide.

The mine's location in the beautiful and well serviced Adelaide Hills helps to attract and retain a high quality workforce who predominantly live within the region. Approximately 200 personnel work at the mine.

The Project is a ten year open-cut mine with throughput of over 2.8Mt pa, producing approximately 80,000t of concentrate, containing about 20,000t of copper metal and associated gold and silver per annum with exploration potential for further copper-gold mineralisation. The potential for further discoveries at Kanmantoo is high. The deposit appears to remain open along strike and down dip where additional drilling could materially increase the resource inventory.

6. **Understanding the community**

The location of the Kanmantoo Copper Mine places it in close proximity of two small townships, Kanmantoo and Callington and about 15 kilometres from the Regional Centre of Mt Barker.

The local community (those living and working within 5 kilometres of the mine) has a strong identity and to respect this fact and to acknowledge that these residents are likely to be impacted more directly that those living further away, the company has made a clear distinction between the local community and the regional community.

The regional community covers the local government area (LGA) of the District Council of Mt Barker (DCMB). Amongst other things, economic and social benefits of the mine are likely to be felt across this area and community services like hospitals and high schools are located here.

The company also appreciates that there are implications for the state as a whole as a result of the scale of the operation at Kanmantoo Copper Mine and its potential to return benefits to this wider group.

Local community

Like any community the local communities of Kanmantoo and Callington represent a diverse range of interests, priorities and perspectives. However it is clear to the company that any consideration of benefits for the community that may arise from the mine is based on the company having the confidence of the community that they can operate in harmony with other community pursuits including residential life and existing businesses like farming and manufacturing.

In December 2013 Hillgrove Resources Limited engaged with the community on plans for a mine life extension of two years (from 2017 – 2019) for its Kanmantoo Copper Mine. It was plain that community support for such an extension required confidence in the community that environmental matters like emissions of dust, noise and vibration could be effectively managed. Whilst the benefits to the community of an extension to mine life were recognised particularly by some groups, the company saw the priority as building community confidence in its environmental performance.

The priorities for the local community were captured in a summary of views expressed during this consultation and these have been adopted by the company and the community (through the Kanmantoo Callington Community Consultative Committee (KCCCC)) as its action list (Appendix 2).

Regional communities

Relative competitiveness

The Regional Institute Australia (RIA) has developed a measure of relative competitiveness for the nation's Local Government Areas (LGAs). The measure known as [In]Sight: Australia's regional competitiveness index is available from the RIA website (source: http://insight.regionalaustralia.org.au)

The index helps to understand how the region is performing in respect of a number of indicators for relative competitiveness. The benefit of this understanding for the company is to help identify how the presence of the mine may assist the community to improve its competitiveness.

The index allows for comparisons to be made between LGAs and benchmarks these nationally in the form of rankings against the 560 LGAs across the county.

A full description of the data used, the definitions of the various indicators and how the comparisons are made is available on the RIA website. It is noted that caution must be taken to recognise that the data is used to generate rankings only and is therefore limited in its scope

The indexes for DCMB and the Rural City of Murray Bridge are shown below.

	Mount Barker (DC)		Murray Bridge (RC)	
	Value	National Ranking	Value	National Ranking
Institutions	Theme ranking	197	Theme ranking	390
Public service	7.50%	143	5.40%	320
Infrastructure & Essential Services	Theme ranking	143	Theme ranking	208
Aviation infrastructure	29.5	212	65.6	308
Port infrastructure	29.5	176	65.6	247
Access to tertiary education services	5.00%	121	2.00%	308
Access to technical or further education	3.50%	163	3.30%	214
Access to hospital services	0.0059	372	0.0069	334
Access to allied health services	12.00%	138	11.00%	202
Access to GP services	4.9	262	5.4	178
Police services	0.0031	155	0.0033	135
Road infrastructure	3.7	316	3.6	303
Access to primary education services	4.9	305	4.4	287
Access to secondary education services	5.1	184	4.4	171
Rail infrastructure	21.2	395	3.8	55
Economic Fundamentals	Theme ranking	136	Theme ranking	208
Building approvals	$1.14	117	$1.01	148
Wage/labour costs	$41,632	227	$34,239	454
Human Capital	Theme ranking	72	Theme ranking	384
University qualification	19.00%	121	7.20%	526
Technical qualification	37.80%	83	31.30%	318
Lifelong learning	44.50%	280	45.10%	245
Early school leavers	52.10%	164	65.80%	442
Health	51.40%	89	63.80%	374
English proficiency	97.30%	39	91.70%	425
Early childhood performance	16.60%	112	11.80%	35
Primary school performance	34.80%	164	21.50%	422
Secondary school performance	29.10%	91	11.90%	424
Labour Market Efficiency	Theme ranking	179	Theme ranking	485
Unemployment rate	4.50%	211	7.30%	474
Young unemployment	11.60%	314	13.00%	390
Participation rate	80.70%	73	68.90%	463
Skilled labour	30.80%	285	19.90%	528
Welfare dependence	15.60%	147	21.20%	389
Technological Readiness	Theme ranking	98	Theme ranking	319

Internet connection	72.50%	51	55.00%	286
Broadband connections	72.00%	100	55.20%	453
Businesses in technology and related industries	7.10%	111	3.10%	325
Workers in ICT and electronics	1.70%	125	0.80%	235
Business Sophistication	Theme ranking	173	Theme ranking	344
Economic diversification	0.05	96	0.17	226
Dominance of large employers	3.20%	340	2.90%	203
Exporters, importers, wholesalers	0.23%	89	0.08%	298
Income source: Own business	$16,034	235	$14,966	260
Access to local finance	0.30%	294	0.34%	277
Innovation	Theme ranking	146	Theme ranking	421
Human resources in science and technology	3.90%	133	1.50%	413
Research and development managers	0.06%	140	0.00%	257
Presence of research organisations	0.00%	70	0.00%	70
Market Size	Theme ranking	60	Theme ranking	256
Business turnover	$15,570,015,000	34	$6,836,025,000	243
Working age population	199,194	90	120,526	254
Natural Resources	Theme ranking	277	Theme ranking	303
Mineral resources	1.60%	226	1.00%	283
Timber resources	5.40%	55	0.00%	118
Commercial fishing and aquaculture	0.21%	86	0.06%	142
Coastal access	29.5	176	65.6	247
National Park	37.1	466	17.7	383
Net primary productivity	29.2	39	1.2	420

Date: 7/4 2014

Data provided by Region Australia Institute

http://www.regionalaustralia.org.au

This sort of information may be important to various groups such as those seeking to invest in the region but it also provides a valuable profile of the region's competitiveness for the whole community in order to contextualise issues of importance like the availability of a skilled workforce and youth unemployment for example.

Adaptive capacity

Another measure to help characterise the region is its adaptive capacity. This is a measure of the region's capacity to manage change. Change could be the result of a major enterprise coming to the area or closing down, or an environmental threat like climate change as well as any number of other factors.

The Adelaide Hills, Fleurieu and Kangaroo Island RDA Board produced its latest Regional Roadmap in 2013. In this document they have presented the adaptive capacity for the DCMB as well as other LGAs in the region. The index was developed by EconSearch for the RDA and full details of the methodology are provided in the Roadmap which is available at http://rdahc.com.au/

In summary, the DCMB is 'strong across most capital groups with the exception of social capital where voluntary work and community strength are lower than the median for LGAs in South Australia. Standouts include a diverse economy, relatively lower proportions of persons 65 years of age and over and lower levels of lone person households'[6].

7. Stakeholder list

Better Together defines the community as 'individuals and groups of people (such as residents) who are not part of an organised structure or group'.

Local and regional communities

- The 'local' community of people in the immediate area and who are directly affected by project-related activities comprise nine landowners, traditional owners (the Peramangk people), local business owners and residents of Kanmantoo and Callington (approximately 900 people).
- The wider communities within the DCMB comprise residents and business owners and others who provide community services for example. Murray Bridge is another important centre about 20 kilometres from the mine that has a similar function to Mt Barker but looser ties with the Adelaide metropolitan area.

Better Together defines stakeholders as 'people who are organised under the banner of a defined group or organisation, often providing representation to a broader group'.

External stakeholders

The following organisations and groups represent particular stakeholders for the mine:

- The traditional owners, the Peramangk people
  The Peramangk people are represented by the Mannum Aboriginal Community Association
- Local residents of Kanmantoo and Callington
  The Kanmantoo Callington Community Consultative Committee (KCCCC)) is a forum where the many and varied groups with an interest in the mine can come together. As well as those listed separately below there are a number of smaller groups like the Oval Committees, sports clubs and local youth all of which can be heard through the KCCCC.
- Local residents of Kanmantoo directly impacted
  The Kanmantoo Action Group was formed in 2013 to represent local residents of Kanmantoo directly impacted by the mine with a focus on environmental matters and emissions particularly
- Environment
  Kanmantoo Landcare Group is the local Landcare Group
- Emergency services
  Callington – Kanmantoo has a CFS unit
- Tourism
  The SA Tourism Commission (SATC) and Adelaide Hills Tourism are stakeholders with an interest in tourism opportunities in the area including mine tourism
- Culture and heritage
  The Peramangk people and other Aboriginal groups are stakeholders with the region being a meeting place and a trading hub for indigenous groups in the past

[6] 2013 – 2016 Regional Roadmap RDA Adelaide Hills Fleurieu and Kangaroo Island source: http://rdahc.com.au/

A local non-indigenous heritage group is emerging from interested individuals particularly with an interest in the mining past of the area

- Education and training
  The Kanmantoo Primary School is the local school closest to the mine
  Other education and training groups include TAFE (at Mt Barker) and primary and high schools with regional catchment
- Local government
  The DCMB is the local government area in which the mine is located
- Regional development
  The Southern Hills and Fleurieu Local Government Association and the Adelaide Hills, Fleurieu and Kangaroo Island Regional Development Australia (RDA) Board are regional development stakeholders
- State government departments and agencies
  The South Australian Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) is the state's regulator for mining. Other departments and agencies that have a significant interest in the mine and its operations include the SA Department of Environment, Water and Natural Resources, Environment Protection Agency (EPA), SA Department of Primary Industries and Regions, SA Department of Planning, Transport and Infrastructure and the SA Department of Further Education, Employment, Science and Technology for example.
- Commonwealth Government departments and agencies
  The following Commonwealth Government departments may be stakeholders of the mine: Department of Agriculture, Department of Communications, Department of Foreign Affairs and Trade (DFAT), Department of Industry, Department of Infrastructure and Regional Development, Department of the Environment
- Local elected members of state and commonwealth government
  Mark Goldsworthy MP is the State Government's elected member for Kavel which is the State electorate in which the mine is located
  Hon Jamie Briggs MP is the Commonwealth Government's elected member for Mayo which is the Commonwealth electorate in which the mine is located
- Media
  The Courier is the regional Newspaper that covers issues related to the mine
  PowerFM and radio 5MU are located at Mt Barker
  ABC 891 is a radio station relevant to the region
  State and National media are also relevant to the mine's operations given its significance to the State

Internal stakeholders

- The Hillgrove Resources Limited Board, the Executive team and shareholders
- staff of the mine
- contractors and suppliers to the mining operation

8. Stakeholder and Community Engagement Framework

Aims of Stakeholder and Community Engagement

- ensuring the local and regional community is kept fully informed about each stage of the mine's development through the provision of clear, accurate and unbiased information in appropriate formats and delivered through a variety of media
- building stakeholder and community awareness in, understanding of, and support for, the company and the Kanmantoo Copper Mine
- building the company's understanding of its stakeholders and the wider community with a focus on addressing priority issues of concern in a timely manner as well as opportunities as they arise
- identifying and realising opportunities for the company to participate as a member of the community and deliver real and measurable benefits to the community
- encouraging community input into topics and issues that help to inform and improve the company's decision making
- ensuring that the relevant regulatory requirements related to community engagement are met

Outcomes and Key Objectives of Stakeholder and Community Engagement

The following table identifies key outcomes and objectives of the Plan. It is based on the Better Together principles

Outcomes **'Better Together' headings**	**Key Objectives**
Outcome1 **We know why we are engaging and we communicate this clearly**	• to identify the company's commitment to effective community engagement • to draw the link between stakeholder and community engagement and the company's decision making • to identify the respective decisions that may be influenced by community input • to identify which factors / decisions can and cannot be influenced by stakeholder and community input? • to take note and respond to the changing nature of the project over time • to meet the company's compliance obligations for community engagement
Outcome 2 **We know who to engage**	• to clearly define stakeholders and community members • to make sure that all relevant stakeholders and community members have been identified • to make sure that stakeholders can continue to be identified (and self-nominate or be referred) through the life of the project • to respect and involve existing stakeholder networks and community leadership groups in the engagement
Outcome 3 **We know the background**	• to understand the community: profile, history, key drivers and priorities and identify what this means for how stakeholders and the community may view the project

Outcomes 'Better Together' headings	Key Objectives
and history	• to ensure that information and approaches reflect the community profile and meet the particular needs of stakeholders and the wider community
Outcome 4 **We begin early (to ensure 'no surprises')**	• to understand and match where possible, the expectations of stakeholders and the community in how, when and where they will be engaged • to promote a 'no surprises' approach by beginning engagement early and allowing time for stakeholders and the community to develop an understanding of the project in a logical sequence
Outcome 5 **We are genuine**	• to provide appropriate mechanism (s) through which information is available to stakeholders and the wider community • to allow appropriate time and opportunity for the community to consider the information • to provide alternative ways for stakeholders to respond to calls for input in a timely manner • to provide appropriate management and responsibility for stakeholder and community engagement within the company • to measure and report on the effectiveness of stakeholder and community engagement
Outcomes 6 **We are creative, relevant and engaging**	• to facilitate the capture of the ideas, comments, suggestions and other input from stakeholders for use in informing decision making by the company • to identify the ways in which stakeholder and community input will be presented for use by the company and other decision makers (where appropriate)? • to identify for the community how their input will be used in decision making • to provide feedback to stakeholders and the community on how their input influenced company decision making • to promote learning from experience

9. Stakeholder and Community Engagement Plan (SCEP) Summary

Why engage?

Who will we engage with?

How can we get to know, understand and appreciate each other?

When will we engage?

How do we make the engagement meaningful?

How can we know that the engagement made a difference?

10. Stakeholder and Community Engagement Action Plan

Why engage?	Who will we engage with?	How can we get to know, understand and appreciate each other?	When will we engage?	How do we make the engagement meaningful?	How can we know that the engagement made a difference?
Present the outputs from the SCEP (input from the community) in a performance orientated (risk based) form consistent with other plans of the company. Use the feedback from the community to inform other company Plans like induction and training and the Mine Closure Plan Use input from the community and encourage company staff and contractors to be aware of the local community's priority issues of concern and potential opportunities and make suggestions to address these Produce a clear statement of company commitment to effective community engagement Regularly publish company updates in the Community Newsletter and make presentations to the KCCCC that clearly identify upcoming decisions of the company that can be influenced by community input Clearly identify for the community where decisions cannot be influenced by the community because of factors like legal requirements or technical constraints Produce a community version of the SCEP (simplified to one A4	Use the definition of stakeholders and community members from the 'Better Together' guidelines Include a stakeholder list in the SCEP that identifies stakeholders and community groups that may be impacted by the project. Involve the community through the KCCCC in reviewing this stakeholder list and continually updating it Include a Communications Plan in the SCEP Ensure that all public publications carry an invitation to participate in the community engagement process either directly by contacting the company or through the KCCCC Continue to support the KCCCC • encourage all KCCCC meetings to be public meetings • support the broad advertising and inclusive invitations to participate in the KCCCC Treat the SCEP as a 'living document' , continually updated as a standing item on the KCCCC agenda	Include a summary description of the local community and the regional community in the SCEP. Identify the local community (within about 5 km of the mine site) as the group that is likely to be most directly impacted by the operations of the mine. Identify the regional community (as defined by DCMB LGA and about 20 km from the mine site) as a group that may have an interest in broader matters including economic and social opportunities and challenges Work with groups like Regional Development Australia and the regional LGA to provide annual updates on changes in the community profile Ensure that timely, accurate, clear and unbiased information is provided to all stakeholders and consider whether particular communities should be targeted on certain issues to make sure there is strong participation. For example it may be that youth employment is an issue and that the regional community may be targeted.	Identify key community expectations for engagement as part of the performance measurement process by using the community version of the SCEP as a guide. Recognise that there may be changes in community priorities in relation to issues (positive and negative) as a result of progress in the project as it moves through stages of the development cycle. Document progress made in easy to understand information sheets so that community members who join the engagement at a later stage are fully aware of the history of the project.	Through the Communications Plan in the SCEP, identify a number of different formats for the provision of information to stakeholders and the wider community and the collection of responses where appropriate. Recognise the usefulness of IAP2 tools in this regard. Include: • published materials like facts sheets and Q and A available in hard copy or in electronic form on the KCCCC website • display materials that may be shown at public events like public meetings, field days and regional shows • presentations by relevant experts • media including editorial in local newspapers and interviews on local radio • social media opportunities • site tours Through the Communications Plan in the SCEP, consider appropriate response times such as lead time for arranging meetings and reasonable time for submitting input. Identify key persons from the senior management team with responsibility for stakeholder and community engagement. Include a standing item on Stakeholder and community engagement on the Hillgrove Resources Board	Include a number of different techniques for gathering community input in the Communications Plan. Recognise the usefulness of IAP2 tools in this regard. Include: • facilitated forums on dedicated topics including those hosted by KCCCC • charrette meetings where experts are invited to participate • 'circus' approaches encouraging responses to display materials and the like • focus groups using existing community group structures • direct responses via telephone and email or personal conversations • surveys and questionnaires Include a performance orientated (risk based) template in the SCEP for the collection of ideas, comments and other community input. Ensure that this is consistent with DMITRE guidelines for PEPR development. Provide a clear explanation of how community input will be used by the company (and others where appropriate) as a matter of routine when community input is sought. Provide feedback to the community on how their input

page). Use this version: • to identify a set of community expectations under the principles of the Plan that can be used to measure performance • to provide a standing item of the KCCCC where progress can be monitored Document the outputs and outcomes that are delivered through the SCEP and provide these to DMITRE where appropriate as evidence of meeting compliance				agenda. Establish a set of six performance indicators (one for each outcome) for effective stakeholder and community engagement. Do this in consultation with the community and reflect community expectations. Report progress regularly as a standing item on the KCCCC agenda.	was used to inform the decision making. This may be as a formal written report, a presentation at a KCCCC meeting or a personal explanation for example. Link administrative tools like the company's complaints register to the identification of topic issues for the community as part of a real time approach that seeks to make timely responses to emerging issues.

APPENDIX 1

HILLGROVE RESOURCES LIMITED

Stakeholder and Community Engagement

Communications Plan

April 2014

Purpose

To complement and enhance the Stakeholder and Community Engagement Plan (SCEP) through the effective use of communications.

Communication strategies

Strategic planning, structure and function

1. Identify, establish and maintain communication with stakeholder groups and community groups

2. Raise stakeholder awareness of the opportunities to be involved in identifying issues of concern and opportunities that may arise with a view to assisting Hillgrove Resources with its decision making

3. Reflect the priority issues for stakeholders and communities of interest directly in the program (eg events agenda) and encourage shared ownership

Data management

1. Identify the range of stakeholders and the community likely to be impacted by the project

2. Enter stakeholder contact information into an electronic data base and manage the data set in accord with company policy related to privacy and data base security.

3. Advise stakeholders that their contact details will be used to enable contact with and between them on matters related to the project.

4. Check the currency of existing contact data at least once per year.

Published information

1. Develop a register of project information (library) that can be accessed by stakeholders and community members to provide those who may join the engagement to fully understand the history and past achievements of the engagement process.

2. Report on the performance of the Stakeholder and Community Engagement program to the community and also through company mechanisms such as the company’s Annual Report

3. Develop and maintain a list of key topics and issues relevant to the project in a performance orientated (risk based) format.

4. Encourage input from a wide range of sources of data and information on issues to build confidence in the integrity of this information

5. Prepare information / facts sheets as required and in a timely manner and in a form (eg Plain English) that is easily recognized by stakeholders and the community

6. Produce a project Newsletter at least once a quarter

- distribute Newsletter by e mail to those stakeholders and community members on the data set who have identified a preference for this medium
- post the Newsletter on the website for download
- have hard copy available for those who prefer this through the Secretariat

7. Seek to understand the community (profile, history and priorities) in order to better understand the position of stakeholder and the community on key issues. Engage with groups like the Regional Development Australia Board and regional LGA who also track changes in environment, social and economic factors (capital) of these communities.

8. Participate in cultural awareness training to ensure communication strategies and techniques are appropriate for the cultural groups in the stakeholder and community group, particularly Indigenous people

9. Facilitate the release, where commercially appropriate, of independent reports related to key issues of concern to the community

<u>Website</u>

1. Establish and maintain on the website, dedicated project web pages for community engagement

2. Include on the homepage of the website, a standing invitation for stakeholders and community members to self nominate to be included on the stakeholder and community member register.

3. Consider social media links on the web page to encourage contributions from the community. This may be a Facebook / Twitter response

4. Build links from the project webpage to other related pages such as employment and business opportunities, company information etc

5. Develop a Q&A facility on the webpage

<u>Face to face meetings, forums and committees</u>

1. Select from a range of face to face methods based on the stage of the project and the issues being addressed, that will appropriately involve the stakeholders and community. These may include:

    a. KCCCC meetings
    b. Individual meetings
    c. Focused forums (small scale issues or locality based)
    d. Displays / 'road shows'
    e. Open days / site visits

2. Utilise existing community networks, particularly where they are managed by key stakeholders to the project like NRM Boards, local Council (DCMB), Regional Development Australia Board, Landcare etc

Complaints

1. Maintain a complaints register and use this to proactively identify emerging issues and opportunities
2. Report on complaints as part of the issues identification and response process.
3. Use complaints as part of the continual improvement program for the project

Current Strategies for Stakeholder and Community Engagement (April 2014)

Kanmantoo Callington Community Consultative Committee (KCCCC)

The Kanmantoo-Callington Community Consultative Committee (K/CCCC) was established in January 2007. The KCCCC is designed as a key mechanism for community engagement related to the proposed redevelopment, operations, and eventual closure of the Kanmantoo Copper/Gold Mine Project. The membership of the KCCCC is drawn from the local community and endorsed by South Australia's Director of Mines, in consultation with the independent Chair.

Open meetings are scheduled to occur each quarter and will be advertised in Hillgrove's newsletter. All interested parties are encouraged to attend to observe proceedings and ask questions.

The KCCCC current Terms of Reference, agendas, meeting notes, issues papers, reports and occasional papers are available at the Hillgrove website (www.hillgroveresources.com.au).

Committee member contact details and a library of other resources, including more detailed presentations on various issues and a range of published material is available on request from the Chairman, Bob Goreing, at (email:bob@cega.com.au) or on 0418 816 788.

Out and about with Hillgrove

Hillgrove is a proud sponsor of the Callington United Eagles Football Club and the Bremer/Callington Cricket Club and look forward to their continued association. Hillgrove is also a supporter of the Callington and Mt Barker Shows and value being approached regarding local events and any support they may provide.

Hillgrove is pleased to host tours of the old Kanmantoo mine and exploration activities around it, having welcomed Callington Primary, Mannum Minerals Club, Resource Industry Alliance, YouthJet, the University of S.A. and Adelaide University during the past year. Group tours can be arranged with notice and provide an excellent understanding of Hillgrove's current activities.

Project Newsletter

The Kanmantoo Copper Project newsletter is designed to keep the local community informed about Hillgrove's activities with regular updates on progress at the mine site and surrounds, and news on Hillgrove out and about in the area. The Kanmantoo newsletter is distributed monthly. Links to the current and past issues of the Kanmantoo Project Newsletter are given at the Hillgrove website (www.hillgroveresources.com.au).

How to Provide us with Feedback

The following mechanisms are available to the community to express their views and feedback on the project:

Website

Hillgrove Resources has an established website (www.hillgroveresources.com.au) which provides an overview of the project, advertises employment opportunities, provides contact details and allows for feedback to provided. The website is reviewed and revised regularly to include current information, including upcoming consultation events and the outcomes of consultation.

E mail and postal address

A project email address and postal address is available to encourage questions or feedback on the project or consultation activities. The email and postal address have been and will be included on all communication materials provided at community information sessions and staffed public displays. The email address is also available from the Hillgrove Resources website.

Telephone contact

Telephone contact details for the Kanmantoo Copper Project can be found on the Hillgrove Resources website.

Display panels

Display panels will be produced and will be exhibited in local communities to provide background on the project and relevant contact details for community members to deliver feedback on the project

Project updates

Project updates are being prepared regularly by Hillgrove Resources. They include information about the progress of the MARP, as well as other major developments. Project updates will be placed on the project website.

Project advertising

Advertisements have been and will be, placed in local and community newspapers to raise awareness of the consultation process, promote the contact details, and advise of consultation activities.

Media releases

Advertising will be supported by media releases, as appropriate, to promote the consultation process and inform the community of major project developments or milestones.

Consultation data base

A database will be maintained to record all stakeholder contact. This database will evolve through periodic review to ensure that all stakeholders have been identified and are included.

The database will be maintained for all stakeholders by documenting all contact details and other details relating to the stakeholder's interest in the project. The consultation database will also document how and when complaints were received and addressed.

Documenting consultation

The information obtained from all forms of ongoing consultation will be documented and notes and responses referenced in the consultation database. The records of consultation undertaken will be entered on a minimum fortnightly basis into the consultation database.

The consultation database will provide detail regarding:

- locations, dates, contact details and lists of participants at workshops or meetings.
- summaries of issues/complaints raised.
- project responses to issues/complaints raised and how these were communicated back to the stakeholders.

Hillgrove will also monitor community engagement through:

- records of attendance at public events and community meetings to gauge the success of stakeholder consultation and to improve ongoing stakeholder consultation.
- articles that appear in the media, particularly letters to the editor.
- number and nature of complaints documented in the Complaints Register, including the person's name and contact details, communication, action taken to resolve the complaint, outcomes and feedback from complainant.

Reviewing Progress

Evaluation is a critical step in the consultation program and is used to identify successful and unsuccessful strategies and guide the development of future activities. In addition, ongoing monitoring facilitates continuous improvements to the program through the application of project learnings.

Each consultation activity is considered both during the course of the activity and in retrospect once complete to determine:

- whether they are effective in meeting the project consultation objectives
- whether they are productive exercises for participants and
- whether improvements can be made.

Stakeholder feedback, obtained from the consultation sessions via feedback forms and comments is an important input to this review.

Appendix 7

Mine Waste (Part 1)

Appendix 7A

Cover Design and Characterisation

Unsaturated Soils Engineering Ltd.
16368 – 10th Avenue, White Rock, BC, CANADA, V4A 1B1
Tel:(604)542-6448 Fax:(604)542-6449

October 27, 2008

Hillgrove Resources Limited
42 Back Callington Road
Callington
SA 5254

Attention: Mr. Marty Adams, Project Manager

Dear Mr Adams

Subject: **DRAFT Report** - Cover Design, Kanmantoo Copper Project

Please accept this report as analyses, design and recommendations for the cover systems to be implemented during closure of the waste rock and tailings cover impoundments at the Kanmantoo Copper Project. A detailed review of the existing data provided by Hillgrove Resources has been completed in order to develop a SoilCover model based on climate data and soil properties for the soil cover profiles. The results of the analyses presented herein indicate that the site is best suited for the application of Store and Release Covers to minimize infiltration rates and drainage from mine waste systems.

Introduction

Geochemical investigations conducted by EGi indicate that significant proportions of the waste rock and tailings to be deposited for the Kanmantoo Copper Project are potentially acid forming (PAF). In order to control the infiltration of meteoric water into PAF mine waste materials, Hillgrove initially proposed a preliminary cover design consisting of a 2.0m thick layer of non acid forming (NAF) waste rock for the waste rock storage facility and a HDPE liner with 1.5m to 1.8m NAF waste rock for the tailings storage facility. A screening level investigation based on preliminary SoilCover modelling was completed by Unsaturated Soils Engineering Ltd. and reported to Hillgrove Resources Ltd., 23 June, 2008. The results of the screening study showed that Net Infiltration rates approaching zero could be achieved for a 1.0m thick NAF cover system. The purpose of this present study is to assess and confirm the suitability of the 1.0 m conceptual cover designs based on more comprehensive investigations with respect to material characterization, soil testing, climate data, and SoilCover modelling. Recommendations are provided for construction of a NAF cover system on the waste rock and tailings impoundments along with the construction of field lysimeters for long-term evaluation and optimization of cover system performance.

Climate Description

The climate at the Kanmantoo site is classified as semi-arid. Mean annual precipitation in the Kanmantoo area is approximately 424 mm with an annual potential evaporation of about 1450mm. These parameters establish a potential evapotranspiration to precipitation ratio greater than 3. Approximately 50% of the precipitation occurs during the winter months between May and September when monthly rainfall exceeds potential evaporation. Intense summer storms occasionally produce more than 100mm within a 24 period and the highest recorded rainfall for Kanmantoo was 115mm in 60 minutes during December 1894.

Soil Cover Design Considerations

The semi-arid climate at the site with a mean annual precipitation of 424mm versus 1450mm of potential evaporation is ideally suited for the application of Store and Release covers to minimize infiltration. Store and Release cover systems rely on the water retaining capacity of the soil within the root zone of the cover to retain infiltration for a sufficient period of time such that the excess soil moisture can be taken up and returned to the atmosphere through the process of evapotranspiration. Store and Release cover systems have been widely used throughout Australia and are often considered to be ‘Best Practice’ by the mining industry.

An excellent example of a Store and Release Cover system can be found at the Kidston Gold Mine in Northern Queensland. The long-term performance and evaluation of the cover systems at the Kidston Gold mine is well documented in the literature and has been described by Durham et al (2000) and Williams et al (2003). The annual precipitation at the Kidston site varies between 400 and 1500 mm/year with a mean annual value of approximately 700 mm/year. Potential evaporation is in the order of 2100mm/year, or about 3 times mean annual precipitation, and virtually all precipitation occurs within a distinct wet season of 4 months between December and March.

One of the specific objectives of the cover design implemented at Kidston was to construct the Store and Release cover in such a way as to minimize run-off. Extreme storms with daily rainfall events up to 300mm have been observed at site resulting in severe surface erosion. As a result, it was decided to form a flat and gently hummocked topography on the final surface of the cover in order to prevent run-off and the associated problems with erosion. Figure No. 1 below shows the surface of the cover constructed at Kidston shortly after installation, prior to the development of a vegetation canopy. It can be seen that the disordered drainage pattern resulted in the formation of ponded water as a result of preventing run-off. The Store and Release cover at Kidston was thus designed to provide sufficient soil water storage capacity that would retain all wet season precipitation without the occurrence run-off. Subsequent observations for the cover systems completed at Kidston have shown that the Store and Release approach to cover design has functioned very well with long-term net infiltration rates approaching zero.

Figure No. 1 Photograph Showing the Newly Constructed Store and Release Cover Surface at the Kidston Gold Mine in Northern Queensland

The primary variables that will control the ultimate design of a Store and Release Cover system are:

1.) Quantity and distribution of annual precipitation and potential evaporation.

2.) Soil properties with respect to hydraulic conductivity and soil water retention or storage characteristic (i.e. Ksat and the Soil Water Characteristic Curve).

3.) Cover thickness or total depth.

4.) Establishment of permanent vegetation.

5.) Erosion and stability (including differential settlement) to ensure long term sustainability.

In general, the Store and Release cover approach is considered suitable if the quantity of annual potential evaporation exceeds precipitation by a factor of two. The evaporation to precipitation ratio for the study area at the Kanmantoo Copper Project is even greater at 3.4 (i.e.1450/424). Given these climatic parameters, the application and design of a Store and Release cover concept for the waste rock impoundments at the Kanmantoo Copper Project is seen to be highly suitable.

Soil Properties

Most of the soils encountered were classified as Clay low plastic to clayey Sand and/or gravelly clayey Sand (i.e. CL and SC/GC). Hydraulic conductivity tests showed that saturated hydraulic conductivity values (Ksat) in the range of 1 x 10^{-8} m/s to 1 x 10^{-10} m/s can be achieved for compacted samples. While the soils investigated were originally evaluated for constructing the proposed compacted clay liner, the same soils described above will also be suitable for the construction of Store and Release covers. In general, the sandy and clayey Gravels and gravelly clayey Sands described as Unit 2A within the Coffey Mining Pty Ltd report, 'Factual Report of Material Search For Proposed Tailings Storage Facility'(23 July, 2007) are considered to be suitable for the construction of Store and Release covers when placed in an non-compacted state.

Further field investigation and sampling was carried out for Hillgrove in August 2008 and samples were obtained for soil classification and saturated hydraulic conductivity testing of non-compacted samples. Aggregate/Soil Test Reports, MAT:MEND08S-06948 and MEND08S-06949 provided by Coffey Information Ltd. report the saturated hydraulic conductivities for non-compacted samples to be 2.9 x 10^{-7} m/s and 7.9 x 10^{-7} m/s with silt and clay contents (i.e. passing 75 um) of 27% and 13% respectively. SoilVision Software was used to determine the Soil-water Characteristic Curves (SWCC) that may be expected for the range of soils reported in the Coffey reports. Appendix A presents the SWCCs obtained from the SoilVision Data-base of 12 soils having soil classifications and grain-size distributions within the range of soils reported by Coffey.

Three SWCCs were selected for the present study to represent soil properties ranging coarse to fine, which are as follows:

Soil Cover Material 1 - Fine NAF oxide Waste Rock obtained from the SoilCover data-base.

Soil Cover Material 2 – Clayey Silty Sand, Soil Reference No. 10706 from the SoilVision data-base.

Soil Cover Material 3 – Silty Clay Sand, Soil Reference No. 10780 from the SoilVision data-base.

Figure No. 2 below illustrates the Soil-Water Characteristic Curves selected for the SoilCover Numerical Modeling described in the following section. It can be seen in Figure No. 2 that each curve exhibits a wide range in soil suction between the air entry value (i.e. at high water content/full saturation) and the residual or fully drained water content; therefore, these soils offer a high capacity to store and release moisture over an extended range of suction corresponding to wet and dry conditions.

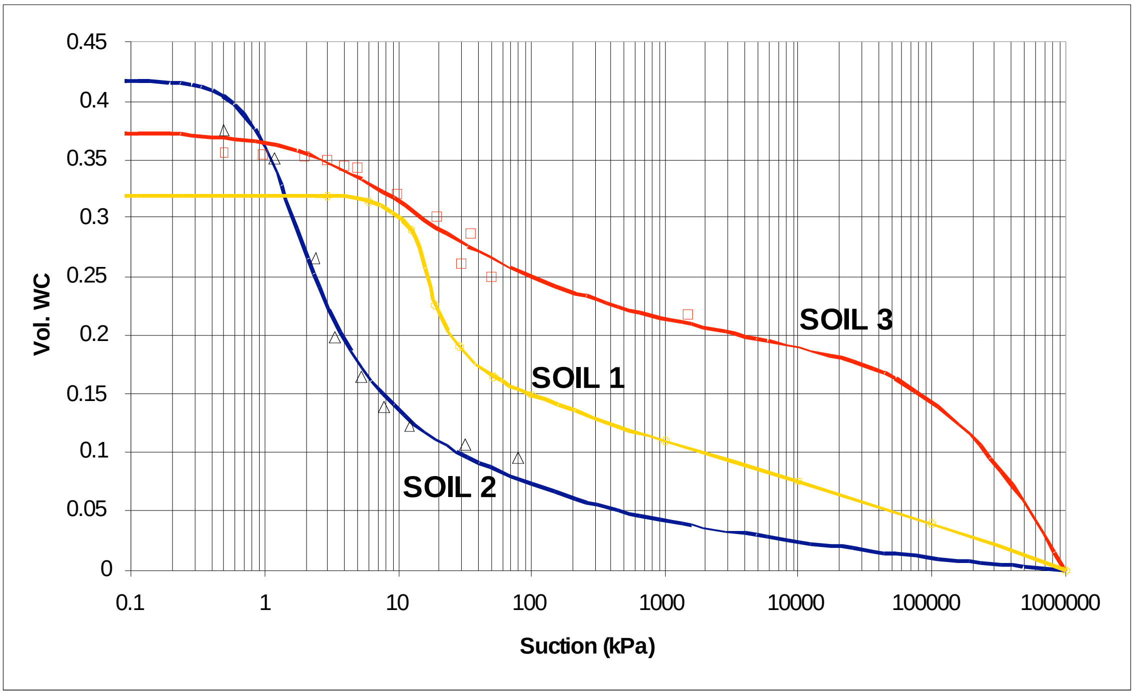

Figure No. 2 Soil –Water Characteristic Curves Selected for SoilCover Modelling

SoilCover Modelling

The numerical model SoilCover (USG 1997) was used to evaluate the Store and Release cover at Kanmantoo. An extensive historical climate database is available for the Kanmantoo site and immediate region. However, daily rainfall records for Adelaide corresponding to the period 1 March 2007 through to 28 February 2008 were selected for the SoilCover model since this data set was the most comprehensive in terms of temperature and evaporation. The total precipitation for the Adelaide data set was 437mm, which is approximately equal to the mean annual precipitation at Kanmantoo (i.e. 424mm). Adelaide also has a similar rainfall pattern to the site.

Store and Release cover systems are typically designed to function most effectively under normal climatic conditions but must also provide protection against infiltration during years with above average rainfall. Therefore, a wet year climate data set was developed by synthesizing a high rainfall year. The mean year precipitation of 437mm was increased by 2 Standard Deviations equivalent to 222mm (established on the basis of the climate record at Kanmantoo for the period 1874 to 2007) to produce an annual wet year precipitation rainfall of 659 mm. Table No. 1 summarises the monthly precipitation and potential evaporation values adopted for the both the typical and wet year SoilCover simulations. Figure No. 3 shows a cumulative plot of the surface water balance for the case of uncovered waste rock with no vegetation during a typical year.

Table No. 1 Summary of Rainfall and Evaporation Data Selected for Modelling

	Typical Year Precipitation	Wet Year Precipitation	Potential Evaporation
Jan	9 mm	20 mm	152 mm
Feb	3 mm	22 mm	90 mm
Mar	25 mm	25 mm	56 mm
Apr	82 mm	82 mm	42 mm
May	45 mm	78 mm	47 mm
Jun	65 mm	95 mm	65 mm
Jul	66 mm	93 mm	90 mm
Aug	26 mm	64 mm	133 mm
Sep	24 mm	62 mm	171 mm
Oct	25 mm	51 mm	186 mm
Nov	30 mm	30 mm	217 mm
Dec	37 mm	38 mm	188 mm
Annual Total	**437 mm**	**659 mm**	**1437 mm**

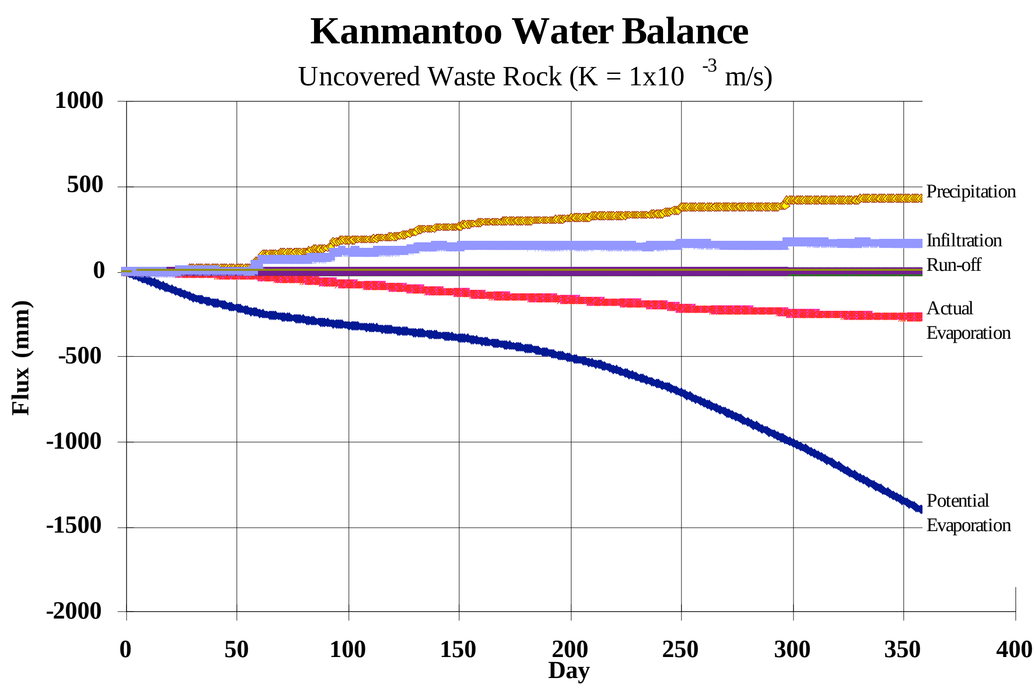

Figure No. 3 Surface Water Balance for Uncovered Waste Rock without Vegetation

The SoilCover model was used to evaluate and test the performance of three 1.0m NAF Cover profiles under atmospheric forcing conditions for both the average year precipitation of 437mm and the wet year precipitation of 659mm. The results for the cases simulated are summarized in Table 2 below.

Table 2 Summary of SoilCover Modeling				
Profile	**Precipitation**	**Vegetation**	**Runoff**	**Net Infiltration**
1.) Uncovered Waste Rock	437 mm	None	< 5 mm	170 mm
2.) Uncovered Waste Rock	659 mm	None	< 5 mm	300 mm
3.) Uncovered Waste Rock	437 mm	Poor	< 5 mm	60 mm
4.) Uncovered Waste Rock	659 mm	Poor	< 5 mm	150 mm
5.) 1.0m NAF Cover Soil 1	437 mm	None	< 5 mm	100 mm
6.) 1.0m NAF Cover Soil 1	659mm	None	< 5 mm	150 mm
7.) 1.0m NAF Cover Soil 2	437 mm	None	< 5 mm	130mm
8.) 1.0m NAF Cover Soil 3	437 mm	None	< 5 mm	105mm
9.) 1.0m NAF Cover Soil 1	437 mm	Poor	< 5 mm	Zero
10.) 1.0m NAF Cover Soil 1	659mm	Poor	< 5 mm	10 mm
11.) 1.0m NAF Cover No. 1	659mm	Good	< 5 mm	< 5 mm
12.) 1.0m NAF Cover No. 2	437 mm	Poor	< 5 mm	Zero
13.)1.0m NAF Cover No.3	437 mm	Poor	< 5 mm	Zero

Four cases (shown as 1 to 4 in Table No.2) were modelled for an uncovered waste rock profile with and without vegetation. A high value of saturated hydraulic conductivity equal to 1×10^{-3} m/s was used for the waste rock profile. Figure No. 3 shows the surface water balance for the uncovered waste rock simulation identified as simulation 1 in Table No. 2. The results of the SoilCover simulations for the uncovered waste profile show that 170mm and 300mm of infiltration occurs for the typical and wet year precipitations of 437mm/year and 659mm, respectively. These values correspond to net infiltrations quantities ranging between 40% and 45% of total precipitation and are considered the maximum infiltration possible at the site. A dramatic decrease in net infiltration can be seen in Table 2 when the simulations for the case of uncovered waste rock are repeated with the inclusion of poorly established vegetation. Poor vegetation corresponds to a Leaf Area Index of 1 and the rooting was set to a depth of 600mm. The net infiltration for uncovered waste rock with poor vegetation was computed to be 60mm and 150mm, or 14% and 23%, respectively for the mean and wet year precipitation simulations. While this example simulation is not considered a realistic option, due to the PAF nature of the waste rock, it helps illustrate the importance of vegetation in reducing infiltration.

A 1.0m thick profile was used to evaluate the three different Store and Release cover systems based on the soil properties summarised above for Materials 1, 2 and 3. The simulations were repeated for both the average and wet year precipitations with and without vegetation and the results are summarized in Table No. 2. The hydraulic conductivity for Material 1 was set equal to 1×10^{-6} m/s based on the SoilCover data base. The hydraulic conductivity for Materials 2 and 3 was set equal to 8×10^{-7} m/s based on the laboratory test results provided by Coffey, which is approximately the same as that for Material 1. These values of hydraulic conductivity are consistent with those for most non-compacted well graded weathered oxide soils/waste rock and are considered representative of the Unit 2A materials described above. Where vegetation was included in the simulations, it was mainly assumed to be poorly established with a Leaf Area Index of 1.0 and a rooting depth of 900mm, except for one case with a wet year (659mm/year) simulation were the vegetation was upgraded to good rating.

Run-off or water shedding was controlled or prevented (i.e. to less than 5mm/year) for all simulations in order to maximize the potential for infiltration. A thin 0.1m zone of high permeability was used in the simulations for each 1.0m cover (i.e. Material 1,2, and 3) to ensure no water shedding.

A dramatic change in Net Infiltration can be seen in Table 2 for the SoilCover model results of the 1.0 m cover profile with vegetation. It is important to note that the values of net infiltration, and run-off, presented in Table 2 are reported to a level of accuracy equal to plus or minus 5mm. The computed value of Net Infiltration is zero for all mean precipitation year simulations with the 1.0 m covers (i.e. Materials 1, 2 and 3) having poor vegetation. A value of zero is reported since each of the simulations showed a tendency to a negative water balance (i.e. water loss or desiccation of the cover profile). The wet year precipitation simulation (i.e. 659 mm/year) for the 1.0 m cover with Material 1 and poor vegetation computed a small value of Net Infiltration equal to 10mm or 1.5% of total precipitation. It is reasonable to assume the quality of vegetation will improve during years with higher rainfall, and thus the wet year simulation was repeated with a good vegetative canopy and the computed Net Infiltration was found to be less than 5mm/year. It is paramount to note that vegetation is a critical component in reducing Net Infiltration for all 1.0m cover profiles. Table No. 2 also presents Net Infiltration for each of the three covers with no vegetation and it can be seen that computed Net Infiltration values between 100mm and 150mm per year occur in the absence of vegetation.

In summary, the results of the SoilCover modelling indicate that Net Infiltration values approaching zero can be achieved for the 1.0m Store and Release cover profiles at the Kanmantoo site using the NAF soils available at site. However, the role of vegetation is critical in achieving successful performance. In addition, while the results of the SoilCover modeling described above indicate that a 1.0m NAF cover with only poor vegetation will prevent rainfall from infiltrating to the underlying PAF waste rock and/or tailings, it is important to note that the SoilCover model has limitations. The primary limitation of the SoilCover model is that the flow of liquid water is assumed to be entirely Darcian (i.e. preferential flow due to macro pores such as cracks and root holes is not accounted for). In addition, calculations for the quantity of run-off that occurs during storm events is difficult to model accurately and thus the model was forced to conditions for no run-off. Full verification of the results presented herein can only be achieved with field scale test plots and careful model calibration.

Recommendations

The results for the SoilCover model described above provide important guidance for the design and construction of the cover systems for the waste rock and tailings impoundments at Kanmantoo. The modelling clearly demonstrates the strong potential for achieving negligible to zero infiltration with a relatively thin 1.0m Store and Release NAF cover system. Furthermore, there appears to be little benefit in implementing a deep barrier layer such as a compacted clay liner or HDPE membrane since these layers would be constructed below a depth of 1.0m where Net Infiltration rates are expected to be negligible. It is recommended that the Store and Release approach to cover design be adopted for the cover systems at Kanmantoo.

While the results of the detailed SoilCover modelling described above show that a 1.0m thick Store and Release cover constructed with the NAF available at Kanmantoo will reduce Net Infiltration rates to values approaching zero, the potential for long-term erosion problems associated with run-off possesses a significant risk. It is therefore recommended that the thickness of the cover be varied and range between 1.0m to 1.5m, such that the final topography of the cover surface has gentle hummocks similar to the Store and Release cover systems implemented at the Kidston Gold Mine shown in Figure No. 1. This will create a rolling surface that captures run-off at a local scale and prevents the development of larger water catchments that accumulate overland flow causing the formation of rills and channels. In addition to reducing the potential for erosion problems, increasing the mean thickness of the cover should add a measure of additional storage capacity for the control of infiltration during periods of high fall. It is also understood that Hillgrove may increase the cover thickness up to 2m. While the increased cover thickness is expected to mitigate much of the erosion risk, maximum erosion rilling depths, net infiltration versus cover thickness, differential dump settlement and other dump stability issues should be assessed before finalizing the cover thickness and placement requirements.

It is important to note that the surface of the waste rock dump immediately below the cover must be coarse and blocky with large voids. This is required to ensure that a capillary break is formed at the base of the NAF cover as well as to prevent rising moisture from either the underlying PAF waste rock or tailings being taken up into the PAF cover through root water uptake. General recommendations for the construction of the Store and Release cover system on waste rock and tailings as well as the installation of field lysimeters for direct measurement of cover performance are described below.

Selection of Materials for Cover Construction
Adequate performance of the cover systems constructed at Kanmantoo depends on the selection and placement of suitable materials with hydraulic properties similar to those used for the numerical model described above. Coffey Mining Pty Ltd excavated more than 200 test pits to depths extending up to 5.5 m. In general, the SC and GC materials encountered are suitable for soil moisture storage in Store and Release covers. Highly plastic, clay rich materials are less suitable since they tend to form a blocky or clod like matrix with cracks and fissures permitting rapid infiltration with little soil water retention when high rainfall events create ponding conditions, particularly after prolonged drying. While most of the materials encountered in the test pits may be used for the Store and Release NAF layer, further investigation to ensure an adequate volume of materials is recommended, particularly for the weathered or oxide waste rock.

Soils types that are best suited for use as Store and Release cover material are silty and/or clayey gravels (i.e. GM and GC) with 15% to 30% passing the 75 micron sieve. Well graded gravels with a high fines content provide excellent soil moisture storage characteristics, resist cracking and the formation of clods, and tend to resist erosion. Silty Sands and Clayey Sands (i.e. SM and SC) also provide excellent soil moisture retention characteristics but tend to be more susceptible to erosion.

Construction
The cover system should be placed such that the thickness of the cover varies between 1.0m to 1.5m. The method of construction used at the Kidston Gold mine is also recommended. The cover system was constructed using Haul Trucks depositing loads to form paddocks as described by Durham et al (2000) and Williams et al (2003). Compaction of the materials is not required and not recommended. The final undulating surface can be created with the use a dozer to gently smooth, but not flatten the peaks of the individual paddock deposits.

The surface of the waste rock dump should be relatively flat lying or slightly concave so as not to promote run-off to the perimeter of the dump. Furthermore, it is understood the batter slopes will use a concave landform and be graded from a maximum slope of 1 to 2.1 (25^o) at RL 90m and decrease downhill to a slope of 1 to

4.7 (12^{o}) below RL 60m. The use of the concave landform is strongly recommended as a primary control measure for the prevention of side-hill erosion. Hummocks may also be created while the sloping cover is being placed using the dozer in such a way as to form a series of staggered lateral scallops as shown in Figure No. 4 below. This method of cover construction proved successful for the 1 to 2 graded side slopes at the Golden Sunlight mine in Montana USA.

Figure 4 Golden Sunlight Mine (Montana USA). Photos showing re-graded 2H:1V slopes. Lateral Scallop Trenches designed to reduce erosion and rilling. Height of Scallops is approximately 0.5 m and the off-set pattern was designed to slow and retain run-off as it cascades down-slope.

A similar approach to the construction of the cover system on the tailings impoundment may also be implemented. However, the NAF cover material must not be placed directly on the tailings. It is recommended a minimum thickness of 1.0m of coarse ROM waste rock be placed over the final surface of the tailings as a capillary barrier between the NAF cover and underlying tailings. The placement of the 1m rock layer will also likely be required to form a trafficable surface for placement of the cover layer. In addition, it is recommended that the need to increase the thickness of the coarse rock layer or the use of a geo-fabric between the tailings and rock layer be considered to prevent the potential upwelling of tailings material into the overlying rock

Field Lysimeters

The performance of the various cover profiles and options may be evaluated using field lysimeters that provide direct measurement of infiltration or drainage rates. Numerical models such as SoilCover are useful design tools for comparison of predicted performance for various cover options, but have significant limitations and can not be relied upon to provide exact predictions without detailed field verification. Alternately, the model becomes a powerful tool once actual field observations are available for model calibration.

The appropriate scale for field lysimeters is typically 10m as shown in Figure 5 below. Schematic drawings are appended to the report illustrating a typical profile for a 10m x 10m lysimeter. The lysimeter is approximately 2.5m deep and lined with HDPE or similar barrier such that all drainage reports to a central sump for discharge to an external collection point for flow measurement and sampling. The profile in the lysimeter consists of waste rock overlain with the desired cover profiles. The lysimeter can be monitored and maintained by field personnel. Flow measurements for both drainage and run-off can be obtained using a simple culvert or tank as a reservoir together with a tipping bucket gauge. Other methods to evaluate cover performance are also available and may be implement *insitu* within the cover system following construction. For example, this can be accomplished by excavating and installing smaller diameter pre-fabricated lysimeters (i.e. 1.5m dia x 2.5m deep) and backfilling the lysimeters with the excavated cover/waste rock materials. Durham et al (2000) showed this approach to be effective at the Kidston Gold mine over the long-term.

Typical instrumentation requirements for the lysimeters include a weather station and a tipping bucket gauge for continuous flow measurements. The collection of water samples and flow measurements can be obtained by mine site staff. Moisture profiling sensors such as TDR - Time Domain Reflectometry and TC - Thermo Conductivity sensors may also be installed. The results of the field lysimeter experiment would ultimately be used to evaluate and verify cover performance with respect to regulatory requirements, constructability, and cost.

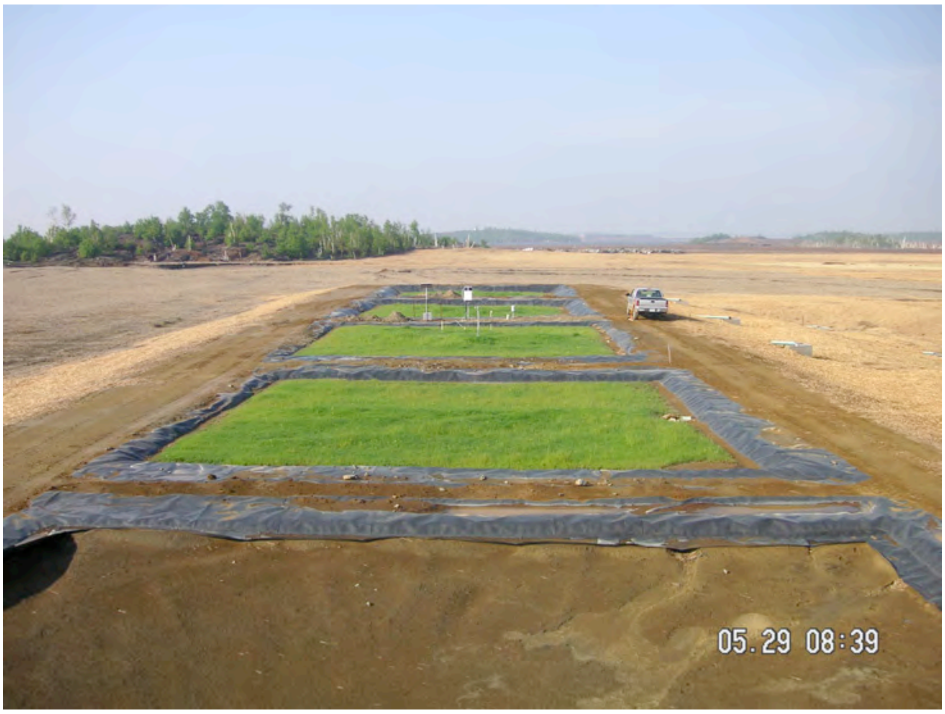

Figure 5 Typical Field Scale Cover Lysimetres

Summary and Closure

The report presented herein is intended to serve as a guide to defining the process, steps, outcomes and deliverables required to achieve an optimum and sustainable cover design that meets ‘Best Practice’ standards for the integrated waste landform system. Note that the cover design work is at a conceptual stage, and further work is required to determine final waste rock dump and tailings requirements.

The results of the SoilCover analysis indicate that 1.0m Store and Release NAF cover systems with vegetated cover will give excellent performance under the climatic regime for the site. Furthermore, soil test results completed for previous studies show that suitable materials for the construction of a NAF waste rock cover should be available. The 1.0m to 1.5m Store and Release cover system recommend herein is considered conservative from the point of view of infiltration control, although there are other considerations such as long term erosion and stability risks that may influence the final thickness required. There appears to be little or no benefit in cover performance with the construction of a compacted clay liner or the installation of a HDPE membrane at the base of the NAF waste rock profile. Based on information available to date, it is expected that the conceptual cover designs outlined in this report will be sufficient for control of water flux through waste rock and tailings, and hence minimize transport of ARD products.

Final cover designs and closure requirements will need to consider the following:

- The presence of vegetation in the cover layer is critical to the success of cover performance, and hence a thorough understanding of the succession, sustainability and water demand of the vegetation to be used in rehabilitation works will be required.
- The modelled cover performance must be confirmed with the construction of field lysimeters, which will also assist evaluation of vegetation requirements.
- The cover construction materials used must match closely to those modelled to be effective, and hence a detailed inventory of suitable materials will need to be established based on more widespread testing of hydrological, physical and geochemical properties.
- Maximum erosion rilling depths and differential dump settlement could impact on the required cover depth to ensure long-term sustainability, and these aspects will need to be evaluated before finalizing cover depths.
- A program of monitoring and maintenance of dump and dump cover integrity will be required after placement and post closure.
- Significant infiltration will occur prior to cover placement resulting in some future seepage. An understanding of the geochemistry (including lag times and element release rates) is required to evaluate the need for longer term treatment or mitigation. The performance of the existing waste rock impoundments should be accessed to help evaluate these issues.

In summary, the thickness of the NAF cover will most likely be determined by the type of vegetation selected and method of construction. Long-term performance of the NAF cover and its physical stability will depend on the quality and sustainability of the vegetation canopy established on the cover at closure. The results for the analyses presented herein should be confirmed with the construction of field lysimeters to compare and confirm the performance of the Store and Release cover system proposed herein.

Yours truly

Dr. G. Ward Wilson, P. Eng., P.Geo.
Unsaturated Soils Engineering Ltd.

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APPENDIX A

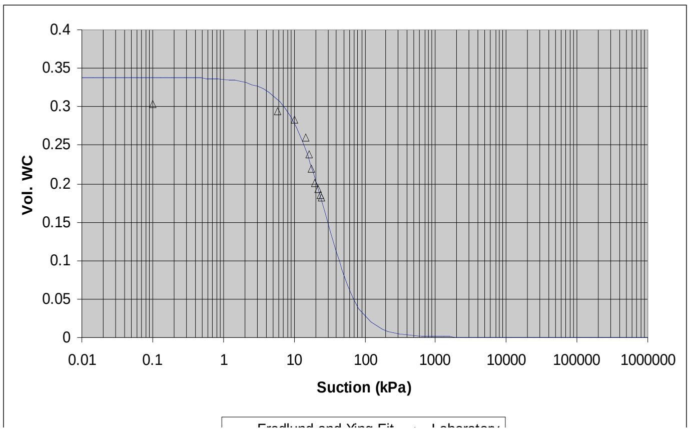


Figure A-1 SoilVision Reference Soil #61 (83% Sand, 16% Silt, 1% Clay)

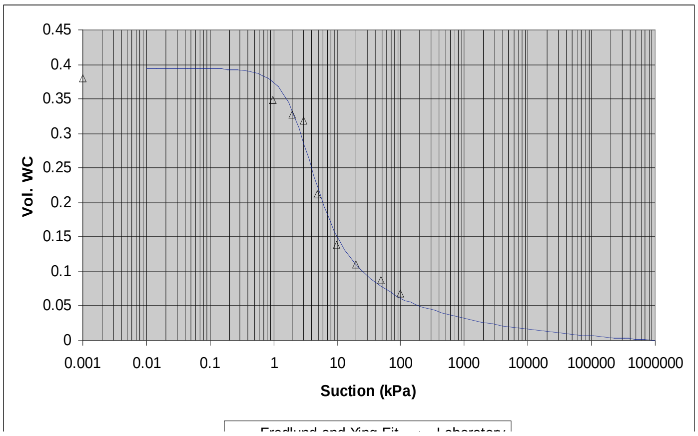


Figure A-2 SoilVision Reference Soil #10700 (85% Sand, 11% Silt, 4% Clay)

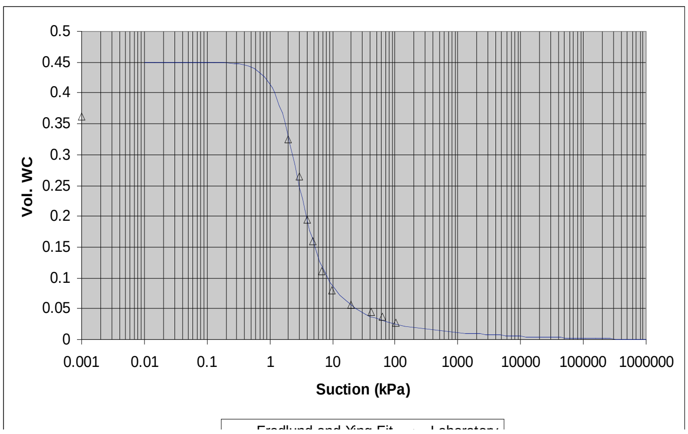


Figure A-3 SoilVision Reference Soil #10704 (88% Sand, 9% Silt, 2% Clay)

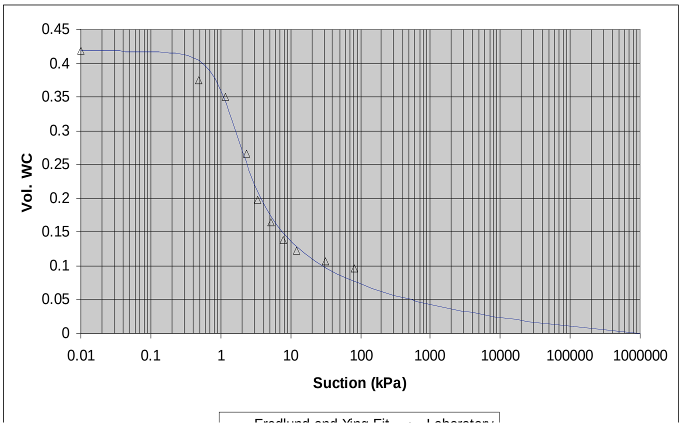


Figure A-4 SoilVision Reference Soil #10706 (90% Sand, 3% Silt, 6% Clay)

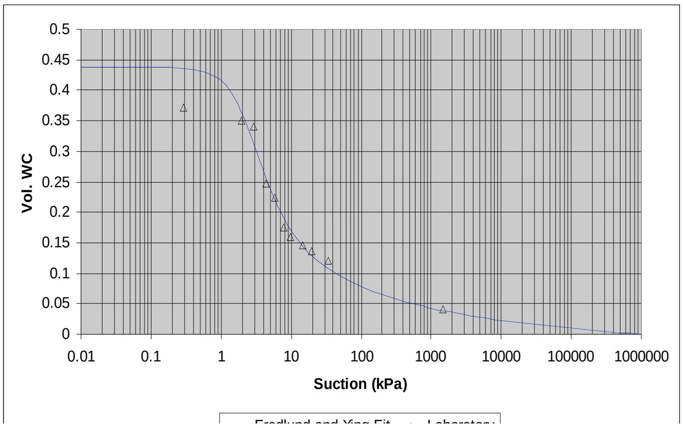


Figure A-5 SoilVision Reference Soil #10711 (80% Sand, 13% Silt, 7% Clay)

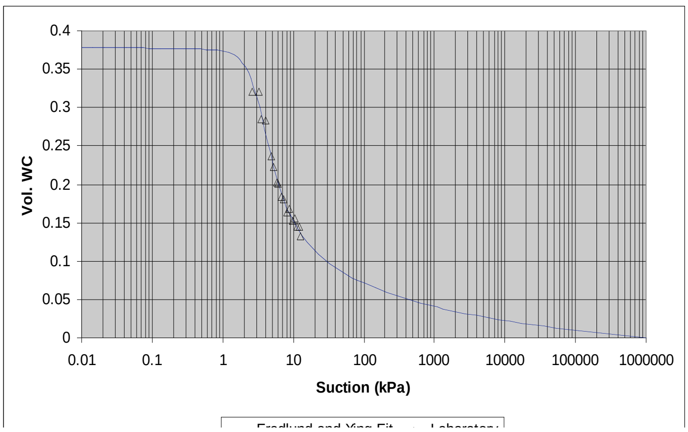


Figure A-6 SoilVision Reference Soil #10733 (73% Sand, 20% Silt, 7% Clay)

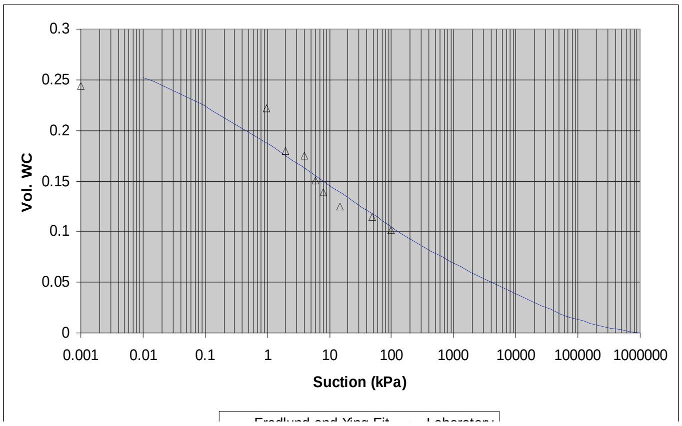


Figure A-7 SoilVision Reference Soil #10745 (81% Sand, 9% Silt, 10% Clay)

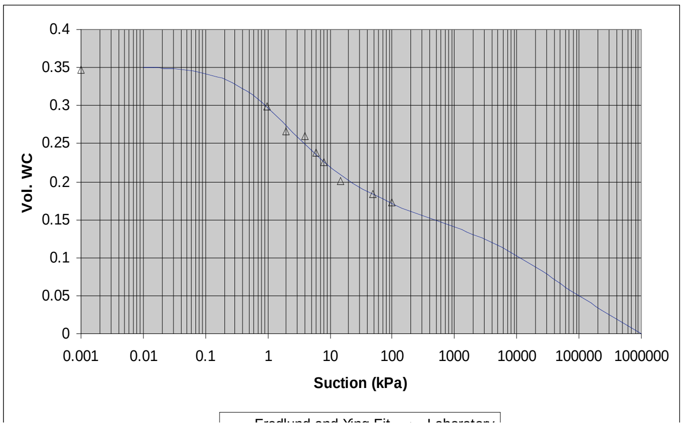


Figure A-8 SoilVision Reference Soil #10746 (69% Sand, 11% Silt, 20% Clay)

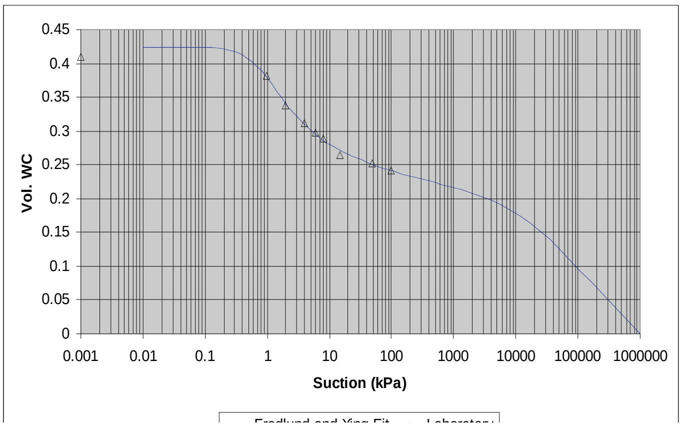


Figure A-9 SoilVision Reference Soil #10747 (64% Sand, 10% Silt, 26% Clay)

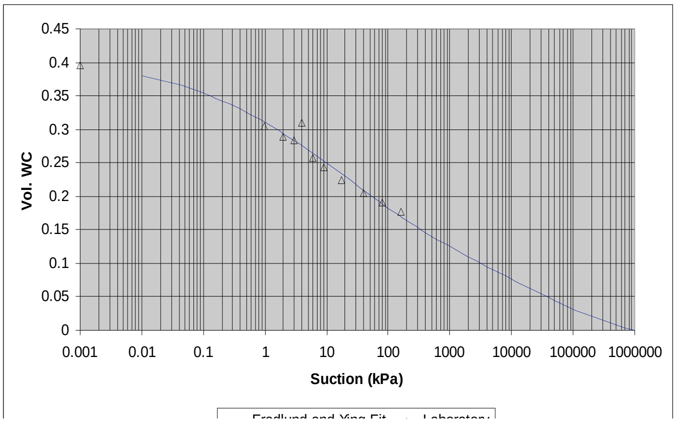


Figure A-10 SoilVision Reference Soil #10751 (66% Sand, 15% Silt, 18% Clay)

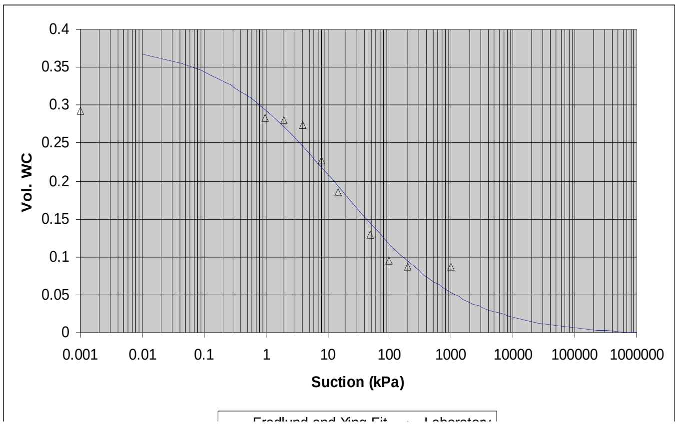


Figure A-11 SoilVision Reference Soil #10757 (61% Sand, 30% Silt, 9% Clay)

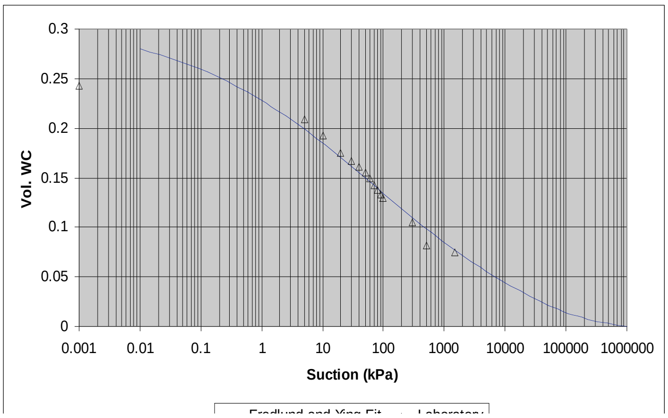


Figure A-12 SoilVision Reference Soil #10762 (72% Sand, 17% Silt, 10% Clay)

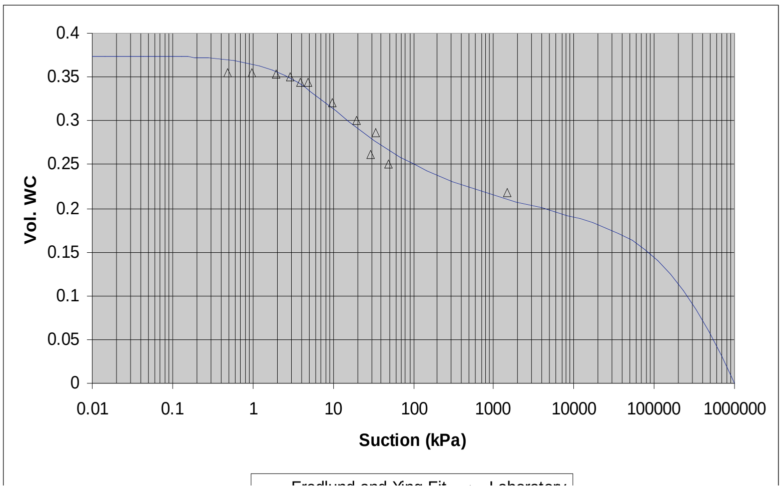
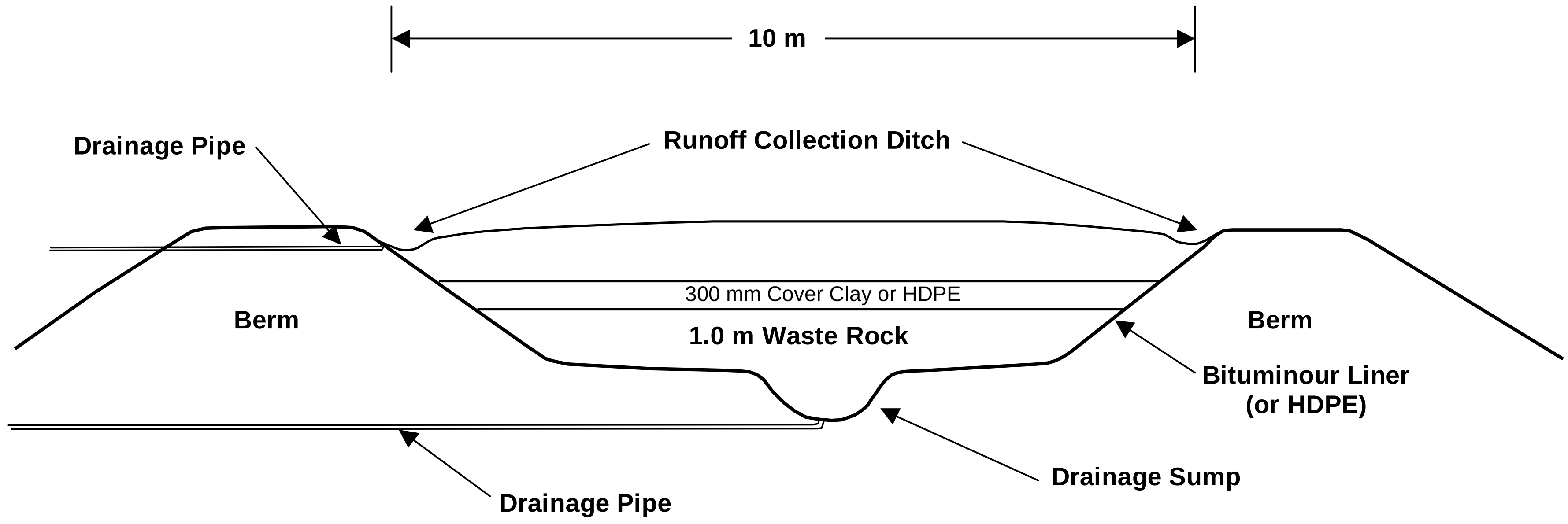


Figure A-13 SoilVision Reference Soil #10780 (57% Sand, 20% Silt, 20% Clay)

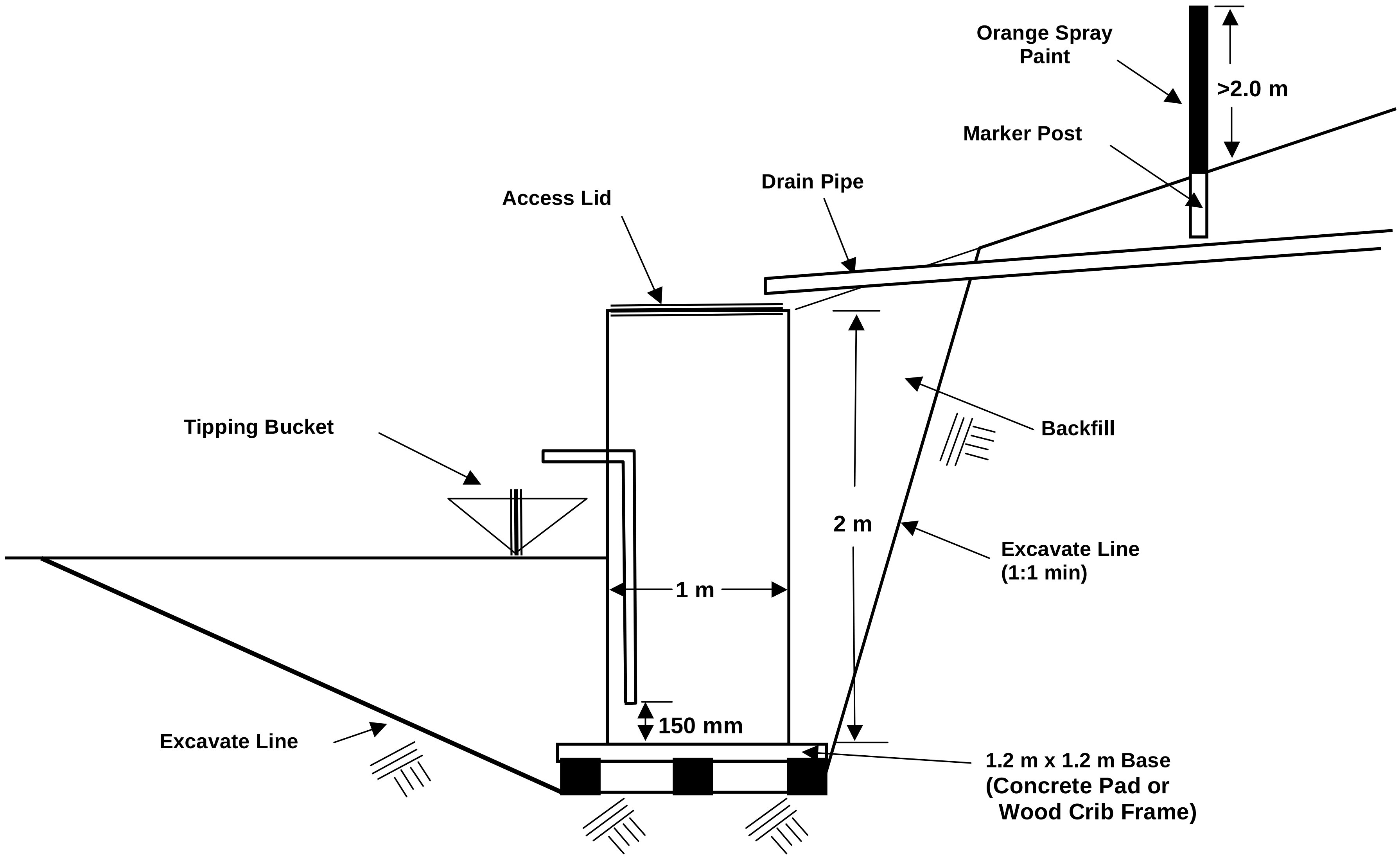
HORIZONTAL LYSIMETER DESIGN

(DRAWING NOT TO SCALE)



Detail for Drainage Reservoir

(*NOT TO SCALE*)



Appendix 7B

Non-Acid Forming Material Balance

Memorandum

SNOWDEN

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To: Marty Adams
Company: Hillgrove Resources Limited
From: Geoff Davidson
Copy:
Date: Monday, 11 February 2008
Project: Kanmantoo copper project
Subject: Updated non-acid forming material balance

MANAGEMENT OF POTENTIAL ACID FORMING MATERIAL

Potential acid forming (PAF) rock has been identified within waste zones of the pit areas. To avoid long term environmental impact from the PAF material, an encapsulation strategy will be adopted (Figure 1). The perimeter of the final formed integrated waste landform (IWL) will be constructed using non-acid forming (NAF) material

Assays from grade control/blasthole drilling will be used to identify PAF waste zones in the operating pit. As the PAF material is excavated it will be hauled to an internal location within the IWL. The NAF material will be dumped along the perimeter zone of the IWL.

In addition to disposal of PAF material in the IWL, the backfill placed in Emily Star and O'Neil will also consist of PAF.

A modelling exercise completed by Hillgrove subsequent to the definitive feasibility study has identified the quantities of NAF and PAF waste shown in Table 1

Table 1 Quantities of NAF and PAF identified by Hillgrove

		NAF	PAF	Total Waste
	SG	2.9	2.9	2.9
Main	M bcm	7.3	10.2	17.6
	Mt	21.3	29.6	51.0
E/S	M bcm	2.7	0.0	2.7
	Mt	7.9	0.0	7.8
Total	M bcm	10.0	10.2	20.3
	Mt	29.2	29.6	58.8

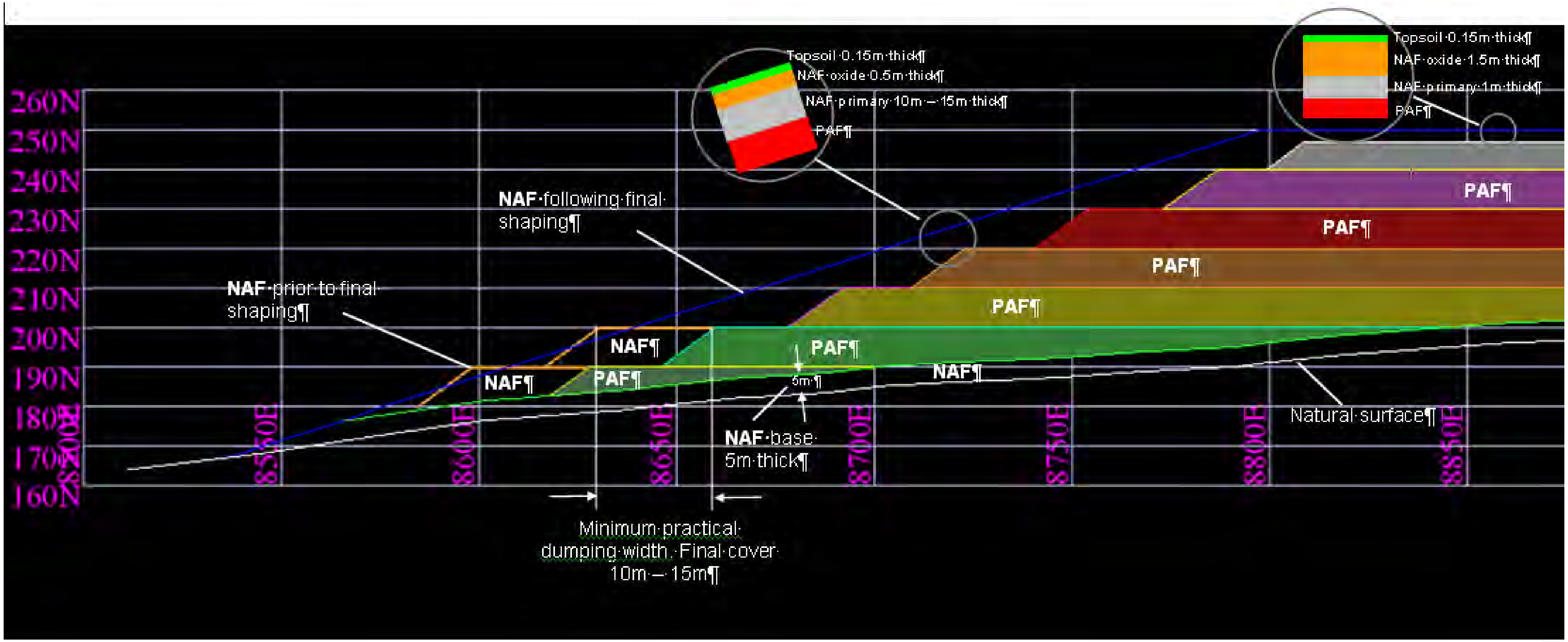
The material balance estimate from the DFS was updated to reflect these quantities and is summarised in Table 2.

Table 2 NAF material balance requirements

Description	Units	DFS	Update
Waste density	t/bcm	2.95	2.95
Swell factor	lcm/bcm	1.25	1.25
Waste produced - Main	M bcm	15.1	15.1
Waste produced - Emily Star	M bcm	2.7	2.7
Waste produced - O'Neil	M bcm	2.4	2.4
Total	**M bcm**	**20.2**	**20.2**
Total Volume produced	M lcm	25.3	25.3
TSF capacity	M lcm	9.1	9.1
WRS capacity	M lcm	11.4	11.4
Emily Star backfill capacity	M lcm	3.1	3.1
O'Neil backfill capacity	M lcm	1.7	1.7
Total site waste storage capacity	**M lcm**	**25.3**	**25.3**
PAF capacity - WRS/TSF	M lcm	9	9
PAF capacity - Emily Star backfilled to within 2.5 m of topo	M lcm	2.9	2.9
PAF capacity - O'Neil backfilled to within 2.5 m of topo	M lcm	1.6	1.6
Total site PAF capacity	**M lcm**	**13.5**	**13.5**
Required NAF	M lcm	11.8	11.8
Required NAF	M bcm	9.4	9.4
Identified NAF - Main pit	M bcm	3.1	7.3
Identified NAF - Emily Star	M bcm	2.7	2.7
Total NAF identified	**M bcm**	**5.8**	**10.0**
NAF deficit (still to be identified)	M bcm	3.6	0.0
NAF deficit (still to be identified)	M t	10.7	0.0

This latest modelling demonstrates that sufficient NAF material is available within the design to achieve the proposed encapsulation strategy acid forming waste.

Figure 1 **Typical section through WRSF showing PAF management strategy**



HILLGROVE RESOURCES

MEMORANDUM

TO: Catherine Davis (Environmental Manager)

FROM: Richard Bradey (Geology Manager)

DATE: November 14, 2008

SUBJECT: Kanmantoo Project Sulphur Model

A digital model of the distribution of sulphur associated with the Kanmantoo copper resource has been developed to quantify potentially acid forming (PAF) and non acid forming (NAF) waste within the proposed Kanmantoo mine plan.

The model was constructed using data from the JORC compliant Kanmantoo resource database. This data comprises reverse circulation and diamond drillhole data along with assay and survey data all compiled within JORC compliant quality management guidelines.

Modelling of the 0.2% and 0.25% sulphur distribution was undertaken using Surpac resource modelling software by a mining and resource geologist with 20 years industry experience and a Member of the Australian Institute of Mining and Metallurgy.

Limitations of the database in regard to the development of the sulphur model included the following; As a result of the drilling being primarily targeting sulphide mineralisation the un-mineralised areas of the mine plan have a lower density of drilling data. Assaying for sulphur was not undertaken for all of the drilling, particularly the older drill holes.

The database limitations were overcome in the modelling process by assuming PAF sulphur levels (>0.2% Sulphur) existed unless the data indicated otherwise.

The model that was developed in this exercise was of a simplified nature which included all areas of PAF within the mine plan in addition to many significant areas of NAF resulting in a model which is strongly conservative.

Richard Bradey
Geology & Site Manager - Kanmantoo Copper Project

Appendix 7C

Geochemical Characterisation of Waste Rock and Ore from the Kanmantoo Project

Prepared By:

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August 2010

Document No. 2042/937

Geochemical Characterisation of Waste Rock and Ore from the Kanmantoo Project

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List of Tables (after text)

List of Figures (after tables)

List of Appendices (after figures)

Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Hillgrove Resources Limited to carry out geochemical characterisation of waste rock, low grade ore and ore from the Kanmantoo Copper Project in South Australia. A combined total of 450 samples of waste rock, low grade ore and ore have been tested from the 2007, 2009, and 2010 sample sets. The objectives of the work were as follows:

- confirm the reliability of degree of weathering criteria for identification of non acid forming (NAF) waste rock;
- refine the preliminary S based criteria for identification of NAF waste rock in unweathered materials; and
- extend geochemical testing for Emily Star and O'Neil Zone deposits.

Results confirm that moderately to highly weathered waste rock is likely to be non acid forming (NAF), and that slightly weathered to fresh materials will be a mixture of NAF, potentially acid forming (PAF) and PAF low capacity (PAF-LC). Results indicate that slightly weathered to fresh waste rock at Emily Star (and possibly Green Zone) will have the lowest ARD potential, and that at Main Zone, NW Zone and NE Zone will have the higher ARD potential. Overall, 45% of slightly weathered to fresh samples were classified NAF, and 55% PAF or PAF-LC. Although the samples assayed may not be a true representation of the actual proportion of ARD rock types within the pit shells, it is likely that a significant proportion of the total waste rock will be PAF/PAF-LC.

Highly weathered and soil materials appear to contain reactive acid buffering minerals and may potentially be used for additional security and control of acid release when used in covers or blends with PAF materials. The acid buffering of other mine materials tested was generally low and poorly reactive, and PAF materials will tend to have a short lag before onset of low pH conditions.

Waste rock and ore are likely to be enriched in Ag, Bi, Co and Cu, and weathered ore materials also appear to show elevated Se. Results indicate that weathered ore and low grade ore are unlikely to contain metals or metalloids that are readily mobilised under circum neutral pH conditions. Under acid conditions, leachates will be associated with elevated metals, including Al, Co, Cu, Fe, Mn, Ni and Zn.

The following waste rock segregation criteria based on geology and S testing are recommended for modelling the distribution of ARD rock types:

NAF: moderately to highly weathered *or*
slightly weathered to fresh and Total S ≤0.3%S

PAF-LC: slightly weathered to fresh and Total S >0.3%S and ≤0.8%S

PAF: slightly weathered to fresh and Total S >0.8%S

Note that PAF-LC materials could potentially be used to supplement operational shortfalls in NAF materials if it can be demonstrated that blending PAF-LC with NAF and/or addition of limestone can render these materials NAF.

The findings of investigations to date have the following implications for materials management:

- Segregation and selective mining of ARD waste rock types will be required to manage ARD from waste rock dumps.
- A programme of routine sampling and geochemical testing of waste rock materials should be carried out during operations to monitor variation in acid potential, reconcile the ARD prediction model and check ARD rock type materials handling and placement.
- Site capability for routine ARD screening testing should be developed to support the above programme. The NAG test is an excellent option due to its high level of discrimination between ARD rock types at Kanmantoo, the robustness of the test, the relatively simple equipment and reagent requirements, and its potential for simplification. Total S testing could also be an option, but would require more complex equipment and training to implement.
- Routine surface and groundwater monitoring should include analysis of pH, EC, Ag, Al, As, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, SO4 and Zn.
- The final pit voids may also be significant sources of ARD, depending on the distribution of sulphidic materials in the final walls and floors.

It is recommended the following be carried out to better define the ARD and metal/metaloid leaching potential:

- The infill S testing programme in progress by Hillgrove should be continued to improve the S model, and any issues with NAF availability should be identified.
- Use the S model to determine a S distribution of final pit shells, and assess the likely overall acid potential from the final pit void.
- Waste rock kinetic testing should be carried out to confirm preliminary lag times indicated by kinetic NAG testing and provide information on leaching characteristics. These data will provide:
  - information to help finalise management strategies for waste rock to minimise oxidation and ARD generation during operations;
  - a basis for assessing the geochemical contribution from the current operations relative to those from previous mining activities;
  - data to predict pit water quality during operations and at closure; and
  - an indication of treatment requirements to minimise liabilities at closure.
- Leach column testing of low grade ore and oxide ore should be carried out to determine leaching characteristics and help assess management requirements for these materials.
- Carry out simplified NAG tests on a range of waste rock materials to determine a suitable method for site implementation.

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Hillgrove Resources Limited to carry out geochemical characterisation of waste rock, low grade ore and ore from the Kanmantoo Copper Project in South Australia. The work follows on from a previous geochemical assessment carried out by EGi in 2007[1].

Mineralisation at Kanmantoo occurs as veins and stockworks within the Cambrian Kanmantoo Group. The mineralisation consists of a number of discrete lenses with relatively sharp boundaries between ore and waste, dipping steeply to the east and striking approximately North-South. The Kanmantoo resource is split into three main deposits, the Main Deposit, Emily Star and O'Neil Zone.

The main deposit surrounding the old workings is split up into a number of zones: Main Zone, Eastern Zone, NE Zone, NW Zone, SE Zone and Green Zone. Mineralisation in the main deposit comprises chalcopyrite, pyrrhotite and magnetite with lesser pyrite, and is hosted by a garnet-andalusite-biotite schist (GABS). Biotite schist occurs peripheral to the GABS unit.

Emily Star and O'Neil Zone are satellite deposits that have different mineralogical associations. Mineralisation at Emily Star is characterised by chalcopyrite and pyrite. Mineralisation in the O'Neil Zone is similar to the Main Deposit but is enriched in gold.

There is a distinct weathering zone of approximately 15 m depth in which most sulphide appears to be completely oxidised. Copper mineralisation in the oxide zone is dominated by malachite, azurite and chalcocite.

The objectives of the work were as follows:

- confirm the reliability of degree of weathering criteria for identification of non acid forming (NAF) waste rock;
- refine the preliminary S based criteria for identification of NAF waste rock in unweathered materials; and
- extend geochemical testing for Emily Star and O'Neil Zone deposits.

Initial work carried out in 2007 indicated that sulphides were mostly completely oxidised in the weathered zone, and hence the degree of weathering routinely recorded in geological logs could potentially be used to reliably classify NAF materials, without the need for specific testing. More widespread geochemical testing was required to confirm an appropriate geological cut off.

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[1] *Hillgrove Resources Limited*, *ARD Assessment of the Kanmantoo Copper Project*, EGi Document No. 2042/771, September 2007.

Sulphur analysis is routinely carried out in ore zones, and the 2007 work indicated a cut off of around 0.2%S could be used to segregate NAF and PAF materials in the fresh rock. Preliminary modelling of the S distribution was carried out by Hillgrove geologists in 2008. Although the S data was biased towards ore zones, the modelling was sufficient to indicate that the Emily Star pit may contain mainly NAF waste rock, and that coherent blocks of NAF materials could be identified in the other pits although the distribution of PAF and NAF was more complex. A materials balance was reported in a memorandum by Snowden in February 2008, which determined that based on the preliminary modelling, there was likely to be sufficient NAF to meet the surface construction and cover requirements[2].

The most reliable and ready sources of NAF appear to be weathered rock and fresh waste rock from Emily Star, but these sources alone will not meet requirements. Furthermore, due to the general lack of storage on site, it will be important to identify an excess of NAF to provide flexibility in scheduling and placement of NAF and PAF materials. It was therefore important to confirm a reliable S cut off criteria for fresh rock, and if possible increase the S cut off value to provide more flexibility in materials segregation and potentially increase the proportion of available NAF waste rock.

Testing in 2007 did not include O'Neil Zone samples and only included 25 samples in 1 hole at Emily Star. A more comprehensive geochemical characterisation programme was required for the Emily Star and O'Neil Zone deposits to account for potential variation in mineralogy, alteration and lithologies.

2.0 Sample Preparation and Test Methodology

A total of 235 waste rock, 49 low grade ore and 67 ore samples were provided to EGi for testing in June 2009 and in March and April 2010. Samples were selected by site personnel in conjunction with EGi to represent the weathered profile from across the deposit and to fill in gaps in coverage from previous testing. With the 2007 samples, a combined total of 450 samples have been geochemically tested.

Samples were provided as splits of pulverised (-75µm) reserves from ore resource definition testing.

Acid neutralising capacity (ANC) and single addition net acid generation (NAG) testing was completed on all samples. Most samples were already assayed for total S by ICP as part of routine resource testing. Leco equivalent (high temperature evolution) total S testing was carried out on selected samples with ICP S values to confirm the suitability of the ICP method, and also on samples not previously assayed for S.

[2] *Management of Potential Acid Forming Material*, Snowden Mining Industry Consultants Pty Ltd, Memorandum to Marty Adams, 11 February 2008.

Further testing was carried out on selected samples to help resolve uncertainties in the above test results and provide a guide to elemental mobilisation, as follows:

- sequential NAG test
- kinetic NAG test;
- acid buffering characteristic curve (ABCC) test;
- multi-element scans of solids; and
- pH, alkalinity/acidity and multi-element scans of deionised water batch extracts carried out at a ratio of 1 part solid to 2 parts water and agitated for 16 hours.

A general description of ARD test methods and calculations used is provided in Appendix A.

Total sulphur assays were carried out by Sydney Environmental and Soil Laboratory (SESL). Multi-element analyses of sample solids were carried out by ALS Laboratory Group (Brisbane). Multi-element analyses of deionised water batch extracts were carried out by ALS Laboratory Group (Sydney). All other analyses were carried out by EGi.

3.0 Standard Geochemical Characterisation

Acid forming characteristics of waste rock, low grade and ore samples are shown in Table 1, comprising total S, MPA (maximum potential acidity), ANC, NAPP (net acid producing potential), ANC/MPA ratio, and single addition NAG. Table 1 includes results from the previous 2007[1] testing in addition to the recent 2009 and 2010 testing.

3.1 Acid Base (NAPP) Results

Total S ranged up to 7.1%S, with approximately 60% of samples having relatively low total S of less than 0.5%S, and 5% of samples having high S values greater than 2%S.

ICP S is routinely determined on a wide sample set as part of Hillgrove Resources analytical testing for resource definition. Figure 1 compares the Hillgrove ICP total S with Leco (and Leco equivalent) total S carried out on the same samples from the 2007 and 2009 testing. The plot shows a strong 1:1 relationship between the ICP S and Leco S results, showing that the ICP S is suitable for determination of total S on Kanmantoo materials.

Figure 2 is a box plot of the distribution of S split by the degree of weathering, showing that weathering strongly effects the distribution of S, with slightly to highly weathered materials having a distinctly lower distribution of S than transition and fresh materials. Weathered materials have median S values of 0.02%S to 0.08%S, compared to median values of 0.3% to 0.5%S for transition/fresh materials. Although the slightly weathered samples have a low median S value of 0.03%S, this group also includes higher S samples with 10% of samples containing more than 1%S.

Figure 3 is a box plot of the distribution of S split by lithology for transitional and fresh samples only, focussing on the influence of lithology on S distribution independent of the weathering effects noted in Figure 2. The plot shows that all lithologies show a similar range of S values, but with the biotite schist (BS) showing a distinctly lower median S of 0.15%S, compared to the other lithologies with similar medians ranging from 0.49%S to 0.66%S. Results indicate that lithology does not strongly control S distribution, except for an apparent lower S in BS lithologies overall. Note that although the fresh/transitional BS samples show a low median S, 30% of the BS samples had S values greater than 1%S and as high as 7%S, indicating that portions of this rock type may be strongly pyritic.

ANC values ranged up to 179 kg H_2SO_4/t but were generally low, with 84% of samples having ANC values less than 20 kg H_2SO_4/t.

Figure 4 is a box plot of the distribution of ANC split by the degree of weathering (excluding the high ANC value of 179 kg H_2SO_4/t). Results show that weathering does not strongly control the distribution of ANC, with median ANC values low and less than 15 kg H_2SO_4/t for all weathering types. However, the highest ANC values were associated with the highly weathered samples. Figure 5 is a box plot of the distribution of ANC split by lithology for transitional and fresh samples only. The plot indicates that lithology does not significantly control ANC distribution.

The net acid producing potential (NAPP) value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the maximum potential acidity (MPA) and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

Figure 6 is an acid-base account plot of ANC versus total S. Figure 7 is the same as Figure 6, but re-scaled to exclude the high S samples and to better represent ANC below 50 kg H_2SO_4/t. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains, and lines for ANC/MPA ratio values of 1.5 and 2 are also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA ratio of l. The ANC/MPA ratio is used as an indication of the relative factor of safety within the NAPP negative domain. Usually a ratio of 2 or more signifies a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to ARD. The plots emphasize the narrow ANC range, with the majority of samples having an ANC less than 20 kg H_2SO_4/t, but a broad range in S content. Approximately 55% of samples are NAPP negative, and most of these (65%) have ANC/MPA ratios of 2 or more.

3.2 Single Addition NAG Results and Comparison with Acid Base Results

NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. A NAGpH < 4.5 indicates the sample is acid producing. Table 1 shows that approximately 45% of the samples tested had a NAGpH greater than or equal to 4.5.

Figure 8 is an ARD classification plot showing NAGpH versus NAPP value. Figure 9 is the same plot rescaled to better represent the NAPP range from -50 to 50 kg H_2SO_4/t. Potentially acid forming (PAF), non-acid forming (NAF) and uncertain (UC) classification domains are indicated. A sample is classified PAF when it has a positive NAPP and NAGpH < 4.5, and NAF when it has a negative NAPP and NAGpH ≥ 4.5. Samples are classified uncertain when there is an apparent conflict between the NAPP and NAG results, i.e. when the NAPP is positive and NAGpH ≥ 4.5, or when the NAPP is negative and NAGpH < 4.5.

The plot shows that most samples plot in the NAF and PAF domain, but a number of samples also plot in the upper right and lower left uncertain domains.

A total of 58 samples plot in the lower left uncertain domain with negative NAPP values but NAGpH values less than 4.5. Results suggest that the ANC measured is partially ineffective, resulting in an underestimation of acid potential in the NAPP value. This was confirmed with ABCC testing (see Section 4.1) and hence the NAG test results are expected to be a more reliable guide to acid potential for these samples.

Eleven samples plot in the upper right uncertain domain. These samples have low ANC values of 15 kg H_2SO_4/t or less and total S values of less than 0.8%S, and the NAG test would normally account for all pyritic S in the sample. These samples are expected to be NAF in accordance with the NAG results, and suggest the presence of non acid generating S forms. Note that many of these samples were highly to moderately weathered, and results confirm that much of the pyrite in these samples is likely to have been oxidised.

4.0 Specialised Geochemical Characterisation

4.1 Acid Buffering Characteristic Curve (ABCC) Testing

Acid buffering characteristic curve (ABCC) testing was carried out on 34 selected waste rock, low grade ore and ore samples to evaluate the availability of the ANC measured. The ABCC test involves slow titration of a sample with acid while measuring the solution pH. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC.

Results are presented in Figures 10 to 21, with calcite, dolomite, ferroan dolomite and siderite standard curves as reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. The siderite standard provides very poor acid buffering, exhibiting a very steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

Moderately weathered samples 40340 (Figure 20) and 40337 (Figure 21) have unusual curves in that the acid consumed to pH 4 is equal to 2-3 times the total ANC. These two samples have high Cu concentrations greater than 3%Cu, and the log descriptions indicate that the Cu occurs as the hydrated copper carbonates malachite and azurite. In these cases the ABCC curves reflect interference from dissolution of malachite and azurite, rather than carbonates. Cu will tend to remain in solution at below pH 5, but once it precipitates the acid consumed will be re-released, and hence there is no net acid neutralisation benefit from reaction of acid with these minerals. However, the results do demonstrate that Cu is readily mobilised from oxide zone ore under acidic conditions.

All of the highly weathered and soil samples show strong buffering (samples 40299 in Figure 12, 40561 and 40532 in Figure 14, 38602 and 40652 in Figure 16, and 40311 in Figure 19), with curves plotting between calcite and dolomite standard curves, and indicating almost all the total ANC in these samples is available and fast reacting. The results suggest surface enrichment of carbonate due to weathering processes, most likely as calcrete or equivalent.

By contrast, all the remaining 26 moderately weathered to fresh samples have profiles that plot between the ferroan dolomite and siderite standard curve, indicating poor reactivity and with 19 of these samples showing only partial (less than 60%) ANC effectiveness.

Results show that soil and highly weathered materials at Kanmantoo may provide a source of readily available acid buffering, potentially offering additional security and control of acid release when used in covers or blends with acid producing materials. However, the ANC in moderately weathered to fresh materials appears to be poorly available and slow reacting. Total ANC values for these materials may therefore overestimate the effective buffering available, resulting in underestimation of acid potential in the NAPP value, confirming that the samples plotting in the lower left uncertain domain are likely to be PAF as indicated by NAG testing.

4.2 Sequential NAG Testing

When testing samples with high sulphide contents it is common for oxidation to be incomplete in the single addition NAG test. Sequential NAG testing overcomes this limitation to an extent through successive additions of peroxide to the same sample. Sequential NAG testing to 5 stages was carried out on six selected samples. Results are presented in Table 2.

Moderately weathered ore sample 40340 had a slightly negative NAPP of -2 kg H_2SO_4/t and a moderate ANC of 21 kg H_2SO_4/t, and sequential NAG testing was carried out to confirm this sample was non acid forming. Results show that the pH remained greater than 4.5 for all 5 stages, and the sample was classified NAF.

The remaining 5 samples had positive NAPP values, and sequential NAG testing was carried out to compare total sequential NAG acidities to NAPP values. Results show that most acid is released in the first stage of the test, with only minor acidity measured after stage 2. The total sequential NAG acidity values to pH 7 were approximately 60-80% of the NAPP values, suggesting that most of the S in this sample is present as reactive sulphide. Results also show that the single addition NAG is a reasonable guide to acid potential in these samples.

4.3 Kinetic NAG Testing

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Kinetic NAG testing was carried out on 15 selected slightly weathered to fresh samples with S values greater than 0.8% S and varying ANC. The kinetic NAG pH and temperature profiles are presented in Figures 22 to 36.

All samples have distinct temperature peaks, indicating that most of the total S in the samples is present as pyrite/pyrrhotite. However, the lag time before acid production (pH <4) in the test varies.

Samples 33402, 33414, 33425, 33452 and 40329 have moderate to high S of 0.81%S to 1.75%S and moderate ANC values of 19 to 29 kg H_2SO_4/t, and show a delay of close to 30 minutes before reaching pH 4. The results suggest materials represented by these samples will have a lag of 2 to 6 months before acid conditions develop in the field.

Sample 33400 has moderate S of 0.85%S and low to moderate ANC of 13 kg H_2SO_4/t, and shows slow rates of acid production, dropping below pH 4 after 100 minutes. The results indicate that materials represented by this sample are likely to have a lag 1-2 years before the onset of acid conditions.

The remaining 9 samples have moderate to high S of 1.0% to 2.5%S and low ANC of 11 kg H_2SO_4/t or less, and show rapid rates of acid production, reaching below pH 4 in the first 10 minutes of the test. The results indicate that pyritic materials with low ANC are likely to produce acid within a week to a few months after exposure.

Overall, results indicate that higher sulphur PAF materials with moderate ANC may have lags of 2-4 months after exposure to atmospheric oxidation conditions, whereas those with ANC values of around 10 or less are likely to react within weeks.

4.4 Multi-Element Analysis of Solids and Water Extracts

A total of 39 samples were selected for multi-element analysis of solids and water extracts. Samples were selected to cover a range of ore and waste rock types and degree of weathering. Results of multi-element scans on solids were compared to the median soil abundance (from Bowen, 1979[3]) to highlight enriched elements.

The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average abundance on a log 2 scale. The GAI is expressed in integer increments where a GAI of 0 indicates the element is present at a concentration similar to, or less than, average abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above average abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

[3] Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, New York, p 36-37.

Results of multi-element analysis are presented in Table 3 and the corresponding GAI values are presented in Table 4.

Results show significant enrichment in Cu for both ore samples and waste rock samples, with associated enrichment in Ag, Bi and Co. Se is enriched in the high to moderate weathered ore and low grade ore samples, with slight enrichment in some of the waste rock samples. Sulphur is mainly enriched in the fresh samples, as discussed in relation to acid forming potential (Section 3.1). There is also slight enrichment of Be in many of the samples, and individual samples are also slightly enriched in As. In addition, there is a single high W concentration of 202 mg/kg, which may be due to contamination or analytical error, as it is 2 orders of magnitude higher than other samples.

The same waste rock sample solids were subjected to water extraction at a solids:liquor ratio of 1:2 and results are provided in Table 5. Most sample extracts had circum neutral pH and low salinity EC values of less than 0.4 dS/m. Elevated Al and Fe were measured in many samples with circum neutral pH values. The presence of elevated Al and Fe in extracts with circum neutral pH values is unexpected, and indicates the presence of colloidal metals or fine particulates in the solution after filtering. This is supported by an association between dissolved Si and Al and Fe. A few samples contain elevated Cu concentrations of greater than 1 mg/L at circum-neutral pH, which may be due to fine particulates but may indicate Cu solubility. The water extract from high S sample 33446 has a low pH of 3.6, and shows elevated concentrations of Co, Cu, Mn, Ni and Zn. Overall results indicate a general lack of metal/metalloid mobilisation except under acid conditions.

Results indicate waste rock and ore are likely to be enriched in Ag, Bi, Co and Cu, and weathered ore materials also appear to show elevated Se. Results indicate that weathered ore and low grade ore is unlikely to contain metals or metalloids that are readily mobilised under circum neutral pH conditions (with the possible exception of Cu). Under acid conditions, leachates will be associated with elevated metals, including Al, Co, Cu, Fe, Mn, Ni and Zn. The solubility of these elements will largely be determined by pH and therefore control of acid generation will effectively control metal leaching. Leach column testing would be required to evaluate the likely seepage quality and release rates of environmentally important elements associated with oxidation of waste rock materials, both under neutral and acid conditions.

5.0 Sample Classification and Segregation Criteria

ARD classifications are provided in Table 1 based on results and discussions above. A total of 45% of samples in Table 1 were classified NAF/UC(NAF), 25% were classified PAF-LC/UC(PAF-LC) and 30% of samples were classified PAF/UC(PAF). Comparison of the ARD classification resulting from full geochemical characterisation with key parameters in Table 1 indicate that routine ARD screening of waste rock for distribution modelling, and reconciliation and checks during operations, could be based on a combination of geological description and ARD testing.

Figure 37 is a plot showing the relative proportion of samples classified NAF, PAF-LC and PAF by the degree of weathering. Note that the classification groupings include the expected classification of the uncertain samples, so that the NAF proportion (shown in blue) includes UC(NAF), the PAF-LC (pink) incudes UC(PAF-LC) and PAF (red) includes UC(PAF). The plot shows that none of the highly weathered samples were classified PAF or PAF-LC. Only a small proportion (6%) of the moderately weathered samples were classified PAF, and a slightly higher proportion (11%) were classified PAF-LC, but all PAF samples and all but 2 PAF-LC samples were ore or low grade ore rather than waste rock. Slightly weathered samples show a more significant proportion of PAF and PAF-LC, accounting for 27% of samples.

The results indicate that highly to moderately weathered waste rock materials can be classified NAF without the need to carry out specific testing (apart from routine checks during operations). The base of moderate weathering has already been defined as the base of oxidation surface in the site geological model, and hence is readily applied to planning and scheduling. However, some adjustments need to be made to the base of oxidation surface, as checks during the site visit showed that some holes have materials described as moderately weathered but are collared in the old pit surface below the true weathering profile. In these cases, decades of exposure have caused the sulphide to partly oxidise, giving the appearance of a moderately weathered material. Only materials logged as moderately to highly weathered within the natural weathering profile should be classified NAF.

ARD classification of materials below the base of oxidation surface (slightly weathered to fresh materials) requires the application of criteria based on ARD testing. Results suggest that total S and NAGpH are the most discriminating parameters for routine ARD classification of these materials.

ICP S has been routinely determined on a wide sample set as part of Hillgrove Resources analytical testing for resource definition, and preliminary S distribution modelling was carried out in 2008[2] based on previous EGi recommendations. The modelling confirmed the presence of minable low S blocks and the potential for S as a waste rock segregation tool.

Figure 38 is a box plot showing the distribution of total S by ARD classification type for all slightly weathered, transitional and fresh samples. The plot shows that at less than or equal to 0.3%S, 90% of NAF samples are included but no PAF samples and a minority of PAF-LC samples. The 0.3%S cut off is therefore the recommended criteria for separating NAF from PAF-LC and PAF.

The range 0.5%S to 0.8%S captures most of the PAF-LC samples but excludes most of the PAF samples, and could be used to separate PAF LC from PAF. PAF-LC materials could potentially be used to supplement operational shortfalls in NAF materials by blending with NAF and/or crushed limestone. Determining appropriate blending ratios and addition rates would require further geochemical investigations.

Figure 39 is a box plot of the distribution of NAGpH by ARD classification for all slightly weathered, transitional and fresh samples. The plot shows a NAGpH of 4.5 discriminates between all NAF and PAF/PAF-LC samples. A NAGpH of 3.5 is appropriate for segregating PAF-LC and PAF. Although NAGpH provides very good discrimination between NAF, PAF-LC and PAF rock types, the total S criteria is still preferred for development of an ARD rock type distribution model because of the existing large and expanding S database, and its direct relationship to sulphide mineralisation. However, NAG testing has strong potential as a site based method for reconciliation of the ARD prediction model and for routine checking. The NAG test could be simplified for site use to ensure ease of use and quick turn around.

Modelling of the S distribution will be required to accurately determine trends in ARD rock type occurrence across the deposit, but results in Table 1 show some general indications of the relative proportions of ARD rock types for the different mineralisation zones. Figure 40 is a plot of the relative proportion of samples classified NAF, PAF-LC and PAF in each of the mineralisation zones for slightly weathered, transitional and fresh samples. The figure indicates the following:

- Main Zone, NW Zone and NE Zone: low proportion of NAF and high proportion of PAF and PAF-LC;
- Eastern Zone, SE Zone and O'Neil Zone: moderate proportion of NAF but a relatively high proportion of PAF and PAF-LC;
- Emily Star: high proportion of NAF and a relatively low proportion of PAF and PAF-LC; and
- Green Zone: all samples were NAF suggesting a possible similar distribution to Emily Star, but only one hole was tested from this zone and results are inconclusive.

Overall, 45% of slightly weathered to fresh samples were classified NAF, and 55% PAF or PAF-LC. Note that testing of an additional 3 holes in 2009/2010 at Emily Star confirmed the low proportion of PAF indicated by testing of the single hole in 2007.

6.0 Conclusions and Recommendations

Results confirm that moderately to highly weathered waste rock is likely to be NAF, and that slightly weathered to fresh materials will be a mixture of NAF, PAF-LC and PAF. Results indicate that slightly weathered to fresh waste rock at Emily Star (and possibly Green Zone) will have the lowest ARD potential, and that at Main Zone, NW Zone and NE Zone will have the higher ARD potential. Overall, 45% of slightly weathered to fresh samples were classified NAF, and 55% PAF or PAF-LC. Although the samples assayed may not be a true representation of the actual proportion of ARD rock types within the pit shells, it is likely that a significant proportion of the total waste rock will be PAF/PAF-LC.

The ANC in the mine materials tested was generally low and poorly reactive, and PAF materials will tend to have a short lag before onset of low pH conditions. Highly weathered and soil materials are an exception with apparently fast reacting acid buffering minerals present, most likely due to surface enrichment of carbonate (calcrete or equivalent) due to weathering processes. These highly weathered and soil materials may potentially be used for additional security and control of acid release when used in covers or blends with acid producing materials.

Waste rock and ore are likely to be enriched in Ag, Bi, Co and Cu, and weathered ore materials also appear to show elevated Se. Results indicate that weathered ore and low grade ore is unlikely to contain metals or metalloids that are readily mobilised under circum neutral pH conditions. Under acid conditions, leachates will be associated with elevated metals, including Al, Co, Cu, Fe, Mn, Ni and Zn.

The following waste rock segregation criteria based on geology and S testing are recommended for modelling the distribution of ARD rock types:

NAF: moderately to highly weathered *or*
slightly weathered to fresh and Total S ≤0.3%S

PAF-LC: slightly weathered to fresh and Total S >0.3%S and ≤0.8%S

PAF: slightly weathered to fresh and Total S >0.8%S

Once the distribution of ARD waste rock types are modelled across the deposit, the materials balance should be assessed to determine whether there is sufficient NAF to meet the surface construction and cover requirements.

Note that PAF-LC materials could potentially be used to supplement operational shortfalls in NAF materials. There may be opportunities to increase the NAF cut off between 0.3%S and 0.8%S if it can be demonstrated that blending PAF-LC with NAF and/or addition of limestone can render these materials benign. It is recommended that S distribution modelling of slightly weathered to fresh waste rock define zones with variable cut offs of ≤0.3%S, ≤0.5%S and ≤0.8%S to take into account possible contributions from PAF-LC materials. Significant increases in material volumes with an increased %S cut off would justify further geochemical investigations to determine appropriate blending ratios and/or limestone addition rates.

NAG testing has strong potential as a site based method for reconciliation of the ARD prediction model and for routine checking. The NAG test could be simplified for site use to ensure ease of use and quick turn around.

The findings of investigations to date have the following implications for materials management:

- ARD management of slightly weathered to fresh waste rock materials will be required to prevent ARD from waste rock dumps.
- A programme of routine sampling and geochemical testing of waste rock materials should be carried out during operations to monitor variation in acid potential, reconcile the ARD prediction model and check ARD rock type materials handling and placement.

- Site capability for routine ARD screening testing should be developed to support the above programme. The NAG test is an excellent option due to its high level of discrimination between ARD rock types at Kanmantoo, the robustness of the test, the relatively simple equipment and reagent requirements, and its potential for simplification. Total S testing could also be an option, but would require more complex equipment and training to implement.
- Routine surface and groundwater monitoring should include analysis of pH, EC, Ag, Al, As, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb, SO4 and Zn.
- The final pit voids may also be significant sources of ARD, depending on the distribution of sulphidic materials in the final walls and floors.

It is recommended the following be carried out to better define the ARD and metal/metaloid leaching potential:

- The infill S testing programme in progress by Hillgrove should be continued to improve the S model. As discussed, the modelling should include cut offs of ≤0.3%S, ≤0.5%S and ≤0.8%S, and any issues with NAF availability should be identified.
- Use the S model to determine a S distribution of final pit shells, and assess the likely overall acid potential from the final pit void.
- Waste rock kinetic testing should be carried out to confirm preliminary lag times indicated by kinetic NAG testing and provide information on leaching characteristics. These data will provide:
  - information to help finalise management strategies for waste rock to minimise oxidation and ARD generation during operations;
  - a basis for assessing the geochemical contribution from the current operations relative to those from previous mining activities;
  - data to predict pit water quality during operations and at closure; and
  - an indication of treatment requirements to minimise liabilities at closure.
- Leach column testing of low grade ore and oxide ore should be carried out to determine leaching characteristics and help assess management requirements for these materials. It is understood that unoxidised high grade ore is not likely to be stockpiled for more than a week during operations, and hence there should be limited opportunities for ARD generation from these stockpiles. However, low grade ore and oxide ore may be stockpiled for a number of years, and could potentially leach acid (low grade ore only) and metals/metalloids.
- Carry out simplified NAG tests on a range of waste rock materials to determine a suitable method for site implementation.

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
KTRC070	Main Zone	1.00	4.00	3.00	GABS	Fresh	WR					33384	2007	0.029	0.006	0.62	19	7	12	0.37	3.4	3	10	PAF-LC
KTRC070	Main Zone	8.00	12.00	4.00	GABS	Fresh	WR	2				33385	2007	0.011	0.005	0.50	15	9	6	0.59	3.3	4	11	PAF-LC
KTRC070	Main Zone	20.00	24.00	4.00	GABSS	Fresh	WR	1				33386	2007	0.010	0.001	0.43	13	10	3	0.76	3.5	4	10	PAF-LC
KTRC070	Main Zone	28.00	30.00	2.00	GABSS	Fresh	WR	1				33387	2007	0.009	0.015	0.24	7	20	-13	2.78	5.6	0	1	NAF
KTRC070	Main Zone	30.00	31.00	1.00	QV	Fresh	WR	1				33388	2007	0.011	0.010	0.25	8	12	-4	1.57	4.7	0	3	NAF
KTRC070	Main Zone	34.00	38.00	4.00	BGCS	Fresh	WR	2		1		33389	2007	0.167	0.053	0.89	27	11	16	0.40	3.5	6	19	PAF
KTRC070	Main Zone	38.00	39.00	1.00	BGCS	Fresh	WR	2				33390	2007	0.073	0.020	0.70	21	11	10	0.51	3.8	3	13	PAF-LC
KTRC070	Main Zone	41.00	44.00	3.00	GABSS	Fresh	WR					33391	2007	0.163	0.073	0.36	11	11	0	1.00	5.6	0	5	NAF
KTRC070	Main Zone	44.00	45.00	1.00	GABSS	Fresh	WR	2		1		33392	2007	0.341	0.170	0.70	21	10	11	0.47	3.4	3	12	PAF-LC
KTRC070	Main Zone	45.00	49.00	4.00	GABSS	Fresh	WR	2		1		33393	2007	0.114	0.035	0.86	26	12	14	0.46	3.3	9	17	PAF
KTRC070	Main Zone	51.00	52.00	1.00	GABSS	Fresh	WR	2				33394	2007	0.047	0.010	0.53	16	15	1	0.92	3.8	3	10	PAF-LC
KTRC070	Main Zone	56.00	57.00	1.00	GABS	Fresh	WR	2		1		33395	2007	0.100	0.070	1.49	46	10	36	0.22	2.7	20	31	PAF
KTRC070	Main Zone	57.00	60.00	3.00	GABS	Fresh	WR	2				33396	2007	0.067	0.063	0.58	18	14	4	0.79	3.4	6	13	PAF
KTRC070	Main Zone	64.00	68.00	4.00	GABSS	Fresh	WR					33397	2007	0.006	0.002	0.11	3	12	-9	3.57	5.6	0	3	NAF
KTRC070	Main Zone	72.00	76.00	4.00	GABSS	Fresh	WR	1		1		33398	2007	0.025	0.004	0.80	24	22	2	0.90	3.1	12	20	PAF
KTRC070	Main Zone	76.00	80.00	4.00	GABSS	Fresh	WR	1		1		33399	2007	0.048	0.008	0.89	27	17	10	0.62	3.0	13	22	PAF
KTRC070	Main Zone	83.00	87.00	4.00	BGCS	Fresh	WR	2		1		33400	2007	0.212	0.015	0.85	26	13	13	0.50	3.2	8	17	PAF
KTRC070	Main Zone	87.00	88.00	1.00	BGCS	Fresh	WR	2		1		33401	2007	0.191	0.000	0.61	19	12	7	0.64	3.5	5	13	PAF-LC
KTRC070	Main Zone	103.00	104.00	1.00	GABSS	Fresh	WR			2		33402	2007	0.168	0.000	0.81	25	29	-4	1.17	3.2	9	19	UC(PAF)
KTRC070	Main Zone	104.00	108.00	4.00	GABSS	Fresh	WR	1		1		33403	2007	0.065	0.010	0.46	14	11	3	0.78	3.7	4	9	PAF-LC
KTRC070	Main Zone	116.00	120.00	4.00	GABSS	Fresh	WR					33404	2007	0.017	0.003	0.42	13	11	2	0.86	3.8	4	9	PAF-LC
KTRC070	Main Zone	120.00	124.00	4.00	GABSS	Fresh	WR					33405	2007	0.010	0.004	0.23	7	12	-5	1.71	4.1	1	5	UC(PAF-LC)
KTRC070	Main Zone	132.00	136.00	4.00	GABSS	Fresh	WR	1				33406	2007	0.002	0.005	0.36	11	12	-1	1.09	3.8	3	9	UC(PAF-LC)
KTRC155	Main Zone	28.00	32.00	4.00	GABSS/GABS	Transitional/Fresh	WR				5020112	40309	2010	0.010	0.022	1.69	52	8	44	0.2	2.7	19	36	PAF
KTRC155	Main Zone	32.00	36.00	4.00	GABS	Fresh	WR				5020113	40310	2010	0.015	0.074	1.09	33	12	21	0.4	3.0	14	34	PAF
KTRC356	Main Zone	0.00	4.00	4.00	Olt/Ocl	Highly	WR				4009451	40561	2010	0.016	0.007	0.09	3	18	-15	6.5	7.3	0	0	NAF
KTRC356	Main Zone	4.00	8.00	4.00	BGCS	Highly	WR				4009452	40562	2010	0.006	0.010	0.09	3	4	-1	1.5	6.2	0	4	NAF
KTRC356	Main Zone	12.00	16.00	4.00	BGCS	Highly	WR				4009454	40563	2010	0.002	0.022	0.30	9	6	3	0.7	6.1	0	3	UC(NAF)
KTRC356	Main Zone	16.00	20.00	4.00	BGCS	Highly	WR				4009455	40564	2010	0.003	0.020	0.20	6	6	0	1.0	6.9	0	0	NAF
KTRC356	Main Zone	20.00	24.00	4.00	GABS	Moderately	WR				4009456	40565	2010	0.084	0.013	0.29	9	7	2	0.8	4.6	0	3	UC(NAF)
KTRC356	Main Zone	24.00	28.00	4.00	GABS	Moderately	WR				4009457	40567	2010	0.047	0.384	0.21	6	6	0	0.9	4.7	0	2	NAF
KTRC356	Main Zone	32.00	36.00	4.00	GABS	Moderately	WR				4009459	40568	2010	0.008	0.016	0.06	2	9	-7	4.9	7.5	0	0	NAF
KTRC356	Main Zone	36.00	40.00	4.00	GABS	Moderately	WR				4009460	40569	2010	0.002	0.007	0.12	4	10	-6	2.7	7.1	0	0	NAF
KTRC356	Main Zone	40.00	44.00	4.00	GABS	Moderately	WR				4009461	40570	2010	0.001	0.014	0.07	2	10	-8	4.7	7.4	0	0	NAF
KTRC356	Main Zone	44.00	48.00	4.00	GABS	Moderately	WR				4009462	40571	2010	0.001	0.014	0.08	2	12	-10	4.9	6.5	0	4	NAF
KTRC356	Main Zone	48.00	52.00	4.00	GABS	Moderately	WR				4009463	40572	2010	0.008	0.016	0.13	4	8	-4	2.0	6.5	0	0	NAF
KTRC356	Main Zone	52.00	56.00	4.00	GABS	Moderately	WR				4009464	40573	2010	0.022	0.033	0.29	9	10	-1	1.1	5.2	0	3	NAF
KTRC356	Main Zone	56.00	60.00	4.00	GABS/BCS	Fresh/Moderately	WR				4009465	40574	2010	0.004	0.018	0.51	16	8	8	0.5	3.5	4	11	PAF-LC
KTRC356	Main Zone	60.00	61.00	1.00	BCS	Fresh	WR	1			5043879	40575	2010	0.001	0.010	1.41	43	6	37	0.1	2.8	14	22	PAF
KTRC356	Main Zone	62.00	63.00	1.00	BCS	Fresh	WR				5043881	40576	2010	0.008	0.050	1.97	60	7	53	0.1	2.6	28	41	PAF
KTRC356	Main Zone	64.00	65.00	1.00	BCS	Fresh	WR	1			5043883	40577	2010	0.181	0.100	6.38	195	11	184	0.1	2.6	37	78	PAF
KTRCD072	Main Zone	0.00	4.00	4.00	GABSS	Slightly	WR					33407	2007	0.021	0.004	0.40	12	15	-3	1.23	3.9	2	8	UC(PAF-LC)
KTRCD072	Main Zone	8.00	12.00	4.00	GABS	Fresh	WR	1				33408	2007	0.014	0.008	0.82	25	14	11	0.56	2.9	13	22	PAF
KTRCD072	Main Zone	16.00	20.00	4.00	GABSS	Fresh	WR	1				33409	2007	0.015	0.007	0.59	18	13	5	0.72	3.2	8	15	PAF
KTRCD072	Main Zone	24.00	28.00	4.00	GABS	Fresh	WR					33410	2007	0.018	0.023	1.15	35	12	23	0.34	2.8	19	28	PAF
KTRCD072	Main Zone	36.00	40.00	4.00	GABS	Fresh	WR					33411	2007	0.005	0.002	0.30	9	10	-1	1.09	3.9	2	7	UC(PAF-LC)
KTRCD072	Main Zone	40.00	41.00	1.00	GABS	Fresh	WR					33412	2007	0.003	0.000	0.39	12	14	-2	1.17	3.8	4	10	UC(PAF-LC)
KTRCD072	Main Zone	41.00	44.00	3.00	GABS	Fresh	WR					33413	2007	0.006	0.000	0.72	22	14	8	0.64	3.2	10	18	PAF
KTRCD072	Main Zone	44.00	48.00	4.00	GABS	Fresh	WR		1	1		33414	2007	0.116	0.038	1.75	54	29	25	0.54	2.8	27	48	PAF
KTRCD072	Main Zone	48.00	49.00	1.00	QV	Fresh	WR					33415	2007	0.165	0.020	1.80	55	27	28	0.49	2.8	19	41	PAF
KTRCD072	Main Zone	83.00	84.00	1.00	GABSS	Fresh	WR			2		33416	2007	0.174	0.020	0.71	22	25	-3	1.15	3.6	4	14	UC(PAF-LC)
KTRCD072	Main Zone	84.00	88.00	4.00	GABSS	Fresh	WR					33417	2007	0.088	0.010	0.88	27	19	8	0.71	3.1	10	21	PAF
KTRCD072	Main Zone	88.00	92.00	4.00	GABSS	Fresh	WR		1			33418	2007	0.017	0.003	0.42	13	18	-5	1.40	3.5	3	9	UC(PAF-LC)
KTRCD072	Main Zone	96.00	100.00	4.00	GABSS	Fresh	WR	1				33419	2007	0.006	0.001	0.61	19	17	2	0.91	3.3	7	15	PAF
KTRCD072	Main Zone	104.00	108.00	4.00	BGCS	Fresh	WR	1	1			33420	2007	0.046	0.005	0.88	27	17	10	0.63	3.1	10	21	PAF
KTRCD072	Main Zone	116.00	119.00	3.00	GABSS	Fresh	WR		1			33421	2007	0.047	0.000	1.30	40	16	24	0.40	2.8	16	30	PAF
KTRCD072	Main Zone	119.00	120.00	1.00	GABS	Fresh	WR					33422	2007	0.067	0.000	1.12	34	16	18	0.47	2.9	13	26	PAF
KTRCD072	Main Zone	129.00	130.00	1.00	GABSS	Fresh	WR			1		33423	2007	0.179	0.050	0.82	25	14	11	0.56	3.1	6	15	PAF
KTRCD072	Main Zone	130.00	134.00	4.00	GABSS	Fresh	WR			1		33424	2007	0.055	0.008	0.64	20	23	-3	1.17	3.3	5	13	UC(PAF-LC)
KTRCD072	Main Zone	134.00	135.00	1.00	GABSS	Fresh	WR					33425	2007	0.050	0.020	1.07	33	19	14	0.58	3.1	14	27	PAF
KTRCD072	Main Zone	135.00	136.00	1.00	GABSS	Fresh	WR					33426	2007	0.017	0.030	0.38	12	21	-9	1.81	3.5	4	8	UC(PAF-LC)

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
KTRC118	NE Zone	8.00	12.00	4.00	GABS	Transitional	WR				5006205	40278	2010	0.025	0.008	0.44	13	9	4	0.7	4.0	2	7	PAF-LC
KTRC118	NE Zone	16.00	17.00	1.00	GABS	Transitional	WR				5049221	40279	2010	0.180	0.040	1.95	60	0	60	0.0	2.7	19	29	PAF
KTRC118	NE Zone	18.00	19.00	1.00	GABS	Transitional	WR				5049223	40280	2010	0.160	0.315	0.28	9	7	2	0.8	5.8	0	0	UC(NAF)
KTRC118	NE Zone	20.00	21.00	1.00	BS	Transitional	WR				5049225	40281	2010	0.242	0.280	0.11	3	8	-5	2.4	6.9	0	0	NAF
KTRC118	NE Zone	21.00	22.00	1.00	BS	Transitional	WR				5049226	40282	2010	0.165	0.170	0.30	9	11	-2	1.2	6.1	0	1	NAF
KTRC118	NE Zone	23.00	24.00	1.00	BS	Transitional	WR				5049228	40283	2010	0.062	0.130	3.02	92	5	87	0.1	3.8	28	41	PAF
KTRC118	NE Zone	25.00	26.00	1.00	BS	Transitional	WR			1	5005706	40499	2010	0.308	0.200	6.97	213	0	213	0.0	2.2	47	78	PAF
KTRC118	NE Zone	26.00	27.00	1.00	GABS	Fresh	WR				5005707	40500	2010	0.049	0.040	1.99	61	13	48	0.2	2.3	37	60	PAF
KTRC118	NE Zone	29.00	30.00	1.00	GABS	Fresh	WR				5005710	40501	2010	0.022	0.090	1.52	47	10	37	0.2	2.6	20	43	PAF
KTRC118	NE Zone	32.00	33.00	1.00	GABSS	Fresh	WR			1	5005713	40502	2010	0.001	-0.010	0.70	21	11	10	0.5	3.4	5	13	PAF-LC
KTRC118	NE Zone	33.00	34.00	1.00	GABSS	Fresh	WR			1	5005714	40503	2010	0.001	-0.010	0.44	13	13	0	1.0	3.8	2	9	UC(PAF-LC)
KTRC118	NE Zone	35.00	36.00	1.00	GABSS	Fresh	WR				5005716	40284	2010	0.002	-0.010	0.53	16	12	4	0.7	3.5	6	12	PAF
KTRC118	NE Zone	36.00	37.00	1.00	GABSS	Fresh	WR			1	5005717	40504	2010	0.002	-0.010	0.70	21	12	9	0.6	3.3	5	12	PAF-LC
KTRC118	NE Zone	38.00	39.00	1.00	GABSS	Fresh	WR			1	5005720	40505	2010	0.003	-0.010	0.23	7	14	-7	2.0	4.6	0	2	NAF
KTRC118	NE Zone	40.00	41.00	1.00	GABSS	Fresh	WR				5005722	40506	2010	0.014	-0.010	0.13	4	14	-10	3.4	6.0	0	0	NAF
KTRC118	NE Zone	43.00	44.00	1.00	GABS	Fresh	WR			1	5005725	40285	2010	0.009	-0.010	0.27	8	17	-9	2.0	4.2	0.3	4	UC(PAF-LC)
KTRC118	NE Zone	46.00	47.00	1.00	GABSS	Fresh	WR	1		1	5005728	40286	2010	0.069	0.010	1.17	36	13	23	0.4	3.0	20	35	PAF
KTRC118	NE Zone	49.00	50.00	1.00	GABSS	Fresh	LG			2	5005731	40507	2010	0.098	0.010	1.24	38	10	28	0.3	2.9	16	35	PAF
KTRC118	NE Zone	50.00	51.00	1.00	GABSS	Fresh	LG				5005733	40508	2010	0.043	-0.010	0.68	21	11	10	0.5	3.3	8	22	PAF
KTRC118	NE Zone	51.00	52.00	1.00	GABSS	Fresh	LG			1	5005734	40509	2010	0.027	-0.010	0.51	16	13	3	0.8	3.5	3	10	PAF-LC
KTRC118	NE Zone	52.00	53.00	1.00	GABSS	Fresh	LG			1	5005735	40510	2010	0.013	-0.010	0.31	9	13	-4	1.4	4.2	0.3	5	UC(PAF-LC)
KTRC118	NE Zone	56.00	57.00	1.00	BGCS	Fresh	HG			1	5005739	40511	2010	0.637	0.350	1.07	33	9	24	0.3	3.8	2	19	PAF-LC
KTRC118	NE Zone	63.00	64.00	1.00	BGCS	Fresh	HG			2	5005747	40512	2010	0.423	-0.010	1.65	50	9	41	0.2	3.0	11	36	PAF
KTRC118	NE Zone	72.00	73.00	1.00	BGCS	Fresh	HG			1	5005757	40287	2010	0.218	0.010	1.02	31	14	17	0.4	3.2	11	30	PAF
KTRC118	NE Zone	76.00	77.00	1.00	BGCS	Fresh	LG			1	5005761	40288	2010	0.254	0.020	1.23	38	13	25	0.3	3.0	9	29	PAF
KTRC118	NE Zone	78.00	79.00	1.00	GABSS	Fresh	WR				5005763	40289	2010	0.012	-0.010	0.48	15	21	-6	1.4	3.7	3	9	UC(PAF-LC)
KTRC118	NE Zone	82.00	83.00	1.00	GABSS	Fresh	WR				5005768	40290	2010	0.004	-0.010	0.30	9	15	-6	1.6	3.8	1	5	UC(PAF-LC)
KTRC118	NE Zone	83.00	84.00	1.00	GABSS	Fresh	WR				5005769	40291	2010	0.013	-0.010	0.64	19	14	5	0.7	3.4	9	17	PAF
KTRC118	NE Zone	84.00	88.00	4.00	GABSS	Fresh	WR				5006209	40513	2010	0.002	0.007	0.41	13	16	-3	1.3	3.6	3	8	UC(PAF-LC)
KTRC118	NE Zone	142.00	143.00	1.00	BGCS	Fresh	HG			1	5005830	40292	2010	0.265	-0.010	0.54	16	16	0	1.0	4.0	1	9	UC(PAF-LC)
KTRC118	NE Zone	157.00	158.00	1.00	BGCS	Fresh	LG				5005845	40293	2010	0.159	0.090	0.64	20	16	4	0.8	3.4	5	17	PAF-LC
KTRC118	NE Zone	161.00	162.00	1.00	BGCS	Fresh	LG				5005851	40294	2010	0.038	0.080	0.50	15	20	-5	1.3	3.8	2	9	UC(PAF-LC)
KTRC118	NE Zone	162.00	163.00	1.00	BGCS	Fresh	LG				5005852	40295	2010	0.026	-0.010	0.31	9	14	-5	1.5	4.3	0.2	4	UC(PAF-LC)
KTRC118	NE Zone	165.00	166.00	1.00	BGCS	Fresh	LG				5005855	40296	2010	0.040	0.020	0.41	13	14	-1	1.1	3.9	2	7	UC(PAF-LC)
KTRC118	NE Zone	170.00	171.00	1.00	GABSS	Fresh	WR				5005860	40297	2010	0.023	0.010	0.48	15	17	-2	1.2	3.9	3	9	UC(PAF-LC)
KTRC297	NE Zone	0.00	1.00	1.00	GABS	Moderately (Fill)	WR				5041765	38644	2009	-0.010	0.014	0.80	24				3.1	6	14	PAF
KTRC297	NE Zone	1.00	2.00	1.00	GABS	Moderately (Fill)	WR				5041766	38645	2009	0.020	0.092	0.13	4				5.5	0	1	UC(NAF)
KTRC297	NE Zone	2.00	3.00	1.00	GABS	Slightly (Jarositic)	WR				5041767	38646	2009	-0.010	0.031	0.47	14				3.7	2	8	PAF-LC
KTRC297	NE Zone	3.00	4.00	1.00	GABS	Slightly (Jarositic)	WR				5041768	38647	2009	-0.010	0.026	0.53	16				3.2	4	8	PAF-LC
KTRC297	NE Zone	4.00	5.00	1.00	GABS	Slightly (Jarositic)	WR				5041769	38648	2009	0.010	0.007	1.25	38				2.7	13	20	PAF
KTRC297	NE Zone	5.00	6.00	1.00	GABS	Slightly (Jarositic)	WR				5041770	38649	2009	-0.010	0.016	1.04	32				2.6	12	18	PAF
KTRC297	NE Zone	6.00	7.00	1.00	GABS	Slightly (Jarositic)	WR				5041771	38650	2009	0.030	0.016	0.89	27				2.7	9	15	PAF
KTRC297	NE Zone	7.00	8.00	1.00	GABS	Slightly (Jarositic)	WR	1			5041772	38651	2009	0.020	0.039	1.41	43				2.5	16	24	PAF
KTRC297	NE Zone	8.00	9.00	1.00	GABS	Slightly (Jarositic)	WR				5041773	38652	2009	-0.010	0.044	1.18	36				2.7	11	18	PAF
KTRC297	NE Zone	9.00	10.00	1.00	GABS	Slightly (Jarositic)	WR				5041774	38653	2009	-0.010	0.075	1.44	44				2.5	15	23	PAF
KTRC297	NE Zone	10.00	11.00	1.00	GABS	Slightly (Jarositic)	WR				5041775	38654	2009	0.100	0.133	2.62	80				2.4	28	44	PAF
KTRC297	NE Zone	11.00	12.00	1.00	GABS	Slightly (Jarositic)	WR				5041776	38655	2009	0.030	0.125	2.08	64				2.4	25	38	PAF
KTRC297	NE Zone	12.00	13.00	1.00	GABS	Fresh	WR	2			5041777	38656	2009	0.020	0.125	1.92	59				2.4	22	33	PAF
KTRC297	NE Zone	13.00	14.00	1.00	GABS	Fresh	WR				5041778	38657	2009	-0.010	0.065	1.21	37				2.5	14	22	PAF
KTRC425	NW Zone	0.00	1.00	1.00	Osu	Soil	LG				KRC006996	40531	2010	0.161	0.180	0.09	3	18	-15	6.9	7.8	0	0	NAF
KTRC425	NW Zone	1.00	2.00	1.00	Osu	Soil	HG				KRC006997	40532	2010	0.151	0.090	0.01	0	20	-20	44.5	7.9	0	0	NAF
KTRC425	NW Zone	5.00	6.00	1.00	GABSS	Moderately	HG				KRC007001	40533	2010	0.349	0.020	0.01	0	9	-9	28.8	7.7	0	0	NAF
KTRC425	NW Zone	9.00	10.00	1.00	GABSS	Moderately	HG				KRC007005	40534	2010	0.651	0.050	0.14	4	10	-6	2.4	7.2	0	0	NAF
KTRC425	NW Zone	13.00	14.00	1.00	GABSS	Moderately	HG				KRC007009	40535	2010	0.558	0.050	0.46	14	9	5	0.6	4.3	0.2	9	PAF-LC
KTRC425	NW Zone	14.00	15.00	1.00	GABSS	Moderately	HG				KRC007010	40536	2010	0.519	0.080	0.61	19	10	9	0.5	3.7	2	14	PAF-LC
KTRC425	NW Zone	16.00	17.00	1.00	GABSS	Moderately	HG				KRC007012	40537	2010	0.148	0.030	0.64	20	9	11	0.5	3.2	7	15	PAF
KTRC425	NW Zone	17.00	18.00	1.00	GABSS	Moderately	HG				KRC007013	40538	2010	0.223	0.070	0.36	11	10	1	0.9	3.9	1	8	PAF-LC
KTRC425	NW Zone	18.00	19.00	1.00	GABSS	Moderately	HG				KRC007014	40539	2010	0.305	0.060	1.12	34	12	22	0.3	3.1	7	18	PAF
KTRC425	NW Zone	19.00	20.00	1.00	GABSS	Moderately	HG			1	KRC007015	40540	2010	0.428	0.020	1.75	54	10	44	0.2	2.7	22	44	PAF
KTRC425	NW Zone	20.00	21.00	1.00	GABSS	Fresh	HG	1			KRC007016	40541	2010	0.739	0.060	1.78	54	4	50	0.1	2.8	12	33	PAF
KTRC425	NW Zone	22.00	23.00	1.00	GABSS	Fresh	LG			1	KRC007018	40542	2010	0.070	-0.010	0.90	28	5	23	0.2	2.9	7	15	PAF

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m) From	To	Interval	Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
KTRC426	NW Zone	8.00	9.00	1.00	GABSS	Moderately	LG				KRC007044	40367	2010	0.128	0.050	0.18	6	14	-8	2.5	6.9	0	0	NAF
KTRC426	NW Zone	9.00	10.00	1.00	GABSS	Moderately	LG				KRC007045	40368	2010	0.105	0.050	0.14	4	15	-11	3.4	6.3	0	0	NAF
KTRC426	NW Zone	11.00	12.00	1.00	GABSS	Moderately	LG				KRC007047	40369	2010	1.041	0.325	0.18	6	13	-7	2.4	6.0	0	1	NAF
KTRC426	NW Zone	12.00	13.00	1.00	GABSS	Fresh	LG				KRC007048	40370	2010	0.261	0.130	0.93	28	6	22	0.2	3.1	11	23	PAF
KTRC426	NW Zone	13.00	14.00	1.00	GABSS	Fresh	WR				KRC007049	40371	2010	0.059	0.010	0.81	25	12	13	0.5	3.1	11	20	PAF
KTRC426	NW Zone	16.00	17.00	1.00	GABSS	Fresh	WR		1		KRC007052	40372	2010	0.025	-0.010	0.89	27	12	15	0.4	3.2	10	17	PAF
KTRC426	NW Zone	25.00	26.00	1.00	GABSS	Fresh	WR			1	KRC007061	40373	2010	0.047	0.040	0.66	20	15	5	0.7	3.6	6	14	PAF
KTRC426	NW Zone	30.00	31.00	1.00	QV	Fresh	HG			1	KRC007069	40543	2010	0.265	-0.010	0.60	18	7	11	0.4	3.5	4	16	PAF-LC
KTRC426	NW Zone	34.00	35.00	1.00	QV	Fresh	HG			1	KRC007073	40544	2010	0.222	-0.010	0.56	17	11	6	0.6	3.5	4	13	PAF-LC
KTRC426	NW Zone	36.00	37.00	1.00	QV	Fresh	HG			1	KRC007075	40545	2010	0.203	-0.010	0.46	14	10	4	0.7	3.5	3	11	PAF-LC
KTRC426	NW Zone	40.00	41.00	1.00	QV	Fresh	HG			1	KRC007079	40546	2010	0.387	0.050	0.54	16	2	14	0.1	3.9	1	16	PAF-LC
KTRC426	NW Zone	42.00	43.00	1.00	QV	Fresh	HG				KRC007081	40547	2010	0.120	-0.010	0.15	5	0	5	0.0	3.3	1	4	PAF-LC
KTRC426	NW Zone	49.00	50.00	1.00	GABSS	Fresh	HG			1	KRC007088	40374	2010	0.360	-0.010	1.28	39	14	25	0.4	3.2	12	27	PAF
KTRC426	NW Zone	55.00	56.00	1.00	GABSS	Fresh	LG				KRC007094	40375	2010	0.106	0.010	1.15	35	14	21	0.4	3.1	14	29	PAF
KTRC426	NW Zone	57.00	58.00	1.00	GABSS	Fresh	LG				KRC007096	40376	2010	0.026	-0.010	0.82	25	15	10	0.6	3.6	7	17	PAF
KTRC426	NW Zone	62.00	63.00	1.00	GABSS	Fresh	WR				KRC007101	40377	2010	0.060	0.050	0.51	15	14	1	0.9	3.5	7	15	PAF
KTRC426	NW Zone	65.00	66.00	1.00	GABSS	Fresh	WR				KRC007104	40378	2010	0.062	0.010	0.34	10	15	-5	1.5	4.2	0.3	4	UC(PAF-LC)
KTRC426	NW Zone	66.00	67.00	1.00	GABSS	Fresh	WR				KRC007105	40379	2010	0.016	-0.010	0.18	5	18	-13	3.3	5.2	0	1	NAF
KTRC426	NW Zone	67.00	68.00	1.00	GABSS	Fresh	WR	1			KRC007106	40380	2010	0.037	0.010	0.47	15	16	-1	1.1	3.6	5	11	UC(PAF-LC)
KTRC426	NW Zone	69.00	70.00	1.00	GABSS	Fresh	WR				KRC007108	40381	2010	0.044	-0.010	0.58	18	15	3	0.9	3.4	7	14	PAF
KTDD060	SE Zone	0.00	2.00	2.00	BGCS	Highly	WR				5044678	38602	2009	0.070	0.074	0.03	1	23	-22	22.4	7.3	0	0	NAF
KTDD060	SE Zone	2.00	4.00	2.00	BGCS	Highly	WR				5044679	38603	2009	0.610	0.087	0.03	1	4	-3	4.2	6.4	0	3	NAF
KTDD060	SE Zone	4.00	6.00	2.00	BGCS	Highly	WR	2			5044680	38604	2009	0.020	0.034	0.10	3	4	-1	1.4	5.7	0	4	NAF
KTDD060	SE Zone	6.00	7.00	1.00	BGCS	Highly	WR	3	2		5044681	38605	2009	0.020	0.081	0.18	6				5.4	0	2	UC(NAF)
KTDD060	SE Zone	7.00	8.00	1.00	BGCS	Highly	WR	3	2		5044682	38606	2009	0.050	0.106	0.40	12	4	8	0.3	5.9	0	1	UC(NAF)
KTDD060	SE Zone	8.00	9.00	1.00	BGCS	Highly	WR	3	2		5044683	38607	2009	0.010	0.049	0.30	9	4	5	0.4	5.1	0	2	UC(NAF)
KTDD060	SE Zone	9.00	10.00	1.00	BGCS	Highly	WR	3	2		5044684	38608	2009	-0.010	0.047	0.78	24	1	23	0.0	5.0	0	2	UC(NAF)
KTDD060	SE Zone	10.00	11.00	1.00	BGCS	Moderately	WR	3	1		5044685	38609	2009	0.020	0.033	0.21	6				5.5	0	2	UC(NAF)
KTDD060	SE Zone	11.00	12.00	1.00	GABS	Moderately	WR	3	1		5044686	38610	2009	0.060	0.044	0.53	16	4	12	0.2	4.8	0	2	UC(NAF)
KTDD060	SE Zone	12.00	13.00	1.00	GABS	Fresh	WR	2			5044687	38611	2009	0.210	0.041	0.18	5				5.6	0	2	UC(NAF)
KTDD060	SE Zone	13.00	14.00	1.00	GABS	Fresh	WR	2	2		5044688	38612	2009	0.050	0.104	0.33	10	7	3	0.7	4.4	1	3	PAF-LC
KTDD060	SE Zone	14.00	15.00	1.00	GABS	Fresh	WR	2	1		5044689	38613	2009	0.020	0.063	0.33	10	6	4	0.6	4.1	1	4	PAF-LC
KTRC173	SE Zone	0.00	1.00	1.00	GABS	Moderately	WR	1			5028465	38614	2009	0.020	0.034	0.03	1	8	-7	10.0	6.3	0	3	NAF
KTRC173	SE Zone	1.00	2.00	1.00	GABS	Slightly	WR	1			5028466	38615	2009	0.020	0.041	0.02	1	15	-14	29.0	6.9	0	0	NAF
KTRC173	SE Zone	2.00	3.00	1.00	GABS	Slightly	WR	2			5028467	38616	2009	-0.010	0.012	0.01	0	15	-15	59.1	7.1	0	0	NAF
KTRC173	SE Zone	3.00	4.00	1.00	GABS	Slightly	WR	2			5028468	38617	2009	-0.010	0.007	0.01	0				6.9	0	0	NAF
KTRC173	SE Zone	4.00	5.00	1.00	GABS	Moderately	WR	2			5028469	38618	2009	0.040	0.020	0.05	2	9	-7	5.4	6.3	0	1	NAF
KTRC173	SE Zone	5.00	6.00	1.00	GABS	Moderately	WR	2	1		5028470	38619	2009	0.020	0.035	0.02	1				7.2	0	0	NAF
KTRC173	SE Zone	6.00	7.00	1.00	GABS	Moderately	WR	2			5028471	38620	2009	0.030	0.024	0.01	0	13	-13	32.4	7.1	0	0	NAF
KTRC173	SE Zone	7.00	8.00	1.00	GABS	Moderately	WR	2			5028472	38621	2009	-0.010	0.014	0.04	1				6.3	0	2	NAF
KTRC173	SE Zone	8.00	9.00	1.00	GABS	Moderately	WR	2			5028473	38622	2009	-0.010	0.005	0.03	1				5.9	0	4	NAF
KTRC173	SE Zone	9.00	10.00	1.00	GABS	Moderately	WR	2			5028474	38623	2009	-0.010	0.012	0.09	3				6.0	0	2	UC(NAF)
KTRC173	SE Zone	10.00	11.00	1.00	GABS	Moderately	WR	2			5028475	38624	2009	1.910	0.120	0.52	16	7	9	0.4	3.8	1	4	PAF-LC
KTRC173	SE Zone	11.00	12.00	1.00	GABS	Slightly	WR	2			5028476	38625	2009	0.120	0.035	0.73	22	7	15	0.3	3.2	5	12	PAF-LC
KTRC173	SE Zone	12.00	13.00	1.00	GABS	Slightly	WR	2			5028477	38626	2009	0.040	0.017	0.37	11	12	-1	1.1	5.4	0	1	NAF
KTRC173	SE Zone	13.00	14.00	1.00	GABS	Slightly	WR	2			5028478	38627	2009	-0.010	0.010	0.11	3	13	-10	3.9	6.4	0	1	NAF
KTRC173	SE Zone	14.00	15.00	1.00	GABS	Fresh	WR	3			5028479	38628	2009	-0.010	0.008	0.05	2				6.9	0	0	UC(NAF)
KTRC173	SE Zone	15.00	16.00	1.00	GABS	Fresh	WR	3			5028480	38629	2009	0.020	0.003	0.11	3				6.4	0	1	UC(NAF)
KTRC173	SE Zone	16.00	17.00	1.00	GABS	Fresh	WR	3			5028481	38630	2009	-0.010	0.003	0.06	2				6.5	0	1	UC(NAF)
KTRC173	SE Zone	17.00	18.00	1.00	GABS	Slightly	WR	3			5028482	38631	2009	0.030	0.009	1.02	31	8	23	0.3	2.9	11	21	PAF
KTRC173	SE Zone	18.00	19.00	1.00	GABS	Fresh	WR	3			5028483	38632	2009	-0.010	0.003	0.19	6	14	-8	2.4	5.3	0	1	NAF
KTRC682	SE Zone	0.00	1.00	1.00	GABS	Moderately	WR				KRC032627	40548	2010	0.165	-0.010	0.45	14	9	5	0.7	4.5	0	3	UC(NAF)
KTRC682	SE Zone	2.00	3.00	1.00	GABS	Moderately	WR				KRC032629	40549	2010	0.497	-0.010	0.10	3	11	-8	3.6	7.2	0	0	NAF
KTRC682	SE Zone	4.00	5.00	1.00	GABS	Moderately	WR				KRC032631	40550	2010	0.254	-0.010	0.40	12	10	2	0.8	4.8	0	3	UC(NAF)
KTRC682	SE Zone	7.00	8.00	1.00	GABS	Moderately	WR				KRC032634	40551	2010	0.019	-0.010	0.37	11	7	4	0.6	4.2	1	5	PAF-LC
KTRC682	SE Zone	8.00	9.00	1.00	GABS	Slightly	WR	1			KRC032635	40552	2010	0.140	0.010	0.81	25	6	19	0.2	3.3	7	16	PAF
KTRC682	SE Zone	9.00	10.00	1.00	GABS	Slightly	WR	1			KRC032636	40553	2010	0.459	0.020	1.64	50	1	49	0.0	2.8	9	22	PAF
KTRC682	SE Zone	10.00	11.00	1.00	GABS	Slightly	WR				KRC032637	40554	2010	0.041	0.020	0.42	13	10	3	0.8	4.2	0.1	4	PAF-LC
KTRC682	SE Zone	12.00	13.00	1.00	GABS	Slightly	LG				KRC032639	40555	2010	0.274	-0.010	0.41	13	12	1	1.0	4.5	0	6	UC(NAF)
KTRC682	SE Zone	14.00	15.00	1.00	GABS	Slightly	LG				KRC032641	40556	2010	0.094	-0.010	0.31	9	12	-3	1.3	4.8	0	2	NAF
KTRC682	SE Zone	16.00	17.00	1.00	GABS	Slightly	HG	2	1		KRC032643	40557	2010	0.423	0.040	3.48	106	0	106	0.0	2.6	28	53	PAF
KTRC682	SE Zone	17.00	18.00	1.00	BGCS	Fresh	HG	3	2		KRC032644	40558	2010	0.543	0.280	7.10	217	0	217	0.0	2.2	81	127	PAF
KTRC682	SE Zone	19.00	20.00	1.00	BGCS	Fresh	HG	1			KRC032646	40559	2010	0.462	0.020	1.73	53	9	44	0.2	2.8	14	30	PAF
KTRC682	SE Zone	21.00	22.00	1.00	BGCS	Fresh	HG	2		2	KRC032648	40560	2010	1.965	0.180	4.07	125	1	124	0.0	2.9	13	61	PAF

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
KTRCD399	SE Zone	0.00	1.00	1.00	GABSS	Moderately (In Pit)	WR				KRC004888	38682	2009	0.020	0.027	0.58	18				3.3	3	7	PAF-LC
KTRCD399	SE Zone	1.00	2.00	1.00	GABSS	Moderately (In Pit)	WR				KRC004889	38683	2009	0.020	0.020	0.88	27				2.9	9	15	PAF
KTRCD399	SE Zone	2.00	3.00	1.00	GABSS	Moderately (In Pit)	WR				KRC004890	38684	2009	0.010	0.020	0.86	26				3.2	6	15	PAF
KTRCD399	SE Zone	3.00	4.00	1.00	GABSS	Slightly (In Pit)	WR				KRC004891	38685	2009	0.020	0.036	1.00	31				3.0	9	19	PAF
KTRCD399	SE Zone	4.00	5.00	1.00	GABSS	Slightly (In Pit)	WR				KRC004892	38686	2009	0.070	0.053	1.00	30				2.9	10	19	PAF
KTRCD399	SE Zone	5.00	6.00	1.00	GABSS	Slightly (In Pit)	WR				KRC004893	38687	2009	0.030	0.039	0.80	24				3.0	7	15	PAF
KTRCD399	SE Zone	6.00	7.00	1.00	GABSS	Slightly (In Pit)	WR	1			KRC004894	38688	2009	0.120	0.067	1.03	31				3.1	8	18	PAF
KTRCD399	SE Zone	7.00	8.00	1.00	GABSS	Slightly (In Pit)	WR	1			KRC004895	38689	2009	-0.010	0.053	0.54	17				3.3	3	9	PAF-LC
KTRCD399	SE Zone	8.00	9.00	1.00	GABSS	Fresh	WR	1			KRC004896	38690	2009	0.100	0.143	1.13	35				3.1	8	18	PAF
KTRCD399	SE Zone	9.00	10.00	1.00	GABSS	Fresh	WR	1			KRC004897	38691	2009	-0.010	0.044	0.49	15				3.6	2	8	PAF-LC
KTRCD120	Eastern Zone	0.00	4.00	4.00	GABS	Highly/Moderately	WR					33427	2007	0.046	0.008	0.31	9	26	-17	2.74	8.2	0	0	NAF
KTRCD120	Eastern Zone	8.00	9.00	1.00	BS	Moderately	WR					33428	2007	0.245	0.000	0.02	1	48	-47	78.43	8.3	0	0	NAF
KTRCD120	Eastern Zone	9.00	12.00	3.00	BS	Moderately	WR					33429	2007	0.186	0.000	0.04	1	17	-16	13.89	7.8	0	0	NAF
KTRCD120	Eastern Zone	12.00	16.00	4.00	BS/GABS	Moderately	WR					33430	2007	0.036	0.004	0.01	0	20	-20	65.36	7.1	0	0	NAF
KTRCD120	Eastern Zone	16.00	20.00	4.00	GABS	Transitional	WR					33431	2007	0.014	0.002	0.01	0	20	-20	65.36	6.9	0	0	NAF
KTRCD120	Eastern Zone	24.00	28.00	4.00	GABS	Transitional	WR					33432	2007	0.072	0.002	0.15	5	18	-13	3.92	4.8	0	2	NAF
KTRCD120	Eastern Zone	32.00	36.00	4.00	GABS	Fresh	WR					33433	2007	0.042	0.002	0.15	5	19	-14	4.14	5.1	0	1	NAF
KTRCD120	Eastern Zone	40.00	41.00	1.00	GABSS	Fresh	WR					33434	2007	0.091	0.010	0.37	11	16	-5	1.41	4.5	0	3	NAF
KTRCD120	Eastern Zone	41.00	44.00	3.00	GABSS	Fresh	WR					33435	2007	0.097	0.010	0.32	10	17	-7	1.74	4.5	0	3	NAF
KTRCD120	Eastern Zone	48.00	52.00	4.00	GABS	Fresh	WR					33436	2007	0.006	0.003	0.16	5	20	-15	4.08	4.9	0	2	NAF
KTRCD120	Eastern Zone	52.00	53.00	1.00	GABS	Fresh	WR					33437	2007	0.006	0.000	0.07	2	21	-19	9.80	6.4	0	3	NAF
KTRCD120	Eastern Zone	54.00	55.00	1.00	GABS	Fresh	WR	2				33438	2007	0.087	0.020	0.92	28	23	5	0.82	3.3	11	20	PAF
KTRCD120	Eastern Zone	55.00	56.00	1.00	QV	Fresh	WR					33439	2007	0.735	0.060	1.02	31	15	16	0.48	3.6	7	22	PAF
KTRCD120	Eastern Zone	56.00	59.00	3.00	GABS	Fresh	WR	1				33440	2007	0.291	0.010	0.71	22	15	7	0.69	3.6	5	16	PAF-LC
KTRCD120	Eastern Zone	60.00	64.00	4.00	GABSS	Fresh	WR					33441	2007	0.002	0.000	0.08	2	21	-19	8.58	6.3	0	4	NAF
KTRCD120	Eastern Zone	72.00	76.00	4.00	GABSS	Fresh	WR	1				33442	2007	0.005	0.006	0.57	17	19	-2	1.09	3.4	7	14	UC(PAF)
KTRCD120	Eastern Zone	80.00	84.00	4.00	GABS	Fresh	WR					33443	2007	0.003	0.004	0.44	13	22	-9	1.63	3.7	4	9	UC(PAF-LC)
KTRCD120	Eastern Zone	88.00	92.00	4.00	GABSS/BGCS	Fresh	WR	1				33444	2007	0.001	0.008	0.77	24	13	11	0.55	2.9	13	20	PAF
KTRCD120	Eastern Zone	96.00	100.00	4.00	GABS	Fresh	WR					33445	2007	0.003	0.008	0.62	19	15	4	0.79	3.2	8	15	PAF
KTRCD120	Eastern Zone	104.00	105.00	1.00	GABS	Fresh	WR					33446	2007	0.474	0.060	2.33	71	8	63	0.11	2.8	20	31	PAF
KTRCD120	Eastern Zone	106.00	109.00	3.00	GABSS	Fresh	WR			2		33447	2007	0.018	0.000	0.35	11	16	-5	1.49	4.1	2	8	UC(PAF-LC)
KTRCD120	Eastern Zone	114.00	115.00	1.00	GABSS	Fresh	WR			2		33448	2007	0.005	0.000	0.69	21	15	6	0.71	3.3	9	17	PAF
KTRCD120	Eastern Zone	118.00	121.00	3.00	BGCS	Fresh	WR			2		33449	2007	0.375	0.023	1.19	36	13	23	0.36	3.1	10	25	PAF
KTRCD120	Eastern Zone	124.00	125.00	1.00	BGCS	Fresh	WR			2		33450	2007	0.047	0.000	0.48	15	17	-2	1.16	4.1	1	8	UC(PAF-LC)
KTRCD120	Eastern Zone	125.00	129.00	4.00	BGCS	Fresh	WR			2		33451	2007	0.046	0.000	0.68	21	23	-2	1.11	3.9	3	12	UC(PAF-LC)
KTRCD120	Eastern Zone	132.00	136.00	4.00	BGCS	Fresh	WR			2		33452	2007	0.099	0.030	1.26	39	20	19	0.52	2.9	15	27	PAF
KTRCD120	Eastern Zone	136.00	137.00	1.00	BGCS	Fresh	WR			2		33453	2007	0.056	0.000	0.59	18	37	-19	2.05	3.9	3	11	UC(PAF-LC)
KTRCD120	Eastern Zone	164.00	165.00	1.00	BGCS	Fresh	WR			2		33454	2007	0.260	0.050	1.45	44	22	22	0.50	3.5	7	23	PAF
KTRCD120	Eastern Zone	166.00	169.00	3.00	GABSS	Fresh	WR			1		33455	2007	0.089	0.023	0.54	17	22	-5	1.33	3.9	2	9	UC(PAF-LC)
KTRCD120	Eastern Zone	170.00	171.00	1.00	GABSS	Fresh	WR			1		33456	2007	0.006	0.000	0.06	2	23	-21	12.53	6.9	0	0	NAF
KTRCD120	Eastern Zone	176.00	180.00	4.00	GABSS	Fresh	WR			1		33457	2007	0.003	0.003	0.05	2	31	-29	20.26	6.3	0	5	NAF
KTRC414	Green Zone	4.00	5.00	1.00	GABS	Moderately	WR				KRC006017	38658	2009	-0.010	0.024	0.01	0	10	-10	26.6	6.5	0	3	NAF
KTRC414	Green Zone	5.00	6.00	1.00	GABS	Moderately	WR				KRC006018	38659	2009	-0.010	0.037	0.01	0	10	-10	52.7	6.9	0	0	NAF
KTRC414	Green Zone	6.00	7.00	1.00	QV	Moderately	WR				KRC006019	38660	2009	-0.010	0.039	0.01	0	14	-14	86.3	7.1	0	0	NAF
KTRC414	Green Zone	7.00	8.00	1.00	GABS	Slightly	WR				KRC006020	38661	2009	-0.010	0.130	0.01	0				6.9	0	0	NAF
KTRC414	Green Zone	8.00	9.00	1.00	GABS	Slightly	WR				KRC006021	38662	2009	-0.010	0.142	0.00	0				7.1	0	0	NAF
KTRC414	Green Zone	9.00	10.00	1.00	GABS	Slightly	WR				KRC006022	38663	2009	0.010	0.157	0.01	0	11	-11	58.0	7.2	0	0	NAF
KTRC414	Green Zone	10.00	11.00	1.00	GABS	Slightly	WR				KRC006023	38664	2009	0.010	0.192	0.02	1				7.4	0	0	NAF
KTRC414	Green Zone	11.00	12.00	1.00	GABS	Slightly	WR				KRC006024	38665	2009	0.020	0.167	0.03	1				7.3	0	0	NAF
KTRC414	Green Zone	12.00	13.00	1.00	GABS	Slightly	WR				KRC006025	38666	2009	-0.010	0.466	0.01	0				7.3	0	0	NAF
KTRC414	Green Zone	13.00	14.00	1.00	GABS	Slightly	WR				KRC006026	38667	2009	-0.010	0.241	0.00	0	13	-13	111.8	7.5	0	0	NAF
KTRC414	Green Zone	14.00	15.00	1.00	GABS	Slightly	WR				KRC006027	38668	2009	0.060	0.273	0.01	0				7.4	0	0	NAF
KTRC414	Green Zone	15.00	16.00	1.00	GABSS	Slightly	WR				KRC006028	38669	2009	0.040	0.086	0.01	0				7.2	0	0	NAF
KTRC414	Green Zone	16.00	17.00	1.00	GABSS	Slightly	WR				KRC006029	38670	2009	0.020	0.073	0.00	0				7.3	0	0	NAF
KTRC414	Green Zone	17.00	18.00	1.00	GABSS	Slightly	WR				KRC006030	38671	2009	-0.010	0.022	0.01	0	13	-13	66.4	7.1	0	0	NAF
KTRC414	Green Zone	18.00	19.00	1.00	GABSS	Slightly	WR				KRC006031	38672	2009	-0.010	0.019	0.01	0				6.9	0	0	NAF
KTRC414	Green Zone	19.00	20.00	1.00	GABSS	Slightly	WR				KRC006032	38673	2009	-0.010	0.008	0.01	0				6.9	0	0	NAF
KTRC414	Green Zone	20.00	21.00	1.00	GABSS	Slightly	WR				KRC006033	38674	2009	-0.010	0.014	0.00	0	16	-16	106.7	6.9	0	0	NAF
KTRC414	Green Zone	21.00	22.00	1.00	GABSS	Slightly	WR				KRC006034	38675	2009	-0.010	0.031	0.01	0				6.9	0	0	NAF
KTRC414	Green Zone	22.00	23.00	1.00	GABSS	Slightly	WR				KRC006035	38676	2009	-0.010	0.041	0.07	2	16	-14	7.3	7.1	0	0	NAF
KTRC414	Green Zone	23.00	24.00	1.00	GABSS	Fresh	WR				KRC006036	38677	2009	-0.010	0.045	0.04	1	13	-12	11.1	6.9	0	0	NAF
KTRC414	Green Zone	24.00	25.00	1.00	GABSS	Fresh	WR				KRC006037	38678	2009	0.010	0.021	0.02	0				7.1	0	0	NAF
KTRC414	Green Zone	25.00	26.00	1.00	GABSS	Fresh	WR				KRC006038	38679	2009	-0.010	0.044	0.03	1				6.9	0	0	NAF
KTRC414	Green Zone	26.00	27.00	1.00	GABSS	Fresh	WR				KRC006039	38680	2009	-0.010	0.068	0.06	2	16	-14	9.0	7.2	0	0	NAF
KTRC414	Green Zone	27.00	28.00	1.00	GABSS	Fresh	WR				KRC006040	38681	2009	-0.010	0.237	0.14	4				6.2	0	0	UC(NAF)

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
KTDD112	O'Neil Zone	40.00	41.00	1.00	BS	Moderately	WR				5052701	40247	2010	0.074	-0.010	0.01	0	13	-13	53.1	7.2	0	0	NAF
KTDD112	O'Neil Zone	42.00	43.00	1.00	GABS	Fresh	WR	1			5052703	40248	2010	0.018	-0.010	0.02	1	15	-14	27.9	7.1	0	0	NAF
KTDD112	O'Neil Zone	43.00	44.00	1.00	GABS	Fresh	WR	1			5052704	40249	2010	0.017	-0.010	0.33	10	12	-2	1.2	3.8	3	7	UC(PAF-LC)
KTDD112	O'Neil Zone	44.00	45.00	1.00	GABS	Fresh	WR	1			5052705	40250	2010	0.064	-0.010	0.95	29	11	18	0.4	2.8	16	24	PAF
KTDD112	O'Neil Zone	47.00	48.00	1.00	GABS	Fresh	LG	1			5052708	40251	2010	0.080	-0.010	0.68	21	11	10	0.5	3.2	8	15	PAF
KTDD112	O'Neil Zone	50.00	51.00	1.00	GABS/GABSS	Fresh	HG	1		1	5052714	40252	2010	0.345	0.020	1.48	45	5	40	0.1	2.7	16	30	PAF
KTDD112	O'Neil Zone	56.20	57.00	0.80	GABSS	Fresh	HG	1		1	5052720	40253	2010	0.834	0.320	2.96	90	3	87	0.0	2.6	20	43	PAF
KTDD112	O'Neil Zone	70.00	71.00	1.00	GABSS	Fresh	HG	1		1	5052734	40254	2010	0.113	0.050	0.21	7	10	-3	1.5	4.0	1	5	UC(PAF-LC)
KTDD112	O'Neil Zone	75.00	76.00	1.00	GABSS	Fresh	HG	1		1	5052740	40255	2010	0.403	7.170	1.20	37	8	29	0.2	3.0	13	31	PAF
KTDD112	O'Neil Zone	85.00	86.00	1.00	GABSS	Fresh	HG			2	5052751	40256	2010	0.039	-0.010	0.26	8	11	-3	1.4	4.1	0.4	4	UC(PAF-LC)
KTDD112	O'Neil Zone	89.00	90.00	1.00	GABS	Fresh	WR				5052755	40257	2010	0.044	-0.010	0.32	10	12	-2	1.2	3.8	2	7	UC(PAF-LC)
KTDD112	O'Neil Zone	91.00	92.00	1.00	GABS	Fresh	WR				5052758	40258	2010	0.015	-0.010	0.23	7	12	-5	1.7	4.0	1	5	UC(PAF-LC)
KTDD112	O'Neil Zone	94.00	95.00	1.00	GABS	Fresh	WR				5052761	40259	2010	0.014	-0.010	0.23	7	12	-5	1.7	4.0	1	4	UC(PAF-LC)
KTDD112	O'Neil Zone	95.00	96.00	1.00	GABS	Fresh	WR				5052762	40260	2010	0.059	-0.010	0.61	19	15	4	0.8	3.1	7	14	PAF
KTDD112	O'Neil Zone	97.00	98.00	1.00	GABS	Fresh	WR				5052764	40261	2010	0.026	-0.010	0.36	11	11	0	1.0	3.5	4	10	UC(PAF-LC)
KTRC127	O'Neil Zone	4.00	8.00	4.00	SAP	Highly	WR				5006281	40298	2010	0.263	0.256	0.05	2	179	-177	117.0	8.9	0	0	NAF
KTRC127	O'Neil Zone	8.00	12.00	4.00	SAP/BS	Highly	WR				5006282	40299	2010	0.036	0.050	0.04	1	15	-14	12.3	7.3	0	0	NAF
KTRC127	O'Neil Zone	12.00	16.00	4.00	BS	Highly/Moderately	WR				5006283	40300	2010	0.021	0.004	0.04	1	10	-9	8.2	6.9	0	0	NAF
KTRC127	O'Neil Zone	40.00	41.00	1.00	GABS	Transitional	WR				5006873	40301	2010	0.211	-0.010	2.07	63	8	55	0.1	2.6	28	41	PAF
KTRC127	O'Neil Zone	43.00	44.00	1.00	GABSS	Transitional	WR				5006876	40302	2010	0.037	0.030	0.79	24	15	9	0.6	3.2	7	13	PAF
KTRC127	O'Neil Zone	44.00	45.00	1.00	GABSS	Transitional	WR				5006877	40303	2010	0.012	-0.010	0.26	8	19	-11	2.4	4.6	0	2	NAF
KTRC127	O'Neil Zone	45.00	46.00	1.00	GABSS	Transitional	WR				5006879	40304	2010	0.009	0.010	0.35	11	18	-7	1.7	4.5	0	3	NAF
KTRC127	O'Neil Zone	53.00	54.00	1.00	GABSS	Fresh	WR			1	5006887	40305	2010	0.009	0.010	0.85	26	15	11	0.6	3.2	12	22	PAF
KTRC127	O'Neil Zone	56.00	57.00	1.00	GABSS	Fresh	WR			1	5006891	40306	2010	0.002	0.020	1.47	45	10	35	0.2	2.7	22	31	PAF
KTRC127	O'Neil Zone	71.00	72.00	1.00	BGCS	Fresh	LG			2	5007009	40307	2010	0.174	-0.010	2.06	63	10	53	0.2	2.9	14	41	PAF
KTRC127	O'Neil Zone	83.00	84.00	1.00	BGCS	Fresh	HG			1	5007022	40308	2010	0.305	0.020	0.55	17	14	3	0.8	3.8	2	13	PAF-LC
KTRC161	O'Neil Zone	2.00	3.00	1.00	GABS	Highly	WR				5027140	40311	2010	0.028	0.140	0.02	1	78	-77	124.3	7.7	0	0	NAF
KTRC161	O'Neil Zone	3.00	4.00	1.00	GABS	Highly	LG				5027141	40312	2010	0.129	0.520	0.02	1	12	-11	18.2	7.1	0	0	NAF
KTRC161	O'Neil Zone	11.00	12.00	1.00	GABS	Highly	HG				5027151	40313	2010	2.225	0.360	0.02	1	5	-4	7.3	7.5	0	0	NAF
KTRC161	O'Neil Zone	12.00	13.00	1.00	GABS	Moderately	HG				5027152	40314	2010	0.786	0.070	0.01	0	10	-10	21.9	7.2	0	0	NAF
KTRC161	O'Neil Zone	16.00	17.00	1.00	GABS	Moderately	HG				5027157	40315	2010	0.677	0.520	0.01	0	7	-7	18.6	7.4	0	0	NAF
KTRC161	O'Neil Zone	23.00	24.00	1.00	GABSS	Moderately	HG				5027164	40316	2010	1.251	0.070	0.05	1	11	-10	7.8	7.6	0	0	NAF
KTRC161	O'Neil Zone	28.00	29.00	1.00	GABS	Moderately	HG				5027170	40317	2010	0.320	0.080	0.005	0	9	-9	60.0	7.1	0	0	NAF
KTRC161	O'Neil Zone	31.00	32.00	1.00	GABS	Moderately	WR				5027173	40318	2010	0.058	0.020	0.003	0	12	-12	122.5	6.9	0	0	NAF
KTRC161	O'Neil Zone	32.00	36.00	4.00	GABS	Moderately/Slightly	WR				5026592	40319	2010	0.056	0.041	0.10	3	9	-6	2.9	6.9	0	0	NAF
KTRC161	O'Neil Zone	36.00	40.00	4.00	GABS	Slightly	WR				5026593	40320	2010	0.082	0.015	0.16	5	10	-5	2.0	5.0	0	1	NAF
KTRC161	O'Neil Zone	40.00	44.00	4.00	GABSS/QV/GABS	Slightly/Fresh	WR				5026594	40321	2010	0.056	0.014	0.24	7	13	-6	1.8	4.5	0	2	NAF
KTRC161	O'Neil Zone	44.00	45.00	1.00	GABSS	Fresh	WR				5027186	40322	2010	0.017	0.020	0.16	5	10	-5	2.0	4.1	1	3	UC(PAF-LC)
KTRC161	O'Neil Zone	45.00	46.00	1.00	GABSS	Fresh	WR				5027187	40323	2010	0.021	0.010	0.24	7	11	-4	1.5	3.8	2	5	UC(PAF-LC)
KTRC161	O'Neil Zone	49.00	50.00	1.00	GABSS	Fresh	WR				5027191	40324	2010	0.008	-0.010	0.02	1	11	-10	17.7	6.9	0	0	NAF
KTRC277	O'Neil Zone	16.00	20.00	4.00	GABS	Slightly	LG				4007107	40514	2010	0.093	0.010	0.06	2	16	-14	8.7	7.2	0	0	NAF
KTRC277	O'Neil Zone	20.00	24.00	4.00	GABS	Slightly	WR				4007108	40515	2010	0.151	0.015	0.11	3	13	-10	3.9	7.5	0	0	NAF
KTRC277	O'Neil Zone	24.00	28.00	4.00	GABS	Fresh	WR				4007109	40516	2010	0.077	0.043	1.66	51	8	43	0.2	2.7	18	30	PAF
KTRC277	O'Neil Zone	32.00	36.00	4.00	GABS	Fresh	WR				4007111	40517	2010	0.040	0.005	0.20	6	16	-10	2.6	4.9	0	1	NAF
KTRC277	O'Neil Zone	40.00	41.00	1.00	GABS	Slightly	WR				5039819	40518	2010	0.018	-0.010	0.45	14	13	1	0.9	3.6	4	11	PAF-LC
KTRC277	O'Neil Zone	41.00	42.00	1.00	GABS	Slightly	LG				5039820	40519	2010	0.199	0.020	1.32	41	6	35	0.1	2.7	15	25	PAF
KTRC277	O'Neil Zone	43.00	44.00	1.00	GABS	Slightly	HG	1		2	5039822	40520	2010	0.385	0.260	2.29	70	2	68	0.0	2.6	21	43	PAF
KTRC277	O'Neil Zone	44.00	45.00	1.00	GABS	Fresh	HG	2		2	5039823	40521	2010	0.458	0.350	2.34	72	1	71	0.0	2.6	22	47	PAF
KTRC387	O'Neil Zone	44.00	45.00	1.00	GABSS	Fresh	WR				KRC003662	40522	2010	0.087	-0.010	0.28	8	16	-8	1.9	4.6	0	2	NAF
KTRC387	O'Neil Zone	55.00	56.00	1.00	BGCS	Fresh	LG				KRC003675	40523	2010	0.105	0.020	0.26	8	13	-5	1.6	4.1	1	5	UC(PAF-LC)
KTRC387	O'Neil Zone	62.00	63.00	1.00	BGCS	Fresh	LG				KRC003682	40524	2010	0.032	0.010	0.43	13	12	1	0.9	3.5	4	10	PAF-LC
KTRC387	O'Neil Zone	65.00	66.00	1.00	BGCS	Fresh	HG	1		1	KRC003685	40525	2010	0.453	0.110	1.18	36	6	30	0.2	3.2	8	25	PAF
KTRC387	O'Neil Zone	78.00	79.00	1.00	BGCS	Fresh	LG	1		1	KRC003698	40526	2010	0.153	0.040	0.48	15	11	4	0.8	3.5	3	14	PAF-LC
KTRC387	O'Neil Zone	82.00	83.00	1.00	BGCS	Fresh	HG	1		2	KRC003702	40527	2010	1.200	0.230	1.68	52	7	45	0.1	3.2	7	41	PAF
KTRC387	O'Neil Zone	102.00	103.00	1.00	BGCS	Fresh	LG				KRC003722	40528	2010	0.076	0.010	0.49	15	8	7	0.5	3.6	3	13	PAF-LC
KTRC387	O'Neil Zone	111.00	112.00	1.00	GABSS	Fresh	LG				KRC003731	40529	2010	0.577	-0.010	1.51	46	7	39	0.2	3.0	11	33	PAF
KTRC387	O'Neil Zone	117.00	118.00	1.00	GABSS	Fresh	WR				KRC003737	40530	2010	0.050	-0.010	0.64	20	9	11	0.5	3.1	9	17	PAF

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification	
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
KTRC417	O'Neil Zone	18.00	19.00	1.00	GABS	Moderately	LG				KRC006350	40338	2010	0.046	0.030	0.02	1	11	-10	18.3	7.2	0	0	NAF	
KTRC417	O'Neil Zone	19.00	20.00	1.00	GABS	Moderately	LG				KRC006351	40339	2010	0.176	0.030	0.62	19	9	10	0.5	3.3	8	17	PAF	
KTRC417	O'Neil Zone	20.00	21.00	1.00	GABS	Moderately	HG			1	KRC006352	40340	2010	3.523	1.245	0.61	19	21	-2	1.1	5.8	0	1	NAF	
KTRC417	O'Neil Zone	23.00	24.00	1.00	GABS	Fresh	HG				KRC006358	40341	2010	0.212	0.100	1.17	36	8	28	0.2	2.8	21	39	PAF	
KTRC417	O'Neil Zone	26.00	27.00	1.00	GABS	Fresh	LG				KRC006361	40342	2010	0.039	0.020	0.52	16	11	5	0.7	3.4	6	13	PAF	
KTRC417	O'Neil Zone	27.00	28.00	1.00	BGCS	Fresh	LG	1			KRC006362	40343	2010	0.053	0.010	0.28	9	14	-5	1.6	4.2	0.4	4	UC(PAF-LC)	
KTRC417	O'Neil Zone	30.00	31.00	1.00	BGCS	Fresh	LG	2			KRC006365	40344	2010	0.163	0.030	1.67	51	10	41	0.2	2.6	31	50	PAF	
KTRC417	O'Neil Zone	37.00	38.00	1.00	BGCS	Fresh	WR	1			KRC006372	40345	2010	0.068	0.050	0.81	25	11	14	0.4	3.5	11	26	PAF	
KTRC417	O'Neil Zone	48.00	49.00	1.00	GABSS	Fresh	WR				KRC006386	40346	2010	0.054	-0.010	0.48	15	17	-2	1.2	3.7	5	12	UC(PAF-LC)	
KTRC417	O'Neil Zone	53.00	54.00	1.00	GABSS	Fresh	WR				KRC006391	40347	2010	0.018	0.020	0.73	22	13	9	0.6	3.2	11	21	PAF	
KTRC417	O'Neil Zone	55.00	56.00	1.00	GABSS	Fresh	WR				KRC006393	40348	2010	0.009	0.020	0.48	15	14	1	1.0	3.3	8	16	PAF	
KTRC417	O'Neil Zone	59.00	60.00	1.00	GABSS	Fresh	WR	1			KRC006397	40349	2010	0.144	0.050	1.59	49	11	38	0.2	2.8	21	37	PAF	
KTRC417	O'Neil Zone	61.00	62.00	1.00	GABSS	Fresh	WR	1			KRC006399	40350	2010	0.016	-0.010	0.24	7	18	-11	2.4	4.1	1	12	UC(PAF-LC)	
KTRC417	O'Neil Zone	66.00	67.00	1.00	GABSS	Fresh	WR				KRC006404	40351	2010	0.020	0.050	1.05	32	13	19	0.4	3.0	13	26	PAF	
KTRC417	O'Neil Zone	68.00	69.00	1.00	GABSS	Fresh	WR				KRC006406	40352	2010	0.007	0.020	0.36	11	16	-5	1.5	4.0	2	7	UC(PAF-LC)	
KTRC417	O'Neil Zone	69.00	70.00	1.00	GABSS	Fresh	WR				KRC006407	40353	2010	0.004	0.020	0.14	4	17	-13	4.0	5.1	0	1	NAF	
KTRC417	O'Neil Zone	72.00	73.00	1.00	GABSS	Fresh	WR				KRC023904	40354	2010	0.003	0.020	0.26	8	18	-10	2.3	4.6	0	3	NAF	
KTRC417	O'Neil Zone	75.00	76.00	1.00	GABSS	Fresh	WR				KRC023907	40355	2010	0.013	0.040	0.45	14	16	-2	1.2	3.7	4	11	UC(PAF-LC)	
KTRC417	O'Neil Zone	79.00	80.00	1.00	GABSS	Fresh	WR	1		1	KRC023911	40356	2010	0.061	0.140	2.23	68	4	64	0.1	2.7	26	37	PAF	
KTRC417	O'Neil Zone	82.00	83.00	1.00	GABSS	Fresh	WR				KRC023914	40357	2010	0.145	0.080	0.55	17	26	-9	1.6	4.1	1	8	UC(PAF-LC)	
KTRC417	O'Neil Zone	84.00	85.00	1.00	GABSS	Fresh	WR				KRC023916	40358	2010	0.010	0.050	0.13	4	27	-23	7.0	6.9	0	0	NAF	
KTRC417	O'Neil Zone	86.00	87.00	1.00	GABSS	Fresh	WR	1		1	KRC023918	40359	2010	0.021	0.010	0.08	3	18	-15	7.1	7.2	0	0	NAF	
KTRC417	O'Neil Zone	89.00	90.00	1.00	GABSS	Fresh	WR				KRC023921	40360	2010	0.002	0.020	0.29	9	16	-7	1.8	4.2	1	5	UC(PAF-LC)	
KTRC417	O'Neil Zone	94.00	95.00	1.00	GABSS	Fresh	WR				KRC023926	40361	2010	0.002	0.020	0.20	6	16	-10	2.6	4.5	0	3	NAF	
KTRC417	O'Neil Zone	122.00	123.00	1.00	BGCS	Fresh	WR				KRC023954	40362	2010	0.003	0.010	0.36	11	18	-7	1.6	4.2	1	6	UC(PAF-LC)	
KTRC417	O'Neil Zone	123.00	124.00	1.00	BGCS	Fresh	WR				KRC023955	40363	2010	0.001	-0.010	0.16	5	17	-12	3.4	5.2	0	1	NAF	
KTRC417	O'Neil Zone	125.00	126.00	1.00	BGCS	Fresh	WR				KRC023957	40364	2010	0.000	0.020	0.22	7	16	-9	2.4	5.4	0	1	NAF	
KTRC417	O'Neil Zone	127.00	128.00	1.00	BGCS	Fresh	WR	1			KRC023959	40365	2010	0.001	-0.010	0.33	10	17	-7	1.7	4.2	0.4	4	UC(PAF-LC)	
KTRC417	O'Neil Zone	133.00	134.00	1.00	GABS	Fresh	WR				KRC023965	40366	2010	0.000	0.010	0.02	1	17	-16	33.7	7.2	0	0	NAF	
KTRC665	O'Neil Zone	23.00	24.00	1.00	GABS	Slightly	WR				KRC031363	40591	2010	0.036	-0.010	0.05	2	13	-11	8.5	7.3	0	0	NAF	
KTRC665	O'Neil Zone	25.00	26.00	1.00	GABS	Slightly	LG				KRC031365	40593	2010	0.325	0.260	0.52	16	12	4	0.8	4.3	0.1	6	PAF-LC	
KTRC665	O'Neil Zone	27.00	28.00	1.00	GABS	Slightly	LG				KRC031367	40595	2010	0.200	-0.010	0.77	24	13	11	0.6	3.6	2	10	PAF-LC	
KTRC665	O'Neil Zone	28.00	29.00	1.00	GABS	Fresh	LG				KRC031368	40596	2010	0.058	-0.010	0.46	14	14	0	1.0	4.2	1	5	PAF-LC	
KTRC665	O'Neil Zone	31.00	32.00	1.00	GABS	Fresh	LG				KRC031371	40599	2010	0.016	0.010	0.52	16	15	1	0.9	3.7	2	9	PAF-LC	
KTRC665	O'Neil Zone	33.00	34.00	1.00	GABS	Moderately	LG				KRC031373	40601	2010	0.180	0.150	0.62	19	13	6	0.7	3.7	2	10	PAF-LC	
KTRC665	O'Neil Zone	34.00	35.00	1.00	GABS	Moderately	LG				KRC031374	40602	2010	0.134	0.200	0.36	11	13	-2	1.2	4.3	0.2	4	UC(PAF-LC)	
KTRC665	O'Neil Zone	37.00	38.00	1.00	GABS	Slightly	HG	2			KRC031377	40605	2010	0.204	0.110	1.36	42	12	30	0.3	3.2	8	23	PAF	
KTRC665	O'Neil Zone	40.00	41.00	1.00	GABS	Fresh	LG	1			KRC031380	40608	2010	0.021	-0.010	0.46	14	15	-1	1.1	3.9	1	6	UC(PAF-LC)	
KTRC665	O'Neil Zone	41.00	42.00	1.00	GABS	Fresh	LG	1			KRC031381	40609	2010	0.919	0.140	1.52	47	12	35	0.3	3.7	2	19	PAF-LC	
KTRC665	O'Neil Zone	42.00	43.00	1.00	GABS	Fresh	LG				KRC031382	40610	2010	0.113	-0.010	0.39	12	14	-2	1.2	4.5	0	3	NAF	
KTRC665	O'Neil Zone	44.00	45.00	1.00	GABS	Fresh	WR				KRC031384	40612	2010	0.012	-0.010	0.27	8	13	-5	1.6	4.5	0	3	NAF	
KTRC665	O'Neil Zone	46.00	47.00	1.00	BGCS	Fresh	WR				KRC031386	40614	2010	0.036	0.020	0.74	23	14	9	0.6	3.7	4	14	PAF-LC	
KTRC665	O'Neil Zone	48.00	49.00	1.00	BGCS	Fresh	WR				KRC031388	40616	2010	0.017	-0.010	0.62	19	13	6	0.7	3.6	3	13	PAF-LC	
KTRC665	O'Neil Zone	52.00	53.00	1.00	BGCS	Fresh	HG				KRC031395	40620	2010	0.533	0.140	3.62	111	0	111	0.0	2.5	19	37	PAF	
KTRC665	O'Neil Zone	55.00	56.00	1.00	GABS	Fresh	LG				KRC031398	40623	2010	0.013	-0.010	0.53	16	15	1	0.9	3.7	3	11	PAF-LC	
KTRC665	O'Neil Zone	59.00	60.00	1.00	GABSS	Fresh	WR				KRC031402	40627	2010	0.049	-0.010	2.06	63	14	49	0.2	2.6	23	39	PAF	
KTRC665	O'Neil Zone	63.00	64.00	1.00	GABSS	Fresh	WR			1	KRC031406	40631	2010	0.045	-0.010	1.41	43	16	27	0.4	2.9	11	21	PAF	
KTRC665	O'Neil Zone	67.00	68.00	1.00	GABSS	Fresh	WR				KRC031410	40635	2010	0.003	-0.010	0.11	3	15	-12	4.5	6.3	0	2	NAF	
KTRC665	O'Neil Zone	73.00	74.00	1.00	GABSS	Fresh	HG	1			KRC031416	40641	2010	0.050	0.080	2.38	73	15	58	0.2	2.5	34	49	PAF	
KTRC665	O'Neil Zone	76.00	77.00	1.00	GABSS	Fresh	WR	2			KRC031419	40644	2010	0.007	0.020	0.50	15	16	-1	1.0	3.7	3	11	UC(PAF-LC)	
KTRC665	O'Neil Zone	78.00	79.00	1.00	GABSS	Fresh	WR			1	KRC031421	40646	2010	0.002	0.050	0.24	7	14	-7	1.9	4.1	0.3	4	UC(PAF-LC)	
KTRC665	O'Neil Zone	81.00	82.00	1.00	GABSS	Fresh	WR	1			KRC031426	40649	2010	0.104	0.090	2.47	76	9	67	0.1	2.5	31	44	PAF	
KTRC665	O'Neil Zone	83.00	84.00	1.00	GABSS	Fresh	WR				KRC031428	40651	2010	0.003	0.010	0.24	7	17	-10	2.3	5.0	0	2	NAF	

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m) From	To	Interval	Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
KTRC022	Emily Star	0.00	1.00	1.00	GABS	Moderately	LG				4000382	40262	2010	0.109	0.020	0.005	0	11	-11	73.4	7.2	0	0	NAF
KTRC022	Emily Star	3.00	4.00	1.00	GABS	Moderately	HG				4000385	40263	2010	0.379	0.020	0.01	0	12	-12	65.4	7.6	0	0	NAF
KTRC022	Emily Star	25.00	26.00	1.00	GABS	Moderately	HG				4000407	40264	2010	0.248	0.010	0.10	3	10	-7	3.4	6.9	0	0	NAF
KTRC022	Emily Star	29.00	30.00	1.00	GABS	Moderately	HG				4000411	40265	2010	1.023	-0.010	0.11	3	7	-4	2.1	6.9	0	0	NAF
KTRC022	Emily Star	30.00	31.00	1.00	GABS	Slightly	HG				4000412	40266	2010	0.110	-0.010	0.02	1	11	-10	15.4	7.2	0	0	NAF
KTRC022	Emily Star	33.00	34.00	1.00	GABS	Slightly	HG				4000415	40267	2010	0.587	0.010	0.14	4	12	-8	2.7	7.1	0	0	NAF
KTRC022	Emily Star	39.00	40.00	1.00	GABS	Highly	WR				4000421	40268	2010	0.018	-0.010	0.01	0	19	-19	100.1	7.2	0	0	NAF
KTRC022	Emily Star	40.00	44.00	4.00	GABS	Highly/Fresh	WR				5006119	40269	2010	0.069	-0.001	0.09	3	15	-12	5.4	7.1	0	0	NAF
KTRC022	Emily Star	44.00	48.00	4.00	GABS	Fresh	WR				5006120	40270	2010	0.033	-0.001	0.07	2	17	-15	7.9	7.5	0	0	NAF
KTRC022	Emily Star	53.00	54.00	1.00	BGCS	Fresh	HG			1	4000435	40271	2010	0.285	-0.010	0.29	9	14	-5	1.6	4.8	0	4	NAF
KTRC022	Emily Star	57.00	58.00	1.00	BGCS	Fresh	HG			1	4000439	40272	2010	1.147	-0.010	1.59	49	5	44	0.1	3.2	9	36	PAF
KTRC022	Emily Star	60.00	61.00	1.00	BGCS	Fresh	HG				4000442	40273	2010	0.621	-0.010	0.88	27	18	9	0.7	3.8	4	23	PAF-LC
KTRC022	Emily Star	67.00	68.00	1.00	BGCS	Fresh	LG				4000449	40274	2010	0.093	-0.010	0.12	4	21	-17	5.6	6.9	0	0	NAF
KTRC022	Emily Star	72.00	73.00	1.00	BS	Fresh	LG				4000454	40275	2010	0.036	0.010	0.06	2	16	-14	9.0	7.2	0	0	NAF
KTRC022	Emily Star	84.00	88.00	4.00	GABSS/GABS	Fresh	WR				5006123	40276	2010	0.007	0.002	0.04	1	17	-16	13.9	7.4	0	0	NAF
KTRC022	Emily Star	120.00	123.00	3.00	BS	Fresh	WR				5006132	40277	2010	0.004	0.005	0.15	5	21	-16	4.6	6.9	0	0	NAF
KTRC217	Emily Star	0.00	4.00	4.00	GABS	Highly	WR				5036842	40652	2010	0.027	0.012	0.05	2	23	-21	15.0	8.5	0	0	NAF
KTRC217	Emily Star	8.00	12.00	4.00	GABS	Highly	WR				5036844	40653	2010	0.008	0.003	0.05	2	12	-10	7.8	6.9	0	0	NAF
KTRC217	Emily Star	12.00	16.00	4.00	GABS	Highly/Moderately	WR				5036845	40654	2010	0.022	0.008	0.06	2	12	-10	6.5	6.9	0	0	NAF
KTRC217	Emily Star	16.00	20.00	4.00	GABS	Moderately	WR				5036846	40655	2010	0.161	0.021	0.05	2	14	-12	9.2	7.6	0	0	NAF
KTRC217	Emily Star	20.00	24.00	4.00	GABS	Moderately	WR				5036847	40656	2010	0.062	0.008	0.05	2	13	-11	8.5	7.4	0	0	NAF
KTRC217	Emily Star	24.00	25.00	1.00	GABS	Moderately	WR				5032808	40657	2010	0.008	-0.010	0.00	0	14	-14	104.0	6.9	0	0	NAF
KTRC217	Emily Star	27.00	28.00	1.00	GABS	Moderately	LG				5032811	40658	2010	0.156	0.010	0.00	0	14	-14	143.0	7.3	0	0	NAF
KTRC217	Emily Star	31.00	32.00	1.00	GABS	Moderately	HG				5032815	40659	2010	1.979	0.405	0.08	2	14	-12	5.8	7.6	0	0	NAF
KTRC217	Emily Star	34.00	35.00	1.00	GABS	Moderately	WR				5032818	40660	2010	0.063	0.020	0.00	0	15	-15	104.3	7.1	0	0	NAF
KTRC217	Emily Star	35.00	36.00	1.00	GABS	Moderately	WR				5032819	40661	2010	0.021	-0.010	0.00	0	13	-13	128.7	6.6	0	2	NAF
KTRC217	Emily Star	36.00	40.00	4.00	GABS	Fresh/Moderately	WR				5036848	40662	2010	0.010	0.003	0.05	2	14	-12	9.2	6.5	0	3	NAF
KTRC217	Emily Star	40.00	44.00	4.00	GABS	Fresh	WR				5036849	40663	2010	0.011	0.009	0.14	4	13	-9	3.0	6.0	0	1	NAF
KTRC217	Emily Star	44.00	48.00	4.00	GABS	Fresh	WR				5036850	40664	2010	0.006	0.049	1.29	39	11	28	0.3	2.8	15	23	PAF
KTRC217	Emily Star	48.00	49.00	1.00	GABSS	Fresh	WR				5032832	40665	2010	0.009	0.030	0.75	23	15	8	0.7	3.3	6	13	PAF
KTRC217	Emily Star	49.00	50.00	1.00	GABSS	Fresh	WR				5032833	40666	2010	0.047	0.030	0.56	17	15	2	0.9	3.7	2	9	PAF-LC
KTRC217	Emily Star	52.00	53.00	1.00	GABSS	Fresh	HG			2	5032836	40667	2010	0.588	0.050	1.77	54	15	39	0.3	3.1	6	20	PAF
KTRC217	Emily Star	53.00	54.00	1.00	GABSS	Fresh	HG	1			5032837	40668	2010	0.216	0.020	0.43	13	15	-2	1.1	4.1	0.3	5	UC(PAF-LC)
KTRC217	Emily Star	54.00	55.00	1.00	GABSS	Fresh	HG				5032838	40669	2010	0.161	0.040	0.35	11	17	-6	1.6	4.7	0	3	NAF
KTRC217	Emily Star	57.00	58.00	1.00	GABSS	Fresh	HG	1		1	5032841	40670	2010	0.406	0.010	0.63	19	15	4	0.8	4.5	0	7	UC(NAF)
KTRC217	Emily Star	58.00	59.00	1.00	GABSS	Fresh	LG			1	5032842	40671	2010	0.128	0.020	0.39	12	16	-4	1.3	4.5	0	3	NAF
KTRC217	Emily Star	59.00	60.00	1.00	GABSS	Fresh	WR				5032843	40672	2010	0.038	-0.010	0.19	6	17	-11	2.9	5.8	0	1	NAF
KTRC217	Emily Star	62.00	63.00	1.00	GABS	Fresh	WR				5032846	40673	2010	0.012	-0.010	0.02	1	22	-21	35.9	6.9	0	0	NAF
KTRC217	Emily Star	66.00	67.00	1.00	BS	Fresh	WR				5032850	40674	2010	0.007	-0.010	0.03	1	18	-17	17.3	6.6	0	2	NAF
KTRC217	Emily Star	69.00	70.00	1.00	BS	Fresh	WR				5032853	40675	2010	0.007	-0.010	0.01	0	20	-20	60.5	7.1	0	0	NAF
KTRC221	Emily Star	0.00	4.00	4.00	GABS	Slightly	WR					33458	2007	0.014	0.008	0.01	0	22	-22	71.90	7.2	0	0	NAF
KTRC221	Emily Star	8.00	12.00	4.00	GABS	Moderately/Slightly	WR					33459	2007	0.085	0.005	0.02	1	22	-21	35.9	7.3	0	0	NAF
KTRC221	Emily Star	16.00	20.00	4.00	GABS	Slightly	WR					33460	2007	0.013	0.004	0.01	0	24	-24	78.4	6.9	0	0	NAF
KTRC221	Emily Star	24.00	28.00	4.00	GABS/BS	Slightly	WR					33461	2007	0.019	0.002	0.03	1	24	-23	26.1	7.1	0	0	NAF
KTRC221	Emily Star	32.00	36.00	4.00	BS	Slightly	WR					33462	2007	0.013	0.009	0.03	1	22	-21	24.0	6.9	0	0	NAF
KTRC221	Emily Star	40.00	44.00	4.00	BS	Slightly	WR					33463	2007	0.007	0.000	0.48	15	22	-7	1.5	3.7	4	9	UC(PAF-LC)
KTRC221	Emily Star	48.00	52.00	4.00	BS	Slightly/Fresh	WR					33464	2007	0.008	0.002	0.03	1	22	-21	24.0	6.6	0	4	NAF
KTRC221	Emily Star	52.00	56.00	4.00	BS	Fresh	WR					33465	2007	0.002	0.001	0.02	1	24	-23	39.2	6.9	0	0	NAF
KTRC221	Emily Star	60.00	64.00	4.00	GABS	Fresh	WR					33466	2007	0.005	0.002	0.01	0	23	-23	75.2	6.9	0	0	NAF
KTRC221	Emily Star	64.00	68.00	4.00	GABS	Fresh	WR					33467	2007	0.004	0.003	0.01	0	26	-26	85.0	6.9	0	0	NAF
KTRC221	Emily Star	72.00	76.00	4.00	GABS/BS	Fresh	WR					33468	2007	0.008	0.002	0.01	0	38	-38	124.2	6.9	0	0	NAF
KTRC221	Emily Star	80.00	81.00	1.00	GABSS	Fresh	WR					33469	2007	0.017	0.000	0.03	1	21	-20	22.9	7.1	0	0	NAF
KTRC221	Emily Star	81.00	85.00	4.00	GABSS	Fresh	WR			1		33470	2007	0.076	0.020	0.10	3	21	-18	6.9	7.2	0	0	NAF
KTRC221	Emily Star	85.00	86.00	1.00	GABSS	Fresh	WR	1				33471	2007	0.067	0.010	0.07	2	21	-19	9.8	7.3	0	0	NAF
KTRC221	Emily Star	87.00	88.00	1.00	GABS	Fresh	WR			2		33472	2007	1.204	0.220	1.50	46	17	29	0.4	3.5	10	34	PAF
KTRC221	Emily Star	88.00	91.00	3.00	GABS	Fresh	WR					33473	2007	0.078	0.023	0.09	3	19	-16	6.9	6.2	0	0	NAF
KTRC221	Emily Star	91.00	92.00	1.00	BGCS	Fresh	WR			2		33474	2007	0.169	0.090	0.19	6	20	-14	3.4	5.2	0	2	NAF
KTRC221	Emily Star	132.00	133.00	1.00	GABSS	Fresh	WR					33475	2007	0.154	0.020	0.18	6	18	-12	3.3	4.5	0	3	NAF
KTRC221	Emily Star	133.00	137.00	4.00	GABSS	Fresh	WR					33476	2007	0.032	0.010	0.04	1	26	-25	21.2	7.1	0	0	NAF
KTRC221	Emily Star	137.00	138.00	1.00	GABSS	Fresh	WR					33477	2007	0.013	0.000	0.02	1	21	-20	34.3	6.9	0	0	NAF
KTRC221	Emily Star	138.00	142.00	4.00	GABSS	Fresh	WR					33478	2007	0.076	0.000	0.07	2	21	-19	9.8	7.2	0	0	NAF
KTRC221	Emily Star	142.00	145.00	3.00	GABSS	Fresh	WR					33479	2007	0.021	0.000	0.03	1	34	-33	37.0	7.1	0	0	NAF
KTRC221	Emily Star	145.00	146.00	1.00	GABSS	Fresh	WR			1		33480	2007	0.019	0.000	0.03	1	21	-20	22.9	7.1	0	0	NAF
KTRC221	Emily Star	151.00	152.00	1.00	GABSS	Fresh	WR					33481	2007	0.096	0.000	0.11	3	20	-17	5.9	6.9	0	0	NAF
KTRC221	Emily Star	152.00	154.00	2.00	GABSS	Fresh	WR					33482	2007	0.076	0.000	0.09	3	21	-18	8.1	7.1	0	0	NAF

Table 1: Acid forming characteristics of waste rock, low grade ore and ore samples.

Hole Name	Location	Depth (m)			Lithology Primary	Weathering	Ore/ Waste	Pyrite Abundance	Pyrrhotite Abundance	Chalcopyrite Abundance	Kanmantoo Sample No.	EGi Sample No	Data Set	Cu (%)	Au (g/t)	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
		From	To	Interval												Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
KTRC227	Emily Star	12.00	16.00	4.00	GABS	Slightly	WR				5036140	38633	2009	0.010	0.037	0.00	0				6.9	0	0	NAF
KTRC227	Emily Star	16.00	20.00	4.00	BS	Slightly	WR				5036141	38634	2009	-0.010	0.008	0.01	0				6.4	0	3	NAF
KTRC227	Emily Star	20.00	24.00	4.00	BS	Slightly	WR				5036142	38635	2009	-0.010	0.011	0.01	0				6.4	0	3	NAF
KTRC227	Emily Star	24.00	28.00	4.00	BS	Slightly	WR				5036143	38636	2009	-0.010	0.014	0.01	0				6.9	0	0	NAF
KTRC227	Emily Star	28.00	32.00	4.00	BS	Slightly	WR				5036144	38637	2009	-0.010	0.017	0.01	0				6.9	0	0	NAF
KTRC227	Emily Star	32.00	36.00	4.00	BS	Slightly	WR				5036145	38638	2009	-0.010	0.019	0.00	0				6.5	0	3	NAF
KTRC227	Emily Star	36.00	40.00	4.00	BS	Slightly	WR				5036146	38639	2009	0.010	0.007	0.00	0				6.4	0	4	NAF
KTRC227	Emily Star	40.00	44.00	4.00	BS	Slightly	WR				5036147	38640	2009	-0.010	0.006	0.02	1				6.5	0	2	NAF
KTRC227	Emily Star	44.00	48.00	4.00	BS	Slightly	WR				5036148	38641	2009	-0.010	0.007	0.37	11				4.2	0.2	3	PAF-LC
KTRC227	Emily Star	48.00	52.00	4.00	BS	Slightly/Fresh	WR				5036149	38642	2009	-0.010	0.005	0.66	20				3.7	2	9	PAF-LC
KTRC227	Emily Star	52.00	56.00	4.00	BS	Fresh	WR				5036150	38643	2009	-0.010	0.006	0.12	4				6.2	0	1	UC(NAF)
KTRC227	Emily Star	126.00	127.00	1.00	GABS	Fresh	HG			3	5033994	40325	2010	2.102	0.365	3.04	93	0	93	0.0	3.0	16	49	PAF
KTRC227	Emily Star	128.00	129.00	1.00	GABS	Fresh	HG			1	5033998	40326	2010	0.223	0.050	0.36	11	13	-2	1.2	4.1	1	7	UC(PAF-LC)
KTRC227	Emily Star	130.00	131.00	1.00	BGCS	Fresh	HG				5034000	40327	2010	0.199	0.030	0.24	7	12	-5	1.6	3.9	1	5	UC(PAF-LC)
KTRC227	Emily Star	131.00	132.00	1.00	BGCS	Fresh	HG			2	5034001	40328	2010	0.441	0.020	0.57	18	20	-2	1.1	4.1	1	11	UC(PAF-LC)
KTRC227	Emily Star	133.00	134.00	1.00	BGCS	Fresh	HG			2	5034003	40329	2010	0.332	0.150	0.99	30	23	7	0.8	3.5	6	25	PAF
KTRC227	Emily Star	134.00	135.00	1.00	BGCS	Fresh	HG			1	5034004	40330	2010	0.110	0.050	0.19	6	14	-8	2.5	4.6	0	3	NAF
KTRC227	Emily Star	136.00	137.00	1.00	GABS	Fresh	HG			2	5034006	40331	2010	0.343	0.100	0.48	15	14	1	1.0	4.1	1	10	PAF-LC
KTRC227	Emily Star	138.00	139.00	1.00	GABS	Fresh	HG			2	5034008	40332	2010	0.773	0.080	0.86	26	12	14	0.5	3.4	6	25	PAF
KTRC227	Emily Star	141.00	142.00	1.00	GABS	Fresh	WR			1	5034011	40333	2010	0.037	-0.010	0.04	1	12	-11	9.5	7.1	0	0	NAF
KTRC227	Emily Star	148.00	149.00	1.00	GABS	Fresh	WR			1	5034018	40334	2010	0.080	-0.010	0.28	9	16	-7	1.9	4.8	0	2	NAF
KTRC227	Emily Star	153.00	154.00	1.00	GABS	Fresh	WR				5034023	40335	2010	0.005	-0.010	0.01	0	10	-10	65.4	7.2	0	0	NAF
KTRC370	Emily Star	23.00	24.00	1.00	GABS	Moderately	HG				KRC001989	40336	2010	0.296	0.050	0.003	0	14	-14	134.6	7.5	0	0	NAF
KTRC370	Emily Star	25.00	26.00	1.00	GABS	Moderately	HG				KRC001991	40337	2010	8.745	0.435	0.12	4	49	-45	13.0	7.9	0	0	NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)
NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Lithology Codes

BS	Biotite Schist
GABS	Garnet Andalusite Biotite Schist
GABSS	Garnet Andalusite Biotite Staurolite Schist
BGCS	Biotite Garnet Chlorite Schist
QMS	Quartz Muscovite Schist
BCS	Biotite Chlorite Schist (not lode schist)
SSQ	Quartzite
MS	Massive Sulphide Zone
QV	Quartz Vein
SHR	Shear
Olt	Laterite
Ocl	Colluvium
Osu	Soil (general)
SAP	Saprolite

Ore/Waste

WR	Waste Rock
LG	Low Grade Ore
HG	High Grade Ore

Sulphide Abundance

1	trace
2	minor
3	moderate
4	strong
5	intense
6	extreme

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF-LC = PAF - Lower Capacity
UC = Uncertain Classification
(expected classification in brackets)

Table 2: Sequential NAG test results for selected waste rock samples.

Hole	Lithology	Weathering	Ore	EGi Sample No	Total S (%)	ANC	NAPP	Stage 1			Stage 2			Stage 3			Stage 4			Stage 5			Cumulative NAG
								NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	$NAG_{(pH7.0)}$
						(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)		(kg H_2SO_4/t)
KTRC118	BGCS	Fresh	HG	40511	1.07	9	24	3.7	2	12	3.5	2	5	4.4	0.1	1	4.8	-	-	5.7	-	-	18
KTRC682	GABS	Slightly		40553	1.64	1	49	2.7	9	19	3.1	3	5	3.6	1	3	3.7	1	3	4.0	1	3	33
KTRCD120	GABS	Fresh		33446	2.33	8	63	2.8	17	35	3.2	5	9	3.6	2	4	3.7	1	3	4.4	0.05	1	52
KTRC417	GABS	Moderately	HG	40340	0.61	21	-2	5.8	-	-	5.3	-	-	5.5	-	-	5.5	-	-	5.7	-	-	-
KTRC665	GABS	Slightly	HG	40605	1.36	12	30	3.2	8	18	3.4	1	3	4.4	0.1	1	4.8	-	-	5.1	-	-	22
KTRC665	GABS	Fresh	LG	40609	1.52	12	35	3.8	1	13	3.5	2	5	4.3	0.1	1	4.6	-	-	4.9	-	-	19

KEY:

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Table 3: Multi-element composition of selected sample solids (mg/kg except where shown).

Element	Detection Limit	Ore/Waste, Weathering and Sample Number																																						
		HG	HG	HG	HG	HG	HG	HG	HG	HG	LG	LG	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR
		High	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	High	High	High	High	High/ Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod/ Slight	Mod/ Slight	Slight	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh
		40313	40533	40536	40317	40340	40263	40265	40659	40337	40369	40601	40562	38606	40298	40268	33427	40567	38618	38624	40549	38659	40247	40655	33459	40319	33463	33402	33405	33410	33415	33416	33425	33446	33449	33454	33465	33467	33471	33474
Ag	0.01	1.49	0.41	1.54	0.18	49.1	0.79	1.03	1.32	41.7	1.21	0.64	0.13	0.53	0.07	0.04	<0.1	0.26	0.12	0.65	1.13	0.09	0.07	0.09	0.4	1.38	0.2	0.3	0.1	<0.1	0.4	0.3	0.2	1.2	1.1	0.7	<0.1	<0.1	0.1	0.3
Al	0.01%	5.27%	6.64%	5.30%	6.44%	3.93%	7.40%	5.98%	5.62%	4.91%	6.91%	6.30%	5.96%	6.82%	6.13%	8.63%	7.39%	5.81%	7.66%	5.88%	6.90%	6.26%	7.47%	8.33%	6.30%	7.32%	7.25%	7.00%	7.05%	6.52%	4.77%	6.66%	6.57%	5.82%	5.89%	6.05%	7.52%	7.71%	7.39%	5.88%
As	0.2	3.3	1.5	1.3	2.9	51.9	2	6.4	4.5	6	3	1.7	1.2	20.4	8.1	1.2	3	2.1	2.6	62.2	1.2	1.4	0.8	1.4	2	3.4	25	<1	<1	2	2	2	2	4	56	1	<1	1	<1	4
Ba	10	190	270	160	220	80	380	140	160	140	230	220	190	40	540	350	291	90	210	140	240	250	590	390	245	250	620	239	235	221	137	181	222	176	167	167	661	785	344	109
Be	0.05	0.88	1.34	1.07	1.03	0.39	1.91	0.88	1.2	0.7	1.6	1.13	0.94	2.04	2.05	1.98	2.1	0.95	3.1	1.31	1.3	1.31	1.92	2.6	2.0	1.5	3.9	2.1	2.1	1.3	1.0	1.3	1.6	2.0	1.8	1.5	4.1	3.0	2.1	1.1
Bi	0.01	54.0	22.6	96.6	11.6	171.0	17.0	6.6	470.0	1125.0	142.0	7.2	2.0	2.8	17.2	3.1		4.8	3.7	96.3	3.8	9.8	0.4	5.6		5.1														
Ca	0.01%	0.04%	0.07%	0.12%	0.04%	0.06%	0.12%	0.10%	0.12%	0.06%	0.08%	0.10%	0.01%	0.07%	3.50%	0.17%	0.64%	0.07%	0.11%	0.09%	0.05%	0.11%	0.20%	0.15%	0.13%	0.05%	2.15%	0.12%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.16%	0.13%	0.90%	0.49%	0.19%	0.69%
Cd	0.02	0.03	<0.02	0.1	<0.02	0.05	0.03	0.09	0.09	0.4	0.05	0.37	<0.02	<0.02	0.09	<0.02	<0.1	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.06	<0.1	<0.02	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ce	0.01	63.6	102.5	90.5	86.2	42.6	86.1	22.7	52.9	42	73.9	83.7	60.8	131.5	86.5	108.5		59.9	91.9	95.6	101.5	98.2	72.1	106.5		95.1														
Co	0.1	33	97	121	27	212	19	23	67	82	87	108	14	18	24	19	29	43	36	186	79	45	27	27	20	13	23	91	24	113	168	72	72	138	148	130	21	22	26	18
Cr	1	73	80	67	87	56	94	87	100	61	78	76	84	89	67	107	74	72	106	99	84	75	89	113	131	89	111	91	83	89	92	91	100	78	71	102	116	84	91	83
Cs	0.05	0.34	5.22	4.39	3.14	3.89	3.28	2.90	5.27	3.11	7.24	3.14	2.78	1.06	4.26	4.42		1.76	3.32	3.11	4.70	4.21	5.70	5.45		3.59														
Cu	0.2	20600	3020	4480	3090	36100	4010	9960	19800	92700	8670	2060	60.7	1020	2620	196	541	496	194.5	1090	5030	377	707	1640	916	670	126	1571	118	233	1492	1625	501	4242	3593	2568	48	57	614	1524
F																	729								861		935	909	1018	966	683	754	934	875	803	733	899	860	984	524
Fe	0.01%	6.1%	8.8%	8.7%	8.8%	10.9%	8.9%	13.0%	10.5%	12.6%	11.3%	9.7%	9.3%	12.5%	5.3%	9.1%	7.5%	12.7%	8.9%	12.9%	9.9%	8.6%	5.7%	7.6%	7.5%	8.8%	4.9%	10.4%	8.9%	10.7%	12.2%	10.7%	8.7%	9.2%	8.6%	11.4%	5.1%	5.9%	10.7%	14.0%
Ga	0.05	16	19	14	17	11	20	17	16	13	20	18	17	19	17	20		18	21	17	21	18	23	25		19														
Ge	0.05	0.20	0.29	0.26	0.28	0.24	0.26	0.42	0.28	0.30	0.31	0.25	0.25	0.39	0.21	0.30		0.33	0.31	0.38	0.34	0.28	0.23	0.27		0.27														
Hf	0.1	2.4	1.9	2.6	2.3	1.3	3.0	2.5	2.2	1.4	1.7	1.9	2.0	3.3	2.9	2.7		2.7	2.4	2.8	2.5	3.1	3.3	3.0		2.7														
Hg	0.005	<0.005	<0.005	<0.005	<0.005	0.040	<0.005	<0.005	0.008	0.071	0.007	<0.005	<0.005	0.171	0.009	<0.005	<0.01	0.014	<0.005	0.012	0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
In	0.005	1.160	0.381	0.481	0.326	1.210	0.381	0.484	1.640	5.070	0.488	0.388	0.392	0.575	0.204	0.310		0.225	0.299	0.290	0.368	0.280	0.214	0.285		0.474														
K	0.01%	0.8%	2.0%	1.7%	1.8%	1.0%	2.1%	1.2%	2.0%	1.6%	2.2%	1.6%	1.3%	1.3%	1.8%	2.6%	2.1%	0.7%	2.3%	1.6%	2.4%	1.9%	3.6%	3.0%	2.4%	2.0%	2.6%	2.3%	2.2%	2.0%	1.9%	1.5%	2.2%	2.2%	2.1%	2.6%	2.9%	3.2%	2.6%	0.9%
La	0.5	34	52	47	45	21	43	11	27	21	37	43	31	65	46	55		30	47	48	51	50	34	55		49														
Li	0.2	4	18	25	18	16	18	14	24	9	24	29	7	30	22	21		12	25	18	18	12	23	28		18														
Mg	0.01%	0.1%	1.4%	1.3%	1.5%	1.0%	1.2%	1.3%	1.4%	1.3%	1.7%	1.4%	0.9%	1.3%	2.9%	1.8%	1.5%	1.2%	1.8%	1.3%	1.4%	1.4%	2.0%	2.0%	1.7%	1.7%	2.1%	1.9%	1.6%	1.6%	1.3%	1.9%	1.7%	1.5%	1.3%	1.7%	2.0%	1.8%	1.7%	1.2%
Mn	5	1100	1560	1500	1580	1780	1040	1980	2130	1980	1840	1630	182	718	1370	1620	1912	2460	1930	2490	1770	1800	2170	2490	2218	1920	2076	1867	1689	2018	1764	2256	1534	1610	1511	2565	2229	2214	1913	3146
Mo	0.05	4.7	2.7	2.9	2.8	5.4	1.8	5.1	3.3	2.4	2.9	0.9	3.2	6.5	2.3	2.2	1.3	4.3	3.8	5.8	1.6	2.8	1.0	1.7	2.5	2.1	1.9	3.1	1.7	6.7	5.0	5.2	4.3	3.6	2.9	3.7	1.4	1.6	2.9	9.1
Na	0.01%	0.19%	0.11%	0.10%	0.08%	0.05%	0.15%	0.05%	0.10%	0.07%	0.06%	0.13%	0.08%	0.11%	0.20%	0.13%	0.15%	0.04%	0.04%	0.06%	0.06%	0.09%	0.18%	0.20%	0.13%	0.08%	1.24%	0.06%	0.05%	0.04%	0.05%	0.05%	0.05%	0.05%	0.05%	0.04%	1.18%	0.81%	0.17%	0.07%
Nb	5	12	14	12	13	7	15	11	11	8	12	12	14	9	10	16		12	13	13	16	15	15	16		15														
Ni	0.2	11	41	58	28	49	40	42	75	67	76	65	21	23	34	50	31	36	64	100	28	29	57	63	59	24	54	47	45	56	52	48	58	51	39	48	55	53	52	19
P	10	250	490	590	160	240	580	470	520	450	500	550	280	1790	130	850	285	440	750	710	520	670	630	710	728	330	846	516	634	638	542	636	741	712	632	551	746	635	765	966
Pb	0.5	43	34	37	25	14	15	8	8	9	19	8	18	10	98	8	15	10	10	9	26	7	123	15	10	23	244	14	8	9	22	16	11	30	11	15	21	12	7	12
Rb	0.1	23	141	131	116	79	149	86	150	104	184	104	162	87	130	170		54	157	108	167	154	190	187		125														
S	0.01%	0.02%	0.02%	0.62%	0.01%	0.64%	0.01%	0.11%	0.09%	0.13%	0.20%	0.66%	0.06%	0.41%	0.04%	0.01%	0.31%	0.21%	0.06%	0.52%	0.09%	0.01%	0.01%	<0.01%	0.02%	0.10%	0.48%	0.81%	0.23%	1.15%	1.80%	0.71%	1.07%	2.33%	1.19%	1.45%	0.02%	0.01%	0.07%	0.19%
Sb	0.05	0.29	0.17	0.30	0.16	1.32	0.22	0.14	1.52	0.90	0.22	0.08	0.06	1.17	0.27	0.08	0.10	0.12	0.13	0.20	<0.05	0.05	0.08	0.15	0.14	0.14	0.10	0.08	0.07	0.08	0.09	0.06	0.23	0.26	0.11	0.09	0.07	0.07	0.07	0.63
Sc	0.1	13	14	11	13	7	14	11	9	9	14	13	11	16	15	15		11	15	12	16	12	15	18		14														
Se	1.0	4.0	4.0	3.0	2.0	5.0	2.0	4.0	7.0	15.0	6.0	2.0	1.0	2.0	2.0	1.0	0.1	2.0	2.0	4.0	3.0	2.0	1.0	1.0	0.1	2.0	0.4	0.7	0.1	0.3	1.6	0.3	0.5	4.3	1.0	2.3	0.0	0.0	0.2	0.7
Sn	0.2	4.9	6.3	5.1	3.3	4.3	4.7	3.6	10.9	27.9	4.9	4.7	5.4	2.8	3.4	5.4	6.9	4.6	4.2	4.5	11.6	4.3	4.5	4.3	5.9	3	6.4	8.1	7.3	9.2	10.7	9.5	7.1	9.2	8.0	10.7	5.2	6.2	9.1	7.2
Sr	0.2	21	30	14	6	17	20	19	11	9	37	30	8	80	318	14	49	40	23	88	38	114	36	26	36	19	169	10	10	9	10	8	10	11	11	8	81	59	16	17
Ta	0.05	0.92	1.09	0.88	0.99	0.52	1.15	0.86	0.83	0.68	0.9	0.94	1.03	0.71	0.79	1.26		0.91	1.07	0.94	1.16	1.13	1.13	1.23		1.12														
Th	0.2	15	18	15	16	9	19	14	12	11	16	15	11	20	16	21	16	15	17	16	18	17	15	21	16	18	17	15	15	14	12	15	15	14	14	12	17	17	19	18
Ti	0.005%	0.34%	0.38%	0.32%	0.38%	0.21%	0.47%	0.32%	0.33%	0.27%	0.31%	0.34%	0.39%	0.26%	0.29%	0.50%		0.32%	0.40%	0.35%	0.42%	0.39%	0.41%	0.43%		0.42%														
Tl	0.02	0.16	0.77	0.67	0.68	0.57	0.64	0.58	0.76	0.58	1.14	0.49	0.60	0.25	0.79	0.70		0.35	0.73	0.57	0.89	0.76	1.60	0.87		0.61														
U	0.1	3.5	3.6	3.0	3.3	3.7	3.5	4.0	2.9	2.5	3.4	4.1	2.3	5.0	1.4	3.6	2.7	4.2	3.3	3.6	4.0	3.4	2.4	4.3	3.7	4.2	3.6	3.1	3.3	3.1	2.6	3.1	3.2	3.0	3.1	3.1	3.7	3.4	3.9	3.8
V	1	60	80	61	81	43	94	63	62	60	85	81	79	81	76	101		73	89	70	89	73	96	104		87														
W	0.1	3.7	1.3	1.3	1.7	1.9	1.6	1.4	2.8	1.7	0.8	2.0	1.4	202.0	3.0	1.4		6.2	3.3	3.2	2.8	1.2	4.5	3.4		1.6														
Y	0.1	23	28	25	25	25	22	29	22	16	45	19	5	23	43	24		33	24	28	30	45	30	32		28														
Zn	2	25	49	51	62	59	124	66	144	148	80	105	55	222	207	53	127	112	75	75	85	78	274	184	115	81	246	76	68	86	83	78	65	131	81	133	173	149	131	47
Zr	0.5	87	64	87	85	46	105	91	81	43	63	71	71	123	106	99		99	89	103	93	108	120	109		96														

< element at or below analytical detection limit.

Table 4: Geochemical abundance indices (GAI) of selected sample solids. Values of 3 or more are highlighted in yellow.

Element	Median Soil Abundance*	**Ore/Waste, Weathering and Sample Number**																																						
		HG	HG	HG	HG	HG	HG	HG	HG	HG	LG	LG	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR
		High	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	High	High	High	High	High/ Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod/ Slight	Mod/ Slight	Slight	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh
		40313	40533	40536	40317	40340	40263	40265	40659	40337	40369	40601	40562	38606	40298	40268	33427	40567	38618	38624	40549	38659	40247	40655	33459	40319	33463	33402	33405	33410	33415	33416	33425	33446	33449	33454	33465	33467	33471	33474
Ag	0.05	4	2	4	1	9	3	4	4	9	4	3	1	3	-	-	-	2	1	3	4	-	-	-	2	4	1	2	-	-	2	2	1	4	4	3	-	-	-	2
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	6	-	-	-	-	3	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	1	2	1	1	-	2	1	1	1	2	1	1	2	2	2	2	1	3	2	2	2	2	3	2	2	3	2	2	2	1	2	2	2	2	2	3	3	2	1
Bi	0.2	7	6	8	5	9	6	4	11	12	9	5	3	3	6	3		4	4	8	4	5	-	4	-	4														
Ca	1.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1		-	-	-	-	-	-	1		-														
Co	8	1	3	3	1	4	1	1	2	3	3	3	-	1	1	1	1	2	2	4	3	2	1	1	1	-	1	3	1	3	4	3	3	4	4	3	1	1	1	1
Cr	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cs	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Cu	30	9	6	7	6	10	6	8	9	11	8	6	-	5	6	2	4	3	2	5	7	3	4	5	4	4	1	5	1	2	5	5	3	7	6	6	-	-	4	5
F	200																1								2		2	2	2	2	1	1	2	2	1	1	2	2	2	1
Fe	4.0%	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1	-	1	1	1	1	1	-	-	-	1	-	1	1	1	1	1	1	1	1	1	-	-	1	1
Ga	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Ge	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Hf	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Hg	0.06	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
In	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
La	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Li	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Mg	0.5%	-	1	1	1	-	1	1	1	1	1	1	-	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mn	1000	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	1	-	-	1	1	1	-	-	-	-	-	-	1	-	-	-	1	1	1	-	1
Mo	1.2	1	1	1	1	2	-	1	1	-	1	-	1	2	-	-	-	1	1	2	-	1	-	-	-	-	-	1	-	2	1	2	1	1	1	1	-	-	1	2
Na	0.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Nb	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Ni	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
S	0.07%	-	-	3	-	3	-	-	-	-	1	3	-	2	-	-	2	1	-	2	-	-	-	-	-	-	2	3	1	3	4	3	3	4	4	4	-	-	-	1
Sb	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sc	7	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-		-	1	-	1	-	1	1		-														
Se	0.4	3	3	2	2	3	2	3	4	5	3	2	1	2	2	1	-	2	2	3	2	2	1	1	-	2	-	-	-	-	1	-	-	3	1	2	-	-	-	-
Sn	4	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	1	-	1	-	1	-	-	1	-
Sr	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Th	9	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ti	0.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Tl	0.2	-	1	1	1	1	1	1	1	1	2	1	1	-	1	1		-	1	1	2	1	2	2		1														
U	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
W	1.5	1	-	-	-	-	-	-	-	-	-	-	-	6	-	-		1	1	1	-	-	1	1		-														
Y	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														
Zn	90	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Zr	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		-														

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 5: Chemical composition of water extracts.

Parameter		Detection Limit	Ore/Waste, Weathering and Sample Number																		
			HG	HG	HG	HG	HG	HG	HG	HG	HG	LG	LG	WR	WR	WR	WR	WR	WR	WR	WR
			High	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	High	High	High	High	High/ Mod	Mod	Mod	Mod
			40313	40533	40536	40317	40340	40263	40265	40659	40337	40369	40601	40562	38606	40298	40268	33427	40567	38618	38624
pH		0.01	7.3	7.5	6.8	7.8	6.9	7.6	7.2	7.9	7.6	7.4	7.2	6.7	6.8	8.8	8.9	8.4	6.6	7.9	6.8
EC	dS/m	0.01	0.15	0.14	0.32	0.11	0.25	0.12	0.28	0.29	0.20	0.19	0.53	0.46	0.20	0.51	0.10	0.15	0.23	0.12	0.39
Alkalinity ($CaCO_3$)	mg/l	1	27	72	18	51	31	30	24	28	41	31	21	18	16	113	75		20	35	15
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.22	2.04	0.14	0.06	1.05	0.05	1.05	0.04	0.49	0.82	0.50	0.24	0.29	0.72	0.64	3.22	0.30	2.28	0.70
As	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.001	0.0007	<0.001	<0.001	<0.001
B	mg/l	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	0.18	<0.05	0.02	0.06	<0.05	<0.05
Ba	mg/l	0.001	0.006	0.012	0.009	<0.001	0.023	0.002	0.013	0.002	0.006	0.007	0.015	0.035	<0.001	0.041	0.003	0.056	0.004	0.015	0.006
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	1	<1	<1	4	<1	4	1	<1	<1	1	1	3	<1	<1	25	<1	18	<1	<1	15
Cd	mg/l	0.0001	<0.0001	<0.0001	0.0006	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	24	4	5	4	6	5	21	8	7	6	4	80	17	12	2	<1	22	8	7
Co	mg/l	0.001	0.002	0.007	0.134	<0.001	0.085	<0.001	0.001	<0.001	<0.001	0.003	0.01	<0.001	<0.001	<0.001	<0.001	0.004	0.001	0.009	0.057
Cr	mg/l	0.001	<0.001	0.004	<0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001	0.002	<0.001	0.001	<0.001	0.002	<0.001	0.010	0.001	0.005	0.002
Cu	mg/l	0.001	0.47	0.33	0.51	0.04	1.33	0.01	0.91	0.05	1.66	0.38	0.07	0.01	0.02	0.06	0.01	0.10	0.02	0.05	0.04
F	mg/l	0.1	0.9	1.6	0.5	1.0	0.7	1.7	0.7	1.9	1.5	1.9	1.2	0.2	0.3	1.7	0.8	0.3	0.5	1.3	0.7
Fe	mg/l	0.05	0.16	3.28	0.20	0.06	1.64	<0.05	1.70	<0.05	0.74	1.35	0.78	0.30	0.41	0.67	0.58	3.79	0.40	3.57	1.06
Hg	mg/l	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	8	31	46	28	38	16	60	59	39	39	94	29	2	22	29	23	24	29	41
Mg	mg/l	1	<1	2	10	<1	8	<1	8	2	3	2	17	3	2	18	<1	5	7	2	15
Mn	mg/l	0.001	0.060	0.074	0.256	0.015	0.457	0.004	0.063	0.007	0.028	0.022	0.022	0.008	0.011	0.018	0.012	0.060	0.093	0.075	1.850
Mo	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001
Na	mg/l	1	27	12	10	7	9	9	5	9	6	10	12	38	32	35	6	7	17	5	12
Ni	mg/l	0.001	<0.001	0.002	0.037	<0.001	0.006	<0.001	0.001	<0.001	<0.001	0.002	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.010
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	<0.001	<0.001	<0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<	<0.01	<0.01	<0.01
Si	mg/l	0.05	2.4	0.9	1.7	1.2	1.8	1.1	1.2	2.0	1.4	1.7	1.3	3.2	2.2	7.1	0.9	5.3	1.5	1.2	1.6
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO4	mg/l	1	<1	2	100	4	58	2	56	86	37	30	186	55	40	81	4	26	39	29	120
Sr	mg/l	0.001	0.009	0.007	0.034	0.002	0.077	0.003	0.009	0.006	0.012	0.013	0.055	0.013	<0.001	0.165	0.002	0.080	0.012	0.007	0.166
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Zn	mg/l	0.005	<0.005	<0.005	0.011	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.007	<0.005	<0.005	0.008	0.010	0.006	0.006	0.008

Parameter		Detection Limit																				
			WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR	WR
			Mod	Mod	Mod	Mod	Mod/ Slight	Mod/ Slight	Slight	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh
			40549	38659	40247	40655	33459	40319	33463	33402	33405	33410	33415	33416	33425	33446	33449	33454	33465	33467	33471	33474
pH		0.01	8.5	8.6	9.0	8.6	7.2	8.2	7.6	7.5	8.1	5.4	5.2	5.3	4.5	3.6	4.9	5.1	7.5	8.1	6.7	7.9
EC	dS/m	0.01	0.14	0.09	0.11	0.08	0.12	0.13	0.12	0.12	0.12	1.52	1.12	1.11	1.88	2.88	1.29	1.55	0.13	0.18	0.13	0.16
Alkalinity ($CaCO_3$)	mg/l	1	60	42	54	55		42														
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	5.14	0.78	0.24	0.24	9.65	0.11	2.59	3.00	6.82	0.74	9.80	1.68	4.21	0.98	0.30	9.47	18.58	14.75	20.27	0.88
As	mg/l	0.001	<0.001	0.001	0.002	0.002	0.0002	0.001	0.0016	0.0006	0.0005	0.0002	0.0005	0.0002	0.0007	0.0008	0.0024	0.0003	0.0006	0.0010	0.0024	0.0012
B	mg/l	0.05	<0.05	<0.05	<0.05	<0.05	0.02	<0.05	0.02	0.03	0.04	0.03	0.01	0.02	<	0.01	<	<	0.02	0.02	<	0.01
Ba	mg/l	0.001	0.036	0.005	0.001	0.001	0.047	0.001	0.048	0.024	0.040	0.035	0.047	0.074	0.023	0.003	0.008	0.041	0.161	0.125	0.130	0.005
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.002	0.002	0.002	<0.001
Ca	mg/l	1	<1	3	3	<1	1	<1	5	1	1	2	1	3	1	2	2	<1	1	1	1	1
Cd	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	0.0011	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	1	4	7	6	3	3	4	3	4	<1	5	8	4	5	<1	3	3	<1	2	<1	3
Co	mg/l	0.001	0.017	0.006	<0.001	<0.001	0.005	<0.001	0.002	0.007	0.004	0.093	0.026	0.031	0.006	1.578	0.119	0.033	0.010	0.008	0.012	0.001
Cr	mg/l	0.001	0.010	0.001	<0.001	<0.001	0.030	0.001	0.020	0.010	0.020	0.010	0.030	0.010	0.010	0.010	<0.001	0.020	0.050	0.040	0.040	<0.001
Cu	mg/l	0.001	1.99	0.03	0.01	0.01	0.60	0.02	0.03	0.08	0.03	0.01	0.24	0.08	0.04	3.68	0.05	0.27	0.06	0.04	0.29	0.03
F	mg/l	0.1	1.6	1.3	1.0	1.3	0.2	0.9	0.3	0.1	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.5
Fe	mg/l	0.05	8.52	0.96	0.06	0.21	13.66	0.10	2.51	5.01	10.42	1.44	21.05	3.81	7.76	7.49	0.68	17.12	21.71	19.26	31.61	1.48
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	47	27	26	12	21	34	53	64	30	74	78	106	66	1	72	93	22	17	33	35
Mg	mg/l	1	3	4	4	<1	4	<1	10	5	3	17	11	44	4	59	16	10	10	7	8	2
Mn	mg/l	0.001	0.180	0.107	0.059	0.009	0.200	0.006	0.100	0.020	0.030	0.130	0.060	0.250	0.030	2.200	0.130	0.040	0.210	0.130	0.060	<0.001
Mo	mg/l	0.001	<0.001	0.003	0.001	<0.001	<0.001	0.002	0.001	0.001	<	<0.001	<0.001	<0.001	0.001	<	<0.001	<0.001	<	<	<	0.007
Na	mg/l	1	5	12	11	10	6	6	14	7	5	6	6	10	6	1	5	4	8	8	6	4
Ni	mg/l	0.001	0.004	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.040	0.010	0.040	0.010	0.720	0.030	<0.001	0.030	0.020	0.020	<0.001
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	0.004	<0.001	<0.001	<0.001	0.002	<0.001	0.021	0.002	0.002	0.002	0.013	0.003	0.002	0.005	0.002	0.003	0.007	0.003	0.004	0.001
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Se	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<	<0.01	0.005	0.001	<	<	0.001	0.001	<	0.004	0.002	0.001	<	<	0.001	0.002
Si	mg/l	0.05	0.9	2.6	1.4	1.1	11.3	0.8	4.2	5.3	8.5	3.0	13.2	4.0	6.1	2.6	1.7	12.1	22.5	18.1	23.8	2.4
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0003	<0.001	<0.001	<0.001	<0.001
SO4	mg/l	1	26	28	26	4	9	20	120	89	23	171	120	311	72	231	153	127	4	2	16	42
Sr	mg/l	0.001	0.011	0.032	0.019	<0.001	0.007	0.002	0.022	0.007	0.003	0.008	0.008	0.017	0.004	0.002	0.007	0.003	0.005	0.004	0.004	0.002
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001		<0.001														
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001		<0.001														
Zn	mg/l	0.005	0.013	<0.005	<0.005	0.006	0.020	0.006	0.010	0.010	0.010	<	0.020	<	<	0.650	0.020	0.030	0.090	0.060	0.100	<

< element at or below analytical detection limit.

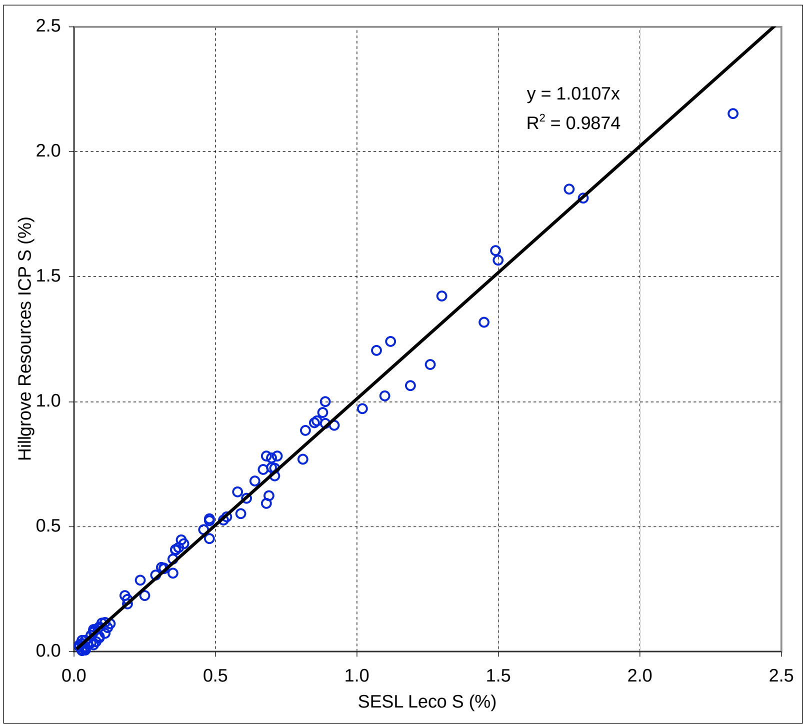


Figure 1: Compares SESL Leco S with Hillgrove Resources ICP S.

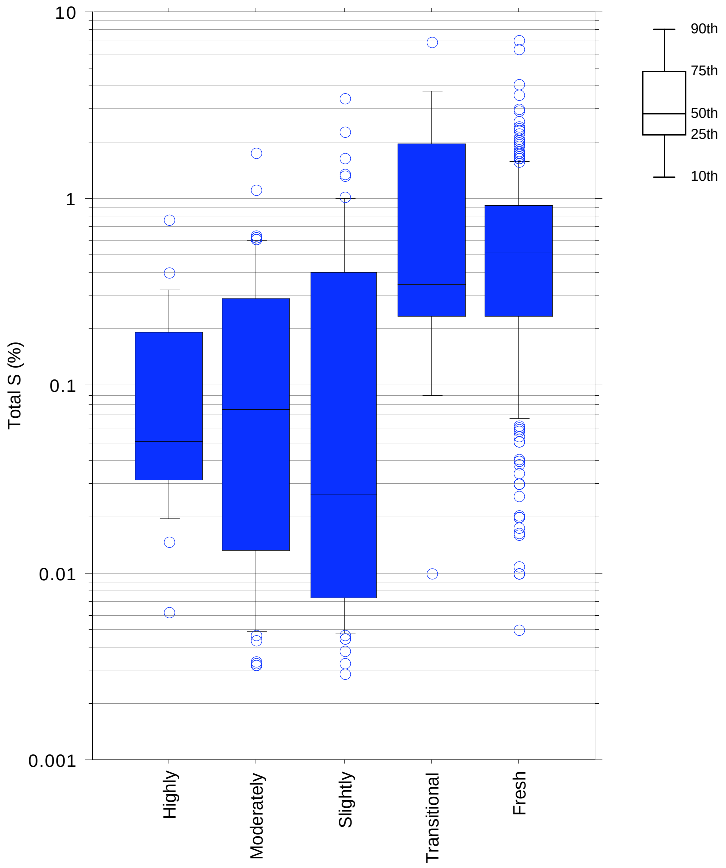


Figure 2: Box plot showing the distribution of total S split by the degree of weathering. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

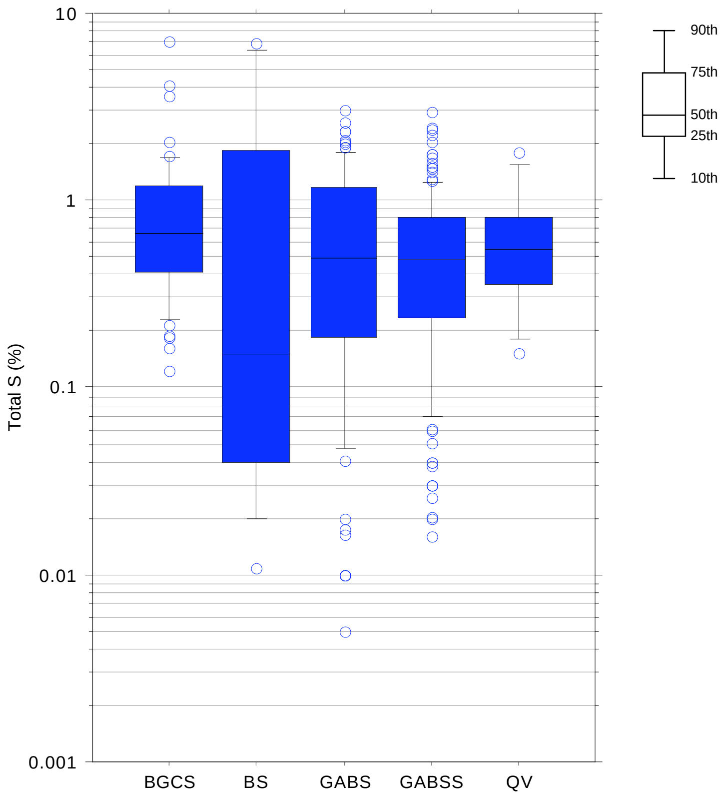


Figure 3: Box plot showing the distribution of total S split by lithology (see Table 1 for lithology codes), excluding slightly to highly weathered samples. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

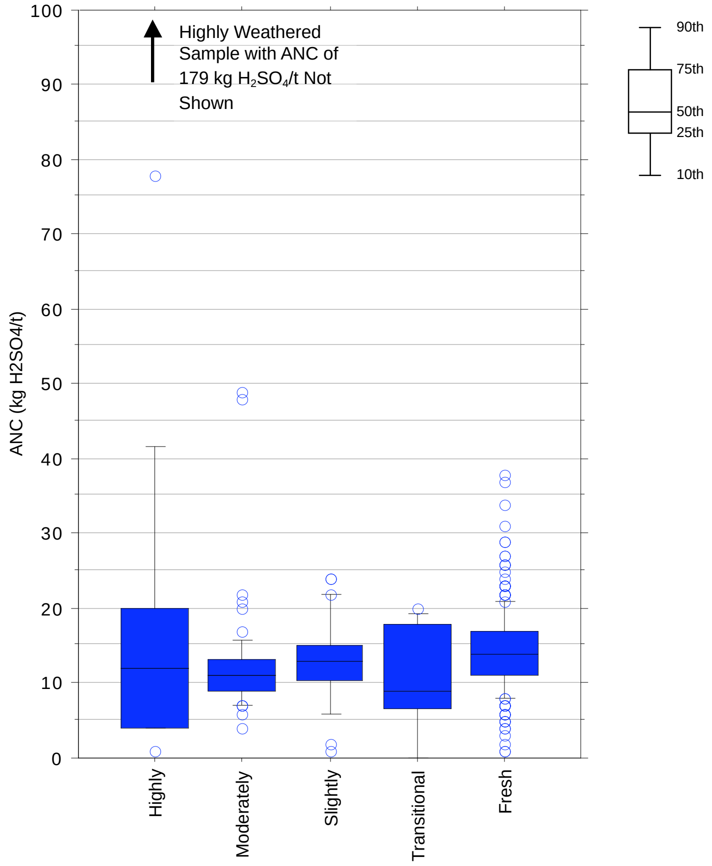


Figure 4: Box plot showing the distribution of ANC split by the degree of weathering. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

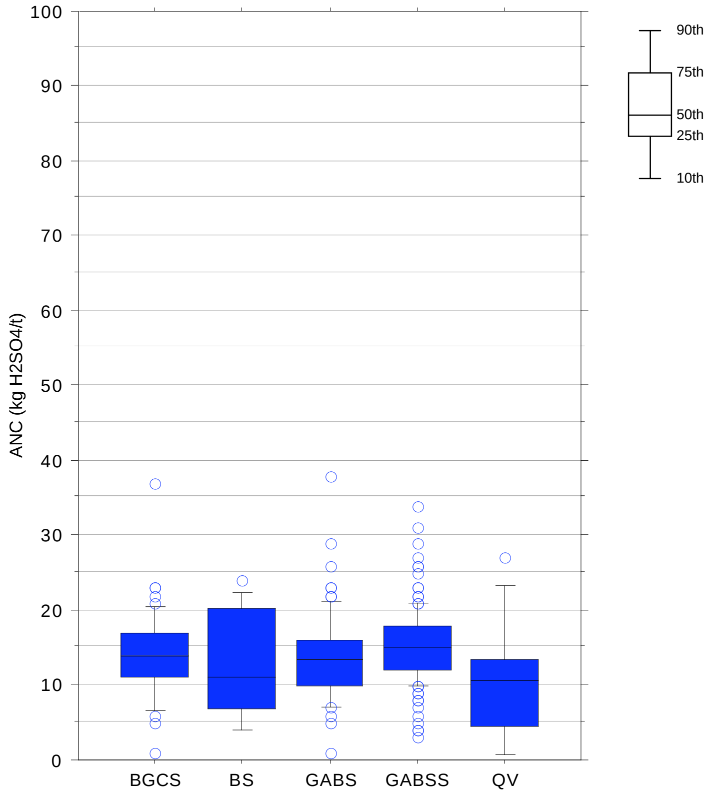


Figure 5: Box plot showing the distribution of total S split by lithology (see Table 1 for lithology codes), excluding slightly to highly weathered samples. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

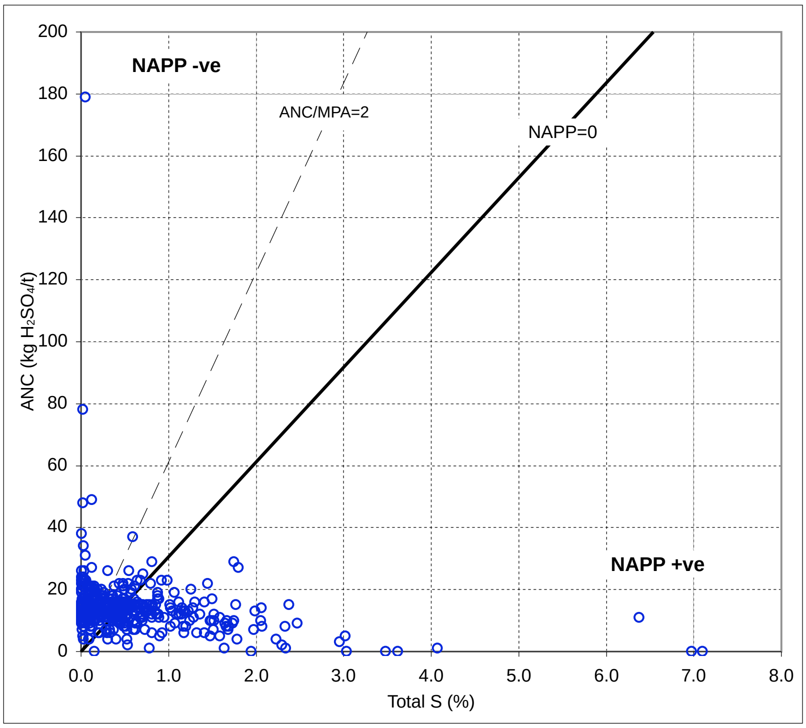


Figure 6: Acid-base account (ABA) plot showing ANC versus total S.

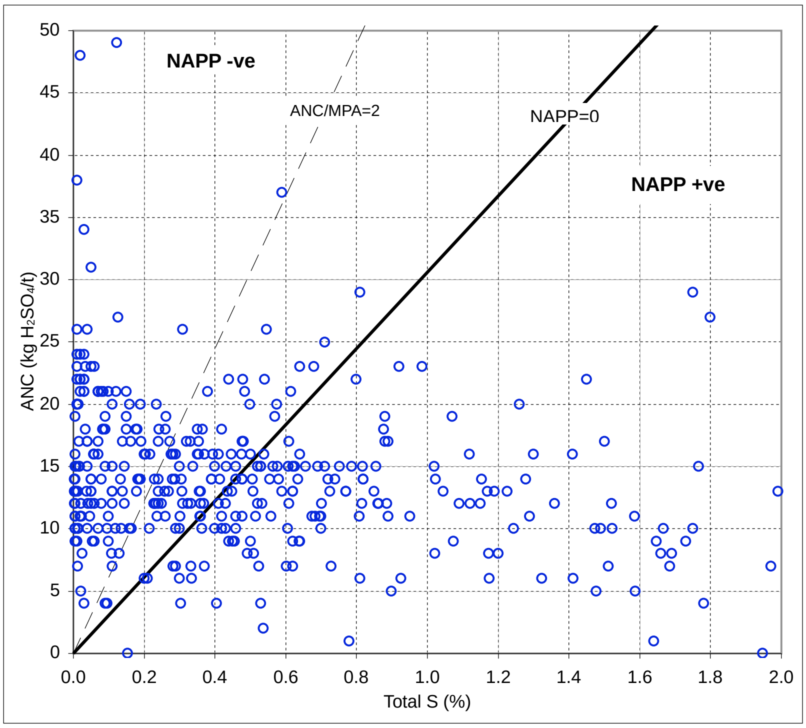


Figure 7: As for Figure 6 but rescaled.

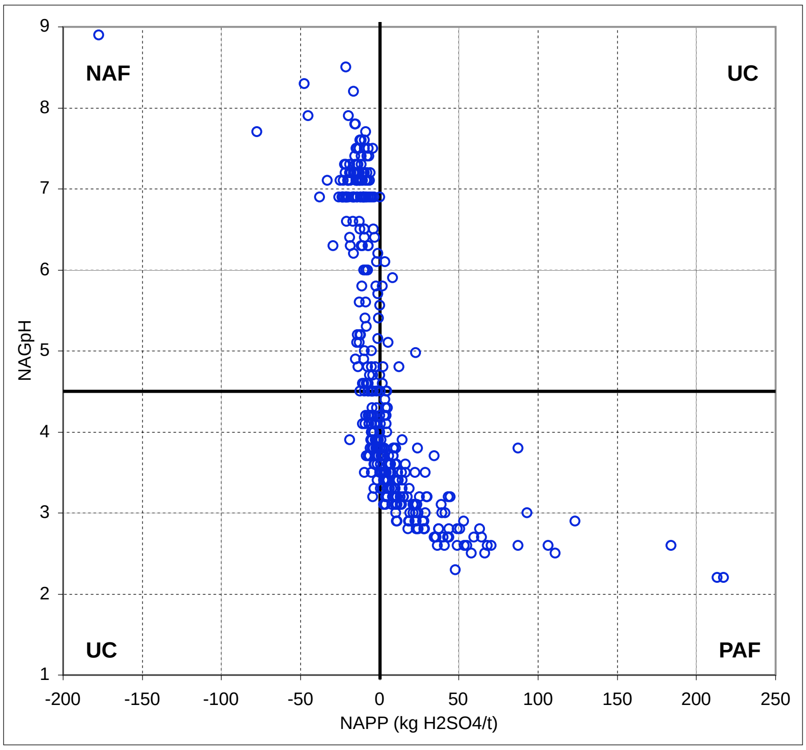


Figure 8: ARD classification plot showing NAGpH versus NAPP, with ARD classification domains indicated.

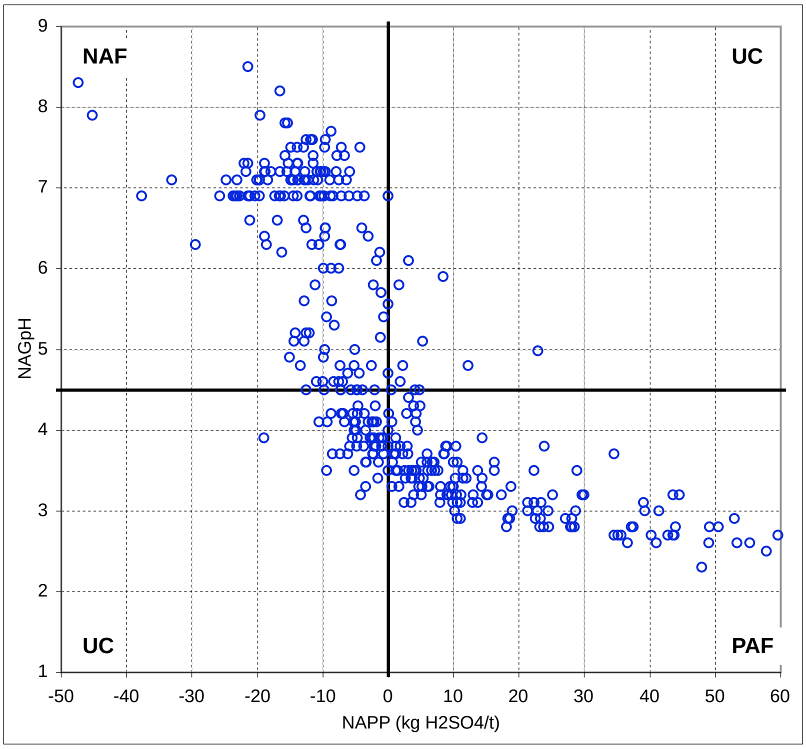


Figure 9: As for Figure 8 but rescaled.

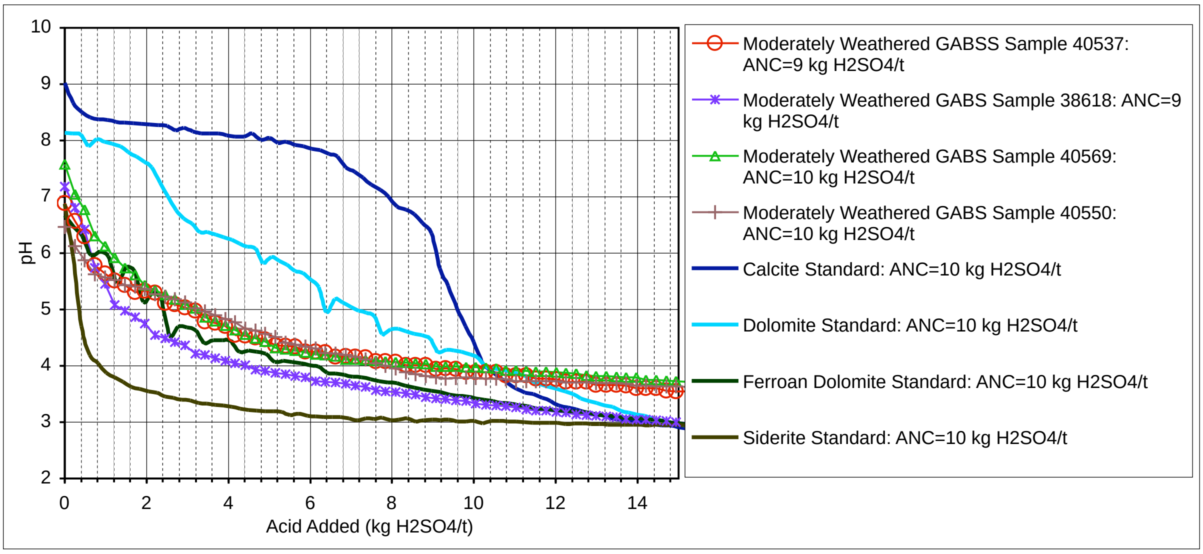


Figure 10: ABCC profile for samples with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

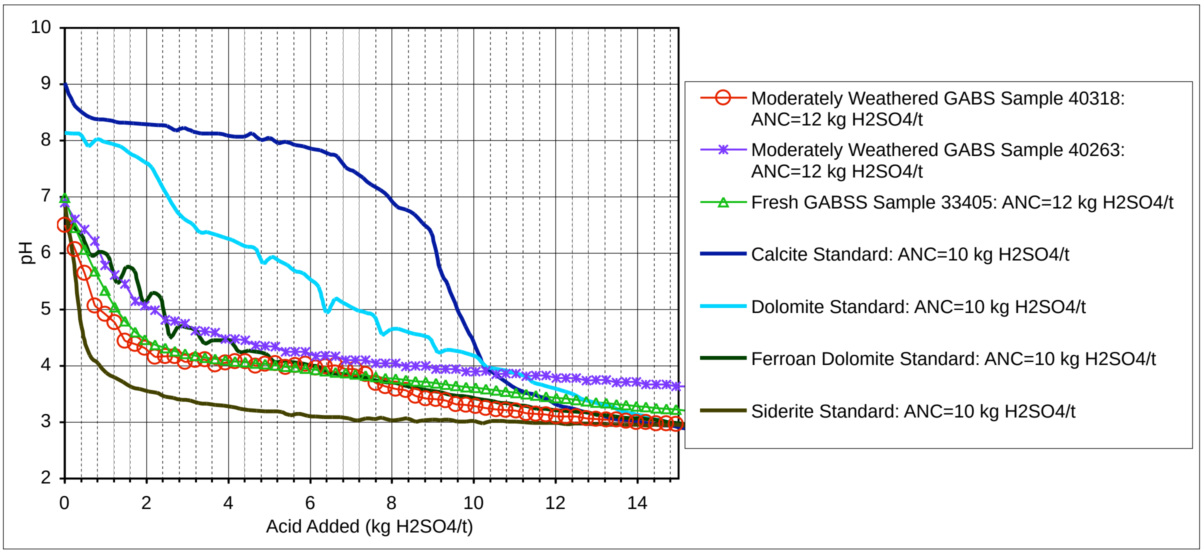


Figure 11: ABCC profile for additional samples with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

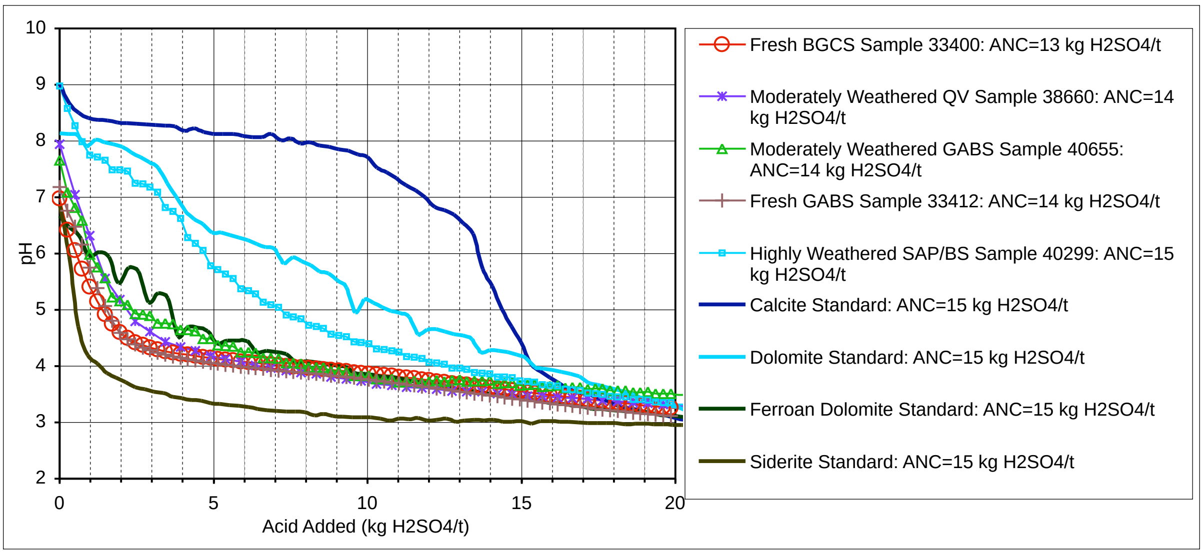


Figure 12: ABCC profile for samples with an ANC value close to 15 kg H_2SO_4/t. Carbonate standard curves are included for reference.

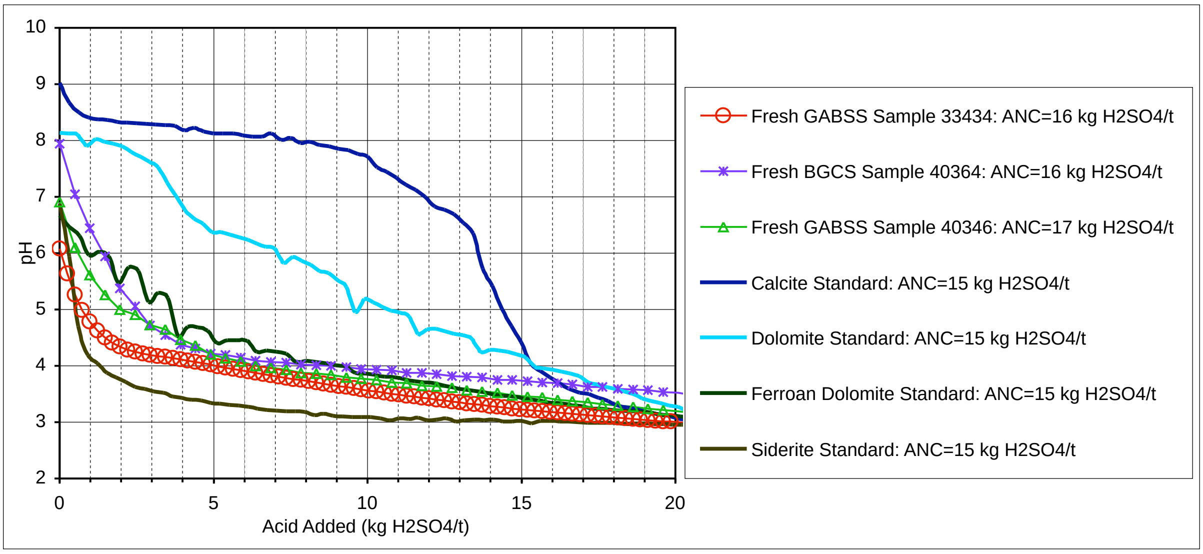


Figure 13: ABCC profile for additional samples with an ANC value close to 15 kg H_2SO_4/t. Carbonate standard curves are included for reference.

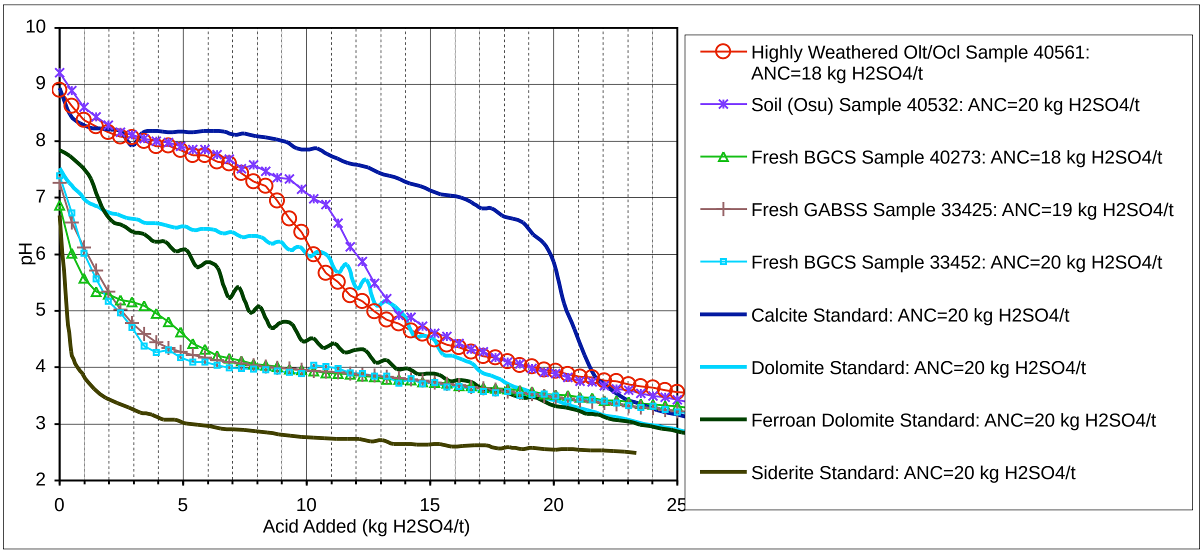


Figure 14: ABCC profile for samples with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

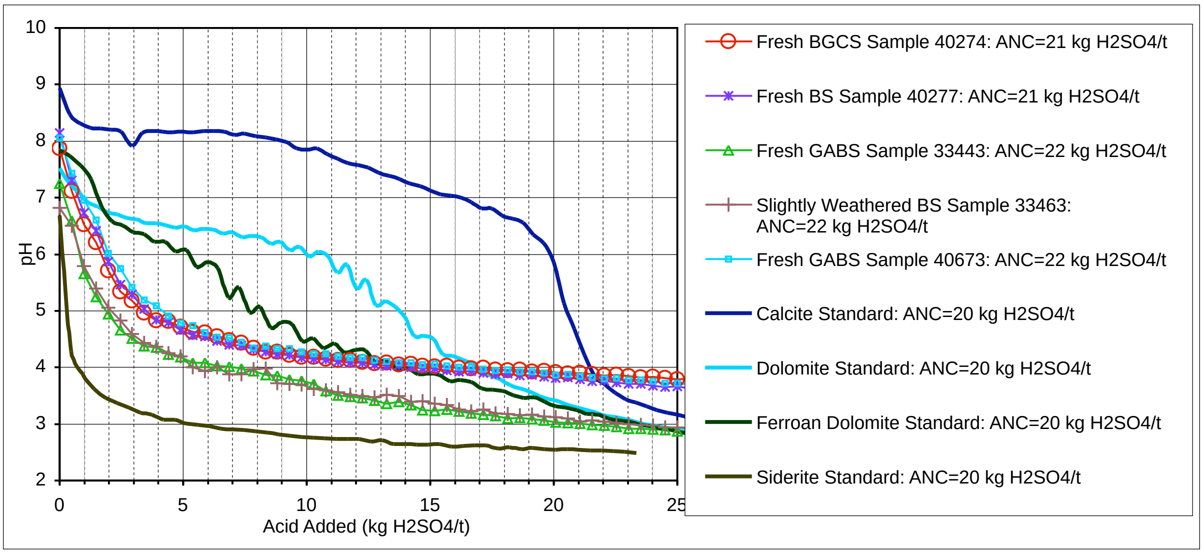


Figure 15: ABCC profile for additional samples with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

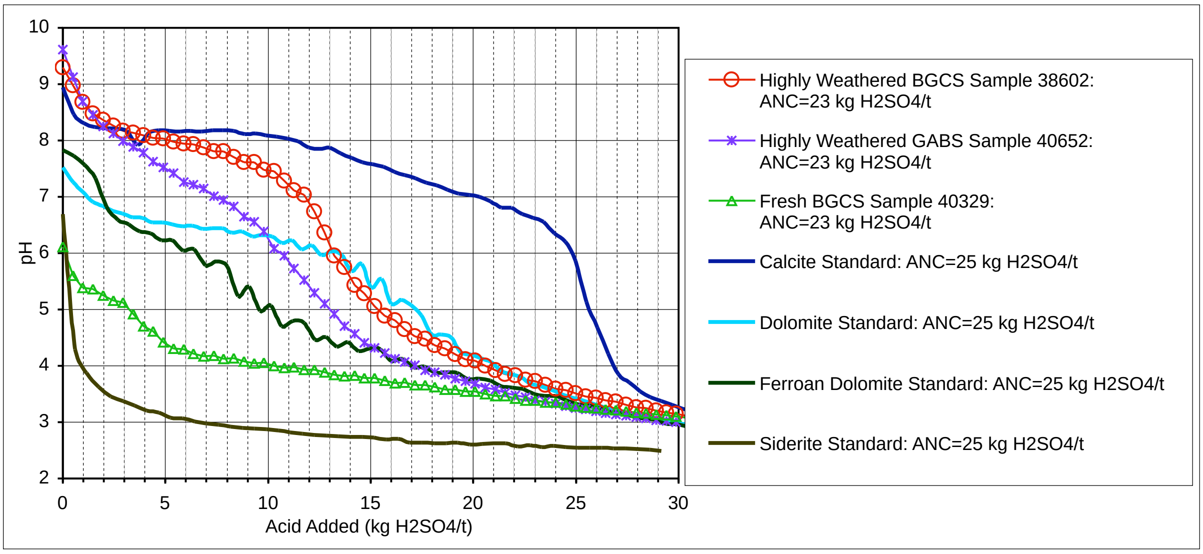


Figure 16: ABCC profile for samples with an ANC value close to 25 kg H_2SO_4/t. Carbonate standard curves are included for reference.

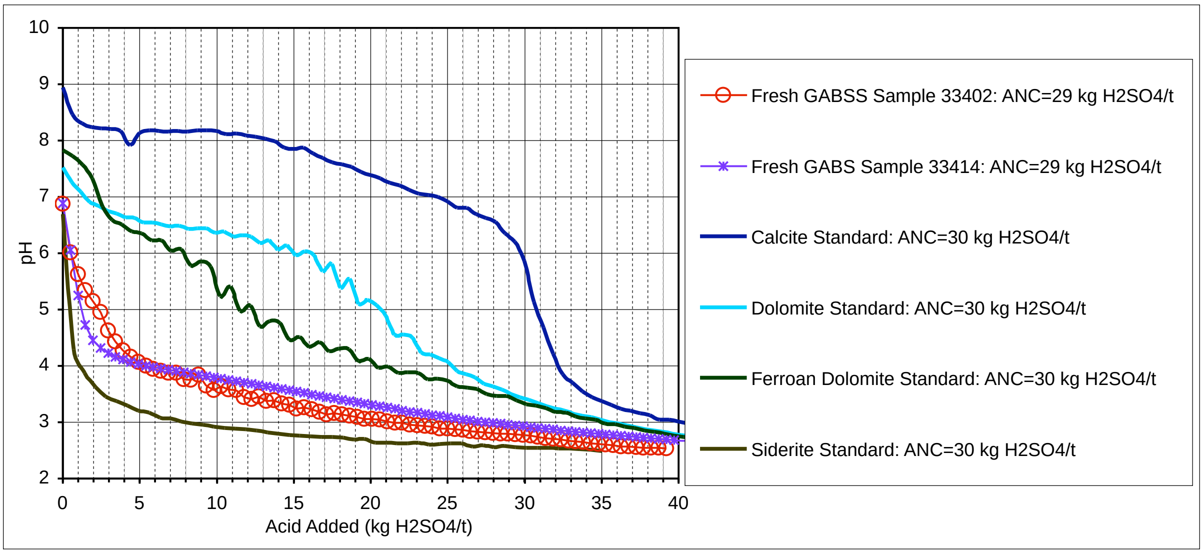


Figure 17: ABCC profile for samples with an ANC value close to 30 kg H_2SO_4/t. Carbonate standard curves are included for reference.

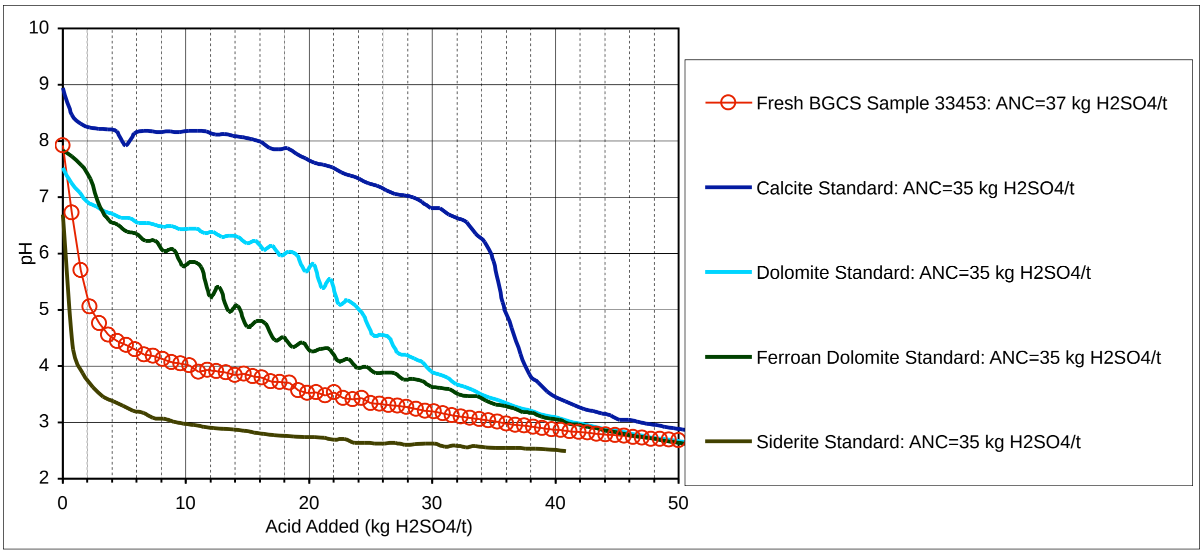


Figure 18: ABCC profile for sample 33453 with an ANC value close to 35 kg H_2SO_4/t. Carbonate standard curves are included for reference.

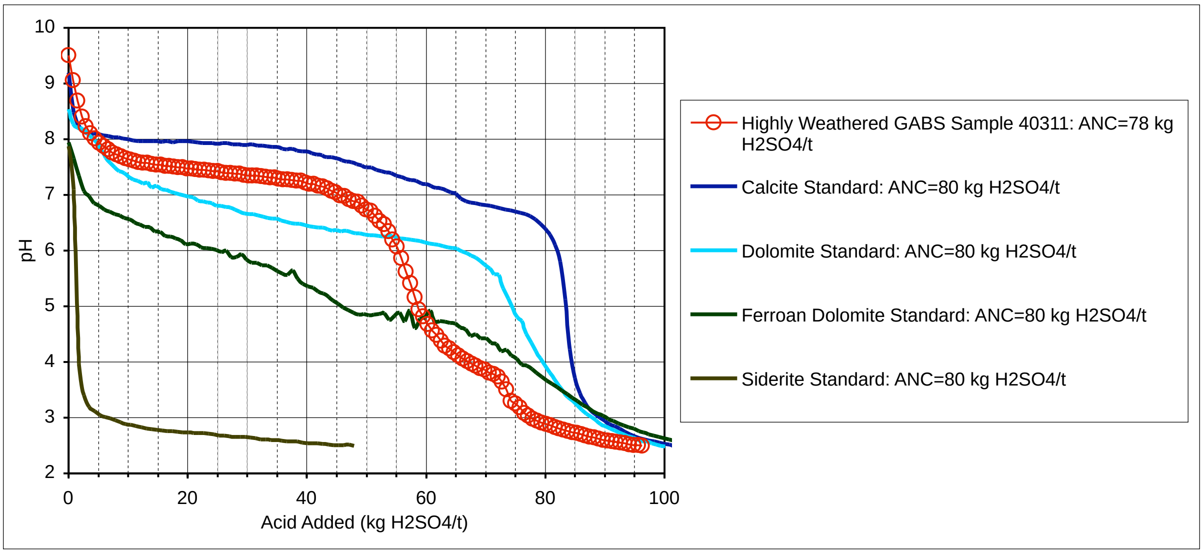


Figure 19: ABCC profile for sample 40311 with an ANC value close to 80 kg H_2SO_4/t. Carbonate standard curves are included for reference.

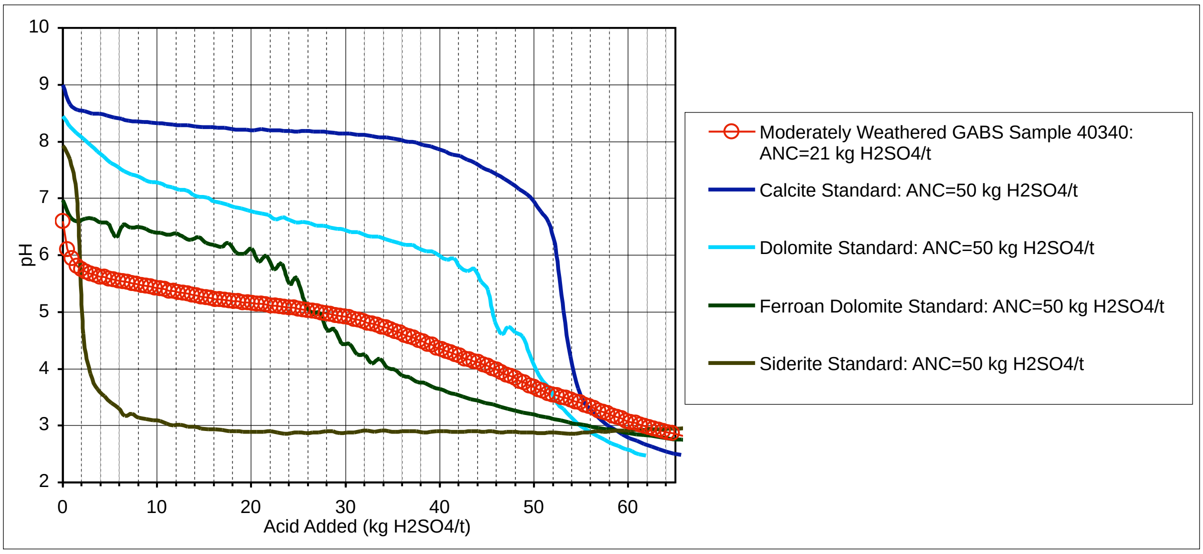


Figure 20: ABCC profile for sample 40340 with an ANC value of 21 kg H_2SO_4/t. Carbonate standard curves are included for reference. Note that the sample profile is affected by dissolution of hydrated Cu carbonates (malachite and azurite).

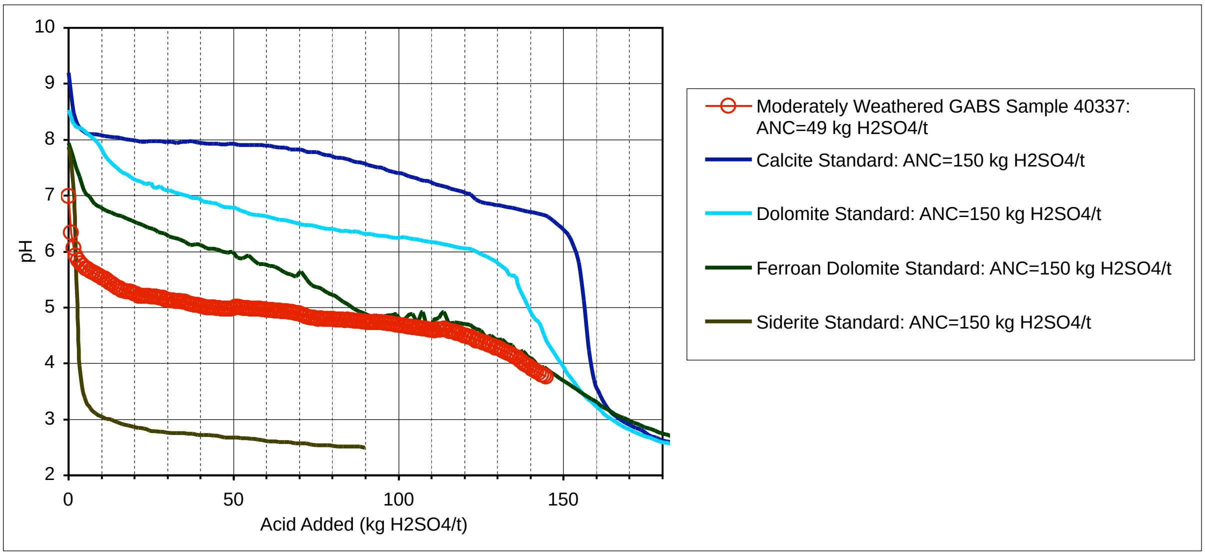
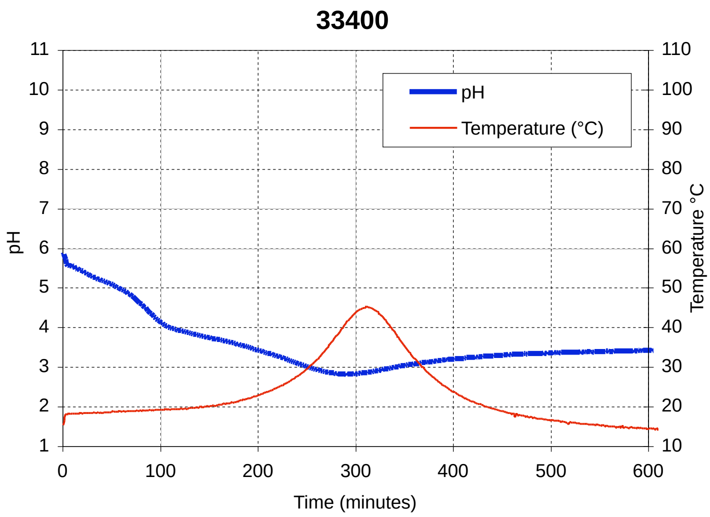
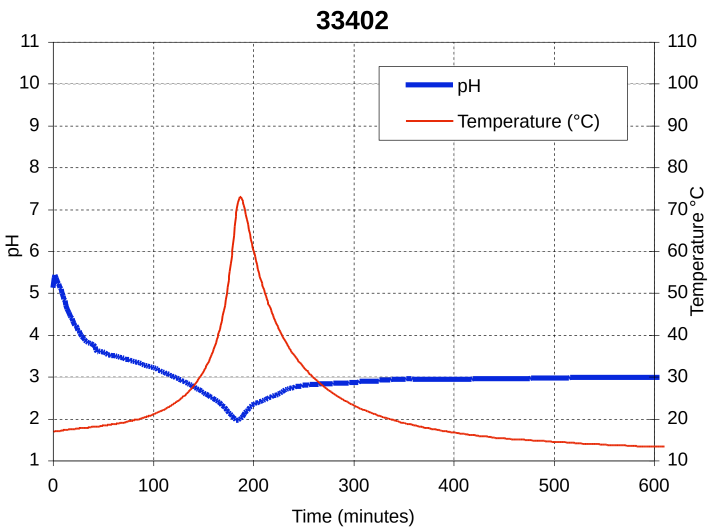


Figure 21: ABCC profile for sample 40337 with an ANC value of 49 kg H_2SO_4/t. Carbonate standard curves are included for reference. Note that the sample profile is affected by dissolution of hydrated Cu carbonates (malachite and azurite).



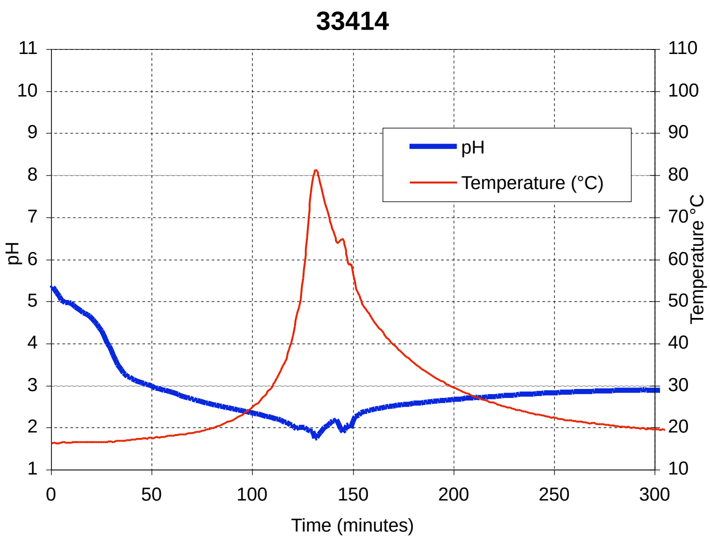
Sample Characteristics
%S = 0.85
ANC = 13 kg H2SO4/t
NAPP = 13 kg H2SO4/t
NAGpH = 3.2

Figure 22: Kinetic NAG graph for sample 33400.



Sample Characteristics
%S = 0.81
ANC = 29 kg H2SO4/t
NAPP = -4 kg H2SO4/t
NAGpH = 3.2

Figure 23: Kinetic NAG graph for sample 33402.



Sample Characteristics
%S = 1.75
ANC = 29 kg H2SO4/t
NAPP = 25 kg H2SO4/t
NAGpH = 2.8

Figure 24: Kinetic NAG graph for sample 33414.

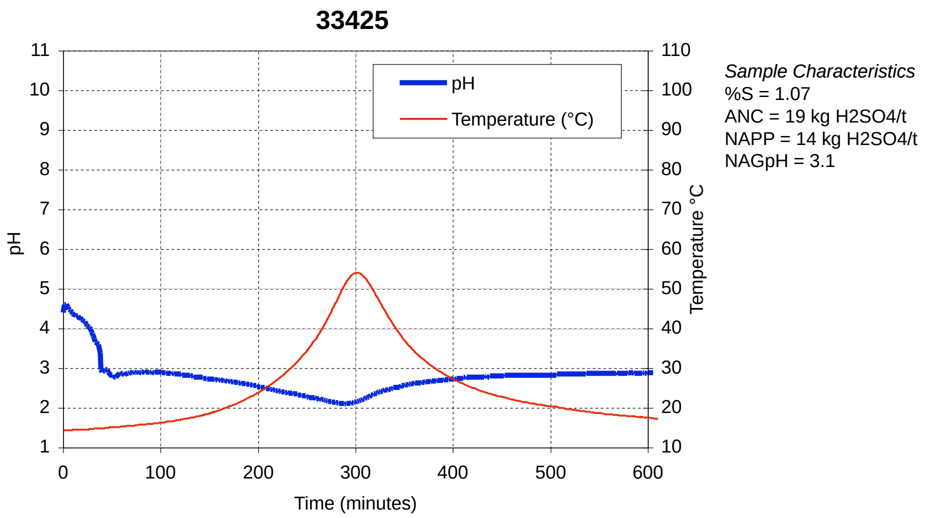


Figure 25: Kinetic NAG graph for sample 33425.

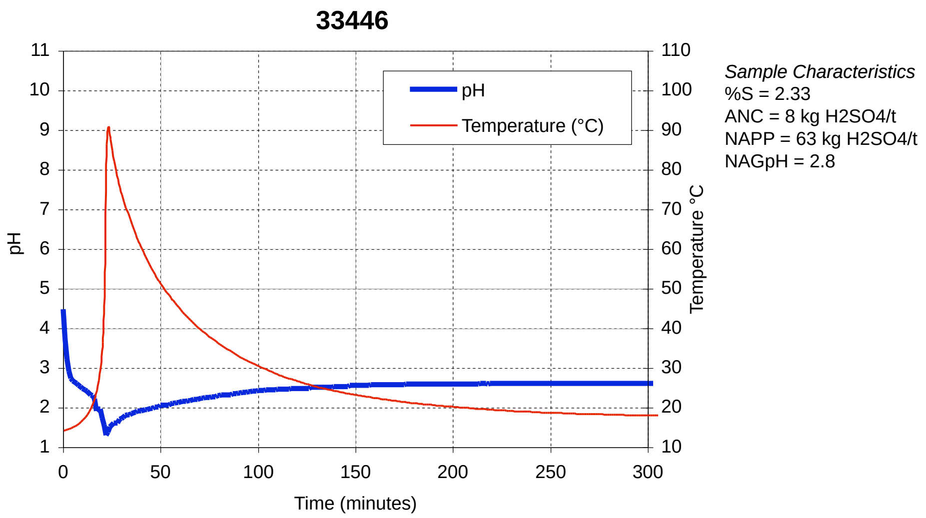


Figure 26: Kinetic NAG graph for sample 33446.

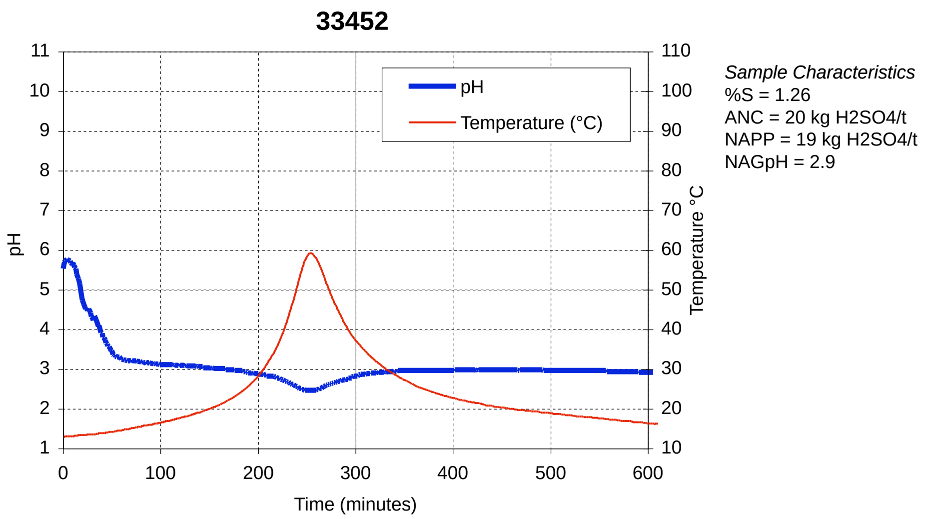
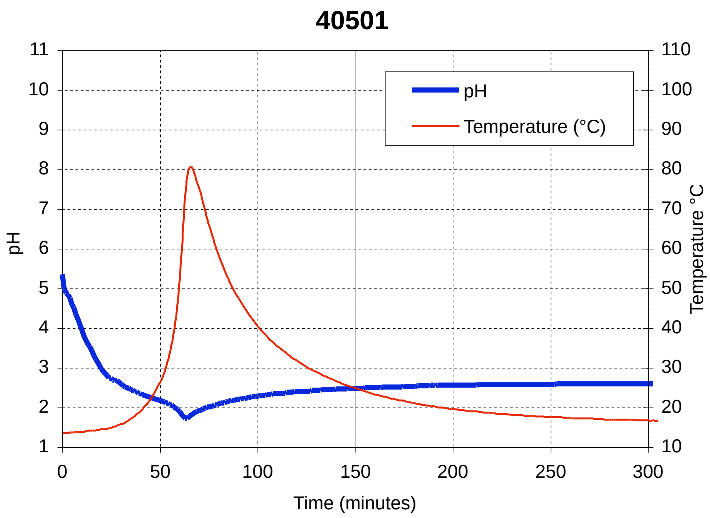
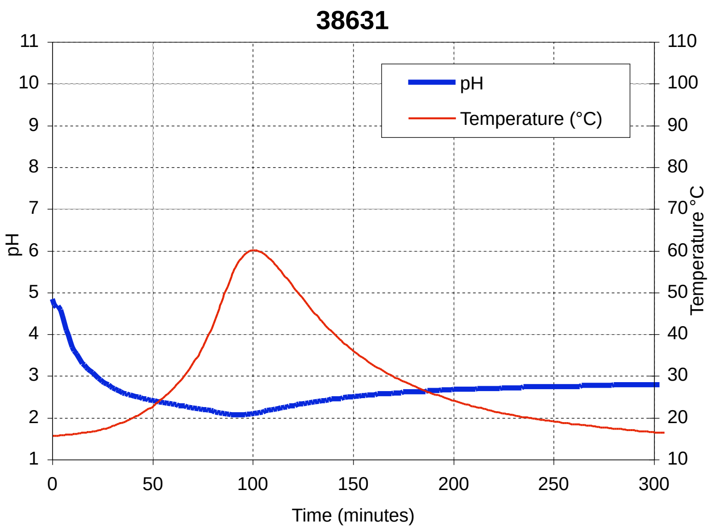


Figure 27: Kinetic NAG graph for sample 33452.



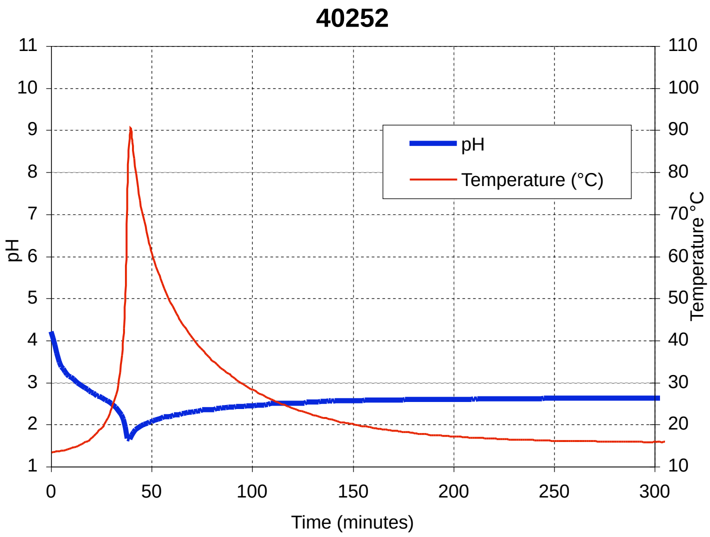
Sample Characteristics
%S = 1.52
ANC = 10 kg H2SO4/t
NAPP = 37 kg H2SO4/t
NAGpH = 2.6

Figure 28: Kinetic NAG graph for sample 40501.



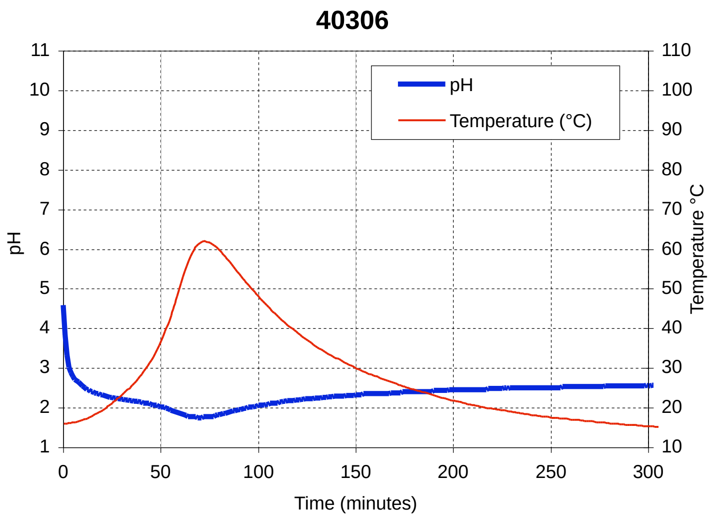
Sample Characteristics
%S = 1.02
ANC = 8 kg H2SO4/t
NAPP = 23 kg H2SO4/t
NAGpH = 2.9

Figure 29: Kinetic NAG graph for sample 38631.



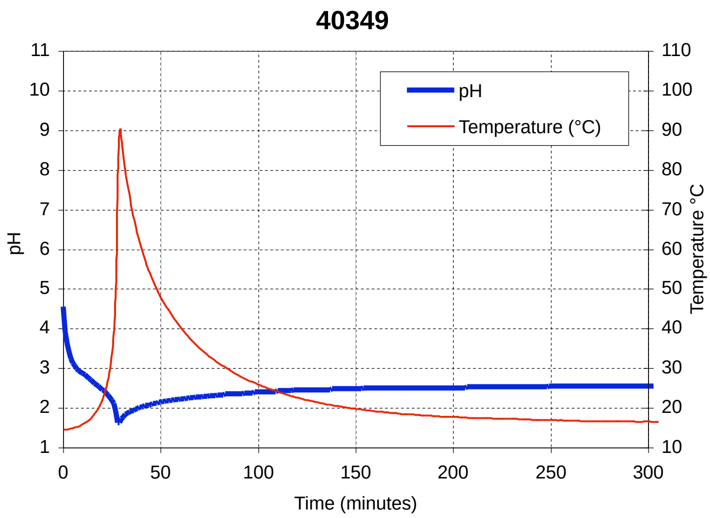
Sample Characteristics
%S = 1.48
ANC = 5 kg H2SO4/t
NAPP = 40 kg H2SO4/t
NAGpH = 2.7

Figure 30: Kinetic NAG graph for sample 40252.



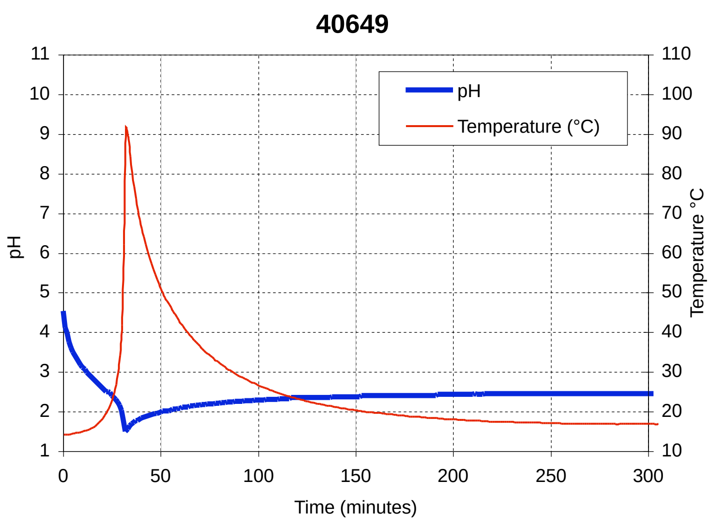
Sample Characteristics
%S = 1.47
ANC = 10 kg H2SO4/t
NAPP = 35 kg H2SO4/t
NAGpH = 2.7

Figure 31: Kinetic NAG graph for sample 40306.



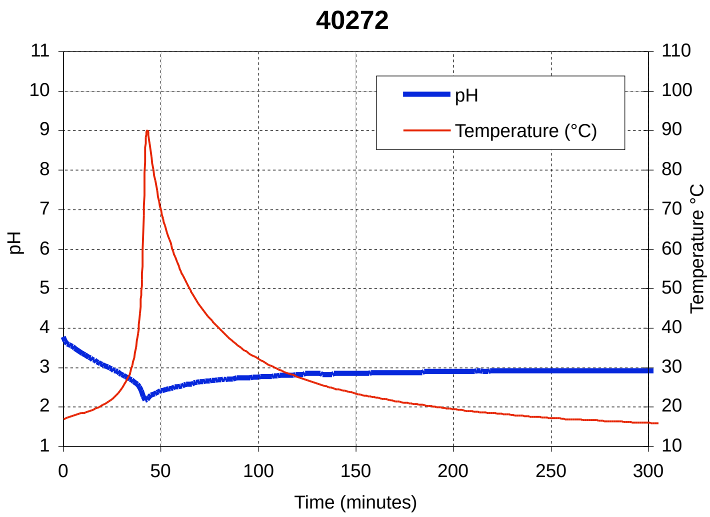
Sample Characteristics
%S = 1.59
ANC = 11 kg H2SO4/t
NAPP = 38 kg H2SO4/t
NAGpH = 2.8

Figure 32: Kinetic NAG graph for sample 40349.



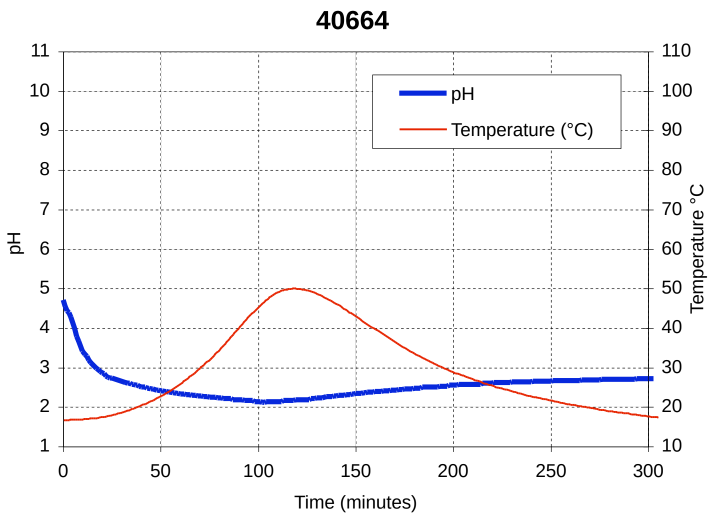
Sample Characteristics
%S = 2.47
ANC = 9 kg H2SO4/t
NAPP = 67 kg H2SO4/t
NAGpH = 2.5

Figure 33: Kinetic NAG graph for sample 40649.



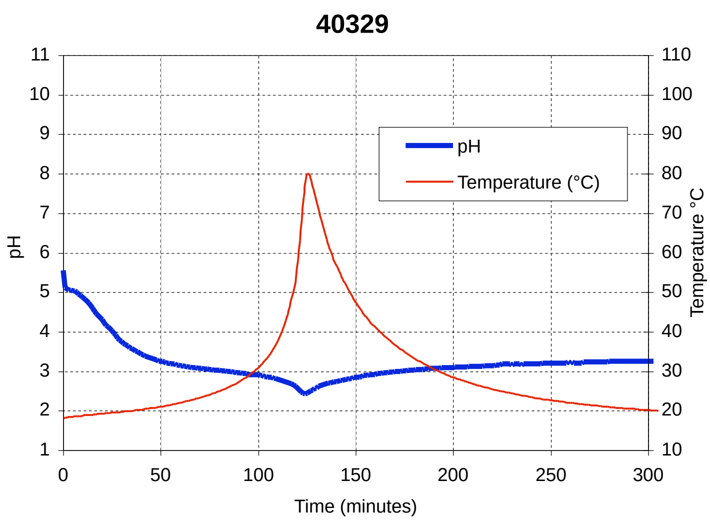
Sample Characteristics
%S = 1.59
ANC = 5 kg H2SO4/t
NAPP = 44 kg H2SO4/t
NAGpH = 3.2

Figure 34: Kinetic NAG graph for sample 40272.



Sample Characteristics
%S = 1.29
ANC = 11 kg H2SO4/t
NAPP = 28 kg H2SO4/t
NAGpH = 2.8

Figure 35: Kinetic NAG graph for sample 40664.



Sample Characteristics
%S = 0.99
ANC = 23 kg H2SO4/t
NAPP = 7 kg H2SO4/t
NAGpH = 3.5

Figure 36: Kinetic NAG graph for sample 40329.

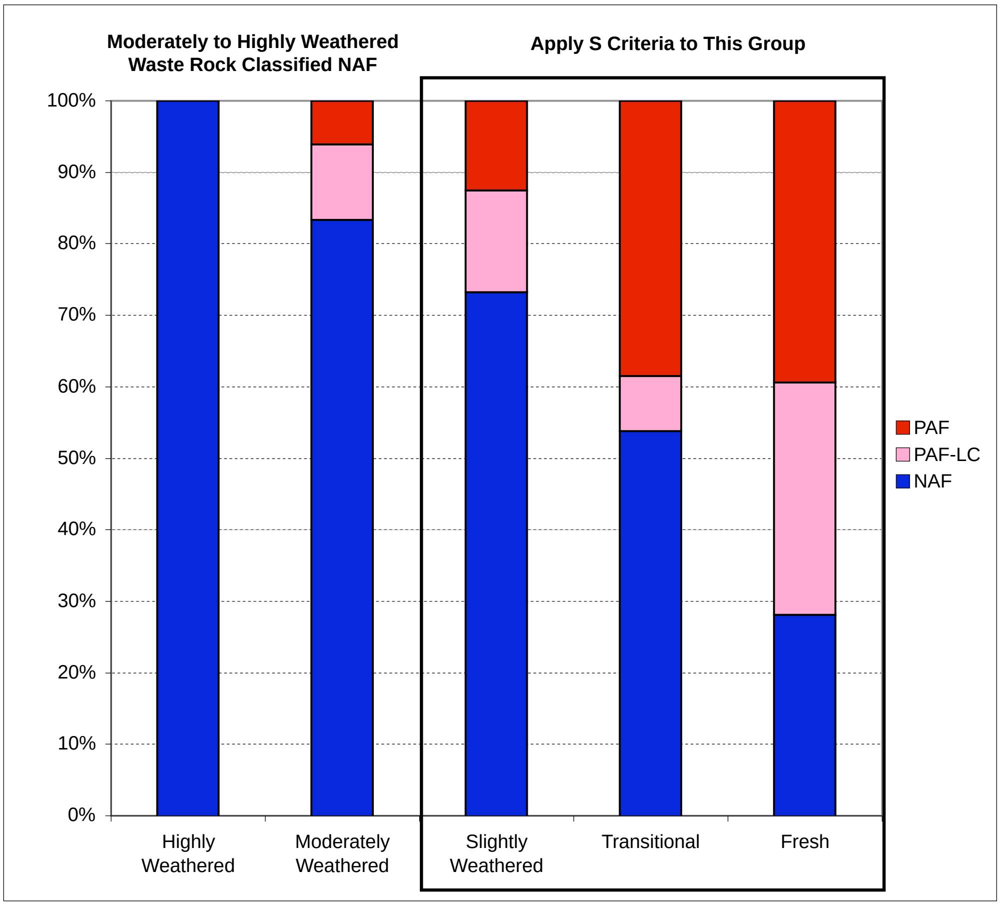


Figure 37: Proportion of ARD classification types by degree of weathering.

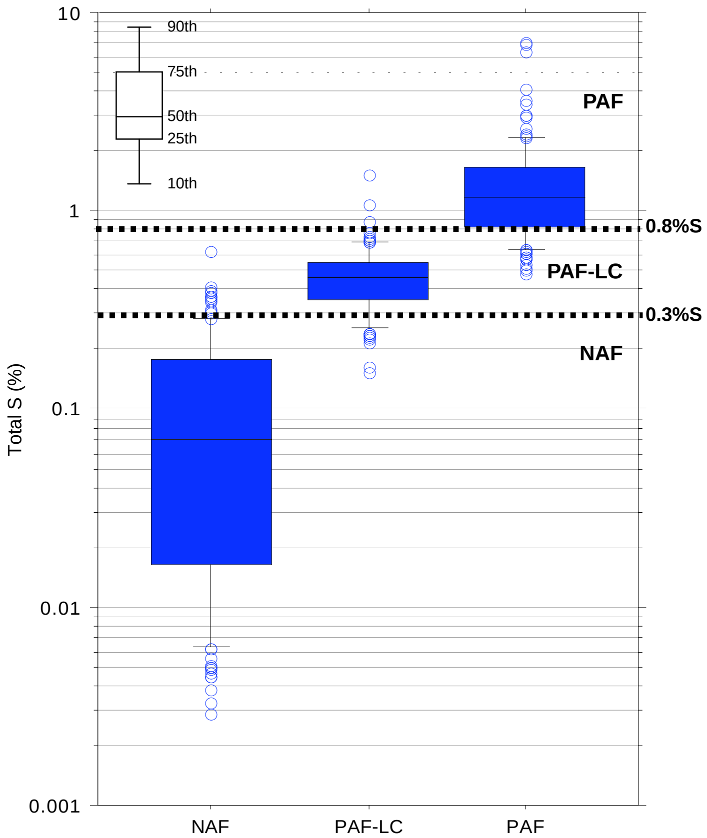


Figure 38: Box plot showing the distribution of total S by ARD classification for slightly weathered, transition and fresh samples only. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

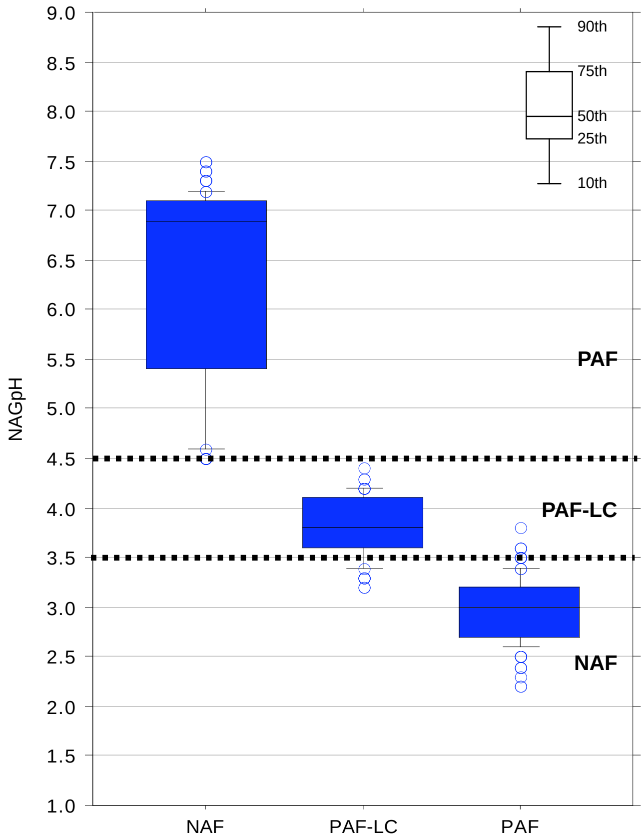


Figure 39: Box plot showing the distribution of NAGpH by ARD classification for slightly weathered, transition and fresh samples only. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

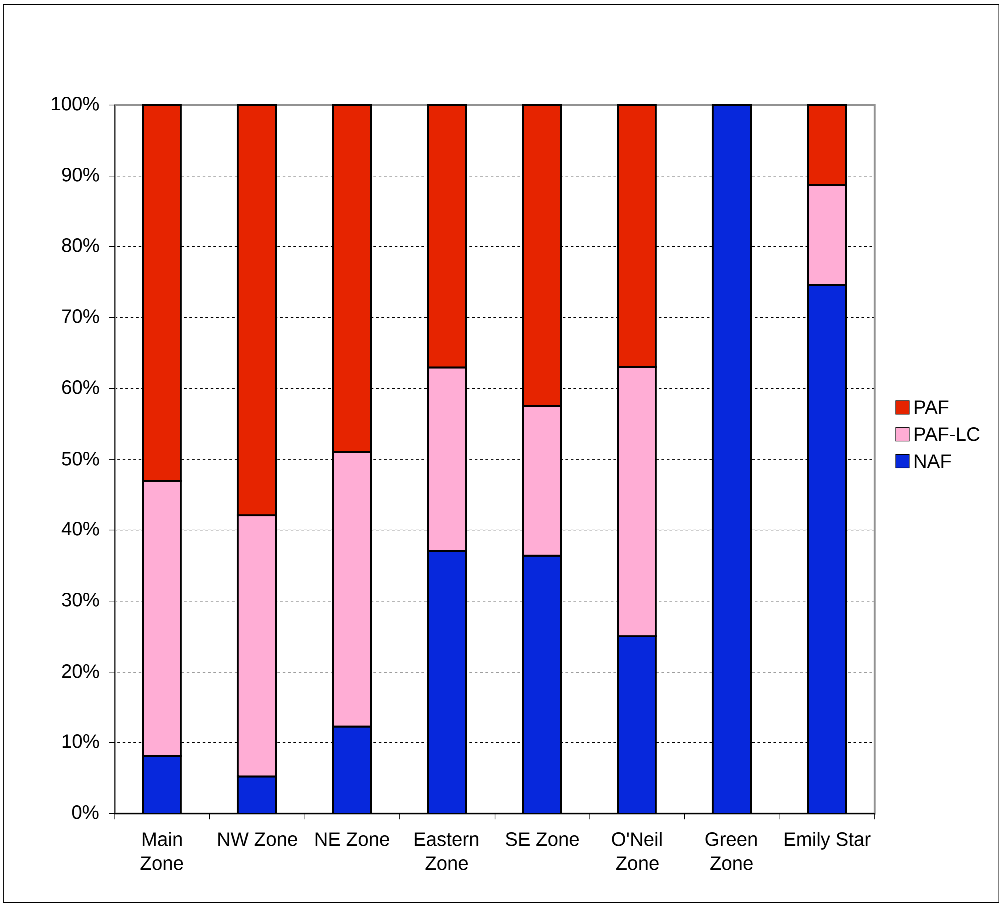


Figure 40: Proportion of ARD classification types by mineralisation zone for slightly weathered, transition and fresh samples only.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

$$\text{MPA (kg } H_2SO_4/t) = (\text{Total \%S}) \times 30.6$$

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

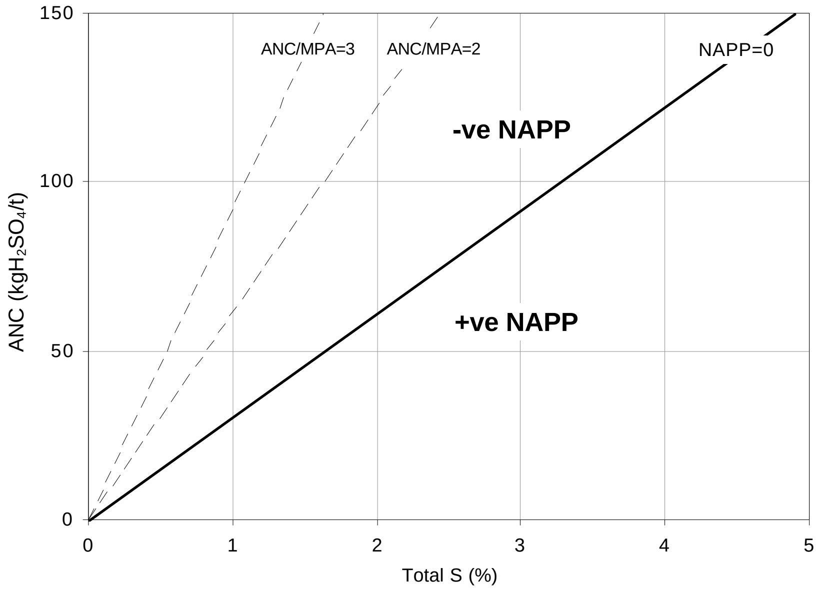


Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

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[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

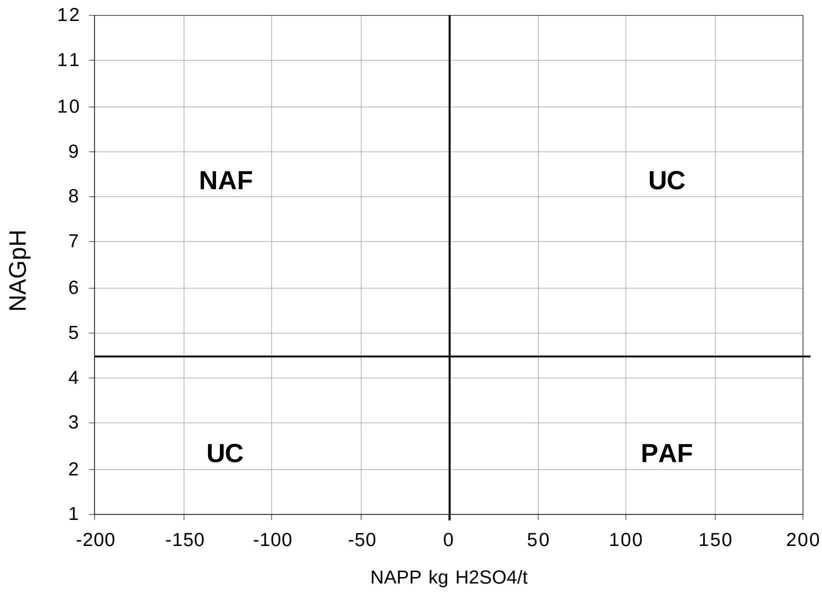

Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

Appendix 7D

Initial Geochemical Investigation

TO:	Hillgrove Resources Limited
ATTENTION:	Catherine Davis
FROM:	Warwick Stewart
DATE:	10 April 2014
REFERENCE NO:	2042/1102
SUBJECT:	Review of Acid Rock Drainage (ARD) Waste Rock Management at Kanmantoo Mine

This memo details the findings of an EGi audit of acid rock drainage (ARD) waste rock type identification and management at Kanmantoo Mine. The audit involved review of various site documents, discussion with relevant personnel, and a site visit on 8th April 2014 to examine the mine and ARD waste rock management procedures.

Waste Rock ARD Classification Criteria

Waste rock is segregated into non acid forming (NAF) and potentially acid forming (PAF) ARD rock types according to the following classification criteria:

NAF – Total S less than or equal to 0.3%S

PAF – Total S greater than 0.3%S

The classification criteria were validated through comprehensive geochemical characterisation work carried out by EGi in 2007[1] and 2010[2] on 450 samples from across the mine site. The EGi work used a variety of techniques including net acid production potential (NAPP), net acid generation (NAG) testing, and a number of specialised tests to confidently classify the samples. This data set was then used to calibrate total S for routine ARD classification of waste rock materials during operations. Sulphur is determined by ICP-OES S for operational monitoring. EGi carried out check testing of ICP-OES S against Leco S in 2010 and confirmed that the ICP-OES S is suitable for determination of total S on Kanmantoo materials.

The basis for the classification criteria is considered appropriate and appears reliable. Ongoing routine checks of the S criteria are recommended to provide confidence and

[1] *Hillgrove Resources Limited, ARD Assessment of the Kanmantoo Copper Project*, EGi Document No. 2042/771, September 2007.

[2] *Geochemical Characterisation of Waste Rock and Ore from the Kanmantoo Project*, EGi Document No. 2042/937, August 2010.

demonstrate reliability. The geochemical characterisation work indicates that single addition NAG testing would be a suitable check.

Waste Rock Segregation

Waste rock segregation was reviewed based on a draft standard operating procedure[3], an internal document on grade control for NAF and PAF waste[4], and supporting discussions and field inspection with site geologists.

Materials are currently segregated using blast hole sample data with geology used to guide the sampling configuration. Blast holes are used for ore grade control, and all blast holes in and around the projected ore zones are sampled. Outside of the ore zones, blast hole sampling echelons are used to represent waste rock material. The sample echelons are oriented roughly perpendicular to the strike of mineralisation, with all blast holes along a given echelon sampled, but with echelons spaced, typically skipping across 3 or 4 lines.

Geological information shows that sulphide mineralisation generally strikes north/south to northeast/southwest. Pyrite and pyrrhotite are the main acid producing sulphides at Kanmantoo and mainly occur as halos to Cu mineralisation, but sometimes as separate zones. These separate pyrite and pyrrhotite zones are oriented on the same strike as the Cu mineralised zones. Based on this information, the blast hole sampling echelons in waste rock are oriented east/west to northwest/southeast. This ensures sampling focuses the greatest density across strike of mineralisation (where variation is also greatest) to define the boundaries of NAF and PAF materials, with the established strike trends and geological knowledge used to correlate NAF and PAF zones between sampling echelons.

Mining is carried out on 12m benches, with each blast hole generally sampled in 3 intervals. Sampling for NAF and PAF segregation is carried out in the same way as grade control for the resource, with on-rig and off-rig representative sample splitting, careful recording of details, and analysis for the same suite of elements (Cu, S, Bi, Ag and Fe). In areas of ore the NAF/PAF sample and grade control sample are the same. Dedicated samplers are generally assigned to blast hole rigs to collect the 3 samples from each hole as they are drilled. In same cases sampling cannot be carried out during drilling (due to samplers being temporarily unavailable) and samples are collected by trowel from the hole collar to represents the entire blast hole depth.

Samples are dispatched to a commercial lab for analysis, and results are generally received within 48 hours, sufficient time to interpret and coordinate mining activities.

Results are entered into grade control models and results interpreted by geologists, taking into account individual blast hole results, geological controls not necessarily allowed for in the model, and the effects of movement of materials due to blasting. Boundaries between NAF and PAF waste rock are applied directly by geologists (rather than relying on modelled boundaries) with some conservatism, e.g. scattered PAF samples within a mostly

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[3] *Blockouts*, Hillgrove Resources Limited, Version 1.1, J. Wilkins, 30/09/2013.

[4] *Grade Control NAF/PAF Waste Methodology*, Hillgrove Resources Limited, Hayden Arbon, No Date.

NAF zone would be classified PAF, narrow NAF zones of 5m or less would be generally classified as PAF with the surrounds, and boundaries between well defined PAF and NAF zones would sit mainly within the NAF zone.
Even using this conservative system of NAF classification the amount of NAF mined is in excess of requirements for the current dump design.

In summary, the sampling configuration is appropriately optimised to represent geological variation. Sampling for NAF/PAF and assignment of PAF and NAF zones involves the same rigour as grade control and includes an element of conservatism. Currently there are no lithological details recorded for blast hole samples. Lithological logging of blast holes and building of a geological model may further enhance the current NAF/PAF identification and segregation and should be considered.

Excavation and Placement of ARD Rock Types

NAF/PAF boundaries are set out on the mine bench by surveyors and geologists using colour coded tape, and a block out map is provided to excavator operators who direct the haul trucks. Each bench is mined in 3 to 4 flitches, and block out maps are provided for each flitch. The excavator operators provide haul truck operators with a material code (i.e. NAF, PAF or ore types) and unique shot/block codes, and haul truck drivers are advised of dumping locations at pre-start meetings.

It is understood that the amounts of the various material types moved and placed are reconciled against what was present in the mining bench, which would pick up any significant discrepancies in misplacement of NAF and PAF. However, there is no system of direct checks of dumped materials. A system of checks (such as testing of dumped materials together with visual inspection) would help monitor the performance of the current excavation and placement procedures.

Waste rock materials are incorporated into an integrated waste landform (IWL), which includes the tailings storage facility. The current dump design includes a 5m base NAF layer, followed by undifferentiated PAF and NAF, with all covered by a 2m NAF store and release cover and vegetated topsoil.

NAF waste rock is currently being used to line the base of the dump, with survey pegs marking out the dumping boundaries. PAF material is placed only in areas where the 5m NAF base layer has been established. Given the excess of NAF, there is an opportunity to improve dump security by increasing the thickness of NAF in the cover layer, including the possible set back of PAF material 100m from the outer surface in slope zones to help control convection.

The cover design was based on modelling work carried out by Unsaturated Soils Engineering Ltd[5] in 2008. The purpose of the cover is to control infiltration through the

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[5] *Cover Design, Kanmantoo Copper Project*, Unsaturated Soils Engineering Ltd, October 27, 2008.

PAF materials and prevent significant transport of ARD oxidation products. The following are key aspects to the successful performance of the cover:

- Sustainable vegetation is established in the cover layer;
- The physical and hydrological properties of the actual cover construction materials need to match the modelled parameters; and
- The cover needs to be sufficiently thick and constructed in a manner that takes into account impacts of erosion and differential settlement.

Confirmation of these aspects should be carried out prior to construction of the final cover. It is understood that investigations into establishing vegetation are in progress, and that test pit investigations in 2007and 2008[6] have confirmed that suitable materials are likely to be available within 6 m or so of surface. It is not known whether erosion and dump settlement studies have been carried out.

In addition, the results of the cover design modelling work should be confirmed by field trials.

Conclusions

Overall the current systems used for identification, segregation and placement of NAF and PAF materials appear to be rigorous and appropriate. Some minor modifications and additions in regards to monitoring and gathering additional data could assist in demonstrating performance.

Cover construction has not yet commenced, but since this component is a key to the long term ARD control on site, investigations into vegetation, cover materials availability, erosion and settlement should be progressed. Field trials should also be established to confirm the modelled performance of the cover.

A summary of the audit findings and recommendations/opportunities are provided in Table 1.

Regards,

Warwick Stewart

[6] Carried out by Coffey Mining Pty Ltd in 2007 and follow up work by Coffey Information Ltd in 2008.

Table 1: Summary of Audit Findings and Recommendations/Opportunities

Item and Findings	Recommendations/Opportunities
Waste Rock ARD Classification Criteria The classification criteria are based on comprehensive test work, are considered appropriate and appear reliable.	Ongoing routine checks of the S criteria are recommended to provide confidence and demonstrate reliability. Single addition NAG testing is likely to be a suitable check method.
Waste Rock Segregation The sampling configuration is appropriately optimised to represent geological variation. Sampling for NAF/PAF and assignment of PAF and NAF zones involves the same rigour as grade control and includes an element of conservatism.	Lithological logging of blast holes and building of a geological model should be considered as it may further enhance the current NAF/PAF identification and segregation.
Excavation and Placement of ARD Rock Types Controls and systems for excavation, dispatch and placement of NAF and PAF materials appear rigorous.	A system of direct checks of dumped materials (such as testing of dumped materials together with visual inspection) would help monitor the performance of the current excavation and placement procedures.
Available NAF materials are in excess of dump design requirements.	The excess NAF provides an opportunity to improve dump security by increasing the thickness of NAF in the cover layer, including the possible set back of PAF material 100m from the outer surface in slope zones to help control convection.
The design of the planned store and release cover appears appropriate for the climate and the mine materials produced. The cover design is based on modelling carried out pre-mining using the data available at the time.	Investigations should be progressed into key controls on the successful performance of the cover. Field trials should be established to confirm the constructability and modelled performance of the cover.

Appendix 7E

Tailings Geochemical Characterisation

HILLGROVE RESOURCES PTY LTD

KANMANTOO COPPER PROJECT

GEOCHEMICAL CHARACTERISATION OF TAILINGS-PROFILE SAMPLES FROM EXISTING TAILINGS-STORAGE FACILITY

Implications for Process-Tailings Management

GRAEME CAMPBELL AND ASSOCIATES PTY LTD
(ACN 061 827674)

JULY 2007

Job No. 0721

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APPENDIX

1.0 INTRODUCTION

Hillgrove Copper Pty Ltd (Hillgrove) are proposing to develop their Kanmantoo Project, which is located in the Mount Lofty Ranges 55 kilometres southeast of Adelaide in South Australia. This is a brownfields development with an existing mine and some infrastructure from previous mining operations, including a tailings-storage facility (TSF) at the site. Overburden removal for mining commenced in August 1970, and treatment of ore commenced in October 1971. Mining ceased in 1975, and the mine placed on care-and-maintenance in 1976.[1]

From the historic operations, a stream of process-tailings (in slurry form) was discharged to an engineered, valley-type TSF (referred to herein as the existing TSF). A new TSF is currently being designed for the proposed project.

Graeme Campbell & Associates Pty Ltd (GCA) was commissioned to carry out geochemical testwork on tailings-profile samples derived from the tailings-bed in the **existing TSF**.

The Static-Testwork Programme focused on the Acid-Formation Potential (AFP), and Multi-Element Composition of the tailings-solids samples.[2] Limited physical testing was also undertaken. In addition, the quality (viz. major/minor-ion chemistry) of tailings-porefluid samples was determined. Finally, the tailings-solids sample tested in the GCA (2007) study for the new TSF was subjected to Kinetic-Testwork (viz. Weathering-Column) to assess sulphide-oxidation rates.

The testwork results are presented and discussed in this report, and implications for process-tailings management highlighted.

[1] Information Source: Email correspondence of 23rd July 2007 from Mr Chris Lane [Coffey Mining Pty Ltd, Perth].

[2] A Static-Testwork Programme comprises "whole-rock" analyses and tests.

Since the orebody is that mined historically, and since the ore-processing routes are broadly similar, the tailings-bed in the existing TSF is an analogue from which lessons may usefully be gained for the design of the new TSF. Due regard needs to be given, however, to the fact that the tailings-bed-surface in the existing TSF was left exposed for several years prior to the construction of a vegetated-cover system during the 1980s.[3]

[3] Topsoil was laid down during 1975 and 1976 on the upper-surface of the tailings-bed. The surfical-tailings were scarified and limed prior to placement of topsoil which was then seeded. (Information Source: Email correspondence of 23rd July 2007 from Mr Chris Lane [Coffey Mining Pty Ltd, Perth]).

2.0 STUDY APPROACH

2.1 Samples

A range of tailings-profile samples was provided to GCA for testing, and are derived from a drilling programme carried out by Coffey Mining Pty Ltd (Adelaide).

The locations of drillholes BH1, BH2, BH3, and BH4, are shown on Figure 1.

Since the drilling was undertaken in May 2007, the moisture status of the tailings-bed should be at the "low-end-of-the-range" (i.e. minimal influences from recent recharge) following the 2006-2007 summer.

Details of sample treatment are given in the laboratory reports presented in Appendix A.

It is understood that the existing TSF operated during the 1970s, and was left exposed for *c.* 5 yrs before being covered with 0.5 m (nominal) of soil/regolith materials with a loam (+/-) texture. The cover supports grasses and shrubs. Although difficult to estimate accurately, under the Mediterranean conditions of the mine-site, the mean-recharge across the cover/tailings-interface may approach several cms per annum, and likely would occur mainly from mid-winter to spring in most years. Prior to covering, the mean-recharge may have locally been within the decimetre+ per year range.

2.2 Testwork Programme

The geochemical testing herein employed methods as described in the GCA (2007) report.

3.0 CHARACTERISATION OF TAILINGS-PROFILE SAMPLES FROM EXISTING TSF

3.1 Physical Characteristics

Values of various physical properties for selected tailings-profile samples from drillholes BH1, BH3 and BH4 are presented in Table 3.1.

The Dry-Bulk-Densities (DBDs) determined on 30-cm sections at different depths were within the range 1.59-2.08 g/cm^3.

Relative-Saturation of Pore-Spaces

The near-saturated state of the samples from BH1 reflect the down-beach position of this drillhole. Under such conditions sulphide-oxidation is negligible (i.e. limited by O_2-diffusion through water-filled pores which is negligibly slow).

The tested samples from BH3 and BH4 had relative-saturations within the range 15.9-21.2 %. These conditions favour sulphide-oxidation, as governed by the reach of the O_2-diffusion front, in turn controlled by sulphide-mineral reactivity.

Intermittent Fines-Enriched Bands

Two depth-intervals (viz. *c.* 8.00-9.00 m, and *c.* 11.60-12.20 m) from drillhole BH3 were used for sectioning to determine the content of fines (i.e. -75µm) determined via dry-sieving. The sections were typically 10 cm in length, except for selected positions where an enrichment in fines was inferred visually (e.g. 12.03-12.05 m as shown on Plate 1). In total, 16 samples were tested.

The range in fines content was 7-24 %. The sample from 12.03-12.05 m had a fines content of 24 %. If this result is excluded, then the range in fines content was 7-15 %, and the mean-fines content was 10 %. The wafer-thin, horizontal laminations shown on

Plate 1 have important implications for maintaining near-saturation conditions locally within the tailings-bed of the new TSF during its active-lifetime.

3.2 Geochemistry

3.2.1 Acid-Base Chemistry of Tailings-Solids

The results from acid-base-chemistry testing on the tailings-profile samples are presented in Table 3.2. The results of related testing on the tailings-solids sample from the GCA (2007) study are also given for comparison.

Key findings include:

- pH-(1:2) values of:
    - *c.* 2-3 within the surface-zone of BH3 (i.e. sulphide-oxidation most intense)
    - *c.* 3-4 typically where unsaturated conditions occur
    - *c.* 4-5 in BH1 associated with near-saturated conditions
- evidence of segregation of sulphide-minerals, and association with tailings-particles of coarser texture (viz. BH3)
- sulphide-decomposition generally at an advanced stage with only minute/trace amounts of "remnant-sulphides", although only modest decomposition in BH3 below the top 4-5 m
- inferred "start-condition" of tailings-solids in existing TSF very similar to the nature of the tailings-solids sample tested in the GCA (2007) study

3.2.2 Multi-Element Composition of Tailings-Solids

The multi-element-analysis results are presented in Tables 3.3-3.5. Reference should be made to the GCA (2007) report for the definition of the Geochemical-Abundance Index (GAI) indicated in these tables.

The tailings-profile samples were variously enriched in Cu, Ag, Bi, and Se. However, none of these enrichments were marked.

The above suite of enriched minor-elements is similar to that observed in the GCA (2007) study.

3.2.3 Quality of Tailings-Porefluids

The analysis results for tailings-porefluid samples from near the bases of BH1 and BH4 are presented in Table 3.6. These samples are derived from turbid fluids drained from the plastic-tubes employed for tailings-profile coring. The tailings-fines were allowed to settle-out, followed by filtration and preservation, for analysis.

The tailings-porefluid samples had pH values of 3.2-4.1, and were variously saline with SO_4 concentrations ranging up to 12,000 mg/L. The salts in solution mainly comprised Fe-sulphates [and most likely dominated by Fe(II)-sulphates].

4.0 REACTIVITY OF TAILINGS-SOLIDS DESTINED FOR NEW TSF

The tailings-solids sample tested in the GCA (2007) study was subjected to kinetic-testing employing a weathering-column similar in design to that described in the AMIRA (2002) document. The column contained *c.* 1.0 kg (dry-solids basis) of tailings-solids, and underwent weekly cycles of desiccation-flushing. At the completion of each drying-cycle, deionised-water was added to elute solutes produced through sulphide-oxidation – this addition was continued until the Electrical-Conductivity (EC) value of the leachate was less than 500 µS/cm.

The analysis results for the column-leachate samples are presented in Table 4.1.

Mass-balance calculations indicate that, during the five (5) weathering-cycles carried out, the Sulphide-Oxidation Rate (SOR) was *c.* 400 mg SO_4/kg/week. Given the Sulphide-S value of 0.78 % (GCA 2007), this SOR estimate means that the sulphide-mineral suite contains reactive varieties, consistent with the occurrence of marcasites (GCA 2007).

The reactive nature of the tailings-solids means that where desaturation occurs within the surface-zone of the dormant tailings-beaches in the new TSF, sulphide-oxidation will be confined close-to-surface. In any case, the high relative-saturation during the active-lifetime of the TSF will suppress sulphide-oxidation via O_2-diffusion control.

5.0 CONCLUSIONS

During the active-lifetime of the new TSF, sulphide-oxidation should be minimal where spigot rotations occur over weeks (c.f. months), so that moist surface conditions occur on the tailings beaches, and near-saturation conditions within the tailings bed. The latter should be favoured by impeding-bands of fines. In addition to curtailed rates of sulphide-oxidation, soluble-alkalinity forms in the “fresh” incoming tailings-slurry will at least partly neutralise any acidity locally generated within the surface-zone of any dormant tailings-beaches.

Although difficult to quantify, soluble-Fe(II) forms should occur in the tailings-pore-fluids, but overall likely not beyond the 10 m/L range when due account is taken of localised sulphide-oxidation within the surface-zone, and mixing/dilution with tailings-pore-fluids derived from the incoming, freshly-deposited-tailings. Since anoxic conditions should prevail at depth, scaling-up of the underdrainage system is considered unlikely, though this is again difficult to quantify *a priori*.

The underdrainage-fluids reporting from the underdrainage-system are anticipated to have a pH of *c.* 5-6 (and possibly slightly higher) with low amounts of latent-acidity in the form of soluble-Fe(II) forms. The Al concentrations should be low (e.g. near-mg/L range), and the Cu concentrations may be within the range 1-10 mg/L. The latent-acidity in the form of soluble-Fe(II) forms means that the underdrainage-fluids could acidify to pH 4 (+/-) upon "daylighting", and ageing in contact with air. However, this acid-producing mechanism should be offset by decant-fluids discharged in larger quantities at a pH likely similar to the tailings-slurry-pH at discharge (i.e. *c.* 8-9). Some form of neutralisation treatment may nonetheless be required as part of the water-conditioning process before the tailings-waters are returned to the process circuit.

It is emphasised that because of the paucity of carbonate-minerals, and the presence of reactive-sulphides, albeit in trace amounts, accurate projection of pH regime and metal-solubility behaviour is difficult for this Project. Monitoring is needed to confirm (or refine) the above anticipated chemistry of the underdrainage-fluids. Routine sampling and analysis is recommended at the discharge-points of both the underdrainage-fluids, and decant-fluids.

6.0 REFERENCES

AMIRA International Ltd, 2002, "ARD Test Handbook", Prepared by Ian Wark Research Institute, and Environmental Geochemistry International Pty Ltd.

Graeme Campbell & Associates Pty Ltd, 2007, "Kanmantoo Copper Project: Geochemical Characterisation of Process-Tailings-Slurry Sample [Static-Testwork] - Implications for Process-Tailings Management", Unpublished report prepared for Hillgrove Resources Pty Ltd.

TABLES

Table 3.1: Physical Characteristics of Tailings-Profile Samples

GCA-SAMPLE-NO.	Depth-Interval (m)	Gravimetric-Water-Content (GWC) [%, w/w]	Dry-Bulk-Density (DBD) [t/m3]	Particle-Density (PD) (t/m3)	Porosity	Volumetric Water-Content (VWC) [%, w/w]	Relative-Saturation (%)
BH4							
GCA7096	1.25-1.55	5.8	1.59	2.93	0.46	9.2	20.0
GCA7094	1.65-1.95	5.4	1.64	2.83	0.42	8.9	21.2
GCA7091	4.65-4.95	5.0	1.58	2.83	0.44	7.9	18.0
BH1							
GCA7102	2.50-2.80	30.4	nm	2.94	nc	nc	nc
GCA7099	5.40-5.70	31.3	1.62	2.95	0.45	50.7	>95
BH3							
GCA7115	4.05-4.35	3.2	1.97	2.98	0.34	6.4	18.8
GCA7112	7.05-7.35	3.3	2.08	3.09	0.33	6.9	20.9
GCA7110	9.80-10.10	2.6	2.07	3.12	0.34	5.4	15.9
GCA7107	13.00-13.30	3.6	1.82	2.93	0.38	6.6	17.4

Notes:
nm = not measured; nc = not calculated.
Relative-saturation is the ratio of VWC and Porosity expressed as a percentage.

Table 3.2: Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Profile Samples

GCA-SAMPLE NO.	Depth-Interval (m)	MC (%, w/w)	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	SO_4-S (%)	Sulphide-S (%)	Cr(II)-Red.-S (%)	TOTAL-C (%)	ANC	NAPP	NAG	NAG-pH
										kg H_2SO_4/tonne			
BH3													
GCA7118	0.00-1.50	4.8	2.8	4.1	1.4	1.2	0.20	0.12	0.03	-8	15	12	2.8
GCA7117	1.55-3.00	3.1	2.9	4.9	1.6	0.82	0.80	0.64	<0.01	-6	31	20	2.5
GCA7116	3.00-4.45	3.5	3.3	2.1	0.88	0.35	0.53	0.51	0.01	7	9.3	17	2.6
GCA7114	5.00-5.95	3.1	3.7	2.0	1.2	0.23	1.0	nm	0.02	10	21	24	2.6
GCA7113	6.00-7.45	4.3	3.2	1.3	0.49	0.15	0.34	0.33	0.01	12	-1.5	8.5	3.1
GCA7111	9.00-10.20	3.2	3.3	0.79	0.61	0.13	0.48	nm	0.03	11	3.7	15	2.8
GCA7109	10.20-11.15	2.8	3.6	0.67	1.2	0.13	1.1	0.85	0.08	11	23	24 (21)	2.6 (2.6)
GCA7108	12.20-13.40	3.2	3.6	0.79	0.73	0.17	0.56	nm	0.05	11	6.2	15	2.7
GCA7106	13.40-14.60	7.3	3.9	0.67	0.95	0.12	0.83	nm	0.05	17	8.4	11	3.0
GCA7105	14.60-15.00	18.2	3.9	0.96	2.1	0.16	2.0	1.5	0.03	8	54	29	2.6
BH1													
GCA7104	0.00-1.55	16.2	3.9	1.7	0.34	0.19	0.15	nm	0.02	12	-7.4	6.3	3.4
GCA7103	1.55-2.90	16.2	4.8	1.5	0.35	0.13	0.22	0.22	0.04	15	-8.2	7.7	3.5
GCA7101	2.90-4.50	26.2	4.4	1.5	0.48	0.13	0.35	nm	0.06	15	-4.2	10	3.1
GCA7100	4.50-5.80	36.4	4.4	1.9	0.58	0.16	0.42	nm	0.10	67	-54	13	3.0
GCA7098	7.00-7.90	39.1	4.4	2.0	0.59	0.15	0.44	0.42	0.08	68	-54	11	3.2

Notes:
MC = Moisture-Content; EC = Electrical-Conductivity; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; NAG = Net-Acid Generation; Cr(II)-Red.-S = Cr(II)-Reducible-S.
pH-(1:2) and EC-(1:2) correspond to pH and EC determined on sample slurries prepared using deionised-water at a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

Table 3.2 (Cont'd): Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Profile Samples

GCA-SAMPLE NO.	Depth-Interval (m)	MC (%, w/w)	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	SO_4-S (%)	Sulphide-S (%)	Cr(II)-Red.-S (%)	TOTAL-C (%)	ANC	NAPP	NAG	NAG-pH
										kg H_2SO_4/tonne			
BH4													
GCA7097	0.00-1.55	5.6	4.5	0.14	0.30	0.31	<0.01	nm	0.07	5	nc	2.8	3.3
GCA7095	1.55-3.00	4.3	4.2	0.14	0.26	0.28	<0.01	nm	<0.01	12	nc	<0.5	7.8
GCA7093	3.00-4.50	4.5	4.2	0.21	0.19	0.21	<0.01	<0.01	0.03	11	nc	2.5	3.3
GCA7092	4.50-5.95	6.5	4.0	0.36	0.23	0.26	<0.01	nm	<0.01	10	nc	2.7	3.3
GCA7090	6.00-7.45	5.9	3.9	0.49	0.21	0.19	0.02	nm	0.03	5	nc	<0.5	6.7
GCA7089	7.50-8.75	17.8	3.6	2.4	0.34	0.33	0.01	0.07	0.01	6	nc	5.3	3.4
GCA7088	9.00-10.45	30.2	3.5	1.5	0.48	0.23	0.25	nm	0.06	12	-4.3	9.7	3.2
GCA7087	10.50-11.50	31.1	3.7 (3.7)	1.9 (1.8)	0.44 (0.43)	0.21	0.23	0.23	0.07	14 (12)	-4.9	5.3	3.4
BH2													
GCA7121	0.00-1.55	8.0	4.3	0.13	0.21	0.22	<0.01	nm	0.04	9	nc	4.3 (4.8)	3.5 (3.3)
GCA7120	1.55-3.00	10.0	4.0	0.29	0.24	0.24	<0.01	nm	<0.01	4	nc	3.8	3.4
GCA7119	3.00-4.50	21.1	3.9	1.2	0.43	0.17	0.26	0.26	0.03	12	-4.0	6.6	3.2

Notes:
MC = Moisture-Content; EC = Electrical-Conductivity; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential;
NAG = Net-Acid Generation; Cr(II)-Red.-S = Cr(II)-Reducible-S; nm = not measured; nc = not calculated.
pH-(1:2) and EC-(1:2) correspond to pH and EC determined on sample slurries prepared using deionised-water at a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH. Values in parentheses represent duplicates.

The following is Table 3.1 from the GCA (2007) report for the new TSF (included here for comparison)

GCA-SAMPLE NO.	MC (%, w/w)	TOTAL-S (%)	SO_4-S (%)	Sulphide-S (%)	CO_3-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
						kg H_2SO_4/tonne				
GCA6298	20.5	0.80 (0.76)	0.03 (0.02)	0.78	0.01 (0.01)	9 (8)	16	13 (13)	3.6 (3.7)	**PAF-[Short-Lag]**

Notes:
MC = Moisture-Content; EC = Electrical-Conductivity; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; AFP = Acid-Formation Potential; PAF = Potentially-Acid Forming;
NAG = Net-Acid Generation; Cr(II)-Red.-S = Cr(II)-Reducible-S; nm = not measured; nc = not calculated.
All results expressed on a dry-weight basis, except for NAG-pH. Values in parentheses represent duplicates.

Table 3.3: Multi-Element-Analysis Results for Tailings-Profile Samples (BH3)

Note: Refer Appendix B in the GCA (2007) report for the definition of the Geochemical-Abundance-Index (GAI) indicated in this table.

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)					AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)				
	1.55-3.00 m [GCA7117]	5.00-5.95 m [GCA7114]	9.00-10.20 m [GCA7111]	12.20-13.40 m [GCA7108]	14.60-15.00 m [GCA7105]		1.55-3.00 m [GCA7117]	5.00-5.95 m [GCA7114]	9.00-10.20 m [GCA7111]	12.20-13.40 m [GCA7108]	14.60-15.00 m [GCA7105]
Al	7.1%	6.5%	6.0%	5.0%	6.8%	8.2%	0	0	0	0	0
Fe	19.5%	14.9%	14.3%	10.3%	16.4%	4.1%	2	1	1	1	1
Na	0.019%	0.037%	0.033%	0.052%	0.043%	2.3%	0	0	0	0	0
K	0.55%	1.0%	0.82%	1.1%	0.91%	2.1%	0	0	0	0	0
Mg	1.3%	1.4%	1.3%	1.4%	1.3%	2.3%	0	0	0	0	0
Ca	0.15%	0.13%	0.12%	0.11%	0.14%	4.1%	0	0	0	0	0
Ag	1.0	0.4	0.6	0.7	2.2	0.07	**3**	2	**3**	**3**	**4**
Cu	1,600	610	460	450	4,200	50	**4**	**3**	**3**	**3**	**6**
Zn	37	46	40	46	48	75	0	0	0	0	0
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	0	0	0	0	0
Pb	10	15	12	18	20	14	0	0	0	0	0
Cr	62	67	62	57	63	100	0	0	0	0	0
Ni	34	43	28	29	42	80	0	0	0	0	0
Co	140	94	66	61	130	20	2	2	1	1	2
Mn	5,000	3,200	2,900	1,800	4,300	950	2	1	1	0	2
Hg	0.02	<0.01	<0.01	<0.01	<0.01	0.05	0	0	0	0	0
Sn	5.2	5.9	8.2	6.1	6.6	2.2	1	1	1	1	1
Sr	6.0	7.9	9	12	18	370	0	0	0	0	0
Ba	59	110	92	120	94	500	0	0	0	0	0
Th	11	11	9.4	9.3	12	12	0	0	0	0	0
U	2.6	2.7	2.3	2.4	2.6	2.4	0	0	0	0	0
Tl	0.23	0.41	0.32	0.42	0.42	0.6	0	0	0	0	0
V	64	70	66	59	61	160	0	0	0	0	0
As	2	1	<1	<1	<1	1.5	0	0	0	0	0
Bi	92	79	48	81	130	0.048	**6**	**6**	**6**	**6**	**6**
Sb	<0.05	<0.05	<0.05	<0.05	0.07	0.2	0	0	0	0	0
Se	2.3	1.5	1.5	1.2	3.2	0.05	**5**	**4**	**4**	**4**	**5**
Mo	0.8	0.8	0.7	1.0	2.1	1.5	0	0	0	0	0
B	<50	51	<50	<50	<50	10	0	2	0	0	0
P	470	480	450	420	460	1,000	0	0	0	0	0
F	250	460	390	430	400	950	0	0	0	0	0

Note: Average-crustal abundance of elements based on Bowen (1979) [see GCA (2007) report]

Table 3.4: Multi-Element-Analysis Results for Tailings-Profile Samples (BH4)

Note: Refer Appendix B in the GCA (2007) report for the definition of the Geochemical-Abundance-Index (GAI) indicated in this table.

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)			AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)		
	0.00-1.55 m [GCA7097]	**3.00-4.50 m [GCA7093]**	**9.00-10.45 m [GCA7088]**		**0.00-1.55 m [GCA7097]**	**3.00-4.50 m [GCA7093]**	**9.00-10.45 m [GCA7088]**
Al	5.3%	5.3%	7.5%	8.2%	0	0	0
Fe	10.5%	8.3%	12.6%	4.1%	1	0	1
Na	0.049%	0.052%	0.11%	2.3%	0	0	0
K	1.3%	1.6%	2.3%	2.1%	0	0	0
Mg	1.5%	1.6%	2.6%	2.3%	0	0	0
Ca	0.079%	0.092%	0.21%	4.1%	0	0	0
Ag	0.3	0.1	0.3	0.07	2	0	2
Cu	390	240	530	50	2	2	**3**
Zn	35	38	73	75	0	0	0
Cd	<0.1	<0.1	<0.1	0.11	0	0	0
Pb	14	15	28	14	0	0	0
Cr	56	53	76	100	0	0	0
Ni	20	25	53	80	0	0	0
Co	35	33	99	20	0	0	2
Mn	1,600	910	950	950	0	0	0
Hg	<0.01	<0.01	<0.01	0.05	0	0	0
Sn	6.7	6.1	14	2.2	1	1	2
Sr	11	9.5	20	370	0	0	0
Ba	140	180	250	500	0	0	0
Th	9.7	9.8	18	12	0	0	0
U	2.3	2.3	4.4	2.4	0	0	0
Tl	0.47	0.62	0.86	0.6	0	0	0
V	70	69	96	160	0	0	0
As	<1	<1	1	1.5	0	0	0
Bi	140	180	250	0.048	**6**	**6**	**6**
Sb	<0.05	<0.05	<0.05	0.2	0	0	0
Se	0.97	0.41	0.64	0.05	**4**	2	**3**
Mo	1.3	1.0	0.7	1.5	0	0	0
B	<50	<50	<50	10	0	0	0
P	410	440	830	1,000	0	0	0
F	530	640	990	950	0	0	0

Note: Average-crustal abundance of elements based on Bowen (1979) [see GCA (2007) report]

Table 3.5: Multi-Element-Analysis Results for Tailings-Profile Samples (BH1 and BH2)

Note: Refer Appendix B in the GCA (2007) report for the definition of the Geochemical-Abundance-Index (GAI) indicated in this table.

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)			AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)		
	BH1 0.00-1.55 m [GCA7104]	BH1 4.50-5.80 m [GCA7100]	BH2 1.55-3.00 m [GCA7120]		BH1 0.00-1.55 m [GCA7104]	BH1 4.50-5.80 m [GCA7100]	BH2 1.55-3.00 m [GCA7120]
Al	7.2%	7.8%	6.0%	8.2%	0	0	0
Fe	11.7%	12.8%	9.1%	4.1%	1	1	1
Na	0.075%	0.10%	0.053%	2.3%	0	0	0
K	2.1%	2.5%	1.8%	2.1%	0	0	0
Mg	2.4%	2.7%	1.7%	2.3%	0	0	0
Ca	0.17%	0.21%	0.12%	4.1%	0	0	0
Ag	0.4	0.4	0.4	0.07	2	2	2
Cu	1,300	440	290	50	**4**	**3**	2
Zn	61	77	46	75	0	0	0
Cd	<0.1	<0.1	<0.1	0.11	0	0	0
Pb	25	26	16	14	0	0	0
Cr	94	110	69	100	0	0	0
Ni	41	45	22	80	0	0	0
Co	79	110	37	20	1	2	0
Mn	1,000	1,100	1,100	950	0	0	0
Hg	<0.01	<0.01	<0.01	0.05	0	0	0
Sn	12	14	7.6	2.2	2	2	1
Sr	19	18	14	370	0	0	0
Ba	220	260	190	500	0	0	0
Th	18	20	13	12	0	0	0
U	4.3	4.8	2.8	2.4	0	0	0
Tl	0.79	0.92	0.69	0.6	0	0	0
V	89	98	75	160	0	0	0
As	1	1	<1	1.5	0	0	0
Bi	64	69	62	0.048	**6**	**6**	**6**
Sb	0.21	0.07	<0.05	0.2	0	0	0
Se	1.1	0.71	0.70	0.05	**4**	**3**	**3**
Mo	1.2	1.1	0.8	1.5	0	0	0
B	<50	<50	<50	10	0	0	0
P	690	800	560	1,000	0	0	0
F	850	1,100	690	950	0	0	0

Note: Average-crustal abundance of elements based on Bowen (1979) [see GCA (2007) report]

Table 3.6: Analysis Results for Tailings-Porefluid Samples

Note: All results in mg/L, except for pH and EC (µS/cm).

ELEMENT/ PARAMETER	BH4 (10.50-11.50 m) [GCA7084]	BH4 (9.00-10.45 m) [GCA7085]	BH1 (7.00-7.90 m) [GCA7086]	ELEMENT/ PARAMETER	BH4 (10.50-11.50 m) [GCA7084]	BH4 (9.00-10.45 m) [GCA7085]	BH1 (7.00-7.90 m) [GCA7086]
Major-Parameters				***Minor-Ions***			
pH	3.2	3.5	4.1	Fe	3,500	2,900	210
EC [µS/cm]	9,800	7,000	5,300	Cu	1.0	<0.1	<0.1
				Ni	5.5	8.2	<0.1
Major-Ions				Zn	2.3	5.5	0.2
				Co	30	31	0.27
Na	120	63	420	Al	3.7	5.5	1.0
K	290	84	310	Cd	0.0019	0.0030	0.0024
Mg	870	330	250	Pb	0.007	<0.005	0.016
Ca	450	470	500	Cr	<0.1	<0.1	<0.1
Cl	170	78	280	Hg	<0.001	<0.001	<0.001
SO_4	12,000	7,700	2,900	As	0.008	0.007	0.002
Si	24	25	16	Sb	<0.0001	<0.0001	<0.0001
				Bi	0.00007	<0.00005	<0.00005
				Se	0.006	<0.005	<0.005
				B	0.5	0.4	0.30
				Mo	0.0017	0.0007	0.0006
				P	<1	<1	<1
				Ag	<0.0001	<0.0001	<0.0001
				Ba	0.0098	0.021	0.042
				Sr	0.14	0.23	1.4
				Tl	<0.0001	<0.0001	<0.0001
				V	<0.1	<0.1	<0.1
				Sn	0.003	0.003	0.002
				U	0.0056	0.0031	0.0028
				Th	0.0011	0.00013	0.00008
				Mn	120	69	17

Note: EC = Electrical Conductivity.

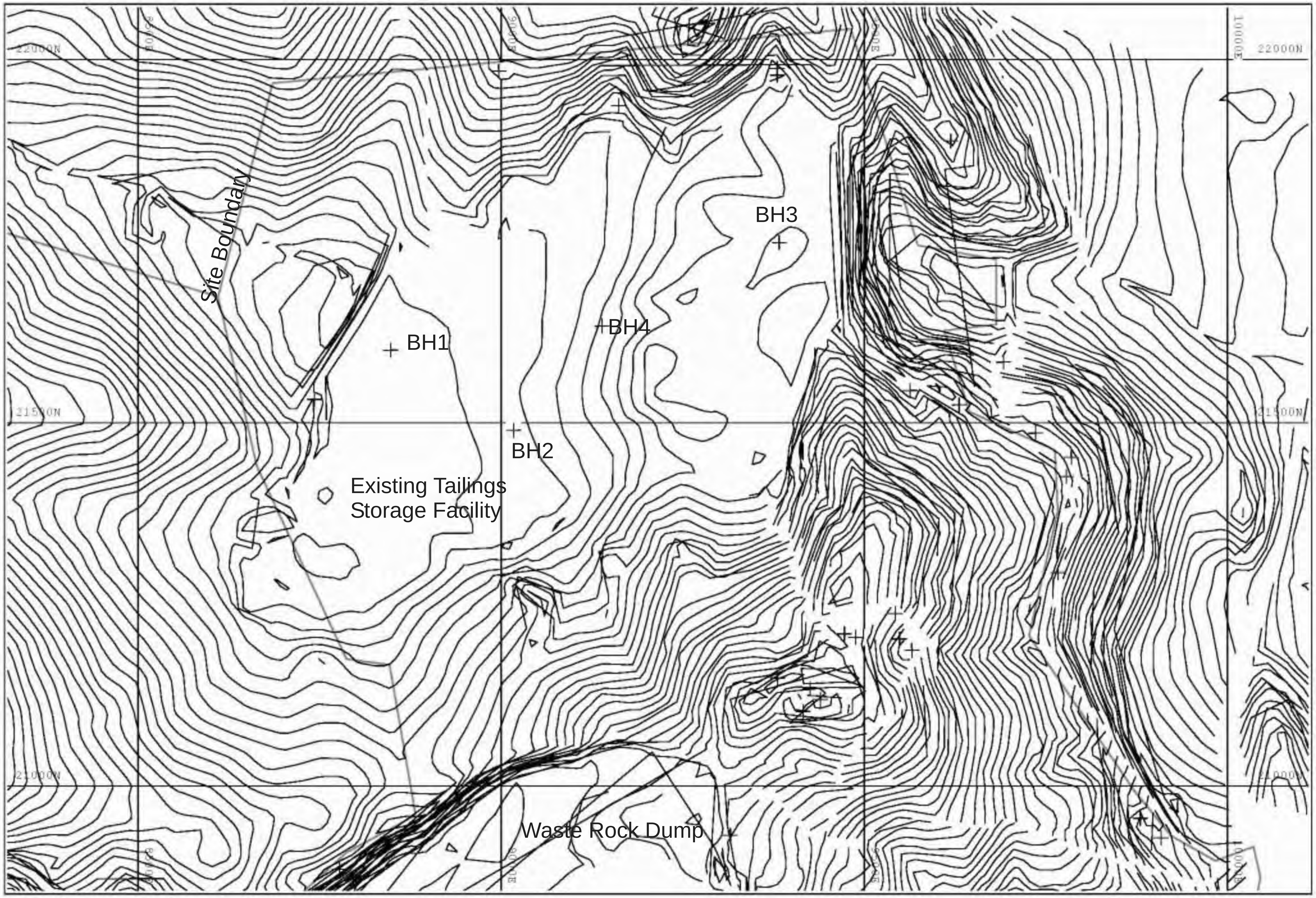
Table 4.1: Analysis Results for Column-Leachates

Note: All results in mg/L, except for pH and EC (µS/cm).

PARAMETER	WEEKLY WEATHERING-CYCLES (GCA6298)						
	1-1	**1-2**	**1-3**	**2**	**3**	**4**	**5**
pH	2.8	3.1	3.2	2.9	2.9	3.0	3.0
EC (µS/cm)	1,700	420	260	890	860	890	790
SO_4 (mg/L)	1,200	140	66	350	390	410	300
Fe (mg/L)	160	7.6	2.8	51	47	62	36
Al (mg/L)	71	4.9	1.6	21	25	26	20
Cu (mg/L)	18	2.4	1.2	4.0	4.5	3.7	2.9
Mn (mg/L)	6.7	0.67	0.25	0.82	1.3	0.84	0.61
Leachate Wt (kg)	0.48	0.99	1.00	1.32	1.51	1.54	1.54

Notes:
EC = Electrical Conductivity.
Tailings-solids sample GCA6298 was that tested in the GCA (2007) study.

FIGURE



Coffey Mining Pty Ltd	ABN 52 065 481 209		
Drawn	JLB	Hillgrove Resources Ltd Kanmantoo Copper Project Location of Drillholes for Geochemical Study	FIGURE 1
Approved	JLB		
Date	10/07/07		
Scale	As Shown		Job no: MEND04511AA

PLATE

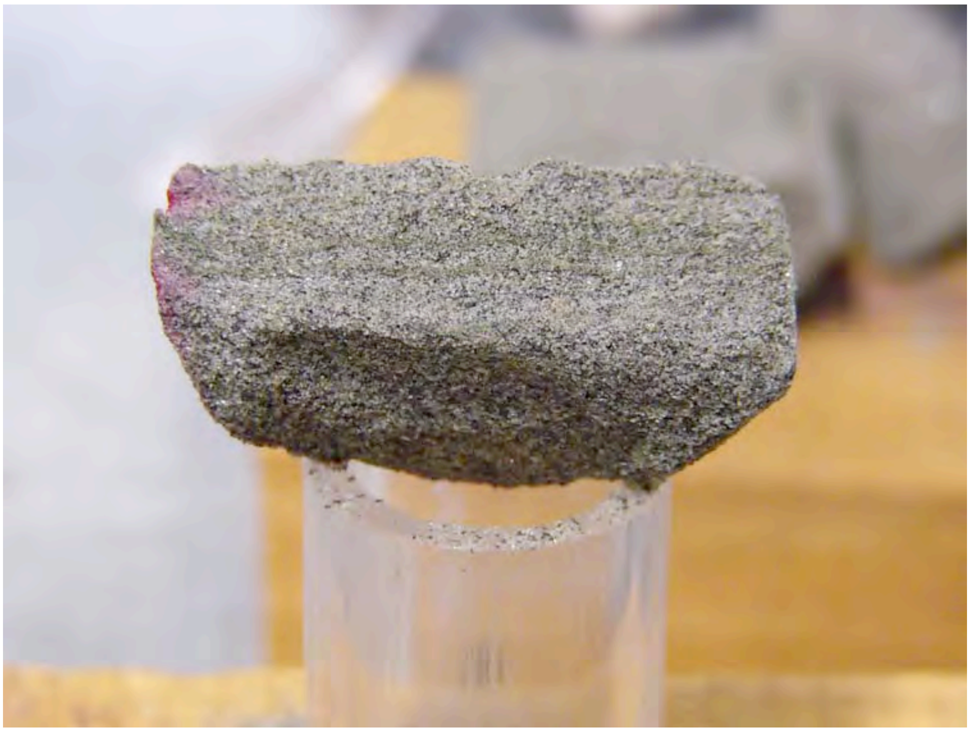


PLATE 1:

Segment of cemented-tailings from BH3, 12.03-12.05 m showing wafer-thin, horizonal laminations.

APPENDIX

LABORATORY REPORTS

Dr G Campbell
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	**143.0/0705837**
No. of SAMPLES	63
CLIENT O/N	GCA0721
PROJECT	Base-Metal Operation
STATE	Tailings-Pore-Fluids and Solids
DATE RECEIVED	28th May, 2007
DATE COMPLETED	4th July, 2007

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

The tailings samples were contained in plastic-walled tubes which were transparent. Tube section were cut with a hack-saw, and contents removed for oven-drying at 80oC in a forced-fan oven which minimises oxidation of sulphide-minerals. After oven-drying, samples were pushed through a 4.75mm sive (brass) and then handmixed prior to testing. Procedures were shown by Dr GD Campbell.

Some grab sub-samples at the time of sampling were taken and deionised-water added to allow measurement of slurry-pH (or “Mud-pH”).

Some samples had tailings-pore-fluids which drained from the tubes, and these pore-fluids were collected, vacuum-filtered (0.45µm membrane), and preserved for analysis, as appropriate.

TAILINGS-PORE-FLUID SAMPLES:

Sample Name	GCA No.	Volume (ml)	Slurry-pH	Slurry-EC (mS/cm)
BH4/1	GCA7084	80	3.2	9.78
BH4/2	GCA7085	220	3.5	6.91
BH1/1	GCA7086	50	4.1	5.29

TAILINGS-SOLIDS SAMPLES:

Sample Name	GCA No.	Slurry-pH	Tray+wet sample (g)	Tray+dry sample (g)	Weight (g) moist-solids	Weight (g) dry-solids	Weight (g) water	Gravimetric Moisture Content
BH4/1a	GCA7087		838.5	644.5	818	624.0	194.0	31.1
BH4/1b	"	4.7	893	686	872.5	665.5	207.0	31.1
BH4/2a	GCA7088		891	694.5	870.5	674.0	196.5	29.2
BH4/2b	"		732.5	562	712	541.5	170.5	31.5
BH4/3a	GCA7089	3.6	578	536.5	557.5	516.0	41.5	8.0
BH4/3b	"		870.5	749.5	850	729.0	121.0	16.6
BH4/3c	"		934.5	746.5	914	726.0	188.0	25.9
BH4/4a	GCA7090		745	712	724.5	691.5	33.0	4.8
BH4/4b	"		746.5	700	726	679.5	46.5	6.8
BH4/4c	"	4.0	737	696	716.5	675.5	41.0	6.1
BH4/5a	GCA7091		645	615	624.5	594.5	30.0	5.0
BH4/5b	GCA7092		824	768	803.5	747.5	56.0	7.5
BH4/5c	"		843	800	822.5	779.5	43.0	5.5
BH4/6a	GCA7093		744.5	713.5	724	693.0	31.0	4.5
BH4/6b	"		819.5	780	799	759.5	39.5	5.2

Sample Name	GCA No.	Slurry-pH	Tray+wet sample (g)	Tray+dry sample (g)	Weight (g) moist-solids	Weight (g) dry-solids	Weight (g) water	Gravimetric Moisture Content
BH4/6c	"		711	686.5	690.5	666.0	24.5	3.7
BH4/7a	GCA7094		673.5	640	653	619.5	33.5	5.4
BH4/7b	GCA7095	4.4	751.5	720.5	731	700.0	31.0	4.4
BH4/7c	"		801	769	780.5	748.5	32.0	4.3
BH4/8a	GCA7096		656	621	635.5	600.5	35.0	5.8
BH4/8b	GCA7097		811	772	790.5	751.5	39.0	5.2
BH4/8c	"	4.8	748	707	727.5	686.5	41.0	6.0
BH3/1a	GCA7105	4.2	1299.5	1102.5	1279	1082.0	197.0	18.2
BH3/2a	GCA7106	4.2	1052	968	1031.5	947.5	84.0	8.9
BH3/2b	"		900.5	855	880	834.5	45.5	5.5
BH3/3a	GCA7107		731	706.5	710.5	686.0	24.5	3.6
BH3/3b	GCA7108	3.9	669.5	649	649	628.5	20.5	3.3
BH3/3c	"		743	720.5	722.5	700.0	22.5	3.2
BH3/5a	GCA7109	3.9	609.5	592.5	589	572.0	17.0	3.0
BH3/5b	"		609	594	588.5	573.5	15.0	2.6
BH3/6a	GCA7110		821	801	800.5	780.5	20.0	2.6
BH3/6b	GCA7111	3.2	983.5	954	963	933.5	29.5	3.2
BH3/8a	GCA7112		829	803.5	808.5	783.0	25.5	3.3
BH3/8b	GCA7113	3.3	939	901	918.5	880.5	38.0	4.3
BH3/9a	GCA7114	4.3	1055	1026.5	1034.5	1006.0	28.5	2.8
BH3/9b	"		992	960.5	971.5	940.0	31.5	3.4
BH3/10a	GCA7115		787.5	763.5	767	743.0	24.0	3.2
BH3/10b	GCA7116	3.6	692.5	669	672	648.5	23.5	3.6
BH3/10c	"		680	658	659.5	637.5	22.0	3.5
BH3/11a	GCA7117	2.8	1098	1061.5	1077.5	1041.0	36.5	3.5
BH3/11b	"		1201.5	1170	1181	1149.5	31.5	2.7
BH3/12a	GCA7118	2.7	1171	1118.5	1150.5	1098.0	52.5	4.8
BH3/12b	Discarded		961.5	906.5	941	886.0	55.0	6.2
BH3/12c	Discarded		816.5	747.5	796	727.0	69	9.5
BH1/1a	Discarded		742.5	556	722	535.5	186.5	34.8
BH1/1b	GCA7098	5.7	582.5	424.5	562	404.0	158.0	39.1
BH1/2a	GCA7099		822	631	801.5	610.5	191	31.3
BH1/2b	GCA7100	5.7	521	387.5	500.5	367.0	133.5	36.4
BH1/3a	GCA7101	5.4	585.5	460.5	565	440	125	28.4
BH1/3b	"		533	434.5	512.5	414	98.5	23.8
BH1/4a	GCA7102		486	377.5	465.5	357	108.5	30.4
BH1/4b	GCA7103	5.4	829	716	808.5	695.5	113.0	16.2
BH1/5a	GCA7104	4.4	555.5	468	535	447.5	87.5	19.6
BH1/5b	"		607.5	538.5	587	518.0	69.0	13.3
BH2/2a	GCA7119	4.2	684.5	563	664	542.5	121.5	22.4
BH2/2b	"		704	564.5	683.5	544.0	139.5	25.6
BH2/2c	"		631	550.5	610.5	530.0	80.5	15.2
BH2/3a	GCA7120	3.9	641	551.5	620.5	531.0	89.5	16.9
BH2/3b	"		719.5	664	699	643.5	55.5	8.6
BH2/3c	"		593.5	566.5	573	546.0	27.0	4.9
BH2/4a	GCA7121	4.3	487	448	466.5	427.5	39.0	9.1
BH2/4b	"		584.5	543.5	564	523.0	41.0	7.8
BH2/4c	"		482.5	451.5	462	431.0	31.0	7.2

NATA Signatory: A Evers
Chief Chemist

Date: 4th July 2007

WORLD RECOGNISED ACCREDITATION

This document is issued in accordance with NATA's accreditation requirements.

Dr G Campbell
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	**143.0/0705929**
No. of SAMPLES	26
CLIENT O/N	GCA0721
PROJECT	Base-Metal Operations
STATE	Tailings
DATE RECEIVED	8th June 2007
DATE COMPLETED	18th July 2007

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

The samples were received as tailings solids which required crushing, drying ,mixing, splitting and fine pulverising in a zirconia bowl.

Results of analysis on:

Element		**S_tot**	**C_tot**	**S-SO4**	**EC**	**pH**
Method		**/LECO**	**/LECO**	**Na2CO3/ GRAV**	**W/METER**	**W/METER**
Detection		**0.005**	**0.01**	**0.01**	**0.01**	**0.1**
Units		**%**	**%**	**%**	**mS/cm**	**NONE**
Sample Name						
Control Blank		X	0.01	X	X	4.4
GCA7087		0.433	0.06	0.21	1.76	3.7
GCA7087	Check	0.430	0.07		1.84	3.7
GCA7088		0.480	0.06	0.23	1.46	3.5
GCA7089		0.333	0.01	0.33	2.33	3.6
GCA7090		0.201	0.03	0.19	0.49	3.9
GCA7092		0.222	X	0.26	0.36	4.0
GCA7093		0.182	0.03	0.21	0.21	4.2
GCA7095		0.253	X	0.28	0.14	4.2
GCA7097		0.297	0.07	0.31	0.14	4.5
GCA7098		0.590	0.08	0.15	1.91	4.4
LECO5		1.999	1.08			
GCA7100		0.571	0.10	0.16	1.88	4.4
GCA7101		0.471	0.06	0.13	1.46	4.4
GCA7103		0.343	0.04	0.13	1.42	4.8
GCA7104		0.333	0.02	0.19	1.61	3.9
GCA7105		2.039	0.03	0.16	0.96	3.9
GCA7106		0.948	0.05	0.12	0.67	3.9
GCA7108		0.725	0.05	0.17	0.79	3.6
GCA7109		1.119	0.08	0.13	0.67	3.6
GCA7111		0.605	0.03	0.13	0.79	3.3
GCA7113		0.490	0.01	0.15	1.30	3.2
GCA7114		1.172	0.02	0.23	1.99	3.7
GCA7116		0.880	0.01	0.35	2.10	3.3
GCA7117		1.522	X	0.82	4.86	2.9

Element		S_tot	C_tot	S-SO4	EC	pH
Method		**/LECO**	**/LECO**	**Na2CO3/ GRAV**	**W/METER**	**W/METER**
Detection		**0.005**	**0.01**	**0.01**	**0.01**	**0.1**
Units		**%**	**%**	**%**	**mS/cm**	**NONE**
GCA7118		1.314	0.03	1.24	4.04	2.8
GCA7119		0.427	0.03	0.17	1.13	3.9
GCA7120		0.232	X	0.24	0.29	4.0
GCA7121		0.203	0.04	0.22	0.13	4.3
LECO8		1.060	1.13			
PD-1				4.32		
S_SO4_A				0.63		
S_SO4_B				1.33		

1. The C,S results were determined from the pulverised portion
2. The Carbon and Sulphur was determined according to Genalysis method number SL_W023.
3. S-SO4 was determined by precipitation of BaSO4 according to Genalysis method number ENV_W039
4. pH and EC were analysed on a 1:2 soil to water extract with results reported on the extract basis according to Genalysis method number MPL_W033.

Acid Neutralisation Capacity (ANC)

Sample Name		Fizz Rating	Sample Weight (g)	Molarity HCl	Molarity NaOH	Initial Efferve scence	colour change *	pH drop *	ANC Solution pH	ANC (kg H2SO4/tonne)
GCA7087		0	2	0.4788	0.1051	None	N	3.2	1.9	13
GCA7087	Check	0	2	0.4788	0.1051	None	N	3.3	1.9	12
GCA7088		0	2	0.4788	0.1051	None	N	3.2	2.0	12
GCA7089		0	2	0.4788	0.1051	None	N	NA	1.8	6
GCA7090		0	2	0.4788	0.1051	None	N	NA	2.0	5
GCA7092		0	2	0.4788	0.1051	None	N	3.2	1.7	10
GCA7093		0	2	0.4788	0.1051	None	N	NA	1.7	11
GCA7095		0	2	0.4788	0.1051	None	N	NA	1.7	11
GCA7097		0	2	0.4788	0.1051	None	N	NA	2.0	5
GCA7098		0	2	0.4788	0.4788	None	N	NA	1.4	67
GCA7100		0	2	0.4788	0.4788	None	N	NA	1.4	68
GCA7101		0	2	0.4788	0.1051	None	N	3.2	2.0	14
GCA7103		0	2	0.4788	0.1051	None	N	NA	2.0	14
GCA7104		0	2	0.4788	0.1051	None	N	NA	2.0	11
GCA7105		0	2	0.4788	0.1051	None	N	NA	1.8	7
GCA7106		0	2	0.4788	0.1051	None	N	NA	1.9	16
GCA7108		0	2	0.4788	0.1051	None	N	NA	1.7	11
GCA7109		0	2	0.4788	0.1051	None	N	3.4	1.8	11
GCA7111		0	2	0.4788	0.1051	None	N	NA	1.8	11
GCA7113		0	2	0.4788	0.1051	None	N	3.3	1.8	11
GCA7114		0	2	0.4788	0.1051	None	N	NA	1.8	10
GCA7116		0	2	0.4788	0.1051	None	N	NA	1.8	7
GCA7117		0	2	0.4788	0.1051	None	N	NA	2.0	-5
GCA7118		0	2	0.4788	0.1051	None	N	NA	1.9	-8
GCA7119		0	2	0.4788	0.1051	None	N	NA	2.0	11
GCA7120		0	2	0.4788	0.1051	None	N	NA	2.0	4
GCA7121		0	2	0.4788	0.1051	None	N	NA	1.7	9

Notes:

1. ANC was determined on the -2mm portion. Acid concentrations are as stated
2. Colour change: * Indicates the appearance of a green colouration as the pH=7 endpoint was approached. Two drops of hydrogen peroxide are added to each sample as the endpoint is approached to oxidise any ferrous iron
3. pH drop : * Indicates a pH drop to a value below 4 on addition of peroxide
4. This procedure according to Genalysis methods number ENV_W035
5. A negative ANC indicates that acid was present in the sample in excess of that added for the test by that amount.

NATA ENDORSED DOCUMENT
Company Accreditation Number 3244
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NATA Signatory: A Evers
Chief Chemist

Date: 18th July 2007

This document is issued in accordance with NATA's accreditation requirements.

LABORATORY REPORT COVERSHEET

Date: 17 July 2007

To: Graeme Campbell & Associates
PO Box 247
Bridgetown WA 6255

Attention: Dr Graeme Campbell

Your Reference: GCA 0721 12660
Laboratory Report No: 56337
Samples Received: 13/07/2007
Samples / Quantity: 12 Soil

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

Shey Goddard
Administration Manager
CAIRNS

Jon Dicker
Manager
CAIRNS

SGS Australia Pty Ltd ABN 44 000 964 278 | Environmental Services Unit 2, 58 Comport Street, Portsmith 4870 QLD Australia www.au.sgs.com
t +61 (0)7 4035 5111 f +61 (0)7 4035 5122

Member of the SGS Group

CLIENT: Graeme Campbell & Associates **Laboratory Report No:** 56337
PROJECT: GCA 0721 12660

LABORATORY REPORT

-------- Our Reference Your Reference	Units	56337-1 GCA 7093	56337-2 GCA 7089	56337-3 GCA 7087
Chromium Reducible Sulfur (S_{CR})	% w/w	<0.005	0.069	0.23

-------- Our Reference Your Reference	Units	56337-4 GCA 7119	56337-5 GCA 7118	56337-6 GCA 7117
Chromium Reducible Sulfur (S_{CR})	% w/w	0.26	0.12	0.64

-------- Our Reference Your Reference	Units	56337-7 GCA 7116	56337-8 GCA 7113	56337-9 GCA 7109
Chromium Reducible Sulfur (S_{CR})	% w/w	0.51	0.33	0.85

-------- Our Reference Your Reference	Units	56337-10 GCA 7105	56337-11 GCA 7103	56337-12 GCA 7098
Chromium Reducible Sulfur (S_{CR})	% w/w	1.5	0.22	0.42

CLIENT: Graeme Campbell & Associates **Laboratory Report No:** 56337
PROJECT: GCA 0721 12660

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD

Chromium Reducible Sulfur (S_{CR})	% w/w	0.005	ASSMAC_22B / CEI-405

CLIENT: Graeme Campbell & Associates **Laboratory Report No:** 56337
PROJECT: GCA 0721 12660

LABORATORY REPORT

QUALITY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate
Chromium Reducible Sulfur (S_{CR})	% w/w	[NT]	56337-1	<0.005 || <0.005
QUALTY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate
Chromium Reducible Sulfur (S_{CR})	% w/w	[NT]	56337-11	0.22 || 0.22 || RPD: 0

NOTES:

LOR - Limit of Reporting.

* This test is not covered by our current NATA accreditation.

Analysis Date: **Between** 13/07/07 **and** 16/07/07

SGS Terms and Conditions are available from www.au.sgs.com

pH-(1:2) & EC-(1:2) TESTWORK

SAMPLE NO.	SAMPLE WEIGHT (g)	SAMPLE + DEION.-W WEIGHT (g)	pH-(1:2)	EC-(1:2) (mS/cm)
GCA7087	30.0	90.0	3.9	1.5
GCA7088	30.0	90.0	3.8	0.95
GCA7089	30.0	90.1	3.8	1.9
GCA7090	30.0	90.4	4.0	0.47
GCA7092	30.0	90.1	4.1	0.30
GCA7093	30.0	90.5	4.3	0.19
GCA7095	30.0	90.3	4.3	0.13
GCA7097	30.0	90.0	4.6	0.12
GCA7098	30.0	90.2	4.6	1.1
GCA7100	30.0	90.5	4.6	1.1
GCA7101	30.0	90.0	4.6	0.98
GCA7103	30.0	90.3	5.0	1.1
GCA7104-1	30.0	90.2	4.0	1.1
GCA7104-2	30.0	90.1	4.0	1.1
GCA7105	30.0	90.2	4.0	0.77
GCA7106	30.0	90.1	4.0	0.56
GCA7108	30.0	90.3	3.8	0.58
GCA7109	30.0	90.4	3.8	0.55
GCA7111	30.0	90.3	3.4	0.62
GCA7113	30.0	90.6	3.3	0.99
GCA7114	30.0	90.3	3.9	1.6
GCA7116	30.0	90.0	3.5	1.6
GCA7117	30.0	90.1	3.1	4.3
GCA7118	30.0	90.1	2.9	3.6
GCA7119	30.0	90.3	4.3	0.49
GCA7120	30.0	90.4	4.2	0.28
GCA7121	30.0	90.5	4.4	0.13

Note: EC = Electrical-Conductivity.
Testwork performed on crushed (nominal -2 mm) samples.
pH-(1:2) and EC-(1:2) values correspond to pH and EC values of suspensions with a solid:solution ration of *c.* 1:2 (w/w) prepared using deionised-water.
Drift in pH-glass-electrode less than 0.1 pH unit between commencement, and completion, of testwork.
Drift in EC-electrode less than 0.05 mS/cm between commencement, and completion, of testwork.
Testwork performed in a constant-temperature room (viz. 21 +/- 2-3 ^{o}C).

pH-(1:2) & EC-(1:2) TESTWORK (REPEAT)

SAMPLE NO.	SAMPLE WEIGHT (g)	SAMPLE + DEION.-W WEIGHT (g)	pH-(1:2)	EC-(1:2) (mS/cm)
GCA7087	30.0	90.1	3.8	0.94
GCA7088	30.0	90.3	3.6	1.1
GCA7089	30.0	90.1	3.7	1.9
GCA7090	30.0	90.4	3.9	0.39
GCA7092	30.0	90.3	4.0	0.34
GCA7093	30.0	90.3	4.1	0.21
GCA7095	30.0	90.2	4.1	0.16
GCA7105	30.0	90.2	3.9	0.81
GCA7106	30.0	90.0	3.9	0.55
GCA7108	30.0	90.3	3.6	0.67
GCA7109	30.0	90.3	3.7	0.60
GCA7111	30.0	90.0	3.3	0.67
GCA7113	30.0	90.3	3.3	1.1
GCA7114	30.0	90.0	3.9	1.4
GCA7116	30.0	90.5	3.5	1.8
GCA7117	30.0	90.4	3.1	4.4
GCA7118	30.0	90.2	2.9	3.7
GCA7119	30.0	90.0	4.2	1.10
GCA7120	30.0	90.1	4.1	0.36
GCA7121	30.0	90.0	4.3	0.16

Note: EC = Electrical-Conductivity.
Testwork performed on crushed (nominal -2 mm) samples.
pH-(1:2) and EC-(1:2) values correspond to pH and EC values of suspensions with a solid:solution ration of *c.* 1:2 (w/w) prepared using deionised-water.
Drift in pH-glass-electrode less than 0.1 pH unit between commencement, and completion, of testwork.
Drift in EC-electrode less than 0.05 mS/cm between commencement, and completion, of testwork.
Testwork performed in a constant-temperature room (viz. 21 +/- 2-3 ^{o}C).

Dr GD Campbell
28th June 2007

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.5 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA7087	3.0	Reaction peaked within 2 hrs	2.9	3.4	390	3.20	5.3
GCA7088	3.0	Reaction peaked within 2 hrs	2.7	3.2	480	5.90	9.7
GCA7089	3.0	Reaction peaked overnight	3.6	3.4	300	3.20	5.3
GCA7090	3.0	Reaction peaked overnight	7.0	6.7	240	-	<0.5
GCA7092	3.0	Reaction peaked overnight	4.4	3.3	300	1.60	2.7
GCA7093	3.0	Reaction peaked overnight	4.3	3.3	300	1.50	2.5
GCA7095	3.0	Reaction peaked overnight	7.1	7.8	280	-	<0.5
GCA7097	3.0	Reaction peaked overnight	4.6	3.3	340	1.70	2.8
GCA7098	3.0	Reaction peaked within 2 hrs	2.7	3.2	620	6.50	11
GCA7100	3.0	Reaction peaked within 2 hrs	2.6	3.0	630	7.40	13
GCA7101	3.0	Reaction peaked within 2 hrs	2.6	3.1	560	6.10	10
GCA7103	3.0	Reaction peaked within 2 hrs	2.9	3.5	440	4.70	7.7
GCA7104	3.0	Reaction peaked within 2 hrs	2.9	3.4	390	3.80	6.3
GCA7105	3.0	Reaction peaked within 2 hrs	2.2	2.6	1,300	17.30	29
GCA7106	3.0	Reaction peaked within 2 hrs	2.4	3.0	830	6.70	11
GCA7108	3.0	Reaction peaked within 2 hrs	2.4	2.7	950	8.90	15
GCA7109-1	3.0	Reaction peaked within 2 hrs	2.2	2.6	1,300	14.40	24
GCA7109-2	3.0	Reaction peaked within 2 hrs	2.2	2.6	1,300	12.40	21
Blank	3.0		5.9	6.5	76	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997). The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Test mixtures boiled for *c.* 2 hours to accelerate reaction with H_2O_2. Then, after allowing the test mixtures to cool, 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted H_2O_2 in the test mixtures (O'Shay *et al.* 1990). K-Feldspar was employed for the Blanks.

Dr GD Campbell
4th July 2007

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.5 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA7111	3.0	Reaction peaked within 2 hrs	2.4	2.8	760	9.00	15
GCA7113	3.0	Reaction peaked within 2 hrs	2.6	3.1	510	5.20	8.5
GCA7114	3.0	Reaction peaked within 2 hrs	2.3	2.6	930	14.10	24
GCA7116	3.0	Reaction peaked within 2 hrs	2.5	2.6	870	9.90	17
GCA7117	3.0	Reaction peaked within 2 hrs	2.5	2.5	1,100	12.20	20
GCA7118	3.0	Reaction peaked overnight	3.1	2.8	660	7.10	12
GCA7119	3.0	Reaction peaked within 2 hrs	2.9	3.2	460	4.00	6.6
GCA7120	3.0	Reaction peaked overnight	4.1	3.4	250	2.30	3.8
GCA7121-1	3.0	Reaction peaked overnight	4.9	3.5	200	2.60	4.3
GCA7121-2	3.0	Reaction peaked within 2 hrs	4.3	3.3	270	2.90	4.8
Blank	3.0		5.9	6.7	55	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997). The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Test mixtures boiled for *c*. 2 hours to accelerate reaction with H_2O_2. Then, after allowing the test mixtures to cool, 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test mixtures again boiled for *c*. 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted H_2O_2 in the test mixtures (O'Shay *et al.* 1990). K-Feldspar was employed for the Blanks.

Dr GD Campbell
4th July 2007

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0705930
No. of SAMPLES	:	11
No. of ELEMENTS	:	32
CLIENT O/N	:	GCA0721 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	Base-Metals Operation (Tailings -Soli
STATE	:	Pulp
DATE RECEIVED	:	08/06/2007
DATE COMPLETED	:	29/06/2007
DATE PRINTED	:	29/06/2007

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

MAIN OFFICE AND LABORATORY

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SAMPLE DETAILS

DISCLAIMER

Genalysis Laboratory Services Pty Ltd wishes to make the following disclaimer pertaining to the accompanying analytical results.

Genalysis Laboratory Services Pty Ltd disclaims any liability, legal or otherwise, for any inferences implied from this report relating to either the origin of, or the sampling technique employed in the collection of, the submitted samples.

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $3.00 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $50.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The 11 samples, as listed in the report, were received as being 'tailings solids' which had been pulverised in a zirconia bowl.

The results have been determined according to Genalysis methods codes :
Digestions : SL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), SL_W013 (D/), SL_W012 (CM/).
Analytical Finishes: ICP_W004 (/OES), ICP_W005 (/MS), and AAS_W004 (/CVAP).

The results included the assay of blanks and international reference standards OREAS 45P and SY-2 and Genalysis in-house standards MPL-1,HgSTD-4, and Se_Std.

The results are expressed as parts per million or percent by mass in the dried and prepared material.

NATA Signatory: A Evers
Chief Chemist

Date: 29th June 2007

This document is issued in accordance with NATA's accreditation requirements.

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	0.1	0.02	1	50	0.1	0.01	10	0.1	0.1	2
DIGEST	A/	D/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA7088	0.3	7.48	1	X	240.7	67.99	2032	X	99.0	76
0002 GCA7093	0.1	5.29	X	X	176.5	40.73	919	X	32.8	53
0003 GCA7097	0.3	5.26	X	X	136.9	77.37	782	X	34.4	56
0004 GCA7100	0.4	7.80	1	X	254.9	63.14	2045	X	101.8	101
0005 GCA7104	0.4	7.15	1	X	217.7	68.91	1642	X	78.3	94
0006 GCA7105	2.2	6.76	X	X	93.3	122.25	1393	X	121.6	63
0007 GCA7108	0.7	5.00	X	X	115.4	80.68	1004	X	60.5	57
0008 GCA7111	0.6	5.91	X	X	91.3	47.05	1159	X	66.0	62
0009 GCA7114	0.4	6.49	1	51	107.2	78.06	1261	X	93.7	67
0010 GCA7117	1.0	7.10	2	X	59.0	91.34	1462	X	130.9	62
0011 GCA7120	0.4	5.96	X	X	187.7	61.33	1127	X	36.1	69
CHECKS										
0001 GCA7088	0.5	7.45	X	X	246.5	67.94	2029	X	100.1	90
STANDARDS										
0001 HgSTD-4										
0002 MPL-1	16.4		784		150.3	27.94	1.24%	5.1	160.3	1153
0003 OREAS 45P		6.54		X						
0004 Se_Std										
0005 SY-2										
BLANKS										
0001 Control Blank	X	X	X	X	X	0.01	16	X	0.1	X
0002 Control Blank										
0003 Control Blank										
0004 Control Blank		X		X						
0005 Acid Blank	X		X		X	0.03	X	X	0.1	X
0006 Acid Blank										
0007 Acid Blank		X		X						

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA7088	389	990	12.59	X	2.30%	2.52%	948	0.7	1002	53
0002 GCA7093	239	633	8.21	X	1.58%	1.58%	904	1.0	514	25
0003 GCA7097	524	524	10.48	X	1.23%	1.47%	1513	1.3	481	20
0004 GCA7100	434	1008	12.77	X	2.42%	2.62%	1072	1.1	994	45
0005 GCA7104	1236	849	11.65	X	2.03%	2.38%	992	1.2	745	41
0006 GCA7105	4195	392	16.37	X	9015	1.21%	4250	2.1	428	42
0007 GCA7108	449	430	10.25	X	1.04%	1.32%	1760	1.0	511	29
0008 GCA7111	451	387	14.28	X	8165	1.28%	2855	0.7	330	28
0009 GCA7114	608	456	14.87	X	9911	1.36%	3133	0.8	366	43
0010 GCA7117	1511	247	19.48	0.02	5428	1.21%	4944	0.8	185	34
0011 GCA7120	286	682	9.04	X	1.71%	1.66%	1018	0.8	526	22
CHECKS										
0001 GCA7088	391	978	12.44	X	2.32%	2.53%	955	0.6	1000	55
STANDARDS										
0001 HgSTD-4				0.29						
0002 MPL-1	1877				2893	3.65%	1882	55.4	2.83%	1758
0003 OREAS 45P			19.20							
0004 Se_Std										
0005 SY-2		4723								
BLANKS										
0001 Control Blank	X	60	X	X	X	X	X	0.2	X	X
0002 Control Blank										
0003 Control Blank				0.01						
0004 Control Blank			X							
0005 Acid Blank	X				X	X	X	X	X	X
0006 Acid Blank				X						
0007 Acid Blank			X							

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	20	2	10	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA7088	828	28	4913	X	0.64	13.3	19.23	17.59	0.86	4.39
0002 GCA7093	435	15	1849	X	0.41	6.1	9.48	9.77	0.62	2.27
0003 GCA7097	408	14	2943	X	0.97	6.7	10.52	9.65	0.47	2.22
0004 GCA7100	795	26	5820	0.07	0.71	14.0	17.21	19.66	0.92	4.71
0005 GCA7104	685	25	3408	0.21	1.09	11.2	18.59	17.07	0.79	4.24
0006 GCA7105	456	20	1.82%	0.07	3.11	6.6	17.21	11.09	0.42	2.55
0007 GCA7108	414	18	6685	X	1.17	6.1	11.07	9.25	0.42	2.33
0008 GCA7111	450	12	6196	X	1.43	8.2	8.71	9.40	0.32	2.25
0009 GCA7114	478	15	1.10%	X	1.48	5.9	7.88	10.61	0.41	2.63
0010 GCA7117	468	10	1.41%	X	2.29	5.2	5.96	10.47	0.23	2.52
0011 GCA7120	553	16	2360	X	0.70	7.6	13.41	12.37	0.69	2.74
CHECKS										
0001 GCA7088	817	28	5031	X	0.61	13.3	19.49	17.37	0.87	4.45
STANDARDS										
0001 HgSTD-4										
0002 MPL-1	582	1526	1.88%	195.28		3.9	402.56	93.87	11.31	8.61
0003 OREAS 45P										
0004 Se_Std					0.64					
0005 SY-2										
BLANKS										
0001 Control Blank	X	X	25	X	X	0.2	X	0.02	X	X
0002 Control Blank					X					
0003 Control Blank										
0004 Control Blank										
0005 Acid Blank	X	X	13	0.07		X	0.06	0.02	X	0.01
0006 Acid Blank										
0007 Acid Blank										

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA7088	96	73
0002 GCA7093	69	38
0003 GCA7097	70	35
0004 GCA7100	98	77
0005 GCA7104	89	61
0006 GCA7105	61	48
0007 GCA7108	59	46
0008 GCA7111	66	40
0009 GCA7114	70	46
0010 GCA7117	64	37
0011 GCA7120	75	46

CHECKS		
0001 GCA7088	96	73

STANDARDS		
0001 HgSTD-4		
0002 MPL-1	250	1189
0003 OREAS 45P		
0004 Se_Std		
0005 SY-2		

BLANKS		
0001 Control Blank	X	X
0002 Control Blank		
0003 Control Blank		
0004 Control Blank		
0005 Acid Blank	X	X
0006 Acid Blank		
0007 Acid Blank		

METHOD CODE DESCRIPTION

A/MS

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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www.coffey.com.au

TEST CERTIFICATE

Client: Graeme Campbell & Associates P/L
Principal: -
Project: Kanmantoo Project
Location: -

Report No.: HERD07S-03156-9
Job No.: LABTHERD00243AA
Date Tested: 28/06/2007

Soil Particle Density
AS 1289.3.5.1

Laboratory Number		HERD07S-03156	HERD07S-03157	HERD07S-03158	HERD07S-03159
Sample Identification		GCA 7091	GCA 7094	GCA 7096	GCA 7099
Temperature of Test	C	20°	20°	20°	20°
Average Soil Particle Density -2.36mm t/m^3		2.83	2.83	2.93	2.95
Average Soil Particle Density +2.36mm t/m^3		-	-	-	-
Average Soil Particle Total Sample t/m^3		-	-	-	-

Remarks: Sampling Method/s - Submitted by client

W. Rozmianiec

Date: 4/07/2007

coffey geotechnics
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TEST CERTIFICATE

Client: Graeme Campbell & Associates P/L
Principal: -
Project: Kanmantoo Project
Location: -

Report No.: HERD07S-03160-63
Job No.: LABTHERD00243AA
Date Tested: 28/06/2007

Soil Particle Density
AS 1289.3.5.1

Laboratory Number	HERD07S-03160	HERD07S-03161	HERD07S-03162	HERD07S-03163
Sample Identification	GCA 7102	GCA 7107	GCA 7110	GCA 7112
Temperature of Test C	20°	20°	20°	20°
Average Soil Particle Density -2.36mm t/m^3	2.94	2.93	3.12	3.09
Average Soil Particle Density +2.36mm t/m^3	-	-	-	-
Average Soil Particle Total Sample t/m^3	-	-	-	-

Remarks: Sampling Method/s - Submitted by client

W. Rozmianiec

Date: 4/07/2007

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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TEST CERTIFICATE

Client: Graeme Campbell & Associates P/L
Principal: -
Project: Kanmantoo Project
Location: -

Report No.: HERD07S-03164
Job No.: LABTHERD00243AA
Date Tested: 28/06/2007

Soil Particle Density
AS 1289.3.5.1

Laboratory Number		HERD07S-03164			
Sample Identification		GCA 7115			
Temperature of Test	C	20°			
Average Soil Particle Density -2.36mm t/m^3		2.98			
Average Soil Particle Density +2.36mm t/m^3		-			
Average Soil Particle Total Sample t/m^3		-			

Remarks: Sampling Method/s - Submitted by client

W. Rozmianiec

Date: 4/07/2007

coffey geotechnics
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TEST CERTIFICATE

Client: Graeme Campbell & Associates
Principal: -
Project: Kanmantoo Project
Location: -

Report No.: HERD07S-03246-61
Job No.: LABTHERD00243AA
Date Tested: 3/07/2007

Particle Size Distribution (Part - % Fines)
AS 1289.3.6.1(Part)

Laboratory No.	Sample Identification	Percent Finer Than 0.075mm (%)
HERD07S-03246	BH3 @ 8.00-8.10	11
HERD07S-03247	BH3 @ 8.10-8.20	8
HERD07S-03248	BH3 @ 8.20-8.30	9
HERD07S-03249	BH3 @ 8.30-8.40	11
HERD07S-03250	BH3 @ 8.40-8.50	15
HERD07S-03251	BH3 @ 8.50-8.60	11
HERD07S-03252	BH3 @ 8.60-8.70	9
HERD07S-03253	BH3 @ 8.70-8.80	8
HERD07S-03254	BH3 @ 8.80-8.90	9
HERD07S-03255	BH3 @ 11.63-11.73	7
HERD07S-03256	BH3 @ 11.73-11.83	10
HERD07S-03257	BH3 @ 11.83-11.93	8
HERD07S-03258	BH3 @ 11.93-12.03	10
HERD07S-03259	BH3 @ 12.03-12.05	24
HERD07S-03260	BH3 @ 12.05-12.13	13
HERD07S-03261	BH3 @ 12.13-12.15	11

Remarks: Sampling Method/s - Submitted by client

NATA

This document is issued in accordance with NATA's Accreditation Requirements. Accredited for compliance with ISO/IEC 17025

Authorised Signature:

W.Rozmianiec
Date: 6/07/2007
NATA Acc. Laboratory No 431

LABORATORY REPORT COVERSHEET

DATE: 25 June 2007

TO: Graeme Campbell & Associates Pty Ltd
PO Box 247
BRIDGETOWN WA 6255

ATTENTION: Dr Graeme Campbell

YOUR REFERENCE: GCA Job no. 0721

OUR REFERENCE: 12289

SAMPLES RECEIVED: 13/06/2007

SAMPLES/QUANTITY: 3 Waters

The above samples were received intact and analysed according to your instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

PETER KEYTE
Business Manager

SGS Australia Pty Ltd | Environmental Services | 52 Murray Road | Welshpool 6106 | Western Australia | www.au.sgs.com
ABN 44 000 964 278 | t +61 (0)8 9458 7278 | f +61 (0)8 9451 3505

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 12289
PROJECT: GCA Job no. 0721

LABORATORY REPORT

Your Reference Our Reference Type of Sample	Units	GCA 7084 12289-1 Water	GCA 7085 12289-2 Water	GCA 7086 12289-3 Water
Chloride, Cl	mg/L	170	78	280
Sulphate, SO_4	mg/L	12,000	7,700	2,900

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 12289
PROJECT: GCA Job no. 0721

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Waters and Wastewaters			
Chloride, Cl	mg/L	1	PEI-020
Sulphate, SO_4	mg/L	1	PEI-020

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 12289
PROJECT: GCA Job no. 0721

LABORATORY REPORT

QUALITY CONTROL	UNITS	Blank	Replicate Sm#	Replicate Sample||Replicate	Spike Sm#	Matrix Spike (%)
Chloride, Cl	mg/L	<1	[NT]	[NT]	Control	95%
Sulphate, SO_4	mg/L	<1	[NT]	[NT]	Control	109%

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 12289
PROJECT: GCA Job no. 0721

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.

This test is not covered by the scope of our NATA accreditation.
SGS terms and conditions are available from www.au.sgs.com

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0706114
No. of SAMPLES	:	3
No. of ELEMENTS	:	31
CLIENT O/N	:	GCA0721 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	Tailings-Porefluid Samples
STATE	:	Solutions
DATE RECEIVED	:	14/06/2007
DATE COMPLETED	:	10/07/2007
DATE PRINTED	:	10/07/2007

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

MAIN OFFICE AND LABORATORY

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SAMPLE DETAILS

DISCLAIMER

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Genalysis Laboratory Services Pty Ltd disclaims any liability, legal or otherwise, for any inferences implied from this report relating to either the origin of, or the sampling technique employed in the collection of, the submitted samples.

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

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SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $3.00 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $50.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ***

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The samples, GCA7084, GCA7085 and GCA7086 were received as being 'tailings porefluids'.

The results have been determined according to Genalysis methods numbers ICP_W004 and ICP_W005.

The analysis included the assay of blanks and Genalysis in-house reference standards. The results are expressed as milligrams per litre or micrograms per litre in the solution.

NATA Signatory: H Pham
ICP Chemist

Date: 10th July 2007

This document is issued in accordance with NATA's accreditation requirements.

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ug/l	mg/l	mg/l	mg/l	ug/l	ug/l	mg/l	ug/l	mg/l	mg/l
DETECTION	0.1	0.1	0.001	0.1	0.5	0.05	0.1	0.2	0.001	0.1
DIGEST										
ANALYTICAL FINISH	/MS	/OES	/MS	/OES	/MS	/MS	/OES	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA7084	X	3.7	0.008	0.5	9.8	0.07	443.6	1.9	29.091	X
0002 GCA7085	X	5.5	0.007	0.4	20.6	X	464.3	3.0	30.199	X
0003 GCA7086	X	1.0	0.002	0.3	41.3	X	498.0	2.4	0.261	X
CHECKS										
0001 GCA7084	X	3.8	0.007	0.4	9.7	0.06	453.2	1.9	30.893	X
STANDARDS										
0001 Alcoa5-OES		2.1		0.9			51.7			0.6
0002 Alcoa8-MS	5.3		0.027		5.0	4.90		5.8	0.519	
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na	Ni	P
UNITS	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
DETECTION	0.1	1	1	1	0.1	0.1	0.5	1	0.1	1
DIGEST										
ANALYTICAL FINISH	/OES	/OES	/MS	/OES	/OES	/OES	/MS	/OES	/OES	/OES
SAMPLE NUMBERS										
0001 GCA7084	1.0	3427	X	283	867.0	111.2	1.7	112	5.5	X
0002 GCA7085	X	2827	X	84	323.1	68.9	0.7	63	8.2	X
0003 GCA7086	X	210	X	310	241.3	16.6	0.6	415	X	X
CHECKS										
0001 GCA7084	1.0	3347	X	301	888.9	110.4	1.9	117	5.5	X
STANDARDS										
0001 Alcoa5-OES	0.3	2		4	62.3	0.5		248	0.6	X
0002 Alcoa8-MS			5				5.3			
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Pb	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	mg/l	ug/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
DETECTION	0.005	0.1	0.005	0.5	1	0.2	0.05	0.1	0.05	0.1
DIGEST										
ANALYTICAL FINISH	/MS	/MS	/MS	/OES	/MS	/MS	/MS	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA7084	0.007	X	0.006	23.1	3	135.1	1.03	X	5.53	X
0002 GCA7085	X	X	X	24.4	3	225.3	0.13	X	3.05	X
0003 GCA7086	0.016	X	X	15.4	2	1364.8	0.08	X	2.76	X
CHECKS										
0001 GCA7084	0.007	X	0.006	23.1	3	135.7	1.01	X	5.60	X
STANDARDS										
0001 Alcoa5-OES				11.1						0.5
0002 Alcoa8-MS	0.007	5.4	0.024		6	482.7	5.61	4.9	5.33	
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Zn
UNITS	mg/l
DETECTION	0.1
DIGEST	
ANALYTICAL FINISH	/OES
SAMPLE NUMBERS	
0001 GCA7084	2.3
0002 GCA7085	5.5
0003 GCA7086	0.2

CHECKS	
0001 GCA7084	2.3

STANDARDS	
0001 Alcoa5-OES	0.5
0002 Alcoa8-MS	

BLANKS	
0001 Control Blank	X

METHOD CODE DESCRIPTION

/MS

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Mass Spectrometry.

/OES

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0705612
No. of SAMPLES	:	7
No. of ELEMENTS	:	5
CLIENT O/N	:	GCA0721 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	Column - Leachates Samples
STATE	:	Solutions
DATE RECEIVED	:	31/05/2007
DATE COMPLETED	:	11/06/2007
DATE PRINTED	:	11/06/2007

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

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Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

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GENERAL CONDITIONS

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Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

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The analysis results reported herein have been obtained using the following methods and conditions:

The 7 samples, as listed in the report, were received as being column leachates.

The results have been determined according to Genalysis methods numbers ICP_W005.

The analysis included the assay of blanks and Genalysis in-house reference standards. The results are expressed as milligrams per litre in the solution.

NATA Signatory: H Pham
ICP CHemist

Date: 8th June 2007

This document is issued in accordance with NATA's accreditation requirements.

ANALYSIS

ELEMENTS	Al	Cu	Fe-Sol	Mn	S
UNITS	mg/l	mg/l	mg/l	mg/l	mg/l
DETECTION	0.01	0.01	0.01	0.01	0.1
DIGEST					
ANALYTICAL FINISH	/OES	/OES	/OES	/OES	/OES
SAMPLE NUMBERS					
0001 GCA6298-1-1	70.80	17.74	155.14	6.64	385.7
0002 GCA6298-1-2	4.82	2.40	7.57	0.67	46.3
0003 GCA6298-1-3	1.54	1.15	2.76	0.25	21.7
0004 GCA6298-2	20.34	3.96	50.75	0.82	114.6
0005 GCA6298-3	24.07	4.50	46.70	1.23	129.2
0006 GCA6298-4	25.48	3.69	61.30	0.84	136.4
0007 GCA6298-5	19.45	2.84	35.57	0.61	99.3
CHECKS					
0001 GCA6298-1-1	66.62	16.71	146.37	6.22	353.4
STANDARDS					
0001 Alcoa5-OES	2.10	0.25	2.13	0.53	21.8
BLANKS					
0001 Control Blank	X	X	X	X	X

METHOD CODE DESCRIPTION

/OES

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

HILLGROVE RESOURCES PTY LTD

KANMANTOO COPPER PROJECT

GEOCHEMICAL CHARACTERISATION OF

PROCESS-TAILINGS-SLURRY SAMPLE

[STATIC-TESTWORK]

Implications for Process-Tailings Management

GRAEME CAMPBELL AND ASSOCIATES PTY LTD
(ACN 061 827674)
JANUARY 2007
Job No. 0616

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TABLES AND APPENDICES

(At Back of Report Text)

SUMMARY OF TECHNICAL TERMS EMPLOYED IN THIS REPORT

ACRONYM	PARAMETER	DEFINITION/DETERMINATION	UNIT
AFP	Acid-Formation Potential		
ARD	Acid-Rock Drainage		
Total-S	Total Sulphur	Analysis Result	% (w/w)
Sulphide-S	Sulphide Sulphur	Testwork Result [i.e. Sulphide-S = Total-S - Sulphate-S]	% (w/w)
ANC	Acid-Neutralisation Capacity	Testwork Result	kg H_2SO_4/tonne
MPA	Maximum-Potential Acidity	Calculation	kg H_2SO_4/tonne
NAPP	Net-Acid-Producing Potential	Calculation	kg H_2SO_4/tonne
NAG	Net-Acid Generation	Testwork Result	kg H_2SO_4/tonne
NAF	Non-Acid Forming	Calculation: • Sulphide-S < 0.3 % • Sulphide-S ≥ 0.3 %, and negative-NAPP value with ANC/MPA ≥ 2.0	kg H_2SO_4/tonne
PAF	Potentially-Acid Forming	Calculation: • Sulphide-S ≥ 0.3 %, and any positive-NAPP value • Sulphide-S ≥ 0.3 %, and a negative-NAPP value with ANC/MPA < 2.0	kg H_2SO_4/tonne
PAF-[SL]	PAF-[Short-Lag]	Estimation [e.g. inferred from 'kinetic' testing]	
PAF-[LL]	PAF-[Long-Lag]	Estimation [e.g. inferred from 'kinetic' testing]	
SOR	Sulphide-Oxidation Rate	Testwork Result [e.g. obtained from 'kinetic' testing]	mg SO_4/kg/week,

Notes:

The **PAF-[SL**] classification applies to PAF-materials (e.g. mine-wastes, and/or process-tailings) that are initially circum-neutral, but acidify (viz. pH less than 5) within weeks-to-months when exposed, and subjected to an "aggressive-weathering" regime typical of well-watered environments (e.g. where unsaturated-conditions prevail for at least a few days [via drainage/evaporation processes] between successive infiltration/flushing episodes that, in turn, occur regularly [e.g. monthly rainfall patterns comprising 1-2+ major-raindays of 10+ mm "on-average" during most of the annual hydrological-cycle]). The occurrence of thin, dilute films of pore-fluids on sulphide-grain surfaces which are regularly flushed constitutes an aeration/moisture regime that is near-optimal for sulphide-oxidation. In such well-watered settings, surface-zones of exposed mine-wastes/process-tailings seldom experience total-suctions in excess of 1+ bars (i.e. 0.1+ MPa).

The **PAF-[LL]** classification applies to PAF-materials where exposure for years (even decades+) may be needed before acidification develops. Circum-neutral-pH during "lag-phase" weathering is chiefly due to "at-source" buffering by carbonate-minerals.

Climate directly influences "lag-phase" duration, and a sulphide-gangue assemblage classified as PAF-[SL] in well-watered settings where the SOR is controlled by **O_2-supply**, may instead be classified as PAF-[LL] in water-limited settings where the SOR is controlled by **H_2O-supply** in terms of both total-suction, and infrequency of "flushing-episodes" (Campbell 2004, 2006). The formation of "secondary-oxidation-products" (e.g. Fe-oxyhydroxides) as indurated, and tightly adhering/cohering deposits, is typically enhanced during "lag-phase" weathering in water-limited settings, and is a further mechanism by with sulphide-oxidation is stifled under the ensuing "mild" weathering-regime. Surface-zones of exposed mine-wastes/process-tailings in such environments are typically characterised by total-suctions well in excess of 1 bar for most of the year. At high total-suctions, even the physical meaning of pore-fluid "films" becomes tenuous.

1.0 INTRODUCTION

Hillgrove Resources Pty Ltd operates the Kanmantoo Copper Project located to the east of Callington, South Australia.

Ore is treated in the mill, and the resulting stream of process-tailings (in slurry form) discharged to an engineered, tailings-storage facility (TSF).

Graeme Campbell & Associates Pty Ltd (GCA) was commissioned to carry out geochemical testwork on a tailings-slurry sample derived from a bench-scale-metallurgical study.

The Static-Testwork Programme focused on the Acid-Formation Potential (AFP), Multi-Element Composition, and Mineralogy of the tailings-solids sample.[1] In addition, the quality (viz. major/minor-ion chemistry) of the tailings-slurry-water sample was determined.

The testwork results are presented and discussed in this report, and implications for process-tailings management highlighted.

[1] A Static-Testwork Programme comprises "whole-rock" analyses and tests.

2.0 STUDY APPROACH

Details of the sampling and testwork programmes, and the calculations and criteria employed for classifying the tailings-solids sample into an AFP category, are presented and discussed in the following sections.

2.1 Testwork Programme

2.1.1 Sample

The tailings-slurry sample was supplied by Ammtec Ltd (Balcatta). Details of the bench-scale-metallurgical study are presented in Appendix A.

The tailings-slurry sample was provided in a 10-L, opaque plastic-pail that was four-fifths-filled with slurry. The height of the tailings-solids was approximately one-tenth of the total-slurry height. The supernatant (viz. tailings-slurry-water) overlying the tailings-solids was decanted via siphoning, vacuum-filtered (0.45-µm-membrane), and preserved for specific analyses.[2]

The 'sludge' of tailings-solids was passed through a 5-mm-nylon sieve, and then homogenised by hand-mixing. The resulting tailings-solids sample was <u>not</u> washed prior to testing.

2.1.2 Testwork

The testwork methods employed in this study are based on recognised procedures for the geochemical characterisation of mine-waste materials, process-liquors and natural-waters (e.g. AMIRA 2002; Morin and Hutt 1997; Smith 1992; Coastech Research 1991; BC AMD Task Force 1989; APHA 1992).

[2] A sub-sample of the 'raw-filtrate' was employed for the analysis of major-parameters. Sub-samples of the filtrate were dosed with HNO_3 and H_2SO_4 for multi-element analyses, and the determination of NO_3-N and NH_3-N, respectively.

Details of the testwork methods are presented in Appendix B.

Part of the testwork was carried out by Genalysis Laboratory Services (Maddington), and SGS Environmental Services (Welshpool). Specialised testing (viz. auto-titrations and Net-Acid-Generation [NAG] Tests) was undertaken by Dr. Graeme Campbell in the GCA Testing-Laboratory (Bridgetown). The mineralogical work was performed by Dr. Roger Townend of Roger Townend & Associates (Malaga).

Copies of the laboratory and mineralogical reports are presented in Appendix C.

2.2 Calculated Parameters

The Maximum-Potential-Acidity (MPA) value (in kg H_2SO_4/tonne) of the tailings-solids sample was calculated by multiplying the Sulphide-S value (in %) by 30.6. The multiplication-factor of 30.6 reflects both the reaction stoichiometry for the complete-oxidation of marcasite/pyrrhotite, by O_2 to "$Fe(OH)_3$" and H_2SO_4, and the different weight-based units of % and kg H_2SO_4/tonne. The stoichiometry of sulphide-oxidation is discussed further in Appendix B. The Net-Acid-Producing-Potential (NAPP) value (in kg H_2SO_4/tonne) was calculated from the corresponding MPA and Acid-Neutralisation-Capacity (ANC) values (i.e. NAPP = MPA - ANC).

2.3 Classification Criteria

In terms of AFP, mine-wastes may be classified into one of the following categories, viz.

- Non-Acid Forming (NAF).

- Potentially-Acid Forming (PAF).

There are **no** unifying, "standard" criteria for classifying the AFP of mine-wastes (e.g. Price 2005; Campbell 2002a,b; Smith 1992), and reflects the diversity of sulphide- and gangue-mineral assemblages within (un)mineralised-lithotypes of varying weathering- and alteration-status. Rather, criteria for classifying AFP may need to be tailored to deposit-specific geochemistry, and mineralogy, and site-specific climate.

The AFP-classification criteria often employed at mining-operations worldwide are:

- **NAF**: Sulphide-S < 0.3 %. For Sulphide-S ≥ 0.3 %, both a negative NAPP value, and an ANC/MPA ratio ≥ 2.0.

- **PAF**: For Sulphide-S ≥ 0.3 %, any positive-NAPP value; negative-NAPP value with an ANC/MPA ratio < 2.0.

In assessing the AFP of mine-wastes, there is consensus that lithotypes with Sulphide-S contents less than *c.* 0.3 % are unlikely to oxidise at rates fast enough to result in acidification (e.g. pH less than 4-5). This position assumes that the groundmass hosting such "trace-sulphides" is not simply quartz, and/or clays (Price 2005; Price *et al.* 1997), and that for a carbonate-deficient gangue, the sulphide-minerals are not unusually reactive (e.g. sulphide-oxidation rates [SORs] less than *c.* 20-40 mg SO_4/kg/flush) [= *c.* 1-2 kg SO_4/tonne/year for weekly flushing/drying-cycles].[3] A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of kinetic-testing (viz. Weathering-Columns) conducted, since the late-1980s, by Dr. Graeme Campbell for mine-wastes of diverse mineralogy in terms of AFP.

[3] Although 'steady-state' SORs (at circum-neutral-pH) for Sulphide-S contents less than 0.3 % may indeed exceed 1-2 kg SO_4/tonne/year, such rates are generally restricted to either sedimentary forms (e.g. framboidal-pyrites, and marcasites), or hydrothermal-sulphides that are ultrafine-grained, and atypically reactive.

The ANC/MPA criteria for the NAF category reflects the need to compensate for less-than-perfect availability of alkalinity-forms (e.g. carbonate-minerals) for neutralisation of acid produced through sulphide-oxidation. A less-than-perfect availability of alkalinity-forms may arise from:

(a) Restricted accessibility of acid to carbonate-grains;

(b) Rate-limiting dissolution of carbonates-grains near pH=6-7; and,

(c) Depletion of carbonate-minerals through rainfall-fed leaching within waste-dumps.[4]

In terms of (a), restricted accessibility of acid to the surfaces of carbonate-grains may occur at different spatial-scales (viz. at the "whole-rock-scale" where rapid flows of Acid-Rock Drainage [ARD] by-pass the calcareous-matrix of rock-fragments [e.g. limestones] via preferential-flow pathways within a waste-dump, and at the "pore/grain-scale" in which the surfaces of carbonate-grains are "blinded/rimmed" by precipitates of Fe(III)-oxyhydroxides [e.g. ferrihydrite-type phases]). As shown by Li (1997), Fe-rich varieties of ferroan-carbonates are especially prone to "surface-armouring" effects (e.g. kinetic-testing of pyritic tailings-solids containing pyrite, ankerites and siderites resulted in acidic leachates when less than one-third of the carbonate-grains had dissolved). The effectiveness, or otherwise, of circum-neutral buffering is closely tied to inter alia the residence-time of pore-fluids in contact with carbonate-grain surfaces, and therefore a function of mine-site climate. In water-limited settings where flushing from infiltration is infrequent, and where moisture dynamics mainly involve slow unsaturated-flow below "field-capacity" (c.f. regular, rapid flow rates near saturation in well-watered settings), longer residence-times favour diffusion of soluble-alkalinity forms across armoured carbonate-grains, and thereby favour neutralisation reactions.

[4] Depletion of carbonate-minerals through dissolution in meteoric-waters is generally minimal in water-limited settings, especially within the "hydrologically-active-zone" (e.g. top 2-3 m) of a waste-dump, since re-precipitation occurs during evapo-concentration when strongly-desiccating conditions return after major wet-spells.

To compensate for the effects of (a) to (c) above, some practitioners advocate that, for a mine-waste sample to be classified as NAF, it must have an ANC/MPA ratio of at least 3.0 (see review of earlier literature by Smith [1992]). In recent years, fundamental-research (especially estimation of reaction-rates for diverse sulphide/gangue-mineral assemblages), and field-experience at mining operations world-wide, have shown that the potential for ARD production is very low for mine-waste materials with ANC/MPA ratios greater than 2.0 (AMIRA 2002; Price *et al.* 1997, Currey *et al.* 1997, and Murray *et al.* 1995).[5] This ANC/MPA ratio is employed in the present work.[6]

The risk posed by handling PAF-lithotypes during the active-lifetime of a deposit is governed primarily by the duration of the lag-phase (i.e. the period during which sulphide-oxidation occurs, but acidification does not develop, due to circum-neutral buffering by gangue-phases [chiefly carbonate-minerals]).[7] Although the duration of the lag-phase for mine-wastes at field-scale cannot be accurately predicted *a priori*, estimates (albeit approximate) may still be needed to identify threshold exposure-times for the safe handling of PAF-lithotypes, and so reduce ARD risk. Estimates of SORs, and lag-phase duration, may be obtained through programmes of kinetic-testing (viz. Weathering-Columns), and consideration of *inter alia* the moisture/aeration-regimes of exposed (i.e. uncovered) mine-wastes under the climatic conditions of the mine-site (especially rainfall distribution in relation to Potential-Evapotranspiration [PET] rates). In the absence of results from kinetic-testing, experience permits "first-pass" estimates of SORs and lag-phase duration to be made from the results of static-testing, and thereby used to further classify PAF-lithotypes into **PAF-[Short-Lag]** and **PAF-[Long-**

[5] Such ANC/MPA ratios are consistent with those indicated from SORs, and carbonate-depletion rates, as reported in the International-Kinetic Database for mine-waste materials from around the world (Morin and Hutt 1997).

[6] It should be noted that mining-regulators in Nevada (USA) classify a mine-waste sample as NAF, if it is characterised by an ANC/MPA ratio greater than 1.2 (US EPA 1994). This lower ANC/MPA ratio reflects the semi-arid conditions typically encountered at mine-sites in Nevada. Although utilised in the early-1990s, it is understood that an ANC/MPA ratio of 1.2 is still entertained by regulators in Nevada for "screening" PAF and NAF varieties of mine-wastes in semi-arid settings.

[7] SO_4 is still produced by sulphide-oxidation during the lag-phase, and appreciable amounts of soluble-forms of certain minor-elements (e.g. Ni and As) may be released at circum-neutral-pH during lag-phase weathering. However, in the latter case, the mine-wastes would need to be at least appreciably enriched in Total-Ni and Total-As to begin with.

Lag] sub-categories. Such "first-pass" estimations are necessarily provisional, and subject to revision, in the light of the outcomes of kinetic-testing, and field observations.

3.0 ACID-BASE CHEMISTRY OF TAILINGS-SOLIDS SAMPLE

The testwork results on the acid-base chemistry of the tailings-solids sample are presented in Table 3.1.

The tailings-solids sample was characterised by (Table 3.1):

- a Sulphide-S content of 0.78 %;
- an ANC value of 8-9 kg H_2SO_4/tonne, and a CO_3-C value of 0.01 %;
- a NAPP value of 16 kg H_2SO_4/tonne; and,
- a NAG-pH value of 3.6-3.7, and a NAG value of 13 kg H_2SO_4/tonne.

The calculated-NAPP and measured-NAG values were well matched.

The testwork results indicate that the tailings-solids sample contained trace amounts of sulphide-minerals (viz. Sulphide-S content of 0.5-1.0 %) in a gangue devoid of carbonate-minerals. The sulphide-mineral suite was dominated by marcasite with sub-ordinate pyrrhotite (Table 4.2).

The tailings-solids sample is classified as <u>PAF</u>, and given both the reactive nature of marcasites, and the "gutless-gangue" in terms of circum-neutral buffering, the sample may be further classified as <u>PAF-[Short-Lag]</u>.

4.0 MULTI-ELEMENT COMPOSITION AND MINERALOGY OF TAILINGS-SOLIDS SAMPLE

The multi-element composition and mineralogy of the tailings-solids sample are indicated by the data presented in Tables 4.1 and 4.2, respectively.[8] The corresponding element-enrichments in the samples, as indicated by the values of the Geochemical-Abundance Index (GAI), are also presented in Table 4.1.[9] It should be noted that these element-enrichments are relative enrichments, based on the element contents typically recorded for unmineralised soils, regoliths and bedrocks (Bowen 1979).

The tailings-solids sample was variously enriched in Ag, Bi and Se (Table 4.1).

The tailings-solids sample mainly comprised quartz, chlorites, biotites, and garnets (Table 4.2). The sulphide-mineral suite was dominated by marcasite over pyrrhotite. Although traces of sphalerite and chalcopyrite were identified in the mineralogical study, the Cu and Zn contents of the tailings-solids sample were only 0.037 %, and 0.005 %, respectively (Table 4.1).

The analysis results indicate that, geochemically, the tailings-solids sample was relatively "clean".

[8] The suite of elements listed in Table 4.1 is grouped into (a) the major-elements (viz. Na, K, Mg, Ca, Al and Fe) making-up the lattices of primary-silicates, sulphides, clays, sesquioxides and carbonates, and (b) minor-elements. A distinction is made between minor-elements which, under neutral-to-alkaline conditions, occur (i) as cationic-hydrolysis forms (e.g. Cu), and (ii) as anions/oxyanions (e.g. As). Anionic forms may exhibit moderate solubility under neutral-to-alkaline conditions.

[9] The GAI is defined in Appendix A.

5.0 QUALITY OF TAILINGS-SLURRY-WATER SAMPLE

The analysis results for the tailings-slurry-water sample are presented in Table 5.1.

The tailings-slurry-water sample had a pH value of 6.1, and a salinity (as Total-Dissolved Solids, TDS) of 650 mg/L (Table 5.1).[10]

The concentrations of minor-elements were below, or close to, the respective detection-limits (Table 5.1). The low concentrations of soluble metals attest to the efficiency of metal-sorption reactions under neutral-to-alkaline conditions (Sposito 1984).[11]

The analysis results indicate that the tailings-slurry-water sample was circum-neutral (viz. pH 6-7, and of potable-salinity, with minor-element concentrations either below, or close to, the respective detection-limits.

[10] Perth scheme-water was employed in the bench-scale-metallurgical study.
[11] Sorption reactions include both adsorption and precipitation reactions (Sposito 1984).

6.0 CONCLUSIONS

Based on the testwork results obtained in this study, it is concluded that the process-tailings-slurry sample was characterised by:

- tailings-solids which are classified as PAF-[Short-Lag];

- tailings-solids which are only moderately enriched in Ag, Bi, and Se; and,

- a tailings-slurry-water which is circum-neutral and of potable-salinity, with very-low concentrations of minor-elements.

During the active-lifetime of the TSF, the exposed surface-zone-tailings on the beaches should largely undergo "lag-phase-weathering", assuming that the exposure-times between deposition-cycles is only a matter of weeks (c.f. months).

Sulphide-oxidation within the surface-zone of the tailings-beaches should be constrained by either:

(a) high moisture contents (e.g. relative-saturations greater than *c.* 80 % [v/v]) initially, due to the settling/shrinking-stage of tailings-ageing; or,

(b) residual moisture contents (corresponding to total-suctions above 10+ bars), due to evaporative-drying, and formation of a surface-crust (likely at the "mm/cm-scale"), especially during the summer months.

However, the roles played by (a) and (b) above will depend closely on the reactivity of the sulphide-minerals (chiefly marcasites), and the (seasonal) unsaturated-moisture dynamics within the surface-zone-tailings. A programme of kinetic-testing (viz. Weathering-Columns) would be required to better project the duration of the lag-phase.

At TSF-closure, some form of dry-cover system will likely be required. Given the Mediterranean climate, and the local mallee-type vegetation communities of trees and shrubs, optimising evapotranspiration to minimise percolation beneath the cover system should prove more challenging than that for vegetated store/release-cover systems at mine-sites within the arid Australian interior (Campbell 2004).

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TABLES

Table 3.1: Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Solids Sample

GCA-SAMPLE NO.	MC (%, w/w)	TOTAL-S (%)	SO_4-S (%)	Sulphide-S (%)	CO_3-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
						kg H_2SO_4/tonne				
GCA6298	20.5	0.80 (0.76)	0.03 (0.02)	0.78	0.01 (0.01)	9 (8)	16	13 (13)	3.6 (3.7)	**PAF-[Short-Lag]**

Notes:
MC = Moisture-Content; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; AFP = Acid-Formation Potential; PAF = Potentially-Acid Forming; NAG = Net-Acid Generation.
All results expressed on a dry-weight basis, except for NAG-pH.
Values in parentheses represent duplicates.

Table 4.1: Multi-Element-Analysis Results for Tailings-Solids Sample

Note: Refer Appendix B for the definition of the Geochemical-Abundance-Index (GAI) indicated in this table.

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)	AV.-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)
	GCA6298		GCA6298
Al	5.4%	8.2%	0
Fe	13.6%	4.1%	1
Na	0.059%	2.3%	0
K	0.91%	2.1%	0
Mg	1.7%	2.3%	0
Ca	0.21%	4.1%	0
Ag	0.8	0.07	**3**
Cu	370	50	2
Zn	50	75	0
Cd	<0.1	0.11	0
Pb	19	14	0
Cr	150	100	0
Ni	54	80	0
Co	68	20	1
Mn	2,300	950	1
Hg	<0.01	0.05	0
Sn	3.3	2.2	0
Sr	11	370	0
Ba	91	500	0
Th	11	12	0
U	3.2	2.4	0
Tl	0.34	0.6	0
V	64	160	0
As	4	1.5	1
Bi	75	0.048	**6**
Sb	0.11	0.2	0
Se	0.99	0.05	**4**
Mo	5.2	1.5	1
B	<50	10	0
P	480	1,000	0
F	540	950	0

Note: Average-crustal abundance of elements based on Bowen (1979).

Table 4.2: Mineralogical Results for Tailings-Solids Sample

GCA6298	
Component	**Abundance**
quartz	dominant
chlorite	major
biotite almandine-garnet	minor
marcasite staurolite magnetite	accessory
pyrrhotite **sphalerite** **chalcopyrite** monazite apatite bismuth	trace

Notes:

dominant = greater than 50 %; major = 20-50%; minor = 10-20 %; accessory = 2-10 %; and, trace = less than 2 %.

Table 5.1: Analysis Results for Tailings-Slurry-Water Sample

Note: All results in mg/L, except for pH and EC (µS/cm).

ELEMENT/ PARAMETER	Tailings-Slurry-Water (GCA6298)	ELEMENT/ PARAMETER	Tailings-Slurry-Water (GCA6298)
Major-Parameters		***Minor-Ions***	
pH	6.1	Fe	0.19
EC [µS/cm]	1,100	Cu	0.01
TDS(gravimetric)	650	Ni	0.24
		Zn	0.11
Major-Ions		Co	0.51
		Al	0.10
Na	96	Cd	0.00033
K	27	Pb	0.0006
Mg	23	Cr	<0.01
Ca	65	Hg	<0.0001
Cl	200	As	0.0004
SO_4	290	Sb	0.00014
HCO_3	10	Bi	<0.000005
CO_3	<1	Se	0.0030
OH	<1	B	0.04
		Mo	0.00009
Nitrogen-Forms		P	0.1
		F	0.2
NH_3-N	2.4	Ag	<0.00001
NO_3-N	1.0	Ba	0.059
		Sr	0.38
		Tl	0.00006
		V	<0.01
		Sn	<0.0001
		U	0.00013
		Th	<0.000005
		Mn	0.72

Note:
EC = Electrical Conductivity; TDS = Total-Dissolved Solids.

APPENDIX A

DETAILS OF BENCH-SCALE-METALLURGICAL-TESTWORK PROGRAMME

Production of a Flotation Tailings Sample for Geo-chemical Testing by G Campbell and Associates.

The flotation tailings sample used for the Geo-chemical test work was derived from three flotation tests conducted on samples from the Kanmantoo copper deposit by AMMTEC laboratories, Balcatta, WA – Job Ref A10080.

Two tests (Ref GS 2420 and GS 2422) were on ore samples from Main zone and the third sample from the smaller O'Neil mineralization zone.

The flotation test conditions adopted for the all tests were as follows;

Ore samples were dry crushed to < 2mm and wet ground in a rod mill to produce a flotation feed sizing of approximately 80% passing 212 microns.

Flotation consisted of a rougher - scavenger stage of 7 minutes using Cytec 3418A (di-thio-phosphinate) as the collector at an addition rate of 50 g\tone of feed together with a small amount approximately 20g\tonne of MIBC (metyl iso-carbinol) as the frother at a pH of 8.5 using lime. The resulting rougher scavenger concentrates, approximately 9% by weight of the feed, were retained for further test investigations. The resulting rougher-scavenger tailings were collected as a pulp in a bucket filled to the brim and dispatched to G Campbell and Associates for geo-chemical test work. The above flotation conditions were used for all three tests however in test GS 2421 on the O'Neil ore zone an addition of 50g\t potassium amyl xanthate was added to the scavenger stage to improve the recovery of a chalcopyrite-pyrite middlings fraction.

An analyses of the key elements in the test work tailings which constituted the submitted sample are outlined below

Test No\Ore Zone	%Wt	%Cu	%Fe	%S
GS2420 (Main)	91.3	0.02	6.2	0.26
GS2422 (Main)	91.9	0.03	6.3	0.88
GS2421 (O'Neil)	91.2	0.07	5.5	1.27

APPENDIX B

TESTWORK METHODS

APPENDIX B

TESTWORK METHODS

B1.0 ACID-BASE-CHEMISTRY TESTWORK ON TAILINGS-SOLIDS SAMPLE

The acid-base chemistry of the tailings-solids sample was assessed by determining:

- Total Sulphur (Total-S) and Sulphate Sulphur (SO_4-S).
- Acid-Neutralisation Capacity (ANC), and Carbonate Carbon (CO_3-C).
- Net-Acid-Producing Potential (NAPP).
- Net-Acid Generation (NAG).

Relevant details of the testwork methods employed are discussed briefly below. Further details are presented in the laboratory reports (see Appendix C).

B1.1 Total-S and SO_4-S Tests

The Total-S value was measured by Leco combustion (@ 1300 ^{o}C) with detection of evolved $SO_{2(g)}$ by infra-red spectroscopy. The SO_4-S value was determined by the Na_2CO_3-Extraction Method (Berigari and Al-Any 1994; Lenahan and Murray-Smith 1986).[1]

The difference between the Total-S and SO_4-S values indicates the Sulphide-S (strictly Non-Sulphate-S) content.

[1] The Na_2CO_3-reagent extracts SO_4-S which occurs as soluble sulphates, and calcium sulphates (e.g. gypsum and anhydrite). It also extracts SO_4 sorbed to the surfaces of sesquioxides, clays and silicates. However, SO_4 present as barytes ($BaSO_4$) is not extracted, and SO_4 associated with jarositic-type and alunitic-type compounds is incompletely extracted.

B1.2 ANC, CO_3-C and pH-Buffering Tests

B1.2.1 ANC Test

The ANC value was determined by a procedure based on that of Sobek *et al.* (1978). This procedure is essentially the "standard" method employed for estimating the ANC values of mine-waste materials (Morin and Hutt 1997; BC AMD Task Force 1989).

The sample was reacted with dilute HCl for *c.* 2 hours at 80-90 ^{o}C, followed by back-titration with NaOH to a pH=7 end-point to determine the amount of acid consumed.[2] The simmering step for *c.* 2 hours differs slightly from the heating treatment of the Sobek *et al.* procedure wherein the test mixtures are heated to near boiling until reaction is deemed to be complete (viz. gas evolution not visually apparent), followed by boiling for one minute. In terms of dissolution of carbonate, primary-silicate and oxyhydroxide minerals, this variation to the Sobek *et al.* method is inconsequential.

The Sobek *et al.* (1978) procedure exposes mine-waste samples to both strongly-acidic conditions (e.g. pH of 1-2), and a near-boiling temperature. Provided excess acid is added, this method ensures that carbonate-minerals (including ferroan- and manganoan-varieties) are dissolved quantitatively, and that at least "traces" of ferro-magnesian-silicates (e.g. amphiboles, pyroxenes, chlorites, micas, etc.), and feldspars, are dissolved. However, under circum-neutral (viz. pH 6-8) conditions required for mine-waste and environmental management, the hydrolysis/dissolution of ferro-magnesian-silicates is kinetically extremely slow (e.g. see review-monograph by White and Brantley [1995]). Near pH=7, the hydrolysis/dissolution rates (under 'steady-state' conditions, and in the absence of inhibiting alteration-rims) of mafic-silicates and feldspars generally correspond to H_2SO_4-consumption rates 'of-the-order' $10^{-11}/10^{-12}$ moles/m^2/s (White and Brantley 1995). As a guide, for minerals of sub-mm grading, such silicate-dissolution rates correspond to Sulphide-Oxidation Rates (SORs) ranging

[2] Two drops of 30 % (w/w) H_2O_2 were added to the test mixtures as the pH=7 end-point was approached, so that any Fe(II) forms released by the acid-attack of ferroan-carbonates and -silicates are oxidised to Fe(III) forms (which then hydrolyse to "$Fe(OH)_3$"). This step ensures that the resulting ANC values are not biased "on-the-high-side", due to the release of Fe(II) during the acidification/digestion step. Such potential bias in ANC values may be marked for mine-waste samples in which "Fe-rich" ferroan-carbonates (e.g. siderite) dominate acid consumption. The addition of the H_2O_2 reagent is <u>not</u> part of the methodology described by Sobek *et al.* (1978).

up to 'of-the-order' 1-10 mg SO_4/kg/week (= *c.* 0.1-1.0 kg H_2SO_4/tonne/year).[3] Maintenance of circum-neutral-pH through hydrolysis/dissolution of primary-silicates is therefore restricted to <u>both</u> "mineral-fines", <u>and</u> slow rates of sulphide-weathering.

Despite the aggressive-digestion conditions employed, the ANC values determined by the Sobek *et al.* (1978) method allow an informed, initial "screening" of mine-waste materials in terms of acid-consuming and pH-buffering properties, especially when due account is taken of gangue mineralogy (Morin and Hutt 1997). Jambor *et al.* (2000, 2002) have presented a compendium of 'Sobek-ANC' values for specific classes of primary-silicates, and assists interpretation of the ANC values recorded for mine-waste materials of varying mineralogy.

B1.2.2 CO_3-C Value

The CO_3-C value is the difference between the Total-C and Total-Organic-C (TOC) values.

The Total-C was measured by Leco combustion (@ 1300 ^oC) with detection of evolved $CO_{2(g)}$ by infra-red spectroscopy. The TOC is determined by Leco combustion on a sub-sample which has been treated with strong HCl to decompose carbonate-minerals.

B1.3 NAPP Calculation

The NAPP value of the tailings-solids sample was calculated from the Total-S, SO_4-S and ANC values, assuming that <u>**all**</u> of the Non-Sulphate-S occurs in the form of marcasite/pyrrhotite. The sulphide-mineral suite in the tailings-solids sample was dominated by marcasite with sub-ordinate pyrrhotite (Table 4.2). NAPP calculations serve as a starting point in the assessment of the acid-formation potential of sulphide-bearing materials.

[3] SORs of this magnitude (at circum-neutral-pH) would typically only be recorded for the oxidation of "trace-sulphides" (e.g. Sulphide-S contents less than 0.5 %).

The complete-oxidation of pyrite (= marcasite) may be described by:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = 2H_2SO_4 + \text{"}Fe(OH)_3\text{"}$$

The complete-oxidation of pyrrhotite may be described by:

$$\text{"}FeS_{(s)}\text{"} + 9/2O_{2(g)} + 5/2H_2O_{(l)} = \text{"}Fe(OH)_{3(s)}\text{"} + 2SO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)}$$

Pyrrhotite is non-stoichiometric, so that expressing pyrrhotite as "FeS" in the above equation represents an approximation of the oxidation reaction (Belzile *et al.* 2004; Janzen *et al.* 2000). Elemental sulphur (as an intermediate-oxidation product) may also accumulate during pyrrhotite weathering (Nicholson and Scharer 1994), especially at low-pH. However, Elemental-S is ultimately oxidised to H_2SO_4 (albeit via a complex, microbially-mediated pathway involving thiosulphate and an array of polythionates).

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite, and/or pyrrhotite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**. The NAPP value of the tailings-solids sample was therefore calculated from the Sulphide-S content (in %S), and 30.6 as the 'conversion-factor' to estimate the amount of acid that may potentially be produced through the aerobic-oxidation of marcasite/pyrrhotite.

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**.

> Note: The above treatment of oxidation-reaction stoichiometry is restricted to oxidation by 'atmospheric-O_2' which is the dominant oxidant at circum-neutral-pH. A different oxidation-stoichiometry applies under acidic conditions (e.g. pH less than 3-4) where soluble-Fe(III) forms prevail, and then function as the chief oxidant (e.g. Rimstidt and Newcomb 1993).

Mechanistic aspects of pyrite-oxidation and pyrrhotite-oxidation at the molecular-scale were recently reviewed by Rimstidt and Vaughan (2003), and Belzile *et al.* (2004), respectively.

B1.4 NAG Test

The NAG Test is a direct measure of a sample's potential to produce acid through sulphide oxidation, and also provides an indication of the reactivity of the sulphides, and the availability of the alkalinity-forms contributing to the ANC (Miller *et al.* 1997, 1994).

In this test, the sample is reacted with H_2O_2 to rapidly oxidise contained sulphides, and allow the produced acid to react with the acid-neutralising materials (e.g. carbonates). The NAG Test supplements the NAPP-based assessment of the acid-formation potential of mine-waste materials (Morin and Hutt 1997).

The procedure employed in this study is based on that for the 'Static-NAG Test' in its 'single-addition' mode, as described in AMIRA (2002), and by Miller *et al.* (1994, 1997). The Start-pH of the 15 % (w/w) H_2O_2 solution (prepared from A.R.-grade H_2O_2) was adjusted to pH=4.5 using dilute NaOH. In addition, the boiling treatment to decompose residual, unreacted-H_2O_2 following overnight reaction was carried out in two stages (viz. boiling for *c.* 2 hours initially, cooling and addition of 1 mL of 0.02 M-$CuSO_4$ to the test mixtures, followed by boiling again for *c.* 2 hours). The addition of Cu(II) salts catalyses the decomposition of any unreacted-H_2O_2, and thereby prevents "positive-blank" values being obtained (O'Shay *et al.* 1990). Pulped K-feldspar was employed for the blanks run for the NAG-testwork.

Prior to the boiling-steps, the pH values of the test-mixture suspensions are measured, and invariably correspond to an "overnight-period" of reaction. Such pH values reflect buffering under ambient conditions <u>without accelerated dissolution of gangue-phases through boiling</u> to decompose any unreacted-H_2O_2. In the interpretation of NAG-testwork data, it is important to take note of the pH values recorded prior to the boiling-steps, especially for mine-waste samples that have <u>both</u> Sulphide-S contents less than *c.* 1 %, <u>and</u> ANC values less than *c.* 10 kg H_2SO_4/tonne (as typically recorded for a 'carbonate-deficient' gangue). Furthermore, oxidation by H_2O_2 is generally at least 10^4-10^5 faster than the SORs recorded during 'kinetic' testing (e.g. Weathering-Columns) of mine-waste samples. If circum-neutral conditions are to prevail during NAG testwork, then the rate of acid consumption by gangue-phases must be proportionately faster (c.f. rates for 'ambient-weathering'). This aspect must also be borne in mind when interpreting NAG-testwork data, especially for mine-waste materials that are devoid of carbonates, since the <u>dissolution/hydrolysis kinetics of primary-silicates are strongly pH-dependent</u>.

B2.0 MULTI-ELEMENT ANALYSES ON TAILINGS-SOLIDS SAMPLE

The total contents of a wide range of major- and minor-elements in the tailings-solids samples were determined through the use of various digestion and analytical techniques. The detection-limits employed are appropriate for environmental investigations.

Element enrichments were identified using the *Geochemical Abundance Index (GAI)*.[4]

The GAI quantifies an assay result for a particular element in terms of the average-crustal-abundance of that element.[5] The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average-crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average-crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average-crustal-abundances.

---

[4] The GAI was developed by Förstner *et al* (1993), and is defined as:

$$GAI = \log_2 [C_n/(1.5 \text{ x } B_n)]$$

where:

C_n = measured content of n-th element in the sample.

B_n = "background" content of the n-th element in the sample.

[5] The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Bowen (1979).

B3.0 ANALYSIS OF TAILINGS-SLURRY-WATER SAMPLE

The tailings-slurry-water sample was analysed for pH, Electrical Conductivity (EC), salinity (as Total-Dissolved Solids, TDS), alkalinity forms, Cl, SO_4, NO_3, NH_3-N, and a wide range of major- and minor-elements employing detection-limits appropriate for environmental investigations

All analyses were performed on appropriately-preserved 'splits' for the determination of specific analytes (see Appendix C).

APPENDIX C

LABORATORY REPORTS

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Consulting Mineralogists

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email: rogertownend@westnet.com.au

GRAEME CAMPBELL AND ASSOC, 10-11-2006

PO BOX 247,

BRIDGETOWN

WA

OUR REF. 21800

YOUR REF 0616

XRD/PLM/SEM ANALYSIS OF ONE TAIL.

(KANMANTOO)

R TOWNEND

Correspondence to Box 3129, Malaga D.C. WA 6945
ACN 069 920 476 ABN 92 076 109 663

RESULTS (XRD/PLM/SEM)

GCA	6298
QUARTZ	DOMINANT
CHLORITE	MAJOR
BIOTITE	MINOR
ALMANDINE GARNET	MINOR
STAUROLITE	ACCESSORY
MARCASITE	ACCESSORY
PYRRHOTITE	TRACE
SPHALERITE	TRACE
CHALCOPYRITE	TRACE
MAGNETITE	ACCESSORY
MONAZITE	TRACE
APATITE	TRACE
BISMUTH	TRACE

GENALYSIS LABORATORY SERVICES PTY LTD

Dr G Campbell
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BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	**143.0/0608152**
No. of SAMPLES	1
CLIENT O/N	GCA0616
PROJECT	Kanmantoo Copper project
STATE	Tailings
DATE RECEIVED	01/09/2006
DATE COMPLETED	26/09/2006

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

The sample was received as tailings solids which required drying at 45 degrees Celcius, mixing, splitting and fine pulverising in a zirconia bowl.

Results of analysis on:

Element	**LOD**	**S_tot**	**S-SO4**	**S-SO4**	**C_tot**	**TOC+C**	**C-CO3**
Method	**/GRAV**	**/LECO**	**Na2CO3/ GRAV**	**SO/OES**	**/LECO**	**OrgC/ LECO**	**/CALC**
Detection	**0.01**	**0.005**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Units	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Control Blank	X	X	X	X			
GCA6298	19.49	0.793	0.03	0.07	0.06	0.05	0.01
GCA6298 Dup	20.56	0.759	0.02	0.06	0.05	0.04	0.01
LECO2		2.31			4.38		
PD-1			4.29				
Graphite-1						1.78	
PD-1				4.29			
Control Blank							
S_SO4_A			0.60				
S_SO4_B			1.29				

1. The C,S results were determined from the pulverised portion
2. The Carbon and Sulphur was determined according to Genalysis method number SL_W043.
3. S-SO4 was determined by removal of sulphide sulphur from the samples by boiling in hydrochloric acid followed by leaching with hydrochloric acid to dissolve the remaining sulphate which is then read by OES, method code SL_W045
4. S-SO4 was also determined by precipitation of BaSO4. TOC+C (acid insoluble carbon compounds and elemental carbon) by LECO after removal of carbonates and soluble organic carbon. These methods are not covered by Genalysis terms of accreditation to NATA

Acid Neutralisation Capacity (ANC)

Sample Name	Fizz Rating	Sample Weight (g)	Molarity HCl	Molarity NaOH	Initial Effervescence	colour change	pH drop	ANC Solution pH	ANC (kg H_2SO_4/tonne)
GCA6298	0	2.004	0.50	0.103	Nil	No	3.4*	2.3	9
GCA6298 Dup	0	2.006	0.50	0.103	Nil	No	3.4*	2.3	8

Notes:

1. ANC was determined on the -2mm portion. Acid concentrations are as stated
2. Colour change: * Indicates the appearance of a green colouration as the pH=7 endpoint was approached. Two drops of hydrogen peroxide are added to each sample as the endpoint is approached to oxidise any ferrous iron
3. pH drop : * Indicates a pH drop to a value below 4 on addition of peroxide
4. This procedure according to Genalysis methods number ENV_W035

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NATA Signatory: R H Essers

Date: 26th September 2006

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Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g) [moist]	Sample Weight (g) [dry]	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
					pH	EC (µS/cm)		
GCA6298	6.3	5.2	Reaction peaked overnight	2.8	3.6	470	13.30	13
GCA6298 (Repeat)	5.8	4.8	Reaction peaked overnight	2.9	3.7	440	11.90	13
Blank	-	3.4		6.1	7.5	71	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997). The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Test mixtures boiled for *c.* 2 hours to accelerate reaction with H_2O_2. Then, after allowing the test mixtures to cool, 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted H_2O_2 in the test mixtures (O'Shay *et al.* 1990). K-Feldspar was employed for the Blanks.

Dr GD Campbell
27th October 2006

ANALYTICAL REPORT

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AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0608153
No. of SAMPLES	:	1
No. of ELEMENTS	:	32
CLIENT O/N	:	GCA0616
SAMPLE SUBMISSION No.	:	
PROJECT	:	Kanmantoo Cooper Project
STATE	:	Ex-Pulp
DATE RECEIVED	:	01/09/2006
DATE COMPLETED	:	11/10/2006
DATE PRINTED	:	11/10/2006

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

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SAMPLE DETAILS

DISCLAIMER

Genalysis Laboratory Services Pty Ltd wishes to make the following disclaimer pertaining to the accompanying analytical results.

Genalysis Laboratory Services Pty Ltd disclaims any liability, legal or otherwise, for any inferences implied from this report relating to either the origin of, or the sampling technique employed in the collection of, the submitted samples.

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $1.95 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $50.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The sample, GCA6298, was received as being a 'tailings solid' which had already been dried and crushed on Genalysis report 143.0/0608152. A 100 gram portion was mixed and split from the bulk prior to being fine pulverised in a zirconia bowl.

The results have been determined according to Genalysis methods codes :
Digestions : SL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), SL_W013 (D/), and SL_W012 (CM/)
Analytical Finishes: ICP_W004 (/OES), ICP_W005 (/MS) and AAS_W004 (/CVAP).

The results included the assay of blanks and international reference standards OREAS 45P, and STSD-2 and Genalysis in-house standards TKC5, AE12 and HgSTD-4.

The results are expressed as parts per million or percent by mass in the dried and prepared material.

NATA Signatory: R H Essers

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	0.1	20	1	50	0.1	0.01	10	0.1	0.1	2
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA6298	0.8	5.18%	4	X	91.0	73.32	2073	X	67.3	142
CHECKS										
0001 GCA6298	0.6	5.31%	4	X	89.4	74.18	1607	X	66.3	129
STANDARDS										
0001 HgSTD-4										
0002 OREAS 45P				X						
0003 STSD-2										
0004 TKC5	15.5	6.03%	629		539.4	30.32	2.46%	5.3	155.4	721
BLANKS										
0001 Control Blank	0.2	X	X	X	0.3	0.02	17	X	X	5
0002 Control Blank	X	X	1		0.1	0.03	12	X	0.2	2
0003 Control Blank										
0004 Control Blank										
0005 Control Blank				X						
0006 Acid Blank	X	X	X		X	0.02	X	X	X	X
0007 Acid Blank										
0008 Acid Blank				X						
0009 Control Blank										

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA6298	354	487	13.48	X	8976	1.65%	2216	5.2	585	54
CHECKS										
0001 GCA6298	362	538	13.57	X	9072	1.67%	2282	4.7	584	53
STANDARDS										
0001 HgSTD-4				0.28						
0002 OREAS 45P			18.79							
0003 STSD-2		992								
0004 TKC5	1806				1.15%	1.67%	1944	61.1	1.71%	2309
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	0.1	X	2
0002 Control Blank	X				X	X	X	0.2	X	2
0003 Control Blank										
0004 Control Blank				X						
0005 Control Blank			X							
0006 Acid Blank	X				X	X	X	X	X	X
0007 Acid Blank				X						
0008 Acid Blank			X							
0009 Control Blank										

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	20	2	10	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA6298	476	19	8183	0.11	0.97	3.3	10.47	10.67	0.34	3.15
CHECKS										
0001 GCA6298	479	19	8262	0.09	0.99	3.2	10.14	10.70	0.34	3.05
STANDARDS										
0001 HgSTD-4										
0002 OREAS 45P										
0003 STSD-2										
0004 TKC5	1992	1478	1.32%	185.26		5.7	575.66	143.06	25.48	15.75
BLANKS										
0001 Control Blank	X	X	16	X	0.02	0.2	X	X	X	0.02
0002 Control Blank	X	2	11	X		0.2	X	0.02	X	0.02
0003 Control Blank					0.02					
0004 Control Blank										
0005 Control Blank										
0006 Acid Blank	X	X	X	X		X	X	0.02	0.02	X
0007 Acid Blank										
0008 Acid Blank										
0009 Control Blank					0.01					

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA6298	63	49
CHECKS		
0001 GCA6298	64	50
STANDARDS		
0001 HgSTD-4		
0002 OREAS 45P		
0003 STSD-2		
0004 TKC5	338	1116
BLANKS		
0001 Control Blank	X	2
0002 Control Blank	X	X
0003 Control Blank		
0004 Control Blank		
0005 Control Blank		
0006 Acid Blank	X	X
0007 Acid Blank		
0008 Acid Blank		
0009 Control Blank		

METHOD CODE DESCRIPTION

A/MS

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0608154
No. of SAMPLES	:	1
No. of ELEMENTS	:	31
CLIENT O/N	:	GCA0616
SAMPLE SUBMISSION No.	:	
PROJECT	:	Kanmantoo Cooper Project
STATE	:	Solutions
DATE RECEIVED	:	01/09/2006
DATE COMPLETED	:	11/10/2006
DATE PRINTED	:	11/10/2006

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
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NOTES

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Company Accreditation Number 3244

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The analysis results reported herein have been obtained using the following methods and conditions:

The sample, GCA6298, were received as being tailings-slurry-water which had been filtered and acidified.

The results have been determined by ICP-MS according to Genalysis method code ICP_W004 and by ICP-OES according to method code ICP_W005.

The analysis included the assay of blanks and Genalysis in-house reference standards. The results are expressed as milligrams per litre or micrograms per litre in the solution as received

NATA Signatory: R H Essers

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	mg/l
DETECTION	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02	0.1	0.01
DIGEST										
ANALYTICAL FINISH	/MS	/OES	/MS	/OES	/MS	/MS	/OES	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA6298	X	0.10	0.2	0.04	58.12	X	64.01	0.30	486.4	X
CHECKS										
0001 GCA6298	X	0.10	0.4	0.04	58.99	X	63.14	0.33	502.9	X
STANDARDS										
0001 Alcoa5-OES		1.85		0.93			47.67			0.48
0002 Alcoa7MS	4.52		26.0		5.64	4.907		4.61	497.1	
BLANKS										
0001 Control Blank	X	X	0.1	X	X	X	X	X	0.2	X

ANALYSIS

ELEMENTS	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na	Ni	P
UNITS	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
DETECTION	0.01	0.01	0.1	0.1	0.01	0.01	0.05	0.1	0.01	0.1
DIGEST										
ANALYTICAL FINISH	/OES	/OES	/MS	/OES	/OES	/OES	/MS	/OES	/OES	/OES
SAMPLE NUMBERS										
0001 GCA6298	0.01	0.19	X	26.3	22.51	0.71	0.08	95.1	0.24	0.1
CHECKS										
0001 GCA6298	0.01	0.19	X	26.4	22.80	0.72	0.09	94.9	0.24	0.1
STANDARDS										
0001 Alcoa5-OES	0.24	1.93		3.8	60.32	0.48		230.9	0.52	0.9
0002 Alcoa7MS			5.1				5.10			
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Pb	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	ug/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
DETECTION	0.5	0.01	0.5	0.05	0.1	0.02	0.005	0.01	0.005	0.01
DIGEST										
ANALYTICAL FINISH	/MS	/MS	/MS	/OES	/MS	/MS	/MS	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA6298	0.6	0.13	2.0	8.00	X	360.73	X	0.06	0.122	X
CHECKS										
0001 GCA6298	0.5	0.14	3.0	7.94	X	378.25	X	0.05	0.121	X
STANDARDS										
0001 Alcoa5-OES				9.86						0.48
0002 Alcoa7MS	5.3	5.00	24.6		4.9	485.03	5.253	4.75	4.971	
BLANKS										
0001 Control Blank	X	X	X	X	X	0.05	X	X	X	X

ANALYSIS

ELEMENTS	Zn
UNITS	mg/l
DETECTION	0.01
DIGEST	
ANALYTICAL FINISH	/OES
SAMPLE NUMBERS	
0001 GCA6298	0.11

CHECKS	
0001 GCA6298	0.11

STANDARDS	
0001 Alcoa5-OES	0.48
0002 Alcoa7MS	

BLANKS	
0001 Control Blank	X

METHOD CODE DESCRIPTION

/MS

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Mass Spectrometry.

/OES

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

SGS

LABORATORY REPORT COVERSHEET

DATE:	3 November 2006
TO:	Graeme Campbell & Associates Pty Ltd PO Box 247 BRIDGETOWN WA 6255
ATTENTION:	Dr Graeme Campbell
YOUR REFERENCE:	GCA Job No. 0616
OUR REFERENCE:	98284
SAMPLES RECEIVED:	08/09/2006
SAMPLES/QUANTITY:	1 Water

The above samples were received intact and analysed according to your instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

DON SARATHCHANDRA
Senior Chemist

SGS Australia Pty Ltd ABN 44 000 964 278 | Environmental Services t +61 (0)8 9458 7278 | 52 Murray Road f +61 (0)8 9451 3505 | Welshpool 6106 | Western Australia | www.au.sgs.com

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 98284
PROJECT: GCA Job No. 0616

LABORATORY REPORT

Your Reference Our Reference Type of Sample	Units	GCA 6298 98284-1 Water
pH	pH Units	6.1
Conductivity @25^{o}C	μS/cm	1,100
Total Dissolved Solids @ 180^{o}C	mg/L	650
Chloride, Cl	mg/L	200
Sulphate, SO_4	mg/L	290
Bicarbonate, HCO_3	mg/L	10
Carbonate, CO_3	mg/L	<1
Hydroxide Alkalinity as $CaCO_3$	mg/L	<5
Fluoride, F	mg/L	0.2
Nitrate, NO_3	mg/L	1.0
Ammonia Nitrogen NH_3-N	mg/L	2.4

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 98284
PROJECT: GCA Job No. 0616

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
--------			
pH	pH Units	0.1	AN-101
Conductivity @25^{o}C	µS/cm	2	AN-106
Total Dissolved Solids @ 180^{o}C	mg/L	10	PEI-002
Chloride, Cl	mg/L	1	PEI-020
Sulphate, SO_4	mg/L	1	PEI-020
Bicarbonate, HCO_3	mg/L	5	PEI-006
Carbonate, CO_3	mg/L	1	PEI-006
Hydroxide Alkalinity as $CaCO_3$	mg/L	5	PEI-006
Fluoride, F	mg/L	0.1	PEI-027
Nitrate, NO_3	mg/L	0.2	PEI-020
Ammonia Nitrogen NH_3-N	mg/L	0.1	PEI-010

CLIENT: Graeme Campbell & Associates Pty Ltd **OUR REFERENCE:** 98284
PROJECT: GCA Job No. 0616

LABORATORY REPORT

NOTES:

LOR - Limit of Reporting.

Nitrate and ammonia were determined from the sulphuric acid preserved sample.

This test is not covered by the scope of our NATA accreditation.

GRAEME CAMPBELL & ASSOCIATES PTY LTD
Specialists in Mine-Waste Geochemistry,
& Soil-Moisture-Retention Testing

P.O. Box 247, Bridgetown, Western Australia 6255
Phone: (61 8) 9761 2829 Fax: (61 8) 9761 2830
E-mail: gca@wn.com.au

0721/2

COMPANY:	Hillgrove Resources Pty Ltd
ATTENTION:	Marty Adams
FROM:	Graeme Campbell
SUBJECT:	Kanmantoo Copper Project: Testwork Results for Drilling Samples from Various Site Areas

NO. PAGES (including this page): 10 DATE: 23rd July 2007

Marty,

The results for the drilling samples from areas in the vicinity of the existing tailings-storage facility (TSF) and seepage-pond are presented in Table 1. Related results for samples from the area of the proposed TSF and waste-rock dumps are presented in Table 2.

The locations of the drillholes are given in the Coffey Mining Pty Ltd report to which this factual memorandum-report is included as an appendix.

The testing undertaken herein provides background geochemical information for the soil/geologic-profiles drilled in the respective areas.

Regards,

Dr GD Campbell
Director

Encl. Tables (2 pages)
Laboratory reports (7 pages)

Table 1: Results for Drilling Samples from Areas in Vicinity of Existing Tailings-Storage Facility and Seepage-Pond

GCA-SAMPLE-NO.	Depth-Interval (m)	pH-(1:2)	EC-(1:2) [mS/cm]	Total-S (%)	Total-Cu (%)	Total-C (%)
<u>KMB011</u>						
GCA7122	1-2	7.8	0.55	0.03 (0.02)	120 (110)	0.28 (0.28)
GCA7123	4-5	7.6	1.2	0.08	84	0.34
GCA7124	7-8	6.5	1.1	0.08	72	0.11
GCA7125	10-11	6.4	1.1	0.10	78	0.13
<u>KMB012</u>						
GCA7126	4-5	8.8	0.35	0.02	64	0.09
GCA7127	9-10	8.6	0.60	0.02	81	0.16
GCA7128	14-15	9.1	0.28	0.02	67	0.03
GCA7129	19-20	9.1	0.23	0.01	28	0.13
<u>KMB013</u>						
GCA7130	4-5	9.0	0.31	0.02	330	0.08
GCA7131	14-15	7.4	0.37	0.05	140	0.19
GCA7132	24-25	7.8	0.27	0.10	23	0.17
GCA7133	29-30	4.3	1.4	5.9	2,800	0.10

<u>Notes</u>:
EC = Electrical-Conductivity.
pH-(1:2) and EC-(1:2) correspond to pH and EC determined on sample slurries prepared using deionised-water at a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

Table 2: Results for Drilling Samples from Area of Proposed Tailings-Storage Facility and Waste-Rock Dumps

GCA-SAMPLE-NO.	Depth-Interval (m)	pH-(1:2)	EC-(1:2) [mS/cm]	Total-S (%)	Total-Cu (mg/kg)	Total-C (%)
KMB016						
GCA7134	5-6	8.2	0.19	0.03	99	0.20
GCA7135	15-16	7.8	0.22	0.05	150	0.12
GCA7136	25-26	8.4	0.12	0.01	10	0.04
GCA7137	35-36	8.7	0.13	0.04	17	0.07
GCA7138	45-46	8.5	0.13	0.10	30	0.24
GCA7139	55-56	6.8	0.48	0.49	49	0.06
KMB017						
GCA7146	5-6	9.1	0.22	<0.01	63	0.06
GCA7147	15-16	9.0	0.18	<0.01	44	0.05
GCA7148	25-26	8.2	0.38	0.18 (0.19)	91 (81)	0.05 (0.04)
GCA7149	35-36	8.5	0.32	0.10	48	0.04
GCA7150	45-46	8.5	0.33	0.15	29	0.02
GCA7151	55-56	8.5	0.42	0.11	22	0.03
KMB018						
GCA7140	5-6	8.9	0.25	<0.01	44	0.14
GCA7141	15-16	9.2	0.14	<0.01	51	0.06
GCA7142	25-26	8.9 (8.9)	0.17 (0.12)	<0.01	16	0.05
GCA7143	35-36	8.8	0.14	<0.01	21	0.08
GCA7144	45-46	8.7	0.14	<0.01	17	0.03
GCA7145	55-56	8.2	0.13	0.03	33	0.05
KMB019						
GCA7152	5-6	8.6	0.15	<0.01	21	0.06
GCA7153	15-16	8.6	0.18	0.02	42	0.12
GCA7154	25-26	8.7	0.23	0.01	33	0.05
GCA7155	35-36	8.5	0.29	0.14	31	0.06
GCA7156	45-46	8.6 (8.4)	0.25 (0.28)	0.07	51	0.04

Notes:
EC = Electrical-Conductivity.
pH-(1:2) and EC-(1:2) correspond to pH and EC determined on sample slurries prepared using deionised-water at a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

Graeme Campbell & Associates Pty Ltd

Laboratory Report

pH-(1:2) & EC-(1:2) TESTWORK

SAMPLE NO.	SAMPLE WEIGHT (g)	SAMPLE + DEION.-W WEIGHT (g)	pH-(1:2)	EC-(1:2) (mS/cm)
GCA7122	30.0	90.3	7.8	0.55
GCA7123	30.0	90.4	7.6	1.2
GCA7124	30.0	90.0	6.5	1.1
GCA7125	30.0	90.0	6.4	1.1
GCA7126	30.0	90.3	8.8	0.35
GCA7127	30.0	90.1	8.6	0.60
GCA7128	30.0	90.2	9.1	0.28
GCA7129	30.0	90.5	9.1	0.23
GCA7130	30.0	90.4	9.0	0.31
GCA7131	30.0	90.0	7.4	0.37
GCA7132	30.0	90.2	7.8	0.27
GCA7133	30.0	90.5	4.3	1.4
GCA7134	30.0	90.0	8.2	0.19
GCA7135	30.0	90.3	7.8	0.22
GCA7136	30.0	90.3	8.4	0.12
GCA7137	30.0	90.1	8.7	0.13
GCA7138	30.0	90.2	8.5	0.13
GCA7139	30.0	90.1	6.8	0.48
GCA7140	30.0	90.4	8.9	0.25
GCA7141	30.0	90.3	9.2	0.14
GCA7142-1	30.0	90.1	8.9	0.17
GCA7142-2	30.0	90.1	8.9	0.12
GCA7143	30.0	90.0	8.8	0.14
GCA7144	30.0	90.1	8.7	0.14
GCA7145	30.0	90.0	8.2	0.13
GCA7146	30.0	90.1	9.1	0.22
GCA7147	30.0	90.3	9.0	0.18
GCA7148	30.0	90.0	8.2	0.38
GCA7149	30.0	90.2	8.5	0.32
GCA7150	30.0	90.0	8.5	0.33
GCA7151	30.0	90.1	8.5	0.42
GCA7152	30.0	90.0	8.6	0.15
GCA7153	30.0	90.2	8.6	0.18
GCA7154	30.0	90.2	8.7	0.23
GCA7155	30.0	90.2	8.5	0.29
GCA7156-1	30.0	90.1	8.6	0.25
GCA7156-2	30.0	90.0	8.4	0.28

Note: EC = Electrical-Conductivity.
Testwork performed on crushed (nominal -2 mm) samples.
pH-(1:2) and EC-(1:2) values correspond to pH and EC values of suspensions with a solid:solution ration of *c.* 1:2 (w/w) prepared using deionised-water.
Drift in pH-glass-electrode less than 0.1 pH unit between commencement, and completion, of testwork.
Drift in EC-electrode less than 0.05 mS/cm between commencement, and completion, of testwork.
Testwork performed in a constant-temperature room (viz. 21 +/- 2-3 ^{o}C).

Dr GD Campbell
18th July 2007

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/0706097
No. of SAMPLES	:	35
No. of ELEMENTS	:	3
CLIENT O/N	:	GCA0721/2 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	
STATE	:	Ex-Pulp
DATE RECEIVED	:	13/06/2007
DATE COMPLETED	:	19/07/2007
DATE PRINTED	:	19/07/2007

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

MAIN OFFICE AND LABORATORY

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SAMPLE DETAILS

DISCLAIMER

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Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $3.00 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $50.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The 35 samples, as listed in the report, was received as being 'rock chips' which required crushing prior to splitting and a 100g portion being fine pulverised in a zirconia bowl.

The results for Cu are based Genalysis method code SL_W001 (A/) with the analytical finishes according to ICP_W004 (/OES). The LECO results have been determined according to Genalysis methods number SL_W023 on the pulverised portion of the samples.

The results included the assay of blanks and Genalysis in-house standard MPL-1 and certified reference material MA-1b.

The results are expressed as parts per million or percent by mass in the dried and prepared material.

NATA Signatory: A P Evers
Chief Chemist

Date: 19th July 2007

This document is issued in accordance with NATA’s accreditation requirements.

ANALYSIS

ELEMENTS	C	Cu	S
UNITS	%	ppm	%
DETECTION	0.01	1	0.005
DIGEST		A/	
ANALYTICAL FINISH	/LECO	OES	/LECO
SAMPLE NUMBERS			
0001 GCA7122	0.28	116	0.024
0002 GCA7123	0.34	79	0.071
0003 GCA7124	0.11	74	0.073
0004 GCA7125	0.13	78	0.092
0005 GCA7126	0.09	59	0.015
0006 GCA7127	0.16	85	0.016
0007 GCA7128	0.03	71	0.012
0008 GCA7129	0.13	29	0.006
0009 GCA7130	0.08	343	0.013
0010 GCA7131	0.19	122	0.041
0011 GCA7132	0.17	23	0.097
0012 GCA7133	0.10	2813	5.835
0013 GCA7134	0.20	108	0.024
0014 GCA7135	0.12	149	0.043
0015 GCA7136	0.04	11	0.008
0016 GCA7137	0.07	17	0.034
0017 GCA7138	0.24	31	0.094
0018 GCA7139	0.06	54	0.487
0019 GCA7140	0.14	41	0.005
0020 GCA7141	0.06	49	0.006
0021 GCA7142	0.05	17	0.006
0022 GCA7143	0.08	20	0.008
0023 GCA7144	0.03	17	0.005
0024 GCA7145	0.05	30	0.028
0025 GCA7146	0.06	61	X
0026 GCA7147	0.05	43	X
0027 GCA7148	0.05	86	0.179
0028 GCA7149	0.04	49	0.095
0029 GCA7150	0.02	30	0.143
0030 GCA7151	0.03	23	0.108
0031 GCA7152	0.06	22	X
0032 GCA7153	0.12	41	0.014
0033 GCA7154	0.05	33	0.009
0034 GCA7155	0.06	32	0.138
0035 GCA7156	0.04	50	0.064

CHECKS

0001 GCA7122	0.28	117	0.016
0002 GCA7148	0.04	83	0.184

ANALYSIS

ELEMENTS	C	Cu	S
UNITS	%	ppm	%
DETECTION	0.01	1	0.005
DIGEST		A/	
ANALYTICAL FINISH	/LECO	OES	/LECO
STANDARDS			
0001 MA-1b	2.48		1.235
0002 MPL-1		1883	
0003 MA-1b	2.49		1.260
0004 MPL-1		1782	

BLANKS			
0001 Control Blank	X	X	X
0002 Control Blank		X	
0003 Acid Blank		X	

METHOD CODE DESCRIPTION

/LECO

No digestion or other pre-treatment undertaken. Analysed by LECO furnace.

A/OES

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers.
Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.